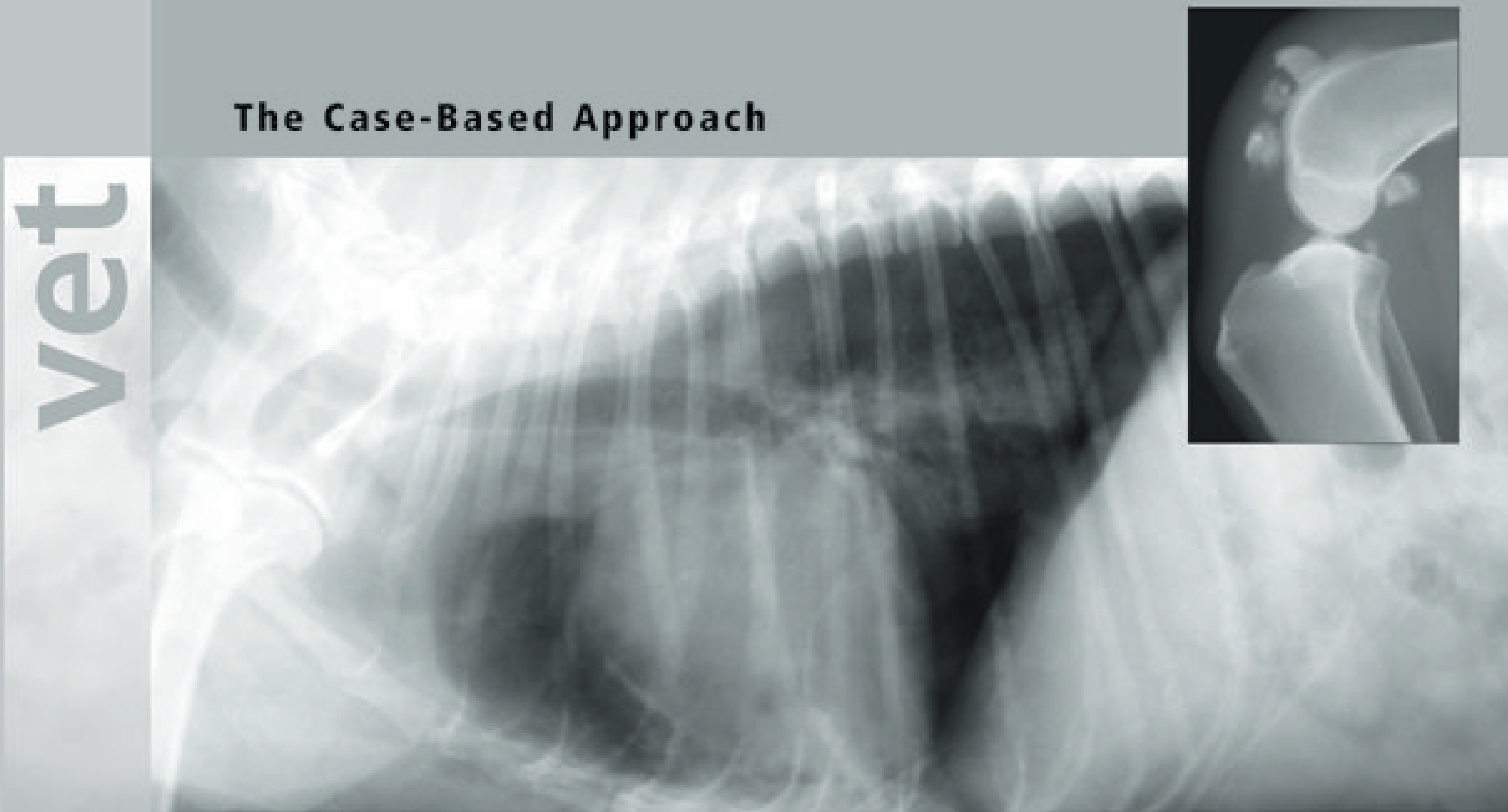
Joe P. Morgan · Pim Wolvekamp

Atlas of Radiology of the Traumatized Dog and Cat

The Case-Based Approach



Second Edition

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Preface

This book has been written in particular for the clinician faced with the diagnostic and treatment problems associated of dealing with trauma patients. The authors at the start in writing made a basic decision to direct the case presentation towards the preponderant use of diagnostic radiology. This not only includes the classical use of radiology for assessing bony structures, but also the use of diagnostic radiology for the evaluation of thoracic and abdominal trauma. When radiography of the thorax is necessary, it is easy for the clinician to make abdominal radiographs too, with minimal trauma to the patient and this procedure can result in a quick evaluation of the clinical status of the patient in which a physical examination may be limited at the best. Many of the abdominal lesions depicted could have been easily diagnosed using ultrasound; however, we have directed the case discussion toward the use of diagnostic radiology because we thought it the better of the two techniques for determining the status of the patient as quickly as possible, meaning that treatment can be instituted more quickly. Also the use of an ultrasound probe in a potentially traumatized abdomen can be associated with some risk. In addition, the efficient use of ultrasound, endoscopy, and laparoscopy is very operator dependent making some clinicians argue strongly for their use, while others are less skillful and not as anxious. Radiographs tend to be evaluated more accurately by a larger percentage of those in veterinary practice today.

Where possible the treatment given to each case is reported, though the treatments used in these cases may not match that which might have been recommended by many of our readers. Unfortunately, the hospital records often do not include the details of why a certain decision was made. Frequently, a particular decision was based on purely financial considerations. In some patients no treatment is reported as they were not treated at our clinic. This may have been simply due to the owner's desire to return to a clinic that was closer to home. In other cases, the reason a patient left the hospital prior to treatment is often not clearly stated in the records.

In some of the patients presented, the case history leaves little doubt that they had possibly been mismanaged. Again, the reasons for any delay in surgical or other treatment are often not described in the records, and indeed there may have even been a very sound reason for the delay.

The preponderance of cases featured in this book are feline. This bias is not intended to give the impression that dogs are less effected by traumatic incidences, but is only a reflection of the fact that the examination of smaller patients usually produces radiographs of higher quality permitting the features or patterns of a particular disease to be more easily reproduced in print.

Despite this bias, we hope our selection of trauma cases may provide you with enjoyment in following in the examination and determination of a diagnosis. The book in the hands of a student hopefully will provide them with an opportunity of exploring some of the methods of evaluation of trauma and emergency patients and to learn that not all traumas are associated with a grave prognosis. The body is really quite resilient and can withstand not only the original trauma, but also diagnostic techniques and even misguided treatment.

Summer 2004

The Authors

Notice

As the detailed descriptions of the radiographs are given in the text of the case studies, either no or only simplified headings are given. Where necessary, grey oblongs have been drawn as pictograms next to a particular heading to show which pictures belong to it.

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Chapter 1

Introduction

Trauma is defined as a suddenly applied physical force that results in anatomic and physiologic alterations. The injury varies with the amount of force applied, the means by which it is applied, and the anatomic organs affected (Table 1.1). The event can be focal or generalized, affecting a single organ or a number of organs. Trauma can result in a patient with apparently minimal injury, a patient who is paralyzed, or a patient who is in severe shock. The patient may be presented immediately following the trauma or presentation may be delayed because of the absence of the animal or because of the hesitancy of the owners.

Most trauma cases in veterinary practise are due to accidents in which the patient is struck by a moving object such as a car, bus, truck, or bicycle. The nature of the injury varies depending on whether the patient is thrown free, crushed by a part of the vehicle passing over it, or is dragged by the vehicle. Other types of trauma result from the patient falling, with the injury depending on the distance of the fall and the nature of the landing. Dogs jumping from the back of a moving vehicle involve falling only a short distance, but the trauma of hitting the road at a high speed results in severe injury to both bone and soft tissues. Other possibilities of trauma occur when the patient has been hit by a falling object, or is kicked or struck by something. Bite wounds are another type of trauma that constitute a frequent cause of injury in both small and large patients, and can be complicated by secondary infection. Penetrating injuries are a separate classification of injury and can be due to many types of projectiles. Gunshots are a common cause of injury in certain societies (Chap. 6). Abuse is a specific classification of trauma and should be suspected in certain type of injuries (Chap. 7). Poisoning presents a unique class of emergency cases (Chap. 8).

Poisonings may result in a generalized hemorrhagic diasthesis. The evaluations of patients who through examination or treatment have sustained injury are also included in the text (Chaps. 2.2.12 & 3.2.8). They may have sustained an injury as a result of the misuse of catheters or the improper insertion of esophageal or tracheobronchial tubes. A patient requiring anesthesia or the post-operative patient may be subject to a unique possibility of unexpected trauma. Another group sustained their injury following ingestion or inhalation of foreign bodies (Chaps. 2.2.13, 2.2.15, 3.2.1 & 3.2.2).

Radiology is a frequently utilized method of examination of a traumatized patient. Its use varies with the nature of the injury and ranges from the techniques used in the emergency patient who is not breathing to those used in a patient several days after the trauma and who is not producing urine, to a patient who is acutely lame.

Table 1.1: Types of trauma or emergency situations

1. Physical trauma
   a. physical forces applied suddenly that result in anatomical and physiological alteration
   b. gunshot injuries
   c. penetrating injuries
   d. bite wounds
2. Iatrogenic injuries during examination or treatment
   a. incorrectly used catheter
   b. inappropriately positioned catheter
   c. post-anesthetic recovery problems
   d. post-surgical injuries
3. Ingested foreign bodies that result in sudden discomfort
4. Ingested or inhaled toxic agents with sudden clinical signs
5. Acute coagulopathies
6. Combinations of injuries
   a. chest wall injury plus lung injury
   b. pulmonary parenchymal injury plus diaphragmatic hernia
   c. pulmonary parenchymal injury plus pleural injury
   d. pulmonary plus mediastinal injury
   e. fracture plus diaphragmatic hernia
   f. thoracic injury plus spinal, pelvic, or limb fractures
   g. thoracic injury plus abdominal injury
7. Abusive injuries

Often radiographic examinations serve to determine which injuries are life threatening, while other studies are undertaken to assess the effectiveness of emergency treatment: e.g. the evaluation of the size of the cardiac silhouette and the size of pulmonary vessels in the treatment of shock patients, or the evaluation of persistent pleural fluid following thoracocentesis. Follow-up studies serve to determine the effectiveness of therapy, for example, by visualising the return of pulmonary function. The creation of a permanent record may be of help to the owner and the clinician in understanding the nature of an injury at a later date.

The case material in this book has been generally divided into those patients with thoracic trauma followed by those with abdominal trauma and finishing with selected musculoskeletal cases, soft tissue damage, gunshot wounds, abuse, and poisoning. Because of the inclusion of patients with multiple injuries, this schedule is not followed exactly.

Cases are presented with minimal histories that the reader will discover are only as accurate as the memory of the owner or their willingness to share information with the clinician. The signalment and clinical history of a case can be specific and they are usually accurate, although you may be presented with a patient found by a person who knows nothing about the injury nor the animal. The clinical history may be totally accurate in such cases where the owner has witnessed the traumatic event, whereas other patients are presented with a history of having been found recumbent or having returned home unable to walk normally. Most of these animals are correctly assumed to have been traumatized, while others have diseases due to another etiology. The reader of this book will discover that the clinical history presented by the owner is not always accurate and frequently is generated as a cover-up for a failure of the owner to present the animal as quickly as would be thought appropriate. In most of the cases, the results are known and included in the descriptions. Unfortunately, some owners chose to reject the offer of treatment and these cases were returned to the referring clinician, making it impossible to learn more about the outcome of the case. In others, an unexpected outcome is discussed. The case material within the text is presented in a consistent pattern as shown in Table 1.2. Not all sections are treated equally in each case.

Table 1.2: Presentation of cases

1 Signalment/History
2 Physical examination
3 Radiographic procedure
4 Radiographic diagnosis
5 Differential diagnosis
6 Treatment/Management
7 Outcome
8 Comments

1.1 Characteristics of a diagnostic radiographic study

Many features need to be considered in how or why to use diagnostic radiology in trauma and emergency patients (Table 1.3). In the event of generalized trauma, radiographs of the entire body are suggested as the most rapid means of determining the general status of the patient. A complete study of the thorax or abdomen should include two views ventrodorsal (VD) and lateral, and permit the evaluation of the thoracic inlet and diaphragm in the thorax, and the diaphragm and pelvis in the abdomen. If the patient is large, more than one radiograph may be required for each routine view. In cats, it is possible because of their smaller size and more uniform tissue density to include the entire patient on a single radiograph. The use of a "catogram" is to be encouraged in this species. This technique is not possible in the dog because of the greater difference in size of the body organs.

The type of radiographic study undertaken may be adapted according to the clinical signs (Table 1.4). In the trauma patient, it is usually less stressful to take a dorsoventral (DV) view of the thorax or abdomen by positioning the patient in sternal recumbency with the forelegs extended cranially and the hind limbs in a flexed position. In the seriously injured patient, it is possible that only a lateral view can be made during the first examination to avoid further injury. It is desirable in such cases to make the second orthogonal view later, especially prior to anesthesia or submitting the patient to surgery.

Table 1.3: Use of radiographic examination in traumatized patients

1. Possible to survey the entire body
   a. if a complete clinical report of the trauma is not available
   b. if a thorough physical examination cannot be conducted
   c. in a manner more extensive than possible by physical examination
2. Possible to limit study only to the area of suspected injury
3. Study can be performed
   a. in a non-traumatic manner
   b. within a few minutes
   c. with minimal cost to the client
   d. with relative ease to the patient
4. Possible to diagnose multiple lesions and determine
   a. which are life-threatening
   b. the sequence of treatment placing life-threatening conditions first
   c. prognosis
   d. time and cost of treatment
5. Assess the effectiveness of emergency treatment
   a. has a hypovolemic status been corrected
   b. has a pneumothorax decreased in volume
6. Assess the effectiveness of therapy
   a. in the event that clinical improvement is delayed
   b. to determine time of discharge
7. Provide a permanent record to enable
   a. owner to understand the lesions and treatment
   b. evaluation of treatment
   c. review of the radiographs
8. Determine preexisting or coexisting non-traumatic lesions and determine their affect on the outcome of the case
9. Provide additional information if the thoroughness of a physical or neurological examination is limited by trauma
10. Determine the status of the patient prior to anesthesia
11. Determine the need for an ultrasound examination in emergency patients
12. Determine the value of presurgical plus postsurgical radiographs

The selection of which lateral view to make or whether to position the patient in a DV or VD position is often predetermined by the nature of the injury. A bandage or splint placed on a limb may make certain types of positioning difficult. It is best to make the first study causing as little stress to the patient as possible until the nature of the injury is more fully determined. Subsequent studies from other angles can then be made, if necessary, for a more complete study.

Table 1.4: The nature of the radiographic study may be altered to include:

1. Special positioning of the patient or x-ray tube
   a. horizontal beam technique
   b. oblique views
   c. right vs left lateral views
   d. dorsoventral (DV) vs ventrodorsal (VD) views
2. Use of contrast studies
   a. gastrointestinal contrast study
   b. urographic contrast study
      I. intravenous
      II. retrograde
3. Increase the number and nature of the radiographic views because of unique trauma
   a. stress studies plus routine studies
   b. abdominal injury plus spinal fracture
   c. thoracic injury plus abdominal injury

1.2 Importance of radiographic quality

A particular problem with the trauma patient is the difficulty in positioning or in achieving a diagnostic radiographic study of the thorax or abdomen. Poor radiographic quality due to technical error(s) greatly increases the possibility of incorrect film evaluation. One should avoid the natural tendency to deny that non-diagnostic radiographs have been produced. It is easy on poor-quality radiographs to call an artifact or normal anatomical variation a lesion, resulting in a false-positive evaluation. More often, the technical errors prevent visualization of a lesion, causing a false-negative evaluation.

If a potential technical problem is recognized at the time of the examination, it is easiest and least expensive to expose another film immediately while the patient is positioned on the table and technical assistance is readily available to assist with positioning. Remember that a technically compromised image can result in a missed diagnosis or, worse, a wrong diagnosis. At its best, this is practicing poor medicine; at its worst, it is intellectual dishonesty and malpractice. Film is the least costly part of a radiographic examination, so why not make an extra exposure if you have any question as to positioning of the patient and subsequent quality of the radiograph.

Thoracic studies of small animals are usually made with the patient recumbent causing compression of the lower portion of the lung so it contains less air than normal (be atelectatic). The resulting increased fluid density in the dependent lobes tends to prevent identification of either infiltrative lesions or space-occupying masses. The compression caused by pressure of the abdominal contents on the diaphragm, the weight of the heart and mediastinal structures, and the pressure of the tabletop against the lower rib cage all prevent lobar filling on the lateral view. The effect of DV vs VD positioning results in either the dorsal or ventral portion of the lung being compressed, though it results in a difference that is much less obvious than that seen in the right vs left lateral views.

The studies of skeletal lesions permit fewer variations from the routine craniocaudal (CrCa), caudocranial (CaCr), and lateral views. Additional views are usually required due to the nature of the injury if it limits how a limb can be positioned. Studies of the spine require care in patient positioning and may demand multiple views to permit a thorough examination of each vertebral segment. Diagnosis of a fracture on one view may limit the comparison with the orthogonal view made at a later time.

A comparison of right and left lateral views, or VD and DV views, always permits a more complete understanding of the character of the intrathoracic or intra-abdominal structures than is seen on a single view. The nature and location of the suspected lesion influences which view is best for evaluation. If pleural fluid is free to move, the use of two lateral views or the DV vs VD views are helpful in providing a more complete evaluation of the lungs, mediastinum, and thoracic wall. The movement of peritoneal fluid is difficult to evaluate on radiographs made in different positionings and are of little diagnostic value.

Abdominal studies of small animals are usually made with the patient recumbent causing any intraluminal air to rise, outlining the more superior portion of the containing organ. When using liquid gastrointestinal contrast material, positioning becomes of particular importance in diagnosis. While air rises to the superior portion of the hollow viscus, the more dense barium sulfate meal or iodinated liquid contrast agent falls to the dependent portion of the organ. It is possible to mix air with the positive contrast agent in either the gastrointestinal organs or in the urinary bladder creating double-contrast studies.

In the event of free peritoneal air or fluid, patient positioning offers little advantage because the free air pools in the most dorsal portion of the abdomen regardless of the patient's positioning and is difficult to visualize using a vertical x-ray beam. Free peritoneal fluid pools in the dependent portion of the abdomen, where it compromises the identification of the serosal surfaces. Such fluid can be recognized principally because of this radiographic pattern.

Errors in film processing can destroy the efforts of good patient positioning and correct film exposure. Processing is strongly influenced by solution temperature and age of the solutions. Use of automatic processors greatly decreases these errors and makes their use almost mandatory in a progressive clinic or hospital.

1.3 Use of correct radiographic technique

The use of correct exposure factors is an absolute necessity especially in thoracic radiography and incorrect settings are a frequent technical problem. These can be related to machine limits, in which instance, it must be realized that your x-ray machine or imaging system (cassette screens and film) does not have an adequate capacity for thoracic radiography. With dyspnea that often follows trauma, the thoracic contents move rapidly and an exposure time of 0.01 second or less may be required to prevent motion artifacts. A longer exposure time results in movement of the lungs and a reduction in the radiographic quality of the radiograph. The use of a combination of faster rare-earth-type intensifying screens and appropriate speed film reduces the radiographic exposure time required and is an alternative to obtaining a more powerful machine. Thoracic radiography should use the: (1) highest kVp possible to allow for use of a decreased mAs, (2) highest mA, and (3) the shortest exposure time settings possible.

Abdominal radiography is much less demanding since organ motion is not a particular technical problem. Also, the contrast between the intrabdominal organs is much lower and the kVp setting is not as critical. Patient preparation is not a concern in most trauma or emergency patients. Often the stomach and bowel are empty, either as a result of the trauma or due to the patient not eating during the days following the trauma and prior to presentation at the clinic. The vomiting patient usually has an empty stomach.

Correct radiographic technique in skeletal studies is not a particular problem because of the possible use of a bright light that permits evaluation of an over-exposed study in a manner not possible in either thoracic or abdominal studies. An underexposed view obviously requires a repeat study. Exposure time is not a problem in studies of the extremities permitting use of higher detail and consequently slower, film-screen combinations.

1.4 Use of a grid technique

The use of a grid contributes greatly to improving the diagnostic quality of the resulting radiograph by removing much of the scatter radiation that produces fogging of the film and loss of contrast. The requirement for its use is dependent on body thickness and the nature of the organs to be radiographed. Grids can be satisfactorily used in either a stationary mode, in which the grid lines are seen on the radiograph, or in an oscillating mode that moves the grid during the exposure time and blurs the grid lines so that they do not create the potentially disturbing parallel lines on the resulting radiograph. A radiograph made using a fine-line stationary grid has visible grid lines that are fine enough so as to not significantly reduce image quality even when used in a stationary mode. The use of a grid requires a marked increase in the radiographic exposure and the type of grid selected should permit the use of an exposure time that is short enough to prevent patient motion. The compromise in the use of a grid is that the improvement in film quality through increased contrast resulting from the limitation of scatter radiation must not be negated by patient motion causing a loss in detail.

A grid is particularly helpful on thoracic studies in dogs whose thoracic measurements are greater than 15 cm. In the smaller patient, the less dense lungs create a minimal amount of scatter and the use of a grid in a thoracic radiograph is not required, though if the thoracic cavity contains pleural fluid or abdominal organs, the grid may be helpful with thoracic measurements over 11 cm. In addition, an obese patient with thick thoracic walls requires the use of a grid at smaller body measurements.

Because the density of the abdominal contents in a normal patient is equivalent to water, trauma does not usually result in a marked alteration in their density and little variation is noted in the amount of scatter radiation produced. Thus, use of a grid in abdominal radiography is always recommended with patients that measure more than 11 cm.

According to these recommendations, the use of a grid is not commonly required in studies of the thorax or abdomen of a cat. The use of a grid is required in radiography of the musculoskeletal system in studies of the spine, shoulder joint, or pelvis/hip joint in which the thickness of the tissues exceeds 11 cm.

1.5 Selection of intensifying screens

The best film-screen combination for radiography of the trauma patient, in the event your x-ray machine has limited power, is fast rare-earth-type screens and matching high-latitude film. This combination permits the use of shorter exposure times and produces low-contrast radiographs without motion artifacts. If your x-ray machine is of a higher milliamperage rating, you have the choice of selecting a slower speed screen and film combination, and still achieve an adequate radiographic exposure at a short exposure time. The use of a slower speed system, especially in extremity studies, improves radiographic quality since the resulting radiograph is much less grainy.

1.6 Radiographic viewing

The radiographs should be dry at the time of evaluation. Wet tank processing often prevents this, since it is often necessary to evaluate the radiographs immediately following their processing to make a decision concerning keeping the patient in the clinic or sending it home. While the radiograph should be re-evaluated following drying, the time required for this is often not taken. The errors in diagnosis associated with this problem alone offer justification for acquiring an automatic processor that permits an immediate examination of a dry radiograph.

Viewing conditions greatly affect your perception of image quality. Even though it is highly unlikely, surroundings should be quiet at the time of film evaluation so that your full attention can be directed toward the radiographs. If possible, it would be best to use an area away from busy clinic activities. An adequate source of illumination is basic for radiographic evaluation. The use of a ceiling light bulb is not adequate, nor is sunlight beaming through a window that is most likely streaked with dirt. Why do we work so hard to make a diagnostic radiograph and then evaluate it under the worst of conditions?

Even with the use of good film viewers, the areas of brightly illuminated viewing surface surrounding a smaller radiograph often used in skeletal radiography reduce the perceived contrast drastically, as the eyes adjust to the bright light making it difficult, even impossible, to see the darker areas on the radiograph. If possible, eliminate such extraneous light sources by using cardboard blockers on the viewboxes placed around the radiographs. It is interesting that viewers of this type with built-in "shades" have been available and are in common usage in European countries for the past 40 years, but, for some unknown reason, viewers of this type are difficult to locate in the United States.

Another problem is that of bright room light reflecting off the radiograph. This can be rather easily corrected by decreasing the room illumination or even moving into a darkened room for film evaluation. A less common problem in radiographic evaluation is the uneven illumination in the viewboxes from different types or different ages of light bulbs or fluorescent tubes.

Often in skeletal radiography, the high contrast between bone and soft tissues makes evaluation of the interface difficult. Thus, early bony callus, post-traumatic periosteal new bone, or minimal soft tissue calcification can be inadvertently overlooked. The use of a separate bright light is helpful in the evaluation of these portions of the radiograph and this technique has also a special importance in the evaluation of overexposed radiographs.

1.7 Radiographic contrast

The term radiographic contrast refers to the comparison of shadows of different film densities. In skeletal radiography, the difference between one region of film density and an adjacent region is great. The greater the film contrast, the more "sharply" or "clearly" the margin of a bone organ or structure appears on the radiograph. Another method to describe the radiograph is to refer to a scale of contrast, which takes into account the entire range of shades of gray from white to black. In skeletal radiography, the dense bones are contrasted with the less dense soft tissues surrounding them so the contrast is high. Still, contrast can be diminished or lost by overexposure or overdevelopment resulting in a radiograph that prevents light from the viewbox from penetrating the periphery of the film and results in an image "without identification of any soft tissues around the bone".

1.8 Film density versus tissue density

Frequently, the use of the term density is confusing because it can refer to film density or tissue density. Film density refers to the "blackness" of a film, i.e. the most black portion of a film prevents light from the view box from penetrating the radiograph and is said to have the highest film density. Thus defined photometrically, density is the opacity of a radiographic shadow to visible light and results from photons having reached that portion of the film. These areas become black after processing, preventing light from reaching the eye during examination of the radiograph.

However, density can also be used to describe tissue that has a high weight per unit volume and so prevents photons from reaching the film resulting in an area of lessened film blackening, or whiteness. Tissue density and film density are therefore inversely proportional. The tissue with the highest density causes the highest attenuation of the x-ray photons and produces the lightest (most white) shadow on the radiograph creating a low film density. The term density should be used only when specifically defining whether it refers to tissue density or film density.

1.9 More about "density"?

Bowen A D. Not DENSITY! Are you Dense? Radiology 176:582, 1990.

Density is a noun, but to be radiologically meaningful it must be qualified by indicating whether it is greater or less than some reference density. The reference density is generally understood to be that of the normal tissue (e.g., lung, muscle, bone) that surrounds the shadow in question. For example, "This increased density in the bone is caused by fragment superimposition". Thus qualified, density also can be used as part of a modifier: "a zone of increased density" meaning tissue that is of greater density than expected.

The choice of "density" as a description of a radiographic change is unfortunate. What we call "increased density" on a radiographic film actually results from a higher tissue density causing less darkening of the film in an area in which fewer photons have interacted resulting in a reduced deposition of silver ions. Are there better terms that we could use? Radiopacity is most exact, for it denotes an attribute of the object: the tissue's impenetrability to x-rays rather than the resultant degree of exposure of the film. Opacity is a truncation of radiopacity and is equally acceptable. Or, perhaps to make things clearer, we should think in terms of "a patch of increased density", "a shadow of water density", or "a lesion similar to bone density".

The appearance of the body's tissues in CT scans is similar to radiographs since it is based on the absorption and transmission of x-rays. In CT terminology, "attenuation" is a collective term for the processes of absorption and scattering by which the energy of an x-ray beam is diminished in its passage through matter. Thus, a "high-density lesion" becomes more appropriately a "high-attenuation" lesion; this terminology could also be used with diagnostic radiology.

1.10 The art of radiographic evaluation

Radiographic evaluation is an art and as such, is an acquired skill where both proficiency and expertise develop slowly. This skill cannot be attained by reading about radiology and passing multiple choice examinations about the subject. Acquisition of this skill can be facilitated by learning the principles of radiographic evaluation, which are then applied to routine radiographic examination. Regardless of the hours spent in the study of books, a skill in radiographic evaluation is primarily acquired by practice, preferably with a skilled teacher as a guide, using selected cases that illustrate the specific principles or features. The untrained or inexperienced reader makes many more errors than the trained reader.

What does radiographic evaluation or radiographic interpretation mean? It is a series of conclusions drawn as a result of the application of a systematic, learned and practiced method of analytical searching of the shadows on the radiographs, which with knowledge, come to take on a special meaning: instead of being an incoherent mass of shades of gray, the shadows acquire life and clinical importance.

Learning normal radiographic anatomy is important since as in all clinical medicine, the most difficult decision is the determination of whether an observation is within normal limits or is indicative of disease. This learning can be enhanced through the study of a series of normal studies or by radiographing the opposite limb of the patient. Many practitioners become discouraged because the skill in evaluation of a radiograph does not develop quickly. Yet, we forget the time required to come to an understanding of the varieties of lung sounds. The learning of any diagnostic method will continue throughout your career and can be enhanced as long as you conscientiously practice it; the same applies to diagnostic radiology.

1.11 Methods of radiographic evaluation

There are two basic methods of radiographic evaluation. The first is to memorize the radiographic features of a selected disease. It is natural for us to want to believe that the course of a disease will follow a set pattern. This approach is taken by traditional textbooks of medicine, in which diseases are presented with a description and an illustration of the typical progression of the disease, including in some cases sample radiographs. We are taught in this manner in school and accept the unmistakable example of a disease as classical. Unfortunately, disease only rarely appears in this manner in true life. Thus, we associate a classical radiographic picture with a specific bone disease and the features can become so fixed in our mind that we demand their presence to assure the diagnosis. If it were possible to effectively teach radiology in this way, radiologists would not be required to teach it and radiographic diagnosis would be taught in medicine courses.

The error with using this approach in radiographic evaluation is similar to the difficulty found in applying textbook knowledge to the reality of a sick animal. The clinical information derived from a patient often is indefinite and ambiguous, and it is the same with radiographic findings. In many patients, unfortunately, the picture of the disease as seen on a radiographic study as well as the clinical picture of the disease are not "typical", and the textbook approach therefore leads to confusion or misdiagnosis. It is sometimes said that the "patient hasn't read the text book" and thus, does not know how the lesion should appear radiographically.

A second and much more accurate method of radiographic evaluation uses radiographic signs or patterns or features. It involves a complete examination of the radiograph, searching for evidence of pathophysiology, and relating the resulting radiographic features to the various conditions that are known to cause them. As there are often many signs or patterns on a radiograph, a systematic analysis using deductive reasoning often leads to the appropriate differential diagnosis.

1.12 Preparing the radiological report

A discussion of the radiological report is thought to be important at this time even though you may feel that it is not necessary in your practice environment. The radiographic findings need to be recorded somewhere in your clinical record even if this is only a statement that radiographs were made and a brief comment of your evaluation. You can record a written report on: (1) the film storage envelope, (2) the clinic record, or (3) a separate radiographic report. Considering what should go into the report can assist you in considering some of the many questions relative to a study that you might otherwise not consider. While the report can be brief, it is helpful if it contains information that might be required in assisting you with a subsequent medicolegal problem.

By answering the questions listed below, you will be reminded of the additional areas you need to examine on the radiograph. Thus, having to answer specific questions is an excellent technique for forcing a more complete examination of the radiographs. Such questions are influenced by the type of people to whom you will communicate your findings and how will this communication take place? The report may be only for yourself, a colleague in your practice, a colleague to whom the case will be referred, or for the owner. The report may be written or delivered verbally. Your relationship to the case usually determines to whom you report the findings. If you are the primary care clinician, you are probably "talking to yourself" or perhaps to a colleague in the clinic. If this is a referral patient, you need to report the findings to the individual who referred the case to you. If the patient is to be referred by you to another clinic, you need to tell that person what you have found on the study (of course, you can just send the radiographs with a note that you did not have time to evaluate them).

Whatever the method of reporting the findings is used, the most complete report would include the following information: (1) a description of patient including the breed, sex, and age, patient number, date, and name of your clinic, (2) a description of the radiographic study including the anatomical region evaluated and any special techniques used such as stress views or oblique views, (3) a note concerning the technical quality of the radiographs, (4) a comment on any limitations in the study due to problems in positioning or on the number of views that were made, (5) a description of the appearance and location of the major lesion using acceptable and understandable terms, (6) a brief comment concerning any secondary lesions such as a congenital/developmental lesion or a degenerative lesion, and (7) your diagnosis, definitive or differential. The inclusion of any information to explain why the radiographic study was not complete can be of great value to you during subsequent litigation.

It is obvious that on even a causal review, this can involve a great deal of time spent on a single radiographic study. As with most things in life, the more time you force yourself to spend in preparing a radiographic report, the more you will put into the thought it takes to make the radiographic evaluation, and the more information you will derive from the study. Answering the questions listed above forces you to give thought in a manner that can prevent you from making some foolish errors.

1.13 Terms to understand in radiology

Aggressive radiographic changes refer to a pattern that is rapidly changing and is often associated with a malignant lesion. These changes can be seen, for example, in a lesion in which malignant transformation of a fracture is secondary to a chronic inflammatory environment or a pathologic fracture extending through a primary bone tumor

Benign radiographic changes refer to a pattern that is slowly changing and is often associated with a benign lesion. Most traumatic lesions are benign in appearance.

Bone density refers to the high mass per unit volume of bone tissue reflecting the high density of the bone. Evaluation of this feature is important in the detection of a pathologic fracture in which the volume of bone tissue is diminished.

Clinical data or signalment refers to the patient's name, age, sex, breed, symptoms, and laboratory findings. Their consideration is important in achieving the correct interpretation of a radiograph or at least in making a complete differential diagnosis.

Clinical history refers to the information provided by the owner concerning the events leading up to the development of particular clinical signs. The history may also include information derived from a previous medical record. Unfortunately, this information is not always correct and is often not complete.

Comparison studies refer to radiographs made of the opposite limb that provide a normal comparison and are especially valuable in skeletally immature patients. Comparison studies can help in the determination of a trauma-induced error in bone organ growth.

Density can refer to mass per unit volume of tissue, in which case bone has a high density. Density can also refer to the blackness of the radiograph, which is determined by the amount of silver present following processing of the film. Thus the two terms, tissue and bone density, are inversely proportional; e.g., a bone with high tissue density produces a shadow on the radiograph that is white and is of low photographic density.

Diagnostic scheme refers to a system for reaching a determination of a differential or definitive diagnosis by combining the clinical findings, findings from the physical examination, laboratory findings, and the results of diagnostic imaging.

Differential diagnosis refers to the decision that the clinical data, findings from physical examination, laboratory findings, plus particular radiographic features are ambiguous and suggest the possibility of more than one cause for the clinical signs listed in an order of decreasing probability.

Film refers to the unexposed radiographic film and is the term usually used through the process of film exposure and film processing. At the time the film is evaluated, it is referred to as a radiograph or a diagnostic radiograph.

Film density refers to the darkness on the radiograph and is inversely proportionate to tissue density. More specifically, it is a measurement of the percentage of incident light transmitted through a developed film. It is also known as radiographic density.

Film-screen combination refers to the matching of a pair of intensifying screens with a particular x-ray film. Both screens and film are produced to have different speeds that reflect the number of x-ray photons required to produce a diagnostic radiograph. The combination is often given a numerical value (100 often refers to an older standard that is still commonly used, the "par" screen system).

Film speed refers to the size and nature of the crystals in the film emulsion that determine the radiographic exposure required to produce a given film density.

"Follow-up" studies refer to a subsequent radiographic study made to elucidate the information contained within the first study.

Grid refers to a devise consisting of alternating strips of lead and a radiotransparent medium which are oriented in such a way that most of the primary radiation passes through, while most of the scattered radiation is absorbed. A grid is used commonly in abdominal studies but uncommonly in patients with traumatic injury to the musculoskeletal system.

kVp refers to the kilovoltage peak or potential and is the maximum potential difference applied between the anode and cathode by a pulsating voltage generator.

"Leave me alone" lesions refer to lesions not thought to be life-threatening and in which biopsy is thought to be non-rewarding or even contraindicated.

Lucency refers to a black shadow on the radiograph created by low tissue density (or radiolucency). The term is also to describe a bone lesion with less than normal bone tissue (lytic lesion).

mAs refers to a combination unit that is the product of the tube current expressed in milliamperage and the exposure time expressed in seconds. It determines the number of photons produced during an exposure.

Opacity refers to a white shadow on the radiograph create by high tissue density (also, radiopacity).

Patient rotation refers to a position in which the limb, head, spine, or pelvis are at an unusual angle to the tabletop resulting in an atypical radiograph. Hopefully, this is a planned rotation to achieve a more diagnostic study and not one that resulted from accidental malpositioning of the patient.

Radiograph refers to an x-ray film that has been exposed during a diagnostic radiographic study and contains information following processing that can lead to a radiographic diagnosis.

Radiographic density refers to the blackness on the radiograph that is determined by the amount of silver present following processing of the film.

Radiographic pattern refers to a characteristic change seen on the radiograph and is related to a pathophysiological change (also called a radiographic feature).

Radiography refers to the technique of patient positioning, film exposure, and film processing that results in the production of a diagnostic radiograph.

Radiology refers to the medical speciality in which radiographic film is exposed during a radiographic examination, thereby producing a radiograph that is subsequently examined. Thus, radiology is the term used to describe the entire field of radiography and radiographic diagnosis. This term is now altered somewhat since the results of many examinations are digitalized and a radiographic film is not used.

Radiolucent refers to a black shadow on the radiograph created by low tissue density that has permitted passage of photons (also lucent or lytic shadow).

Radiopacity refers to a white shadow on the radiograph created by high tissue density that has prevented the passage of photons (also opaque shadow)

Radiopaque refers to the ability of tissue to absorb x-ray photons.

Recumbent indicates that the patient is positioned with its body laying on the table-top.

Repeat studies (films) are additional radiographic views made following the discovery that the first radiographs were nondiagnostic for some reason.

Roentgen refers to the Professor of Experimental Physics at Wurzburg, Germany who discovered x-rays on November 8, 1895. The term is synonymous with x-ray (also roentgen beam or x-ray beam).

Sequential studies refers to subsequent radiographic studies made to record a change in the radiographic appearance of a lesion (also follow-up study).

Signalment refers to the patient's name, age, sex, breed, symptoms, and laboratory findings and are important in assisting in the correct interpretation of a radiograph.

Skyline view refers to a special method of patient positioning that allows the x-ray beam to be directed so it projects a particular bone or part of a bone free of the surrounding skeletal structures.

Stress studies refer to the special positioning of a body part in an unnatural anatomical position to determine the status of the soft tissues supporting a joint or for the detection of a small fracture fragment.

Standard positioning refers to the positioning of the patient used for a routine radiograph, i.e. craniocaudal, dorsopalmar, dorsoplantar, lateral, dorsoventral and ventrodorsal, etc.

Suspect diagnosis refers to a disease that is suspected to be the cause of the clinical signs present in a patient. Such a diagnosis can be made, or changed, at any time during the acquisition of additional information from various diagnostic studies.

Technical error refers to a mistake in the exposure or processing of a film, or in the positioning of the patient that results in a radiograph, in which the ability to diagnose a lesion is compromised.

Tissue density refers to the weight per unit volume of a body part and is inversely proportional to film density.

Chapter 2

Radiology of Thoracic Trauma

2.1 Introduction

2.1.1 Value of thoracic radiology

Radiology is a most important diagnostic tool in the investigation of thoracic trauma because it reveals more specific information than a physical examination and can be easily performed in an inexpensive, quick, and safe manner, thereby providing rapid results on which to base decisions relative to diagnosis and/or treatment. The x-ray image is a transillumination of the body at the moment the film is made. It is this ability to see a representation of the interior of the patient, impossible by palpation or auscultation that accounts for the great value of thoracic radiography. The good contrast provided by the air in the lungs opens up a window to the thoracic organs on non-contrast radiographs to an extent not possible with the abdominal radiographic study. Accurate radiographic diagnosis is vital because physical signs of thoracic organ dysfunction following trauma are often ambiguous. In addition, a radiographic study provides a temporal dimension that permits evaluation of changes as they appear in the progression of a disease. Comparison of studies reveals the success or failure of treatment and can show the development of unexpected consequences, such as a post-traumatic pneumonia in a contused lung. Radiographs reproduce the character of the patient's thorax on film that can be examined both at the time of the original examination as well as later.

While thoracic injuries are common and often life threatening, the thorax and its contents are not as easily injured as might be expected. The thorax is tough and resilient due to its strong, spring-like ribs. The lungs add protection against impact to the heart through their air-cushion effect. Because of this protection, virtually all clinically important thoracic injuries are due to high-energy forces generated by violent trauma. Puncture or crushing wounds are other forms of traumatic injury to the thorax that do not usually involve high-energy and yet can be extremely damaging. Thoracic injuries are often part of a constellation of injuries involving several areas of an animal's body.

2.1.2 Indications for thoracic radiology

The clinical situations suggesting the need for thoracic radiography include: (1) patients with known or suspected thoracic trauma, (2) patients with trauma-induced respiratory dysfunction, (3) patients in shock, (4) trauma patients prior to surgery, (5) older patients with concurrent disease thought to compromise recovery from the traumatic injury, or (6) age-related pulmonary or cardiac disease thought to compromise the traumatic injury. Another reason for thoracic radiography is to evaluate known or suspected non-cardiogenic edema following several types of uncommon trauma such as electrical shock, near-drowning, head trauma, or near-asphyxiation.

2.1.3 Patient positioning

Positioning of the patient influences the appearance of thoracic organs. In certain trauma patients, the manner of positioning is predetermined by the nature of the injury. In others, positioning can be selected for the study that is felt to offer the best opportunity of evaluating a particular portion of the thorax. For example, in a dog with a thoracic wall injury, it is possible to consider placing the injured side next to the tabletop in an effort to achieve the smallest object-film distance; however, there may also be the need to place the injured lung lobes in a superior position, so that they can attain maximum inspiration and thus create a better opportunity for accurate radiographic evaluation. It is difficult to make firm recommendations concerning positioning and the effect of variation in body positioning needs to be understood before any decision is made (Table 2.1).

2.1.4 Radiographic evaluation of thoracic studies

There are two basic methods of radiographic evaluation. The first technique is to "memorize" the appearance of all disease or pathologic changes that might be found in a traumatized thorax, and then examine the radiograph looking carefully for those changes. An approach of this type is taken by traditional textbooks of medicine, in which diseases are presented with a description and an illustration of the typical radiological appearance. The difficulty with this approach is similar to the difficulty found in applying textbook knowledge to the reality of a sick animal. Clinical information of the traumatized patient is often indefinite and ambiguous. It is the same with the information available from a radiograph. In many patients, the radiologic picture of a disease is not "typical", and the textbook approach therefore can lead to confusion or misdiagnosis.

Table 2.1: Effect of positioning on the appearance of thoracic radiographs

1. Left side down, lateral view
   a. dependent organs in the abdomen are moved cranially
      I. the air bubble in the fundus of the stomach is moved cranially
      II. the left crus of the diaphragm is more cranial.
      III. the air bubble in the pyloric antrum is caudal to the right crus of the diaphragm.
   b. the caudal vena cava silhouettes with the right crus as it penetrates this structure and is more caudal in position
2. Right side down, lateral view
   a. dependent organs in the abdomen are moved cranially
      I. the air bubble in the fundus of the stomach is moved caudally
      II. the right crus of the diaphragm is more cranial.
      III. the air bubble in the fundus of the stomach is caudal to the left crus of the diaphragm.
   b. the caudal vena cava silhouettes with the right crus as it penetrates this structure and is more cranial in positioning
3. Dorsoventral view
   a. the x-ray beam strikes the diaphragm at nearly a right angle
   b. a distance equal to the length of 3–4 vertebral bodies exists between the shadow of the ventral portion of the diaphragm (the cupula) and the two dorsally located crura
   c. the heart "hangs" in a position on the midline that is more anatomically correct
4. Ventrodorsal view
   a. the x-ray beam strikes the diaphragm almost parallel to its surface;
   b. a short distance exists between the shadow cast by the ventral portion of the diaphragm (the cupula) and its two dorsally located crura
   c. the heart "falls" laterally, a malposition more evident in a deep-chested patient

A more accurate method of radiographic evaluation uses the identification of a particular "radiographic sign" that is indicative of specific pathophysiologic changes and an understanding of the diseases in which that particular sign is known to occur. As there are often many such signs on a radiograph involving more than one organ, a systematic analysis using deductive reasoning often leads to the appropriate differential diagnosis.

Any successful examination of a radiograph must be systematic in order to ensure that all parts of the radiograph are fully examined. The best system is anatomical and includes the conscious examination of each anatomical structure within a given region in the body. Identification of bronchi, arteries and veins, and interlobar fissures directs the evaluation toward each individual lung lobe. Start the examination centrally, proceed next to the mid-lung, and finally examine the periphery of the lung, looking for any radiographic pattern that is different and thus, indicative of disease.

Compare the appearance of the right and left lung fields, or the adjacent lung lobes. Look especially for unusual tissue density, unequal degrees of inflation, and change in the size or number of vascular structures within the lung. The configuration of a patient's thorax can be deep and narrow, intermediate, or shallow and wide, and this configuration influences the appearance of the lung fields. Pulmonary vessels and bronchi need to be examined equally on both the lateral and DV or VD views.

The appearance of the heart on both orthogonal radiographic views is important in generating the true character of the heart in three dimensions. Configuration of the thorax greatly influences the appearance of the heart shadow. In addition, shock causes hypovolemia and microcardia, whereas hemopericardium gives the appearance of cardiomegaly. The change in patient position from DV to VD alters the appearance of the heart shape, whether normal or pathological.

In the normal patient, the pleural space cannot be visualized. In the trauma patient, this normally minimal space may be filled with hemorrhage, chyle, pleural fluid, air, or abdominal viscera. The pleural contents can have a generalized or focal location, and can move or be fixed in position.

The mediastinal space contains the heart plus the air-filled trachea, usually an empty esophagus, aorta and other major vessels, and lymph nodes. This space is divided radiographically into: (1) the cranial mediastinal space, that contains the trachea, esophagus, great vessels, thymus, and the sternal and cranial mediastinal lymph nodes; (2) the central mediastinum that includes the heart, aortic arch, esophagus, tracheal carina, and the hilar region with its major vessels and lymph nodes; and (3) the caudal mediastinum that includes the descending aorta, esophagus, and caudal vena cava. These structures are partially hidden from visualization on the radiograph in the normal patient by the accumulation of mediastinal fat and the absence of any air-filled structures that provide contrast other than the trachea. The mediastinum in the trauma patient can be filled with blood (hemomediastinum) causing an increased size, increased fluid density, and a complete loss of visualization of the mediastinal organs. It may also be filled with air (pneumomediastinum) causing a reduction in tissue density that contrasts with the mediastinal organs making them more easily identifiable. Both air and fluid may be found in some trauma patients. In rare trauma cases, the mediastinum can be filled with a mass lesion such as a herniated abdominal organ or blood clots following a hemomediastinum creating a mass-lesion effect.

The thoracic wall includes the vertebrae, sternebrae, and ribs, including the costovertebral joints, costochondral junctions, and costal cartilages. The most common post-traumatic changes in the thoracic wall include subcutaneous air and soft tissue swelling in addition to the injuries to the ribs. Other radiographic changes seen in the thoracic wall are artifactual and include shadows caused by nipples, skin nodules, skin folds, wet hair, dirt and debris, bandage material, and subcutaneous fat.

Examination of the position and shape of the diaphragm is of great importance in detecting injury to that structure. On the lateral view, the angle between the diaphragm and spine may vary with the phase of respiration. The angle in inspiration is smaller as the diaphragm moves caudally and becomes more parallel to the spine. The triangle formed by the caudal border of the heart, the ventral portion of the diaphragm, and the caudal vena cava is another indicator of the position of the diaphragm and the degree of inspiration. This space is smaller on expiration preventing evaluation of that portion of the lung.

On the DV or VD view, the angle between diaphragm and thoracic wall can vary slightly. On both views, the diaphragm is more cranial and convex and has greater contact with the heart on expiration. This position, though, may result in a superimposition of a part of the heart shadow over the diaphragm causing summation. The heart shadow appears relatively larger on the expiratory film because of the diminished size of the thoracic cavity. The ribs are closer together and at a greater angle with the spine on expiration.

The stage of respiration during radiography influences the radiographic appearance of the thorax, but this may be impossible to control in the trauma patient. A film exposed in expiration has significantly different features when compared with those exposed at full inspiration, and these are sufficient to cause misdiagnosis of lung disease. At expiration, the lungs are relatively more radiopaque and smaller in size and appear to contain an increased amount of fluid. Because of the manner in which the patient breathes, especially a trauma patient placed in position on an x-ray table, the movement of the diaphragm is relatively minimal, often no more than 5–10 mm, thus the discussion of attempting to make the exposure in inspiration is usually a moot one.

Panic breathing in the trauma patient often causes aerophagia and filling of the stomach with air (Case 2.53).

2.1.5 Radiographic features in thoracic trauma

The major types of structural damage to the thorax caused by trauma can be divided into five categories: (1) thoracic wall disruption, (2) pleural fluid or air, (3) diaphragmatic hernia with resulting pleural fluid and pleural masses, (4) lung parenchymal injury, and (5) mediastinal injury. These and other features of thoracic trauma are presented in the following.

2.1.5.1 Disruption of the thoracic wall

The traumatized chest wall often has lesions due to injury to the soft tissue and ribs (Table 2.2). Radiography can define and evaluate the extent of the underlying damage. Injury of the chest wall results in a diminished respirational efficiency and restricted expansion of the rib cage. The soft tissues often sustain major injuries since they are not well protected. Radiopaque debris is often found on and under the skin. Subcutaneous emphysema is common and is usually secondary to a break in the skin, but can be associated with an internal injury in which air leaks into the subcutaneous compartment, e.g. injury to the trachea (Table 2.3).

Skeletal structures can be injured in the traumatized patient and examination of the vertebrae, sternebrae, ribs, costochondral junctions, and the proximal part of the forelimbs should be complete. Injury to the ribs is most frequent and the fractures are usually simple. A combination of fractures can create an unattached segment of thoracic wall and cause a "flail" chest and a unique form of injury with paradoxical thoracic wall motion. Injuries to the sternebrae are usually not of great clinical importance, but add information concerning the nature and severity of the trauma. It is also important to differentiate between open and closed thoracic wall injuries.

Detection of fractures of the surrounding bony structures can suggest the cause and location of the thoracic trauma. It follows that a patient with rib fractures can be assumed to have sustained underlying lung trauma. Often the appearance and bilateral location of the fractured ribs suggests puncture wounds as would be associated with dog bites. Fractures/luxations of the thoracic vertebrae, if without marked segmental displacement, can be overlooked because of not causing any obvious neurologic signs or problems in locomotion.

Furthermore, the location of the injured thoracic wall directs attention to the underlying pleura and lung, and often reveals a pocketing of pleural fluid associated with a collapsed lung lobe. Pneumothorax may be detected instead of pleural fluid. Radiographs prove helpful in the evaluation of secondary changes, such as pulmonary and/or mediastinal hemorrhage with mediastinal shifting, or diaphragmatic rupture with displacement and/or incarceration of the viscera.

2.1.5.2 Pleural space

In the trauma patient, this normally minimal space can be filled with fluid (pleural effusion, hemorrhage, or chyle), or air (pneumothorax), or can contain abdominal viscera (diaphragmatic hernia). Pleural fluid can be freely movable, trapped, or loculated; however, in trauma patients the fluid is often freely movable. A mass lesion associated with a diaphragmatic hernia can be generalized or focal depending on the viscera that are displaced into the thoracic cavity.

2.1.5.3 Pneumothorax

Pneumothorax is the collection of free air within the pleural space, resulting in a loss of intrathoracic negative pressure, thus allowing the lungs to recoil away from the thoracic wall. It is one of the most common sequelae to thoracic trauma and can be found with penetrating chest wall injuries or, more commonly, following rupture of the lung parenchyma or bronchi with an intact chest wall. Tension pneumothorax is a unique form of pneumothorax and is fortunately not common (Cases 2.59–2.61). Usually, a pneumothorax is bilateral because the thin mediastinum ruptures easily at the time of the original trauma or because it is fenestrated; however, it can also be unilateral.

Table 2.2: Radiographic features of thoracic wall injury

1. Features on lateral view
   a. soft tissues
      I. swollen (Cases 2.11 & 2.19)
      II. subcutaneous air (Cases 2.1, 2.3, 2.12, 2.38, 2.58 & 2.62)
         i) pockets
         ii) linear distribution
   b. debris on skin or within soft tissues (Cases 2.6, 2.12)
   c. injured soft tissues (Cases 2.14, 2.19 & 2.38)
      I. intercostal muscle tear
      II. lacerated muscle
   d. ribs
      I. fractures
         i) undisplaced fragments (Cases 2.24 & 2.30)
         ii) malpositioned fragments (Cases 2.12, 2.37 & 2.52)
         iii) multiple fragments ("flail chest") (Cases 2.4, 2.5 & 2.9)
      II. costovertebral luxation (Cases 2.16 & 2.56)
      III. separated ribs (intercostal muscle tear) (Cases 2.3 & 2.58)
      IV. injured soft tissues (Case 2.7)
      V. injury to the costal arches is often not noted (Case 2.45)
   e. sternal injury (Cases 2.5 & 2.7)
   f. pleural space underlying the thoracic wall injury
      I. fluid (hemorrhage)
      II. air (pneumothorax) (Case 2.3)
   g. lungs adjacent to the thoracic wall injury
      I. retraction from thoracic wall (pneumothorax and atelectasis) (Cases 2.3, 2.65 & 2.68)
      II. increased density (contusion) (Cases 2.4, 2.5 & 2.7)
   h. paracostal hernia (Cases 2.14, 2.16 & 2.17)
2. Features on VD or DV view
   a. soft tissues
      I. swollen (Cases 2.2, 2.19 & 2.20)
      II. subcutaneous air (Cases 2.30, 2.38, 2.58 & 2.61)
         i) pockets
         ii) linear distribution
   b. debris on skin or within soft tissues (Cases 2.6 & 2.82)
   c. injured soft tissues (Cases 2.63 & 2.82)
   d. ribs
      I. fractures
         i) undisplaced fragments
         ii) malpositioned fragments (Cases 2.2, 2.8, 2.19 & 2.52)
         iii) multiple fragments ("flail chest") (Cases 2.4 & 2.5)
      II. costovertebral luxation (Case 2.16)
      III. costochondral luxation
      IV. separated ribs (intercostal muscle tear) (Case 2.14)
   e. pleural space
      I. fluid (hemorrhage) (Cases 2.19 & 2.31)
      II. air (pneumothorax) (Cases 2.37, 2.54 & 2.55)
   f. lungs adjacent to the thoracic wall injury
      I. retraction from thoracic wall (pneumothorax and atelectasis) (Cases 2.3, 2.65 & 2.68)
      II. increased density (contusion) (Cases 2.24, 2.30 & 2.32)
   g. paracostal hernia (Cases 2.14, 2.16 & 2.17)

Pneumothorax that develops in the absence of trauma is considered spontaneous. It may be a primary spontaneous pneumothorax or a secondary spontaneous pneumothorax, i.e. is a sequela to chronic parenchymal lung disease. It is difficult to determine the influence of trauma in many patients with pneumothorax. Known trauma resulting in air within the pleural space can be due to a penetrating wound to the thoracic wall or to an injury with a blunt instrument to the thorax while the glottis is closed, causing alveolar rupture .

Table 2.3: Origin of air in subcutaneous emphysema

1. Following a penetrating wound to the thoracic wall
   a. skin laceration permits entry of air (Cases 2.2, 2.3, 2.4, 2.6 & 2.7)
   b. hidden skin wound permits entry of air (Case 2.18)
   c. surgical procedure permits entry of air (Case 2.44)
2. Following blunt trauma to thoracic wall
   a. secondary to pneumomediastinum
   b. upper airway tear (Case 2.62)
   c. esophageal tear
   d. intercostal injury with a pneumothorax
3. Following cervical trauma
   a. wound through skin (Case 2.62)
   b. wound with tracheal tear (Case 2.70)
   c. wound with esophageal tear
4. Gas-forming organism (uncommon)

Pneumothorax is one of the most common sequelae to thoracic trauma and the types and causes of pneumothorax are listed in Tables 2.4 and 2.5. The radiographic features of pneumothorax are shown in Table 2.6. A number of technical problems plus a group of pathologic conditions can make an erroneous radiographic diagnosis of pneumothorax possible (Table 2.7).

Table 2.4: Types of pneumothorax

1. Open pneumothorax – pleural pressure less than or equal to atmospheric pressure (Cases 2.1 & 2.5)
   a. thoracic wall wound tearing the thoracic wall pleura
   b. referred to as a "sucking pneumothorax"
   c. air moves through thoracic wall opening
2. Closed pneumothorax – pleural pressure less than or equal to atmospheric pressure
   a. thoracic wall intact (Cases 2.30 & 2.32)
   b. traumatic lung lesion
   c. rupture of developmental pulmonary bullae (Cases 2.28, 2.54 & 2.65)
3. Combination of pneumothorax with thoracic wall lesion and lung lesion (Case 2.75)
4. Tension pneumothorax – pleural pressure greater than or equal to atmospheric pressure (Cases 2.55, 2.58, 2.59 & 2.75)
   a. occurs in either open or closed pneumothorax
   b. due to a type of valve mechanism in the lung (thoracic wall) that
      I. permits air to enter pleural space during inspiration
      II. prevents air from escaping during expiration
5. Secondary to iatrogenic injury to the tracheal/bronchial wall (Cases 2.68 & 2.71)
6. Secondary to thoracocentesis (Case 2.21)

2

Table 2.5: Causes of pneumothorax

1. Open pneumothorax – only traumatic (Cases 2.1 & 2.5)
   a. puncture wound
   b. bite wound
   c. gunshot wound
   d. trauma with rib fractures
2. Closed pneumothorax – can be post-traumatic or spontaneous in normal or diseased lung (Cases 2.30 & 2.32)
   a. torn visceral pleura with fractured ribs
   b. rupture of emphysematous pulmonary bullae
   c. tearing of pleural adhesions
   d. rupture of pleural blebs/cysts
   e. rupture of pulmonary abscess
   f. subcutaneous emphysema with mediastinal tear secondary to pneumomediastinum
   g. tracheal tear with mediastinal tear secondary to pneumomediastinum
   h. main-stem bronchial tear with mediastinal tear secondary to pneumomediastinum
   i. esophageal tear with mediastinal tear secondary to pneumomediastinum
3. Tension pneumothorax (Cases 2.59–2.61)
   a. with any open or closed pneumothorax
   b. presence of a valve or flap-like mechanism
      I. in lung
      II. in chest wall
4. Unilateral pneumothorax with airtight mediastinum (irrespective of type) (Cases 2.28 & 2.58)
   a. tearing of a fibrinous pleuritis
      I. secondary to inflammatory pleuritis
      II. secondary to surgery
   b. tearing of adhesions between lung lobe and mediastinum
      I. secondary to inflammatory pleuritis
      II. secondary to surgery
5. Bilateral pneumothorax with fenestrated mediastinum (irrespective of type) (Cases 2.32, 2.71 & 2.75)

2.1.5.4 Pleural fluid

The radiographic features of pleural effusion are loss of the cardiac silhouette, loss of the diaphragmatic silhouette, retraction of the lung lobes, and visualization of the lung fissures (Table 2.8). The fluid is most often movable and can change in position remarkably between the DV and VD views. The collection of fluid can be symmetrical or asymmetrical with a mediastinal shift. While the fluid is usually effusive, it can also be due to hemorrhage or chylous, secondary to rupture of the thoracic duct. Thoracocentesis is required to determine the character of the fluid. The volume of the pleural fluid is increased in patients with chylothorax or in a patient with lung torsion. Fluid can be trapped around an atelectic lobe and tends to remain rather fixed in position. Generally, pleural fluid is much more readily identified than pleural air, even when the volume of fluid is minimal. Hemothorax causes a potentially more serious clinical problem and can be secondary to a wide range of etiologies (Table 2.9). A pleural lesion can be focal suggesting a chronic lesion with fibrosis (Cases 2.11 & 2.59).

Table 2.6: Radiographic features of pneumothorax

1. Lungs
   a. retraction of lung borders from the thoracic wall (Cases 2.28, 2.58 & 2.68)
   b. separation of lung borders from diaphragm (Cases 2.1, 2.3, 2.52 & 2.58)
   c. increase in lung density (due to partial collapse) (Case 2.54)
   d. vascular and bronchial shadows do not extend to the thoracic wall (Cases 2.28, 2.58 & 2.68)
2. Diaphragm
   a. caudal displacement (Cases 2.3 & 2.4)
   b. radiolucent zone separates lungs and diaphragm (Cases 2.3 & 2.9)
3. Pleural place
   a. radiolucent space between lungs and thoracic wall (Case 2.53)
   b. radiolucent fissures between lung lobes
4. Heart
   a. separation of cardiac apex from the diaphragm or sternum (Cases 2.12, 2.15, 2.28, 2.56, 2.58 & 2.65)
   b. appears smaller because of increase in size of thoracic cavity
5. Mediastinum
   a. lateral shift with unequal distribution of pleural air (Cases 2.32 & 2.59)
6. Thoracic cavity
   a. increased width
   b. ribs are at right angle to the spine (Case 2.75)
   c. increased length of thoracic cavity (Case 2.4)

Table 2.7: Causes of erroneous radiographic diagnosis of pneumothorax

1. Skin folds superimposed over the thorax (Cases 2.9, 2.52, 2.72 & 2.97)
2. Overexposed radiograph making vascular shadows difficult to identify
3. Pulmonary
   a. vascular hypoperfusion
   b. thromboembolism
   c. hyperinflation
   d. pulmonary emphysema
4. Pneumomediastinum
5. Subcutaneous emphysema causing superimposed linear shadows
6. Atrophy of the muscles in the thoracic wall

2.1.5.5 Diaphragmatic rupture

The diaphragm is ruptured by a forceful impact on the abdomen when the glottis is open and the lungs can be collapsed permitting the diaphragm to move cranially. Radiography is performed to determine the presence of diaphragmatic injury and to localize the rupture site.

Radiographs can show loss of part or all of the diaphragmatic shadow, absence of part or all of the normal caudal silhouette of the heart, as well as increased tissue density in the thorax

Table 2.8: Radiographic features of pleural fluid (effusive fluid, blood, or chyle)

1. Lungs
   a. retraction and difficulty in visualization of lung borders from thoracic wall (Cases 2.18 & 2.45)
   b. retraction of lung border from spine (Case 2.65)
   c. increase in pulmonary fluid density due to pocketed pleural fluid plus partial collapse of the lungs (Cases 2.3, 2.25 & 2.37)
   d. vascular and bronchial shadows do not extend to the thoracic wall (Cases 2.29 & 2.30)
2. Diaphragm
   a. caudal displacement (Cases 2.8 & 2.31)
   b. flattened (Cases 2.8, 2.31 & 2.37)
   c. fluid causes separation between lungs and diaphragm (Case 2.65)
   d. ventral diaphragm silhouettes with pleural pool on DV view (Case 2.21)
   e. dorsal crura of the diaphragm silhouettes with pleural pool on VD view
3. Pleural place
   a. radiodense fluid
      I. between the lungs and thoracic wall (Cases 2.9 & 2.18)
      II. between interlobar fissures (Cases 2.21 & 2.30)
      III. trapped within mediastinal recesses (Case 2.46)
      IV. pocketing (Cases 2.11, 2.14 & 2.22)
   b. costodiaphragmatic angles are blunted
   c. lung lobe tips are rounded
   d. fluid freely movable when comparing
      I. DV with VD view (Cases 2.20 & 2.31)
      II. right and left lateral views
      III. recumbent and erect views
4. Heart
   a. cardiac silhouette is elevated from the sternum on the lateral view (Case 2.40)
   b. cardiac shadow silhouettes completely with the pleural pool on DV view and partially on the lateral view (Cases 2.18 & 2.30)
5. Mediastinum
   a. lateral shift if fluid collection is unilateral (Case 2.19)
   b. tracheal elevation as mediastinum shifts laterally (Case 2.19)
   c. width is
      I. widened on DV view
      II. more normal width on VD view
6. Thoracic wall
   a. ribs are at right angle to spine (Case 2.21)
   b. increased size of thoracic cavity (Case 2.44)

Table 2.9: Etiologies of hemothorax

1. Arterial bleeding (high pressure)
   a. intercostal arteries
   b. tracheobronchial arteries
   c. internal thoracic arteries
   d. great vessels (uncommon)
2. Venous bleeding (low pressure)
   a. pulmonary veins
   b. intrathoracic veins
3. Diaphragmatic hernia with prolapsed liver or spleen
4. Abdominal hemorrhage moving through a diaphragmatic tear
5. Hemomediastinum with hemorrhage moving through a torn mediastinum
6. Coagulopathies such as rodenticide poisoning

due to the presence of displaced viscera and secondary pleural fluid. A shift in the position of the abdominal organs assists in diagnosis since the liver, spleen, air- or ingesta-filled stomach, air- or ingesta-filled duodenum, air- or ingesta-filled intestinal loops, or air- or fecal-filled colon can all be displaced completely or partially in a cranial direction into the thoracic cavity. This cranial shift in the position of the abdominal organs may be only within the abdomen itself or can extend into the thoracic cavity. In either event, the radiographic appearance of both the thorax and abdomen varies markedly from normal. Gastric dilatation of the stomach can occur, if it is lodged within the thoracic cavity and the pylorus is occluded. A barium sulfate follow-through study can be performed to demonstrate the presence of concealed gastrointestinal segments lying within the thoracic cavity, or to demonstrate a dislocation of the pyloric antrum and duodenum within the abdomen.

Pleural effusion occurs due to vascular constriction by a ring-like diaphragmatic tear with an associated entrapment of a liver lobe, omentum, or small bowel loop(s), or by torsion. Hemorrhage into the pleural cavity that is secondary to the trauma can contribute to the volume of pleural fluid.

A congenital/developmental pericardiodiaphragmatic hernia can be complicated by trauma and is usually characterized by a dilated pericardial sac, a ventral silhouetting between the heart shadow and the diaphragm, and possible hernial contents that all can be recognized on the radiograph (Case 2.51).

The radiographic features that may be found with a traumatic diaphragmatic hernia are listed in Table 2.10.

2.1.5.6 Damage to lung parenchyma

Abnormalities of the lung parenchyma include pulmonary contusion (hemorrhage), lung rupture or laceration with formation of pulmonary hematomas, or bullae formation (pneumatocele). Most animals with blunt thoracic trauma suffer some degree of pulmonary contusion, with resulting edema and hemorrhage in the lung parenchyma. Pulmonary contusion is caused by the rapid compression and subsequent decompression of the lungs, and results in a disruption of the alveolar-capillary integrity, thus causing a diffuse bruising of the underlying lung with concurrent hemorrhage and edema of the alveolar and interstitial spaces. These changes cause several radiographic patterns to become apparent (Table 2.11). The most common is a diffuse increase in fluid content within the lung. In addition, pulmonary hematomas can be formed if localized bleeding is trapped within the pulmonary parenchyma, forming a fluid-dense pocket (Table 2.12). Pulmonary cysts are uncommon, but are presumed to represent a coalescence of ruptured airspaces within the lung parenchyma and can be seen as localized, spherical radiolucent lesions that are filled with air or with a combination of air and fluid (Table 2.13).

2

Table 2.10: Radiographic features of traumatic diaphragmatic hernia

1. Features on lateral view
   a. diaphragm
      I. incomplete visualization of both leaves (Cases 2.43 & 2.45)
      II. silhouetting of ventral diaphragm with pleural fluid (Case 2.46)
      III. slope is altered (Cases 2.18 & 2.42)
      IV. asymmetry between the leaves (Case 2.46)
   b. pleural space
      I. pleural fluid (Cases 2.18 & 2.50)
         i) free-moving
         ii) shifts in location when comparing opposite lateral views
      II. pleural mass lesions
         i) with soft tissue density (liver, spleen, omentum)
         ii) containing air and/or ingesta (stomach, small bowel) (Cases 2.43 & 2.44)
         iii) containing air and/or granular material (feces in colon) (Case 2.41)
   c. cardiac silhouette
      I. shifted dorsally or cranially (Cases 2.41 & 2.43)
      II. cardiac apex not identifiable
   d. lung lobes
      I. separation of lung lobes from diaphragm due to
         i) pleural fluid (Case 2.18)
         ii) abdominal viscera
      II. separation between lung lobes due to fluid in lobar fissures (Case 2.21)
      III. partial collapse with an increase in fluid density (Cases 2.23 & 2.40)
      IV. displacement as indicated by location of the air-filled mainstem bronchi (Case 2.41)
      V. possible torsion made possible because of pleural fluid
   e. mediastinum
      I. dorsal displacement of trachea (Case 2.41)
      II. dorsal displacement of main-stem bronchi
   f. thoracic wall
      I. fractured ribs, costal arch (Case 2.45)
      II. fracture/luxation of the sternebrae
      III. fractured spine (Case 2.50)
      IV. subcutaneous emphysema
   g. abdomen
      I. cranial displacement of pyloric antrum and duodenal bulb (Cases 2.45 & 2.46)
      II. gastric dilatation
      III. absence of shadow caused by the fat in the falciform ligament
      IV. absence or displacement of abdominal viscera (Case 2.50)
2. Features on VD or DV views
   a. diaphragm
      I. incomplete visualization of both crura (Cases 2.41 & 2.43)
      II. asymmetry (Case 2.46)
   b. pleural space
      I. pleural fluid (Case 2.50)
         i) free-moving
         ii) shifts in location between VD and DV views (Case 2.20)
      II. pleural mass lesions
         i) with soft tissue density (liver, spleen, omentum)
         ii) containing air and/or ingesta (stomach, small bowel) (Cases 2.1 & 2.40)
         iii) containing air and/or granular material (feces in colon) (Case 2.41)
   c. cardiac silhouette
      I. shifted laterally (Cases 2.40, 2.44 & 2.45)
   d. lung lobes
      I. separation of lung lobes from diaphragm due to
         i) pleural fluid (Case 2.18)
         ii) abdominal viscera
      II. separation of lung lobes from thoracic wall due to
         i) pleural fluid
         ii) abdominal viscera
      III. separation between lung lobes due to fluid in the lobar fissures
      IV. partial collapse with an increase in fluid density (Cases 2.40 & 2.43)
      V. displacement
   e. mediastinum
      I. lateral displacement of trachea (Case 2.44)
      II. lateral displacement of air-filled mainstem bronchi (Case 2.41)
      III. generalized mediastinal shift (Case 2.45)
   f. thoracic wall
      I. fractured ribs
      II. subcutaneous emphysema
   g. abdomen
      I. cranial displacement of pyloric antrum and duodenal bulb (Case 2.46)
      II. gastric dilatation
      III. absence of abdominal viscera (Case 2.44)

Atelectasis is an important feature of lung disease and refers to a diminution in lung lobe volume indicating a partial or total alveolar air loss (Table 2.14). It may be difficult to differentiate between atelectasis and pneumonia on a radiograph. Atelectasis can be partial or complete depending on the degree of air and volume lost. Several types of atelectasis are recognized: (1) passive that occurs with uncomplicated pneumothorax or pleural effusion; (2) compressive that occurs if the intrapleural pressure exceeds the atmospheric pressure, or if a mass lesion impinges on the surrounding alveoli; (3) obstructive that occurs as a result of the resorption of the alveolar gases following a total obstruction of a main bronchus; (4) adhesive that alludes to the inability of the alveoli to remain open because they lack a layer of surfactant; and (5) cicatrization due to fibrosis. Traumatically induced atelectasis usually results from the passive or compressive forms.

In the event of a failure of an atelectic lobe to begin to reinflate within several days following injury, the possibility of a more severe injury should be considered. The most likely complication is post-traumatic pneumonia that results in a persistent area of increased fluid density within the lobe. The radiographic features of this type of pneumonia are listed in Table 2.15.

Table 2.11: Radiographic features of lung contusion

1. Infiltrative patterns with
   a. lobular, lobar, or multiple lobe distribution (Cases 2.7 & 2.64)
   b. no special relationship to hilar region (Cases 2.24 & 2.32)
   c. often adjacent to chest wall injury (Cases 2.5 & 2.30)
2. Air-bronchogram pattern indicates more severe lung contusion (Case 2.8)
3. Increased fluid density in the lung because of
   a. hemorrhage due to trauma (Cases 2.23 & 2.30)
   b. atelectasis secondary to pneumothorax (Case 2.12)

Table 2.12: Radiographic features of a pulmonary hematoma

1. Nodular shape (often tear-drop) (Case 2.38)
2. Size is often 2–3 cm in diameter
3. Number
   a. more than one in the same lobe
   b. more than one in adjacent lobes
4. Density
   a. uniform fluid density (Case 2.37)
   b. can have lucent center if blood is replaced with air
5. Margination is sharp
6. Wall thickness is thin, if contrasting air is present
7. Surrounding lung with pulmonary contusion
8. Location
   a. tendency for peripheral location in lung lobe (Case 2.37)
   b. often subpleural
9. Resolution
   a. resolution requires weeks/months
   b. can remain as a pulmonary nodule
   c. fluid from hematoma can resolve leaving a persistent cavitary lesion

Table 2.13: Radiographic features of traumatic pulmonary cysts (pneumatoceles or pulmonary bullae)

1. Nodular shape (Case 2.75)
2. Size is often 2–3 cm in diameter (Case 2.28)
3. Number
   a. more than one in the same lobe (Case 2.33)
   b. more than one in adjacent lobes (Cases 2.54 & 2.75)
4. Density
   a. cavitary lesions (Case 2.75)
   b. contents within the cyst
      I. air filled (most common) (Cases 2.54 & 2.75)
      II. fluid filled (Case 2.65)
      III. both air and fluid are present
   c. air-fluid level identified on horizontal beam radiograph
   d. if primarily fluid filled can appear to be a hematoma
5. Margination is sharp (Cases 2.28 & 2.54)
6. Wall thickness is thin, if contrasting air is present (Case 2.33)
7. Surrounding lung with pulmonary contusion (Case 2.19)
8. Resolution
   a. can resolve within 3–6 weeks
   b. can remain as a cavitary lesion (Case 2.75)

Table 2.14: Radiographic features of atelectasis

1. Definition – diminution in lung lobe volume
2. Clinical importance
   a. causes venoarterial shunting
   b. can be confused with pneumonia
3. Types
   a. passive or relaxation atelectasis (Cases 2.47 & 2.57)
      I. small amount of fluid or air accumulation in the pleural space
      II. right middle and left cranial lobes are selectively affected
      III. contused lobes collapse to a greater degree
      IV. airways usually unobstructed
      V. usually reversible
   b. compression atelectasis (Cases 2.44, 2.54, 2.65 & 2.71)
      I. intrapleural pressure exceeds atmospheric pressure
         i) tension pneumothorax
         ii) large pleural effusions or pleural mass
      II. airways usually unobstructed
      III. usually reversible
   c. obstructive or resorptive atelectasis (Cases 2.55, 2.73, 2.88 & 2.89)
      I. total obstruction of a main bronchus or its branches
      II. collapse can be central or peripheral
      III. important features
         i) airway drying
         ii) mucous secretion tenacity
         iii) mucous ciliary action inhibition
         iv) inefficient cough mechanism
         v) seen with prolonged lateral recumbency
      IV. airless state in lobe can be achieved in 24–36 hours
      V. absence of air bronchograms
   d. adhesive or nonobstructive atelectasis
      I. inability of alveoli to remain open
         i) absence of surfactant
      II. seen in adult respiratory distress syndrome
      III. a problem in trauma to a previously diseased lung
   e. cicatrization atelectasis
      I. due to chronic fibrosis or scar formation
      II. poor prognosis
      III. a problem in previously diseased lung
4. Radiographic features (Cases 2.44, 2.54, 2.55 & 2.58)
   a. direct changes
      I. diminished lung volume
      II. altered lung shape
      III. displacement of interlobar fissures
      IV. vascular rearrangement
      V. bronchial rearrangement
   b. indirect signs
      I. local increase in fluid density
      II. mediastinal shift toward side of diminished volume
      III. cranial displacement of hemidiaphragm on affected side
      IV. compensatory overinflation of unaffected lobes

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Table 2.15: Radiographic features of post-traumatic pneumonia

(Cases 2.2, 2.10, 2.14, 2.22, 2.26, 2.29, 2.30, 2.37 & 2.38)
(persistent and dependent on nature of injury)

1. Lung
   a. increased infiltrative density
   b. distribution related to site of lung injury
   c. prominent air bronchograms
   d. shape of lung lobe remains constant
2. Pleural space features
   a. minimal pleural fluid
   b. pneumothorax
3. Mediastinal shift minimal toward affected side
4. Thoracic wall features
   a. rib fracture
   b. subcutaneous emphysema

Table 2.16: Radiographic signs of esophageal disease that can mimic a dorsocaudal thoracic mass

1. Sliding esophageal hernia (Cases 2.97 & 2.98)
   a. stomach
      I. partially herniated into the thorax
      II. gastric rugal folds within the thorax
      III. hernia can contain gastric contents
   b. gastroesophageal junction malpositioned cranially within the thorax
   c. freely moving hernia
2. Paraesophageal hiatal hernia
   a. stomach
      I. partially herniated into the mediastinum
      II. gastric rugal folds within the thorax
      III. positioned alongside the caudal esophagus
      IV. hernia can contain ingesta
   b. gastroesophageal junction at normal location
3. Gastric invagination into the esophagus
   a. dilated esophagus
   b. stomach
      I. partially herniated into the esophagus
      II. gastric rugal folds within the caudal esophagus
   c. gastroesophageal junction at normal location
4. Esophageal diverticulum (Case 2.99)
   a. dilated esophagus
      I. diverticulum can contain ingesta
      II. smooth esophageal wall
   b. gastroesophageal junction at normal location
   c. stomach in normal location

A group of lesions at the gastroesophageal junction can cause a dorsocaudal thoracic mass that may appear to be pulmonary in nature (Table 2.16). If large enough and well demarcated, their relationship with the esophagus may be apparent; however, if the lesion border is diffuse or surrounded by mediastinal fluid, they must be considered to be pulmonary. Fortunately, the use of a barium sulfate swallow can immediately prove their relationship with the esophagus and whether they are trauma related.

2.1.5.7 Mediastinal injury

The mediastinal space contains the heart plus the air-filled trachea, esophagus, major vessels, and lymph nodes. It is divided into the cranial mediastinal space, the central mediastinal space, and the caudal mediastinal space. The mediastinum in the trauma patient can be filled with blood (hemomediastinum) (Table 2.17) and have an increased density, or can be filled with air (pneumomediastinum) and be radiolucent (Tables 2.18 and 2.19). Fluid usually migrates cranially causing an increased width of the mediastinum on the DV or VD views, and an increased depth on the lateral views. This increased density is often overlooked on the first radiographic study because of the presence of superimposed pleural fluid. Mediastinal fluid is often more clearly identified on a second study made when the patient has failed to recover clinically as would have been expected from the nature of the trauma, and following the clearing of the pleural fluid, whereby a better evaluation of the mediastinum is permitted. Mediastinal air is, in comparison, more easily identified on a radiograph and tends to spread throughout the entire space contrasting all of the mediastinal viscera. A combination of blood and air may be present (pneumohemomediastinum).

Table 2.17: Radiographic features of hemomediastinum

1. Usually found in the cranial mediastinal space (Cases 2.4 & 2.35)
   a. increased fluid density
   b. mass-like lesion
   c. tracheal elevation
   d. increased width and depth of cranial mediastinum
2. Associated bleeding can cause (Cases 2.1, 2.20 & 2.32)
   a. pleural hemorrhage
   b. pulmonary hemorrhage
   c. pericardial hemorrhage
3. Associated free air can cause a pneumohemomediastinum

Table 2.18: Radiographic features of pneumomediastinum

1. Increased visualization of the: (Cases 2.7, 2.12, 2.63 & 2.64)
   a. esophagus
   b. tracheal wall
   c. aorta
   d. azygous vein
   e. caudal vena cava
   f. major cranial vessels
2. Possibly associated with:
   a. pneumopericardium
   b. retroperitoneal air (Case 2.62)
   c. subcutaneous emphysema (Cases 2.7, 2.12, 2.61, 2.63 & 2.65)
   d. pneumohemomediastinum

Table 2.19: Causes of pneumomediastinum

1. Esophageal damage
2. Tracheal damage
3. Pulmonary injury
   a. bronchial rupture
   b. alveolar rupture
   c. increased alveolar pressure with rupture due to respiratory tract obstruction
4. After laryngeal surgery
5. Following facial trauma

2.1.5.8 The heart

Injury to the heart and great vessels is uncommon because of the protection provided by the chest wall and lungs. Traumatic injuries of the cardiovascular system are seldom recognized radiographically, because when the thoracic trauma is severe enough to damage these organs, the patient dies quickly. In the event that such a patient is presented, determination of the character of the heart is important. A comparison of the appearance of the heart on both orthogonal radiographic views is necessary in generating the true character of the heart in three dimensions. The configuration of the thorax greatly influences the radiographic appearance of the heart shadow. Patient positioning also alters the shape of the heart seen on the radiograph.

A common pattern is seen in the trauma patient with shock that is characterized by hypovolemia and microcardia, whereas less often, hemopericardium causes the appearance of a cardiomegaly. The heart shadow can be separated from the sternum due to a pneumothorax. Myocardial contusion can cause bleeding with a resulting hemothorax, hemopericardium, and hemomediastinum. Hemothorax is the collection of blood in the pleural space and appears on both views radiographically as a typical pleural effusion. Hemopericardium causes an increase in the size of the cardiac silhouette on both views with a marked rounding of the cardiac shadow. Hemomediastinum is characterized with difficulty by the increase in mediastinal fluid.

2.1.5.9 The esophagus

Injury to the esophagus can be the result of foreign bodies, esophageal stricture, or esophageal rupture. The radiographic features of esophageal trauma are better identified following the use of an orally administered barium sulfate suspension (Table 2.20).

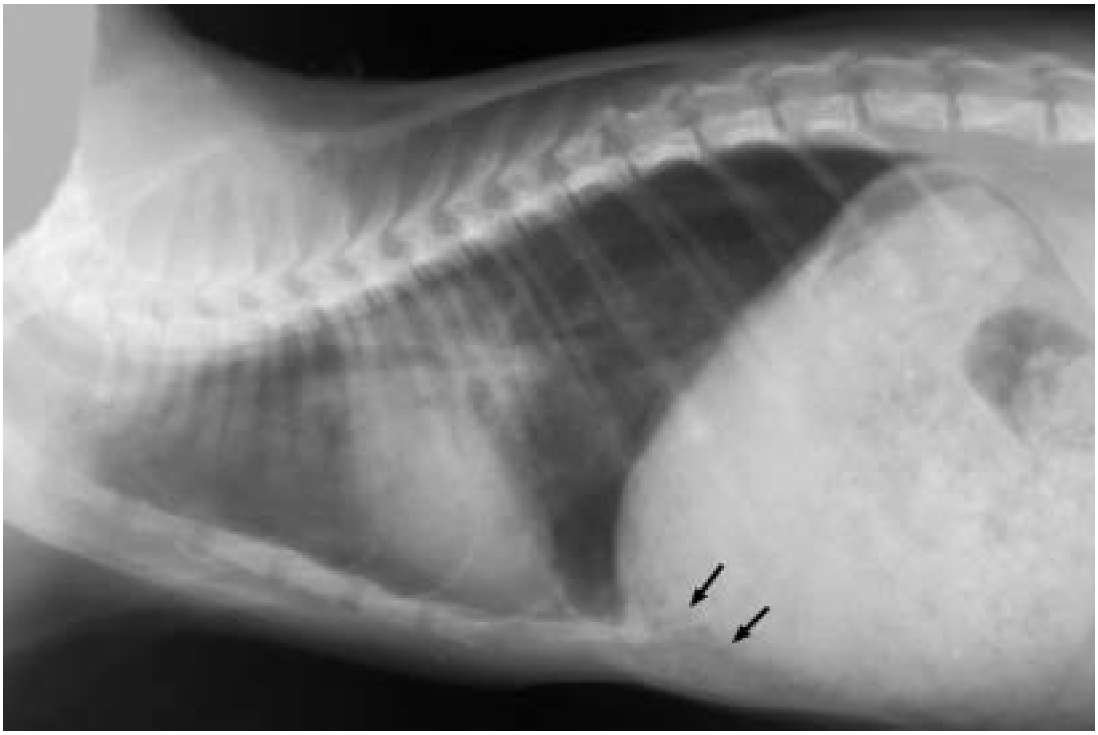
Table 2.20: Radiographic features of esophageal trauma using an orally administered barium sulfate contrast agent

1. Displacement of the intact esophagus
2. Leakage of contrast agent (Cases 2.91 & 2.95)
   a. through esophageal tear into the mediastinum
   b. through esophageal tear and mediastinal tear into the pleural space
3. Malformed or dilated esophagus
4. Esophageal foreign body (Cases 2.91, 2.92, 2.93 & 2.99)
   a. partial obstruction
   b. complete obstruction
5. Esophageal stricture
   a. post-traumatic
   b. postsurgical esophagitis

2.2 Case presentations

2.2.1 Thorax wall injury

Case 2.1



Signalment/History: "Muffy" was a shorthaired kitten that had a history of falling from a second-story window.

Physical examination: The kitten was suffering from marked respiratory distress. The right thoracic wall palpated as though there was a soft tissue injury with subcutaneous emphysema.

Radiographic procedure: Positioning of the kitten was relatively easy and both views of the thorax were made.

Radiographic diagnosis: A minimal separation of the 5th and 6th ribs on the right (DV view, arrow) was associated with generalized subcutaneous emphysema. The retraction of the lung lobes from the diaphragm on the lateral view was indicative of a pneumothorax. Generalized pulmonary contusion due to hemorrhage/edema caused increased lung density resulting in a silhouetting of the lung over the heart shadow, making the heart difficult to identify. Pleural effusion was not noted. The trachea was normal in position. The diaphragm was intact.

The stomach was distended and filled with ingesta. Abdominal contrast was lacking, probably because of the age-dependent absence of peritoneal fat; however, the presence of peritoneal fluid was considered.

Differential diagnosis: The radiographic changes were typical for those associated with thoracic trauma. On the lateral view, the subcutaneous emphysema caused an uneven fluid density, which when superimposed over the fat in the falciform ligament suggested a peritonitis (arrows).

Treatment/Management: Determination of the origin of the abnormal pleural air is often important in treatment. The finding of a rib injury suggested a possible skin wound that could have caused the subcutaneous emphysema and an open pneumothorax. However, the pneumothorax could have also been closed and have resulted from a rupture of the lung due to the increase in pressure within the lung created as the cat struck the ground with its glottis closed. The skin lesion was minimal in this kitten indicating that the latter etiology was more likely. As a consequence, the treatment was symptomatic only. "Muffy" recovered nicely.

Case 2.2

Signalment/History: "Snoopy" was a 1-year-old, female mixed breed dog who had been attacked by two larger dogs. The thorax was wrapped with a bandage in an effort to reduce the flow of air into the pleural space and to prevent the obviously fractured rib ends from further injuring the underlying lungs.

Physical examination: The severe injury to the right chest wall was evident and crepitus was apparent on palpation of the ribs.

Radiographic procedure: Two views of the thorax were made.

Radiographic diagnosis: Soft tissue swelling along the right thoracic wall with subcutaneous emphysema was seen over the badly distorted fractured ribs on the right. The bandaging had collapsed the subcutaneous space on the right side and forced most of the subcutaneous air to relocate along the left thoracic wall. Underlying injury to the right middle lung lobe had caused its collapse with additional injury to the right caudal lobe dorsally (black arrows). The cardiac silhouette was shifted to the right and the left hemidiaphragm was shifted caudally to permit compensatory hyperinflation of the left lung. Pneumothorax was difficult to detect because of the shadows caused by the subcutaneous air and the bandage around the thorax. The diaphragm was intact.

Treatment/Management: The dog was treated with cage rest and radiographs made three days later showed a decrease in the subcutaneous emphysema. Collapse of the right middle lung lobe remained. The right caudal lobe had cleared completely and was aerating normally.

As an uncomplicated contusion to a lung lobe with only hemorrhage and edema should clear within 24 to 48 hours following trauma, but whereas the radiographs made on day 3 showed continued right middle lobe collapse, it was assumed that either the trauma had been more severe than supposed, bronchial obstruction was present, or a pneumonia was superimposed over the injured lung. "Snoopy" was placed on antibiotic therapy because of the possibility of a secondary pneumonia in that lung lobe and she improved clinically within the next few days and was discharged.

Comments: Note how difficult and incomplete the radiographic interpretation would have been if only a single lateral radiograph of the thorax had been made; having two views makes the study more complete.

2

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Case 2.3

Signalment/History: "Chamois" was a 7-year-old, female Maltese Terrier that had been bitten across the thorax by a larger dog.

Physical examination: A definite defect associated with the suspected puncture wound was palpable in the right thoracic wall with associated subcutaneous emphysema. The lung fields on the right were quiet on auscultation, while more normal lungs sounds were heard on the left.

Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis: Subcutaneous emphysema was present on the right cranial chest wall plus a wide separation of the right 7th and 8th ribs that indicated a tearing of the intercostal muscles (arrow). The increase in fluid density in the right middle lung lobe plus the loss in volume suggested both contusion and atelectasis. The right caudal lung lobes as well as the left lung appeared to be well inflated. A portion of the right scapula created an apparent region of increased fluid density in the region of the right cranial lobe. Retraction of the caudal lung lobes from the diaphragm on the lateral view indicated a pneumothorax. Minimal pleural effusion was evident on the right. The diaphragm was intact with the left hemidiaphragm more caudal in position. Identification of the spleen confirmed the absence of adjacent peritoneal fluid.

Treatment/Management: "Chamois" was treated conservatively and recovered.

Comments: The trauma was more of a puncture wound suggesting the possibility of severe injury to the underlying lung that could require a longer time in healing. Pocketing of pleural fluid often occurs around partially collapsed lung lobes.

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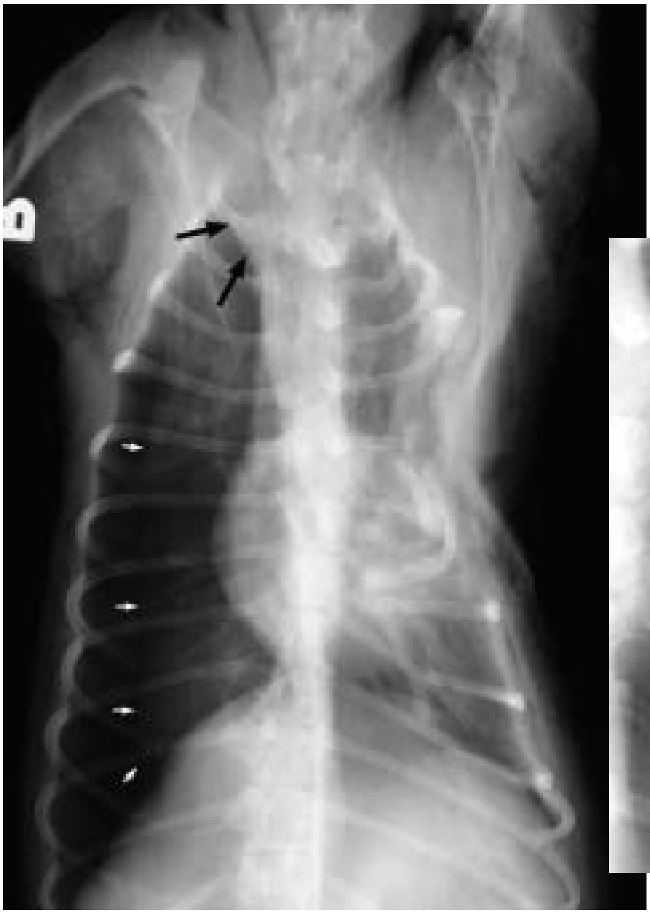
Case 2.4



Signalment/History: "Peppy", a 2-year-old, male Pekingese, had been found by his owner in respiratory distress several hours earlier. The owner assumed another dog had attacked him.

Physical examination: Physical examination was difficult to conduct because of pain. Subcutaneous emphysema was palpated along the left thoracic wall, along with an obvious displacement of the mid-thoracic ribs.

Radiographic procedure: It was difficult to position the dog for the DV view because of the soft tissue injury around the left shoulder.

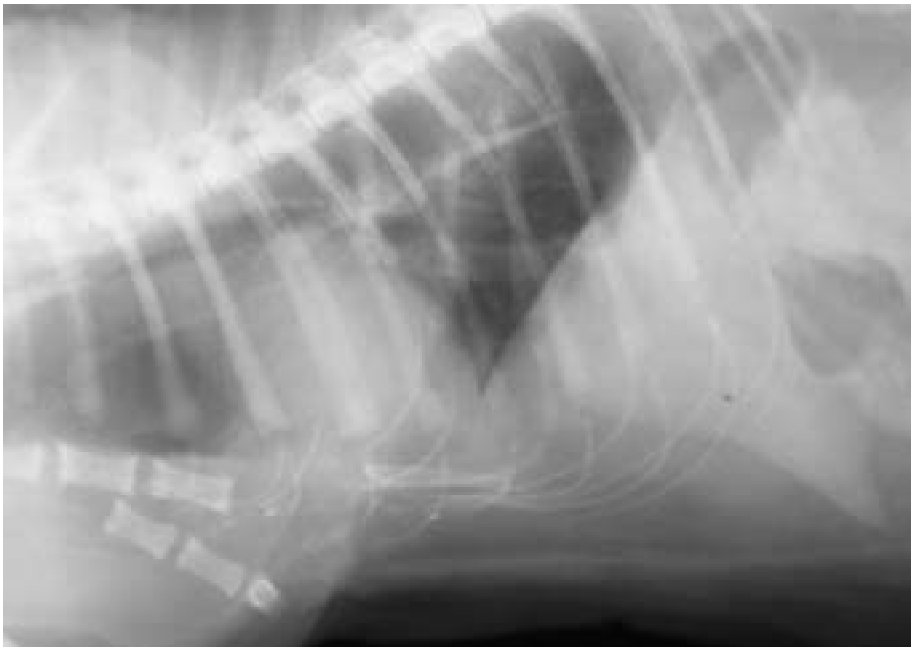
Radiographic diagnosis: Severe thoracic wall injury was evident with multiple fractures of the left 5th, 6th, 7th, and 8th ribs resulting in a flail chest. Generalized subcutaneous emphysema was present. The left lung lobes had a loss in volume plus an increased fluid density, probably resulting from a combination of pulmonary contusion and atelectasis. The right lung lobes had only a minimal increase in fluid density from the passive atelectasis caused by the pneumothorax (white arrows). The collapse of the left lobes and severe injury to the chest wall probably resulted in the pleural air shifting into the right hemithorax. The left lung collapse had resulted in a minimal mediastinal shift to the left. The cranial mediastinum was widened at the level of the first ribs suggesting a hemomediastinum (black arrows). No pleural fluid could be identified, although it was difficult to make any judgment of possible fluid in the left hemithorax. The cardiac silhouette appeared separated from the sternum because of the mediastinal shift. The caudal displacement of the right hemidiaphragm was expected with the lung changes noted.

Treatment/Management: The patient was not left for treatment.

Comments: A pneumothorax on the side opposite to the trauma is not very common and indicates the presence of a fenestrated mediastinum. The origin of the subcutaneous air is probably associated with the puncture wound although a lung lobe could also have been lacerated. A skin laceration, especially in the axillary region, can function as a "pump" activated by movement of the forelimb thereby filling the subcutaneous space with air.

The position of the mediastinum in this patient is affected by: (1) atelectasis on the right, (2) pneumothorax on the right, and (3) lung injury with lobar collapse on the left. The free pleural air contrasts with the aorta and esophagus on the lateral view making them more visible.

Note that the lateral view is oblique as shown by the location of the rib ends dorsally and ventrally. Also, the shoulder joints are not superimposed. Oblique positioning of this type can be easily corrected by the placement of small sponge wedges under the sternum and under the ventral portion of the abdomen.



Case 2.5

Signalment/History: "Rax", a 9-year-old, male DSH cat, had been attacked by a dog 10 days previously. Following the trauma, he had run away and had been missing for the intervening 10 days. He had only returned home on the day of presentation.

Physical examination: Palpation of the thorax indicated marked abnormality in the region of the sternum with severe soft tissue swelling. The cat was dyspneic.

Radiographic procedure: Thoracic radiographs were made with the background knowledge that they were probably made 10 days after the injury.

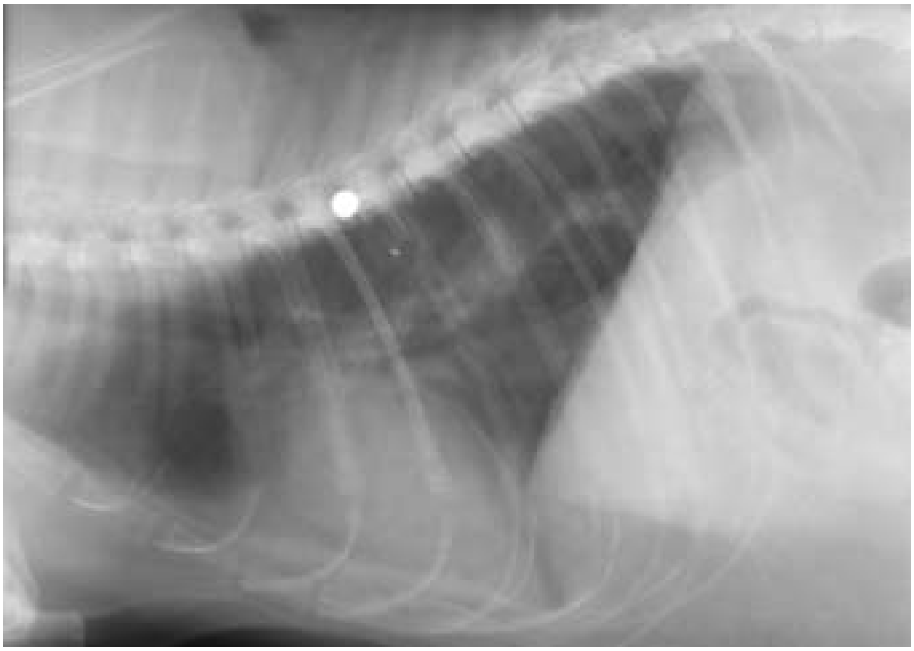
Radiographic diagnosis (day 10): Injury to the sternum had resulted in a ventral and cranial displacement of sternebrae 6, 7, and 8 (top left). The xiphoid process remained in a near-normal position. Injury to the thoracic wall on the left had caused a flail chest with multiple fractures of left ribs 7–10, which were characterized by fragment displacement and severe injury to the thoracic musculature (DV view). Subcutaneous emphysema was seen. The left crus of the diaphragm was shifted cranially, but appeared to be intact. The left lung lobes had an increased water density indicating contusion and atelectasis to the caudal half of the cranial and caudal lobes.

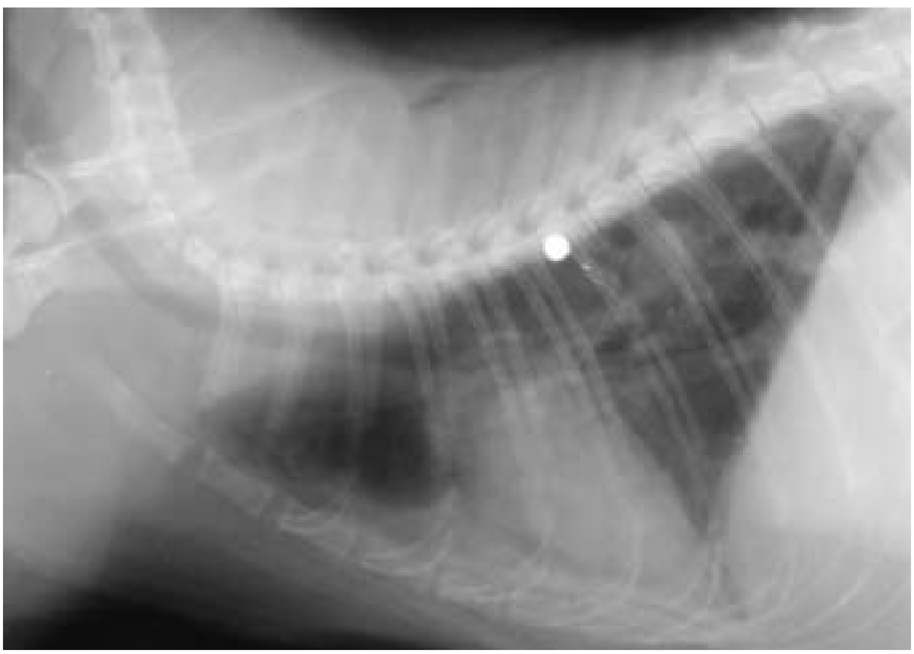
Treatment/Management: This case was unusual since the history suggested that the cat had been injured 10 days prior to presentation for treatment. It illustrates how survival can be achieved if one lung remains functional despite the open pneumothorax and severe injury to one chest wall.

Additional radiographs were made nine days later (top right) following surgical repair of the flail chest by the placement of an external splint around the chest wall, which permitted a lateral "fixation" of the larger rib fragments to the external device.

It is remarkable that "Rax" continued to improve clinically and was eventually released.

Case 2.6





Signalment/History: "Blimp", an obese, 5-year-old, male DSH cat, was dyspneic and had a puncture wound in the right thorax and subcutaneous emphysema on the left.

Physical examination: The obesity of this cat made it almost impossible to auscultate the lungs or to learn of the status of the patient by physical examination.

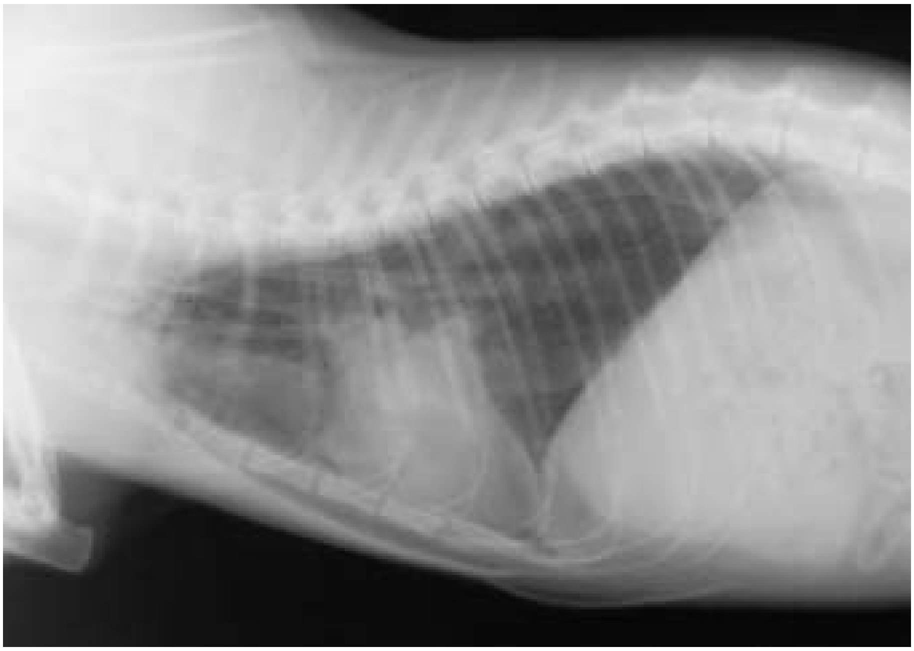
Radiographic procedure: Radiographs were made of the thorax with the hope of learning more of the origin of the puncture wound and its severity. Two right lateral views were made, one on greater inspiration.

Radiographic diagnosis: A marked infiltrative pattern within the lung lobes was located primarily in the middle and caudal lobes on the right (DV). The pattern was assumed to be interstitial since an air-bronchogram pattern could not be identified. Subcutaneous emphysema was more severe on the left and a single metallic pellet lay in the soft tissue at the level of the 9^{th} rib on the left. Fracture of the 7^{th} rib on the right with a small metallic fragment adjacent to the fracture site suggested the shot had passed through the thorax. The diaphragm was intact. Pleural fluid was difficult to evaluate because of the cat's obesity.

Treatment/Management: The fracture plus identification of the single pellet indicated a gunshot wound resulting from a high-pressure airgun. "Blimp" recovered and returned to his life of leisure.

Comments: The cat's obesity had resulted in the deposition of fat adjacent to the parietal pleura making the detection of minimal pleural fluid impossible. Lack of inspiration in this obese patient made determination of the severity of lung injury impossible.

2



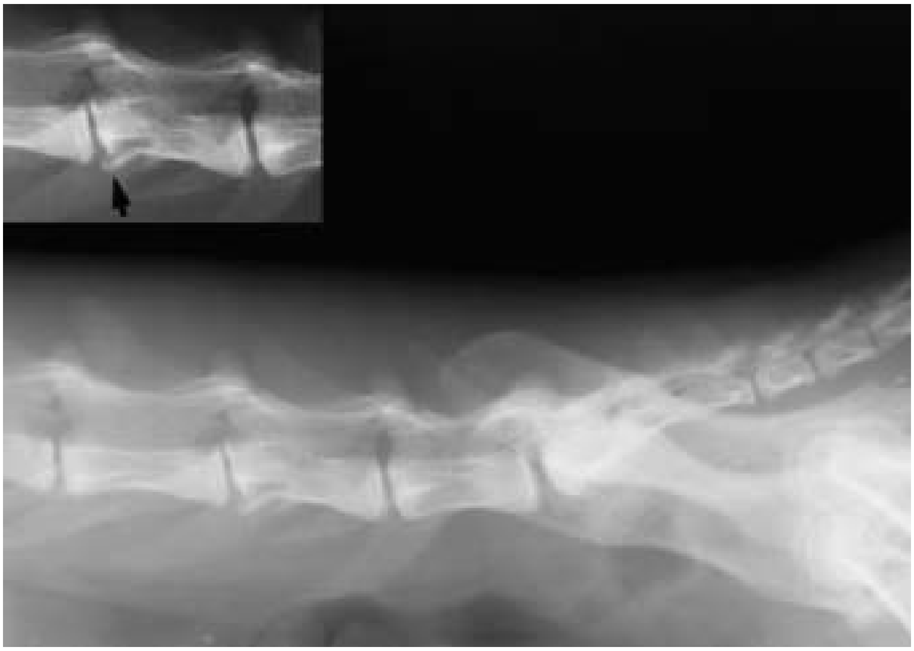
Case 2.7

Signalment/History: "Grenigo" was a 2-year-old, male DLH cat who had been hit by a car 12 hours earlier.

Physical examination: The cat was dyspneic and unable to stand. He did not seem to be able to move his pelvic limbs. Deep pain was evident in the pelvic limbs.

Radiographic procedure: Radiographs were made of the thorax and of the lumbar spine and pelvis.

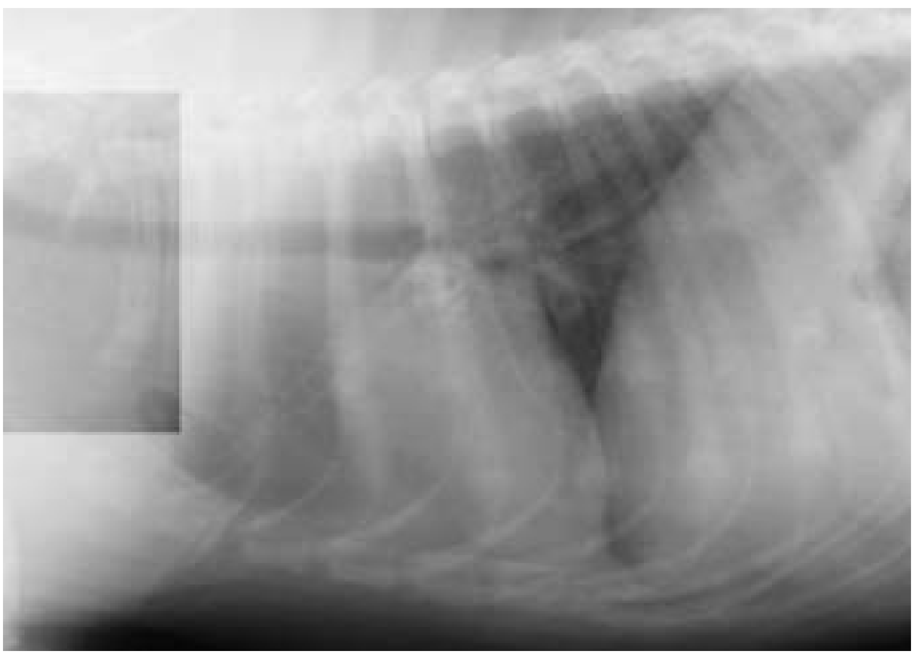
Radiographic diagnosis (thorax): Extensive subcutaneous emphysema was located primarily on the left. The 5th rib on the left was fractured and the separation of the ribs indicated intercostal muscle tearing (white arrows). Widening of the space between sternebrae 3 and 4 suggested a luxation. Extensive pulmonary contusion was most severe on the right, but also affected the left cranial lobe. Pneumothorax was principally on the left and minimal. Signs of pneumomediastinum were prominent.



Radiographic diagnosis (lumbar spine): A compression fracture involved the body of L6 with collapse of the L5–6 disc space (arrow). Bony fragments appeared to be driven dorsally into the spinal canal. Both hip joints were unstable probably due to hip dysplasia.

Treatment/Management: "Grenigo" was treated conservatively. The pulmonary contusion regressed rather quickly. By maintaining a strict control on movement, the vertebral fracture healed in two weeks permitting him to eventually walk almost normally.

Case 2.8



Signalment/History: "Asta", a 6-month-old, female German Shepherd puppy, had been struck by a car one hour prior to presentation for treatment.

Physical examination: She was unable to rise to a standing position. She had no pain sensation in the right forelimb and minimal voluntary movements in the left forelimb.

Radiographic procedure: Radiographs were made of the thorax as a part of a clinical work-up for a trauma patient.

Radiographic diagnosis: An increase in fluid density was noted in the cranial lung lobes. It was more prominent on the right side, probably indicating pulmonary contusion. It was difficult to evaluate the width of the mediastinum on the VD view, but the presence of mediastinal thickening due to hemorrhage was considered. A fracture of the first rib on the left was identified. Air-bronchograms in the left cranial lobe (arrow) indicated injury to that lung also.

The injury in the axillary region in a patient with neurologic deficits in a forelimb suggested that the soft tissue injury was more important than the minimal lung and rib lesions.

Treatment/Management: Both a brachial plexus injury and pelvic injury were suspected. The cervico-thoracic injury was partially confirmed by identification of the rib fracture. Additional radiographic studies of the thoracic inlet region were made using a more penetrating x-ray beam, but added no new information. Pelvic radiographs were made and showed only a developmental transitional lumbosacral segment with an associated malposition of the pelvis and did not indicate a recent fracture.

"Asta" was diagnosed with an avulsion type injury to the brachial plexus and did not recover the use of her forelimb.

Comments: Cranial mediastinal width is difficult to detect in a case such as this and mediastinal hemorrhage was not confirmed.

Because of the large size of the dog, an error was made in not including the entire diaphragm on the DV radiograph. The marked caudal displacement of the left hemidiaphragm was only suspected on the DV view. On the lateral view, the shadow of the dorsal crura on the left was positioned caudally.

2

Case 2.9

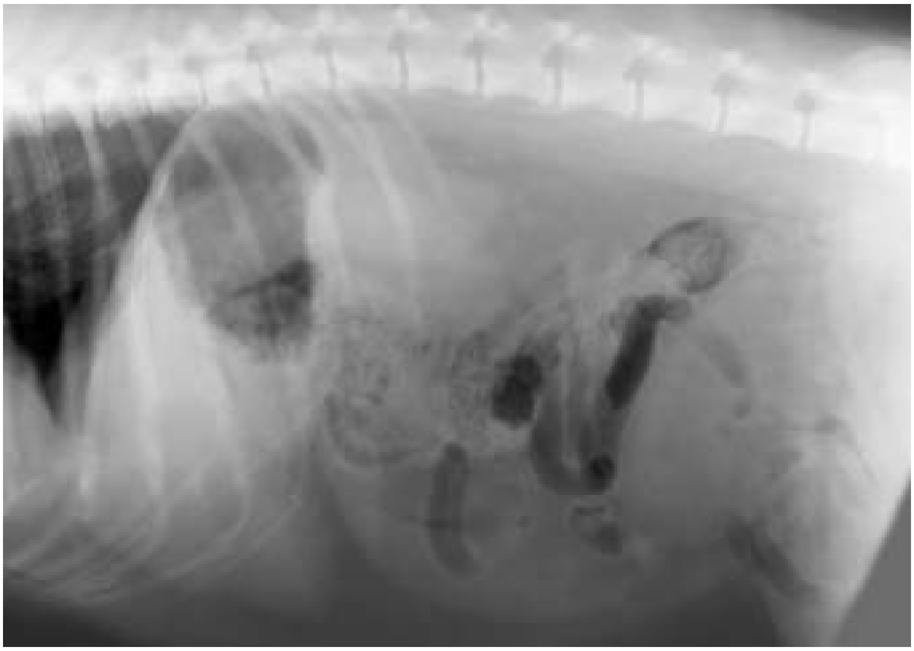
Day 1

Signalment/History: "Ginger" was an obese, 10-year-old, female Golden Retriever, who had been hit by a car several hours earlier and was presented with a flail chest.

Physical examination: Palpation of the thorax indicated severe injury to the ribs on the right. A soft tissue mass was evident in the inguinal region, but this was not thought important at the time.

Radiographic procedure: Initially on day 1, only thoracic radiographs were made due to the condition of the patient. But because of the caudal location of the thoracic trauma, injury to the liver, pancreas, and gall bladder needed to be considered and abdominal studies were made as soon as the patient was stabilized.

Radiographic diagnosis (day 1, thorax): Multiple fractures of the 9^{th}–12^{th} ribs on the right were noted with fragment displacement (flail chest), causing a marked deformity of the caudal portion of the right thoracic wall. Loculated pleural fluid, probably a hemothorax, was present in the caudal right hemithorax. This was associated with a volume loss caused by the caudal lobe atelectasis. The pulmonary vessels were small indicating shock. The apparent slight mediastinal shift to the left was thought to be the result of spinal curvature due to positioning and not due to trauma. A pneumothorax was expected in association with the chest wall injury, but a pattern of pleural air was difficult to identify. A small pattern of air separated the left caudal lung lobe from the chest wall and the diaphragm, but the volume was much less than antic-



Day 3

ipated considering the nature of the injury. The diaphragm was intact with the ventral portion more cranial in position than normal. A minimal amount of peritoneal fluid, probably hemorrhage, caused a reduced contrast in the abdomen.

Radiographic diagnosis (day 3, abdomen): Intestinal loops were noted within a right inguinal hernia. Loss of peritoneal shadows suggested the presence of peritoneal fluid. Liver, gastric gas bubble, and spleen were identified in their normal positions. The diaphragm was intact. Failure to identify the urinary bladder was thought to be an important finding.

Differential diagnosis: The distention of the single small bowel loop could mean: (1) an obstructive lesion associated with the hernia, (2) a paralytic ileus associated with damage to the blood supply to a solitary loop, or (3) a paralytic ileus associated with spillage of urine into the peritoneal cavity. This question was resolved at the time of abdominal surgery.

Treatment/Management: The inguinal hernia was repaired. The associated bowel loop was found to have a good blood supply and not to be torsed. "Ginger" was discharged with a persistent chest wall deformity and the possibility of being a "chronic respiratory cripple".

Comments: "Ginger" is an example of the importance of making both thoracic and abdominal radiographic studies recognizing that this technique can be of immediate value in the evaluation of the entire patient.

Case 2.10

Signalment/History: "Buster" was a 1-year-old, male Golden Retriever with a history of chronic cough.

Physical examination: The examination did not contribute to an understanding of the clinical signs. There was no history of trauma that might have preceded the cough.

Radiographic procedure: Multiple views were made of the thorax.

Radiographic diagnosis: The injury to the right thoracic wall was long-standing with malunion rib fractures and thickened pleural shadows indicative of pleural scaring. The cardiac shift toward the site of injury suggested pleural adhesions with atelectasis. The lesion was not identified on the lateral view.

Treatment/Management: The post-traumatic changes caused a failure of normal expansion of the right middle lobe, a probable defect in the ciliary clearing mechanism, and a possible chronic pneumonia. Three separate DV radiographs were made to insure that the apparent shift in position of the mediastinum was not due to improper positioning of the patient during radiography. The apparent cardiomegaly may have been real or the result of the heart's malposition.

Treatment was limited to the purely symptomatic.

2

At presentation

Case 2.11

Signalment/History: "Quake" was an 8-year-old, male Schnauzer mixed-breed with a history of a left-sided thoracic mass thought to be secondary to a bite wound.

Physical examination: No evidence of soft tissue injury was noted. The soft tissue mass was firm, not warm, and not fluctuant.

Radiographic procedure: The intensity of the radiographic beam used for the thoracic studies was increased to permit a better evaluation of the thoracic wall.

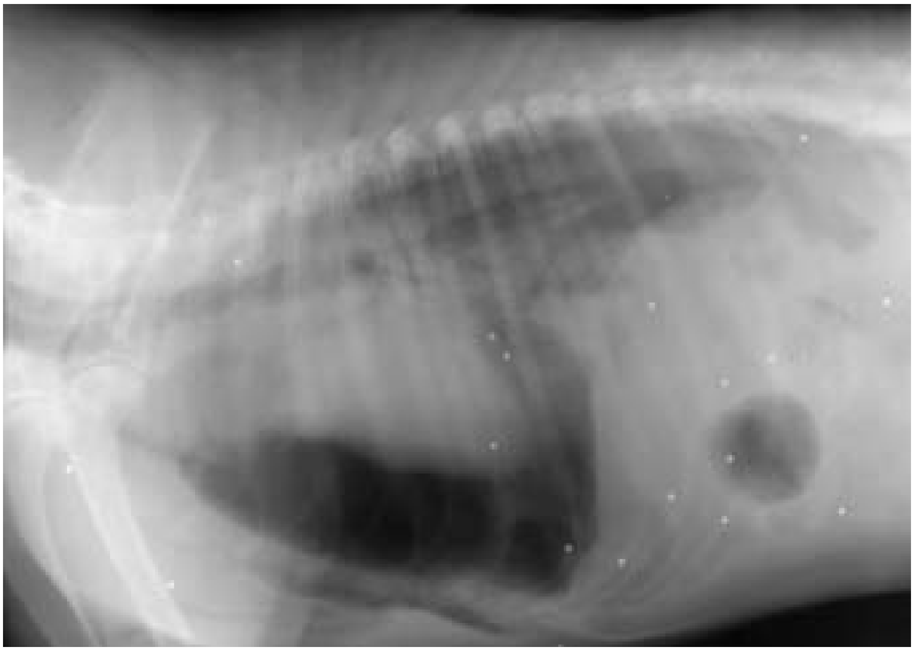
Radiographic diagnosis: A concave defect in the thoracic wall on the left (arrows) was associated with an increase in the width of the extra-thoracic musculature. Focal pleural thickening or trapped pleural fluid lay adjacent to the defect. No rib fractures were noted. The cardiac and pulmonary structures were normal. The lateral view did not contribute to the evaluation of the thoracic wall lesion.

Differential diagnosis: The differential diagnosis of a flattened, focal, pleural thickening in the absence of rib lesions includes: (1) inflammatory pleuritis that can be acute or chronic, and active or quiescent, (2) a soft tissue tumor invading from the extra thoracic region such as a fibrosarcoma, (3) a pleural tumor such as a mesothelioma, or (4) chronic chest wall injury.

Treatment/Management: Surgical exploration resulted in the removal of a plant awn that had partially penetrated into the thoracic cavity. A follow-up study made three months later showed only a persistent pleural thickening as a consequence of the infection and the surgery.

Month 3

2



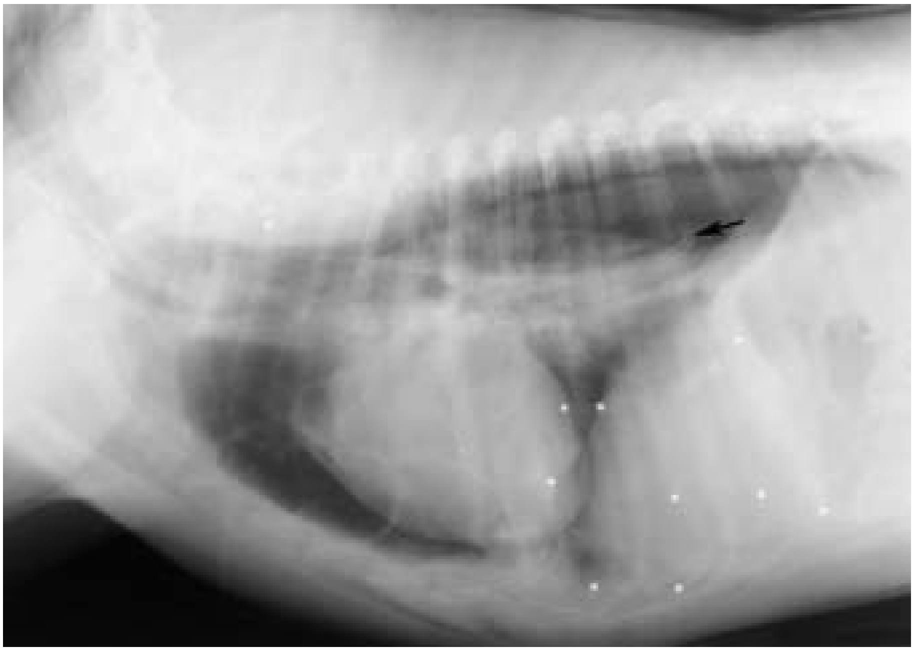
Case 2.12

Referral radiographs

Signalment/History: "Sandy", a 5-year-old, male Queensland Heeler, had been hit by a car 24 hours earlier.

Physical examination: The examination was difficult because of the obtunded status of the dog. Abnormalities in the left chest wall could be palpated.

Radiographic diagnosis (referral radiographs): Referral radiographs showed a massive pneumothorax with extensive separation of the cardiac silhouette away from the sternum. The lung lobes on the right and the cranial lobe on the left showed pulmonary contusion. Rib fractures were present on the left. A pneumoperitoneum was suspected. The status of the diaphragm was uncertain, especially in the region of the esophageal hiatus. Metallic shotgun pellets were noted, but were thought to be incidental.



Day 2

Radiographic diagnosis (day 2): The pneumothorax was persistent, however, the pulmonary contusion/atelectasis was less than in the referral radiographs. Pneumomediastinum could now be seen. The subcutaneous emphysema on the left was still evident. The fractured ribs showed further separation between the 5th and 6th ribs on the left. The diaphragm appeared intact on this study. The tip of a thoracic tube on the right lay at the level of the 9th rib (DV view, arrow).

▶▶

2

Day 4

Radiographic diagnosis (day 4): The status of the patient improved after being on the pleura-vac for two days. The pneumothorax decreased and the right lung re-inflated. The pneumomediastinum was still evident and the chest wall injury remained unchanged. A chest tube remained in position on the left side.

Treatment/Management: The pneumothorax recurred following removal of the thoracic tube on day 4, thereby delaying recovery. The appearance of the lungs and the extensive pneumothorax suggested little functional lung tissue at the time of the first study. The radiographic appearance is a warning that the lung injury was more severe than normally seen with the usual blunt trauma. The pneumomediastinum was probably present on the first study as indicated by the gas within the soft tissues at the thoracic inlet. This also is a possible indication of injury to either a main stem bronchus or the trachea and is indicative of a probably prolonged recovery.

Case 2.13

Signalment/History: "Tom" was a 1-year-old, male DLH cat with a malformed thoracic cavity thought to have occurred following an accident. The owner was concerned because of the "strange shape of the chest".

Physical examination: The abnormality in the sternum was easily palpated; however, no pain or soft tissue swelling was noted. Heart sounds were much more prominent on the left side.

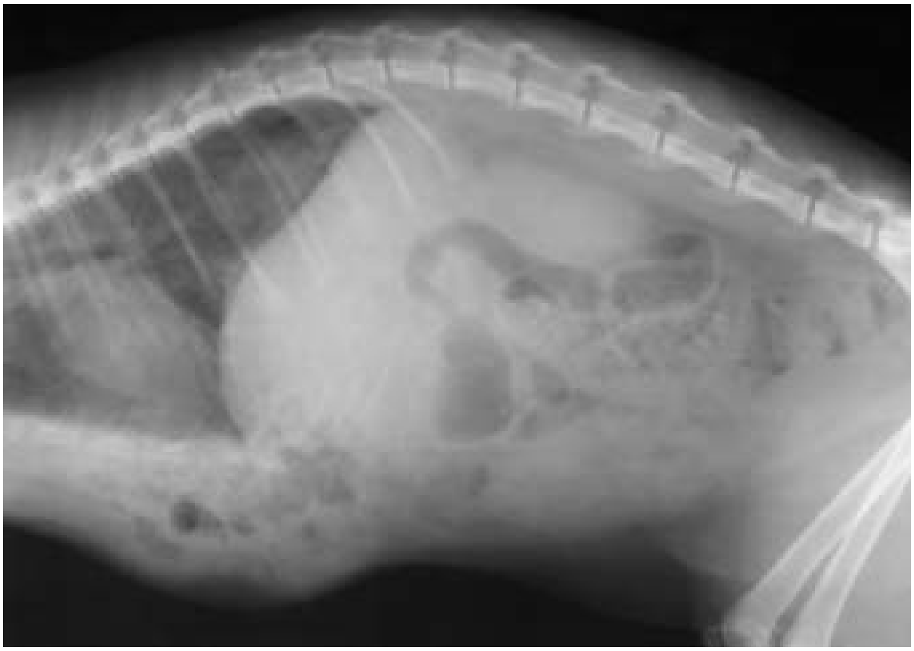
Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis: A congenital anomaly of the sternum had caused the xiphoid process to be angled dorsally and to the right (arrows). As a result, the apex of the heart was shifted to the left against the thoracic wall. The lung fields were normal. The diaphragm was intact, but was shifted caudally. The liver shadow was shifted ventrally and caudally.

Treatment/Management: The congenital anomaly had caused marked changes in the conformation of the thorax without markedly affecting the function of either the lungs or heart. As a consequence, no treatment was considered.

2

2.2.2 Paracostal hernia



Case 2.14

Day 1

Signalment/History: "Baby" was a 7-month-old, male DSH cat who had been missing from home for several days.

Physical examination: He was depressed, dyspneic, and in shock.

Radiographic procedure: Lateral views of the whole body were made.

Radiographic diagnosis (day 1, whole body, lateral view): A large soft tissue mass lay ventral to the xiphoid process on the right side. It contained air-filled bowel loops plus disseminated air indicative of subcutaneous emphysema. The abdominal wall and ventral liver border could not be identified suggesting the presence of peritoneal fluid. Adjacent to the diaphragm was an area of increased fluid density within the dorsal part of the caudal lung lobes possibly due to either a pulmonary lesion such as hemorrhage or even a lesion affecting the gastroesophageal junction.

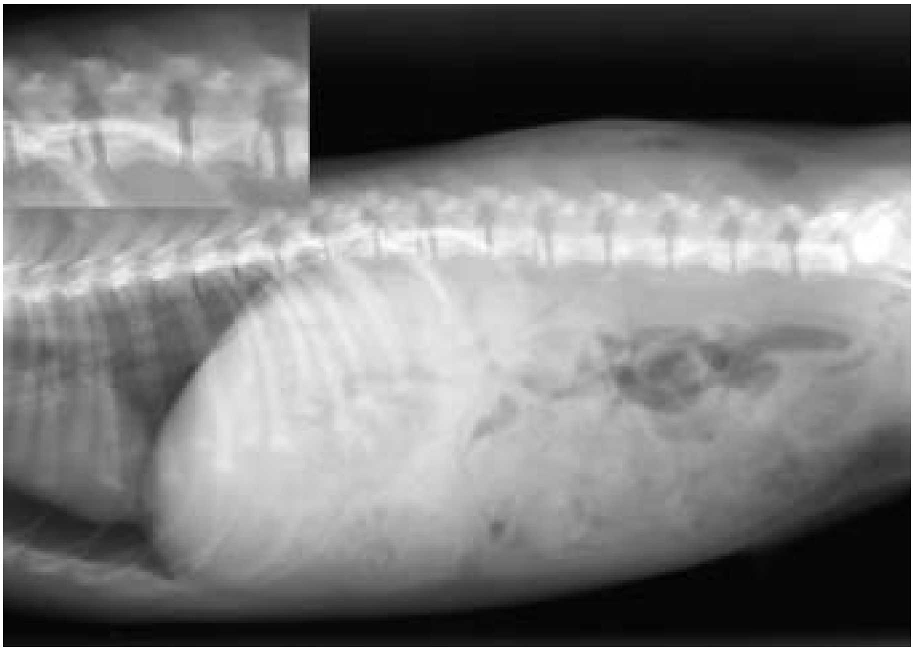
2

Day 2

Radiographic diagnosis (day 2, DV and lateral views): Radiographs made two days later continued to show the extra-thoracic mass, but without the presence of air-filled bowel loops. Diffuse air again suggested subcutaneous emphysema from a puncture wound in the skin. The DV view confirmed a pulmonary lesion and located it in the caudal lobe on the right. The continued presence of the pulmonary lesions suggested the cause was more than just a contusion. Disruption of the 10^{th} and 11^{th} ribs on the left indicated the nature of the injury as a probable bite wound with injury on both sides of the thorax. Pleural fluid pocketed around the dorsal segment of the right caudal lobe suggested a failure of that lobe to fully inflate. The possibility of peritoneal fluid remained. The absence of bowel loops in the hernial sac provided an excuse to postpone surgery.

Treatment/Management: After three days in the clinic during which antibiotics were used to treat the unknown cause of an elevated WBC count, "Baby" collapsed and emergency surgery identified rents in the stomach and a bruised ileum. A tear in the dorsal diaphragm was identified without herniation of abdominal contents. Necrotic omentum was noted in the paracostal hernia. Peritonitis and pneumonia were evident at necropsy two days later.

Comments: It was thought that this patient had been treated rather too conservatively in the face of the radiographic and clinical findings, which suggested the presence of a more severe clinical situation.



Case 2.15

Signalment/History: A male, mixed-breed puppy was found lying by the roadside and was brought to the clinic for treatment.

Physical examination: A soft tissue mass was palpable on the right abdominal wall. The physical examination was limited.

Radiographic procedure: Abdominal radiographs were made.

Radiographic diagnosis: Air-filled small bowel loops were displaced laterally into a soft tissue pocket along the right abdominal wall. The bowel loops within the hernia did not appear distended. The 11^{th} and 12^{th} ribs on the right were fractured. An increase in fluid density of the caudal lung lobes was noted as well as a pneumothorax, which had resulted in separation of the cardiac silhouette from the sternum. Subcutaneous emphysema was present over the caudal abdomen. End-plate fractures of the bodies of T13 and L2 helped to explain the extreme pain exhibited by the puppy.

Treatment/Management: A major problem in diagnosis in this puppy was to distinguish whether the air pockets located in the hernial sac were within bowel loops or represented free subcutaneous air that had pocketed. The tendency for the air to be defined into well-marginated patterns suggested that it was more likely to be lying within bowel loops.

The hernia was repaired, the bowel loops replaced within the peritoneal cavity, and the puppy closely confined until the fractures had healed.

2

Case 2.16

Signalment/History: A young, male Chihuahua had been found by a friend of the owner laying on its side and breathing with great difficulty after being attacked by larger dogs. He was brought to the clinic.

Physical examination: A large soft tissue mass could be palpated on the left body wall.

Radiographic procedure: Radiographs were made of the caudal portion of the body.

Radiographic diagnosis: Incomplete fractures of the last ribs on the left were noted with a costovertebral luxation of the last two ribs. The underlying lungs appeared normal. Herniation of air-filled bowel loops, spleen, mesenteric fat, and a part of the stomach filled the paracostal hernial sac on the left. A soft tissue mass just cranial to the bowel loops had an uneven fluid density and was thought to be hemorrhage (hematoma). The small bowel loops were air-filled and distended suggesting a paralytic ileus.

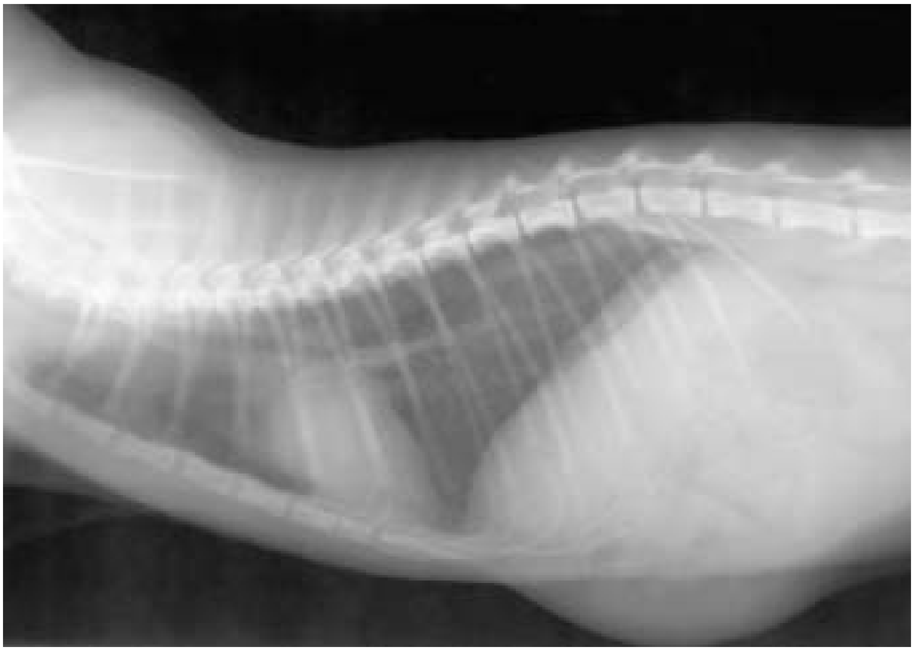
The displaced gastric shadow had the pylorus on the left side. Although the fundus was displaced cranially, it was thought not to be herniated through a diaphragmatic tear. Uniform fluid density within the cranial abdomen suggested a focal peritoneal hemorrhage or peritonitis.

Note that the trauma did not affect the underlying lungs and had not caused a generalized peritoneal hemorrhage or peritonitis. The distention of the stomach with air suggested a pyloric stenosis.

Treatment/Management: At surgery, the gut was partially twisted on its mesentery with secondary necrosis. No tear in the diaphragm could be found. The dog was discharged after surgery.

2

2.2.3 Pleural fluid



Case 2.17

Signalment/History: This mature, female DSH cat was a stray that was found by the new owner to have a prominent swelling on the right side of her body.

Physical examination: The prominent soft tissue mass was easily palpable and the contents could be readily compressed.

Radiographic procedure: Whole body radiographs were made.

Radiographic diagnosis: The soft tissue swelling was centered around the last ribs on the right and contained discretely outlined air-filled structures thought to be bowel loops. The stomach was enlarged and fluid-filled suggesting the possibility of a pyloric obstruction. No injury to the chest wall was seen except for injury to the last asternal ribs on the right. The diaphragm was intact. The lungs appeared normal. No pleural fluid was noted.

Treatment/Management: The owner refused treatment of the paracostal hernia and the cat was lost to follow-up. The bowel loops were not distended and the possibility of a bowel obstruction was considered minimal; still, the owners were advised that surgical repair was recommended.

Case 2.18

Signalment/History: "Olive" was a 2-year-old, female Old English Sheepdog with a history of being unable to breathe when placed in dorsal recumbency. She became acutely dyspneic when positioned on her back and the owners believed she had been shot by the neighbors.

Radiographic procedure: Studies of the thorax were ordered because of the history of dyspnea.

Radiographic diagnosis: A massive pleural effusion was present, characterized by retraction of the lung lobe margins from the thoracic wall. The cardiac silhouette was difficult to evaluate, but was probably normal in size, shape, and position. The lung fields were also difficult to evaluate, but the cranial main-stem bronchi were folded caudally suggesting the presence of a cranial intrathoracic mass. The diaphragmatic shadows were difficult to assess, but they appeared to be located caudally and were flattened. No evidence of chest wall injury was noted. A severe congenital sternal anomaly resulted in only 5 or 6 segments being present.

Treatment/Management: Treatment was medical and the possibility of lung lobe torsion was not proven.

Case 2.19

Signalment/History: "August" was a 4-month-old, male Australian Shepherd who had been in a dogfight two days previously.

Physical examination: An injury to the left thoracic wall could be palpated. It was possible to insert several fingers between the displaced ribs.

Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis (day 1): Disruption of the caudal ribs on the left was associated with intercostal muscle tearing, soft tissue swelling in the thoracic wall, and minimal subcutaneous emphysema; all of which were indicative of a massive puncture wound. Extensive pleural bleeding in the left hemithorax and collapse of the underlying lung lobes resulted in a mediastinal shift to the right. Note the cavitary lesion in the left caudal lobe that represents a traumatic pneumatocele. The tracheal shadow was elevated as a result of the heart moving into the right hemithorax. The presence of hemorrhage within the mediastinum could not be evaluated.

Day 1

Day 2

Day 4

Radiographic diagnosis (day 2, DV view only): Radiographs done the next day showed a lesser amount of pleural fluid with an increase in the aeration of the left lung lobes.

Radiographic diagnosis (day 4, DV view only): Radiographs taken two days later showed a worsening of the condition with a marked increase in the amount of pleural fluid causing a more extensive mediastinal shift to the right. Note the shifting of the carina (arrow). The left lung did not appear to contain any air at this time.

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Treatment/Management: Surgery to remove the hemorrhaging left caudal lung lobe was performed on day 4. Radiographs made on day 10 showed a partial aeration of the remaining lung lobes on the left. The left hemidiaphragm was shifted cranially and the accessory lobe had shifted into the left hemithorax. All of these changes resulted in a minimal mediastinal shift to the left. The rib injuries were not treated.

Detection of a traumatic pneumatocele indicated a more severe injury to the lung than expected with a typical blunt trauma, and suggested that lobectomy might be required to stop the hemorrhage.

The possibility of abdominal organ injury was considered because of the caudal location of the injury; however, treatment for an abdominal injury was not required.

Day 10

Case 2.20

Signalment/History: "Duke" was a 7-year-old, male German Shepherd with a history of having sustaining stab wounds to the thorax three days earlier. He had been given emergency treatment and was referred with a history of hemothorax that had been increasing in volume as shown by daily thoracic radiographs.

Physical examination: He was thought to be in DIC at the time of admission to the hospital and was having PVCs.

Radiographic procedure: The thoracic study included both VD and DV views.

Radiographic diagnosis: The pleural fluid was massive and was freely movable when the DV and VD views were compared. It was suspected to be hemorrhage because of the history. The fluid pooled around the right middle lobe and the caudal portion of the left cranial lobe, indicating some degree of atelectasis. Mediastinal widening was suspected to be the result of a hemomediastinum with the possibility of organized blood clots within that structure. This was more evident on the VD view.

A diffuse pulmonary pattern was noted throughout the lungs without evidence of an air-bronchogram pattern. The cardiac silhouette was identified and thought to be within normal limits; however, the examination was compromised by the presence of pleural fluid. The failure to identify a displacement of the lung lobes or mediastinum suggested an absence of any pleural masses. The minimal soft tissue thickening noted on the left thoracic wall was assumed to be secondary to the trauma.

No evidence of peritoneal fluid was noted. Minimal spondylosis deformans was evident in the caudal thoracic spine.

Small circular shadows on the lateral view are attachments for the leads from the EKG machine.

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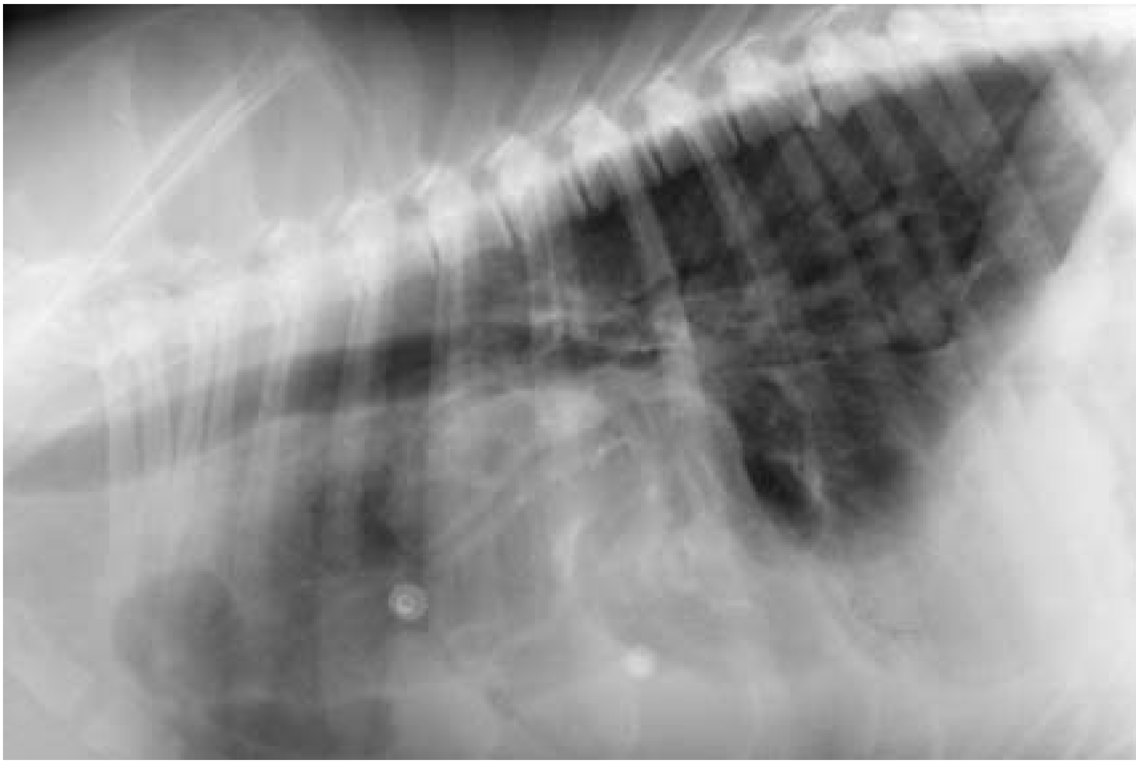
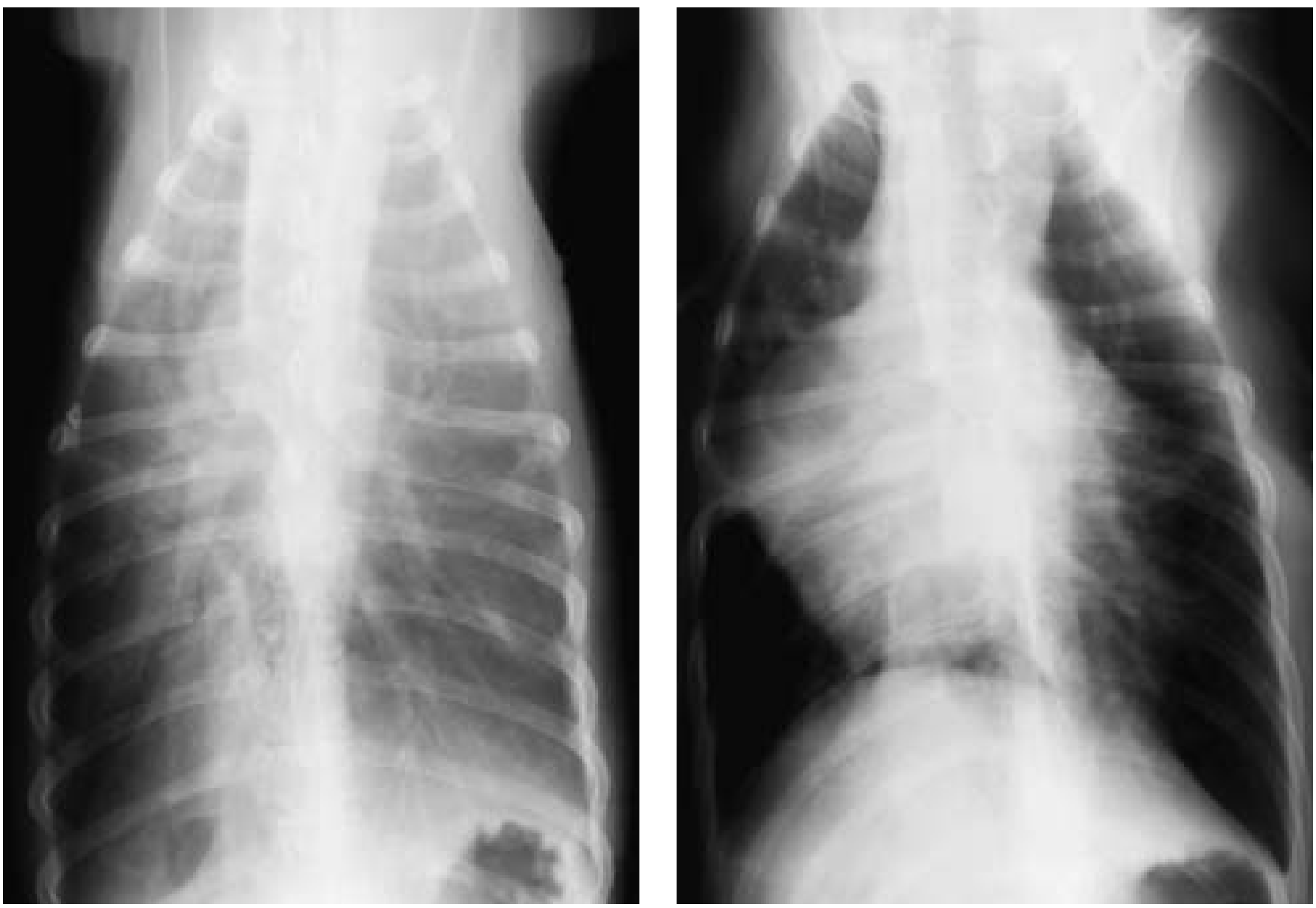


Day 1



Day 25

Radiographic diagnosis (day 25): Resolution of the pleural fluid was remarkable along with the identification of normal pulmonary bronchovascular markings.

Treatment/Management: Stab wounds are a different form of trauma from the more common blunt chest trauma resulting from automobile accidents. The absence of alveolar fluid and the presence of pleural fluid instead suggested a puncture-type wound to the lungs. An important aspect in this case could be seen on comparison of the DV and VD views of the first study that showed not only the amount of pleural fluid and how freely it moved, but the relatively uninjured lung lobes as well. The diaphragm was not visualized on the DV view but was thought to be normal on the VD projection.

If the injury was truly a "stab wound" resulting in pleural and mediastinal hemorrhage, why was not a pneumothorax present as well? A thoracic wall injury secondary to a stab wound probably closes immediately and does not permit air to enter the thoracic cavity. In this case, it seems possible that the lung lobes had not been injured and the bleeding had resulted from some other vascular injury.

The presence of secondary pneumonia is always difficult to determine in trauma cases with lung lobe contusion and/or atelectasis. That was not a problem in this dog. "Duke" recovered completely following conservative treatment and returned to work on the police force.

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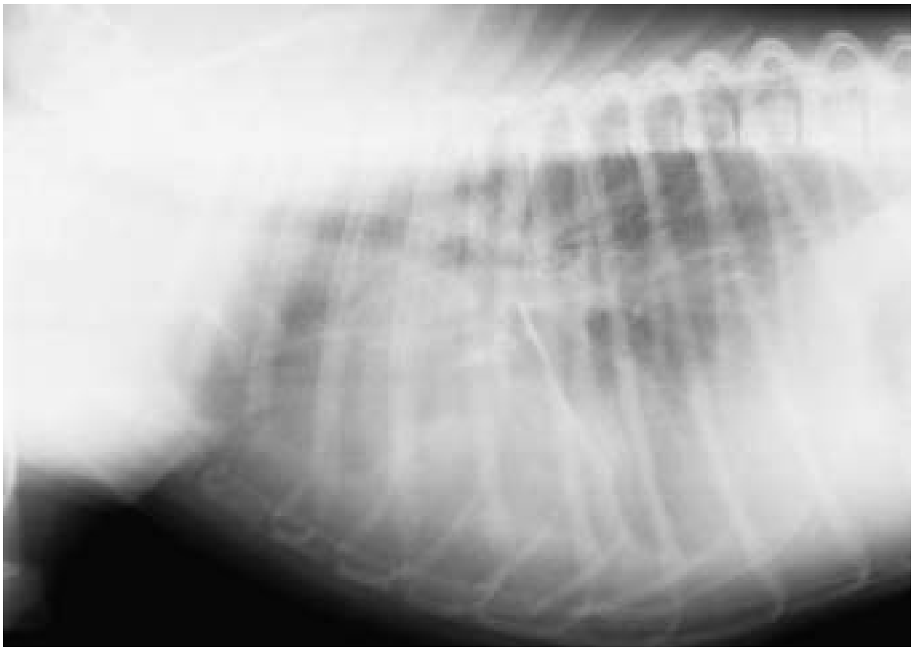


Case 2.21

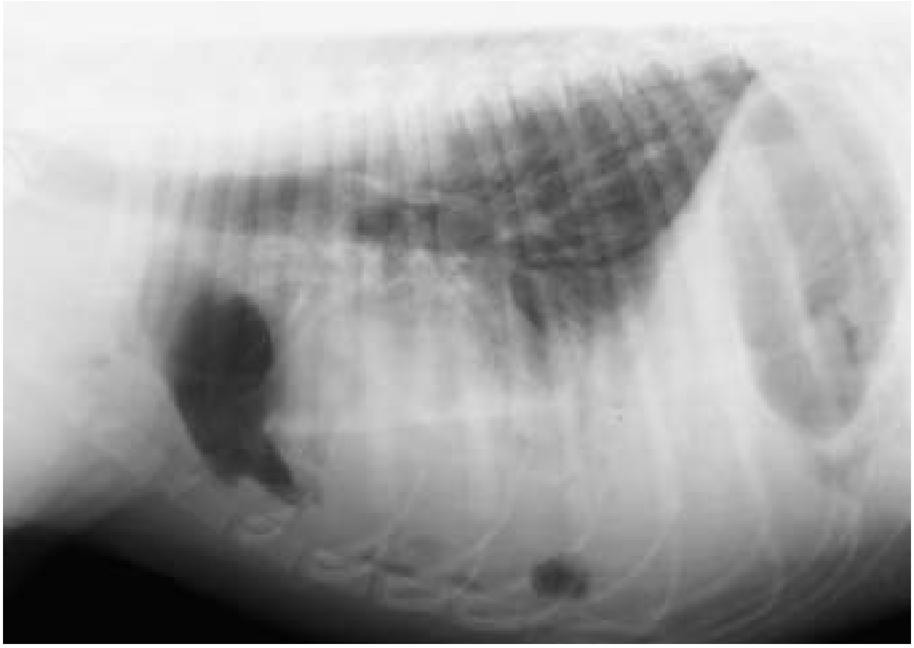
Day 1

Signalment/History: "Roy" was a 4-year-old, male English Pointer with a history of chronic dyspnea. Small quantities of purulent pleural fluid had been aspirated in the past. A grass awn had been removed from the thoracic wall 1 year previously.

Physical examination: Lung sounds could not be auscultated and the heart sounds were muffled. The patient was dyspneic and slow to move.

Radiographic procedure: Thoracic radiographs were made.

Radiographic diagnosis (day 1): Massive pleural fluid was seen on both views and prevented evaluation of the lung lobes. Pleural fluid had infiltrated into the fissures between the lung lobes. The bronchi and pulmonary vessels could not be seen completely, but they were thought to be in their normal position, which ruled out any pulmonary mass lesions. The diaphragm could not be completely identified ventrally. The thorax was widely expanded.



Day 2

Radiographic procedure (day 2): Radiographs were made on day 2 following the removal of 675 ml of purulent pleural fluid. The lung lobes could be better evaluated A fluid-dense mass was noted within the accessory lobe, which silhouetted with the heart shadow and the diaphragm. A minimal pneumothorax probably secondary to the placement of the needle for aspiration of the pleural fluid was present. The normal position of the gastric air bubble helped to rule out a diaphragmatic hernia.

Treatment/Management: Chronic trauma was considered in this patient, but the nature of the pleural fluid was strongly suggestive of an inflammatory lesion. The geographical location in which the dog lived had grass awns. This fact, plus the past history of grass awn migration into the thoracic wall, suggested that abscessation within the accessory lobe was the primary diagnosis. The dog was operated and the affected lobe removed. A grass awn was identified as the cause of the abscess. Recovery of the patient was difficult because of the chronic infection.

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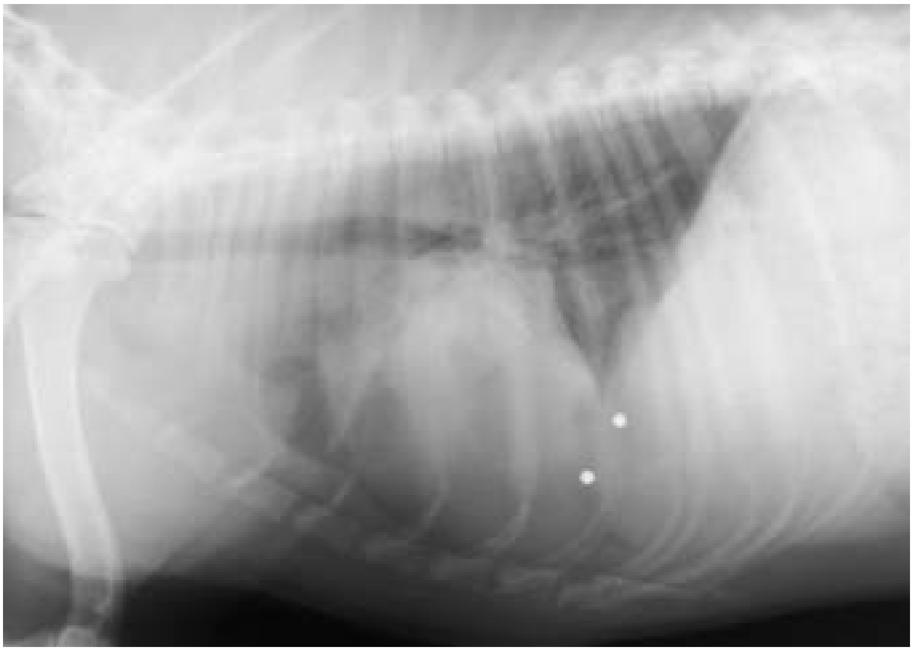

Case 2.22

Day 3

Signalment/History: "Kato" was a 4-year-old, male Brittany presented two days after an accidental gunshot wound in the chest inflicted by his owner.

Physical examination: He was quiet, alert, with pale mucous membranes, and afebrile. Increased sounds could be heard in the left lung.

Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis (day 3): Extensive pleural fluid was present. It was movable as indicated by comparison of the DV and VD views. A pulmonary infiltration was suspected in the caudal aspect of the left cranial lobe, but this was difficult to prove because of the pleural fluid that had pocketed in that region. The width of the mediastinum was thought to be normal. No evidence of pneumothorax was noted.

Two metallic pellets were located within the thorax on the right side ventrally. On comparison of the DV and VD views, they appeared to be fixed in position. It was assumed that the fluid was the result of hemorrhage secondary to the gunshot wound, but the injury to the lung was difficult to assess.

Radiographic diagnosis (day 16): A persistent mild pulmonary infiltrative pattern remained in the caudal half of the left cranial lung lobe with the probability that pleural fluid had remained pocketed around that lobe. The two metallic pellets could still be identified; however, one had moved cranially and was thought lie within the cardiac silhouette, most probably within the pericardial sac.

Treatment/Management: The location of the pellet remained questionable. The cranial metallic pellet was observed fluoroscopically to move dependent on the heart beat and was therefore determined to be located within the pericardial sac.

The pulmonary effusion was slow to clear suggesting either secondary pneumonia or severe pulmonary damage. The dog was discharged without treatment of the metallic foreign body. "Kato" was only four years old and should have recovered to have healthy lungs without any residual disease.

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Day 16

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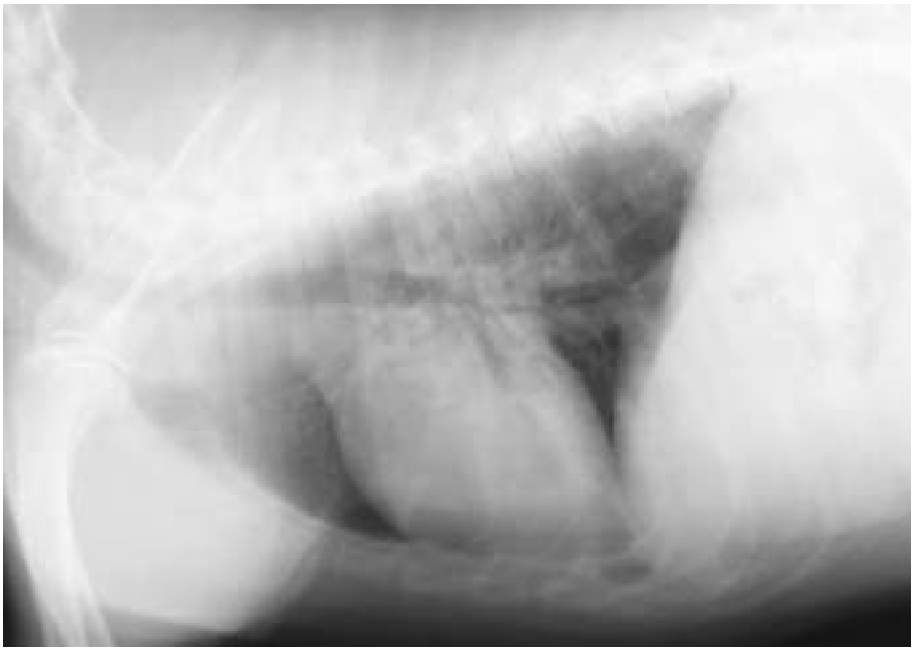
2.2.4 Lung injury



Case 2.23

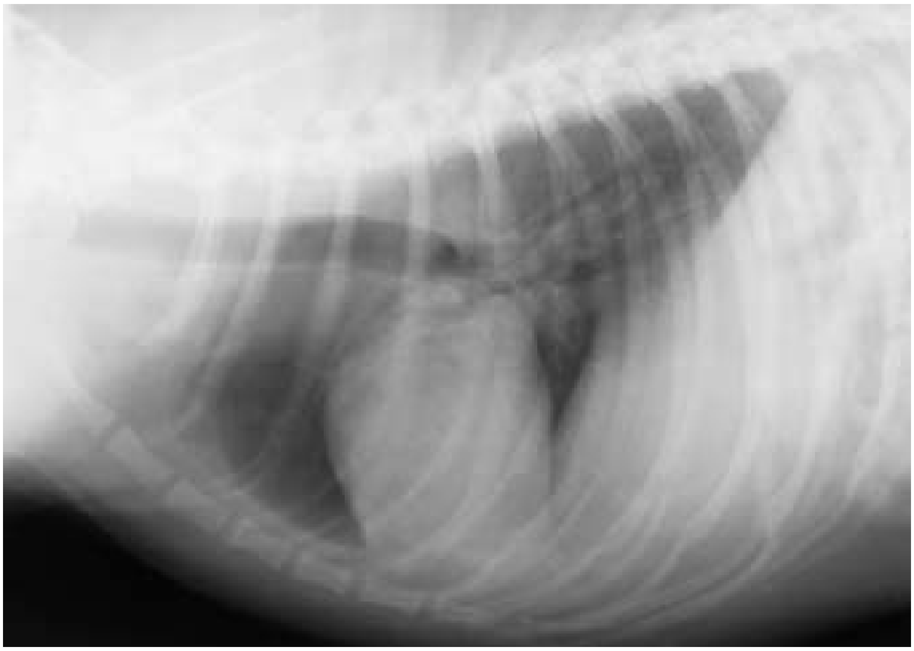
Signalment/History: "Gypsy", a 5-year-old, female Brittany, had been hit by a car.

Physical examination: On physical examination, she had increased lung sounds and dyspnea.

Radiographic procedure: Routine studies of the thorax were performed.

Radiographic diagnosis: Pulmonary contusions in the left lung lobes caused an increase in fluid density that was most prominent in the left caudal lobe, and was most likely the result of pulmonary hemorrhage. Minimal pleural fluid was noted and no pleural air could be identified. The chest wall, diaphragm, mediastinum, heart, and great vessels were all normal.

Treatment/Management: While the owners were greatly concerned because they had witnessed the trauma to the dog, the radiographic findings suggest that the injury was rather minor. The dog was released after two days in the hospital following conservative therapy.



Case 2.24

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Signalment/History: "Faswa" was a 5-year-old, female Border Collie who had been struck by a car two days previously.

Physical examination: As she had remained dyspneic and was not moving normally, "Faswa" was brought to the clinic for examination.

Radiographic procedure: Thoracic radiographs were made.

Radiographic diagnosis: Minimal subcutaneous emphysema was present on the right side with an incomplete fracture of the 8th rib. An old malunion fracture of the 9th rib was present on the right. The diaphragm was intact. A small amount of pleural fluid was present, but the major finding was the atelectic right middle lung lobe with a minimal contusion of the right caudal lobe.

Treatment/Management: The right middle lung lobe is comparatively small and yet has a large surface area. If injured or diseased, it can be quickly collapsed by the adjacent aerating lobes leading to the term "right middle lobe syndrome". Notice that this lobe is superimposed over the cardiac silhouette on the lateral view, so the increase in fluid density cannot be appreciated on that view. A small portion of the hemorrhage in the caudal lobe is noted just dorsal to the hilar region on the lateral view.

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Case 2.25

Signalment/History: "Tammy" was a 6-year-old, female Labrador Retriever who had been struck by an automobile one hour earlier.

Physical examination: She was slightly dyspneic and non-weight bearing on the right forelimb.

Radiographic procedure: Studies were made of the thorax with additional views of the right scapula.

Radiographic diagnosis (thorax): Collapse of the right middle lobe and an increase in density due to hemorrhage within the caudal lung lobes were noted. The caudal lobes silhouetted with the diaphragm on the lateral view. Because of the lung lobe collapse, the cardiac silhouette was shifted toward the right. Pocketing of pleural fluid was seen around the more severely affected lobe. Compensatory overinfiltration of the caudal lobe resulted in a cranial shifting of the right middle lobe. The diaphragmatic shadow could be seen on the DV view. No injury to the thoracic wall was noted.

Radiographic diagnosis (scapula): A comminuted fracture of the right scapula was present, but did not extend into the shoulder joint.

Treatment/Management: Air-bronchograms could be clearly identified in "Tammy's" lungs indicating a more extensive amount of fluid than seen in the typical contused lung. She was given several days rest and returned to her owner. The fracture was not treated.

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Case 2.26

Signalment/History: "Sampson" was a 3-month-old, male German Shepherd that had been struck by a large board falling across his body.

Physical examination: The dog was in shock when presented and showed great pain. An abdominal tap was negative for fluid.

Radiographic procedure: The thorax was radiographed.

Radiographic diagnosis (day 1): Pulmonary contusion was principally in both caudal lobes and the right cranial lobe, with the presence of air bronchograms. Minimal loculated pleural fluid was present on the left side caudally. The diaphragm appeared to be intact, although the right crus could not be seen clearly.

Day 1

Radiographic diagnosis (day 3): Radiographs made two days later showed a clearing of the pleural fluid on the right, but increased consolidation of the right middle lobe and left cranial lobe. The right cranial lobe was hyperinflated. Pleural fluid was considered to be possibly present on the left.

Treatment/Management: Failure of the fluid in the lung to clear within 48 hours indicates a more severe injury than just pulmonary contusion. The patient was treated with antibiotics and recovered suggesting that pneumonia had been present secondary to the trauma.

Day 3

Case 2.27

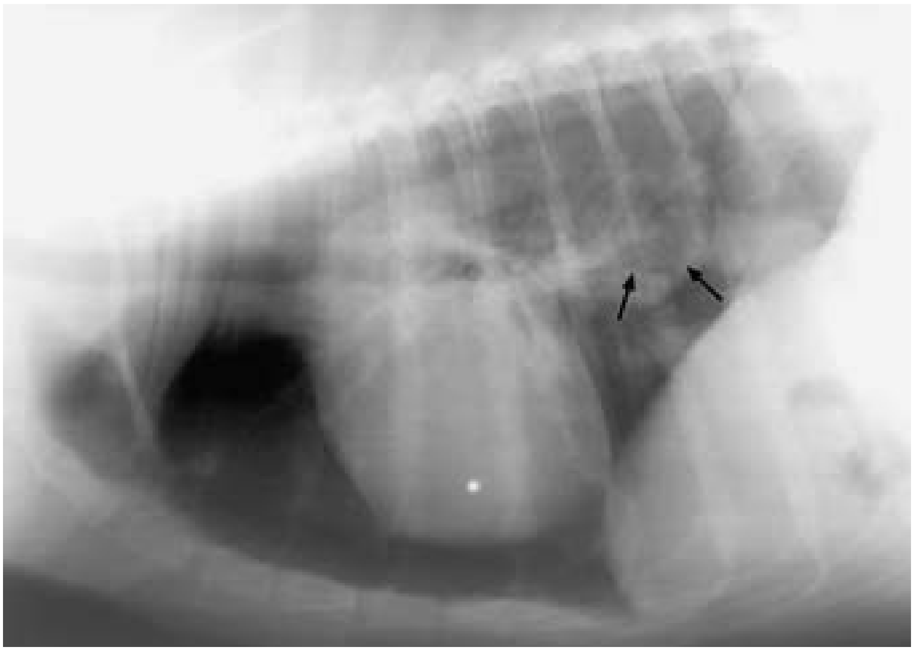
Signalment/History: "Sugar Bear", a 4-year-old, male Akita, had been caught in a fire one week earlier. He had been unconscious immediately after the fire, but then appeared to make a complete clinical recovery.

Physical examination: He was reported to convulse daily, but appeared relatively normal when presented in the clinic.

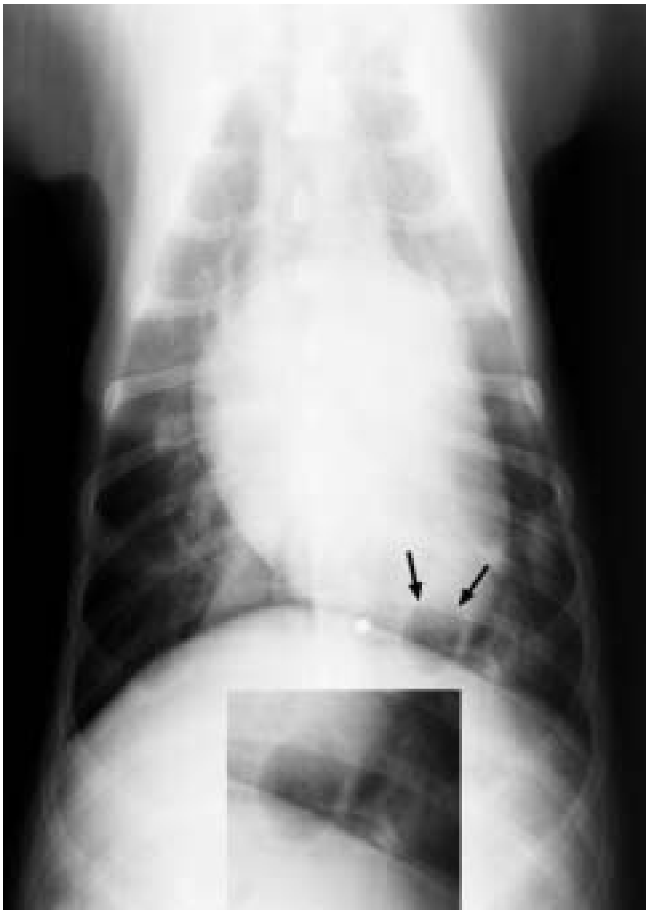
Radiographic procedure: Thoracic radiographs were made because of the history.

Radiographic diagnosis: An increase in fluid density in the central portion of the lung field was associated with prominent airway markings. The increase in fluid density around the walls of the bronchi was thought to be associated with the inhalation of noxious agents and also possibly with additional thoracic trauma associated with the fire. A region in the left cranial lobe had increased fluid density, but this was thought to be due to the oblique position of the patient at the time of radiography.

Treatment/Management: "Sugar Bear" failed to improve clinically and was euthanized. At necropsy, cortical necrosis was noted secondary to the anoxia from smoke inhalation at the time of the fire. In the lungs, the main bronchi and smaller broncheoli were filled with a tenacious clear fluid with "black specks". The alveolar walls were congested. All the lung pathology was secondary to the inhalation of smoke.



Case 2.28



Signalment/History: "Lady" was a 4-year-old, female, mixed-breed dog who had been hit by a car.

Physical examination: On physical examination, she was dyspneic with decreased lung sounds on the left side.

Radiographic procedure: Studies of the thorax were made.

Radiographic diagnosis: The heart shadow was separated from the sternum on the lateral view and the lung lobes were separated from the chest wall on the left indicative of a pneumothorax. An increase in lung density suggested pulmonary contusion/hemorrhage in both the right and left lung lobes. A large lucent cyst with sharp margins was in the left caudal lobe and represented a traumatic pneumatocele (arrows). A second smaller cyst was located just lateral to the larger lesion. A metallic object lay in the ventral mediastinum (air-gun pellet). Minimal peritoneal effusion (hemorrhage) was noted, indicated by a inability to identify the ventral border of the liver.

Treatment/Management: Because of the suspected peritoneal fluid, "Lady" had a retrograde cystogram performed that proved the urinary bladder to be intact. However, she was found to have a pelvic fracture involving the left hip joint.

Continued monitoring of the effects of the injury to the lungs was important in this dog because the finding of the pneumatocele indicated a more severe trauma than is usually seen in trauma patients with the possibility of secondary infection occurring because of the pooling of stagnant blood.

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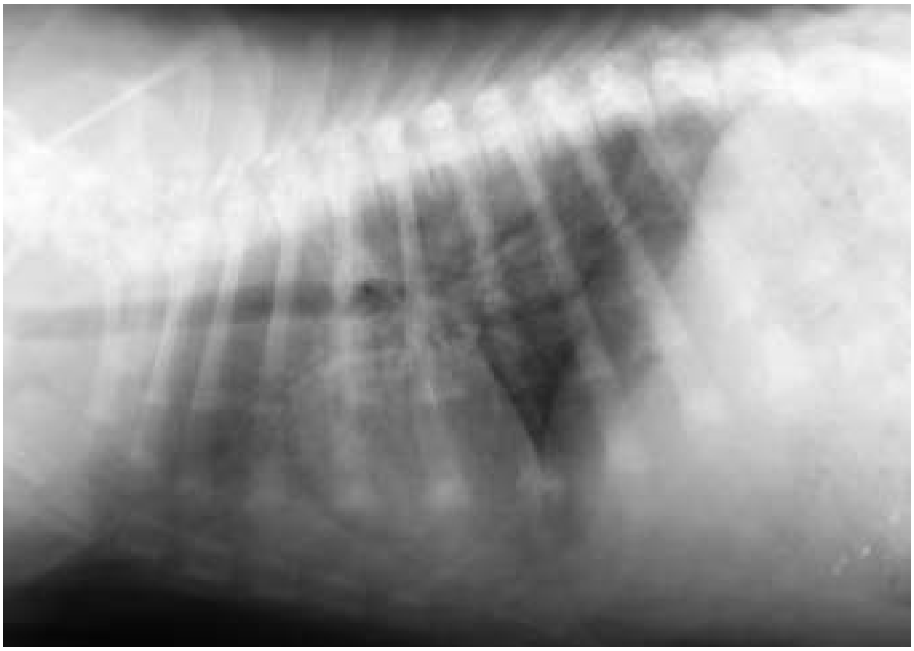

Case 2.29

Day 1

Signalment/History: "Snagglepus" was a 4-month-old, female Doberman Pinscher who had been hit by a car and was brought immediately to the clinic.

Physical examination: Breathing was labored.

Radiographic procedure: Radiographs of the thorax were made.

Radiographic diagnosis (day 1): Severe pulmonary hemorrhage affected all the lung lobes, but was more severe on the right. Generalized pleural fluid was also more evident on the right. Both the thoracic wall and the diaphragm were intact.

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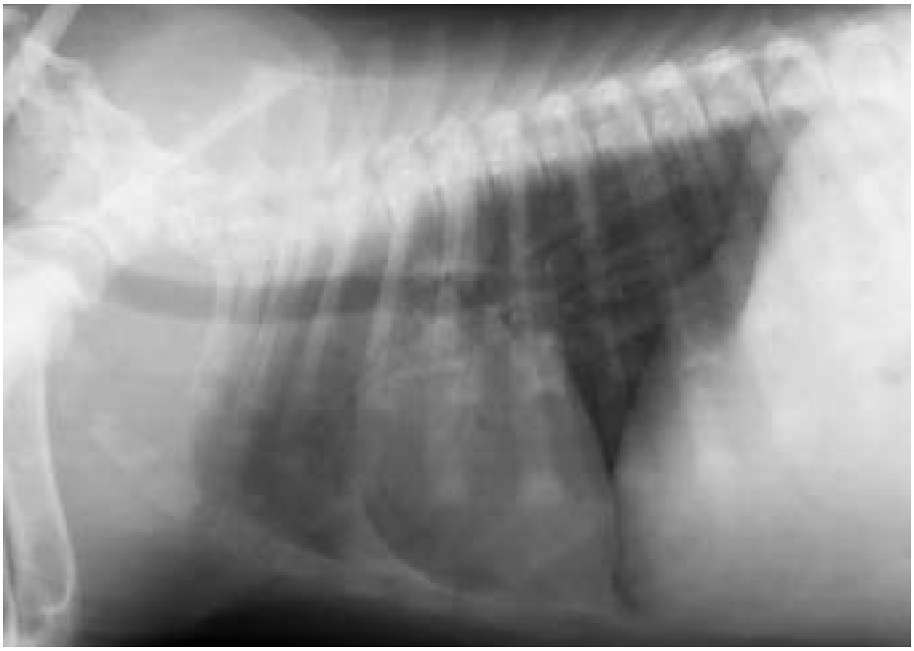

Day 3

Radiographic diagnosis (day 3): These radiographs showed a marked clearing of the pulmonary edema and hemorrhage from all but the right cranial lobe. Pleural fluid was still present. Note that the thoracic cavity remained as distended as at the time of presentation.

Treatment/Management: It was recommended that the dog remain hospitalized to await the diagnosis of why the right cranial lobe was failing to re-aerate. This was especially worrisome because the cranial lung lobes are normally well protected from trauma by the shoulder muscles. The possibility of either secondary pneumonia or a bronchial blockage from a mucous plug causing an obstructive atelectasis was considered. The normal anatomical location of the airways in the lobe tended to rule out torsion.

The puppy was discharged several days later in good health. As in most patients, the cause for the delay in healing of the cranial lobe could not be determined absolutely.

Case 2.30

Day 1

Signalment/History: A stray female cat was observed being struck by a car and was brought to the clinic.

Physical examination: A limited examination indicated dyspnea and abnormal lung sounds.

Radiographic procedure: Thoracic radiographs were made.

Radiographic diagnosis (day 1): The left thoracic wall had minimal subcutaneous emphysema. The adjacent left lung lobes were increased in fluid density, suggesting pulmonary contusion and hemorrhage. A minimal pneumothorax was present and of a closed nature. On the lateral view, pleural fluid could be seen on the left trapped in the fissure between the cranial and caudal lobes. A single non-displaced fracture was noted in the left 8^{th} rib.

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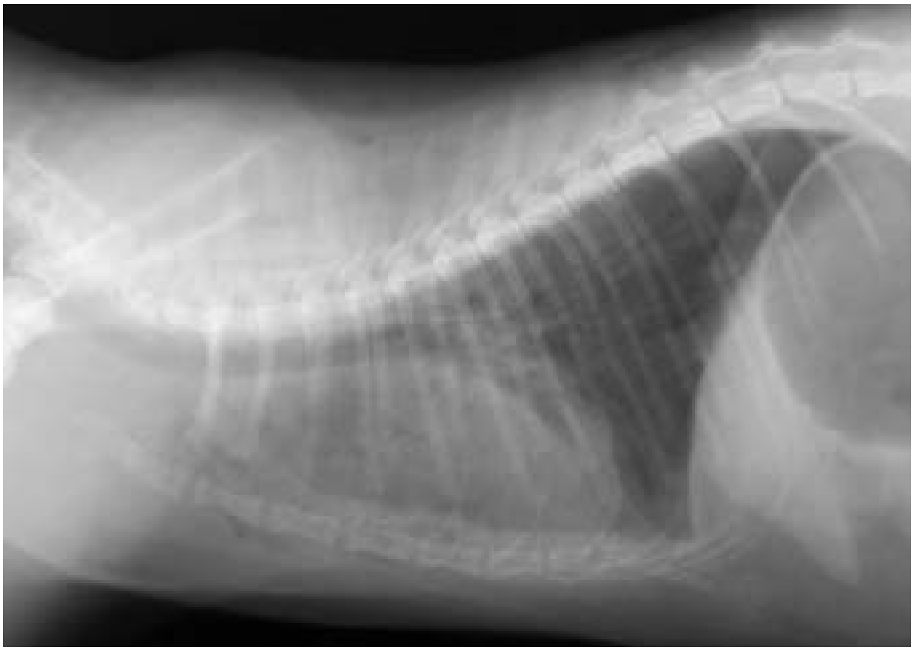


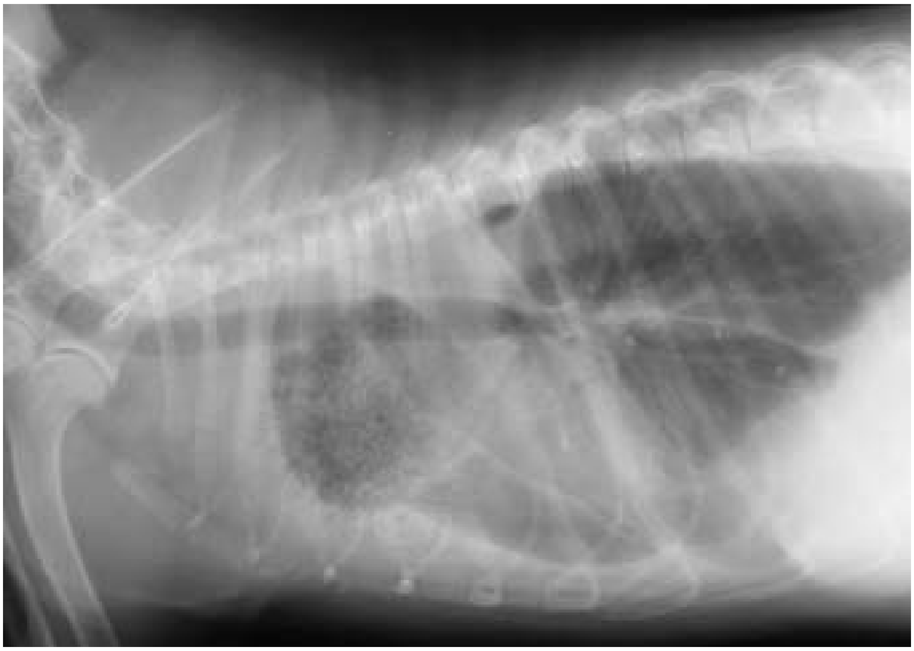
Day 2

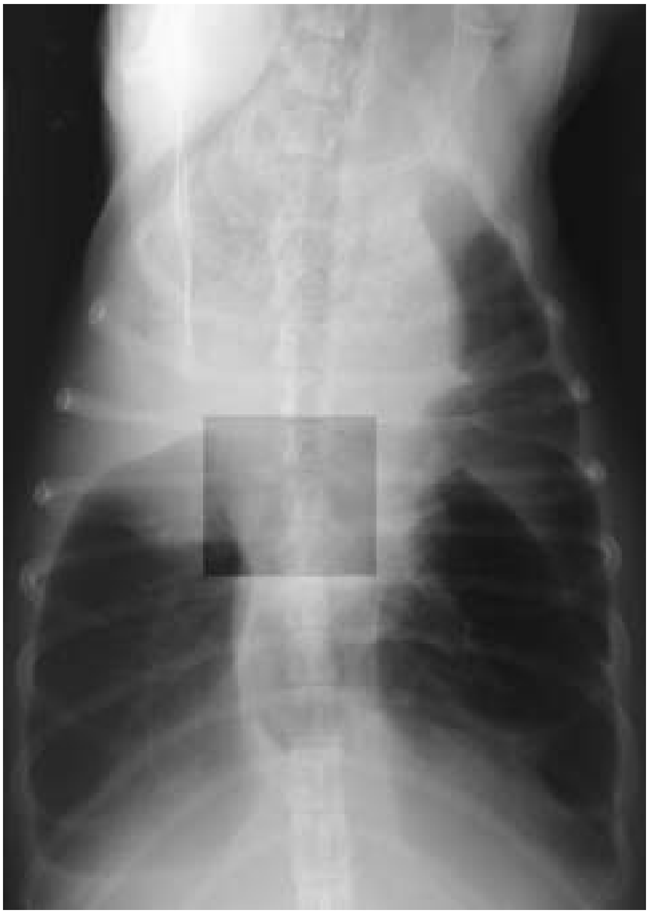
Radiographic diagnosis (day 2): Radiographs made the next day showed a marked increase in liquid density within the right cranial lobe and both parts of the left cranial lobe, with accentuation of the air-bronchogram pattern. The volume of the pleural fluid was increased and silhouetted with the cardiac silhouette. Note in particular the fluid between the cardiac silhouette and the sternum. The subcutaneous air had also increased in volume.

Treatment/Management: The increase in severity of the radiographic changes matched the increase in severity of the cat's clinical signs, especially the dyspnea. The lungs showed an increasing fluid density that could be explained either by continued hemorrhage or a secondary pneumonia. The stress aerophagia continued to demonstrate something of the clinical status of the cat.

The cat was treated medically and finally recovered. She was later adopted. The amount of body fat suggested that for a stray cat, she had been eating rather well.

Case 2.31





Signalment/History: "Teddy Bear" was a 3-year-old, female Chow Chow who had been in chronic renal failure for the previous 18 months. She had been undergoing dialysis and was a frequent patient in the hospital. She had chewed out a PEG tube placed earlier and even proceeded to pull out a second tube. The latest admission was because of persistent pleural fluid and having suddenly developed dyspnea.

Radiographic procedure: The thoracic studies were made because of the dyspnea.

Radiographic diagnosis: An area with a mottled, granular appearance was noted lying within a fluid dense mass in the right cranial hemithorax. This mass had an intermixed lucent gas pattern that suggested necrotic tissue often present following a lung torsion. A rim surrounding the mass had a homogeneous soft tissue/fluid density. The right cranial lobe bronchus terminated just distal to the carina. The right middle lung lobe was also airless with bronchial termination. Extensive freely moving pleural fluid was noted on both the DV and VD views. The chest wall was expanded and the diaphragm was caudal and flattened. The trachea was on the midline suggesting there was no mediastinal mass. Chronic secondary joint disease was evident in both shoulders

Treatment/Management: A right cranial and middle lung lobectomy was performed to correct the chronic lung torsion. The history of repeated anesthesia in which the patient was placed in a unusual body position plus the presence of pleural fluid were probable causes of the torsion of the lung lobes.

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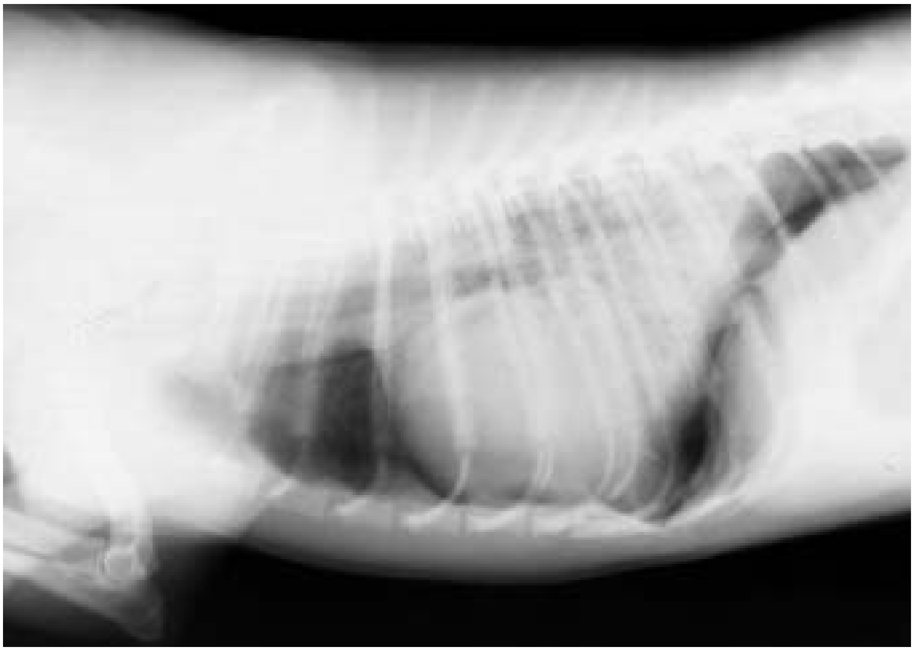
Case 2.32



Signalment/History: "Pal" was a 1-year-old, male Cocker Spaniel who was severely dyspneic after being struck by a car.

Physical examination: The dog had a swollen abdomen and was comatose.

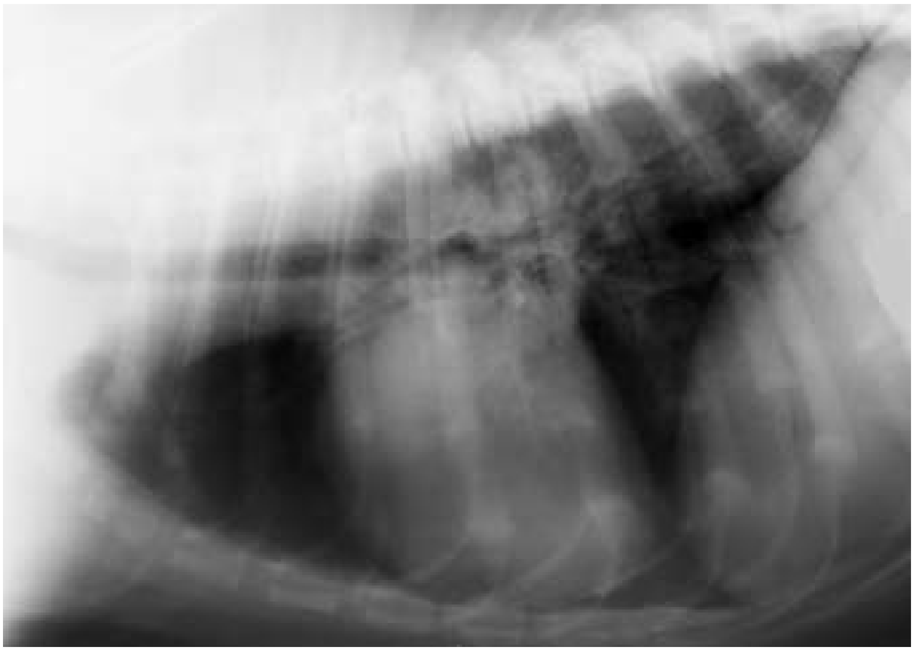
Radiographic procedure: The thorax was radiographed.

Radiographic diagnosis: The right lung lobes and the left caudal lobe showed a marked increase in fluid density, probably a result of hemorrhage from lung contusion. Only the left cranial lobe was fully aerated, while the others had an increased fluid density that silhouetted with the cardiac silhouette. The marked increase in fluid density in the lung lobes indicated atelectasis plus pulmonary hemorrhage. The pulmonary vessels were small suggesting hypovolemia.

The bilateral pneumothorax was easily identified because of the air contrasting with the fluid content in the lungs. A minimal amount of pleural fluid was pocketed caudally, adjacent to the diaphragm at the costophrenic angles. The cardiac silhouette was rounded with increased sternal contact suggesting a hemopericardium. A mediastinal shift to the left was noted. The dilated gas-filled stomach suggested panic breathing and the severity of the respiratory distress.

Treatment/Management: "Pal" died shortly after radiography due to a ruptured liver with peritoneal bleeding, pulmonary hemorrhage, pericardial hemorrhage, and cerebral hemorrhage.

Comments: It requires the combination of atelectasis plus pulmonary contusion to obtain a lung density of this severity.



Case 2.33

Signalment/History: "Shadow" was a 1-year-old, female Great Dane who had sustained head trauma.

Physical examination: On physical examination, the left pupil was not responsive to light and depressed frontal bone fractures were noted.

Radiographic procedure: Because of the unknown nature of the trauma, thoracic radiographs were made.

Radiographic diagnosis: A perihilar pattern of increased pulmonary density unusual in a young dog was present and was thought, because of the clinical history, to represent neurogenic pulmonary edema. Pulmonary congestion was present in the right lung lobes; perhaps a post-traumatic lung edema/hemorrhage. Pneumatoceles were present in the right middle lobe (DV enlargement, arrows).

The pulmonary vessels could not be identified due to shock. The thorax was expanded with scalloping of the lung borders. The diaphragm was caudal and flattened.

Treatment/Management: Fortunately, members of this breed possess massive frontal bones that provide good protection for the brain from direct trauma. "Shadow" recovered and was ultimately released to her owners.

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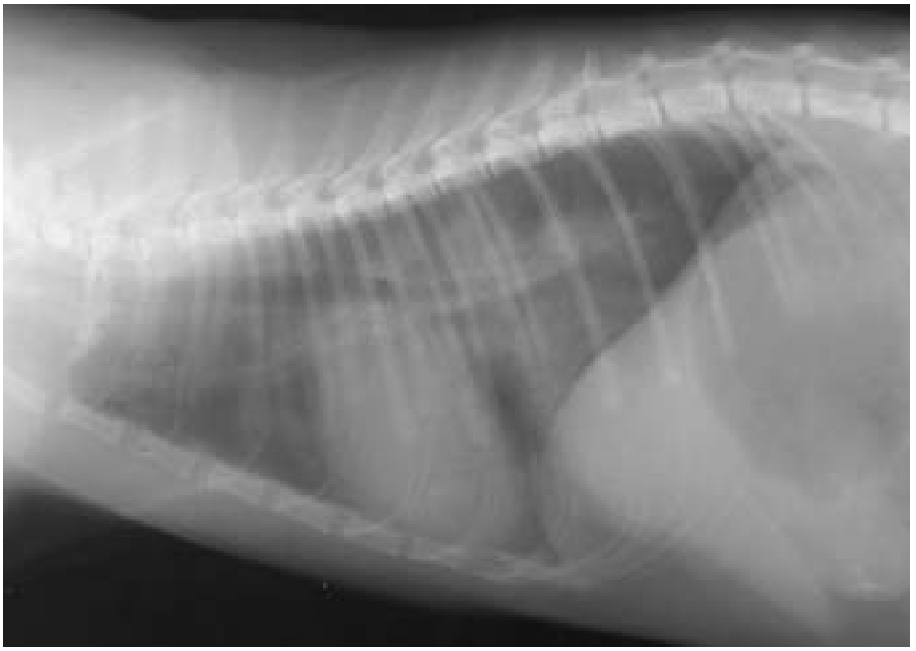


Case 2.34

Day 1

Signalment/History: "Wojo", a 1-year-old, male DSH cat, had been caught in a garage door and was trapped in that position for 30 minutes, enduring great pressure on his thorax.

Physical examination: Dyspnea was severe.

Radiographic procedure: Thoracic radiographs were made.

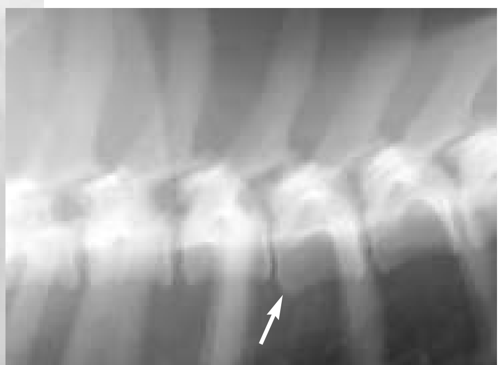
Radiographic diagnosis (day 1): Pulmonary infiltrate was noted throughout all the lung lobes, being most prominent caudally. Minimal pleural fluid was present. No injury to the thoracic wall was detected. No peritoneal fluid was noted.

Day 5

Radiographic diagnosis (day 5): Radiographs made four days later showed resolution of both the pulmonary and pleural fluid.

Treatment/Management: The pulmonary contusion was probably the result of a rupture of pulmonary alveoli due to the supreme effort required at inspiration against the great external pressure on the thorax caused by the door. However, an air-bronchogram pattern was not prominent. The rather rapid healing suggested that there was no direct trauma to the lungs from the door closing on the cat.

Case 2.35



Signalment/History: "Kila" was an 18-month-old, female Golden Retriever who had been hit by a car 24 hours earlier.

Physical examination: She could not walk when presented for treatment. However, she had a superficial pain reflex, a normal panniculus reflex, and normal patellar reflexes.

Radiographic procedure: Studies were made of the thorax because she was a trauma case. Additional views were made centering on the thoracic spine.

Radiographic diagnosis: An accumulation of alveolar fluid in the right lobes caused alveolar patterns. No air-bronchograms could be identified clearly. No pleural fluid was noted. The diaphragm was intact. The chest wall was normal. The cranial mediastinum was thought to be widened, especially considering the rather thin body wall.

A fracture-luxation of T5–6 was noted (arrow).

Treatment/Management: Because the presence of pain perception is a favorable finding, "Kila's" fracture was treated. Treatment was in the form of a body cast with the dog positioned beneath a metal "grate" to prevent movement. Later radiographs made after clinical recovery showed the affected vertebra to have remained in position.

2

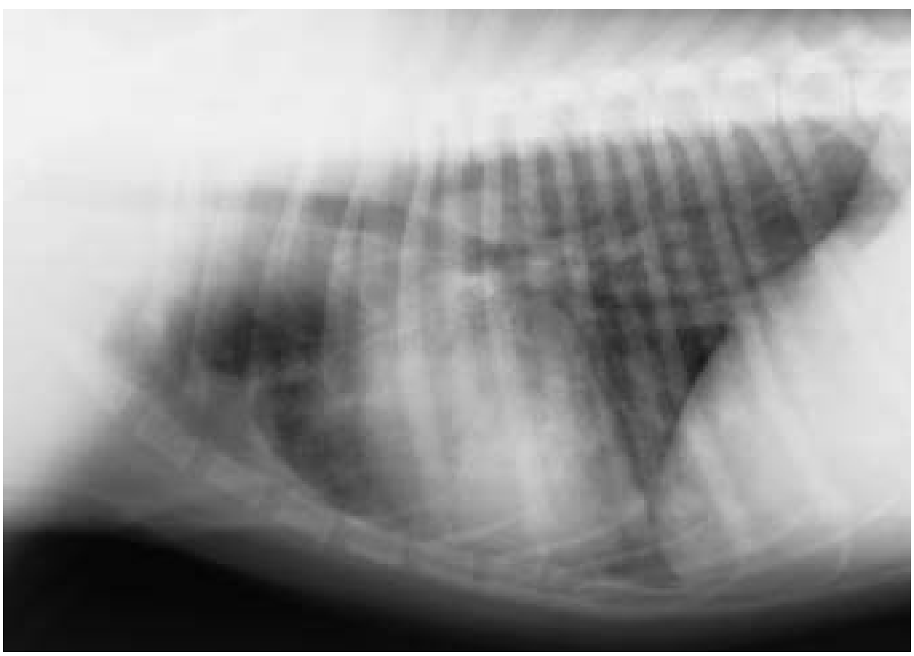
Case 2.36

Signalment/History: "Harvey", an 8-month-old, male Hound, had a history of having been found recumbent by the side of the road. The owners admitted that he had not been well recently and had been coughing. The case was registered as a possible "hit by a car".

Radiographic procedure: Radiographs of the thorax were made because of the clinical history of a young dog with a cough.

Radiographic diagnosis (day 1): A disseminated diffuse increase in pulmonary density involved both the interstitium and peribronchiolar tissues. In addition, a poorly marginated, 5-cm-in-diameter mass was located distally in the right middle lobe. Interstitial nodularity was adjacent to the mass lesion. A round, well-marginated, 2-cm mass lay dorsal to the tracheal bifurcation and was possibly a mediastinal lymph node. A slight separation of the pulmonary lobes suggested pleural fluid. The diaphragm was located caudally and flattened. The apex of the cardiac silhouette was shifted to the left chest wall, possibly as an effect of pleural adhesions. Focal pleural thickening was evident on the left chest wall also suggesting chronic pleural disease.

Day 1

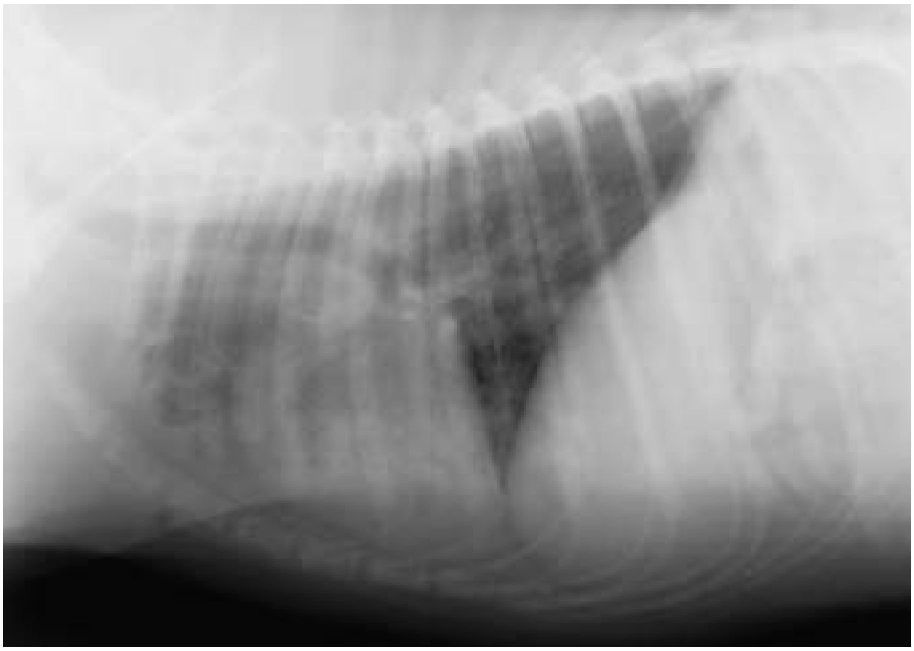


Radiographic diagnosis (10 months following the surgical removal of the right cranial and middle lobes due to foreign body induced bronchopneumonia): The marked tracheal deviation to the right, right-shift of the cardiac silhouette, and herniation of the left cranial lung apex into the right hemithorax were all postsurgical. The pleural thickening and fluid collection in the cranial portion of the right hemithorax were the effects of the chronic pleuritis plus possible postsurgical changes. Generalized peribronchial thickening suggested persistent chronic bronchial disease, while the prominent air bronchograms ventrally suggested a more recent pneumonia.

Treatment/Management: "Harvey" was quickly seen on the first study to have chronic lung disease with a possible mass lesion. Following unsuccessful medical treatment, he was treated surgically with removal of the pneumonic lung lobes that were secondary to a foreign body.

Comments: The frequency of inhalation of plant awns with associated pulmonary infection is influenced by the geographical location and is dependent on the presence of wild grasses and a dry climate. "Harvey" was typical of many of these patients in that he continued to suffer from pulmonary disease as seen on the follow-up radiographs. The role of possible trauma from being struck by a car was not important in this patient.

10 months later



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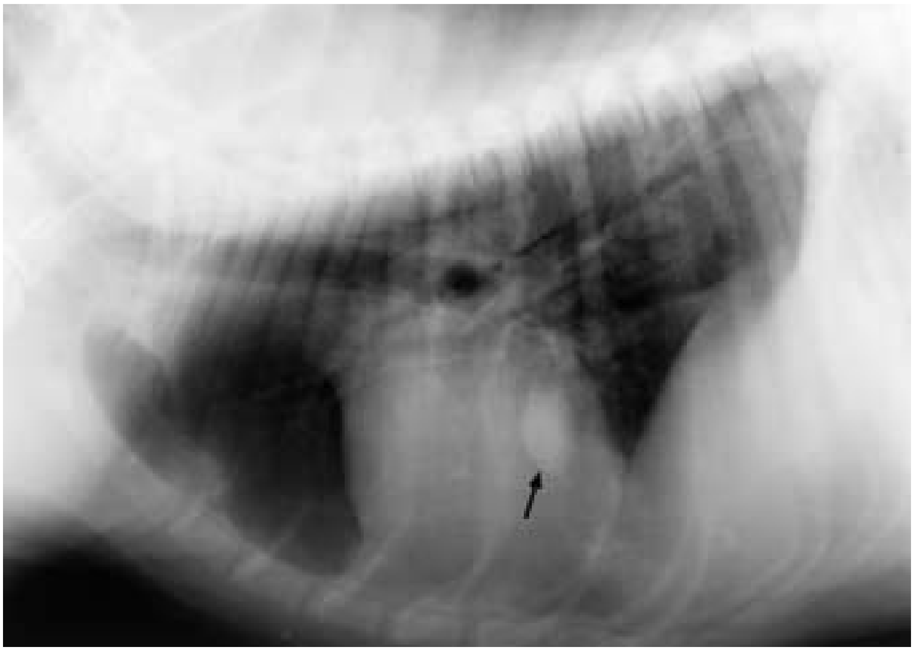
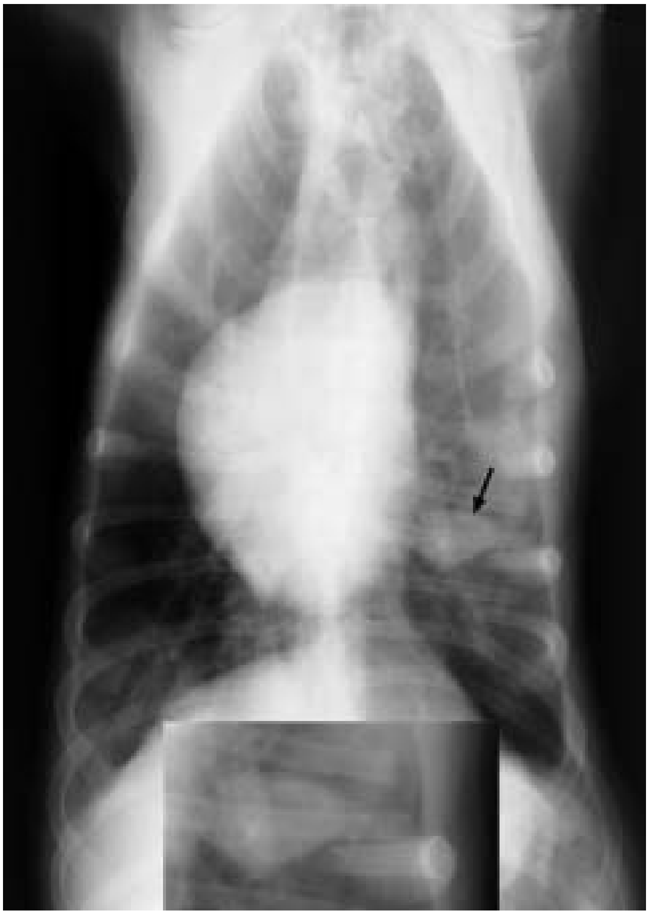
2.2.5 Pulmonary hematoma



Case 2.37



Signalment/History: "Corky" was a 5-year-old, male Golden Retriever who had been struck by a car 10 days previously and had been hospitalized since that time. He was referred to this clinic for the repair of his pelvic fractures.

Physical examination: On physical examination, he was 8–10 % dehydrated, febrile, and had harsh lung sounds especially on the left.

Radiographic procedure: Radiographs were made of the thorax for the first time since the trauma.

Radiographic diagnosis (day 10 post trauma): Massive thoracic wall injury was seen with fractures of 5 ribs on the left with a marked displacement of the fragments. Unequal filling of the left lung fields was evident. Caudal lobe hyperinflation with generalized increased peribronchial shadows was present. A sharply defined soft tissue mass, 2 x 3 x 3 cm in size, situated possibly in the caudal aspect of the left cranial lung lobe was probably a post-traumatic hematoma (arrows). This was indicative of a severe lung injury with parenchymal damage, which had permitted the pooling of blood within the pulmonary parenchyma.

An infiltrative pattern in the right caudal lobe included an air-bronchogram. The presence of this type of infiltrative pattern for a period this long after trauma suggested a secondary pneumonia following the original pulmonary hemorrhage. The left hemidiaphragm was caudal and flattened. Minimal pleural fluid, probably the result of hemorrhage, was trapped around the injured left lung. The dorsal crus of the diaphragm on the right could not be identified due to silhouetting with the pneumonic lobe. The retrosternal lymph node was enlarged.

Treatment/Management: "Corky" had a cardiac arrest and died 48 hours after the radiographic study.

At necropsy, a hematoma was identified on the cranial aspect of the left caudal lung lobe. Lung sections from the right caudal lobe had hemorrhage, fibrinous exudate, and parenchymal necrosis typical of an acute coliform pneumonia. It was suspected that *E. coli* had been present at the time of the injury as a bacteremia and had subsequently localized in the injured caudal lobes, which provided a good culture medium. The distribution of the necrosis was different to the cranioventral distribution typical of aerogenous pneumonias. The pleural fluid had become infectious in nature. Myocardial injury was present, but was limited to the outermost one-fifth of the myocardium. The retrosternal lymph node was not examined.

2

2

Case 2.38

Signalment/History: "Kami" was a 4-year-old, male Lhaso Apso who had been bitten by a large dog.

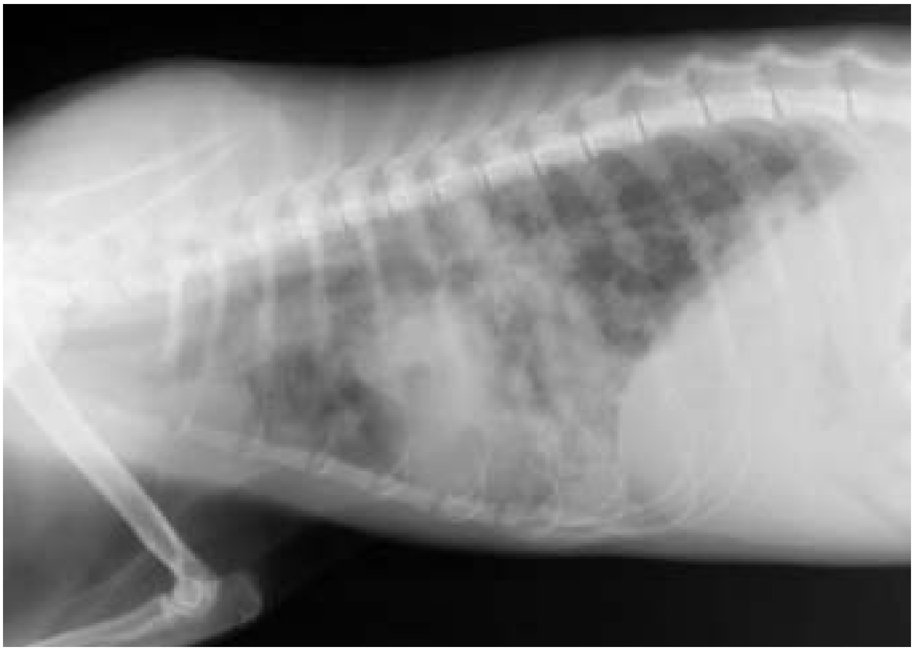
Physical examination: The examination was difficult because of the size of the dog and because of the severe dyspnea.

Radiographic diagnosis: Both views of the thorax were attempted, although it was thought that the positioning would not be good.

Radiographic diagnosis: The large volume of generalized subcutaneous air compromised the evaluation of the intrathoracic injury. The injury to the intercostal muscles was bilateral and resulted in an increase in the distance between the injured ribs. Most severe was the fracture of the 5th rib on the right, with fragment displacement. The pulmonary injury affected the right middle lobe, which showed an increase in fluid density due to hemorrhage. However, a more prominent injury on the right was in the caudal lobe (arrows) and caused a wedge-shaped pulmonary lesion indicative of an obstructive atelectasis or possibly a large pulmonary hematoma. The diaphragm was intact. Free pleural air was pocketed on the right. The sternal changes were congenital.

Treatment/Management: Despite the bilateral injury to the thoracic wall and the obstructive atelectasis, "Kami" recovered nicely with conservative treatment.

2.2.6 Interstitial nodules



Case 2.39

Day 1

Signalment/History: "Little Girl", a 9-month-old, female DSH cat, had a history of dyspnea characterized by rapid breathing. She had been listless for several months. Fecal examination was negative for lungworms.

Radiographic procedure (day 1): A patchy infiltrative pattern was present throughout the lungs with a tendency toward nodular formation. No pleural fluid could be seen. The diaphragm was intact but caudal in position. The cardiac silhouette was normal in size, shape, and position. The differential diagnosis included any granulomatous lesion. A metastatic tumor was not considered because of the age of the patient.

Treatment/Management: The cat was treated with antibiotics without any improvement in her medical status.

▶▶

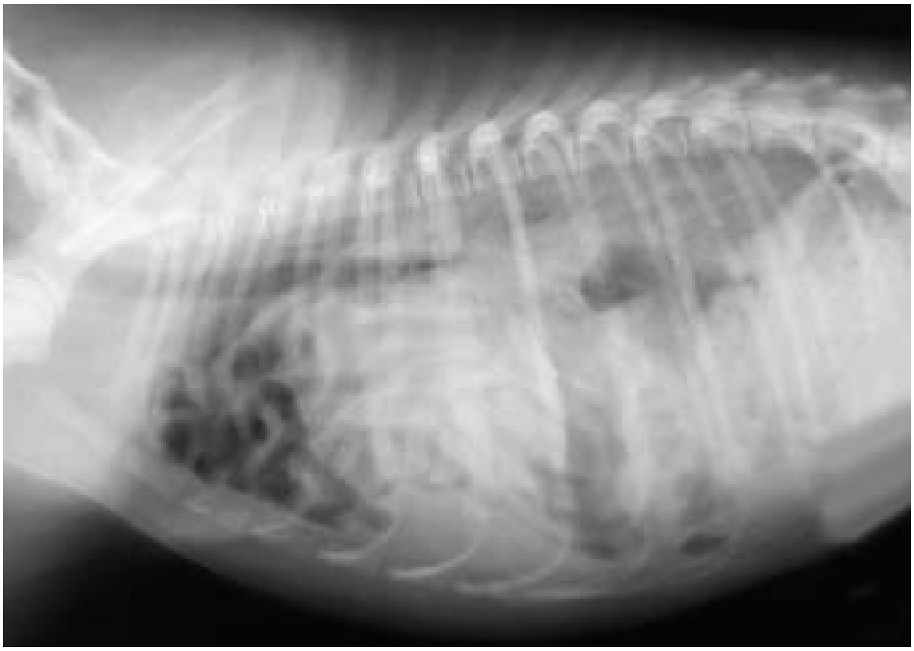
Day 25

Radiographic diagnosis (day 25): Further coalescence of the pulmonary nodules was seen with patches of emphysematous lung. Minimal pleural fluid was present. A granulomatous pneumonia remained the most likely diagnosis.

Treatment/Management: Because of the poor prognosis associated with the lack of improvement in the status of the kitten, the owners chose to have the patient euthanized. Necropsy examination showed a marked involvement of all lung lobes. Pus could be forced from the lung upon application of pressure. The nodules were generally between 1 and 2 cm in diameter. The alveoli were distended and contained a cellular population of macrophages and PMN cells. The macrophages were filled with fat indicative of a chronic, lipid inhalation pneumonia. The alveolar walls were thickened.

Presented with this information, the owner said that she had been giving the cat oil daily to prevent “hair balls”. Without a history of chronic administration of oil, a definitive diagnosis could not have been reached from the radiographs and physical examination alone.

2.2.7 Diaphragmatic hernia



Case 2.40

Signalment/History: "Sir" was a 6-month-old, male Miniature Poodle, who had been struck by a car 12 hours earlier.

Physical examination: No heart or lung sounds could be detected on the right side.

Radiographic procedure: The thorax was radiographed.

Radiographic diagnosis: The right hemithorax was filled with air-filled loops of small bowel. The heart was displaced to the left and elevated. The diaphragm could not be seen on either view. The increase in fluid density within the thoracic cavity was due to a contusion of the lungs, pleural fluid, and the fluid density of the bowel. The air- and ingesta-filled stomach was identified in a near-normal location in the abdomen. The 4th rib on the right was fractured near the costovertebral joint.

Treatment/Management: The diagnosis was rather easy because the air-filled loops of bowel lay within the thoracic cavity. The owners decided to have the hernia repaired at another clinic and took the poodle home.

Case 2.41

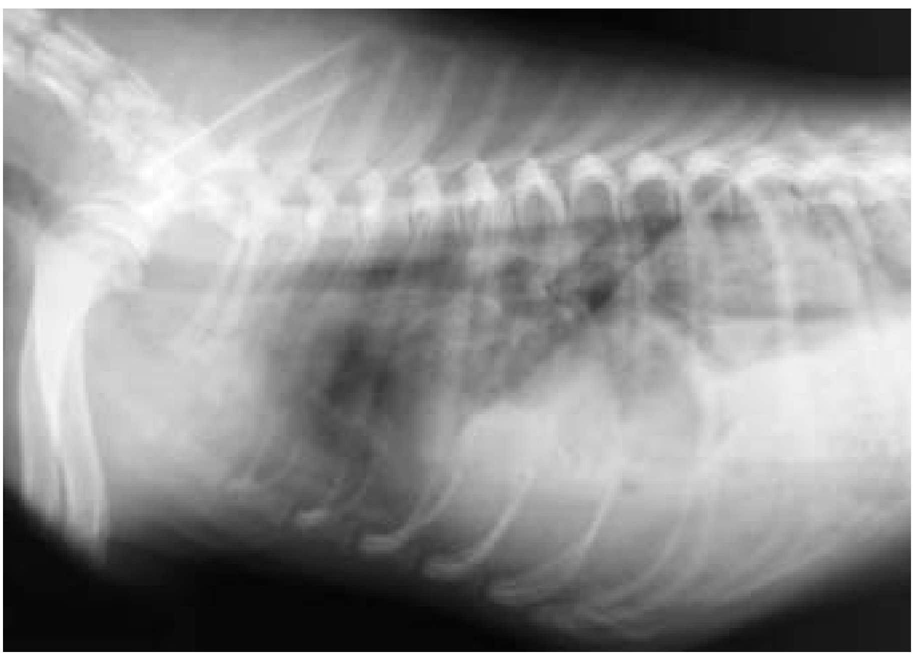
Signalment/History: "Tuffy" was a 1-year-old, male, mixed-breed dog, whose the owner thought he had been kicked by a horse.

Physical examination: While the dog's temperature was normal, breathing was restricted and he was comfortable only when standing. Heart sounds could not be detected on the left side.

Radiographic procedure: Studies were made of the thorax.

Radiographic diagnosis: The diaphragm could not be identified on the left side on the DV view and was positioned cranially on the left side on the lateral view. Both of these positionings were suggestive of diaphragmatic hernia. Ingesta or fecal material within the thoracic cavity on the left supported this diagnosis. A portion of the right hemidiaphragm was identified in its normal position, suggesting injury to the left side only. The cardiac silhouette and the hilus were shifted to the right with malposition of the main-stem bronchus to the left caudal lobe; both suggestive of a mass lesion. Prominent air-bronchogram patterns were noted indicative of alveolar flooding. Minimal pleural fluid was more prominent on the left side of the thorax. The liver shadow was difficult to localize.

Treatment/Management: The diaphragmatic hernia was characterized by several radiographic features. Mediastinal shift could be detected by locating the region of the tracheal bifurcation and the main-stem bronchi. Elevation of the tracheal shadow resulted from lateral shifting of the heart. Uneven distribution of pleural fluid is common with a diaphragmatic hernia and often reflects the degree of lung lobe collapse.



Comments: In the young patient, the pattern of calcification of the costal cartilages is rather orderly.

Case 2.42

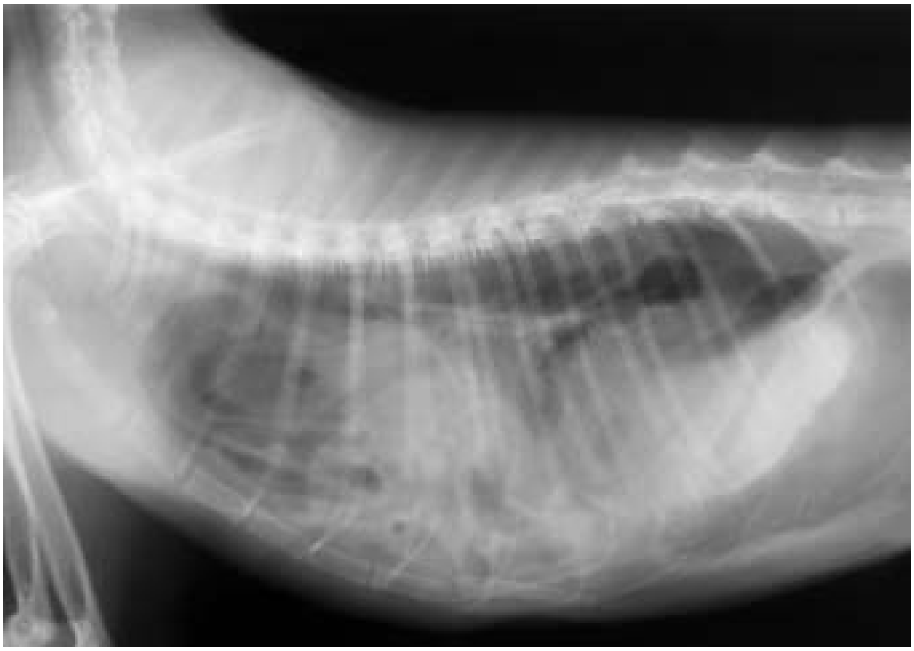
Signalment/History: A 3-year-old, male DSH cat was presented with a history of trauma that had occurred 10 days earlier.

Physical examination: The cat was depressed and slightly dyspneic on presentation.

Radiographic procedure: The whole body was included in the study.

Radiographic diagnosis: Small bowel loops occupied most of the right hemithorax with a mediastinal shift to the left. The air-filled stomach remained within the abdomen, but was shifted to the midline with the pylorus displaced ventrally and cranially. No evidence of chest wall injury was noted. A caudal displacement of the dorsal portion of the diaphragm could be seen.

Treatment/Management: The diaphragmatic tear extended from the sternal attachment 5 cm to the right. All of the small bowel, liver, and spleen were within the right hemithorax. The liver had a 360° twist around its pedicle and was incarcerated. The cat survived the surgery and was released to his owner.



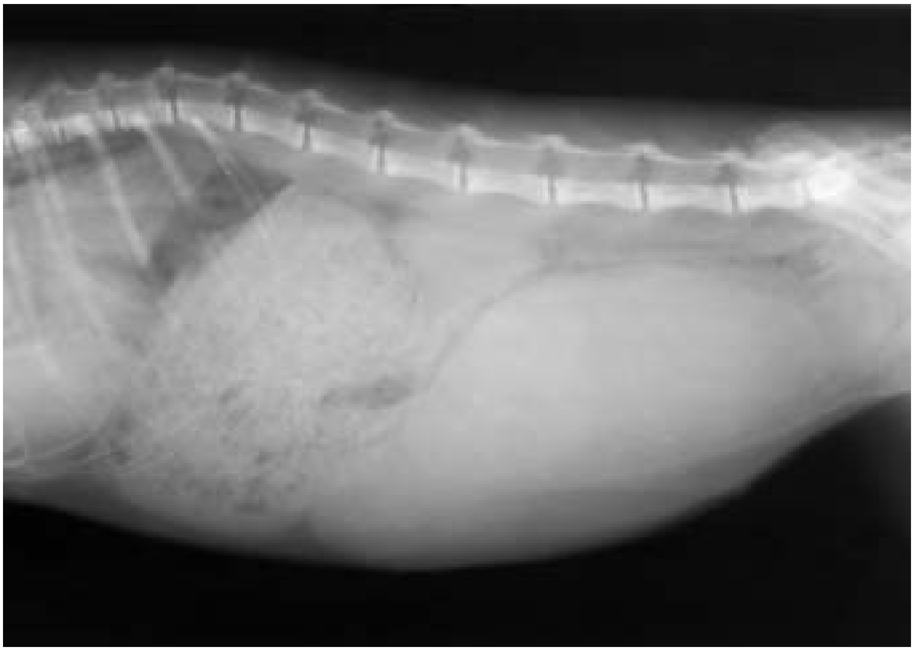
Case 2.43

Signalment/History: "Kitten" was a 10-month-old, female mixed breed cat with a history of dyspnea lasting for several months. The owners suspected that the cat had been traumatized six months previously.

Physical examination: Lung sounds were abnormal and the abdomen palpated empty.

Radiographic procedure: Whole body radiographs were made.

Radiographic diagnosis (thorax): A number of intrathoracic masses were present, some with uniform fluid density and others that included air. The cardiac silhouette was shifted dorsally along with the trachea. The diaphragm could not be identified ventrally or on the right side. The lungs were atelectic.



Radiographic diagnosis (abdomen): A large fluid density mass with a scattered mineralized pattern occupied the ventral midabdomen. The ingesta-filled stomach was crowded cranially and ventrally. Air-filled bowel extended cranially on the right into the thoracic cavity.

Comments: The dyspnea caused by the diaphragmatic hernia had been made more severe by the progressive increase in the size of the cat's gravid uterus.

2

Case 2.44

Signalment/History: "Menace" was a 6-year-old, male DSH cat with a two-month history of dyspnea, anorexia, and depression. The differential diagnosis included thymic lymphosarcoma.

Physical examination: The examination did not contribute anything to the evaluation of the case.

Radiographic procedure: The thorax was studied because of the tentative diagnosis of lymphosarcoma. An additional single lateral view of the abdomen was made.

Radiographic diagnosis: The thorax was expanded to maximum size. The pleural space was filled with air-containing viscera. The trachea was shifted to the left. The cardiac silhouette was in the left hemithorax. The diaphragm was located caudally, but could not be visualized on the ventral midline.

The single lateral view of the abdomen showed an absence of small bowel shadows.

Treatment/Management: The diaphragmatic hernia was confirmed by surgical exploration of the abdomen. Primary pulmonary disease was not considered on these radiographs because the atelectasis was thought to be caused by the pleural masses. Both pneumothorax and pneumomediastinum were present the day following surgery. Radiographs made three days post-surgery showed a minimal persistent pneumothorax; however, the lungs were expanded and of normal density.

Comments: Failure to identify the abdominal organs in their normal location often suggests their displacement into the thoracic cavity and diagnosis of a diaphragmatic hernia.

Case 2.45

Signalment/History: "Trouble" was a stray 1-year-old, male DSH cat who was presented with a history of rapid breathing for the previous five days.

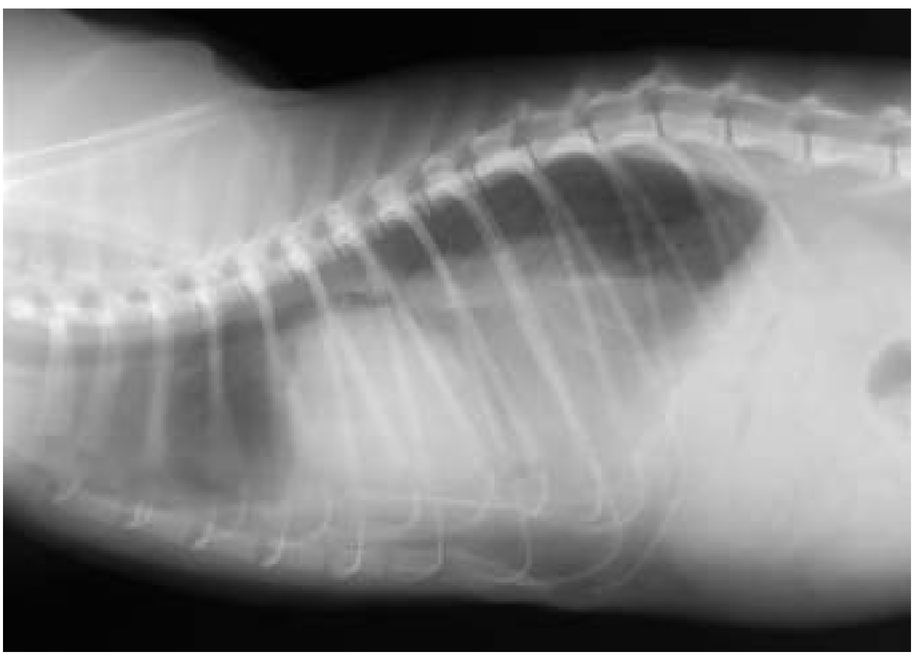
Physical examination: Little could be learned from the examination. The thoracic wall was intact; however, injury was suspected on palpation of the costal cartilages. The heart and lung sounds could not be auscultated on the right. Cardiac sounds were stronger on the left.

Radiographic procedure: Radiographs of the thorax were made.

Radiographic diagnosis: An intrathoracic mass on the right side caused a mediastinal shift to the left and an elevation of the trachea. The heart was in contact with the left thoracic wall. The lung lobes appeared to be displaced dorsally. In the right hemithorax, the lung margins were retracted from the chest wall. A partial diaphragmatic shadow could be identified dorsally on the lateral view. The presence of a pleural mass was thought to be the cause of the retraction of the lung lobes and the mediastinal shift. Pleural fluid was thought probable. No thoracic wall injury was noted except for fractures of the caudal costal arches. The gastric shadow was shifted cranially to lie adjacent to the diaphragm, but remained within the abdominal cavity. The tentative diagnosis was a diaphragmatic hernia.

Treatment/Management: "Trouble" was successfully operated for the hernia.

Comments: While a thoracic mass other than a pleural mass resulting from a diaphragmatic hernia was possible in this patient, it was unlikely considering the age, clinical history, and the presence of the costal arch fractures.



Case 2.46

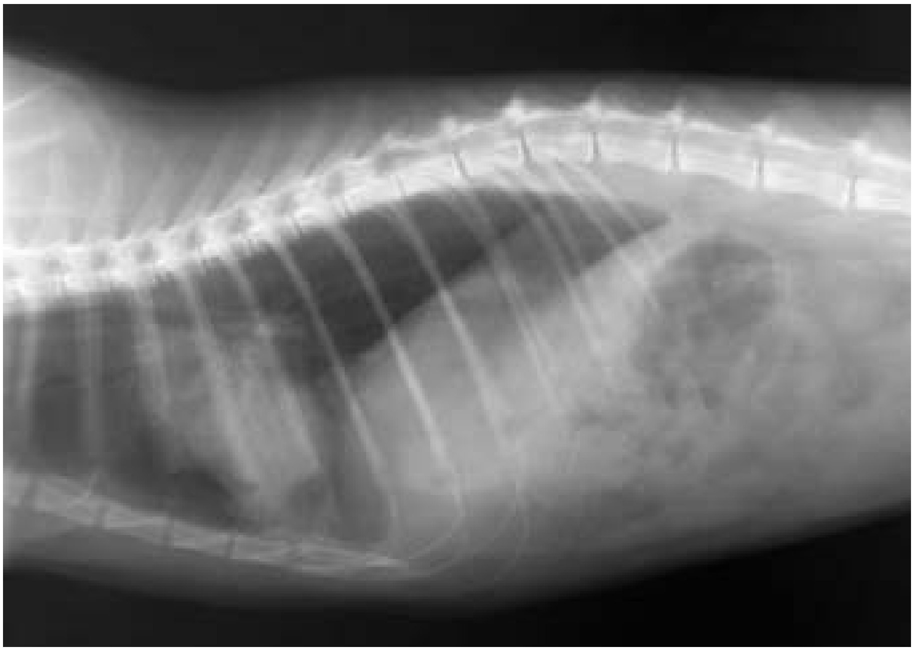
Signalment/History: “Siri” was a 3-year-old, female Siamese with a history of presumed trauma according to her owner. She was known to have bilateral hip dysplasia.

Radiographic procedure: “Whole-body” radiographs were made because of the unknown nature of the injury and the small size of the patient.

Radiographic diagnosis: Cranial displacement of the right hemidiaphragm was matched by a caudal displacement of the left hemidiaphragm. More important in the diagnosis of a diaphragmatic hernia was the cranial displacement of the air-filled pyloric antrum. The heart was shifted into the left hemithorax. Minimal pleural fluid was trapped around the heart and the ventral mediastinum. A minimal increase in right middle lobe density suggested pulmonary hemorrhage secondary to trauma. No sign of chest wall trauma was noted.

Treatment/Management: The diagnosis of a diaphragmatic hernia was suggested by the shift in position of the air-filled abdominal organs, the asymmetry of the crura of the diaphragm, and the inability to see the cupula of the diaphragm. The patient was thin with little contrast between her abdominal organs because of the lack of fat, which suggested that the injury may have been long-standing. The radiographic diagnosis of a hernia is much more difficult in a patient in which a hollow viscus is not displaced. The hernia was proven surgically.

Whole body radiographs should include the thoracic inlet and the pelvic canal. These were cropped for publication.



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Case 2.47

Signalment/History: "Dale" was a 1-year-old, male Siamese with a chronic cough of two months duration.

Radiographic procedure: Thoracic radiographs were made to evaluate the cause of the coughing. The history did not suggest a traumatic etiology.

Radiographic diagnosis: Radiodense material having the appearance of small bone fragments was located within the central portion of the thoracic cavity caudally. The mass was lobulated and surrounded by pleural fluid that caused silhouetting with the diaphragm ventrally. The mass effect elevated the trachea dorsally. The heart was difficult to visualize, but a shadow typical for the heart was displaced dorsally. The bony fragments were treated as a contrast agent enabling the location of the displaced gastric shadow.

Treatment/Management: The diaphragmatic hernia was repaired successfully. The cause for the hernia or the time of the injury was not determined.

Case 2.48

Signalment/History: "Jazabelle", a 3-year-old, female DSH cat, was depressed without any clinical history of trauma.

Physical examination: The clinical examination was unremarkable except for the failure to auscultate lung sounds on the caudal right side.

Radiographic procedure: Radiographic views of the thorax were made.

Radiographic diagnosis: A mass effect was created in the caudal right thorax silhouetting with the diaphragm and displacing the heart markedly to the left. Air-filled bowel loops were present within the mass. If pleural fluid was present, it seemed to be trapped on the right side caudally. Stomach air could not be identified in its normal position within the abdomen. A congenital anomaly affecting the xiphoid was present; a type rather common in the feline.

Comments: Many pulmonary lesions can become consolidated and cause trapped pleural effusion, however, major bronchi should be at least partially identifiable throughout the mass. In this cat, the trachea was shifted to the left and no airway shadows could be seen within the mass. The large air shadow extending from the cranial abdomen to the right hemithorax was indicative of small bowel and confirmed the diagnosis of a diaphragmatic hernia.

2

Case 2.49

Noncontrast

Signalment/History: This cat had no history of trauma, but had been listless for the previous few days with more recently occurring episodes of dyspnea.

Physical examination: Heart and lung sounds could not be heard on the right side.

Radiographic procedure: Radiographs were made of the thorax with the possibility of a contrast study if required.

Radiographic diagnosis: A mass-like lesion lay in the caudal right hemithorax and extended into the caudal left hemithorax with displacement of the heart shadow cranially, dorsally, and to the left.

Because of the failure to identify any air-filled bowel loops in the thoracic cavity, a barium meal was used which clearly showed the displacement of the stomach into the thoracic cavity.

Treatment/Management: The diagnosis was confirmed at surgery.

Contrast

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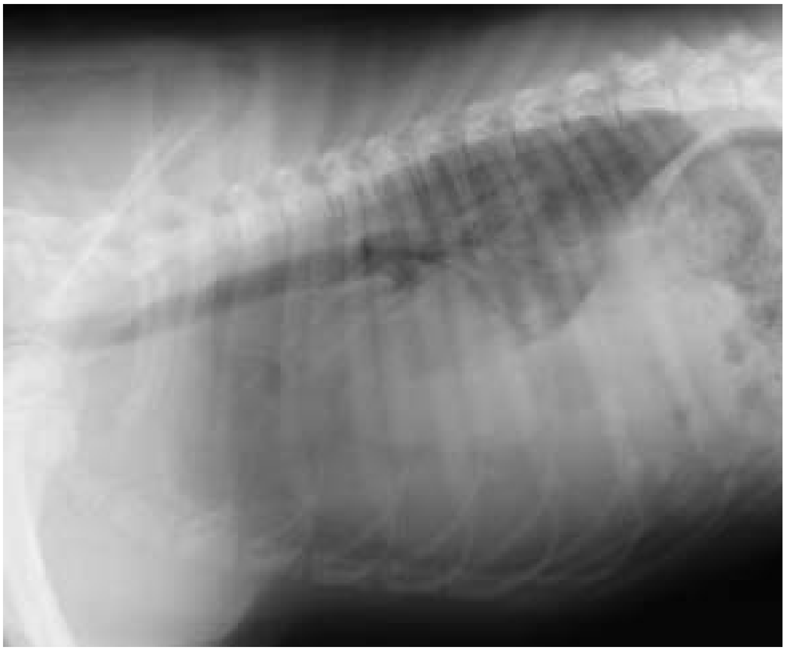
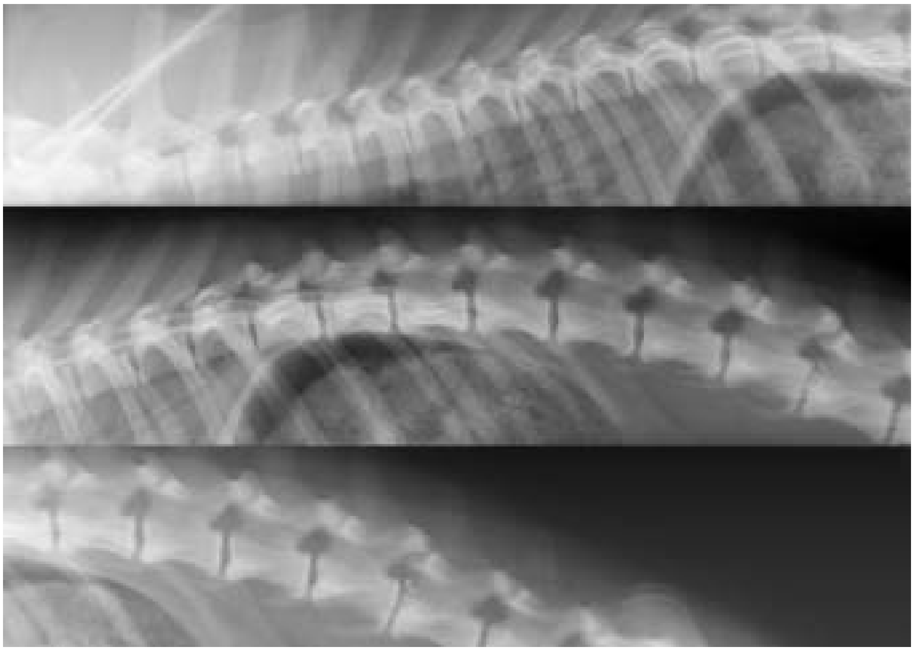


Case 2.50



Signalment/History: "Cody" was an 11-month-old, male Labrador Retriever who had been hit by a car four hours earlier.

Physical examination: The dog was dyspneic and appeared to have great pain on palpation of the lumbar spine.

Radiographic procedure: Only lateral radiographs were made because of the suspicion of extensive injuries.

Radiographic diagnosis: The pleural fluid was thought to be hemorrhage. In addition, an increase in fluid density in the lungs was noted. An elevation of the cardiac silhouette suggested either displaced abdominal organs or some other pleural mass. The diaphragm could not be completely identified and provided another feature suggestive of a diaphragmatic hernia. The liver shadow was displaced cranially into the thoracic cavity and the stomach axis was shifted cranially. Neither the spleen nor the urinary bladder could be identified within the abdominal cavity.

A fracture-luxation at L4–5 did not cause marked segmental displacement, but did indicate additional trauma. Following identification of the spinal fracture, lateral views of the thoracolumbar spine were made permitting further identification of the fracture with small fragments identified within the spinal canal. Retroperitoneal fluid was suggestive of hemorrhage associated with the fractures.

Treatment/Management: The diaphragmatic hernia was repaired and the vertebral fracture/luxation was stabilized surgically.

The status of the urinary system remained in doubt. The urinary bladder appeared intact on a retrograde cystogram using 60 ml of contrast agent. On an excretory urogram using 70 ml of contrast agent injected intravenously, positive contrast agent was extravasated retroperitoneally and peritoneally around the left kidney, suggesting a ureteral avulsion on that side. The renal pelvis on the right was distended indicating obstruction to flow and a possible right ureteral tear as well. The urinary lesions were both treated conservatively because of the owner's choice not to spend additional money. "Cody" survived and was subsequently released to his owner.

Case 2.51

Signalment/History: "Morris" was a 1-year-old, male DSH cat that had possibly been traumatized 48 hours earlier. According to the owner, he had been either struck by a car or kicked by a cow.

Physical examination: The cat was dyspneic and could not bear weight on the left pelvic limb.

Radiographic procedure: Studies were made of the thorax and pelvis.

Radiographic diagnosis (thorax): The pericardial sac was dilated and contained gas-filled small bowel loops that extended from the abdomen through the diaphragm into the pericardial sac. The trachea was displaced dorsally by the mass effect. The surrounding lung appeared normal in appearance. Note the appearance of the body of the 7th thoracic vertebral segment. Hemivertebrae are unusual in cats. Could this be a compression fracture?

Radiographic diagnosis (pelvis): The fracture of the left femoral neck was intertrochanteric and extracapsular. The age of the fracture was difficult to determine because of the fragment position.

Treatment/Management: Pericardio-diaphragmatic hernias often display a change in dynamics following trauma. At surgery, the liver, gall bladder, most of the jejunum, the ileum, and a part of the colon were within the pericardial sac. The radiographic appearance of the lung tissue was normal regardless of its being compressed by the enlarged pericardial sac.

2

2.2.8 Pleural air

Case 2.52

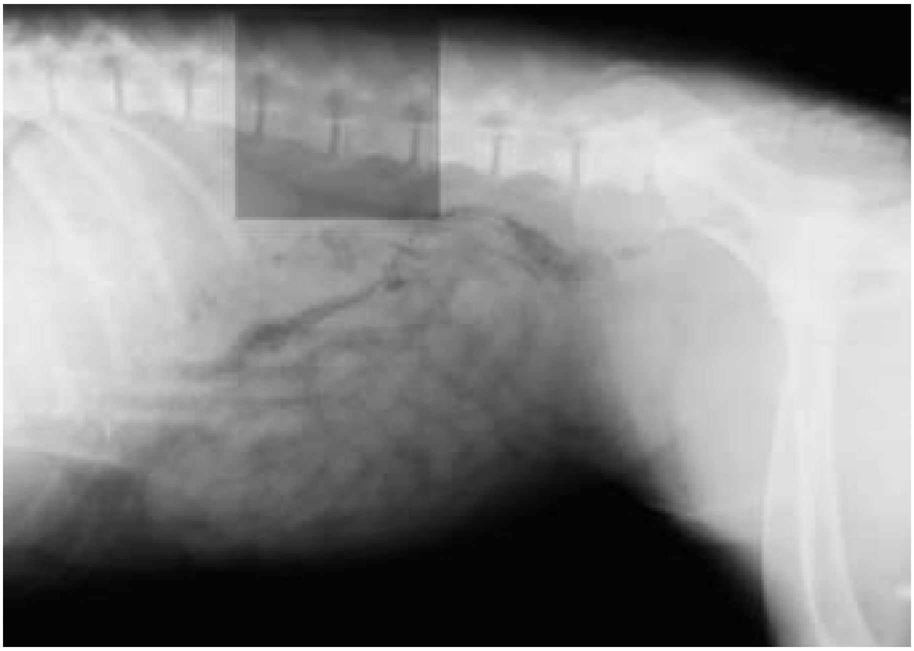
Day 1

Signalment/History: "Ruff" was a 6-month-old, male Golden Retriever who had been struck by a car 3 days previously.

Physical examination: Palpation of the thorax revealed a probable injury to the caudal ribs on the right. The dog breathed in a careful manner and was unwilling to take a deep breath.

Radiographic procedure: Radiographs were made of the thorax using a technique that would permit evaluation of the ribs.

Radiographic diagnosis (day 1, thorax): Radiographs showed a pneumothorax that was characterized by elevation of the cardiac silhouette away from the sternum and separation of the borders of the caudal lung lobes from the diaphragm. Pulmonary contusion was noted adjacent to the fractures of the 9th, 10th, 11th, 12th, and 13th ribs on the right. The fluid density in the cranial mediastinum adjacent to the sternum was probably a hemomediastinum. A prominent skin fold extended across the caudal right lung field on the DV study.



Radiographic diagnosis (day 1, abdomen; lateral view only): Abdominal radiographs showed a physeal fracture of L4 with separation and displacement of the cranial end plate. Small bowel loops were distended with fluid. Skin folds were prominent in the cranial abdomen.

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Day 12

Radiographic diagnosis (day 12, thorax): Radiographs made 11 days later showed clearing of the fluid from the lungs and disappearance of the pleural air.

Treatment/Management: The bowel was possibly distended because of the trauma itself or perhaps due to an injury to the spinal cord. No clinical signs were associated with the small bowel and no treatment was required.

The patient was re-evaluated 11 days after the initial presentation for neurological deficits and was noted to only have pain over the lumbar spine and some hesitancy in walking. He was treated with cage rest for several weeks and was able to walk normally when released.

Comments: Rib fractures are most easily recognized radiographically when the fractures are within the bony portion of the rib and there is a marked displacement of the fragments. Fractures near the costovertebral joints are surrounded by heavy muscle and do not usually show fragment displacement. Fractures near the costochondral junction are difficult to identify because of the cartilage content of the ribs. Fortunately, these types of fracture are not of great clinical importance and when over-looked, probably do not affect the selection of treatment or prognosis of the case.

Case 2.53

Signalment/History: "Pumpkin", a 5-month-old, female DSH cat, had been struck by an automobile.

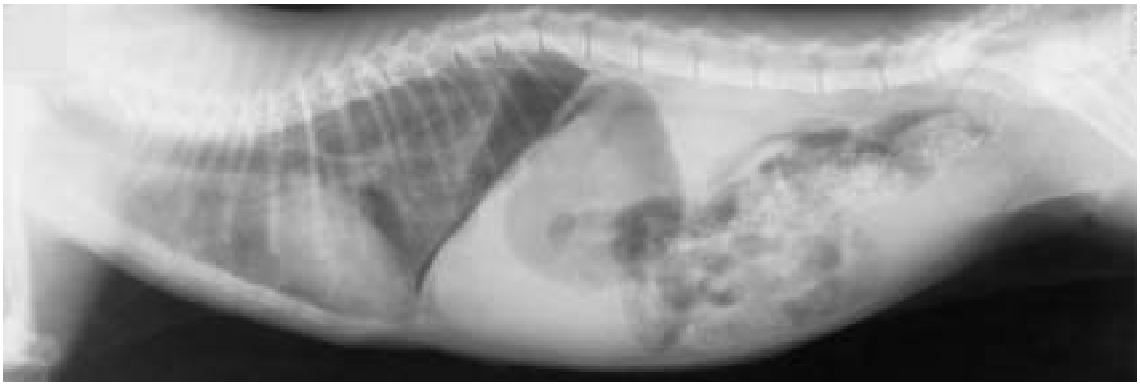
Physical examination: The cat was presented in severe respiratory distress.

Radiographic procedure: The whole body was radiographed.

Radiographic diagnosis: Extensive pulmonary hemorrhage was noted throughout the lungs. It was unusual that the pneumothorax could be seen on the lateral view, but was difficult to identify on the DV view as it only caused a thin radiolucent line along the left thoracic wall. The diaphragm was intact on both views.

Stress aerophagia had resulted in an air-filled stomach and bowel loops. Distended bowel loops of this degree could be the result of an ileus secondary to loss of blood supply to a portion of the gut or torsion of the mesenteric blood supply.

Identification of the ventral border of the liver ruled out the accumulation of peritoneal fluid. Note the absence of the usually large fat-filled falciform ligament.

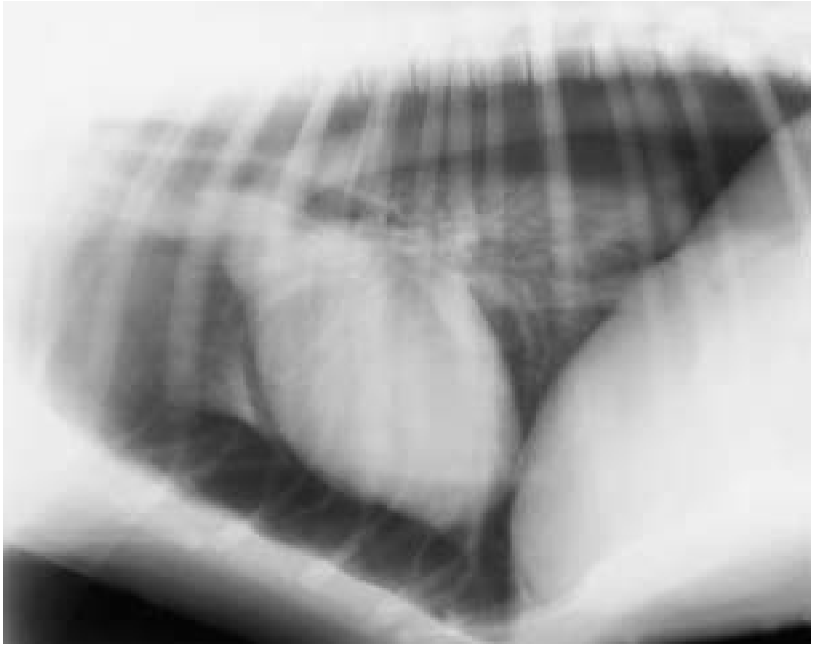


Treatment/Management: "Pumpkin" died shortly after the radiographs were made. The necropsy findings were limited to the contused lung with some pleural hemorrhage in addition to fractures of the costal arches. The air-filled bowel was apparently the result of aerophagia.

Comments: Although the degree of pulmonary contusion was not severe, what was important in this patient and led to her death was the fact that all of the lobes were similarly affected.

2

Case 2.54



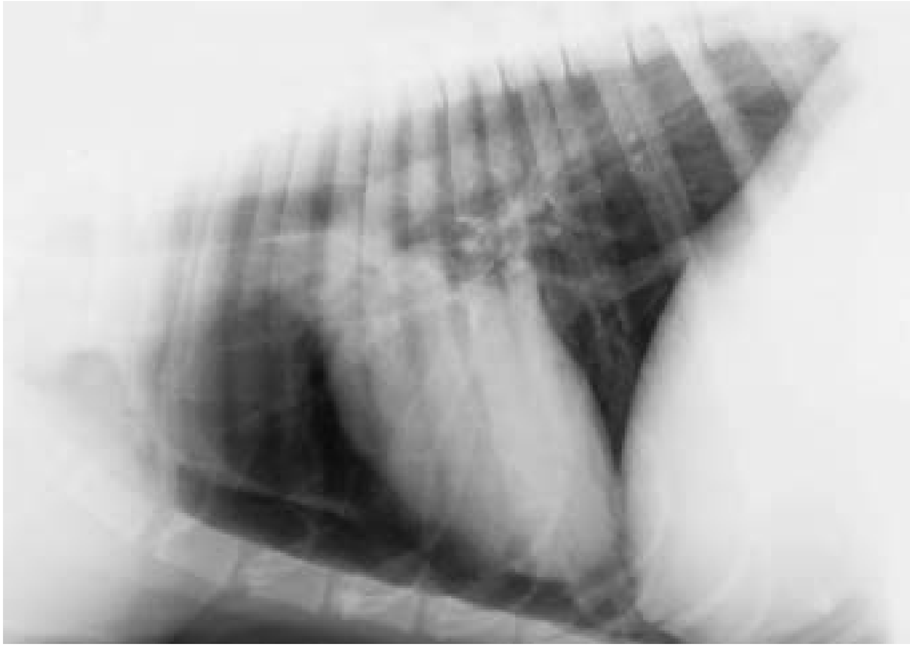
First study

Signalment/History: "Greizelda" was a 2–year-old, female Great Dane presented with a history of having had dyspnea for one week.

Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis (first study): A pneumothorax caused marked lung lobe atelectasis and separation of the cardiac silhouette away from the sternum. A single air-filled cyst in the lung was identified just caudoventral to the carina.

Treatment/Management: The thorax was tapped and 4,800 ml of air was removed from the pleural space.



Second study

Radiographic diagnosis (second study): The second radiographic study showed a marked reduction of the volume of the pneumothorax. The right middle lobe remained collapsed (arrow).

Treatment/Management: It was not known on which side the pneumothorax originated. Because of the persistent collapse of the right middle lobe, the surgeon chose to perform a thoracotomy on that side and luckily was able to identify multiple pulmonary cysts in all of lobes.

Histologic examination of the lobes suggested some superficial cysts were lined with ciliated columnar and stratified squamous epithelium, while others more deep in location indicated an etiology of chronic bronchiectasis.

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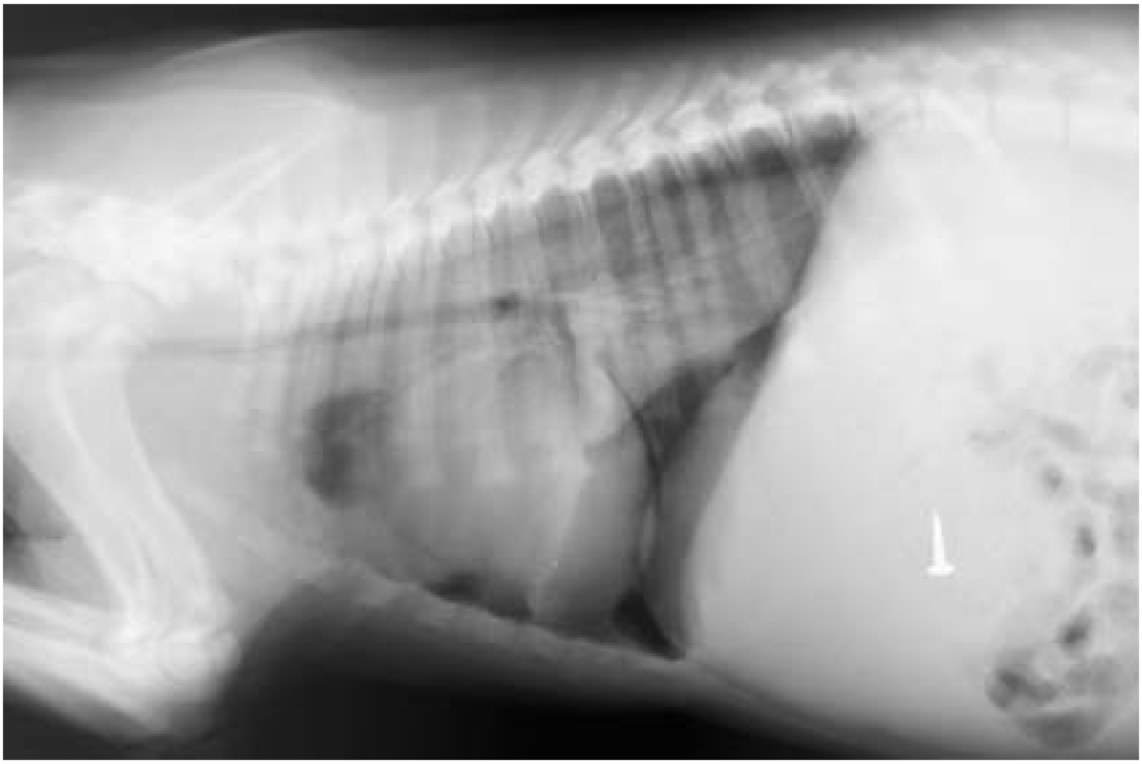

Case 2.55

Signalment/History: "Sadie" was a 3-month-old, female Golden Retriever puppy with a history of a successful removal of a bronchial foreign body the day before. Removal of gastric foreign bodies was attempted at the same time and was only partially successful. The owner was concerned about the condition of the patient feeling that she was not breathing normally.

Radiographic procedure: Whole body radiographs were made.

Radiographic diagnosis: Pneumothorax was present with a suspected collapse of the accessory lung lobe. A small amount of pleural effusion was noted. The thoracic wall was normal except for malunion fractures of the 9^{th} and 10^{th} ribs on the right. The gastric metallic foreign body was thought to be a tack.

Differential diagnosis: The atelectasis of the accessory lobe suggested injury to that bronchus. The pneumothorax was bilateral and had occurred after bronchoscopy and endoscopy. No evidence of pneumomediastinum could be seen. The origin of the intrathoracic air is presumably secondary to a puncture of the trachea, bronchus, or esophagus with formation of a tract through the mediastinum.

How long the bronchial foreign bodies had been present could not be determined. It was possible that the foreign bodies had resulted in a secondary, inflammatory lesion in the tracheal or bronchial wall or even an esophageal wall lesion. It was also possible that a tear in the wall of the bronchus or trachea had occurred during removal of the foreign body, or that a tear in the esophageal wall had occurred during removal of the gastric foreign body (a piece of glass).

Comments: Note the large costochondral "knobs" typical for this stage of skeletal development.

Malunion fractures of the ribs are not uncommon in puppies, but the cause is rather difficult to explain.

Note the absence of peritoneal fat in this puppy. The small bowel gas pattern is typical for an active animal frequently swallowing air.

2

Case 2.56

Day 1

Signalment/History: "Trixie" was a 7-year-old, female DLH cat who had been bitten by a dog an hour earlier.

Physical examination: The cat was dyspneic. Subcutaneous air could be palpated on the right chest wall.

Radiographic procedure: Radiographs of the thorax were made.

Radiographic diagnosis (day 1): A pneumothorax was indicated by separation of the cardiac silhouette from the sternum. Subcutaneous emphysema was evident on the right. An increase in lung density dorsally on the right was noted; however, the oblique positioning made evaluation difficult. In addition, this obliquity falsely suggested rib fractures. The diaphragm was intact.

Day 3

Radiographic diagnosis (day 3): The radiographs made 2 days later clearly showed the resolution of the pneumothorax and most of the pulmonary hemorrhage. This study showed more clearly the absence of rib fractures.

Comments: The distribution of lung hemorrhage was somewhat unique in "Trixie" in that the dorsal lobes are generally better protected from trauma. However, the nature of a bite wound in a small patient permits any part of the thorax to be injured by the puncture wounds. Fractures were thought to be present near the costovertebral joints, an area difficult to diagnose. The location of the lung contusion gives support to the possibility of rib fractures in this region.

2

Prior to myelography

Natural respiration

Case 2.57

Signalment/History: "Murphy" was a 9-year-old, male Border Collie who underwent anesthesia for a myelogram. The radiographic procedure was delayed and he remained anesthetized for a prolonged period of time.

Radiographic procedure: Thoracic studies were made prior to the myelogram, following the use of positive pressure, and during the use of positive pressure.

Radiographic diagnosis (prior to myelography under anesthesia): Marked atelectasis of the right lung was compensated by the hyperinflation of the left lung. The resulting mediastinal shift was prominent.

Radiographic diagnosis (natural respiration under anesthesia following positive pressure): Some reinflation of the right lung had occurred, but all the lobes remained partially atelectic.

Positive pressure

Radiographic diagnosis (made during use of positive pressure under anesthesia): The right lung was reinflated. Minimal pleural fluid was evident. The left cranial and accessory lobes fail to re-inflate completely.

Comments: Atelectasis associated with anesthesia and prolonged patient positioning without manual inflation of the lungs is common. Because of the time involved in some radiographic procedures, it is frequent that during the series of radiographs directed at another part of the body, atelectasis is noted. This case is more severe than usual, possibly due to a bronchial mucous plug that functioned as a one-way valve.

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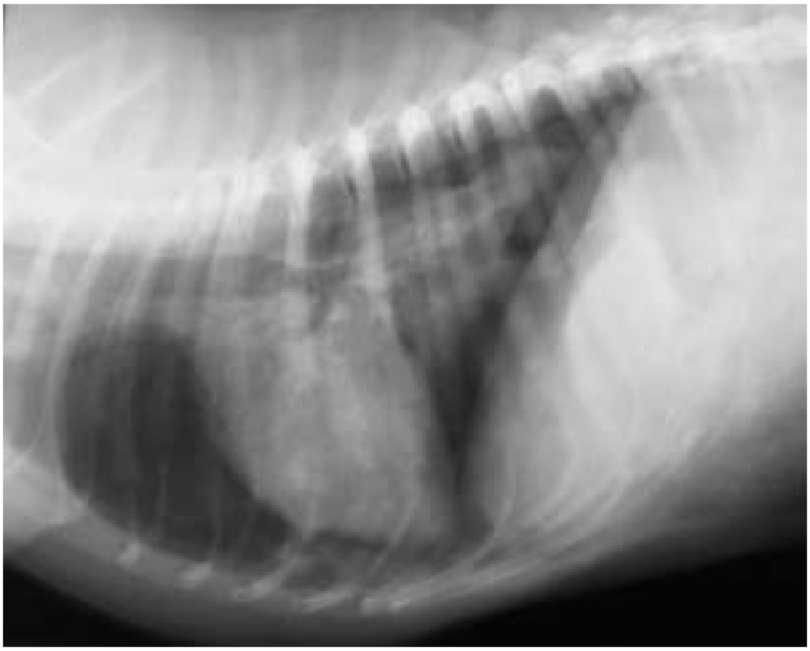


Case 2.58

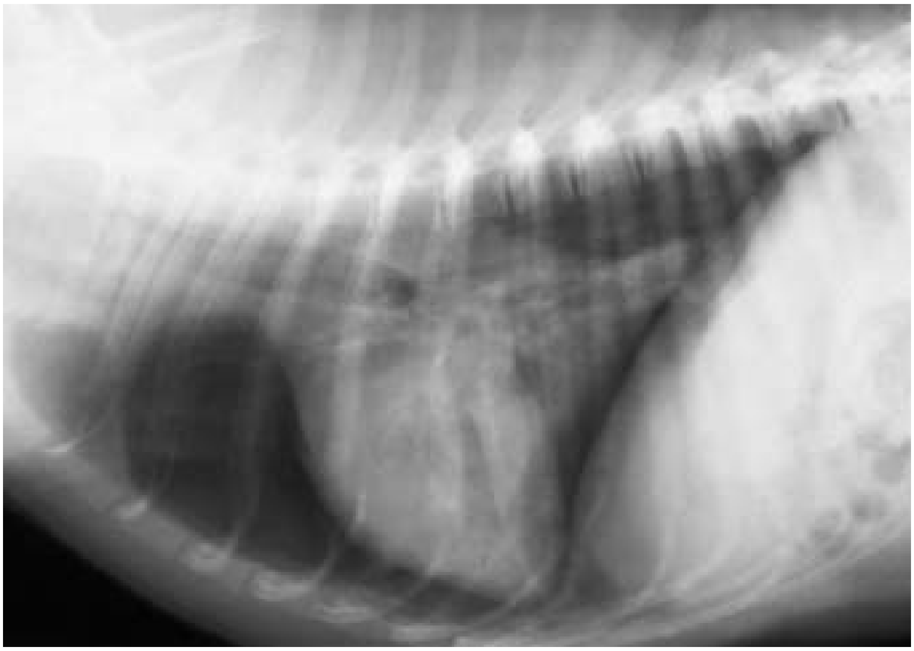
Day 1

Signalment/History: "Shorty" was a 2-year-old, male Chihuahua mixed breed who was presented at the clinic following being attacked by a larger dog.

Physical examination: The patient was dyspneic and injuries to the thoracic wall were present.

Radiographic procedure: The thorax was radiographed.

Radiographic diagnosis (day 1): Subcutaneous emphysema was evident on the right side with increased separation between the 6th and 7th ribs. There was also a single fracture of the right 6th rib. Marked pneumothorax on the right caused separation of the atelectic right middle and caudal lung lobes from the diaphragm and from the chest wall. The pneumothorax resulted in a minimal elevation of the heart shadow away from the sternum with displacement to the left. The diaphragm was intact.



Day 3

Radiographic diagnosis (day 3): Radiographs made on day 3 showed a lessening of the volume of the pneumothorax. The right middle and caudal lobes had regained a part of their normal degree of aeration. The amount of subcutaneous air had decreased.

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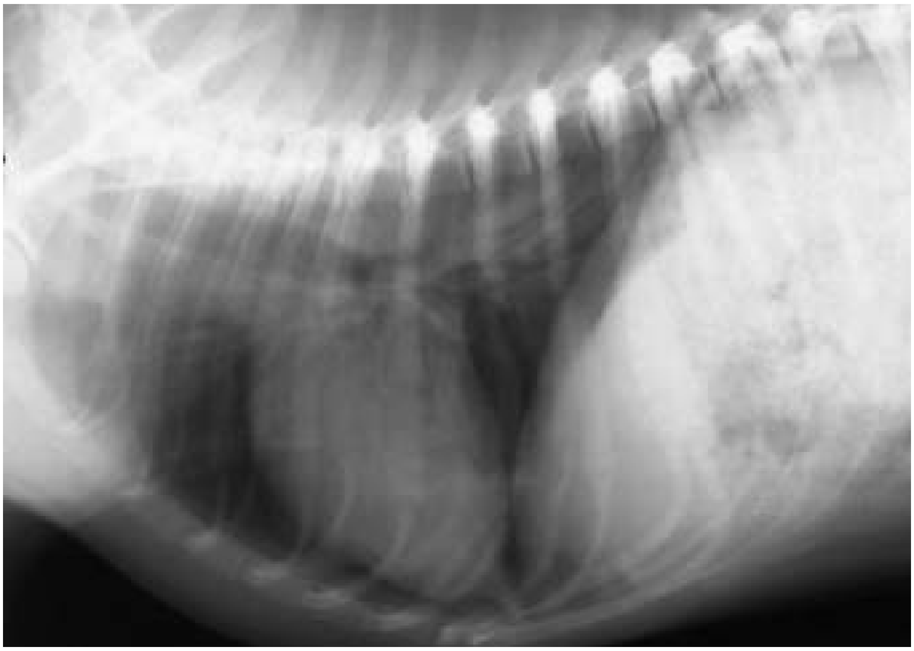


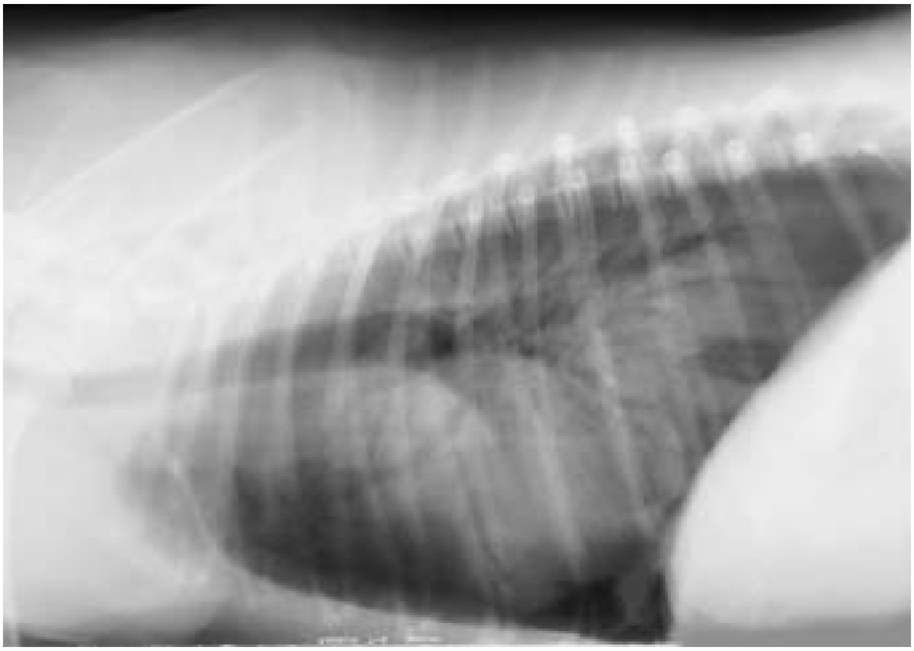
Day 4

Radiographic diagnosis (day 4): Radiographs made on day 4 showed almost a complete disappearance of the pneumothorax. The right middle and caudal lobes were more aerated as indicted by the decrease in fluid density. The amount of subcutaneous air continued to decrease.

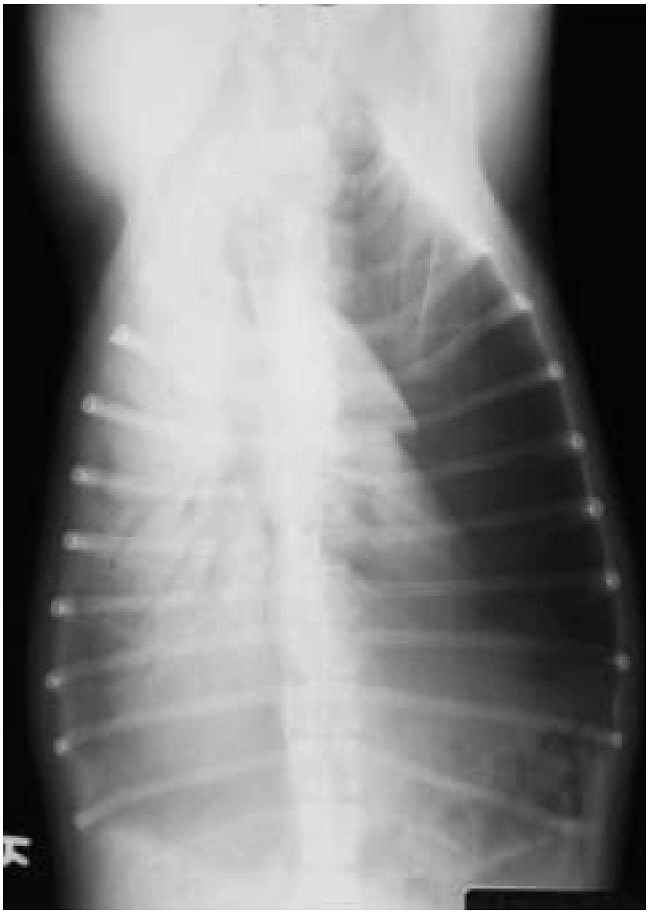
Treatment/Management: "Shorty" was treated conservatively and experienced a spontaneous clearing of his chest lesions.

Comments: Note the fluid density within the affected lung lobes on the first study is more than would be expected with only pulmonary contusion and was the result of atelectasis as well. The return to near normal was to be expected in this type of trauma patient.

2.2.9 Tension pneumothorax



Case 2.59



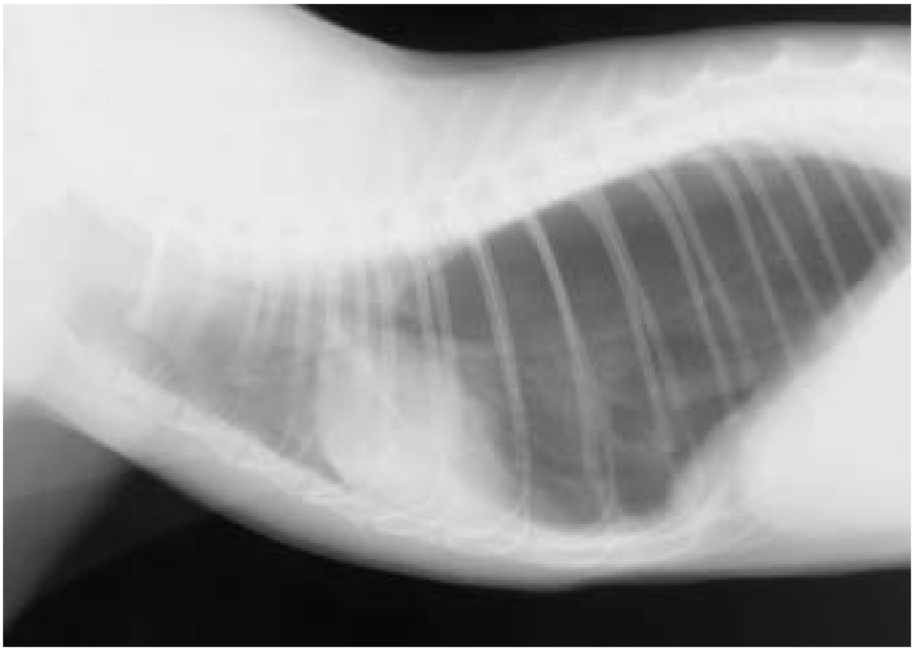
Signalment/History: "Sam" was a 4-year-old, female mixed breed dog who had been hit by a truck.

Physical examination: The dog was in shock and dyspneic and the examination was limited.

Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis: The thoracic cavity was distended with a tension pneumothorax and collapse of the lung lobes on the left. Pulmonary contusion of the lobes on the right could also be seen. An air-bronchogram pattern was present in the right lobes. The mediastinal shift was to the right.

Treatment/Management: "Sam" responded to immediate treatment to relieve the pneumothorax. She was kept under observation in an intensive care unit and the pneumothorax did not recur. She was discharged within several days.



Case 2.60

Day 1, Noncontrast

Signalment/History: "Felix" was a 1-year-old, male DSH cat with a 4-month history of left sided pyothorax with frequent drainage. *Streptococcus fecalis* and *E. coli* had been cultured from the lesion. Treatment was thought to be effective and he was discharged from the clinic. The owner reported that clinical signs had not improved and that the cat remained lethargic and had problems in breathing.

Radiographic procedure: Progressive thoracic radiographs were made.

Radiographic diagnosis (day 1): Noncontrast radiographs showed a massive loculated pneumothorax in the caudal hemithorax on the left, with a marked mediastinal shift to the right. The heart shadow was against the right chest wall. The right lung was partially atelectic. The left lung could not be identified and was assumed to be collapsed.

Day 1, Barium swallow

Radiographic diagnosis (day 1): A barium swallow showed normal passage of the contrast meal through an esophagus that was markedly displaced to the right. A minimal amount of contrast agent had been inhaled and was demonstrated in the bronchi.

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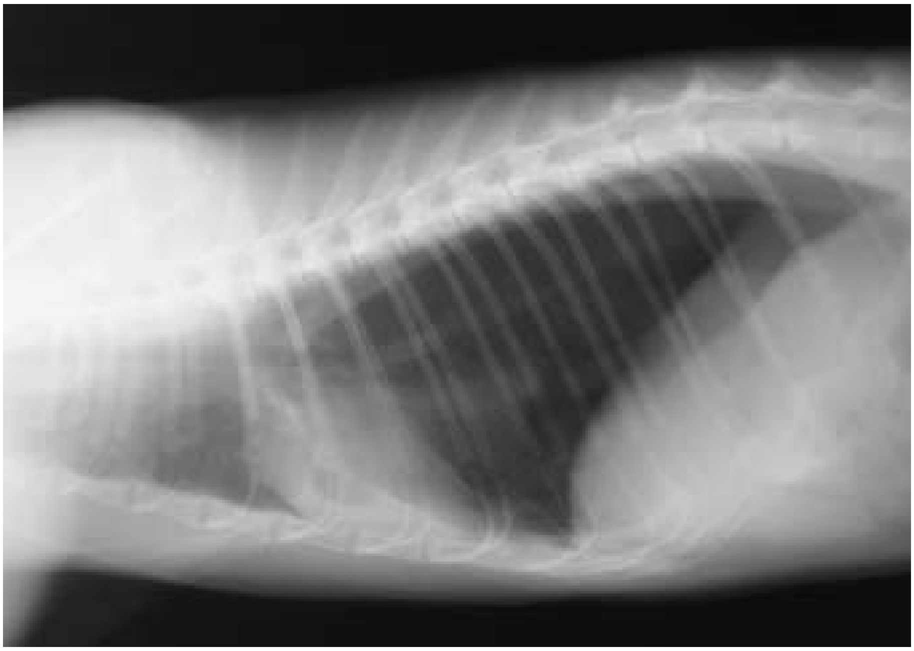
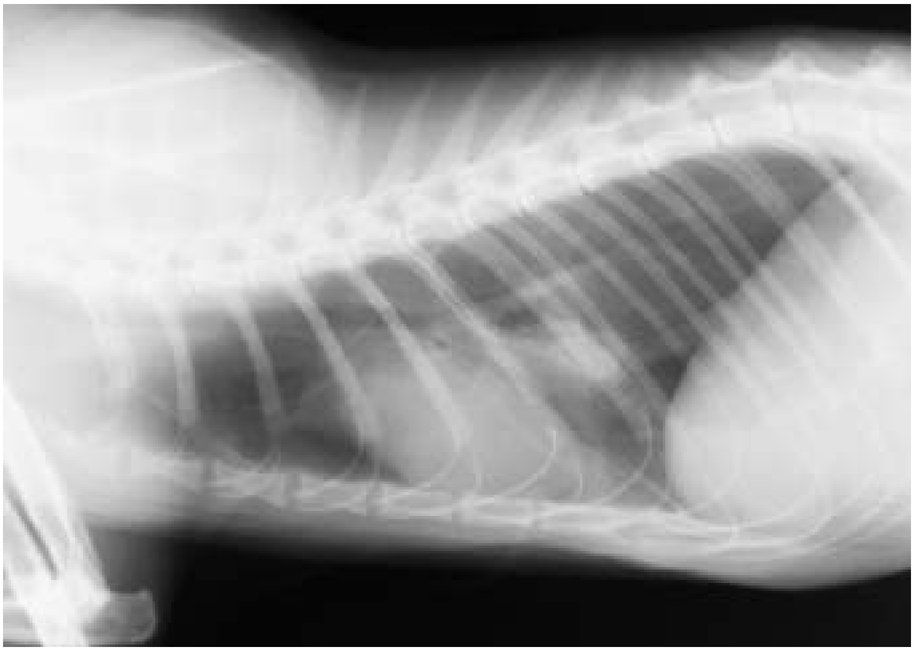


Day 8

Radiographic diagnosis (day 8): This study followed needle aspiration of the air, but showed no change in the volume of the loculated pneumothorax that was being treated as a tension pneumothorax.



Day 15

Radiographic diagnosis (day 15): Following a thoracotomy in which a tear in the left lung was sutured, re-inflation of the lung had occurred, although not completely. The pneumothorax could not be identified on these radiographs. Pleural scarring plus the chest wall incision site had left a persistent fluid-density shadow on the left side. The surgical incision on the left was just caudal to the heart shadow as could be identified on the lateral view.

Treatment/Management: Failure of a pneumothorax to heal quickly suggested a more severe pulmonary lesion or the creation of a flap-like lesion that permitted the tension pneumothorax to develop. The surgery was successful, although it might be thought to have been delayed a bit too long.

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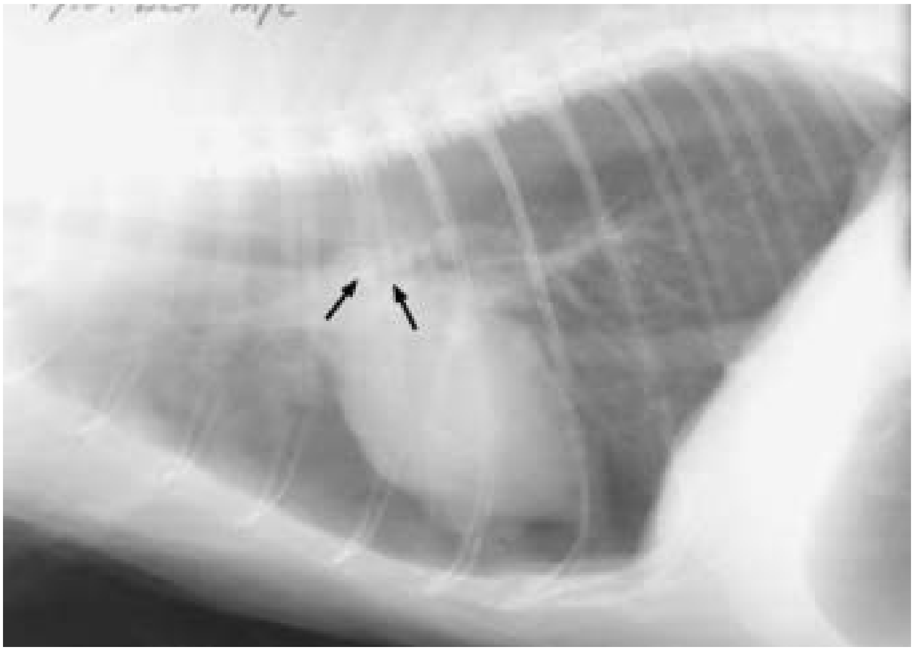
Case 2.61



Signalment/History: "Sly" was a 4-year-old, male Siamese cat with no history of medical problems until 24 hours previously when he stopped breathing for some minutes. The owners suspected trauma since the cat had been away from the house for a few hours. The acute onset of dyspnea was remarkable.

Physical examination: The severity of the dyspnea was severe and as a consequence, a complete physical examination was not possible. In addition, the cat was aggressive and frightened. Despite this, the examination suggested that an upper airway problem was not likely.

Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis: The thoracic cavity was distended with a prominent mediastinal shift to the left. A unilateral tension pneumothorax on the right had caused the cardiac silhouette to move away from the sternum. The left lung was partially atelectic. Most important was the failure to visualize the air-filled lumen in the distal trachea that suggested a possible intratracheal foreign body (arrows).

Treatment/Management: Unfortunately, a decision was made to treat only the pneumothorax. Following placement of a chest drain, the dyspnea continued and the owners elected euthanasia rather than surgical exploration to determine the cause of the pneumothorax.

On necropsy examination, a distal tracheal foreign body (chicken bone) at the level of the origin of the bronchus to the left cranial lobe had caused a severe necrotizing tracheitis/bronchitis. The mediastinum was edematous, emphysematous, and congested. Because of chronicity, adhesions prevented a pneumomediastinum and instead a flap-like opening in the wall of the mediastinum led directly to the production of a tension pneumothorax. It was, therefore, understandable that despite the placement of a chest drain, the pneumothorax had persisted. The mediastinitis was not appreciated clinically or radiographically; however, the abnormality in the distal trachea should have received more immediate attention. Probably the increased lung density noted on the lateral view was from the mediastinal effusion superimposed over the density from the lungs.

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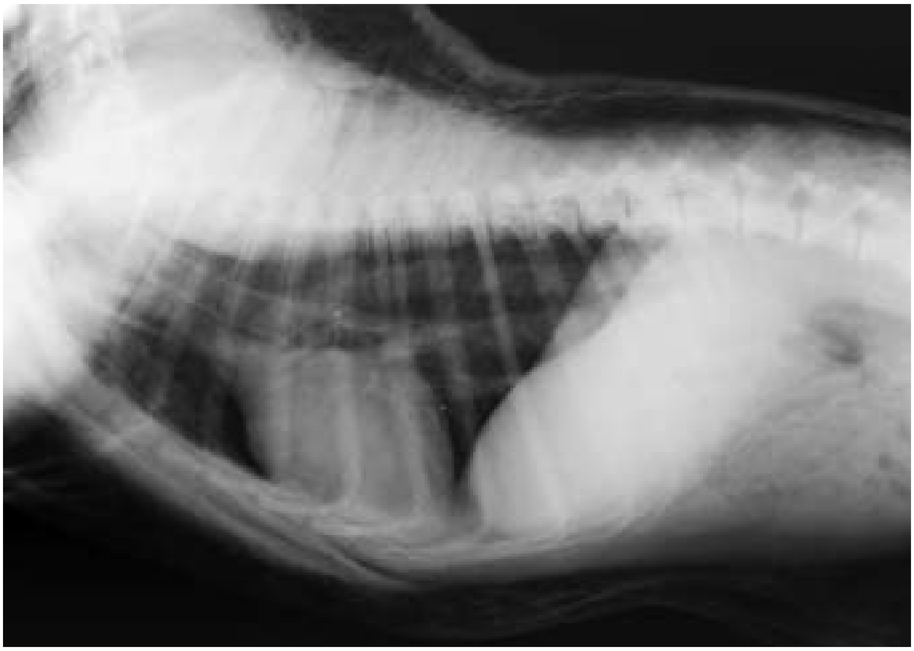
2.2.10 Pneumomediastinum



Case 2.62

Signalment/History: "Clyde", a 4-year-old, male Beagle, was found by the owner to be "enlarged" and "distended".

Radiographic procedure: Whole body radiographs were made.

Radiographic diagnosis: A prominent subcutaneous emphysema and pneumomediastinum were evident. The increased lung pattern was thought to be due to the subcutaneous air surrounding the thorax. No signs of injury to the thoracic wall were noted. The multiple metallic subcutaneous foreign bodies were shotgun pellets and although widely distributed, were probably not associated with the current clinical problem.

Treatment/Management: The origin of the subcutaneous air could not be ascertained radiographically. A careful search of the skin located a small injury in the cervical region. At surgery, a small hole in the trachea was found at the level of C3. The overlying muscles were torn, suggesting a bite wound. Any tear or rupture of the trachea or main-stem bronchi can leak air.

An opening in the skin, especially in the axilla, can permit a "pump-like" action that fills the subcutaneous space with air. "Clyde" inflated the subcutaneous space on each inspiration with air entering through the skin lesion and from the hole in the trachea until he "pumped" himself up like a balloon. The air had moved through the thoracic inlet and filled the mediastinal space.

Case 2.63

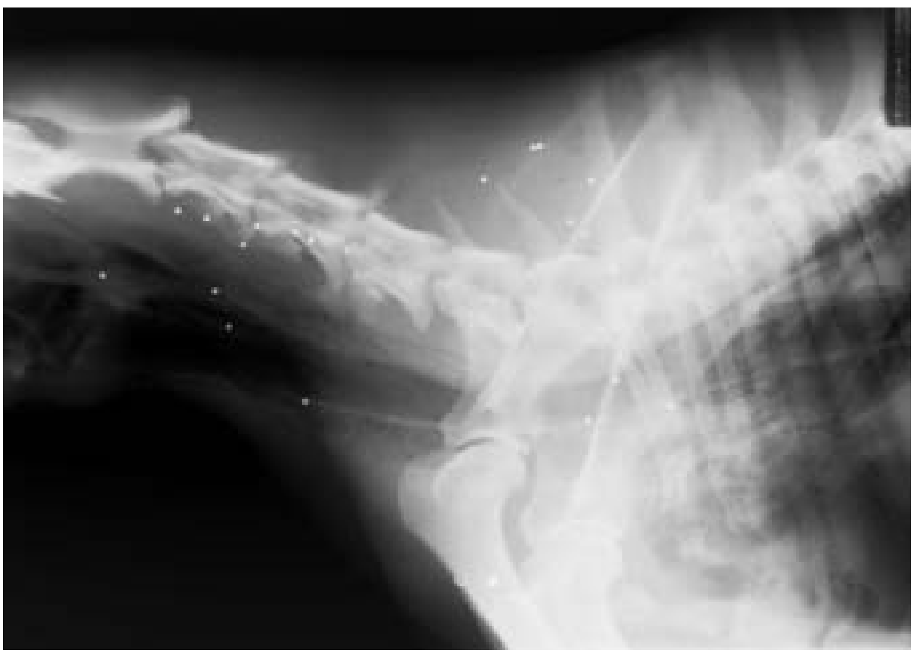
Signalment/History: A cat was found lying on the road by a pedestrian and was brought to the clinic.

Physical examination: Subcutaneous emphysema was easily palpated over the thorax.

Radiographic procedure: Radiographs were made of the thorax and the whole body.

Radiographic diagnosis: Prominent subcutaneous emphysema was evident, in addition to a pneumomediastinum and retroperitoneal air. No signs of injury to the thoracic wall could be seen.

Comments: Air will dissect from the subcutaneous space into the mediastinal space. If the amount of air is sufficient, it is possible that it will then dissect from the mediastinal space into the retroperitoneal space. In this cat, the cause of the subcutaneous air was not known. The presence of the air suggests a more severe lesion than is actually present. Determination of the origin of the air is probably more critical in assigning its clinical importance.



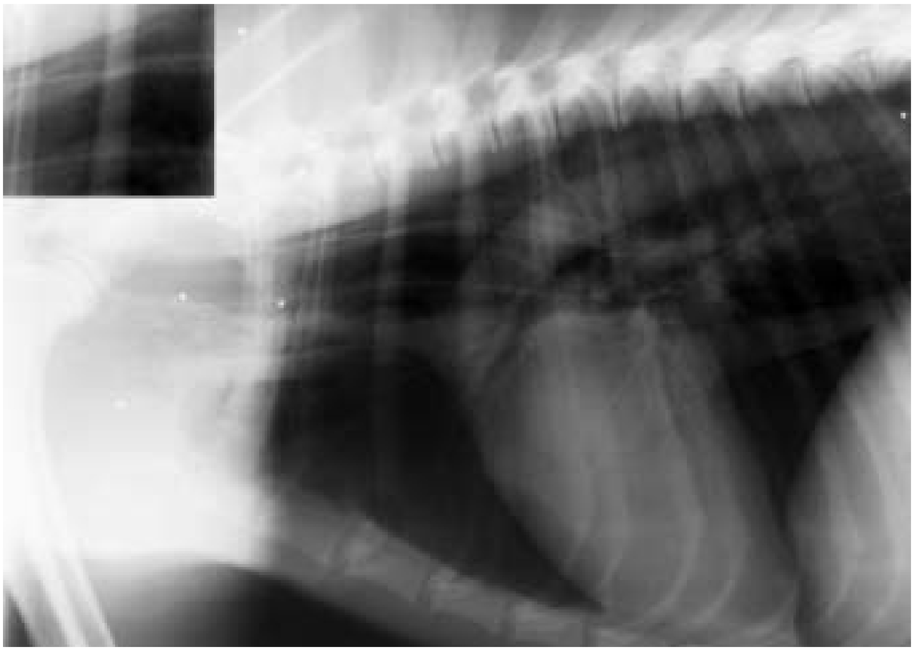
Case 2.64

Signalment/History: "Amee" was a 2-year-old, female Borzoi presented in shock following being shot in the neck and shoulder on the left.

Physical examination: The dog was not able to stand and a complete neurologic examination was not carried out. Multiple soft tissue injuries were noted around the head and neck; however, it was not possible to ascertain if there was any thoracic injury.

Radiographic procedure: Lateral radiographs were made of the head and cervical region, with a complete study of the thorax.

Radiographic diagnosis (head and cervical region): Multiple metallic pellets were located in the head and cervical region indicating an injury from a shotgun fired from a short distance. No fluid density was noted in the nasal passages or in the frontal sinuses. Air that had dissected between the soft tissues in the neck permitted identification of both surfaces of the tracheal walls and was the origin of a pneumomediastinum.



Radiographic diagnosis (thorax): Subcutaneous emphysema in the cervical region was noted, plus a typical pattern of air within the mediastinum that was indicative of a pneumomediastinum. No evidence of lung injury was noted. Multiple shotgun pellets were present.

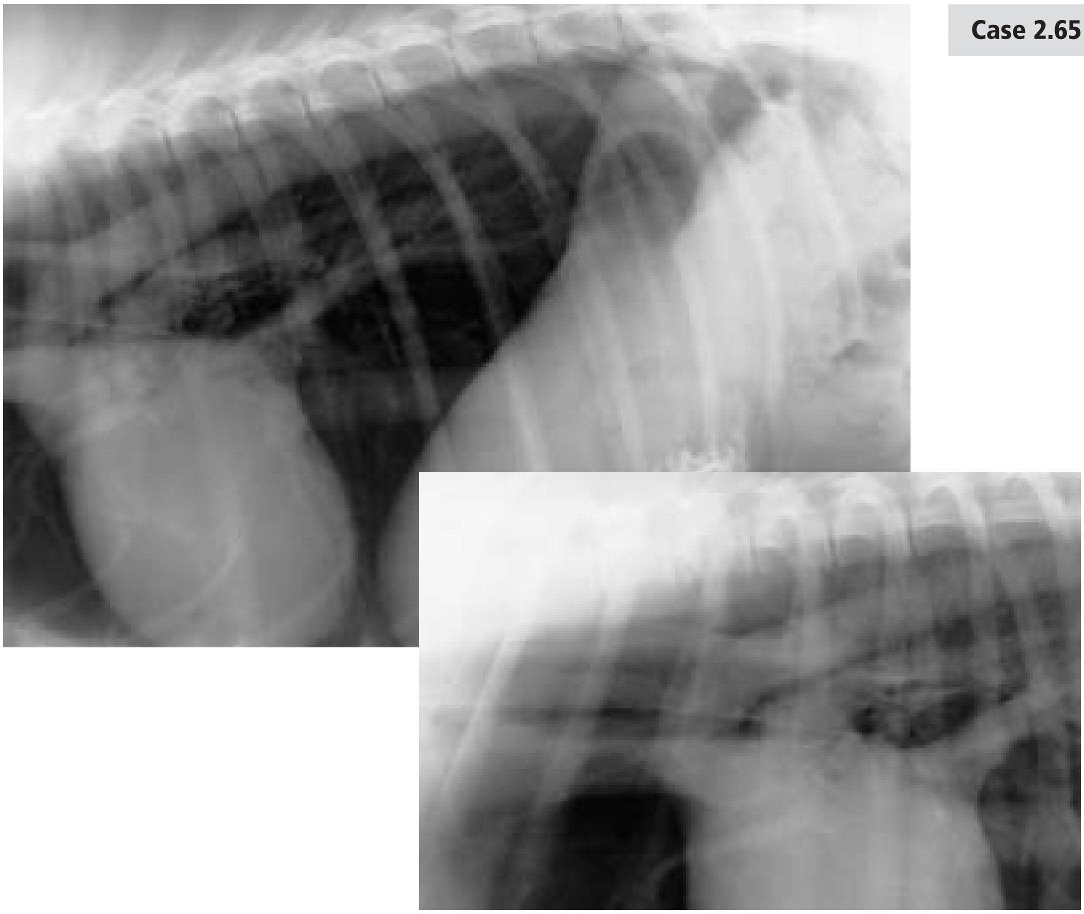
Comments: Determining the source of the free air permits a better understanding of the prognosis in such a case. The holes in the skin can be large enough to permit the air to enter the subcutaneous spaces and pass into the mediastinum, although such holes are in themselves usually of little clinical importance.

It was possible in this case that one of the pellets had injured the larynx or trachea permitting air to pass into the mediastinum. This would have been of greater clinical importance. An injury to the esophagus may leak air and may lead to a mediastinitis and be of great importance clinically; however, it is uncommon that an injury of this type would produce such a prominent pneumomediastinum as seen in "Amee".

Endoscopy is strongly indicated in this type of patient. Several of the pellets were malformed indicating that they had struck bone.

Often only lateral views are made in a deep-chested patient such as "Amee" until more is known of the injury.

Case 2.65



Signalment/History: "Wendy", a large 1-year-old, female Scottish Deerhound, had run into a tree the day before.

Physical examination: The dog would not walk on her right forelimb. Crepitus was elicited following palpation of the right shoulder. Movement of the shoulder joint was painful. She was depressed with shallow breathing at the time of examination.

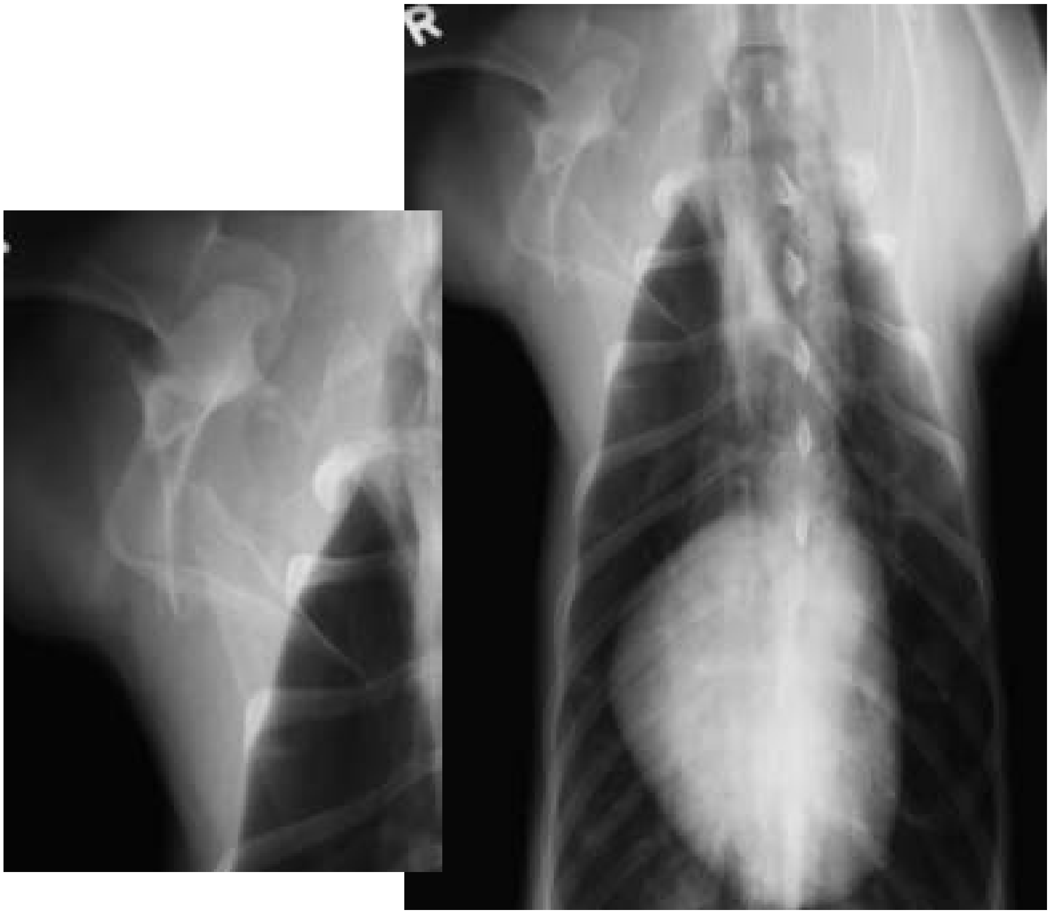
Radiographic procedure: Radiographic studies included multiple views of the thorax plus the region of the right shoulder.

Radiographic diagnosis: Hyperlucent lung fields were noted, but these were possibly due to the body conformation of a deep-chested dog with a thin chest wall. All of the major cranial mediastinal vessels and the tracheal wall could be clearly identified indicating a pneumomediastinum. The pulmonary vessels were also easily seen, but this was thought to be the result of the breed of dog and did not indicate an abnormal lung pattern. The cause of the pneumomediastinum could not be detected radiographically. A comminuted fracture of the right scapula with fragment displacement was seen.

The study included a lateral view of the cervical region and thoracic inlet, neither of which indicated injury to the upper airway or esophagus

Treatment/Management: The scapular fracture was permitted to heal without surgical stabilization of the fracture fragments. The dog was discharged to the referring clinician several days later.

Comments: Hyperlucent lung fields can be the result of the conformation of the thorax or can represent an actual pulmonary hyperinflation. The character of the pulmonary vessels is more easily evaluated in patients in whom the lungs are filled with air. Because of "Wendy's" deep chest, caution should be used in the evaluation of the cardiac silhouette on the DV/VD views, since minimal obliquity of the thorax markedly influences the appearance of the heart shadow.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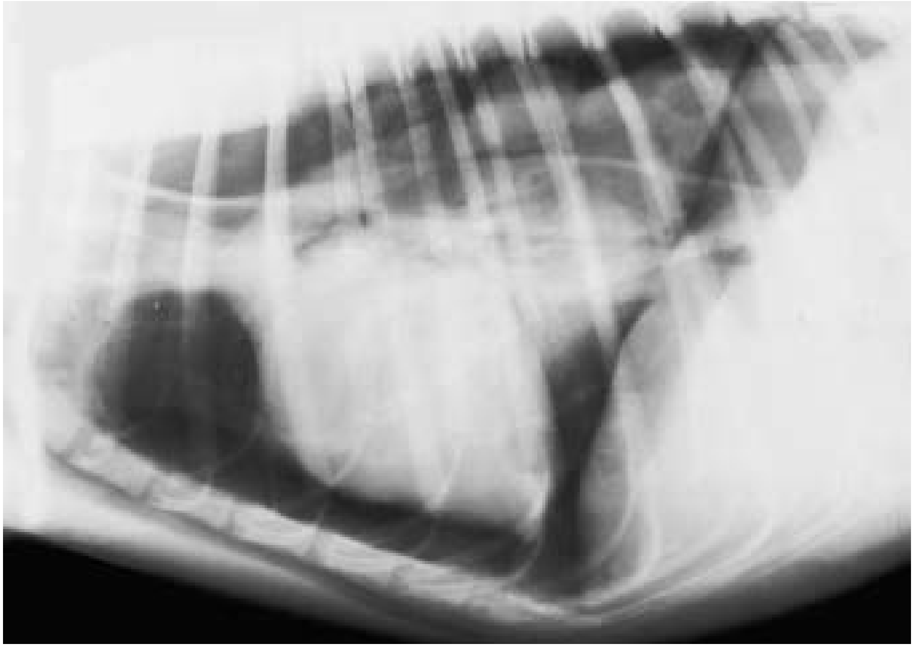

Case 2.66

Day 1

Signalment/History: "Shep" was a 1-year-old, male German Shepherd mixed breed, who had been hit by a car 12 hours previously.

Physical examination: The examination was difficult to perform and only demonstrated marked dyspnea.

Radiographic procedure: Because of the dog's difficulty in breathing, only a lateral thoracic radiograph was made.

Radiographic diagnosis (day 1): The single lateral radiograph was underexposed, but still clearly showed a large pneumothorax characterized by the elevation of the cardiac silhouette away from the sternum and retraction of the lung lobes dorsally from the spine and diaphragm. The ability to visualize both sides of the tracheal wall, the aortic arch, and serosal surface of the air-filled esophagus was indicative of a pneumomediastinum. Collapse of the caudal lung lobes suggested both pulmonary contusion and atelectasis. Liquid-dense, well-circumscribed pulmonary nodules plus air-filled, cyst-like lesions were found in the dorsal lobes caudally. The diaphragm was intact.

Day 4

Radiographic diagnosis (day 4): The study on this day showed a complete resorption of the pneumothorax, though persistence of the pneumomediastinum. The lung lesions persisted on the right side caudally. The fluid density nodule remained in its dorsal position.

Treatment/Management: The nodular lesions suggested a more serious lung injury that was slower to repair than just a simple lung contusion following blunt trauma. The etiology of the pneumomediastinum remained undetermined as frequently occurs.

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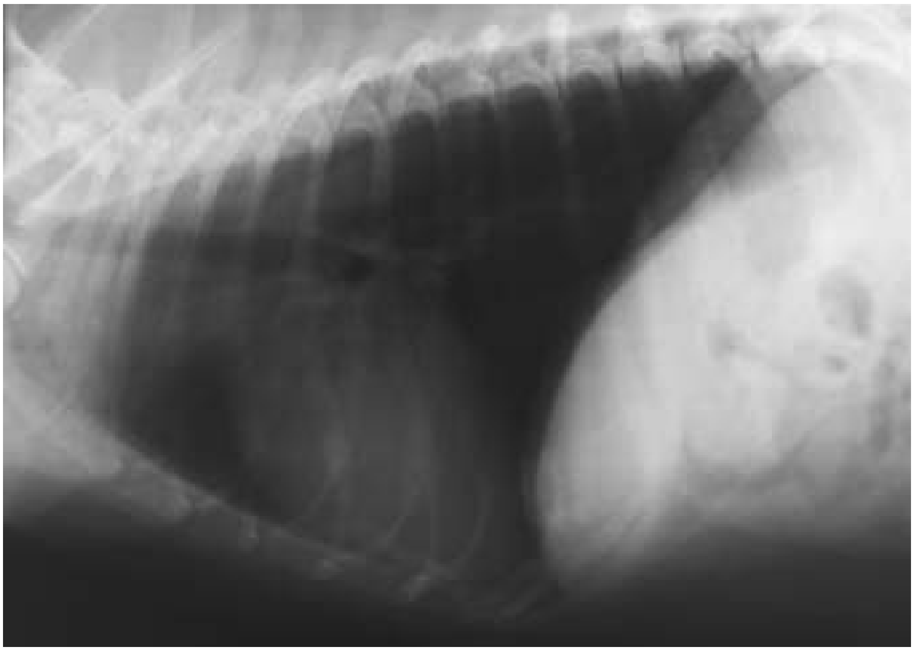
2.2.11 Hemomediastinum

Case 2.67

Day 1

Signalment/History: "Romo" was a 5-year-old, male Spaniel mixed breed, who had been hit by a car and was referred several days after the accident along with post-trauma radiographs.

Radiographic diagnosis (immediate post-trauma): The radiographs were made on expiration and were underexposed/underdeveloped. However, a large cranial mediastinal fluid density could still be seen suggesting a mediastinal mass probably the result of hemorrhage. The tracheal shadow was shifted toward the right thoracic wall.



Day 5

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Radiographic diagnosis (day 5, lateral view only): Regression of the depth of the cranial mediastinal mass suggested resorption of the blood. The lungs were normal for a dog this age.

Comments: Hemorrhage within the mediastinum is thought to not be as important clinically in the dog as in man, where it pools caudally and does not drain freely resulting in a persistent inflammatory process. In the dog, disappearance of the blood appears to occur rather easily, but does occur at a slower rate than the clearing of pleural fluid. It is helpful to monitor the clearance radiographically since change would confirm the suspicion of mediastinal fluid. A clinically more important abscess, tumor, or hematoma in the mediastinum would not change in size or shape as quickly on the follow-up radiographs.

Case 2.68

Signalment/History: "Raggs" was a moderately obese, 7-year-old, male Poodle with a history of having been hit by a car seven days earlier.

Physical examination: He presented with a right forelimb paralysis due to a probable avulsion of the brachial plexus.

Radiographic procedure: Thoracic radiographs were made to assess additional damage other than the neurological injury.

Radiographic diagnosis: An increase in cranial mediastinal thickness with indistinct borders extended ventrally toward the sternum and suggested mediastinal fluid possibly hemorrhage. Note that the thickness of the cranial mediastinal shadow was greater than the width of the extrathoracic soft tissue, indicating that the width was probably not the result of fat deposition, but was a pathological condition. The generalized increase in pulmonary density was probably due to underinflation of the lungs (note the cranial position of the diaphragm and moderate obesity of the dog). The obesity also caused minimal pleural thickening. A single airgun pellet lay dorsocaudaly within the mediastinum adjacent to the aorta and esophagus. No bony abnormality was present.

Treatment/Management: The mediastinal thickness was probably the result of hemorrhage. The airgun pellet may have been unrelated to the current medical problem and seemed to be in a position that would not cause any of the clinical signs. The absence of bony changes is typical in patients with suspected brachial plexus injuries.

"Raggs" was a patient with an old gunshot wound and a more recent history of being hit by a car. Both traumatic events needed to be given consideration in the exploration of the clinical signs. Additional radiographic studies needed to be made of the right forelimb and cervicothoracic spine because of the paralysis.

"Raggs" did not show any marked improvement in his neurological signs and was taken home by the owner without any further radiographic studies being done.

Comments: The rule of measurement of the width of the mediastinum on the DV view in comparison to the width of the extrathoracic soft tissue is a helpful one in determining whether the mediastinal width is the result of fat accumulation or actually represents a pathological condition.

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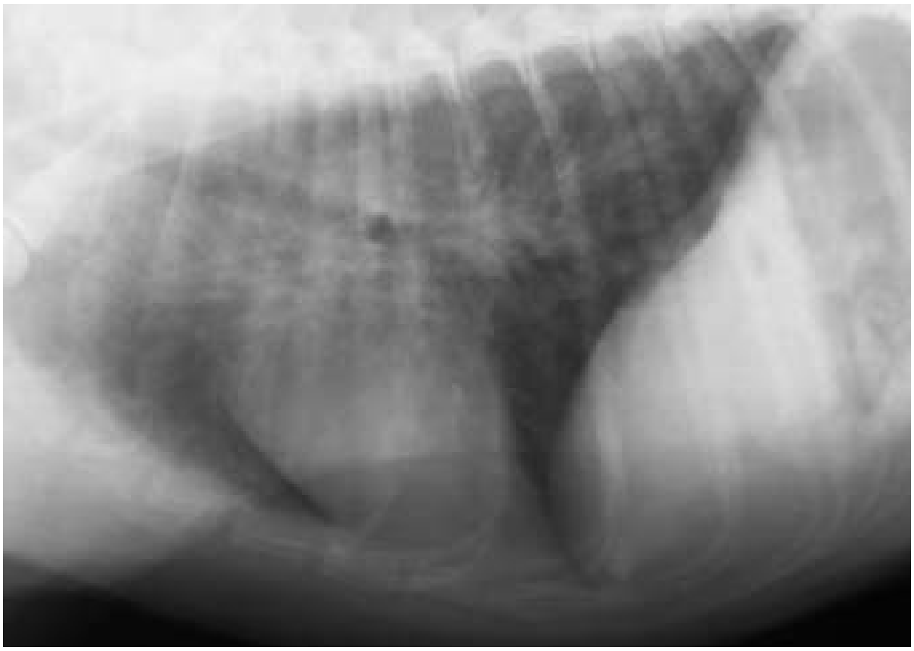
2.2.12 Iatrogenic injury

Case 2.69



Day 1

Signalment/History: "Princess" was a 2-year-old, female mixed breed with a chronic, productive cough for the previous two months. The cough had been treated symptomatically with no success. No history of trauma was suggested.

Radiographic diagnosis (referral day 1): Radiographs made at the referral clinic were indicative of a peribronchial pulmonary pattern indicating a lower airway disease. The perihilar region was more dense than normal, but did not appear as a mass lesion. The possible value of a tracheal wash was discussed. An unexpected dyspnea had then developed within 12 hours after performing the tracheal wash and the patient was referred.

Day 3

Radiographic diagnosis (day 3): A marked pneumothorax was evident with retraction of the lung lobes from the thoracic wall and separation of the cardiac silhouette from the sternum. The pleural air was mostly on the left. The density of the atelectic lungs was higher than before.

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Day 4

Radiographic diagnosis (day 4): The pneumothorax had diminished and the lung lobes were more normal in appearance with an increase in aeration.

Treatment/Management: It was feared that the tracheal wash had been performed in such a manner that it caused a tearing of the lung tissue resulting in the pneumothorax and unexpected dyspnea. The dog recovered with conservative treatment and was discharged.

Case 2.70

Signalment/History: "Charlie Brown" was a 14-year-old, male Miniature Poodle that had had a surgical procedure the day before. He had made an unremarkable recovery, but was found moribund 14 hours after the surgery.

Radiographic procedure: Radiographs were made because of the abnormal lung sounds in the caudal portion of the thorax.

Radiographic diagnosis: Increased fluid density was noted in all the lung lobes except for the right cranial lobe. That lobe was overinflated and had herniated across the midline to the left side. Air bronchograms were present in all the affected lobes in addition to an accentuated airway pattern. Silhouetting caused an inability to visualize the caudal vena cava. No pleural fluid could be identified. The diaphragm was intact. Note the distention of the trachea.

Treatment/Management: The increase in pulmonary fluid could best be explained by a high-permeability type pulmonary edema due to an intrinsic trauma such as aspiration of acid material. The patient died, but a necropsy examination was not permitted.

Case 2.71

Signalment/History: "Saki" was a 3-year-old, male mixed breed cat that had had dental surgery eight days earlier. The day following surgery, he began to "inflate".

Physical examination: A subcutaneous emphysema was prominent.

Radiographic procedure: Radiographs were made of the entire body.

Radiographic diagnosis: The massive subcutaneous emphysema and pneumomediastinum made evaluation of the cervical trachea and lung fields difficult. The dorsal position of the cardiac silhouette was the result of a congenital anomaly of the xiphisternum.

Treatment/Management: Surgery was delayed for 12 days because of a deteriorating clinical condition. At that time, a 3-cm long tear in the tracheal wall at the thoracic inlet was repaired. "Saki" died four days after surgery. The presence of a necrotizing inflammatory process involving the larynx, trachea, esophagus, and lungs was noted at necropsy. The exact cause of the tracheal injury was assumed to have occurred at the time of the anesthesia for dental surgery.

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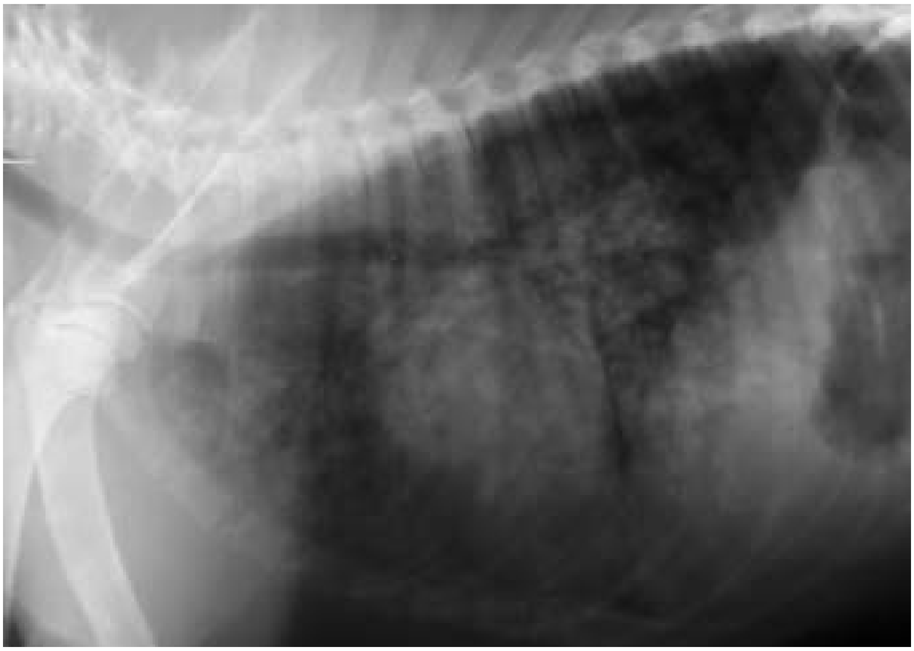


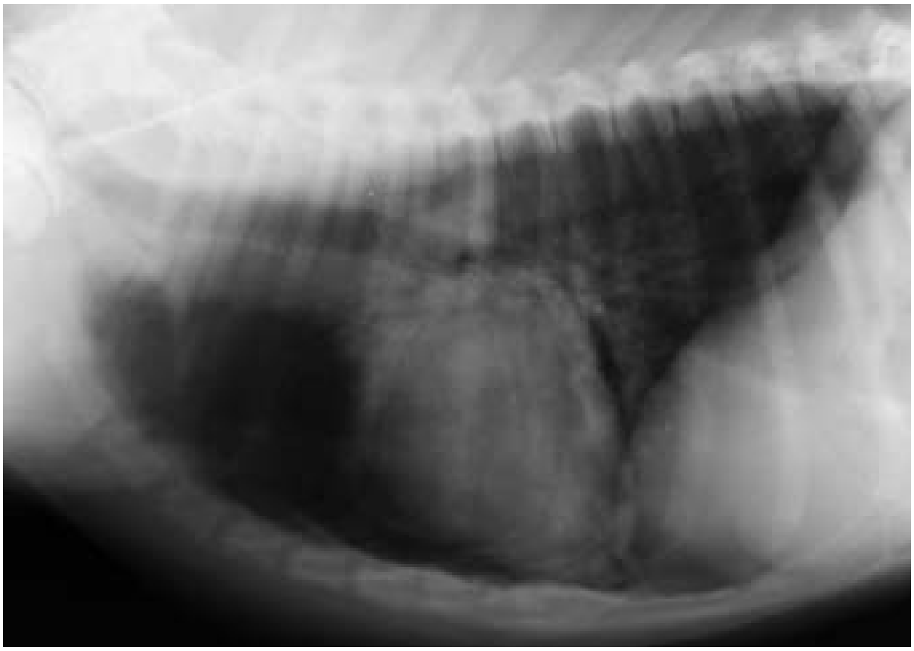
Case 2.72

Day 1

Signalment/History: "Niko" was a 1-year-old, male Akita with a history of dyspnea, tachypnea, and nasal hemorrhage. It was thought that the epistaxis could be the result of pulmonary hemorrhage because of its frothy appearance. The owner did not know of any trauma.

Radiographic procedure (day 1): Multiple pulmonary nodules had coalesced causing sufficient fluid density in the lungs to create air-bronchogram patterns. The nodular pulmonary pattern was thought to be nonspecific and possibly compatible with a metastatic tumor, hematogeneous bacterial pneumonia, fungal pneumonia, or parasitic pneumonia. No pleural fluid was noted and the heart shadow was normal in size, shape, and position.

Treatment/Management: A transtracheal wash was performed that collected cells indicative of a pyogranulomatous inflammation with a moderate eosinophilic component.



Following transtracheal wash

Radiographic diagnosis (following the transtracheal wash): A marked bilateral pneumothorax with atelectasis of all lobes could be seen.

Comments: It was thought that the diagnostic procedure had probably resulted in the pneumothorax.

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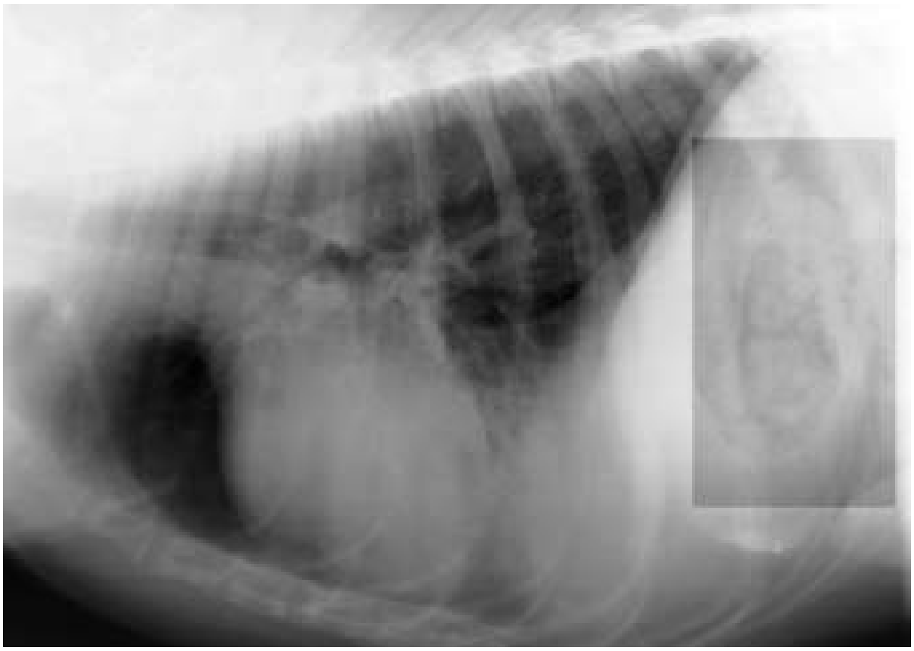
Case 2.73



Signalment/History: "Fritz", a 5-year-old, male Doberman Pinscher, had eaten a kitchen sponge. The owner had attempted to induce vomiting by feeding him salt water and vegetable oil. "Fritz" began to cough and gasp for air following this medication.

Physical examination: The dog was febrile and dyspneic at the time of admission to the clinic.

Radiographic procedure: Radiographs were made of the thorax. The study was overexposed but was not repeated.

Radiographic diagnosis: An increase in fluid density was present within the right middle and accessory lobes with a generalized air-bronchogram pattern supporting the clinical diagnosis of an aspiration pneumonia. The presence of thickened pleura adjacent to malunion fractures of the 6th, 7th, and 8th ribs on the right suggested an old trauma.

A gastric foreign body was suggestive of the sponge that the owners reported the dog had eaten.

Note the silhouetting of the radiodense accessory lung lobe with the caudal vena cava making that structure difficult to visualize.

Treatment/Management: Lipid aspiration pneumonia was diagnosed by combining the clinical history plus the radiographic pattern. "Fritz" was radiographed eight days later and the pneumonia was clearing. Lipid pneumonia clears more slowly then typical airway-oriented pneumonia. It is difficult to safely administer any oily medication since it does not stimulate a cough reflex if it enters the upper airways and so it tends to be inhaled.

Case 2.74

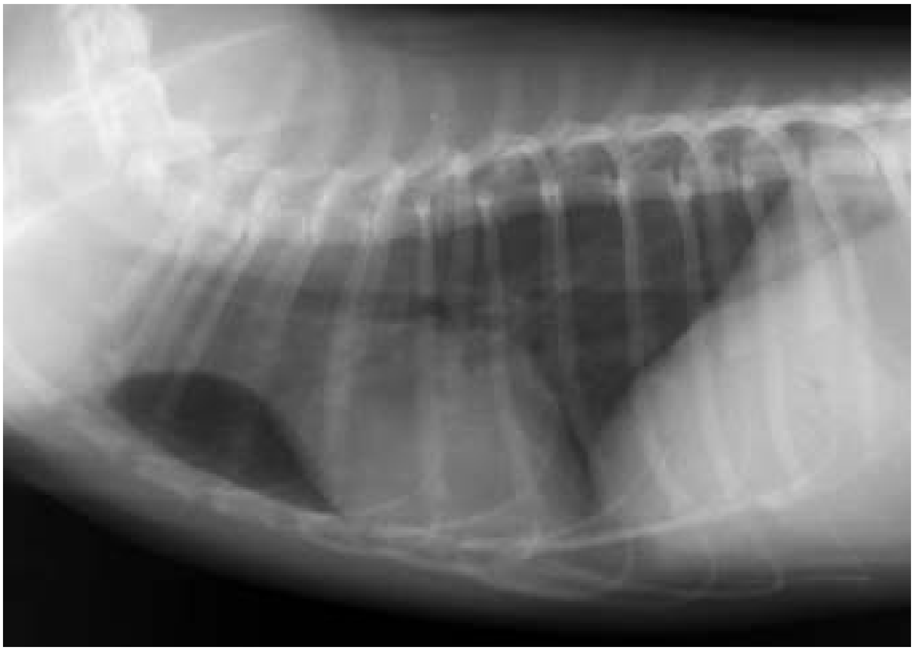
Day 1

Signalment/History: “Ming” was an 8-month-old, female Pekingese who had experienced difficulty swallowing a piece of meat, and had choked and collapsed. The owner removed the meat from the dog’s oropharynx and began cardiopulmonary resuscitation.

Physical examination: When presented to the clinic, “Ming” was alert, exhibited open-mouth breathing and had marked bronchovesicular sounds bilaterally.

Radiographic procedure: The thorax was radiographed.

Radiographic diagnosis (day 1): A generalized increase in pulmonary density was evident throughout the lung fields with a minimal air-bronchogram pattern. The diaphragm was located caudally and flattened, suggesting obstructive emphysema. The cranial mediastinum was widened, but this was thought to be breed dependent.

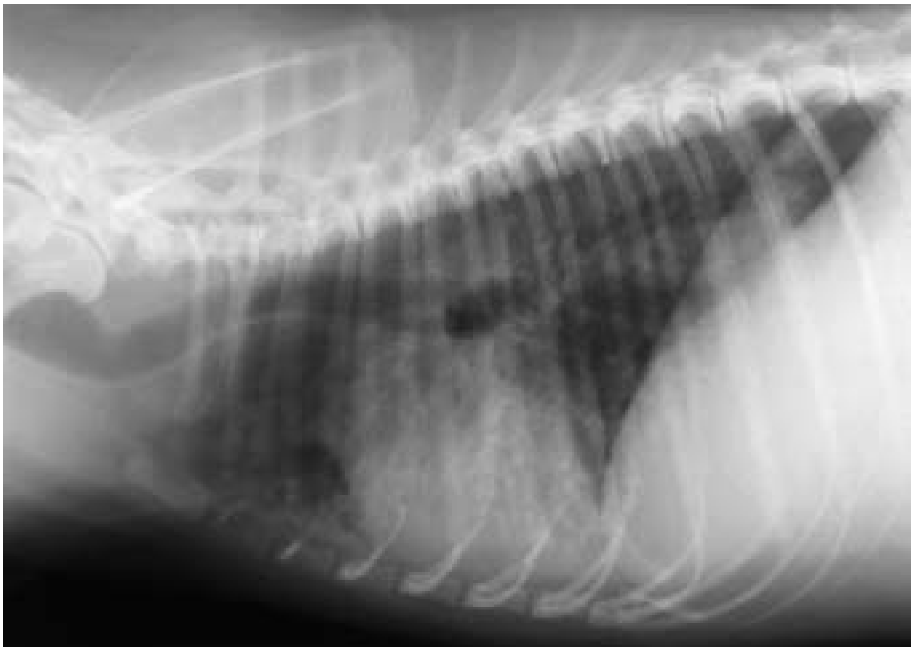


Day 2

Radiographic diagnosis (day 2): A persistent increase in pulmonary density in the left lung strongly suggested pneumonia.

Treatment/Management: It was thought that because of the small size of the dog, the resuscitation had caused trauma to the thorax and that the changes within the lung lobes represented pulmonary hemorrhage. It was also possible that small portions of food had been aspirated and so the lung changes could have been due to aspiration pneumonia. In addition, an obstructive component may have been present causing an associated obstructive atelectasis

The slow clearing of the pulmonary density plus the increase in density in the left lung on the second day both suggested the development of a secondary airway-oriented pneumonia. A simple transudate secondary to trauma should have cleared more quickly. The dog was discharged after a short stay in the clinic.



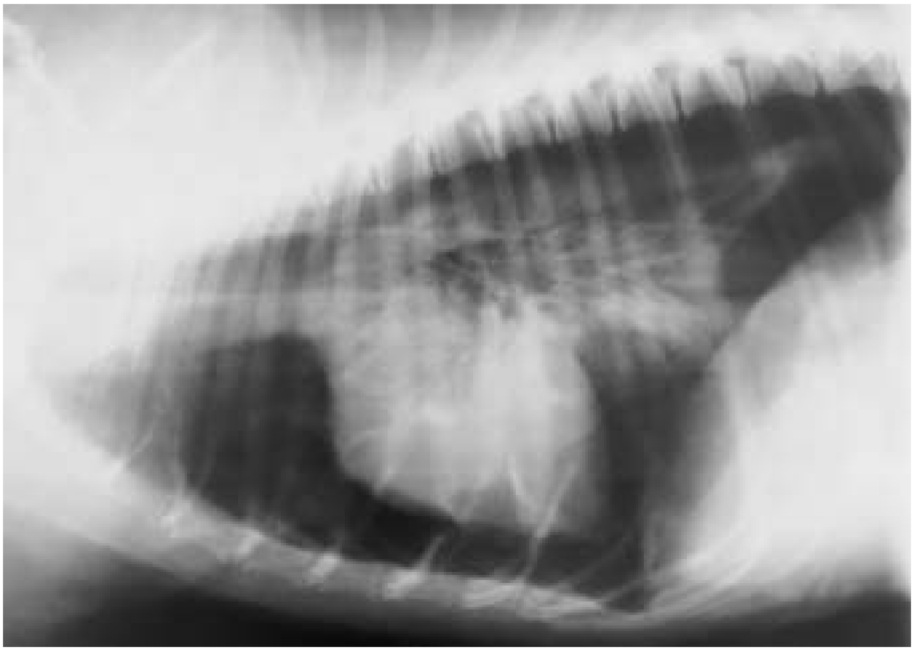
Case 2.75

Signalment/History: A 12-year-old, female Beagle belonging to a colony was subjected to anesthesia for a dental procedure. Following recovery, the dog was put into a cage for the night. The next day, the dog was depressed and did not respond to stimuli.

Radiographic procedure: The thorax was radiographed.

Radiographic diagnosis: Patchy pulmonary fluid was seen in all the lobes, though it was more severe ventrally. Air-bronchogram patterns were noted peripherally. No pleural fluid was noted. The trachea was dilated. The thoracic cavity was expanded.

Treatment/Management: The dog died shortly after the radiographs were made and was found at necropsy to have a generalized, acute aspiration bronchopneumonia secondary to aspirated vomitus.



Case 2.76

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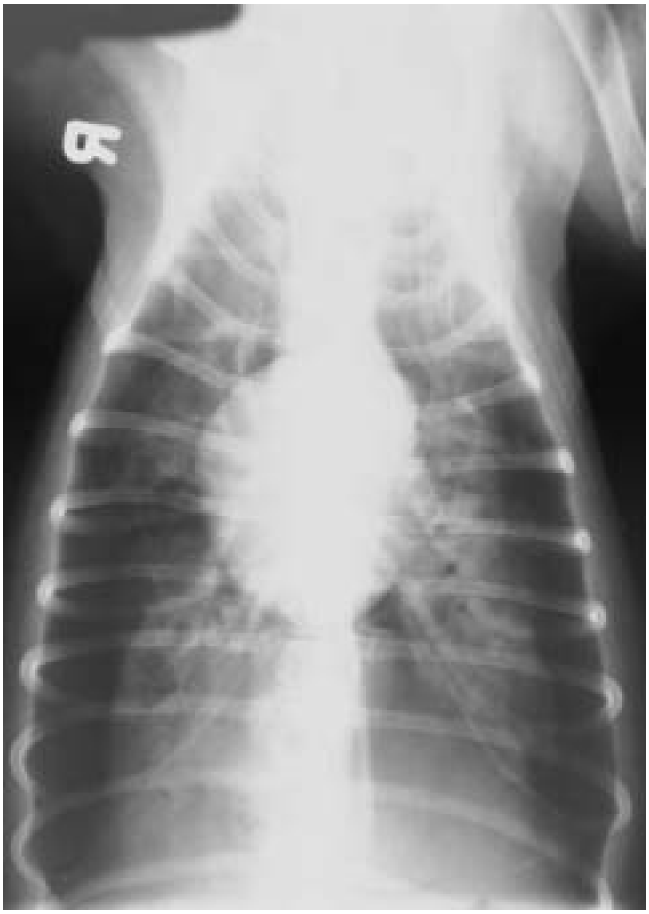

Signalment/History: "Zazzie" was a 15-year-old, female Poodle that had been given anesthesia for a dental extraction and had experienced a prolonged recovery. During this time, manual inflation of the lungs was performed several times. At presentation, she was awake but had difficulty in breathing.

Radiographic procedure: Radiographs were made to determine the cause of the dyspnea.

Radiographic diagnosis: A bilateral pneumothorax was associated with atelectic lungs, which included radiolucent cysts (pneumatoceles). No pleural fluid was noted. The chest cavity was expanded with the ribs at right angles to the spine. The cardiac silhouette was separated from sternum due to the pneumothorax.

Treatment/Management: The excessive pulmonary pressure as a result of the "bagging" during anesthesia could have resulted in rupture of pulmonary bullae causing the pneumothorax. These bullae may have been developmental or secondary to chronic emphysema.

It is remarkable that "Zazzie", after recovery, was admitted to the clinic two months later with severe dyspnea and a tension pneumothorax. She underwent cardiac arrest and died. On necropsy, the lungs were atelectic, but in a randomly irregular manner because of the interposed pulmonary cysts, which were thought to be developmental.

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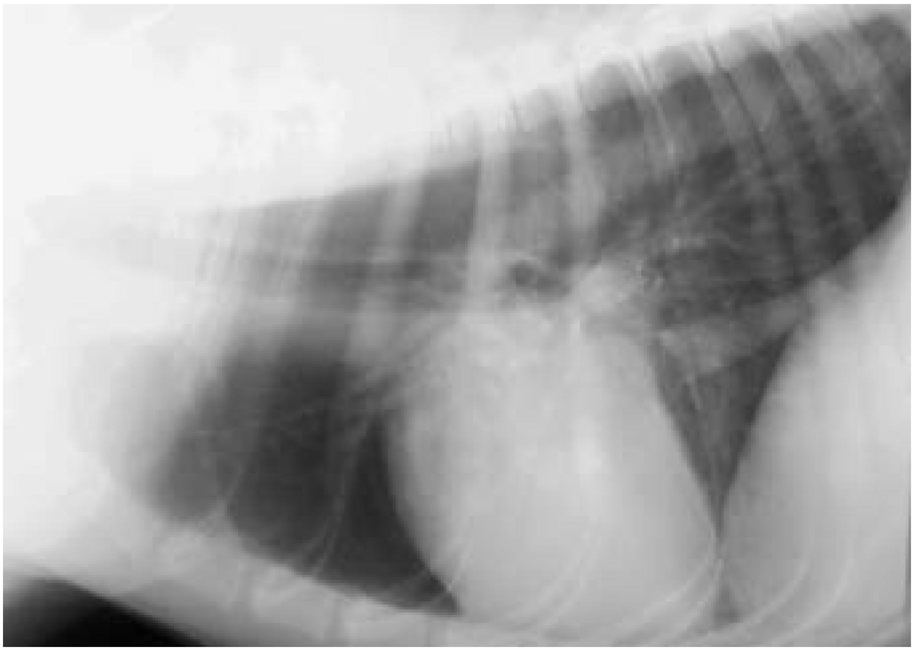


Case 2.77

Day 1

Signalment/History: "Codie", a 2-year-old, female German Shepherd, developed a sudden onset of dyspnea and a suspicion of trauma.

Physical examination: Because of the dyspnea, the thorax was radiographed immediately.

Radiographic diagnosis (day 1): Extensive pulmonary fluid caused prominent air bronchograms in the middle lobes. The etiology could not be elucidated from the radiograph; however, a dilated esophagus depressed the air-filled trachea and indicating the possibility of an aspiration pneumonia. Note that the pulmonary lesions are only clearly identifiable on the DV view. It is possible, but unusual for an airway-oriented pneumonia to have a bilateral symmetry such as in this case.

Treatment/Management: "Codie" was treated for pneumonia. She was operated on five days later for a suspected intussusception detected on palpation as an abdominal mass without any additional thoracic radiographs being made.

Day 6

Radiographic diagnosis (day 6): Radiographs made post-operatively showed a marked progression of the pulmonary lesions with the left caudal lobe being the only near-normal lobe. The remaining lobes had an increased fluid content with a prominent air-bronchogram pattern. Silhouetting with the heart shadow reflected the amount of fluid content in the lungs. The dilated esophagus remained evident and continued to depress the air-filled trachea.

Outcome: The dog subsequently died. At necropsy, esophageal dilatation plus a secondary inhalation pneumonia were found. The abdominal exploratory surgery added stress to the dog and also positioned it in dorsal recumbency for several hours, probably adding to the flow of the acid-rich gastric fluids into the lungs.

Comments: Several errors had possibly been made in the handling of this patient. First, the importance of the distended, air-filled esophagus present on the first radiographs was not appreciated. Second, a second set of pre-operative radiographs was not made due to the assumption that the status of the lungs would remain static. When radiographs were made post-operatively, the progression of what was then assumed to be aspiration pneumonia was evident.

2

2

Case 2.78

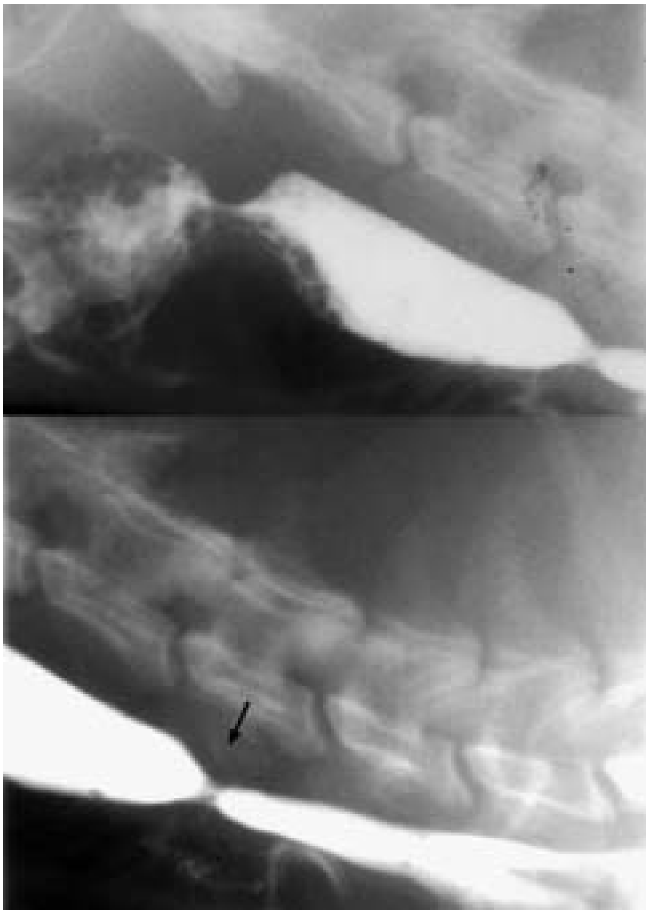
Referral

Signalment/History: "Fluffy", a 2-year-old, male DLH cat, was presented with a history of gagging and regurgitation of undigested food. If fed liquids, he did not vomit. These findings followed an earlier clinic stay lasting three weeks that had been required to correct a urinary blockage. He had been anesthetized during that hospitalization.

Radiographic procedure: Thoracic studies were made with liquid barium and barium mixed with kibble (dried cat food).

Radiographic diagnosis: The liquid swallow revealed a small esophageal stricture at the level of C4 (referral and liquid barium swallow, arrow). The kibble meal allowed a more thorough understanding of the stricture (arrow).

Treatment/Management: The stricture was thought to be due to an esophagitis as a result of regurgitation during recovery from the anesthesia.



Liquid barium swallow

Barium swallow mixed with kibble

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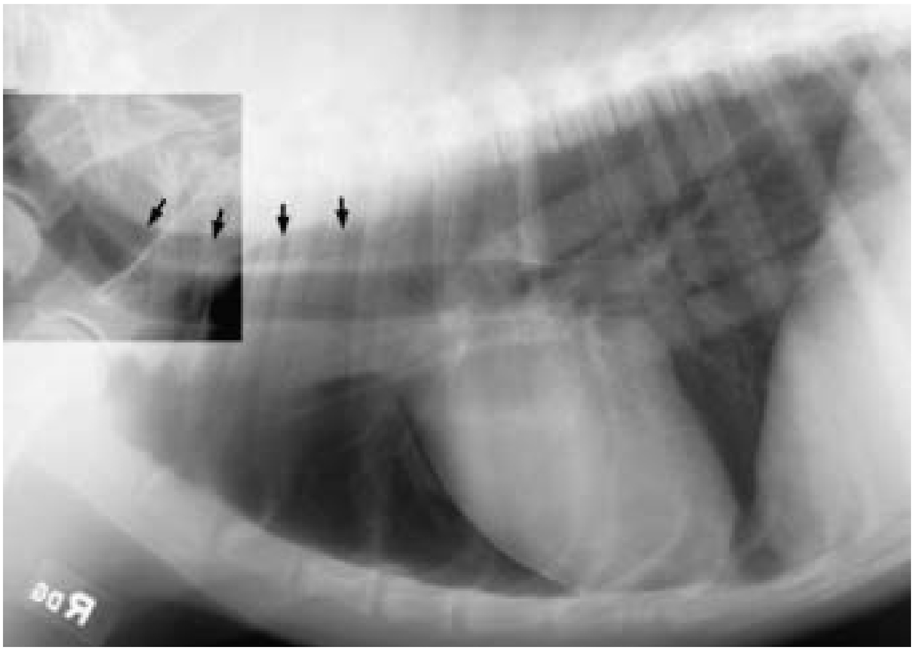


Case 2.79

Noncontrast

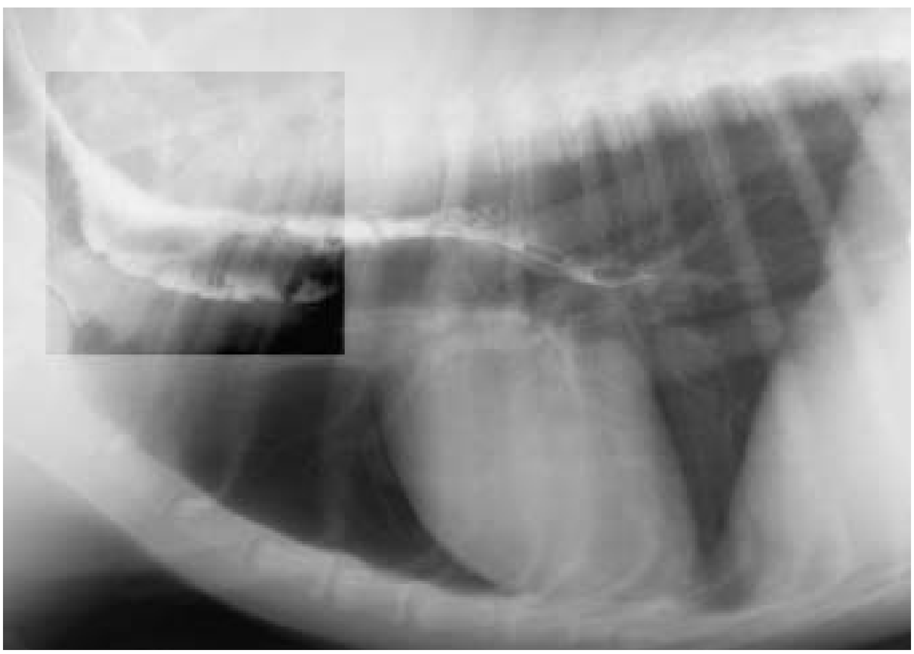
Signalment/History: "Shampoo" was a 10-year-old, male Labrador Retriever mixed breed with a chronic history of dysphagia and regurgitation. He ate only blended food and could only do that successfully if the food was placed in an elevated position. The clinical problem had started some days following abdominal surgery.

Radiographic procedure: Thoracic radiographs were made followed by contrast studies using only a liquid barium meal.

Radiographic diagnosis: An air-filled dilated esophagus extended from the thoracic inlet to the carina, and appeared to be "wrapped-around" the trachea (arrows). The mediastinum did not appear to be increased in size. The lungs appeared normal.

The bolus of barium sulfate showed a persistent proximal esophageal dilatation with a failure to pass an apparent stricture at the heart base. A portion of the more liquid swallow passed the constricted segment and flowed into the caudal portion of the esophagus. The mucosal surface appeared roughened. The exact nature of the esophageal lesion was not evident on these studies.

Contrast



Treatment/Management: Endoscopy was limited to the cranial portion of the esophagus where granular-type lesions could be identified within the wall. Fibrotic-like tissue extended across the esophageal lumen and appeared to act as strictures. Examination of tissue removed by biopsy was consistent with that resulting from a chronic esophagitis. The clinical history suggested that the injury to the esophagus could have been secondary to regurgitation at the time of the surgery.

2

2

Case 2.80

Day 1

Signalment/History: "Duke", a 10-month-old, male Golden Retriever, had a history of difficulty in swallowing. He was referred following an attempt to perform a contrast study of the esophagus in another clinic.

Physical examination: The dog was definitely dyspneic with abnormal lung sounds.

Radiographic procedure: Studies of the thorax were made.

Radiographic diagnosis (day 1): Barium sulfate contrast agent was seen within the main-stem bronchi of the four lobes of the right lung and a portion of the left lung. The bronchi appeared to be ectatic. The barium sulfate had the appearance of being obstructive and did not extend beyond the 3rd or 4th generation of bronchi. No evidence of lung disease could be seen. A diffuse pattern of barium sulfate remained within a dilated segment of the cranial mediastinal esophagus that seemed to place dorsal pressure on the hilar region.

Note the malposition of the right main-stem bronchi. This may be a result of hyperinflation of the left lung or could suggest a congenital right lung disease.

Day 3

Radiographic diagnosis (day 3): The barium sulfate within the main-stem bronchi remained unchanged from the earlier study except for the progression of the contrast meal into the left side. The bronchi continued to appear abnormal. There was no change in the size of the affected lung lobes and no increase in lung density suggestive of pneumonia or atelectasis. Clearance of the diffuse pattern of barium sulfate in the esophagus was noted.

Differential diagnosis: Bronchiectasis was suspected as it could explain why "Duke" could not clear the liquid foreign body that had been aspirated during the attempted esophogram. The contrast agent was thick as indicated by its density and failure to spread distally within the lungs.

The atonic wall of the dilated esophagus suggested chronic esophageal disease.

The radiographs of this bronchial foreign body clearly show one of the major problems in the use of contrast agents. Because the contrast agent appears to be tube-shaped, it is assumed that it is a solid plug; however, it may be only a coating of barium sulfate on the bronchial wall. That it was indeed a coating on the wall would explain not only how the passage of air continued to occur into all of the lobes and why the lungs failed to become atelectic with absorption of the air, but also why a pneumonia did not develop.

Treatment/Management: "Duke" was discharged without any explanation of the radiographic changes.

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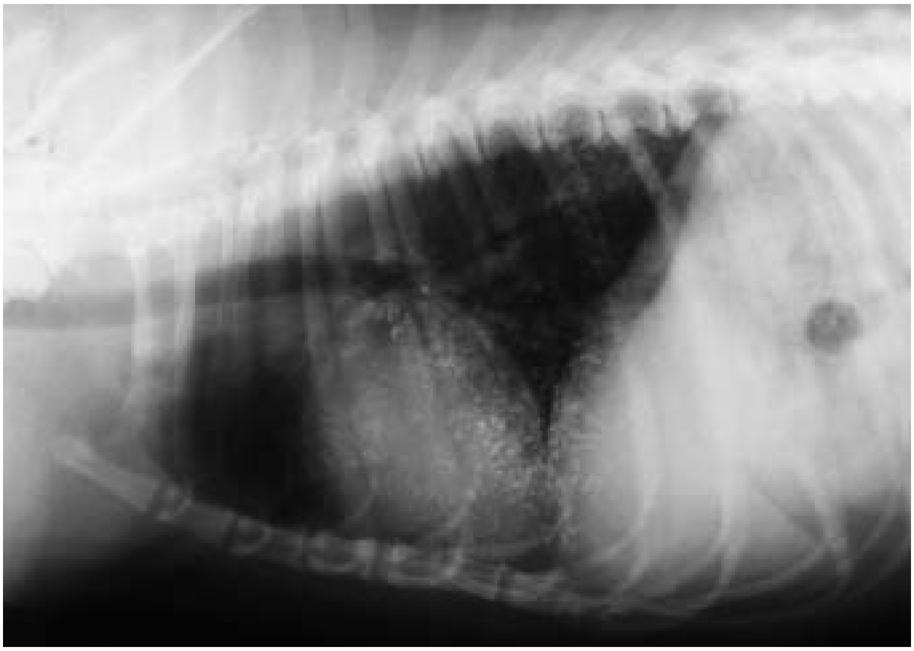


Case 2.81

Signalment/History: "Wow" was a 9-year-old, female Terrier with a history of chronic, intermittent vomiting for the previous six months. She had been given a barium sulfate upper-intestinal radiographic study at the referring clinic several days earlier.

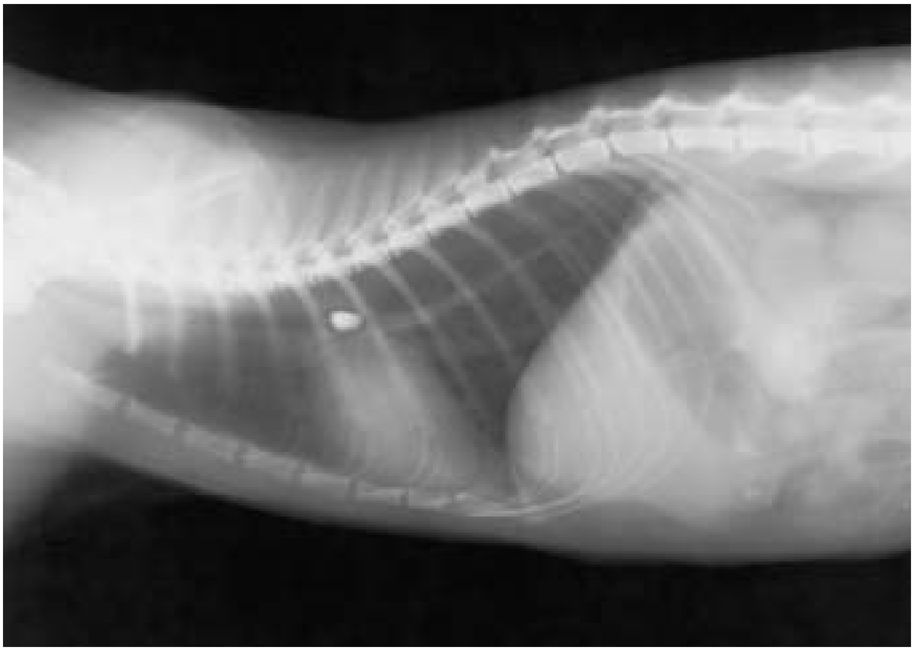
Radiographic procedure: She had thoracic radiographs prior to anesthesia for a scheduled laparotomy.

Radiographic diagnosis: Alveolarization of barium sulfate was primarily in the caudal lung lobes. No pulmonary masses, pleural fluid, or mediastinal shift were evident. No changes were present in the thoracic wall. The diaphragm was in its normal location. A spondylosis deformans typical for a dog of this age was also apparent.

Treatment/Management: Inhalation of barium sulfate suspension is not a life-threatening event when it is alveolarized and distributed widely as in this dog.

Differential diagnosis: In the absence of the clinical history in a case such as this, other causes of diffuse alveolar densities include several chronic diseases such as inhalation of powdered mineral material. This creates a radiographic pattern because of its density. Other inhaled materials such as asbestos or powered plant material could result in a secondary, alveolar mineralization throughout the lungs that might appear similar to the barium sulfate in this case.

2.2.13 Tracheal/bronchial foreign bodies



Case 2.82

Signalment/History: "Tuffy" was a mature, male DSH cat with a history of acute onset of coughing and dyspnea that was intermittent in severity.

Physical examination: Observation of the cat clearly showed a difficulty in breathing that changed in nature.

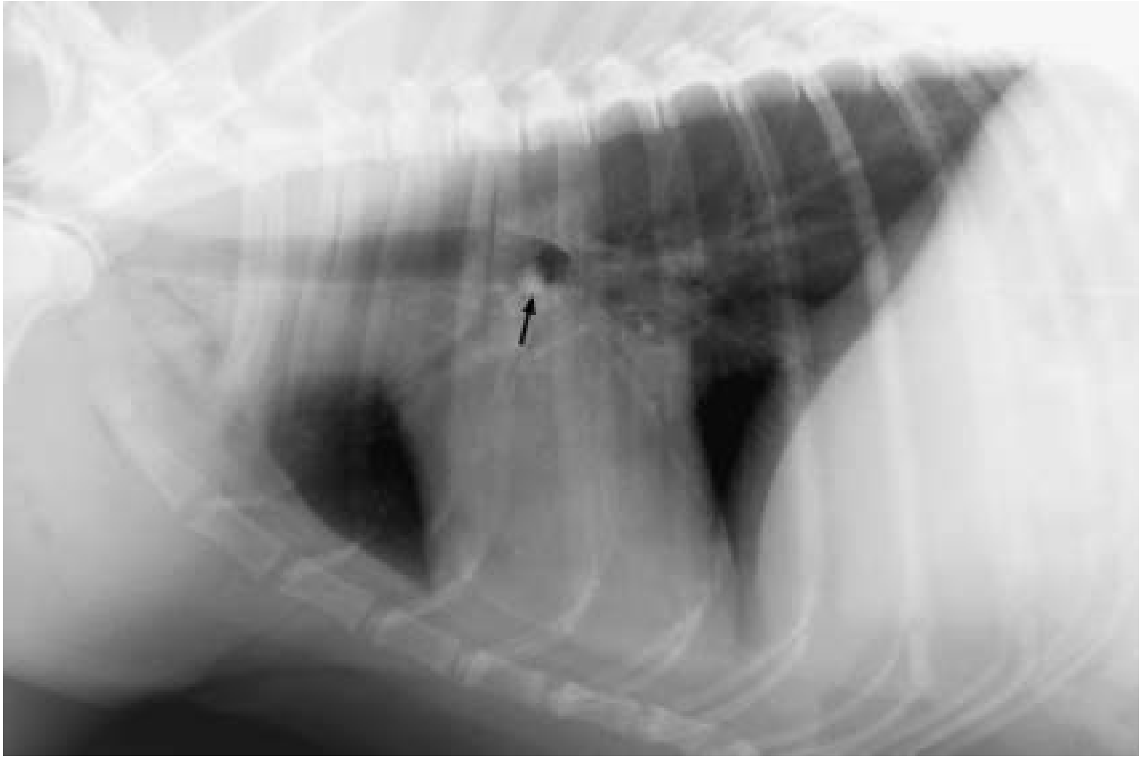
Radiographic procedure: Radiographs were made of the thorax.

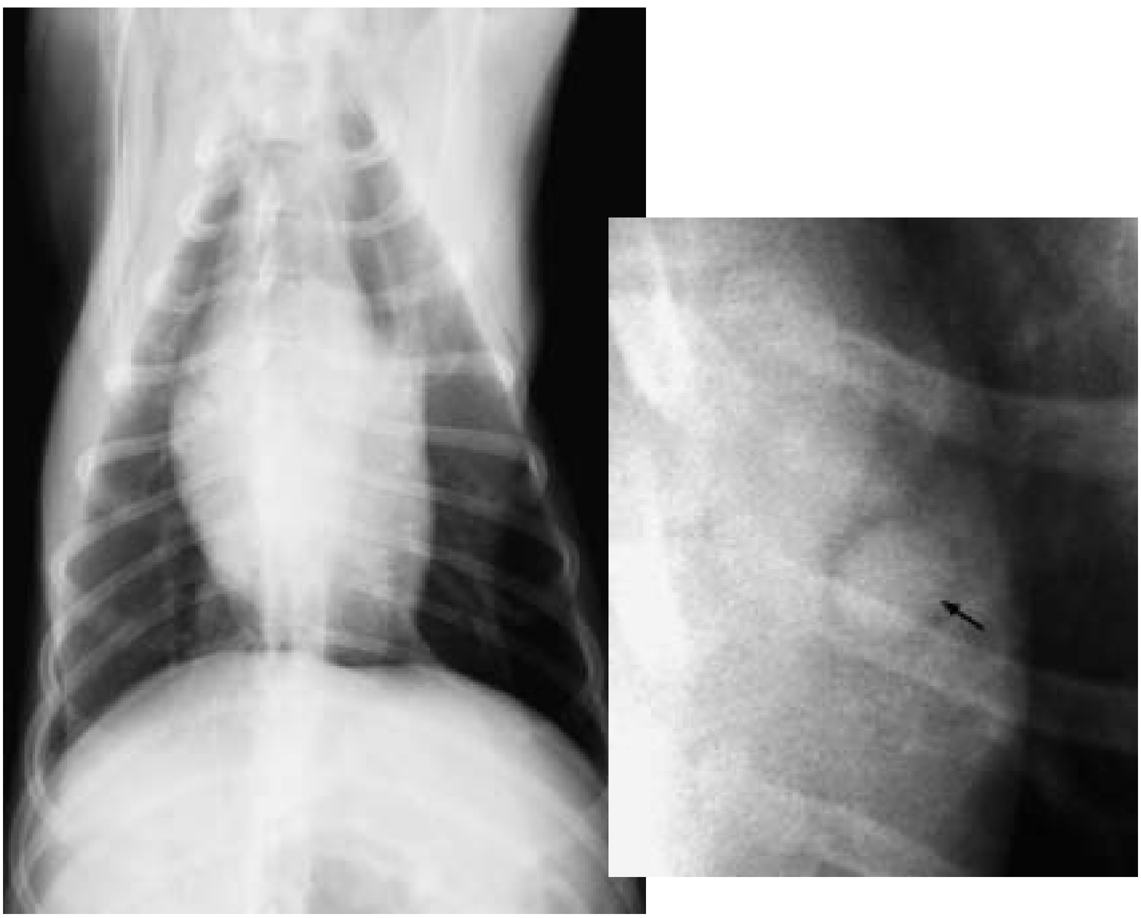
Radiographic diagnosis: A radiopaque foreign body filled the lumen of the trachea at the tracheal bifurcation. No inflammatory response was noted around the foreign body and the lung lobes did not show any signs of either obstructive atelectasis or obstructive emphysema.

Treatment/Management: A rock was removed through the use of bronchoscopy and "Tuffy" was discharged. Note the difficulty in identifying the foreign body on the DV view, even though it had a high tissue density.

Comments: A comparison of inspiratory and expiratory thoracic radiographs is valuable in determining the obstructive nature of a tracheal foreign body.

Case 2.83





Signalment/History: "Mia" was an 8-year-old, female Australian Cattle dog who had been attacked by four dogs the day before. She had received supportive care at an emergency hospital and was transferred to this hospital with severe bite wounds.

Physical examination: The dog had severe skin lesions; some of which had been treated surgically. More interesting was the dog's pattern of breathing that suggested a partial airway obstruction.

Radiographic procedure: Because of the respiratory signs, radiographs were made of the thorax. The stifle joint was also radiographed because of the bite wounds.

Radiographic diagnosis (thorax): A circular, sharply defined, radiodense object lay within the lumen of the right cranial main-stem bronchus and was suspected to be a foreign body (arrows). The remaining pulmonary structures were within normal limits. The cardiovascular structures were within normal limits. Subcutaneous emphysema in the soft tissues on the right lateral cranial thorax was prominent. The appearance of the foreign body varied according to which side of the patient was dependent at the time of radiography.

Radiographic diagnosis (stifle joint lateral view): A severe soft tissue injury with subcutaneous emphysema involved the left pelvic limb. It had been treated with gauze pads identified by radiopaque markers. A rubber Penrose drain was near the stifle joint. No evidence of bone or joint injury could be seen.

Treatment/Management: The bronchial foreign body influenced the clinical signs of this patient, but it is somewhat difficult to relate it to the traumatic incident. It is possible the foreign body had been present for some time without causing an obstruction, although it had stimulated a chronic bronchitis. The peribronchial shadows are more prominent than expected although "Mia" was 8 years of age and the prominence of the airway shadows can be age related.

Comments: Examine the pulmonary vessels and judge if the dog is in shock.

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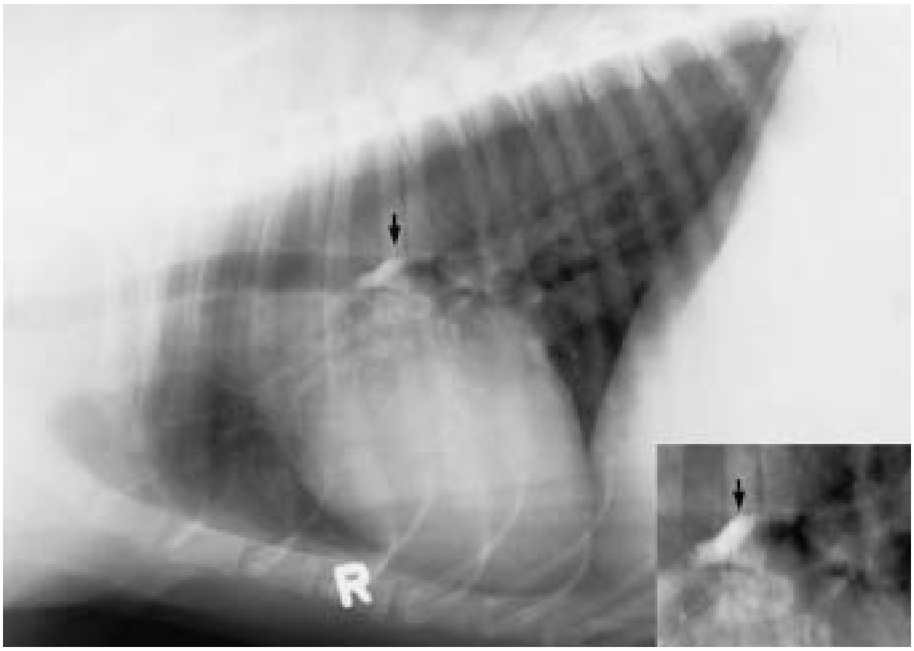


Case 2.84

Signalment/History: "Ginger" was a 7-year-old, female German Shepherd who had had an acute onset of wheezing and coughing seven days earlier. She had been treated systematically for the past week and then referred for further examination.

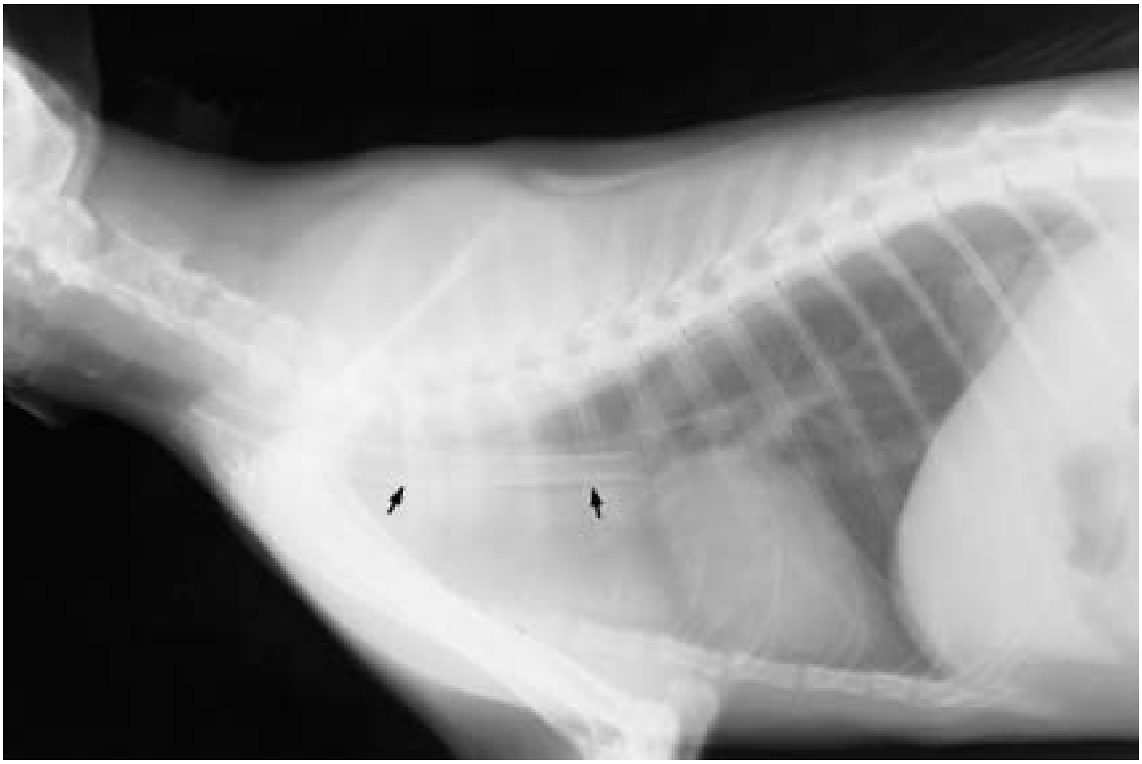
Physical examination: A cough could be elicited by palpation of the cervical trachea.

Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis: A radiodense foreign body with a density similar to that of bone was present just proximal to the carina (arrows). No evidence of bronchial obstruction was noted.

Treatment/Management: The foreign body was removed by bronchoscopy. Note the more coarse lung markings in this older dog are probably the result of chronic airway disease (bronchitis). Prominent skin folds lay across the ventral thorax.

Case 2.85

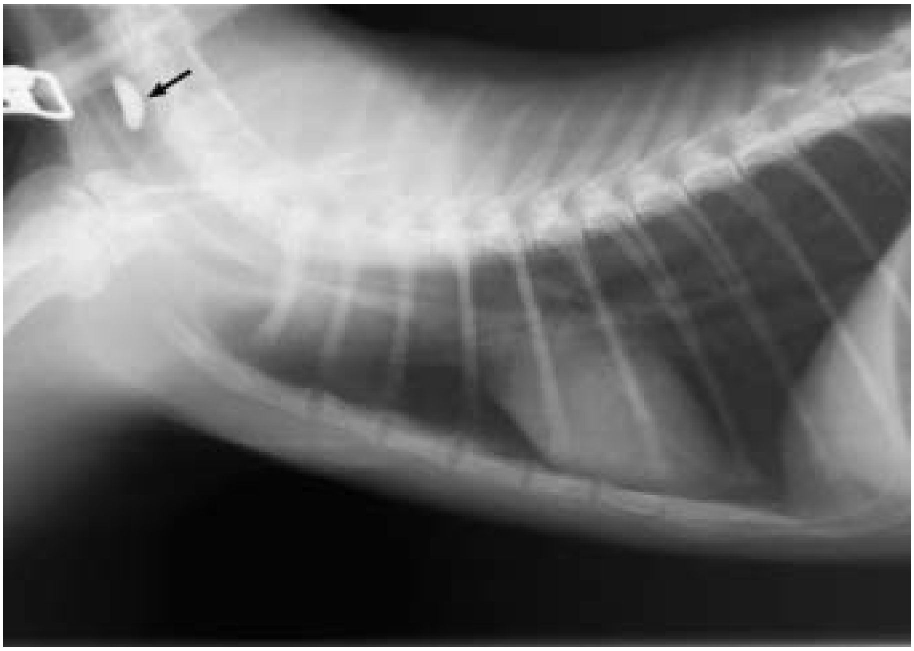


Signalment/History: "Jenny", a 1-year-old, female DSH cat, had been subjected to elective surgery and was in recovery, when it was noted that the endotracheal tube, which had not been previously removed, had been chewed in half.

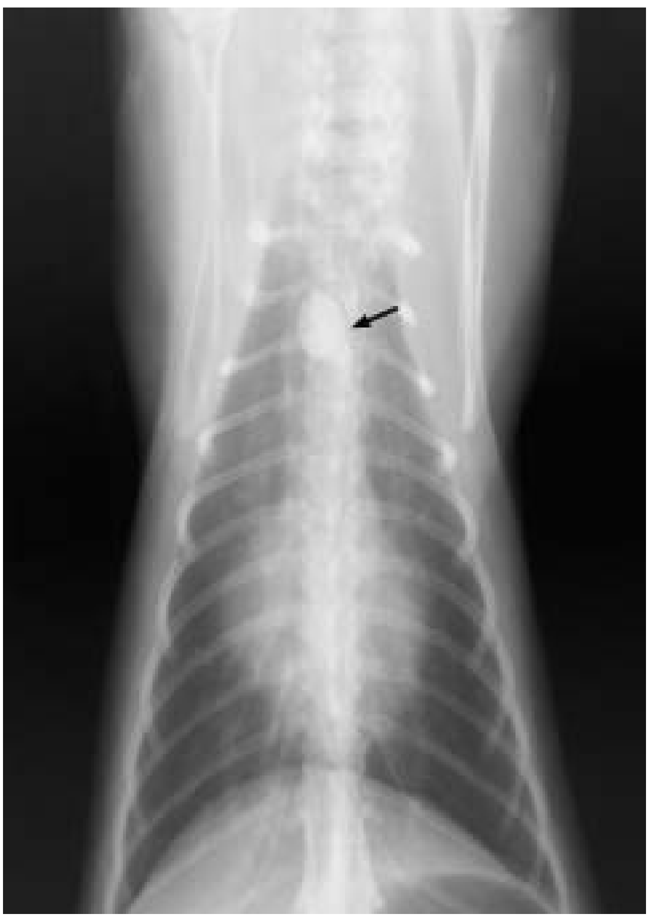
Radiographic procedure: A single lateral view of the cervical region and thorax was made.

Radiographic diagnosis: A portion of the endotracheal tube was located in the distal portion of the trachea (arrows).

Comments: Positioning of the forelimbs in this manner makes it possible to evaluate both the cervical and thoracic segments of the trachea.



Case 2.86



Signalment/History: "Muffet" was a 3-year-old, female DHL cat with a three- to four-day history of a harsh cough.

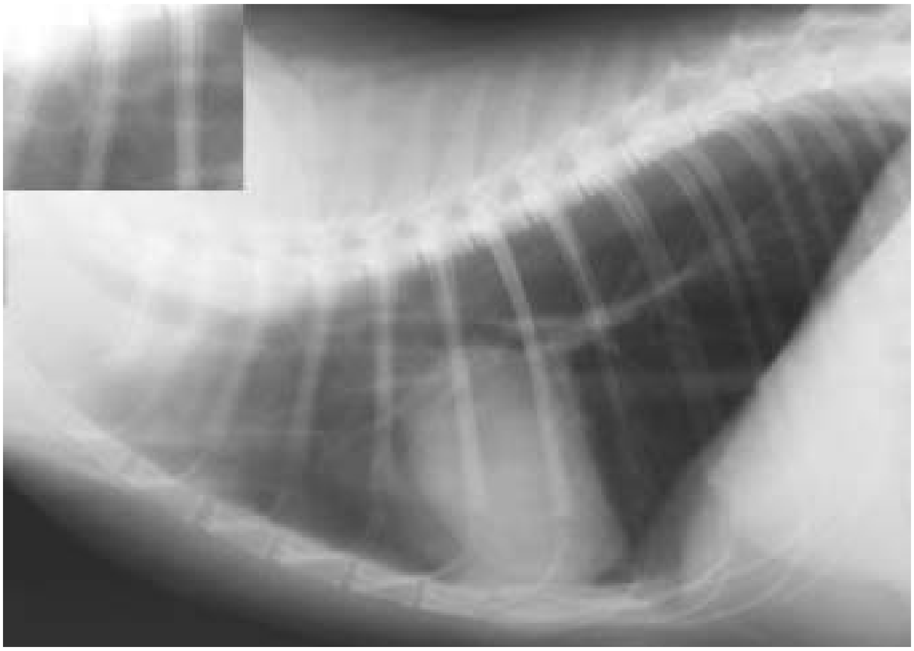
Physical examination: The lungs were difficult to auscultate. The abdomen on physical examination was distended with gas-filled bowel loops.

Radiographic procedure: The thorax was radiographed because of the clinical signs.

Radiographic diagnosis: A radiopaque, mid-cervical, freely movable tracheal foreign body was present, most probably a pebble (arrows). The hyperinflated lung fields were an indication of the partially obstructive nature of the foreign body. The gas-filled cranial esophagus and distended stomach were possibly stress related.

Treatment/Management: An upper airway foreign body can function as a valve permitting the passage of air in only one direction. In "Muffet", it appears as though the pebble permitted air to pass into the lungs, but it at least partially obstructed the trachea on expiration resulting in an obstructive emphysema.

The free movement of the foreign body could be ascertained by a comparison of the location of the object on the two views. This movement could result in changeable clinical signs with the foreign body being obstructive only part of the time.



Case 2.87

2

Signalment/History: "Raja" was a 2-year-old, male Siamese cat that had been struck by a car two weeks previously. He then had began to show both an inspiratory and an expiratory dyspnea that became more severe. Earlier radiographs were not available for examination.

Physical examination: He was difficult to examine because of the dyspnea.

Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis: A tracheal stenosis was identified by an interruption in the pattern of the air-filled intratracheal shadow at the level of T3–4. A pneumomediastinum reported on earlier radiographs was no longer present.

Treatment/Management: At the time of surgery, a 1–2 cm long fibrous band extended between the torn ends of the trachea. This tube-like structure was removed and a tracheal anastomosis was performed. Post-surgical radiographs showed a trachea with a lumen of normal width.

Comments: The studies were limited to lateral views because of the difficulty in visualization of the trachea on the DV/VD views. It is possible to make VD oblique views to provide additional information about the trachea.

Case 2.88

Signalment/History: "George" was an 11-year-old, male DSH cat with a four-week history of coughing, wheezing, and dyspnea. These symptoms were partially responsive to prednisone therapy. Previous endoscopy had shown an edematous larynx and biopsy revealed a laryngeal polyp.

Physical examination: Increased respiratory stridor was noted on physical examination with an increased expiratory effort. Palpation of the trachea and larynx, as well as an oral examination were unremarkable. An intrathoracic obstructive lesion was suspected.

Radiographic procedure: Lateral views were made of the cervical region and a complete study of the thorax.

Radiographic diagnosis: Indistinct shadows in the terminal trachea and carina suggested a tracheal foreign body or mass (arrows). The mediastinum had a greater fluid density over the base of the heart. The diameter of both the extrathoracic and intrathoracic trachea was small. The lungs were hyperinflated without infiltrative or pulmonary mass lesions. The minimal peribronchial shadows were compatible with the age of the patient. The diaphragm was caudal and flattened. The patient was noted to be obese. The spondylosis deformans present was compatible with the cat's age. A metallic air-gun pellet lay in the soft tissues ventral and to the left of the rib cage.

Treatment/Management: Bronchoscopy revealed a small (0.5 x 1.0 cm), flat rock covered with casseous exudate at the level of the carina. Following removal of the foreign body, "George" was placed on Clavamox for 10 days to prevent extension of the secondary bacterial infection. He was then discharged with resolution of his dyspnea.

Comments: It is considered poor medical practice to treat a patient with a history of respiratory distress for four weeks without making a radiographic study of the thorax.

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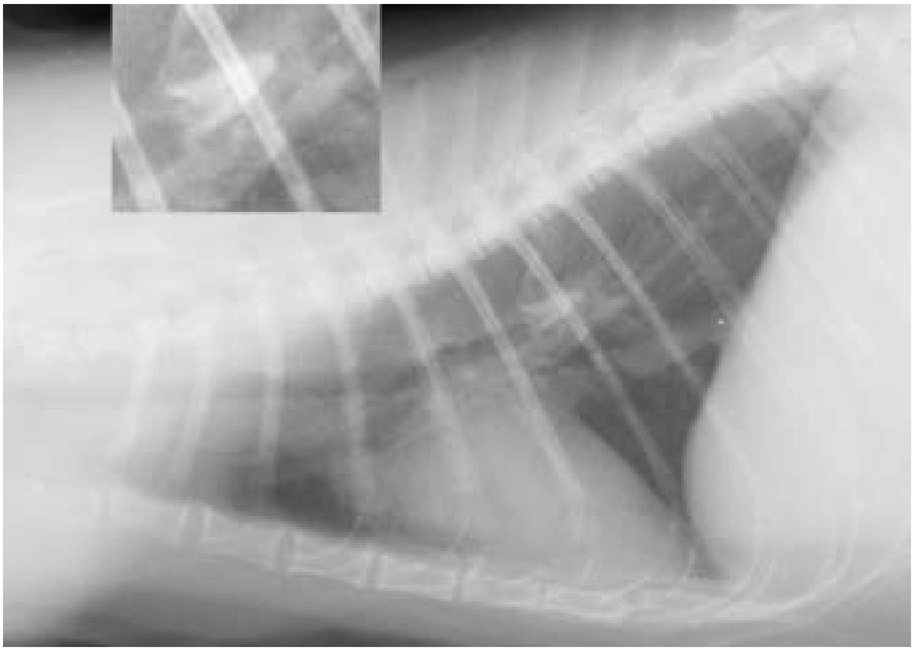


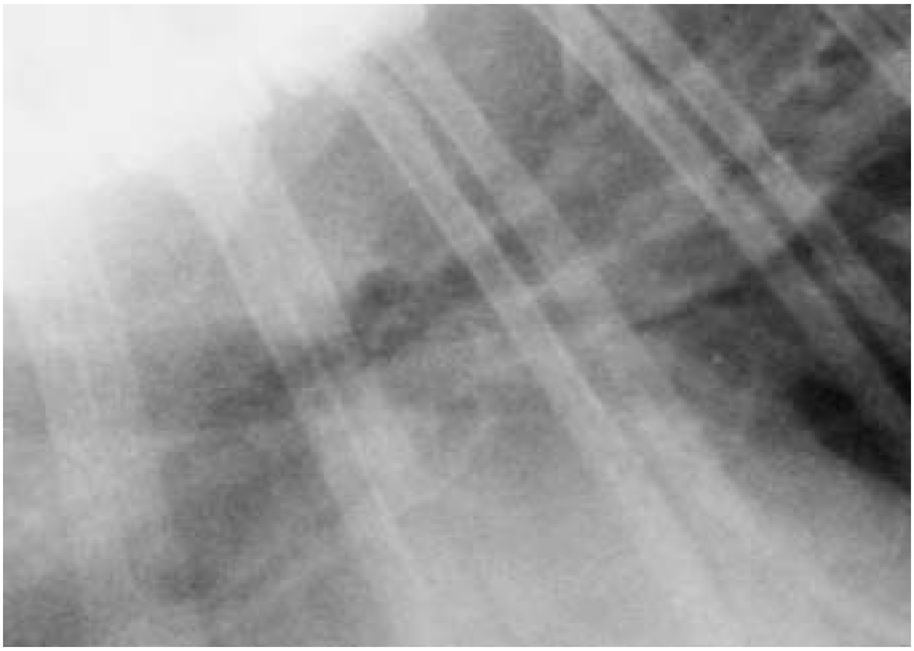
Case 2.89

Day 1

Signalment/History: "Smoochy", a 7-year-old, female DSH cat, was presented with a history of having had a bronchoscopy examination two weeks previously in search of a tooth that was thought to have been inhaled.

Radiographic procedure: The radiographic examination was a search for the missing tooth.

Radiographic diagnosis (day 1): A radiopaque foreign body was located in the right, main-stem bronchus to the caudal lung lobe and had the appearance of a tooth. Minimal lung congestion with the appearance of a plate-like atelectasis was evident distal to the obstruction. The minimal mediastinal shift to the right was probably due to the atelectasis. The remaining lung fields were normal.



Day 2

Radiographic diagnosis (day 2): The previously identified radiopaque foreign body had been removed. The lung congestion distal to the site of the foreign body was less prominent. A static left-sided cardiomegaly was evident.

Comments: The foreign body appeared to be slightly obstructive causing atelectasis of the right lung and compensatory hyperinflation of the left lung. This imbalance had been corrected by the time of the second study.

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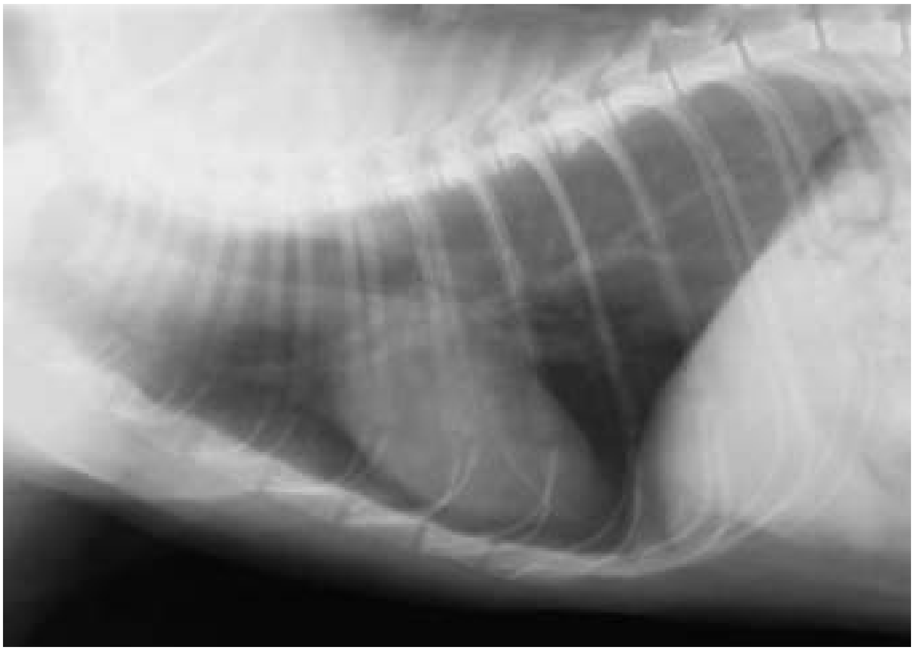


Case 2.90

Day 1

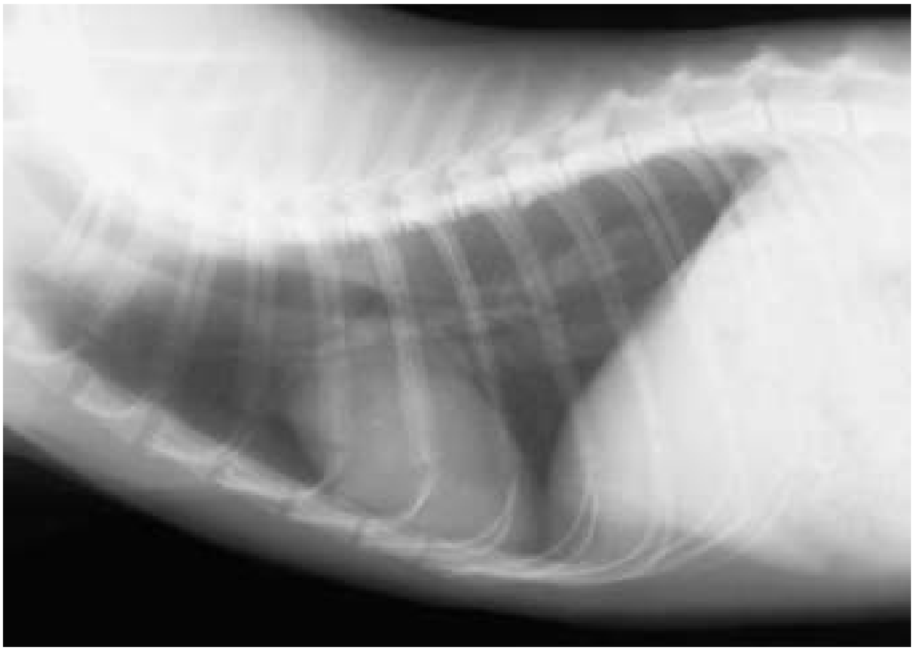
Signalment/History: “Bruce” was a 1-year-old, male DSH cat with an acute onset of “gagging”.

Physical examination: The rate of respiration was increased and a marked expiratory effort was noted.

Radiographic procedure: Routine studies were made of the thorax.

Radiographic diagnosis (day 1): An increase in fluid density within the left caudal lung lobe was associated with a mediastinal shift to the left. This appeared to be an obstructive atelectasis and could have been associated with a bronchial foreign body. The air-filled trachea was truncated at the hilar region as seen on the lateral view. The failure to see the normal air-filled carina supported the diagnosis of an intratracheal foreign body.

Treatment/Management: The foreign body was a plant head and it was removed from the left main-stem bronchus using a bronchoscope.



Day 2, post surgery

Radiographic diagnosis (day 2, post surgery): The re-inflation of the obstructed lobe had occurred in the previous two days. The mediastinal shift was no longer present, and the appearance of the hilar region was normal.

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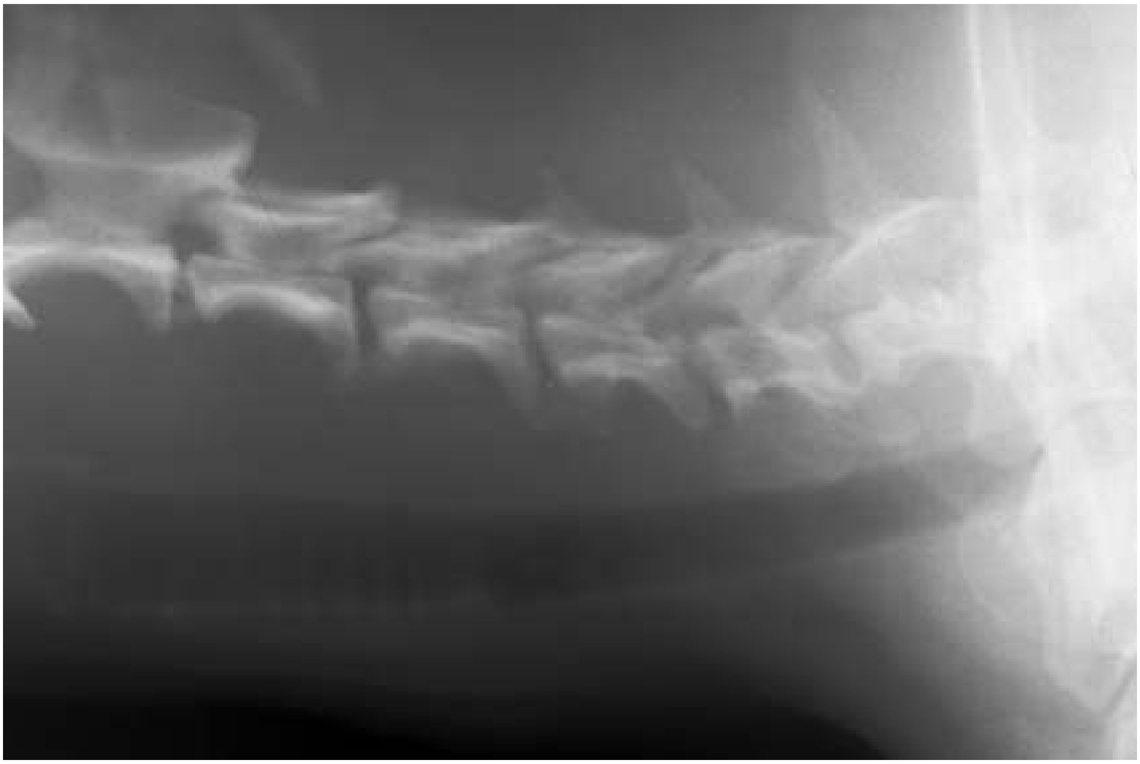
2.2.14 Tracheal injury

Case 2.91

Day 1

Day 8

2



Day 23

Signalment/History: "Tina" was a 2-year-old, female Pit Bull Terrier mixed breed with a history of having been in a fight with another dog one month earlier. She had difficulty in swallowing, which had begun at the time of the fight and she had vomited partially digested food at times since then, unassociated with eating. Her breathing was difficult.

The radiographic interpretation of the thorax one month previously showed the lungs to be poorly inflated resulting in an increase in both interstitial and peribronchial density.

Radiographic procedure: Because of the history of a bite wound to the neck, the radiographic study was directed toward that region.

Radiographic diagnosis (day 1, cervical region): The tracheal stenosis was 1 cm in length and involved 5 or 6 tracheal rings at the level of C5. The lesion was probably posttraumatic.

Radiographic diagnosis (day 8 post surgery, cervical region): The lumen of the stenotic segment was wider and was almost $^2/_3$ of its normal diameter. A ring of soft tissue protruded into the tracheal lumen at the level of C5. The ventral soft tissue edema was probably postsurgical.

Radiographic diagnosis (day 23, cervical region): The diameter of the post-traumatic tracheal stenosis was almost normal and the ring of intraluminal soft tissue at level of C5 had almost completely regressed.

Treatment/Management: The surgical biopsy revealed fractured tracheal rings with one ring protruding into the lumen being the primary cause for the stricture. The broken rings were calcified forming a cartilaginous callus around the trachea.

It is interesting that the clinical signs had suggested a problem with swallowing; however, the immediate treatment was directed toward the tracheal stenosis. The possibility of adjacent esophageal injury would indicate the need for study of that organ as well.

2

2.2.15 Esophageal foreign bodies

Case 2.92

Noncontrast

Barium swallow

Signalment/History: "Tina Maria" was a 14-year-old, female Miniature Poodle with a clinical history suggestive of an esophageal foreign body for the previous three weeks.

Physical examination: The dog was alert but thin with almost no body fat.

Radiographic procedure: Both non-contrast and contrast studies were performed in an evaluation of the esophagus.

Radiographic diagnosis: A radiodense esophageal foreign body with the marginal features and density of a bone was located just dorsocranial to the heart (arrow). No air or fluid was noted within the mediastinum as would have been expected if the esophageal wall had been punctured. Tracheal elevation was associated with bilateral cardiomegaly.

The barium sulfate swallow confirmed the location of the foreign body and showed no leakage of the contrast agent. The foreign body was not obstructing and permitted fluid to pass, thus enabling the patient to survive during the previous three weeks.

Treatment/Management: The bone was removed surgically; however, the patient died one day later. At necropsy, the esophagus had a single perforation 1 mm in diameter at the site of the foreign body. The trachea also had a 1 mm in diameter hole in the center of the inflammatory response at the same location. These findings support the clinical history of the foreign body having been present for three weeks and indicate the nature of the secondary changes that can occur in the event of failure to remove a foreign body promptly, especially if it has sharply protruding parts that can penetrate the esophageal wall.

Comments: Unfortunately, a focal mediastinitis cannot usually be identified on a radiographic study of the esophagus, with or without contrast agent, because the pocket of inflammation closes the sites of penetration and does not alter the appearance of the esophagus, trachea, or surrounding mediastinum. Even if air should escape through the site of penetration, the amount is usually so minimal that it cannot be recognized on a radiograph.

2

Case 2.93

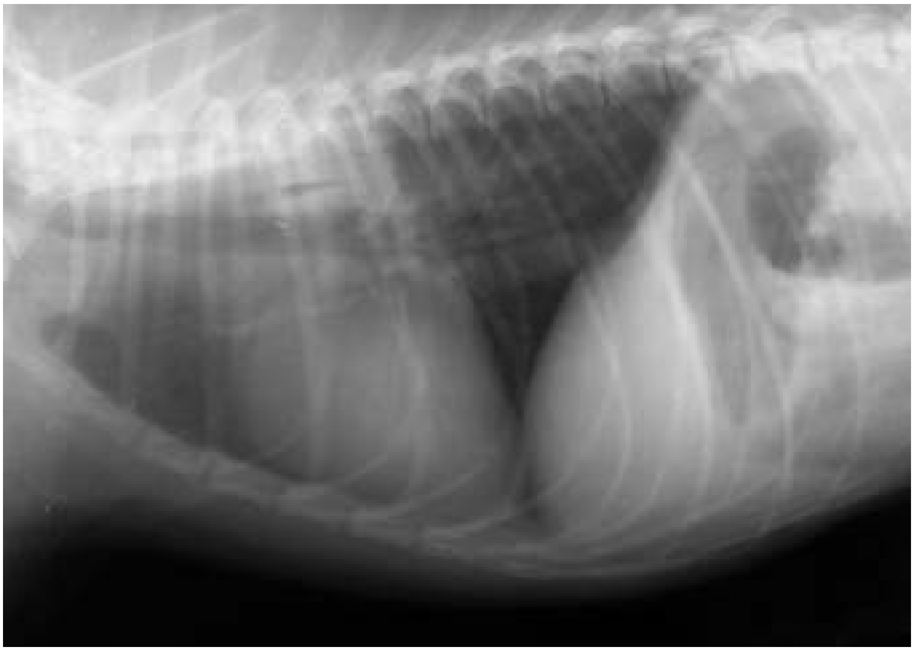
Day 1

Signalment/History: "Abby" was a 3-year-old, female mixed breed who had been intermittently retching after having eaten a "rawhide bone" eight days earlier. Referral radiographs were available for examination.

Radiographic diagnosis (day 1, referral lateral view only): An increase in fluid density in the dorsocranial mediastinum suggested the presence of a radiolucent esophageal lesion, possible a foreign body. A localized mediastinitis associated with the lesion could explain the presence of some of the fluid. No evidence of a pulmonary lesion was noted.

Radiographic diagnosis (day 3, referral lateral view only): The mediastinal mass had a similar appearance as on day 1.

Radiographic diagnosis (day 3, referral lateral view only with barium sulfate swallow): The contrast swallow identified a linear intraluminal object within the distended esophagus over the heart base. A part of the swallow had passed into the stomach.



Day 3

Day 3, barium swallow ▶▶

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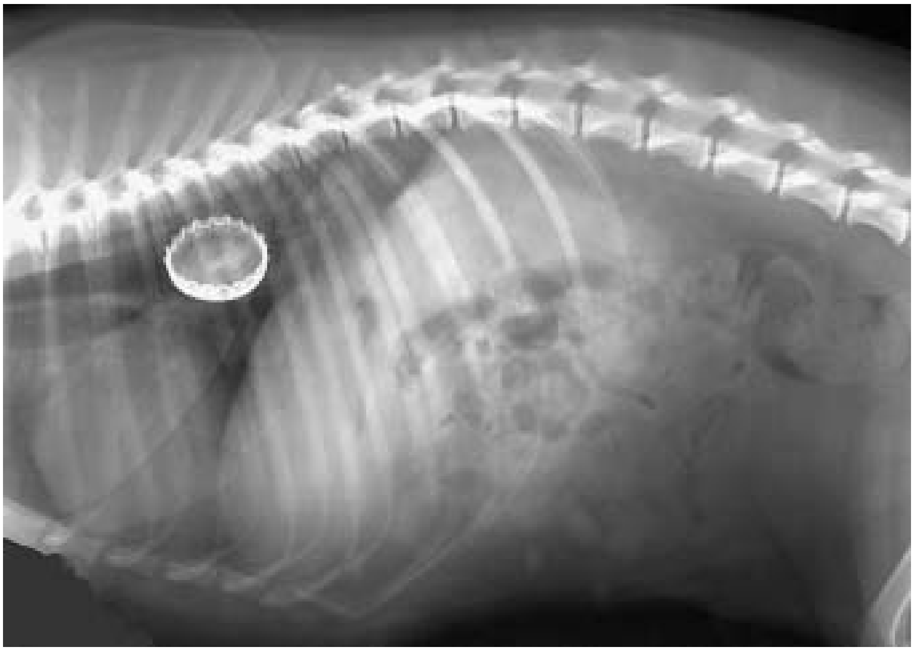
Day 4

Radiographic diagnosis (day 4, referral DV and lateral view): The liquid density mass over the heart base was unchanged. However, collapse of the right cranial lobe with an air-bronchogram pattern was indicative of collapse due to aspiration pneumonia or an obstructive atelectasis associated with an extrabronchial mass.

Treatment/Management: The pulmonary lesion compromised what might have been a simple esophageal foreign body and suggests penetration or a periesophageal inflammatory lesion. "Abby" died shortly after surgical removal of the esophageal foreign body due to a ruptured esophagus. It was not clear from the clinical record why surgical removal of the foreign body had been delayed.



Case 2.94

Signalment/History: "Boscoe" was a mature female Beagle with a history of repeated attempts to regurgitate food.

Radiographic procedure: Whole-body radiographs were made to look for a foreign body.

Radiographic diagnosis: A radiopaque esophageal foreign body lay within the caudal aspect of the esophagus. The lung fields were within normal limits.

Treatment/Management: A bottle cap was withdrawn from the esophagus using a retractor.

2

Case 2.95

Without esophageal tube

With esophageal tube

2

Signalment/History: "Muggy" was a 5-month-old, male Lhasa Apso who had swallowed a fishhook.

Radiographic procedure: Radiographs included the cervical esophagus.

Radiographic diagnosis: The first radiographs showed the hook at the thoracic inlet with the point more distal. The VD view showed the cranial mediastinum was widened, but a puppy this age has a persistent thymus gland that can prove difficult to differentiate from mediastinal thickening secondary to injury.

A second study was made with an esophageal tube in position. The hook had turned but not moved, suggesting that it was fixed in position.

Treatment/Management: An unsuccessful attempt was made to retract the hook with the result that it was driven firmly into the esophageal wall. It was then removed on a subsequent attempt using an endoscope.

2

2.2.16 Esophageal injury

Case 2.96

Noncontrast

Signalment/History: "Pia", a 1-year-old, female Queensland Heeler, was presented with acute signs of vomiting and discomfort.

Physical examination: Following examination, the tentative diagnosis was that of a diaphragmatic hernia. However, the presence of subcutaneous emphysema did not exactly fit that diagnosis.

Radiographic procedure: Studies were made of the thorax and cervical region. These were followed by a barium swallow.

Radiographic diagnosis (noncontrast): Subcutaneous emphysema and pneumomediastinum made evaluation of the infiltrative pattern throughout the lung fields difficult to evaluate. The mediastinum was increased both in depth and width, suggesting an accumulation of mediastinal fluid associated with a mediastinitis. The cause of the mediastinal air and fluid could not be determined. The cardiac silhouette was shifted to the right perhaps influenced by the VD positioning. The diaphragm was intact on both views.

2

Barium swallow

Radiographic diagnosis (barium swallow): The liquid contrast agent was injected through a tube with its tip lying in the proximal portion of the esophagus. The liquid immediately leaked into the periesophageal tissues on the left side and into the mediastinum. Leakage of this magnitude indicated an extensive tear in the wall of the esophagus (arrows).

Treatment/Management: "Pia" died shortly after the examination and the owners prevented a necropsy examination. It was thought that the dog had received a severe bite wound; however, the owner refused to support this possibility.

Case 2.97

Liquid barium swallow

Signalment/History: "Hastey Hattie" was a 1-year-old, male mixed breed cat that had been experiencing vomiting immediately after eating solid food for the previous four weeks.

Radiographic procedure: Studies of the thorax were followed by contrast studies including both liquid and solid swallows.

Radiographic diagnosis: An esophageal stricture was indicated by identification of a narrowing of the lumen that permitted passage of the liquid swallow. The esophageal meal identified the lesion more clearly with the failure of the solid food to pass through it.

Treatment/Management: The studies made with the liquid meal showed passage through the site of stricture with only a suggestion of a hold-up at the level of C6–7. The studies made with the liquid agent mixed with normal cat food created a bolus that was unable to pass through the site of esophageal stricture at C6–7 (arrows). It caused a dilation of the proximal esophagus until such a time when the cat regurgitated the bolus. The owners refused treatment and promised to control the nature of the food given to the cat.

Solid barium swallow

2

2

Case 2.98

Noncontrast

Signalment/History: "Chu" was a 6-month-old, male Sharpei with a history of post-prandial vomiting over the previous few days. An esophageal obstruction was suspected because of "toys" that were missing from the home.

Radiographic procedure: Routine thoracic studies were made followed by a positive contrast esophagram.

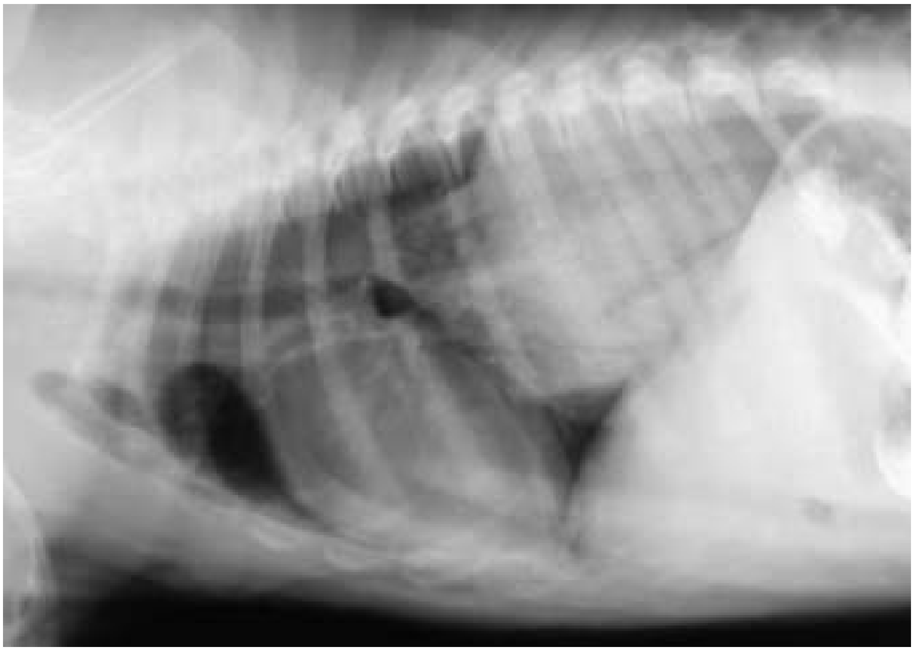
Radiographic diagnosis (thorax): Two large sharply marginated, thin-walled, fluid and air-filled saccular structures with two separate compartments were noted within the caudal thorax dorsally on the midline. It was thought they represented air-filled caudal mediastinal masses. The caudal trachea was displaced ventrally supporting the diagnosis of a mediastinal mass. The right caudal lobe bronchus was shifted laterally and ventrally with minimal collapse. A bronchial pattern caused the presence of "ring signs" and "tram lines". The ribs were expanded markedly. Skin folds falsely suggested a pneumothorax on the DV view.

Esophagram

Radiographic diagnosis (esophagram): A gastric hiatal hernia of the fundic portion of the stomach was identified following the use of a double contrast study with barium sulfate mixed with air. It extended cranially to the level of T7. Rugal folds were seen extending across the line of the diaphragm confirming the hernia. An increased density of the accessory lung lobe suggested aspiration pneumonia plus a possible atelectasis. The dog's swallowing function was normal under fluoroscopy; however, the esophagus was redundant at the thoracic inlet and caudal to the heart shadow.

Comments: Conducting the radiographic study was complicated by difficulty in positioning of the patient and there was a question of whether the saccular structure was filled with fluid or air. The bronchial pattern indicated probable chronic aspiration with secondary chronic bronchitis.

2



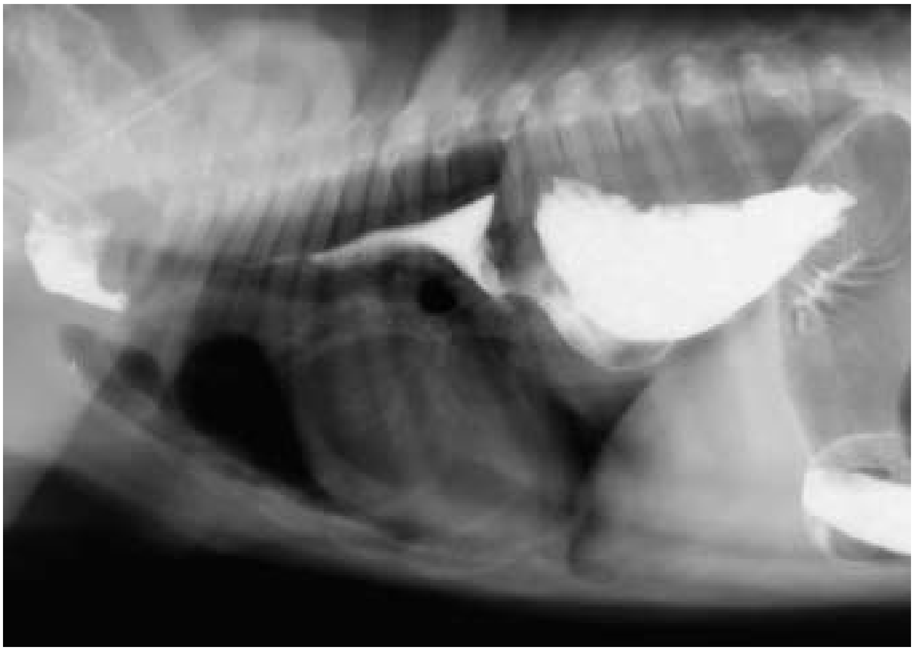
Case 2.99

Noncontrast

Signalment/History: "Widgie", a 4-month-old, male Sharpei, was presented with a history of anorexia for two weeks. It was suspected that he had been "bothered" by dogs belonging to the neighbors. The dog was in acute depression, hypothermic and in shock.

Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis (noncontrast): A large, sharply marginated soft tissue density mass in the right hemithorax was located dorsally with a portion appearing to extend into the caudal left hemithorax. The mass was thought to be a pulmonary mass or a caudal mediastinal mass. In addition, there was a widening of the cranial mediastinum. The bronchus to the accessory lobe was displaced laterally and an air-bronchogram pattern in the right caudal lobe suggested pneumonia or an atelectic lobe. The bronchial pattern in the left cranial lobe suggested chronic inhalation. The prominent skin folds were typical for the breed.



Esophagram

Radiographic diagnosis (esophagram): A gastric hiatal hernia of the fundic portion of the stomach with rugal folds extending into the thoracic cavity was identified. The increased density of the accessory lung lobe was more clearly defined suggesting aspiration pneumonia and/or atelectasis. The lateral displacement of the left accessory lobe bronchus was apparent as in the noncontrast study. The formation of a bolus and its passage to the thoracic inlet was normal under fluoroscopy. A redundant esophagus began at the thoracic inlet, with the dilated esophagus extending caudally to heart.

Treatment/Management: The lesion in "Widgie" had an unusual radiographic appearance since it was fluid-filled. This made the possibility of a solid tumor-like mass more likely.

"Widgie" responded successfully to treatment for shock while hospitalized. He was not operated immediately and the aspiration pneumonia was ignored. When he began to vomit blood four days later, he was euthanized at the owner's request.

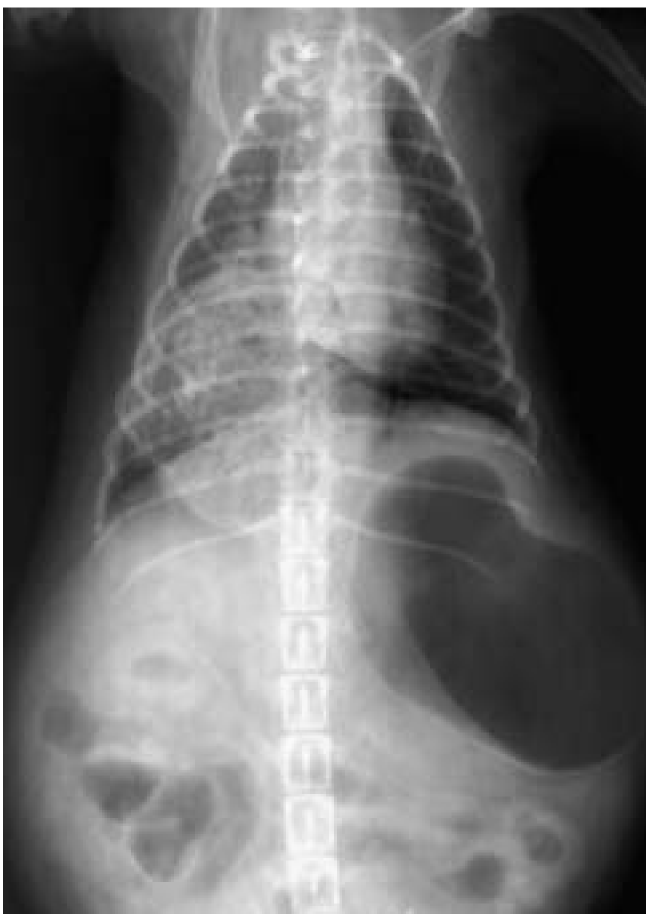
At necropsy, the entire stomach, left lateral liver lobe, the papillary process of the caudate liver lobe, and the spleen were herniated into the thoracic cavity. A 2-cm-in-diameter erosion was found on the mucosal surface of the stomach and may have been the source of the acute hemorrhage. The extensive herniation of abdominal contents was not noted on the original radiographs and appeared to have been acute. Severe secondary aspiration bronchopneumonia was detected at necropsy.

Comments: "Widgie" should have been operated on sooner.

2

Case 2.100

Noncontrast



Signalment/History: "Shammie" was a 5-year-old, female Toy Poodle with an acute history of coughing and vomiting. The referral diagnosis was an esophageal foreign body with a secondary bronchitis/pneumonia.

Physical examination: The examination provided little information.

Radiographic procedure: Routine thoracic radiographs were followed by an esophagram that included a fluoroscopic examination.

Radiographic diagnosis (noncontrast): A large sharply defined, thin-walled mass was located in the dorsocaudal right hemithorax. The mass contained a granular-like pattern suggestive of ingesta mixed with air. The mass was thought probably not to be pulmonary.

As a result of the mass, there was a ventral displacement of the carina. There was also a slight infiltrative pattern within the left caudal lung lobe that could have been due to pneumonia. The cardiac shadow was within normal limits. The air-filled gastric shadow was within the abdominal cavity as was the liver. The right hemidiaphragm was flattened and was located caudal to the left hemidiaphragm. No evidence of thoracic wall injury was noted. The air-filled stomach suggested panic breathing.

Contrast

Radiographic diagnosis (contrast study, VD views only): The fluoroscopic examination and esophagram demonstrated a generalized esophageal dilatation with prominent caudal esophageal sacculation. The gastroesophageal junction was located in its normal position. The barium sulfate entered the stomach under fluoroscopic control; however, the dilated esophagus exhibited only weak peristaltic activity. The gastro-esophageal junction was again noted to be in a normal position.

Treatment/Management: "Shammie" was operated. The caudal esophagus was a "bladder-like" structure 3 x 4 cm in diameter with walls that were 2–4 mm thick. This structure was removed surgically with closure of the esophageal defect. The esophagus was adherent to the surrounding lung lobes making removal of the right caudal and accessory lobes necessary. Postsurgical hemothorax coupled with pre-existing pneumonia resulted in cardiac arrest immediately after the surgery, resulting in the death of the patient.

The etiology of the esophageal diverticulum was not determined.

Comments: Note that the intrathoracic mass did not fit the shape or position of any of the lung lobes and is therefore not likely to be of pulmonary etiology. On several of the studies, the right caudal bronchus was markedly displaced laterally. The mixed pattern of air and fluid density was unlike that found in pulmonary disease. This lesion fitted a diagnosis of an esophageal diverticulum. The radiographs were over-exposed and were not of maximum value in the determination of lung disease.

3

Chapter 3

Radiology of Abdominal Trauma

3.1 Introduction

3.1.1 The value of abdominal radiology

Radiology is a diagnostic tool used in the investigation of abdominal trauma, which can be easily performed in an inexpensive, quick, and safe manner, providing rapid results on which to base decisions relative to diagnosis and /or treatment. The x-ray image allows the visulisation of the abdominal organs if the abdominal fat provides sufficient contrast. Good contrast outlining the location and status of the gastrointestinal organs can also be provided by air, ingesta, and feces contained in the hollow organs. Radiographic contrast studies permit the evaluation of both the gastrointestinal and urinary tracts, either anatomically or functionally.

The radiographic evaluation of abdominal radiographs of a traumatized patient should be performed in an organized manner and include the systematic examination of all the anatomic structures including the peripheral soft tissues, surrounding bony structures, retroperitoneal space, peritoneal cavity,- in addition to the solid abdominal organs, and the hollow viscera.

3.1.2 Indications for abdominal radiology

The abdominal organs are thought to be more vulnerable to trauma than the thoracic organs probably because they are not protected by a bony case. Iatrogenic trauma can result from perforation due to the passage of a urinary catheter or following endoscopy, organ laceration following paracentesis, inadvertent ligation during surgery, or the development of post-surgical strictures or adhesions. The rupture of abdominal organs in trauma patients can result in peritoneal hemorrhage, bacterial peritonitis, bile peritonitis, uremic peritonitis, or pancreatitis, all of which can create a similar radiographic pattern. Abdominal injury due to trauma may be limited, but often it involves injury to the intrathoracic structures, diaphragm, vertebrae, and pelvis as well (Table 3.1).

The clinical situations suggesting the need for abdominal radiography include: (1) patients with a known or suspected abdominal trauma, (2) patients who are vomiting, (3) patients who are not producing urine, (4) patients in shock, and (5) trauma patients prior to surgery.

Table 3.1: Injury to specific abdominal organs secondary to trauma may include

1. Body wall (Cases 3.12, 3.13, 3.14, 3.15, 3.16 & 3.19)
   a. laceration
   b. perforation
   c. herniation
2. Abdominal organs
   a. liver – displacement, rupture, subcapsular hemorrhage, herniation, lobe avulsion (Cases 2.32, 2.42, 2.50, 2.51, 2.99 & 2.100)
   b. gall bladder – rupture, avulsion, herniation (Cases 2.9 & 2.51)
   c. spleen – torsion, subcapsular hemorrhage, herniation, rupture (Cases 2.16, 2.42 & 2.99)
   d. pancreas – rupture (Case 2.9)
   e. stomach – herniation, rupture, volvulus, aerophagia (Cases 2.14, 2.99, 2.100, 3.3 & 3.4)
   f. bowel – herniation, mesenteric torsion/volvulus, perforation/rupture, infarction, obstructive ileus, paralytic ileus (Cases 2.9, 2.42, 2.51, 3.10, 3.13, 3.16, 3.18 & 3.22)
   g. kidney – subcapsular hemorrhage, rupture, avulsion, acute hydronephrosis, renal artery injury (Cases 2.50, 3.20, 3.24 & 3.35)
   h. ureter – rupture, acute hydroureter, avulsion (Cases 3.20, 3.23, 3.24, 3.29 & 3.35)
   i. urinary bladder – rupture, intramural hemorrhage, intraluminal hemorrhage, avulsion, herniation, retained catheter (Cases 3.18, 3.19, 3.20 & 3.21)
   j. urethra – avulsion, rupture, foreign body (Cases 3.12, 3.22, 3.25, 3.26, 3.27, 3.28, 3.29 & 3.30)
   k. prostate gland – herniation (Case 3.20)
   l. mesentery – tear, herniation, torsion (Cases 2.16 & 3.36)
   m. uterus (Cases 2.43, 3.31 & 3.34)

The clinical signs of patients with abdominal trauma can vary from profound shock due to blood loss to those showing only lameness due to an associated musculoskeletal injury. A careful physical examination may be able to determine injuries in addition to those clinically apparent.

3.1.3 Radiographic evaluation of abdominal radiographs

There are two basic methods of radiographic evaluation. The first technique is to "memorize" the appearance of all disease or pathologic changes that might be found in a traumatized abdomen, and then examine the radiograph looking carefully for those changes. An approach of this type is taken by traditional textbooks of medicine, in which diseases are presented with a description and an illustration of the typical radiological appearance. The difficulty with this approach is similar to the difficulty found in applying textbook knowledge to the reality of a sick animal. Clinical information of the traumatized patient is often indefinite and ambiguous. It is the same with the information available from a radiograph. In many patients, the radiological picture of a disease is not "typical", and the textbook approach therefore may lead to confusion or misdiagnosis.

A more accurate method of radiographic evaluation uses the identification of particular radiographic "signs" or "features" that are indicative of pathophysiologic changes, and an understanding of the diseases in which such signs or features are known to occur. The number of these signs is much less in abdominal radiography than in thoracic radiography.

Any successful examination of a radiograph must be systematic in order to ensure that all parts of the radiograph are completely examined. The best system is anatomical and includes the conscious examination of each anatomical structure within a given region in the body. Start the radiographic examination by evaluating the gastrointestinal tract. The stomach usually contains either air and/or ingesta permitting its identification. The duodenal loop often contains air and is located against the right abdominal wall on the DV view and lies within the midabdomen on the lateral view. Small bowel shadows are scattered in a nondescript pattern. In contrast, the cecum and colon are specific in location and can be identified by the presence of feces.

Identification of the ventral liver margin and adjacent splenic shadow is often incomplete and is dependent on the fat within the falciform ligament. The margin of the head of the spleen is best seen lateral to the stomach shadow on the DV/VD projection. The renal shadows can be clearly seen if the perirenal fat provides sufficient contrast. The urinary bladder is identified more easily if it is partially distended. Overlying small bowel and colonic shadows may make identification of the bladder difficult or impossible.

Study of the periphery of the abdomen should include the diaphragm, vertebrae, pelvis, perivertebral space, abdominal musculature, and the pelvic inlet. Spurious or artifactual radiographic changes seen in the abdominal wall include shadows caused by nipples, skin nodules, skin folds, wet hair, dirt, and bandaging material. Subcutaneous fluid, subcutaneous air, and subcutaneous fat alter the appearance of the abdominal wall. These vary widely, being dependent on the patient and the nature of the injury.

The stage of respiration has little effect on the radiographic appearance of the abdomen, although it is better to make the exposure on expiration, when the abdominal cavity is at its greatest size. As a consequence, the diaphragm is more cranial and convex and has greater contact with the heart on expiration than inspiration. This position results in a superimposition of a part of the heart shadow over the diaphragm. A portion of the caudal lung lobes can be identified on most abdominal radiographs.

3.1.4 Radiographic features in abdominal trauma

Positioning of the patient influences the appearance of the abdominal organs. In certain trauma patients, the manner of positioning is determined by the nature of the injury. In others, positioning can be selected for the radiographic study that is felt to offer a better opportunity of evaluating a particular abdominal organ. For example, in a dog with a known abdominal injury it is possible to consider placing the injured area next to the tabletop in an effort to achieve the smallest object-film distance. However, in the event of a suspected spinal fracture, it may be better to use a DV positioning and not risk fighting with the patient to obtain a view in which the spine would be next to the tabletop, thereby causing further injury to the spine. It is not possible to make any firm recommendations in the case of trauma patients, though the effect of positioning on the appearance of the organs in the differing positions needs to be understood before an interpretation is made (Table 3.2).

Table 3.2: Effect of positioning on the appearance of abdominal radiographs

1. Left side down, lateral view
   a. the gastric gas bubble moves into to the pyloric antrum and the duodenum is located in the ventral portion of the cranial abdomen
   b. the left crus of the diaphragm is more cranial.
2. Right side down, lateral view
   a. the gastric gas bubble moves into the fundus of the stomach located dorsally just caudal to the left crus
   b. the right crus of the diaphragm is more cranial.
3. Dorsoventral view
   a. the gastric gas bubble fills the dorsal portion of the fundus of the stomach creating a circular shadow on the left side of the abdomen in contact with the left crus
   b. the separation between the cupula and the dorsal crura is shorter and often is a distance of the length of 1–2 vertebral bodies
4. Ventrodorsal view
   a. the gastric gas bubble occupies the pyloric antrum creating a linear pattern that crosses the midline
   b. the separation between the cupula and the dorsal crura is longer and often is a distance of the length of 2–3 vertebral bodies

3

3.1.4.1 Peripheral soft tissue trauma

The muscles of the abdominal wall can be identified radiographically because the layers of fat adjacent to the peritoneum and between the muscle layers all provide good tissue contrast. The pattern seen on the radiograph varies widely dependent on the obesity of the patient. This tends to make identification of the muscles easy and any injury to the abdominal wall that results in edema/hemorrhage accumulation tends to cause a blending of the muscle layers together on a radiograph. Indeed, the radiographic diagnosis of edema or hemorrhage in the abdominal wall is made by the failure to easily identify the normal radiolucent muscle stripes. In addition, the abdominal wall may contain gas shadows with the gas lying free within the layers of the abdominal wall or just beneath the skin following a puncture wound. A major form of peripheral soft tissue trauma is organ herniation with displacement of solid abdominal viscera outside the abdominal cavity through a diaphragmatic, paracostal, inguinal, perirenal, ventral, or umbilical tear or rupture. If air- or ingesta-filled bowel loops are herniated, their identification is relatively easy to make on the radiograph regardless of the location of the herniation. In comparison, if solid parenchymatous organs are herniated, the ability to identify them is dependent on the contrasting surrounding tissue environment. For example, if the spleen is paracostal and surrounded by contrasting subcutaneous fat, it will be visible on the radiograph, whereas if the liver is intrathoracic and surrounded by pleural fluid, it will not be possible to identify it radiographically.

Often soft tissue swellings are detected on physical examination and suggest the possibility of hernia, but such findings on palpation need to be differentiated from hematomas, seromas, or freely moving blood/or edema. The use of oral contrast agents assists in the identification of herniated bowel, while the use of intravenous urographic contrast agents assists in the localization of a herniated urinary bladder.

3.1.4.2 Fractures

The detection of fractures of the surrounding bony structures can suggest trauma to the adjacent abdominal viscera. A patient with a rupture of the urinary bladder or urethra can have an associated pelvic or lumbosacral fracture/luxation. Fracture/luxations of the vertebrae in conjunction with abdominal injury can be overlooked because of their not causing any obvious or detectable neurologic signs or problems in locomotion at the time of trauma.

3.1.4.3 Peritoneal fluid

There are numerous causes of peritoneal fluid. The fluid can result from hemorrhage and be due to laceration or crushing of the liver, gall bladder, spleen, pancreas, or kidneys; though it is possible the fluid may only be irritative in its etiology. A uremic peritonitis can follow rupture of the urinary bladder or injury to the urethra or ureter at the bladder neck. An additional source of peritoneal fluid results from volvulus, torsion, or incarceration of the bowel. It is possible for the peritoneal fluid to become infected because of bowel wall injury and the fluid may even be grossly septic due to the rupture of a hollow viscus or following a puncture wound with a lesion through the abdominal wall.

It is usually not possible to determine the character of peritoneal fluid from a radiograph. However, certain generalizations can be made. The larger the quantity of fluid, the more likely it is to be effusive or urine. The more focal it is, the greater is the possibility that the fluid is septic or hemorrhagic. Paracentesis can be helpful in making a determination of the nature of the fluid.

The detection of peritoneal fluid can be a difficult radiographic finding and depends on the distribution of the fluid in the abdomen and the amount present (Table 3.3). A large quantity of fluid that is distributed throughout the abdomen causes abdominal distention with a marked loss of contrast, so that the serosal surfaces of the bowel loops can no longer be identified. If there is a large quantity of fluid, it comes into contact with the urinary bladder, liver, spleen, and abdominal wall making it impossible to identify these normally easily identifiable structures. With a large amount of fluid, bowel loops tend to "float" and be separated from each other. It is difficult to move fluid within the peritoneal space to improve radiographic diagnosis and thus, there is little value in using positional radiographic techniques. This contrasts markedly with the value in observing the movement of fluid within the pleural cavity.

If the volume of fluid is small, or is localized, the radiographic diagnosis is even more difficult. This diagnostic problem can occur with suspected pancreatic injury where the pancreatitis is localized or in a focal injury to the bowel with a localized septic peritonitis. Compression studies, if performed gently, can be helpful in moving normal abdominal structures away from the site of injury to enhance visualization of the traumatized organ. Identification of a foreign body within the peritoneal cavity can be made easier using compression that shifts the overlying small bowel loops.

Re-evaluation of the peritoneal space is indicated in patients that fail to recover from trauma in an expected manner, since it is possible that bleeding in the peritoneal cavity cannot be identified until hours after the trauma, when the patient's blood volume has been restored and the blood pressure has returned to normal. Peritonitis may also not be evident on early radiographs.

Table 3.3: Radiographic features of peritoneal fluid

(Cases 2.14, 3.5, 3.8, 3.10, 3.11, 3.15, 3.17, 3.21, 3.22, 3.24, 3.29 & 3.30)

1. Loss of contrast between abdominal organs
2. Failure to identify
   a. liver margin
   b. spleen
   c. urinary bladder
   d. serosal surface of bowel
   e. abdominal wall
3. Bowel loops in a patient with peritoneal effusion
   a. appear to float
   b. are widely separated
4. Increase in tissue density within the peritoneal space
5. Distended abdomen

3.1.4.4 Peritoneal air

The presence of peritoneal air may follow the perforation or rupture of a hollow viscus, rupture of the urinary bladder, or a perforating wound through the abdominal wall. Peritoneal air tends to remain in small pockets and is difficult to identify radiographically, because it lies within the mesenteric and omental folds. Also the air bubbles are distributed over a large portion of the abdomen and are not seen in one pocket, because most abdominal radiographs are made with the patient recumbent (Table 3.4).

If a large amount of air is present, diagnosis is easier. The air tends to accumulate around the liver if the radiograph is made with the patient in lateral positioning. Both sides of the diaphragm are visible due to the pulmonary air cranially and the free peritoneal air caudally. On the DV view, the air can gather around the kidneys and make them more easily visualized. This can be difficult to understand since the air is peritoneal and the kidneys are retroperitoneal; however, the kidneys are freely movable so that peritoneal air contrasts sharply with their margins. An important radiographic sign is the sharp identification of both the serosal and mucosal surfaces of a bowel wall indicating that peritoneal air is present.

The easiest method of confirming suspected peritoneal air is to make a radiographic study using a horizontal x-ray beam. By positioning the patient on the x-ray table in lateral recumbency for 10–15 minutes prior to making the exposure, the air collects in the uppermost portion of the abdominal cavity and creates a pocket that can be more easily identified beneath the abdominal wall. Using the left lateral positioning of the patient permits the gas to collect between the right diaphragmatic crus and the liver. It can be more readily identified in this location because the peritoneal air is away from, and so not confused with, the air in the fundus of the stomach. While this technique has a high percentage of accuracy in the detection of the free air, it is not commonly performed because of the time and effort to achieve it.

Abdominal air can be present for a period of several days to several weeks following laparotomy, abdominal paracentesis, or the use of pneumoperitoneography as a diagnostic technique and can be mistaken for air associated with a traumatic event. An accurate clinical history is important in such cases.

Table 3.4: Radiographic features of peritoneal air

(Cases 3.9, 3.10 & 3.15)

1. Air pockets can be identified
   a. between liver and diaphragm
   b. adjacent to kidneys
   c. between stomach and diaphragm or around stomach
2. Air creates triangular or circular-shaped pockets if located between bowel loops
3. Bowel wall thickness is identified because of the air in the bowel lumen and the air in the peritoneal cavity. This means that the air contrasts with both serosal and mucosal surfaces of the bowel wall.

3.1.4.5 Retroperitoneal fluid

If fluid comes from an injured kidney or ureter and is blood or urine, it often remains retroperitoneal and can be identified radiographically by a large fluid-dense mass lying in a perivertebral location that effects the position of the adjacent organs (Table 3.5). The renal shadows can remain visible because they hang ventrally into the peritoneal space. A caudodorsal accumulation of fluid may create a mass-like effect and result in the ventral displacement of the descending colon and rectum.

Vertebral fractures can be associated with injuries causing the presence of retroperitoneal fluid. It is also possible for fluid to accumulate in the retroperitoneal spaces within the pelvic cavity due to hemorrhage secondary to a pelvic fracture.

Table 3.5: Radiographic features of retroperitoneal fluid

(Cases 2.50, 3.18, 3.21 & 3.23)

1. Retroperitoneal space
   a. increase in size
   b. increase in fluid density
   c. disappearance of radiolucent perivertebral fat shadows
   d. non-visualization of sublumbar muscles (quadratus lumborum, psoas major, psoas minor)
2. Kidneys
   a. displaced ventrally
   b. incomplete visualization
   c. asymmetry of renal size
3. Descending colon and rectum are displaced ventrally
4. Associated fractures
   a. vertebral
   b. pelvic

3

3

3.1.4.6 Retroperitoneal air

Retroperitoneal air is uncommon and is more often secondary to pneumomediastinum, with the air passing from that region into the retroperitoneal space. Another possibility is a tearing of the peritoneum and passage of air from the peritoneal space into the retroperitoneal space. Trauma to the pelvic region can also permit air to move into the retroperitoneal space. A final possibility is a puncture wound into the retroperitoneal space with the presence of a gas-producing microorganism. The radiographic features for this condition involve an increase in contrast created by the air as well as a possible mass effect with abnormal positioning of the adjacent organs (Table 3.6).

Table 3.6: Radiographic features of retroperitoneal air

(Cases 3.9 & 3.17)

1. Increased visualization of the
   a. sublumbar muscles (quadratus lumborum, psoas major, psoas minor)
   b. kidneys
2. Ventral displacement of
   a. kidneys
   b. small bowel
   c. descending colon and rectum
3. Secondary to
   a. pneumomediastinum
   b. peritoneal air
   c. subcutaneous emphysema or infection
   d. pelvic canal air

3.1.4.7 Organ enlargement

Enlargement of solid parenchymatous abdominal organs in cases of trauma can be due to subcapsular or encapsulated hemorrhage following hepatic, splenic, or renal injury. Enlarged renal shadows can also be due to hydronephrosis following ureteral rupture. Since the fluid is contained beneath the capsule, the border of the organ remains visible on the radiograph, but the organ can appear larger, or with a different shape or contour than usual. This radiographic feature is not commonly seen.

3.1.4.8 The pelvis

In the event of generalized trauma, pelvic radiographs are relatively easy to perform and permit the evaluation of the soft tissues containing the distal colon and rectum, plus the terminal ureters, urinary bladder, and urethra in addition to the caudal lumbar vertebra, lumbosacral junction, sacrum, caudal vertebrae, sacroiliac joints, pelvis, hip joints, and the proximal femurs. Any of these structures can be traumatized and require treatment. Often a combination of injuries effecting both the soft tissues and bone or joint is present (See also Chap. 4.2.16 Pelvis).

3.1.5 Use of contrast studies in the traumatized abdomen

3.1.5.1 Urinary tract trauma

Traumatic lesions of the urinary tract are frequent and excretory urography (Table 3.7) and retrograde urethrocystography (Table 3.8) can be helpful diagnostically. Excretory urography is the most easily performed technique, since the trauma patient probably has a venous catheter in place because of a requirement for fluid therapy. Therefore, it is convenient to inject a positive contrast urographic agent at a rate of 1 to 2 ml/kg bw. Radiographs made at 5 to 10 minutes after the injection will show the bilateral function of normal kidneys. Following trauma, one or both kidneys can fail to excrete the contrast agent because of renal artery thrombosis, renal artery tear, avulsion of the kidney, or kidney injury. The contrast agent can accumulate within the renal subcapsular space indicating renal laceration. If the contrast agent leaks into the retroperitoneal space this indicates renal laceration or ureteral tear. The contrast agent can also leak into the peritoneal space if the peritoneum is torn subsequent to any of these injuries. Sequential radiographs will show the character of the ureters, the position of the urinary bladder, and the status of the bladder wall.

If it is possible to catheterize the urinary bladder in a retrograde direction, the location of the bladder, the status of the bladder wall, and the status of the urethra can be determined. The urethra is evaluated following repositioning of the catheter tip so that it lies within the distal urethra.

Table 3.7: Radiographic features of excretory urography in trauma patients

(Cases 3.18, 3.20, 3.23, 3.24, 3.27, 3.29 & 3.32)

1. Failure of normal renal opacification/excretion by contrast agent because of a
   a. torn renal artery
   b. torsion of the renal artery
   c. thrombosis of a renal artery
2. Extravasation of contrast medium into the
   a. subcapsular space because of renal laceration
   c. peritoneal space because of renal laceration and capsular tear
   d. retroperitoneal space because of renal laceration and capsular tear
   e. retroperitoneal space because of ureteral tear
3. Hydronephrosis because of ureteral injury
4. Hydroureter because of ureteral injury
5. Failure of normal visualization of urinary bladder because of
   a. renal or ureteral injury that fails to funnel contrast agent into bladder
   b. incomplete filling of bladder because of tear in the bladder wall
6. Peritoneal extravasation of contrast agent because of bladder wall tear
7. Extravasation of contrast agent into the pelvic spaces because of
   a. bladder neck injury
   b. proximal urethral injury

Table 3.8: Radiographic features of retrograde urethrography/ cystography in trauma patients

(Cases 3.12, 3.19, 3.20, 3.21, 3.22, 3.25, 3.26, 3.27, 3.28, 3.29 & 3.30)

1. Extravasation of contrast medium into the
   a. peritoneal space because of bladder wall injury
   b. peritoneal space because of proximal urethral injury
   c. pelvic space because of
      I. proximal urethral injury
      II. bladder neck injury
   d. peri-urethral space because of urethral injury
2. Contrast column may indicate an abnormal mucosal surface due to
   a. injury
   b. stricture
   c. tear
3. Malposition of the
   a. urinary bladder
   b. urethra
4. Foreign body (catheter)

3.1.5.2 Gastrointestinal tract trauma

Traumatic lesions of the intestinal tract are frequent and are generally identified by evaluation of noncontrast radiographs and the identification of peritoneal fluid or air. In patients with a rupture of the wall of the stomach or bowel, it is possible that the tear is large enough to permit the release of ingesta or the barium contrast agent into the peritoneal cavity; however, this is an uncommon finding. Often the most important radiographic finding is simply a determination of the location of the hollow viscus. Displacement of a part of the gastrointestinal tract is common in hernias and this is readily determined by identifying the positive contrast within the displaced stomach or small bowel (Table 3.9).

When used, these contrast studies involve the oral administration of barium sulfate suspension according to the following schedule: 8–10 ml/kg bw in small dogs that weigh less than 10 kg, 5–8 ml/kg bw in medium-sized dogs that weigh between 10–40 kg, and 3–5 ml/kg bw in large dogs that weigh more than 40 kg; and 12–16 ml/kg bw in the cat. These dosages are necessary to insure a meal volume that will induce normal peristalsis. Often, however, the study is made only to evaluate the location of an organ and the amount of barium sulfate meal administered can be less. Radiographs are then made shortly after the administration of the meal, but they can also be made at varying time intervals following administration of the contrast agent depending on the information to be gained. In trauma patients, these studies are rarely functional in nature, but are only made to identify the location of the organ and the integrity of its walls.

Table 3.9: Radiographic features of gastrointestinal trauma following orally administered contrast agent

(Cases 3.3–3.9)

1. Displacement of
   a. gastro-esophageal junction
   b. stomach
   c. small bowel
2. Distention of
   a. stomach
   b. small bowel
3. Extravasation of contrast agent into
   a. peritoneal space
4. Failure of transit of contrast agent

Gastric foreign bodies

Gastric foreign bodies are noted frequently on the radiographic studies. Their identification is dependent on their density (Table 3.10), and if surrounding gastric air provides contrast or if ingesta hides the object. If the foreign bodies are obstructive, the clinical importance is greater. Most are only impressive because of their radiographic appearance that is often influenced by the patient positioning.

Table 3.10: Radiographic density of common gastric foreign bodies

(Cases 3.1, 3.2, 3.5, 3.6, 3.7 & 3.8)

1. Greatest density
   a. glass with high lead content
   b. metallic objects
   c. heavy plastic objects
   d. gravel and rocks
   e. large bony fragments
2. Medium density
   a. aluminum sheets or strips
   b. glass with low lead content
   c. plastic toys
   d. ornaments
   e. small bone fragments
3. Lowest density
   a. ingesta
   b. cloth strips or cloth toys
   c. plastic sheets orbags
   d. paper
   e. string or rope

3.2 Case presentations

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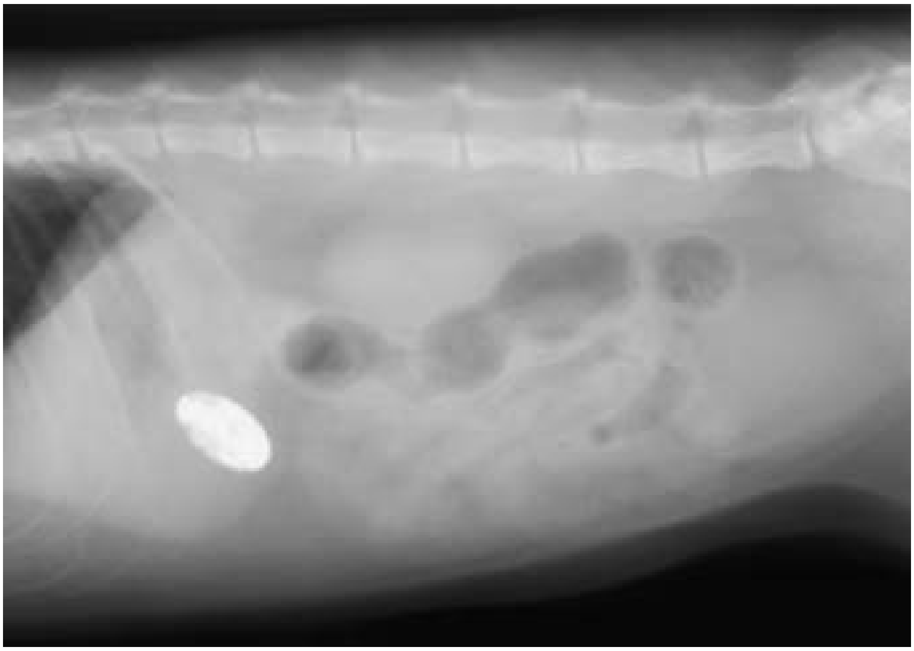
3.2.1 Gastric foreign bodies and dilatation



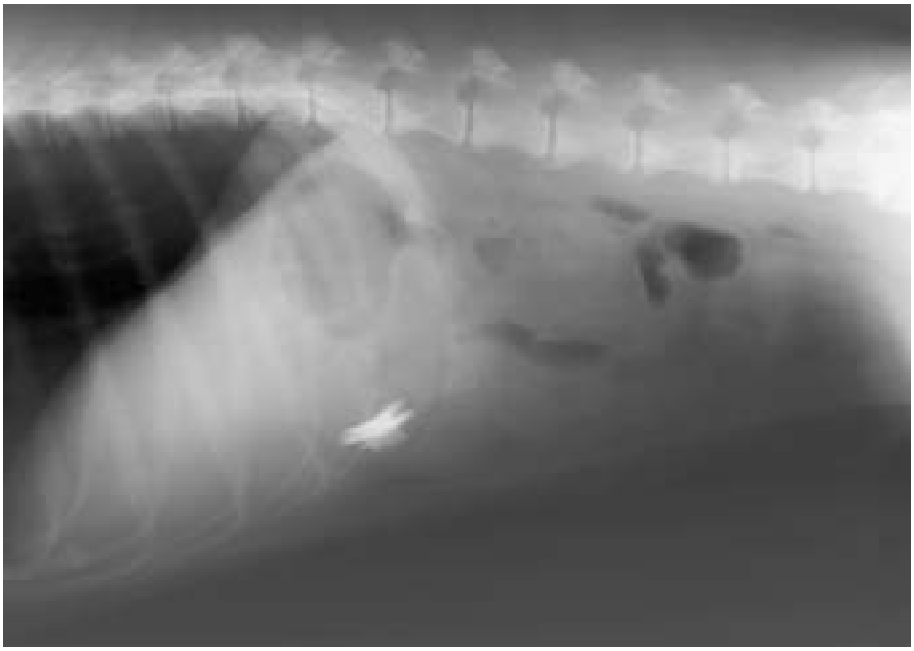
Case 3.1

Signalment/History: "Frosty", a 14-month-old, female DSH cat, was presented because of intermittent vomiting over the previous 1 to 2 months. Vomiting occurred every two to three days and contained bile-stained fluid without food. The use of lamb and turkey diets was unsuccessful in correcting the clinical signs. No radiographic studies had been made.

Radiographic procedure: Abdominal studies were made assuming a possible gastric foreign body.

Radiographic diagnosis: A 2-cm-in-diameter, discoid object with a metallic density and a slightly irregular border lay within the region of the pylorus. The small bowel loops were filled with fluid, but not distended. The colon was gas-filled. No radiographic signs of an obstructive ileus were noted.

Treatment/Management: A partially dissolved copper penny was removed by gastroscopic technique. The pyloric antrum was noted to be highly inflamed. The chronic gastritis resulting from the foreign body was thought to be the cause of the vomiting. "Frosty" improved clinically following removal of the foreign body.



Case 3.2

Signalment/History: "Chris" was a 6-year-old, female German Shepherd with a history of depression, vomiting, and hematuria over the previous two days.

Physical examination: The abdomen was tender on physical examination.

Radiographic procedure: The abdomen was radiographed.

Radiographic diagnosis: Radiopaque gastric foreign bodies could be seen with a tissue density suggesting either a metallic, glass-like, or dense plastic composition.

Note the difference in radiographic density of the foreign bodies according to the patient's position. The lack of contrast between the abdominal organs suggested the presence of peritoneal fluid.

Treatment/Management: "Chris" died from chronic pyelonephritis that had resulted in hypertension, myocardial vascular damage, uremia, widespread mineralization, and parathyroid hyperplasia.

The gastric foreign bodies were glass, but were not thought to have contributed to the production of the clinical signs. Dogs often eat a variety of debris along with their usual diet or sometimes find these objects in a convenient garbage can. In either situation, the resulting radiographic shadows are prominent and may suggest clinical importance. The debris may be obstructive or may be injurious to the mucosal surface; however, if small, they usually pass through the gastrointestinal tract and do not cause more than acute, short-lived clinical problems.

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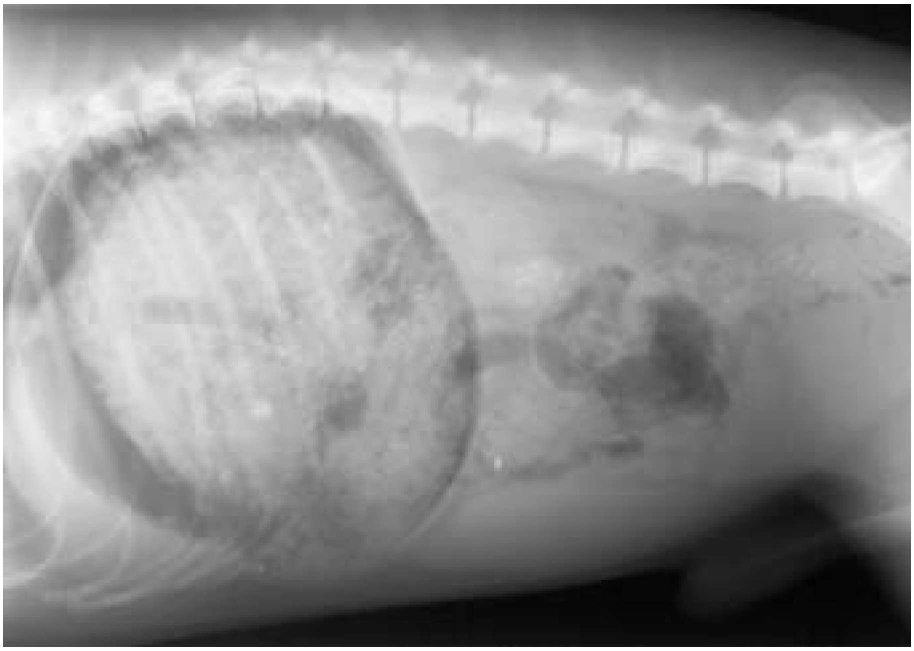

Case 3.3

Signalment/History: "Bingo" was a 1-year-old, dachshund mixed breed with a history of gagging and choking after eating.

Physical examination: The abdomen was distended on palpation, but was not noticeably painful.

Radiographic procedure: Abdominal radiographs were made.

Radiographic diagnosis: The stomach was distended and filled with ingesta. No evidence of a "pillar" sign or "shelf sign" was present that could have suggested a gastric volvulus/torsion. The pylorus was on the right side in its normal position. The colon was filled with feces that had the same appearance as the gastric contents. The small bowel loops were air filled but not distended.

Treatment/Management: The patient was treated as having marked gastric distention and was given a cleansing enema.

Radiographic diagnosis: Radiographs made after the enema showed the stomach to have emptied. Small bowel loops could not be identified. The colon had refilled after the enema.

Treatment/Management: "Bingo" was thought to have had overeaten and returned to normal after the enema.

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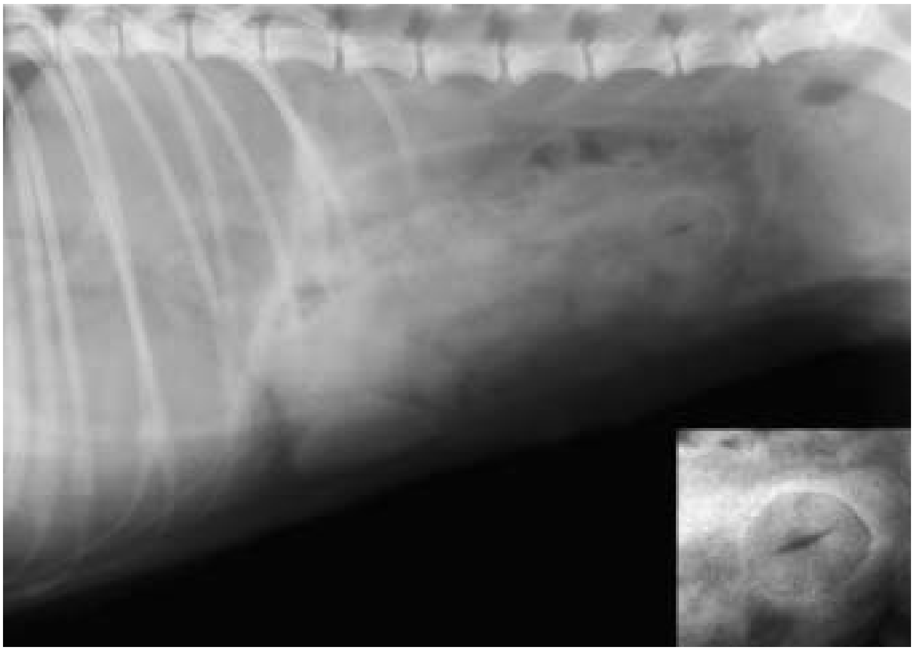
3.2.2 Small bowel foreign bodies



Case 3.4

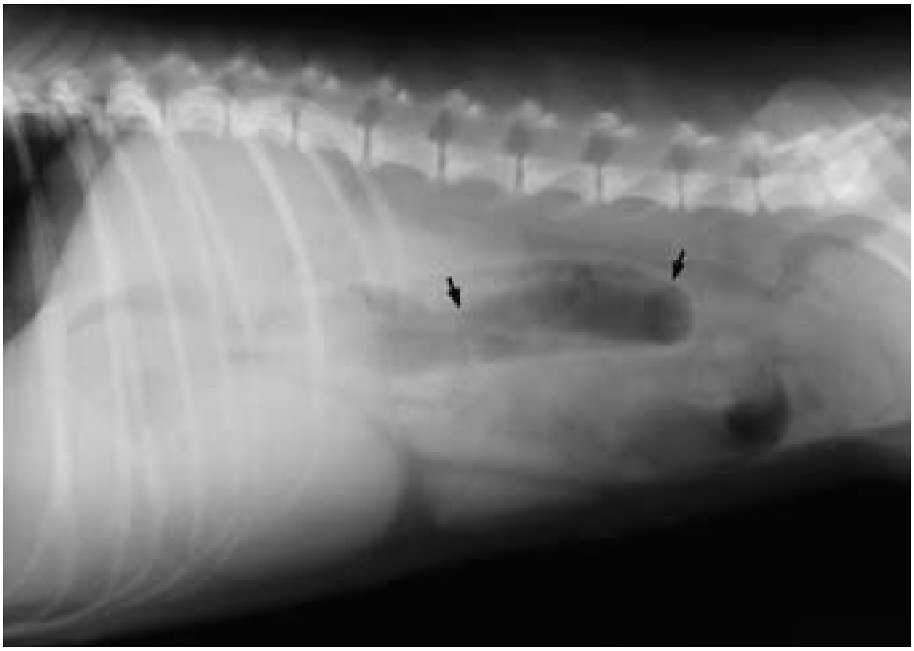
Day 1

Signalment/History: "Pepper" was an 8-year-old, female Terrier mix with a history of vomiting for several days.

Physical examination: Palpation of the abdomen revealed a hard mass in the caudal abdomen the size of a "nut".

Radiographic procedure: Radiographs were made of the abdomen.

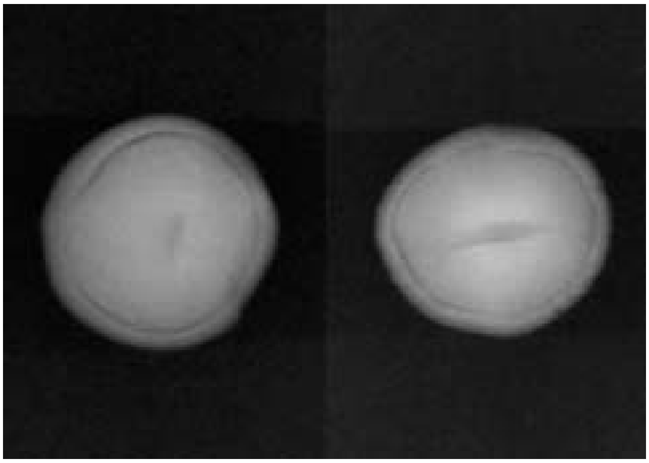
Radiographic diagnosis (day 1): The stomach was distended and filled with air and fluid. The small bowel loops were filled with fluid, although they had a normal diameter. A 2-cm-in-diameter foreign body was located in the midportion of the caudal abdomen. It had a "slit-like" lucency in the center, in addition to a "ring shaped" lucency around its edge.



Day 2

Radiographic diagnosis (day 2): Studies made one day later again showed a distension of the fluid-filled stomach. The foreign body had the same appearance and was in the same location. A sentinel loop of distended fluid-filled bowel was diagnostic of being secondary to an obstructing foreign body (arrows).

Treatment/Management: The nut was removed from the bowel surgically and "Pepper" recovered quickly. In some societies, it is possible to determine the season of the year and holidays by the character of the foreign bodies found in the bowels of pets.



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Case 3.5

Noncontrast

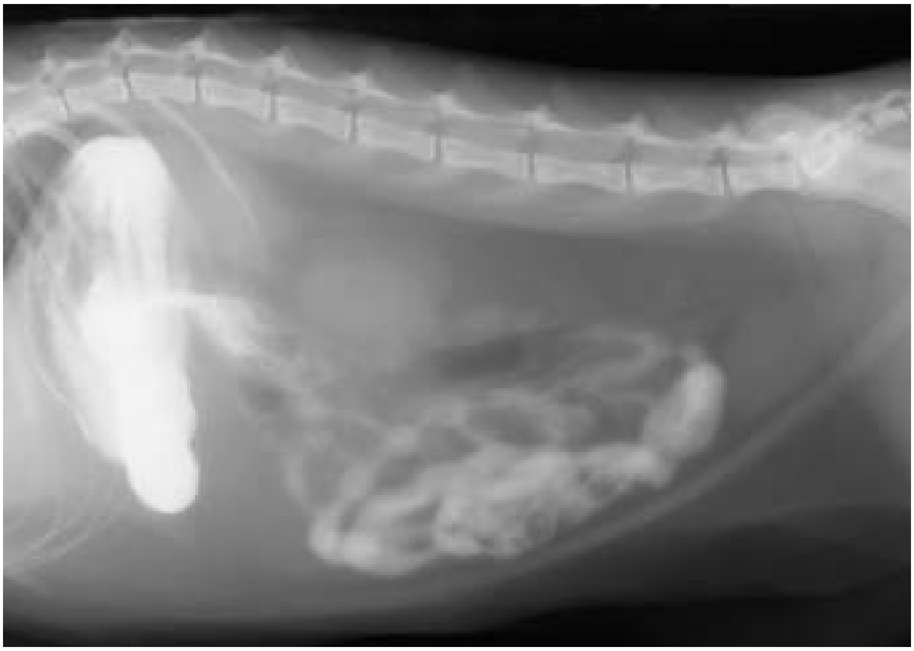
Signalment/History: "Jenny" was a 1-year-old, female DSH cat who was vomiting. She had been anorectic for several weeks.

Physical examination: A cranial abdominal mass was evident on palpation.

Radiographic procedure: Abdominal radiographs were made, followed by a compression study to further clarify the nature of the suspect mass. Following failure of that procedure to insure a specific diagnosis, a barium sulfate meal was used to further identify the nature of the mass.

Radiographic diagnosis (noncontrast): A poorly marginated mass with a granular consistency was located in the left cranial abdomen, immediately caudal to the liver. Loss of mucosal borders suggested the possibility of focal peritoneal fluid. Both the stomach and small bowel loops were empty. A proximal partially obstructing intestinal lesion was suspected.

The use of a compression device separated the questionable mass from the liver and stomach indicating that it was probably intestinal and was not associated with a focal peritoneal effusion.



Barium sulfate meal

Radiographic diagnosis (barium sulfate meal): Radiographs made 20 minutes after the administration of a contrast meal showed a lesion in the descending duodenum that was characterized by a marked distention of the bowel with the contrast agent mixing with an intraluminal mass. A portion of the liquid meal passed the lesion and was seen within the distal bowel loops. The contrast study confirmed the presence of a partially obstructing luminal mass within the descending duodenum.

Treatment/Management: A mass of thick paper was removed at surgery and "Jenny" was discharged a happy cat.

Comments: Intraluminal foreign bodies tend to distend the bowel lumen and prevent the contrast meal from outlining a smooth mucosal surface. If some of the meal passes the foreign body, the distal bowel loops will be partially filled. A differential diagnosis radiographically should include an intestinal tumor.

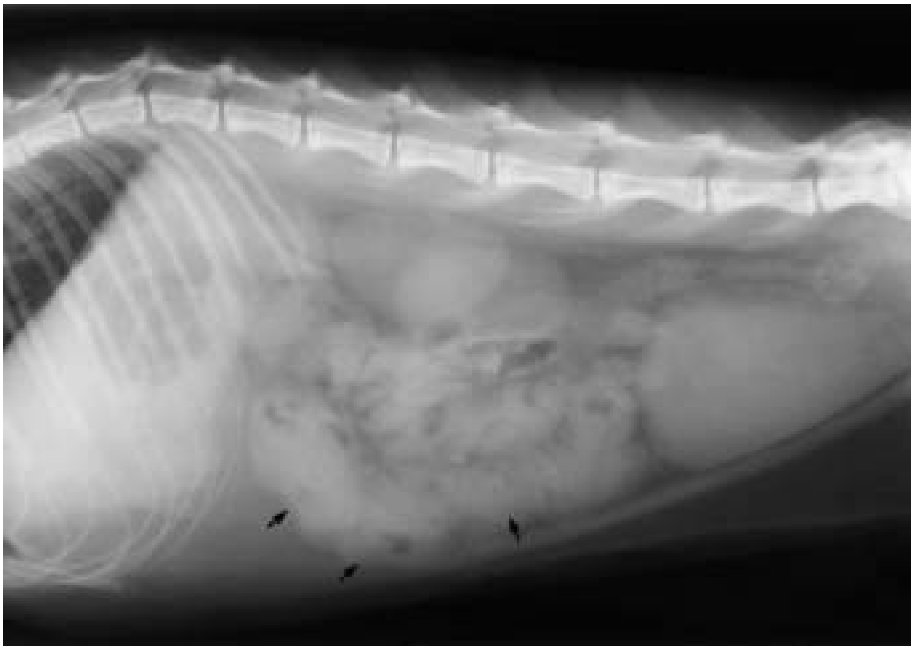
Case 3.6

Signalment/History: "Grace" was a 10-month-old, female DSH cat with a history of vomiting for a period of seven days.

Radiographic procedure: Radiographs were made of the abdomen because the length of the clinical history suggested an obstructive type lesion.

Radiographic diagnosis: A mid-abdominal metallic foreign body was associated with enlarged, fluid-filled small bowel loops. The lack of visualization of definite serosal margins suggested the possibility of an associated peritonitis.

Treatment/Management: Surgical removal of the metallic "can-opener" required a bowel resection. Unfortunately "Grace" had a complicated recovery and died in the clinic twelve days after surgery. Necropsy located a small bowel abscess at the site where the intestinal anastomosis was performed.



Case 3.7

Signalment/History: "Shannon", a 1-year-old, female Siamese cat, had a history of having swallowed thread a week earlier. On presentation, she was vomiting and had been anorectic for the previous five days.

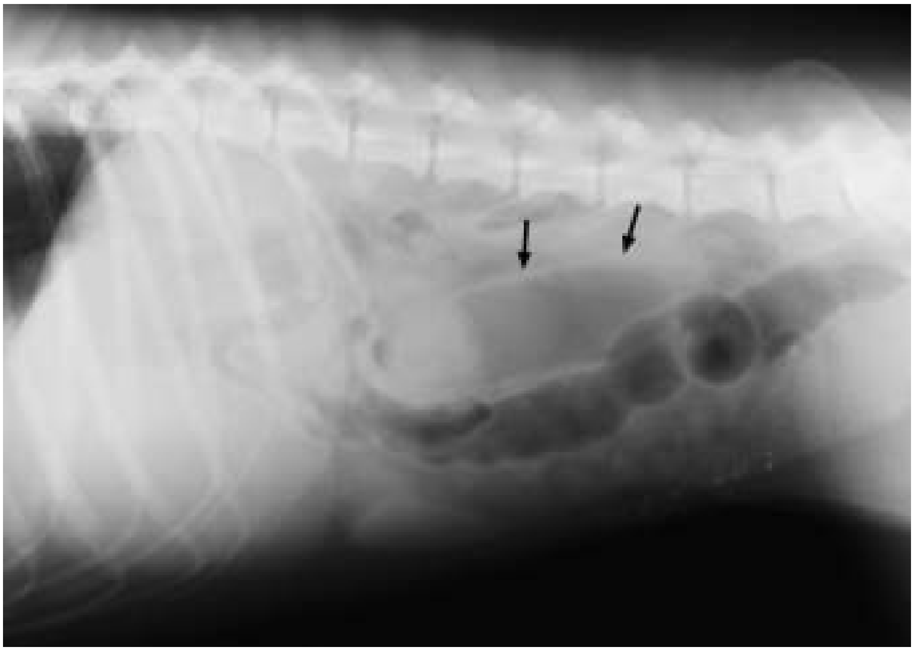
Physical examination: The abdomen was painful on palpation and multiple bowel loops felt thickened, suggesting a linear foreign body.

Radiographic procedure: Studies of the abdomen were made.

Radiographic diagnosis: The small bowel loops were thickened, clumped together on the right side of the abdomen and contained small pockets of air (arrows). A radiographic pattern of this type would be expected in a patient with a small bowel linear foreign body causing a partial obstruction.

Treatment/Management: What was initially a partial small bowel obstruction became complete after the inflammatory changes caused by the linear foreign body cutting through the bowel wall resulted in an adhesive mass. The surgical treatment involved bowel resection, but was not successful.

Comments: Because the bowel wall essentially heals itself as the string "cuts" through it, the peritonitis in such cases remains focal in location and a widespread inflammatory process in the peritoneal cavity is not typically a part of this syndrome.



Case 3.8

Signalment/History: "Chamois" was a 2-year-old, female Labrador Retriever with a four-day history of vomiting. Diarrhea was noted during the previous 24 hours.

Physical examination: Dilated small bowel loops were palpated.

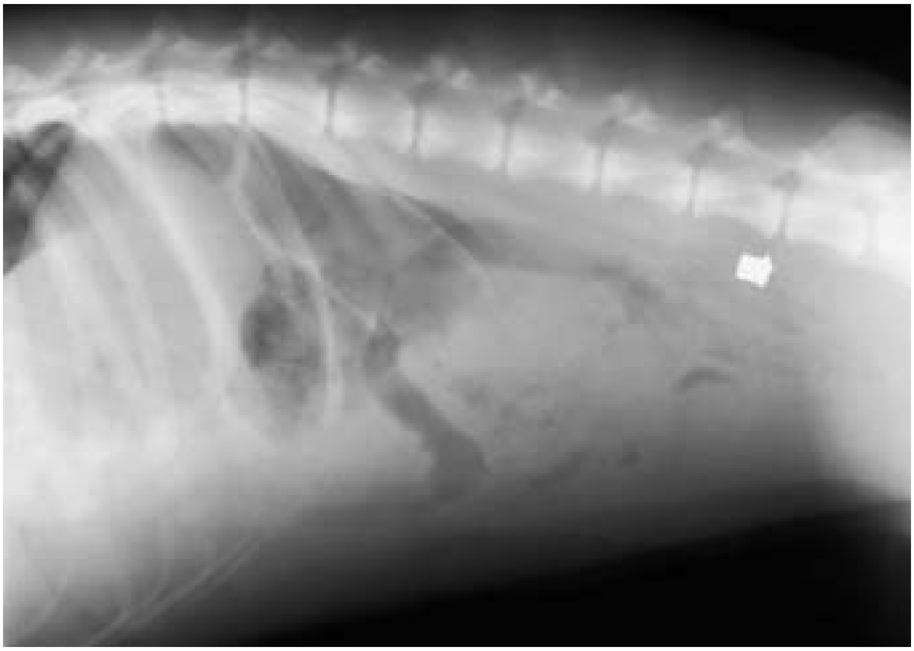
Radiographic procedure: Abdominal studies were made.

Radiographic diagnosis: A single distended gas-filled small bowel loop was visible indicative of obstructive bowel disease (arrows). Note that the gastrointestinal tract both cranial and caudal to the site of obstruction was empty. Separation of the distended small bowel from the larger colon was difficult; however, the appearance of the bowel walls made identification of the loops possible. The small bowel wall was smooth, while the colonic wall had a typical corrugated appearance. Also, the small bowel loop was dorsal to the colon and far to the right. In comparison, the colon was far to the left on the DV view in a more normal location.

Note on both views the fluid dense mass within the lumen of the distended loop that represents the foreign body.

Comments: A single loop ("sentinel loop") syndrome is typical of an early complete bowel obstruction that is often the result of an intraluminal mass (foreign body); however, a bowel wall tumor can cause a similar pattern radiographically, if it should quickly develop into an obstructive lesion.

3.2.3 Peritoneal fluid



Case 3.9

Signalment/History: "Bonnie", a 2-year-old, female Great Dane, had a bullet wound in her left flank.

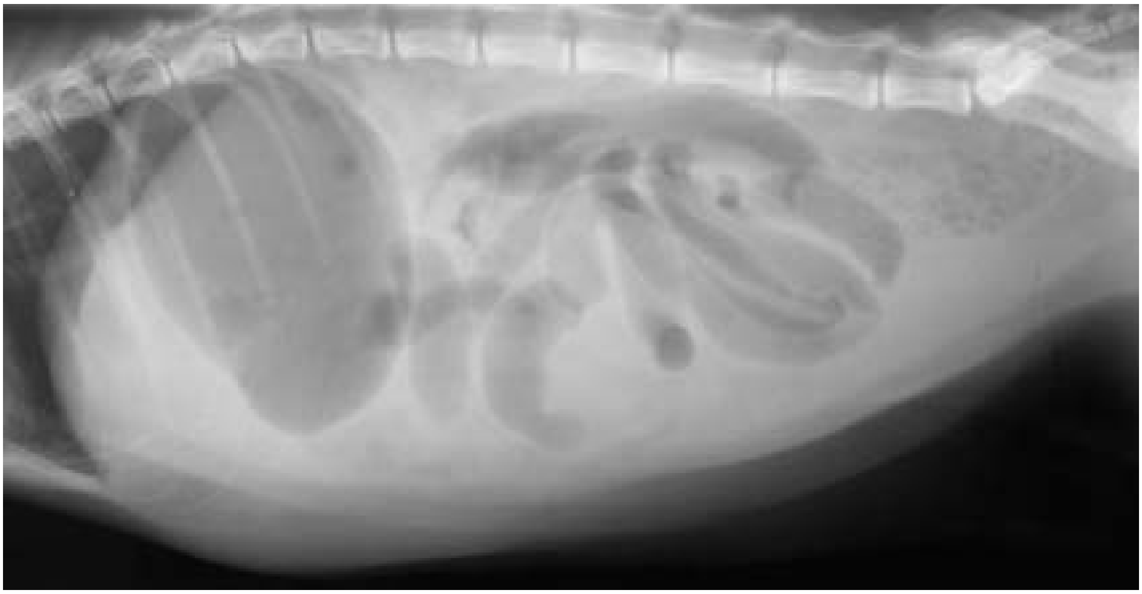
Physical examination: The abdomen was painful on palpation.

Radiographic procedure: Radiographs were made of the abdomen searching for the bullet tract.

Radiographic diagnosis: The metallic bullet lay within the retroperitoneal space on the midline just ventral to L6–7. The abdomen had lost contrast probably due to accumulation of peritoneal fluid. The pattern of gas within the abdomen did not follow that seen normally with bowel gas and free peritoneal air was suspected. The retroperitoneal space had lucent linear shadows suggesting free air in this location also. One air-filled bowel loop was greatly distended suggesting the possibility of an ileus.

Treatment/Management: The metallic fragment was typical for a rifle bullet that has struck only soft tissue and as a consequence was only slightly malformed. An abdomen with the appearance of free fluid and air strongly suggests the likelihood of a ruptured bowel.

"Bonnie" was returned to the referring clinician for surgery and was lost to follow-up.



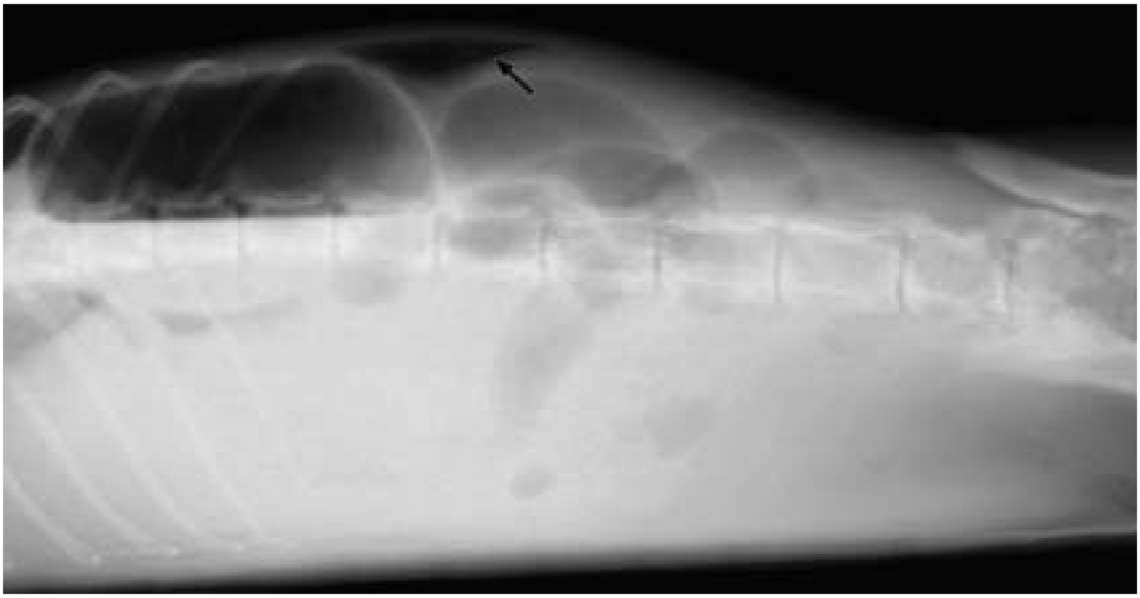
Case 3.10

Signalment/History: "Regulus", a 10-month-old, male DSH cat, was presented with a history of vomiting after being absent from home for several days.

Physical examination: The abdomen was painful on palpation.

Radiographic procedure: Radiographic studies of the abdomen were made.

Radiographic diagnosis: A diffuse pattern of peritoneal fluid was noted throughout the abdomen, but principally surrounding the body of the stomach. Scattered pockets of air were indicative of pneumoperitoneum. The air-filled, distended small bowel was indicative of a paralytic ileus. Note how the bowel loops appear to "float" on the surface of the peritoneal fluid. Feces remained within the distal colon.



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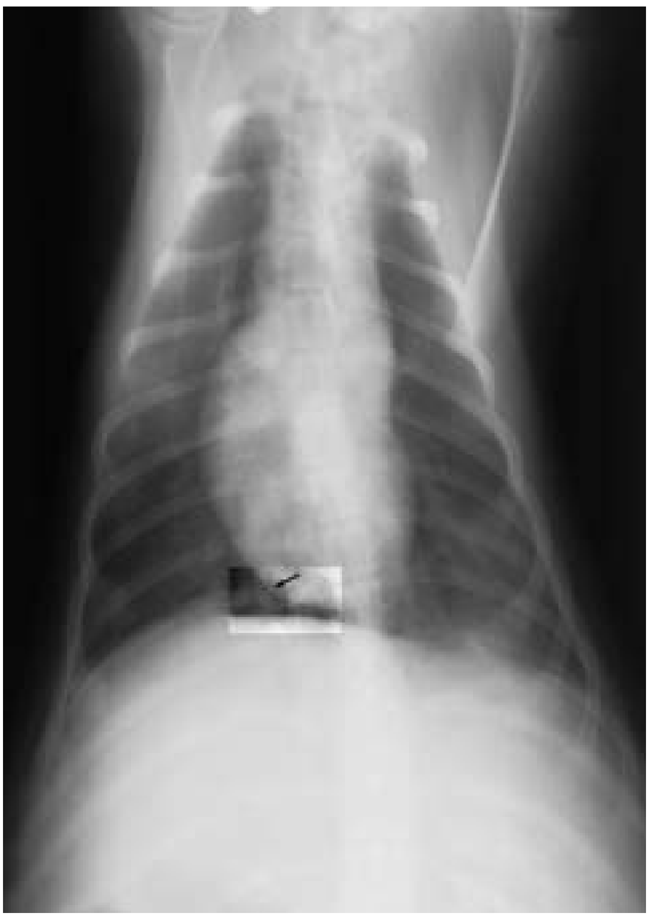
A positional study using a horizontal beam was made with the dog in right lateral recumbency. This permitted movement of the peritoneal air to a pocket just caudal to the body of the stomach (arrow).

Treatment/Management: A perforated jejunum was located at surgery, which required a bowel resection. The cat was discharged following a recovery period in the clinic. The specific cause of the perforation was not determined.

Case 3.11



Signalment/History: "Freya" was a 5-month-old, female mixed-breed dog who had been hit by a car and was presented in shock.

Physical examination: The examination was limited; however, palpation indicated that bones in the dog's forelimb were fractured. Pelvic fractures were suspected as well.

Radiographic procedure: Radiographs were made of the thorax. Following their evaluation, it was determined that additional studies of the caudal abdomen/pelvis, and the right forelimb could be made without risk to the patient.

Radiographic diagnosis (thorax): Lung contusion was minimal, though it was more severe caudally on the left in association with minimal pleural effusion. Fractures of the right 9th (arrow), 11th, 12th, and 13th ribs near the costovertebral joint were difficult to diagnose. Both the cardiac silhouette and the pulmonary vessels were smaller than expected, probably due to shock.

Radiographic diagnosis (caudal abdomen): Loss of contrast between the abdominal organs was due to peritoneal fluid. A sacral fracture, left sacroiliac fracture/luxation, and right acetabular fracture were present. A distal femoral fracture on the left was almost overlooked on the radiographic evaluation.

Radiographic diagnosis (right forelimb): Transverse fractures of the right radius and ulna were noted on additional studies.

Treatment/Management: The study of the abdomen was limited to the pelvic region. The cause of the peritoneal fluid and the severity of the shock were not evaluated. The dog died four hours following the radiographic studies after an attempt at controlling the intra-abdominal hemorrhage was unsuccessful.

In this patient, the absence of extensive injury to the thorax did not match the severity of the abdominal and skeletal injuries.

3.2.4 Inguinal hernias

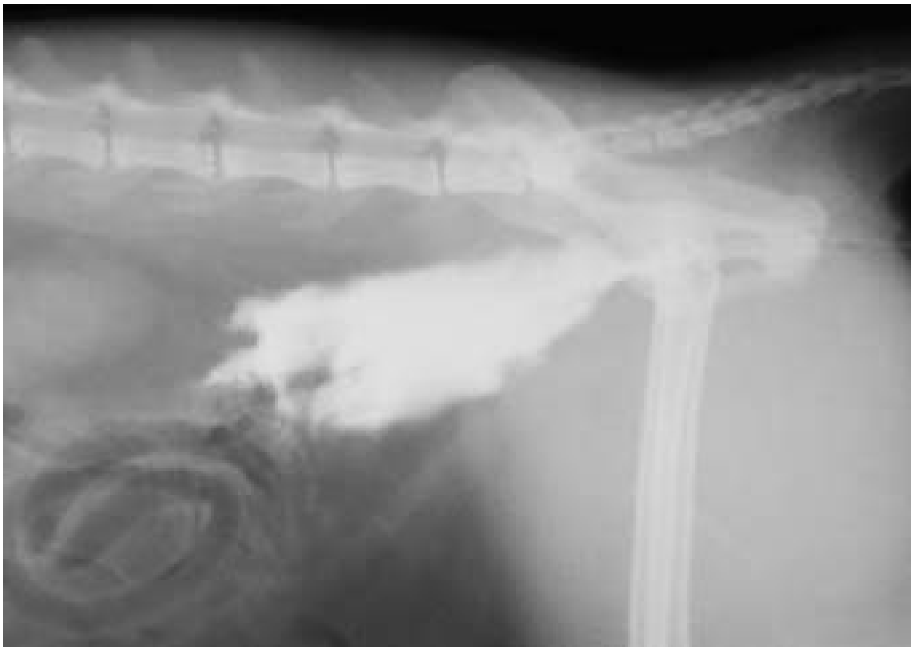
Case 3.12

Signalment/History: “Blackie” was a 4-year-old, female DSH cat who had been hit by a car eight days earlier and was referred because the cat did not have the full use of its pelvic limbs.

Physical examination: The pelvis palpated abnormally with a suggestion of crepitus bilaterally. A full feeling in the inguinal region suggested a soft tissue injury.

Radiographic procedure: Abdominal radiographs were made followed by a retrograde urethrogram.

Radiographic diagnosis (abdomen): Small bowel loops filled with air extended across the abdominal wall into the inguinal region indicating an inguinal hernia. The abdominal wall could not be identified on the right on the DV view. The air-filled bowel loops extended laterally far beyond the limits of the abdominal cavity. The urinary bladder could not be identified. The bilateral sacroiliac luxations were noted with a cranial displacement of the pelvis.



Retrograde urogram

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Radiographic diagnosis (retrograde urogram): The contrast medium leaked into the peritoneal cavity indicating a tear in the urethra or bladder wall. The tip of the catheter had been placed in the bladder limiting the information relative to the urethral injury.

The hip joints could be studied more clearly on the VD view and showed bilateral arthrosis, probably secondary to hip dysplasia.

Treatment/Management: At surgery, a rupture in the vaginal wall was repaired in addition to an urethral tear and the inguinal hernia.

Case 3.13

Signalment/History: "Tai Chi" was a 5-year-old, male Pekingese, who had been absent from home for several days. Upon return, the owners noted he was vomiting and then became anorectic. No stool had been passed.

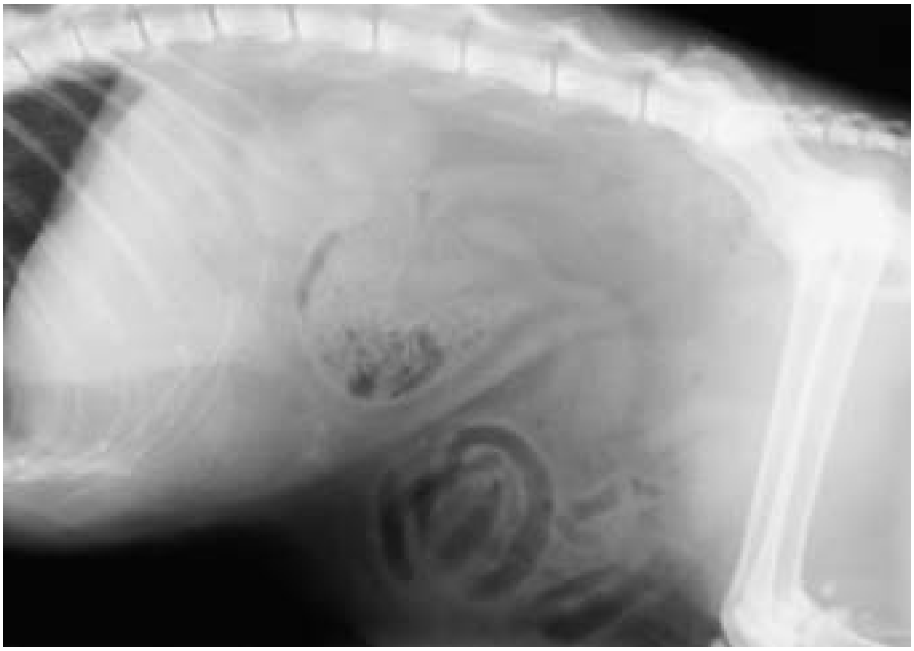
Physical examination: Scrotal swelling was evident on physical examination with the exact nature of the scrotal contents not determined.

Radiographic procedure: Caudal radiographs were made in an effort to more fully evaluate the nature of a suspected hernia.

Radiographic diagnosis: Multiple, small, well-circumscribed inguinal gas shadows were thought to be small bowel gas patterns, in which case an inguinal hernia was present (arrows). The pelvis was difficult to evaluate properly because of patient positioning.

Treatment/Management: Exploration of the suspected inguinal hernia revealed an incarcerated distal jejunum that required an intestinal anastomosis. An infarcted right testicle was removed surgically.

Comments: Herniated bowel loops cannot be considered a trivial lesion. Less likely etiologies for such an inguinal gas collection include the presence of a gas-producing organism causing an infectious lesion or a break in the skin permitting the entrance of subcutaneous air.



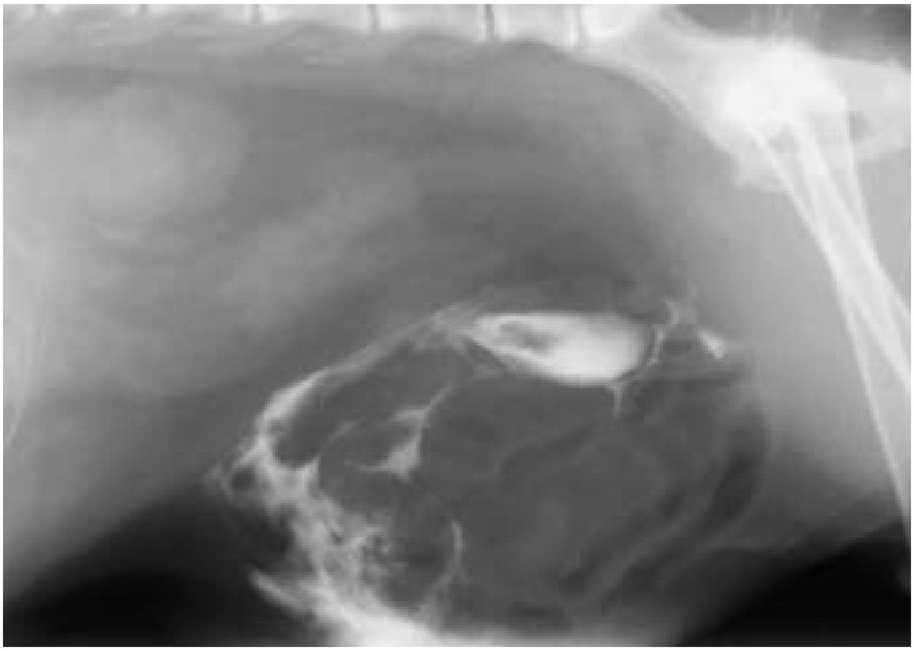
Case 3.14

Signalment/History: "Toot" was a 5-year-old, male DSH cat that was presented to the clinic following suspected trauma.

Physical examination: An inguinal hernia containing easily palpated bowel loops was found. Identification of the urinary bladder was questionable.

Radiographic procedure: Routine studies of the abdomen failed to identify the location or status of the urinary bladder, so a retrograde contrast study was performed.

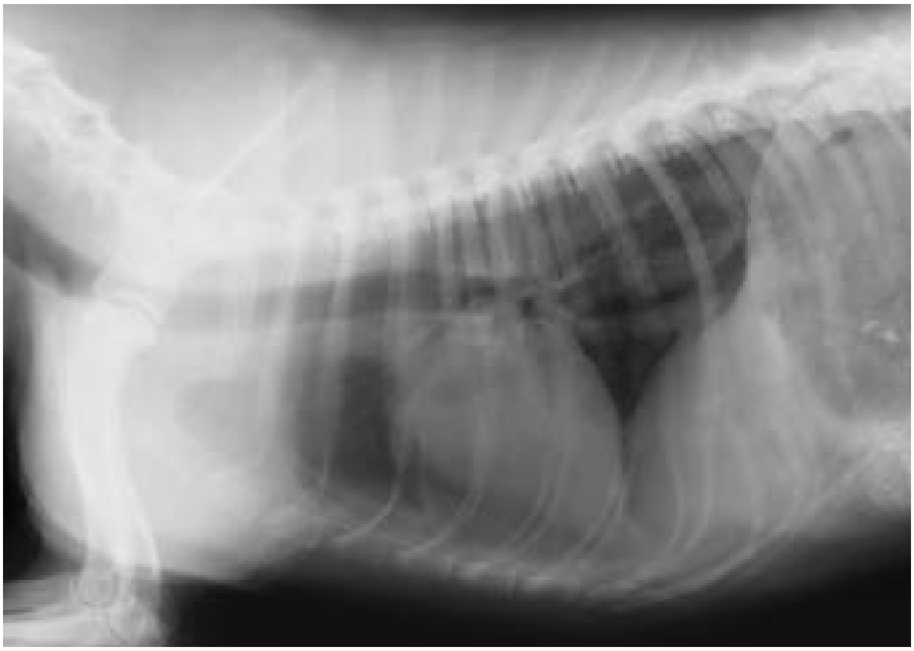
Radiographic diagnosis (abdomen): The left-sided inguinal hernia contained multiple gas-filled, small bowel loops. The luminal diameter of the bowel loops was thought to be within normal limits (<11cm) and did not suggest bowel obstruction. The urinary bladder could not be identified on the noncontrast study. Left femoral head and neck fractures were seen.



Retrograde cystogram

Radiographic diagnosis (retrograde cystogram): This showed the displaced and ruptured urinary bladder lying within the hernial sac. The bladder was partially filled and lay just ventral to the abdominal wall. The majority of the contrast agent spilled into the hernial sac.

Treatment/Management: Treatment was not permitted and the cat was euthanized.



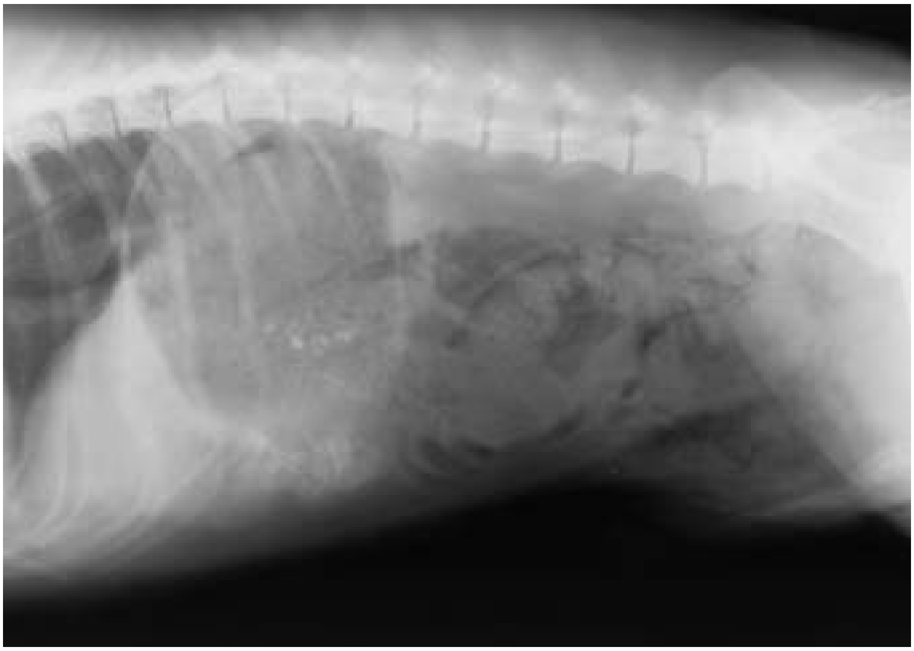
Case 3.15

Signalment/History: "Canoe", a 3-year-old, male mixed-breed dog, had received crushing injuries from an automobile accident and was presented in shock.

Physical examination: The examination was severely limited by the condition of the patient.

Radiographic procedure: Thoracic and abdominal radiographs were made.

Radiographic diagnosis (thorax): Generalized lung contusion was more severe on the right side. Fluid pooling adjacent to the sternum just cranial to the heart shadow suggested a minimal pleural effusion. Minimal pneumothorax was present on the left. Cranial mediastinal widening suggested the possibility of a hemomediastinum. The pulmonary vessels were small, indicative of shock. The diaphragm appeared to be intact. No thoracic wall injury was noted. The stomach was air-filled and distended, the result of panic breathing.



Radiographic diagnosis (abdomen): Subcutaneous emphysema was associated with a right-sided inguinal hernia that contained intestinal loops. The urinary bladder could not be identified. Pneumoperitoneum was suggested by the indistinct linear gas patterns that were not compatible with the air within the bowel loops. The loss of contrast between the organs suggested peritoneal fluid. The diaphragm had remained intact.

Radiographic diagnosis (abdomen, horizontal beam): Free peritoneal air was pocketed just beneath the diaphragm making it rather easy to identify (arrows).

Treatment/Management: The injuries were extensive and severe; however, "Canoe" was treated conservatively except for a surgical repair of the inguinal hernia. He was discharged a healthy dog.

Case 3.16

Signalment/History: "Rufus" was a 6-month-old, male mixed-breed cat admitted because he could not walk on the right pelvic limb. The lameness had had an acute onset.

Physical examination: Examination suggested a right femoral fracture. Additional crepitus was noted on palpation of the pelvis. The status of the hip joints was not determined. Soft tissue swelling was prominent especially around the right pelvic limb.

Radiographic diagnosis: A comminuted, midshaft, right femoral fracture was complicated by an apparent right inguinal hernia with bowel loops extending subcutaneously and distally into the pelvic limb. The bowel loops were thought to be excessive in diameter and were considered obstructed. Pubic and ischial fractures had resulted in separation of the two halves of the pelvis. The right femoral neck was fractured; however, the exact nature of that fracture could not be determined because of the unique positioning of the pelvic limb. The right sacroiliac joint was separated. The urinary bladder could not be identified.

Treatment/Management: Surgery resulted in a reduction of the obstructed bowel loop and stabilization of the femoral fracture. A femoral head ostectomy was used to treat the femoral head/neck fracture. The urinary bladder was found to be uninjured.

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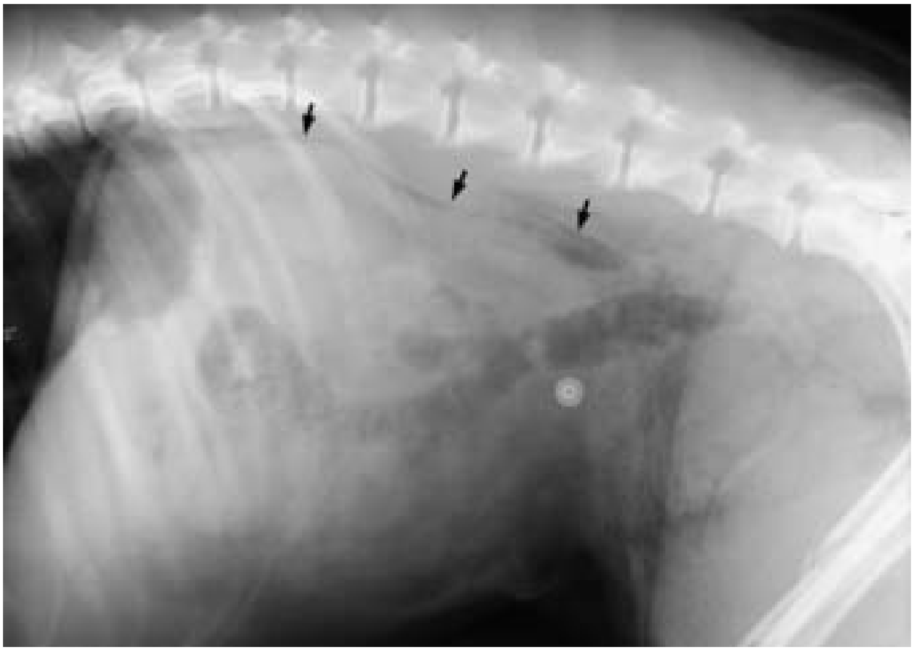
3.2.5 Renal, ureteral, and urinary bladder injury



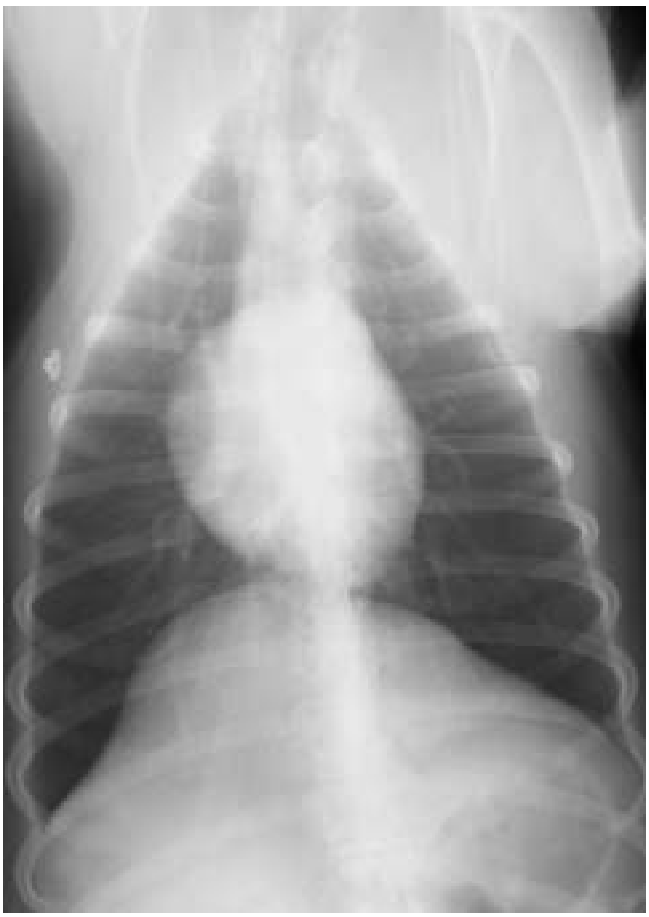
Case 3.17

Signalment/History: "Amber" was a 6-year-old, female mixed-breed dog with a clinical history of possible trauma. She was not able to walk normally.

Physical examination: On physical examination, a femoral fracture was detected. Abrasions of the skin suggested the possibility of more widespread injury.

Radiographic procedure: Both the thorax and abdomen were radiographed because the injury appeared to involve the whole body.

Radiographic diagnosis (abdomen): Marked subcutaneous emphysema was noted surrounding the injured pelvic limb. In addition, retroperitoneal air was evident ventral to the lumbar spine (arrows). The urinary bladder could not be identified and the presence of peritoneal fluid supported the diagnosis of a rupture of the bladder. Bilateral sacroiliac separation was present.



Radiographic diagnosis (thorax): The thorax was examined for evidence of a pneumomediastinum, which could have resulted in air migrating from the thorax into the retroperitoneal space. The thorax appeared normal except for having a small cardiac silhouette and small pulmonary vessels both suggesting shock.

Treatment/Management: The femoral fracture was open and the retroperitoneal air may have gained entrance in that manner. A rupture at the bladder neck or proximal urethra could also have resulted in retroperitoneal air. Both of these causes for retroperitoneal air are considered uncommon, but as there was no evidence of pneumomediastinum in this dog, they were taken into consideration. No evidence of a puncture wound in the dorsal abdomen was found that could have resulted in abdominal air.

"Amber" recovered from surgery for the repair of the ruptured bladder and the fractured femur.

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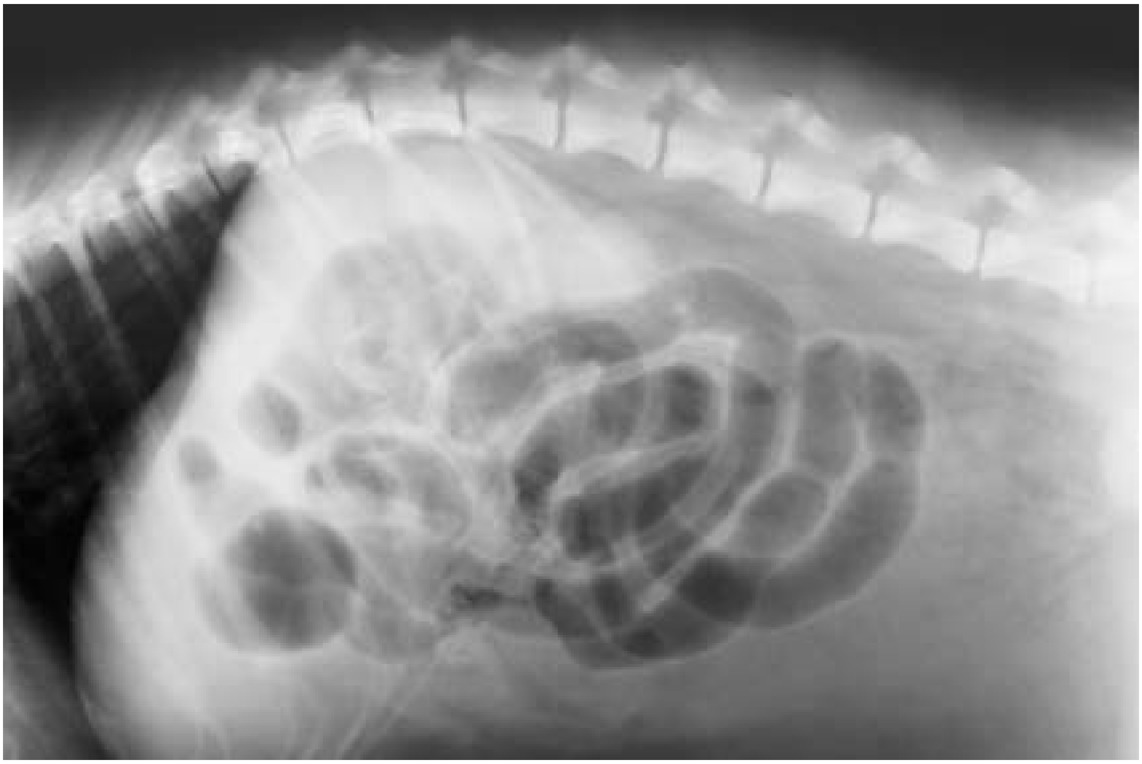

Case 3.18

Noncontrast

Signalment/History: "Lady", a 9-month-old, female Collie, had been hit by a truck 24 hours previously. She was in an emergency clinic being treated for shock. The BUN level and the WBC count were elevated.

Physical examination: Crepitus was detected in the pelvis. The dog had not been observed to urinate since the accident and the bladder could not be identified by palpation.

Radiographic procedure: Only lateral radiographs were made of the abdomen and pelvis because of the severity of the injuries.

Radiographic diagnosis: Marked gaseous distention of small bowel loops in the midabdominal region suggested a paralytic ileus. Loss of contrast between the abdominal viscera, failure to clearly identify the urinary bladder, and failure to identify the ventral abdominal wall all indicated free peritoneal fluid. Small air pockets throughout the abdomen suggested the presence of free peritoneal air, too. Retroperitoneal fluid indicated possible hemorrhage. An indistinct fluid-density inguinal mass was also thought to be probably due to free hemorrhage.

Treatment/Management: The small cardiac silhouette and small pulmonary vessels were noted radiographically to increase in size following administration of IV fluids. During this time, the urinary bladder was noted to remain constant in size suggesting that urine was leaking from the bladder. It was decided that an excretory urogram was necessary.

Radiographic diagnosis (10 minutes following intravenous injection): Leakage of radiopaque contrast medium in both the peritoneal and retroperitoneal spaces was suggestive of a ruptured bladder neck and/or a torn ureterovesical junction (arrows).

Treatment/Management: The paralytic ileus could have been the result of the trauma indicating injury to the vascular supply, mesenteric torsion, or herniation through a mesenteric tear. In addition, it could have been the response to urine within the peritoneal cavity. The dog was euthanized and the body taken home without any further examination.

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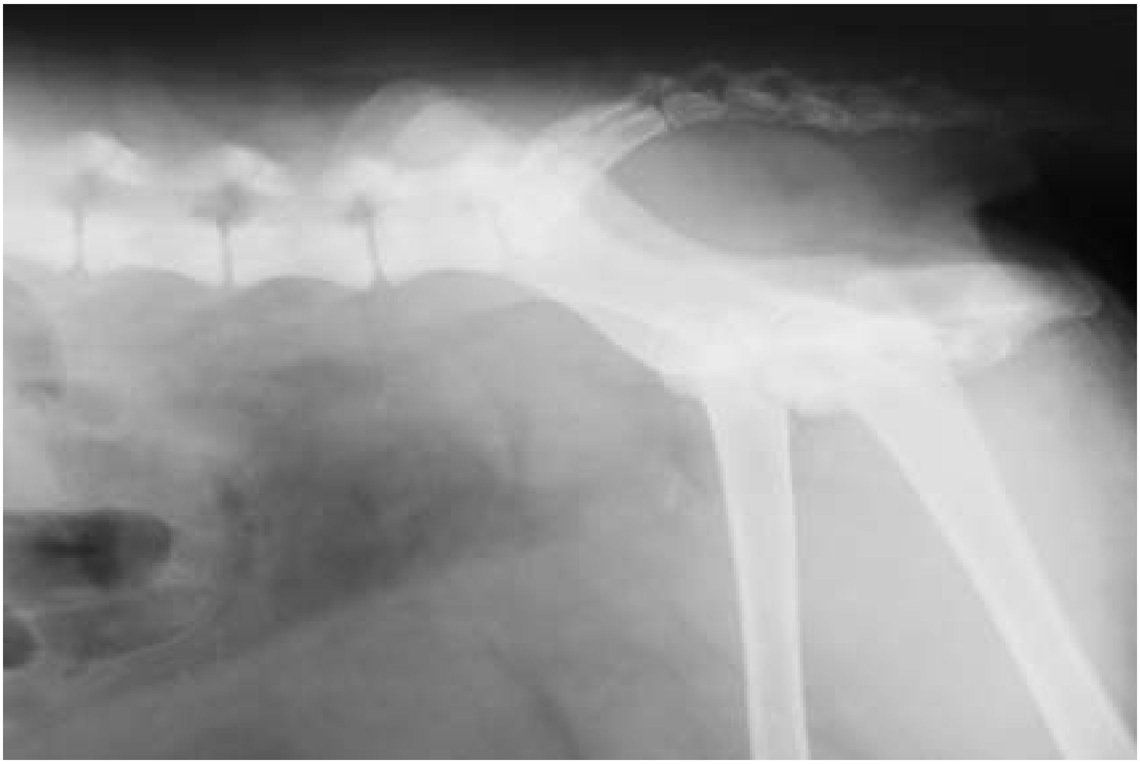

Excretory urogram

Case 3.19

Signalment/History: An adult male cat had been found by the road unable to move and was brought to the clinic.

Physical examination: The patient was dyspneic and an inguinal hernia was palpated.

Radiographic procedure: Thoracic and abdominal studies were made.

Radiographic diagnosis (thorax): A massive pneumothorax had caused the collapse of the right lobes and a mediastinal shift to the left. Pulmonary contusion had induced an increase in fluid density in the left lung. An injury to the right thoracic wall had fractured a number of ribs. Minimal subcutaneous emphysema was present. The diaphragm appeared intact.

Radiographic diagnosis (abdomen): The urinary bladder appeared within an inguinal hernia on the left, which also contained air-filled small bowel loops. A right-sided pelvic fracture included injury to the floor of the pelvis, but did not affect the hip joint. Stress aerophagia resulted in the stomach being distended with air.

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Retrograde cystogram

Radiographic diagnosis (retrograde cystogram): The retrograde study showed the catheter tip lying within the urethra and a flow of contrast agent into the peritoneal cavity and into the hernial sac. This extra-vesicular flow of the contrast agent and the failure to fill the bladder with the agent suggested a rupture of the urethra or bladder neck. The bladder was thought to be within the hernial sac.

Treatment/Management: The cat was euthanized and the necropsy confirmed the radiographic findings of a bladder neck tear.

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Case 3.20

Noncontrast

Signalment/History: “King” was an 8-year-old, male Collie with a suddenly appearing caudal mass. The owners suspected that the dog had been struck by a car several weeks earlier.

Physical examination: The mass was soft and fluid-filled, but not painful on palpation. Both hip joints had limited motion.

Radiographic procedure: Both views were made of the abdomen and of the pelvis. In addition, both intravenous urography and retrograde cystography were performed.

Radiographic diagnosis (noncontrast): A poorly marginated, soft tissue mass of uniform fluid density lay ventral to the tail causing the gas-filled rectum to be displaced dorsally (arrows).

Malunion pelvic fractures had caused a marked stenosis of the pelvic canal. The hip joints were difficult to evaluate.

A healed caudal sacral fracture had induced a dorsal displacement of the distal fragment.

Radiographic diagnosis (intravenous urography/retrograde cystography): A bilateral hydronephrosis and hydroureter was more prominent on the left on the ten-minute study. The trauma had caused a displacement of the urinary bladder and prostate gland into the perineal hernia. A urethral catheter positioned into the urinary bladder could be identified on the study.

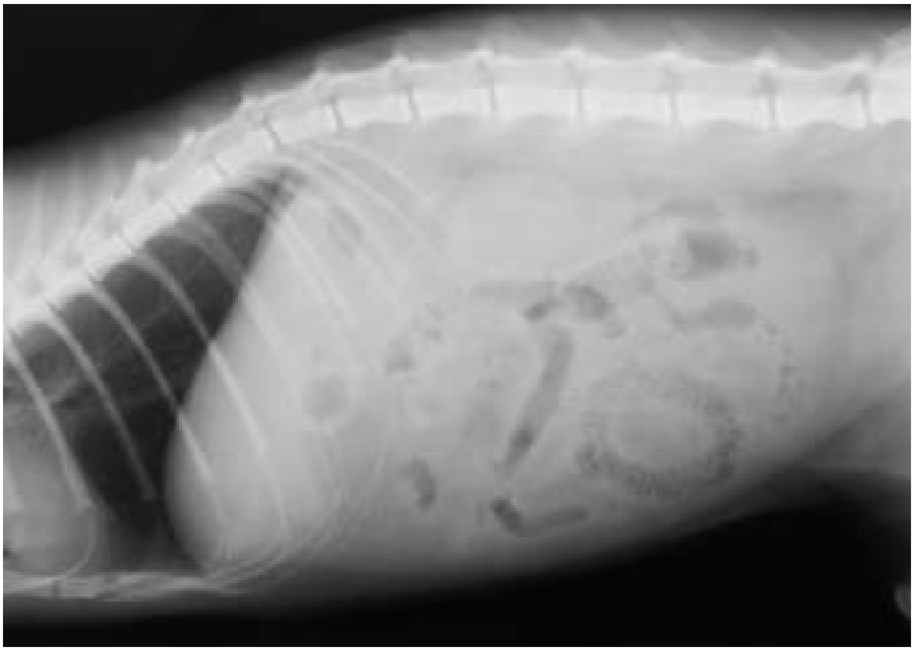
Retrograde cystography

Bilateral retention of the contrast agent in the pelvis and ureters following the intravenous injection was evident on the 10-minute study. On the 30-minute study, drainage had occurred from the right kidney and ureter; however, retention of contrast agent persisted on the left side (arrows).

Comments: It is interesting to speculate whether the retroflexion of the bladder had occurred at the time of the trauma that caused the pelvic fractures or was secondary to chronic straining in the months following the fractures. The owners were correct in that the dog had been traumatized; however, the trauma probably had been several months previously and not weeks as they had thought.

In the evaluation of the pelvic trauma, the status of the femoral heads is important since their injury causes a major complication to treatment and healing, as well as the ultimate prognosis. In this patient, the femoral heads and necks appear not to be traumatized. In comparison, the collapse of the pelvic inlet is important clinically.

It was possible to correct the location of the abdominal organs surgically, but little could be done concerning the malunion fractures or injury to the acetabula.



Case 3.21

Signalment/History: A male DSH cat was found lying by the side of the highway apparently having been struck by a car.

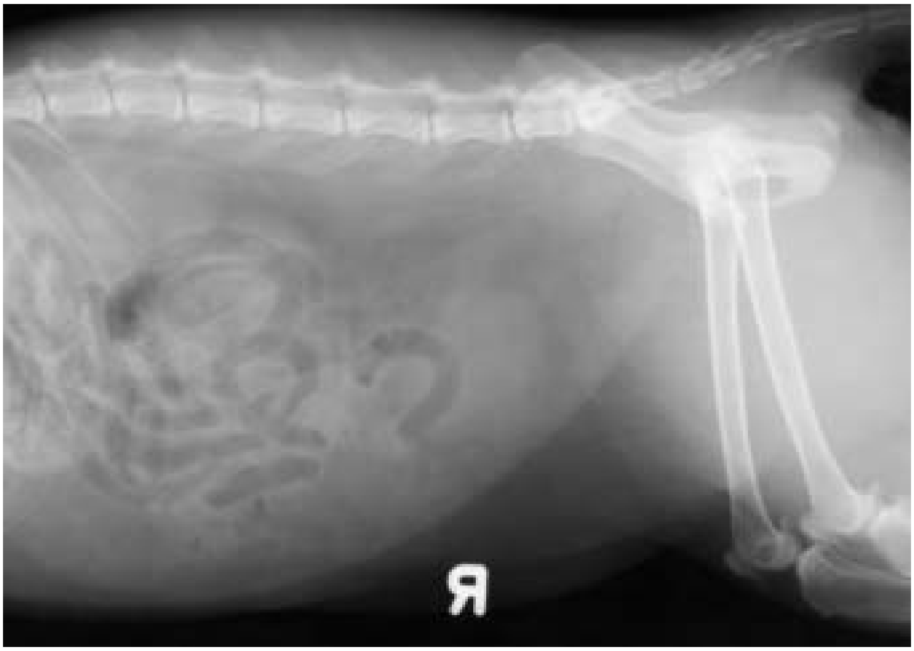
Radiographic procedure: Whole body radiographs were made, followed by a retrograde cystogram.

Radiographic diagnosis (abdomen): Small bowel loops were "floating" within an abdomen without contrast and so the latter was thought to contain peritoneal fluid. The urinary bladder could not be identified.

Retrograde cystogram

Radiographic diagnosis (retrograde cystogram): The positive contrast agent partially filled the urinary bladder; however, a large portion of the contrast agent spilled into the retroperitoneal cavity, peritoneal cavity, and extended into the pelvic cavity.

Outcome: At necropsy, a 1–2 cm tear was located just cranial to the trigone region of the urinary bladder. A tear in this location had permitted urine to escape into all of the adjacent body cavities. Splenic rupture with hemoperitoneum was also noted.



Case 3.22

Noncontrast

Signalment/History: "Ollie" was a 2-year-old, male DSH cat with clinical signs of urinary obstruction.

Physical examination: On palpation, the urinary bladder was difficult to feel and the abdomen felt somewhat distended. During the examination, a catheter was passed into the bladder, but only a small amount of sanguinous fluid could be removed.

Radiographic procedure: Noncontrast studies were made of the abdomen and were followed by a retrograde cystogram.

Radiographic diagnosis (noncontrast): A fluid density mass was located in the caudal abdomen ventrally, but in a location thought cranial to the expected location of the urinary bladder. Bowel loops were air-filled and appear to "float" on a "sea" of peritoneal fluid, possibly urine. Loss of peritoneal contrast further supported the diagnosis of peritoneal fluid. Free peritoneal air was difficult to identify, but a large air dense shadow was noted in the midabdomen dorsally on the lateral view, and on the left side of the abdomen on the VD view.

Retrograde cystogram

Radiographic diagnosis (retrograde cystogram): A small amount of positive contrast agent was injected through the catheter with the agent passing directly into the peritoneal cavity ventrally and to the right. The shadow thought to be the urinary bladder did not fill with any of the contrast agent.

Treatment/Management: The owner refused treatment. At necropsy, the catheter was found to have passed through an opening in the urethra located 3 mm from the bladder neck. The tip of the catheter was 4 cm beyond the urethral rupture into the peritoneal cavity at the time of injection. The appearance of the urethral tear suggested a chronic lesion possibly following an earlier effort at catheter placement.

While the study confirmed an injury, placement of the catheter tip within the urethra would have been more informative and would have demonstrated a lesion that could have been more easily repaired than was originally thought.

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Case 3.23

Noncontrast

Signalment/History: "Frodo", an 11-month-old, female DSH cat, was presented with a painful attitude.

Physical examination: She was febrile and had abrasions on the skin of the right pelvic limb. Palpation of the abdomen disclosed pain principally on the left. Trauma was suspected.

Radiographic procedure: Abdominal studies were made and were followed by an intravenous urogram.

Radiographic diagnosis (noncontrast): The left kidney was displaced laterally with an indistinct soft tissue shadow located at the side of its shadow. On the lateral view, the sublumbar musculature was not sharply contrasted against the retroperitoneal fat, and fluid was suspected in that compartment. These findings suggested retroperitoneal fluid, perhaps urine, and an intravenous urogram was performed.

Intravenous urogram

Radiographic diagnosis (intravenous urogram): Studies made at 30 minutes following injection of the contrast agent demonstrated hydronephrosis in the left kidney with distention of the proximal portion of the left ureter and leakage of urine containing the contrast agent into the retroperitoneal space. The distal portion of the left ureter was filled with contrast agent. The study showed a normally functioning kidney on the right side and filling of the urinary bladder with contrast agent.

Treatment/Management: An unsuccessful attempt at surgical repair of the torn ureter was followed by a second operation in which the affected kidney and proximal ureter were surgically removed. The filling defect in the proximal portion of the urinary bladder was probably caused by a blood clot. "Frodo" recovered and renewed his search for Sam and Gollum.

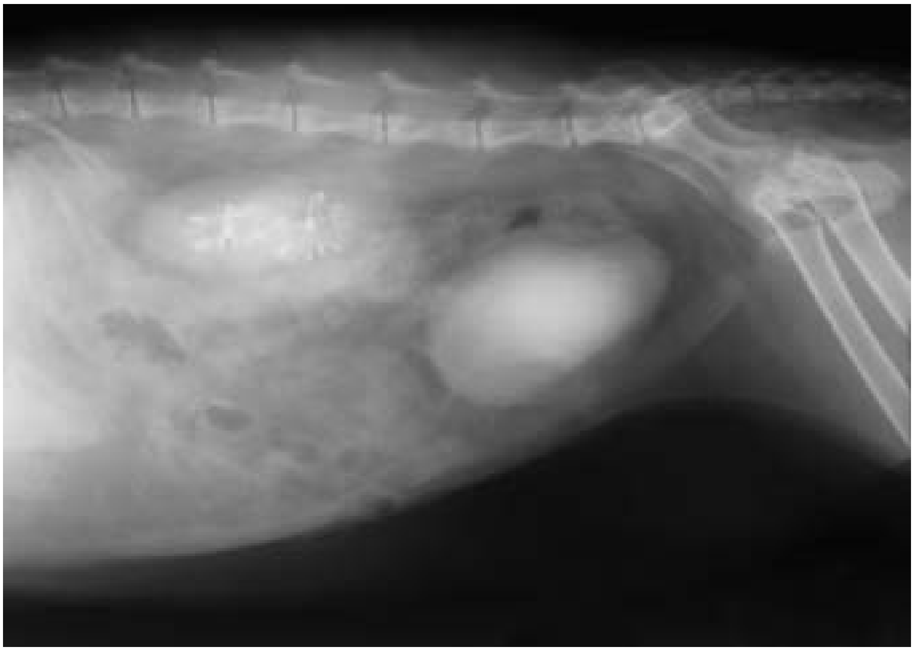
Case 3.24

Noncontrast

Signalment/History: A male DSH cat was found lying near the side of the highway after apparently being struck by a car.

Radiographic procedure: Whole body studies were made, followed by an intravenous urogram.

Radiographic diagnosis (noncontrast): Small bowel loops were seen to "float" within an abdomen thought to contain peritoneal fluid. The urinary bladder could not be clearly identified. Because of these findings, it was assumed that the urinary bladder might be ruptured and an intravenous urogram was performed.



Intravenous urogram

Radiographic diagnosis (intravenous urogram): Radiographs were made at 10 minutes and filling of the renal pelves was evident. At 20 minutes, the hold-up of contrast agent in the renal pelves was abnormal and the filling of the proximal ureters suggested ureteritis, which could have been post-traumatic. However, the major finding was the leakage of contrast agent into the perirenal tissues on the left (arrows). A diagnosis of a ruptured kidney was made.

Treatment/Management: The rupture of the kidney was followed clinically and the cat improved without surgical intervention and was discharged after three weeks. Radiographs made two years later showed the left kidney to be of normal size, shape, and position.

Comments: Even despite its retroperitoneal position, renal injury often causes tearing of the peritoneum and leakage of urine or blood into the peritoneal space.

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3.2.6 Urethral injury

Case 3.25

Noncontrast

Signalment/History: "Rogue", a 2-year-old, male Bichon Frise, was presented with a history of recurrent urinary calculi.

Physical examination: The urinary bladder was easily palpable. Physical examination was limited because of the questionable status of the bladder and urethra.

Radiographic procedure: Routine studies were made of the caudal abdomen, followed by retrograde urography.

Radiographic diagnosis (noncontrast): The noncontrast studies showed a distended bladder with air bubbles probably secondary to the removal of urine from the bladder. No cystic or urethral calculi were noted. The absence of peritoneal contrast suggested the presence of peritoneal fluid.

Radiographic procedure (retrograde urography): The catheter tip was positioned within the penile urethra and a radiograph made following a small injection of positive contrast agent. Subsequently, a larger injection was made.

The flow of contrast agent outlined a badly damaged urethral mucosa at the urethral arch with extravasation of the contrast agent into the periurethral tissues. The prostatic urethra was dilated. A portion of the contrast agent flowed into the urinary bladder, which appeared intact.

Retrograde urography

Outcome: A necropsy examination followed unsuccessful emergency surgery. The urethra was ruptured just distal to the ischial arch and a calculus was located in the surrounding tissues. A necrotic cystitis was evident. It was thought that the calculus had been driven through the urethral wall by the passage of a urethral catheter at an earlier date.

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Case 3.26

Noncontrast

Signalment/History: “Andy”, a 1-year-old, male DSH cat, was presented for emergency treatment of a blocked urethra. He had had dysuria for seven days and was thought to have not urinated for at least 24 hours prior to presentation.

Physical examination: A large, firm bladder was palpated and a local anesthetic was sprayed into the urethra. Immediately following this medication, the bladder could not be palpated.

Radiographic procedure: Noncontrast studies of the abdomen were made and followed immediately by a retrograde urethrocystogram.

Radiographic diagnosis (abdomen): Distention of the small bowel was indicative of a paralytic ileus. The loss of abdominal detail suggested the presence of peritoneal fluid while the pattern of free peritoneal air indicated a pneumoperitoneum.

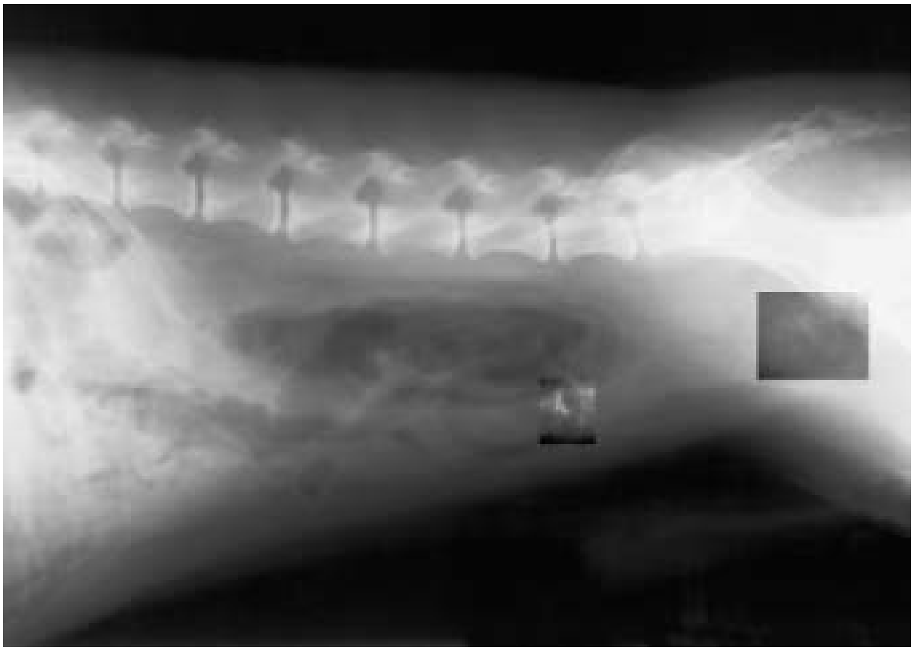
Retrograde urethrocystogram

Radiographic diagnosis (retrograde urethrocystogram): The catheter tip was positioned in the urinary bladder and partially filled that structure. Some of the urine-containing contrast agent was seen to have escaped from a tear in the midportion of the urethra, while a part of the liquid had spread into the retroperitoneal space dorsally.

A long-standing left femoral neck fracture could be seen with resorption of the femoral head and the formation of a pseudoarthrosis.

Comments: The location of the catheter tip during the retrograde study determines your ability to demonstrate a proximal urethral injury. In this patient, the urine flowed out of the bladder into the urethra and demonstrated the urethral tear. It might have been better to have positioned the catheter tip first of all in the urethra to ensure identification of the urethral tear and then move the catheter tip into the bladder to determine the status of the bladder wall.

The complete disappearance of the left femoral head on this study indicates an injury of several months duration.

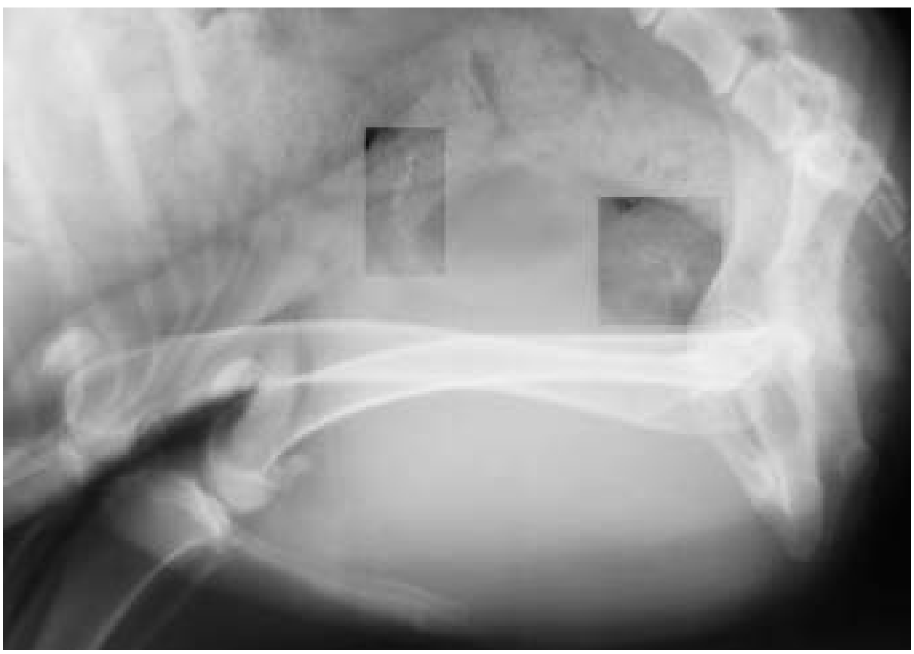


Case 3.27

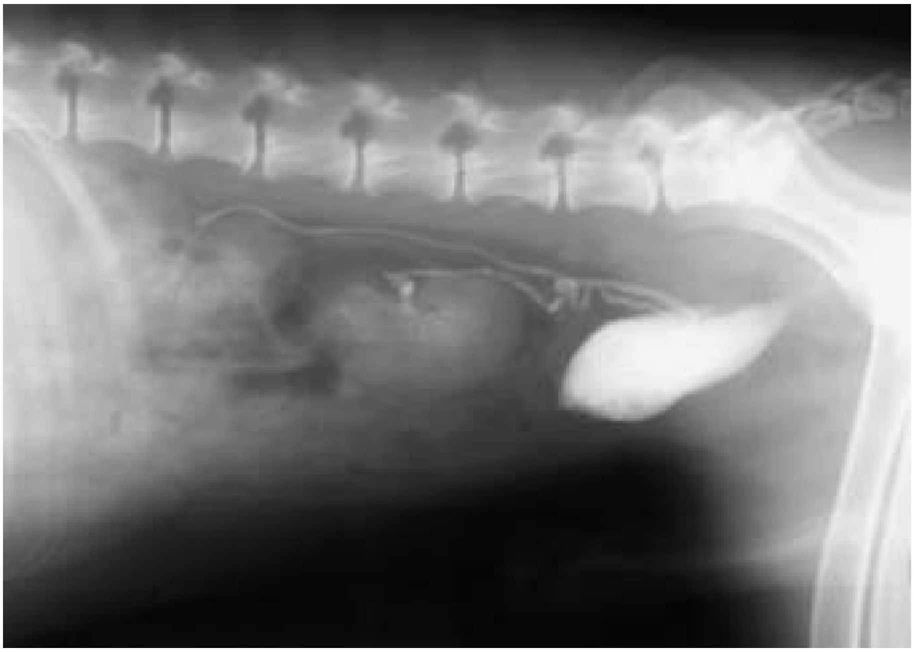
Signalment/History: "Simpson" was a 4-year-old, male Dalmatian with a chronic history of urethral blockage, which had been treated medically but had also required a prepubic urethrostomy.

Radiographic procedure: Noncontrast studies of the abdomen were performed and were followed by an intravenous urogram.

Radiographic diagnosis (abdomen): Areas of calcification were noted in the region of the fundus of the urinary bladder and also more caudally in the region of the prostate gland.



Noncontrast



Intravenous urogram

Retrograde urogram

Radiographic diagnosis (intravenous urogram): The intravenous study showed normal functioning kidneys with persistent filling of tortuous ureters indicative of ureteritis. Filling defects in the urinary bladder suggested intraluminal blood clots and/or radiolucent calculi. Areas of calcification were identified within the thickened bladder wall and within the prostate gland.

Radiographic diagnosis (retrograde urethrogram): Retrograde studies were made following injection of the positive contrast agent with the tip of the catheter at the end of the penis. A retained catheter from an earlier study extended into the area of the prostatic urethra (arrows). Marked mucosal distortion at the end of the penis suggested both intraluminal calculi as well as mucosal stricture.

Treatment/Management: Removal of the calculi and sand from the bladder, plus removal of the retained catheter were carried out surgically.

Comments: Filling defects within the urinary bladder in an older patient always require the inclusion of bladder wall tumor in the differential diagnosis. Dystrophic calcification within the bladder or prostate gland can be the result of chronic inflammatory disease or can be associated with neoplasia.

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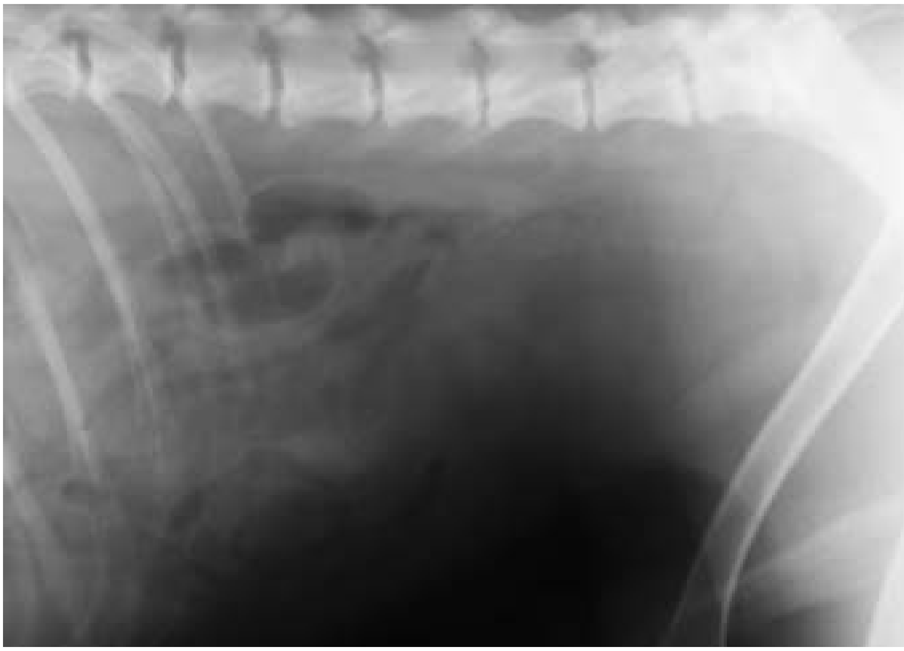


Case 3.28

Noncontrast

Retrograde urethrogram

Signalment/History: A 3-year-old, male Boxer was brought to the clinic because the owner had noted blood in his urine.

Physical examination: Examination indicated that what the owner thought was a red coloration in the urine, was instead, actually bleeding from the penis.

Radiographic procedure: Noncontrast studies were made of the abdomen with a special view of the urethral region with the pelvic limbs flexed. A retrograde urethrogram was then performed.

Radiographic diagnosis (noncontrast): No evidence of any calculi was seen on the noncontrast studies. The urinary bladder was difficult to identify. No signs of peritoneal fluid were evident as would be anticipated with a bladder rupture.

Radiographic diagnosis (retrograde urethrogram): The retrograde study was performed with the catheter tip just proximal to the penile urethra. Contrast agent was seen to fill the urethra and enter the bladder in a normal fashion. Rather unexpectedly, the contrast also entered the corpus cavernosum of the penis and drained into the venous return (arrows).

Treatment/Management: Further information was obtained from the owner that included a chronic history of difficult urination, which had required frequent catheterization. It was assumed that repeated urethral trauma had caused injury to the mucosa.

Comments: While the radiographs were rather remarkable, of more importance was the potential stricture at the site of the mucosal injury and the possibility of continued dysuria.

Day 1

Day 2

Case 3.29

Signalment/History: "Pokey" was a 2-year-old, male mixed-breed dog who had been hit by a car.

Physical examination: Palpation of the pelvic limb suggested a fractured femur. The caudal abdominal wall appeared to be torn or ruptured.

Radiographic procedure: A single lateral view of the abdomen was made to evaluate possible abdominal injury as well as to obtain a single view of the fracture. On day 2, a retrograde urethrogram was performed.

Radiographic diagnosis (day 1, immediately post trauma): Failure to identify the abdominal wall plus loss of abdominal contrast indicated the presence of peritoneal fluid. Displacement of the bowel loops from the caudal region suggested an inguinal mass resulting from the trauma. Peritoneal hemorrhage and/or edema, and urinary bladder rupture or herniation were all considered. The midshaft oblique femoral fracture was noted along with fractures of the floor of the pelvis.

Day 4

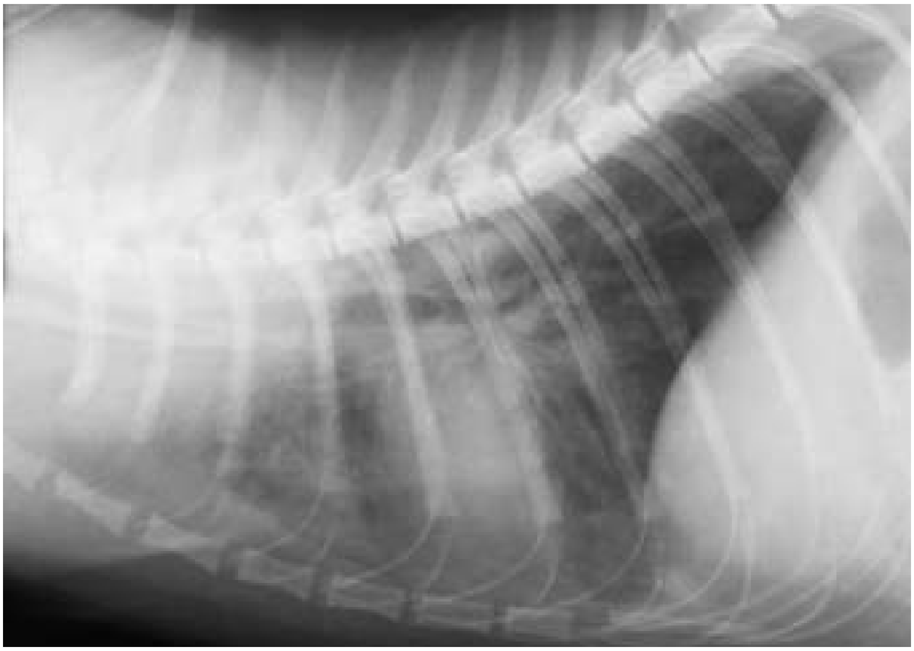
Radiographic diagnosis (day 2, retrograde urethrogram): Extravasation of contrast agent into the pelvic extension of the retroperitoneal space and into the inguinal region could be seen in the urethrogram. Contrast agent failed to enter the urinary bladder probably due to a urethral rupture at the bladder neck. Air bubbles made a specific pattern in the urethra. Contrast agent had been spilled on the hair coat and caused a peculiar pattern of radiographic artifact.

Treatment/Management: Surgery was performed without further evaluation of the upper urinary system. The urethral rupture and injury to the abdominal wall were both repaired. Injury to the right ureter was noted, but not treated.

Radiographic diagnosis (day 4, intravenous urogram, 20-minute studies): Delayed emptying of the right kidney was persistent on the later studies of the examination. The left kidney and ureter appeared to function normally. A separation of the right sacroiliac joint and public and ischial fractures were noted.

Treatment/Management: "Pokey" had a hemolytic crisis and died ten days after surgery. A stricture of the distal right ureter was noted at necropsy and was incorporated in the urethral scar causing delayed emptying.

Comments: In some trauma patients, it is appropriate to evaluate both the upper and lower portions of the urinary system before proceeding to surgery.



Case 3.30

Signalment/History: "Freedom" was a 1-year-old male Siamese cat who had been traumatized in some manner and was found outside of the house by his owner.

Physical examination: The cat was in severe shock.

Radiographic procedure: Both thoracic and abdominal radiographs were made, followed by a retrograde cystogram.

Radiographic diagnosis (thorax): A diffuse increase in fluid density within the lungs was more prominent on the left side. This was compatible with pulmonary hemorrhage following trauma. Pleural fluid was minimal but thought to be present bilaterally. The diaphragm appeared to be intact and the thoracic wall did not show any signs of injury. The caudal vena cava was enlarged.

Radiographic diagnosis (abdomen): Peritoneal fluid was indicated by the loss of contrast between the peritoneal organs and by the air-filled bowel loops appearing to float on the "sea of fluid". The abdominal wall could not be seen clearly and the urinary bladder was unidentifiable. A fracture through the right half of the sacrum in conjunction with the right pubic and ischial fractures made the right hemipelvis free of bony attachment. The hip joints were normal. The change in alignment between the vertebral bodies of L6 and L7 seen on the lateral view was thought to be congenital and not post-traumatic.

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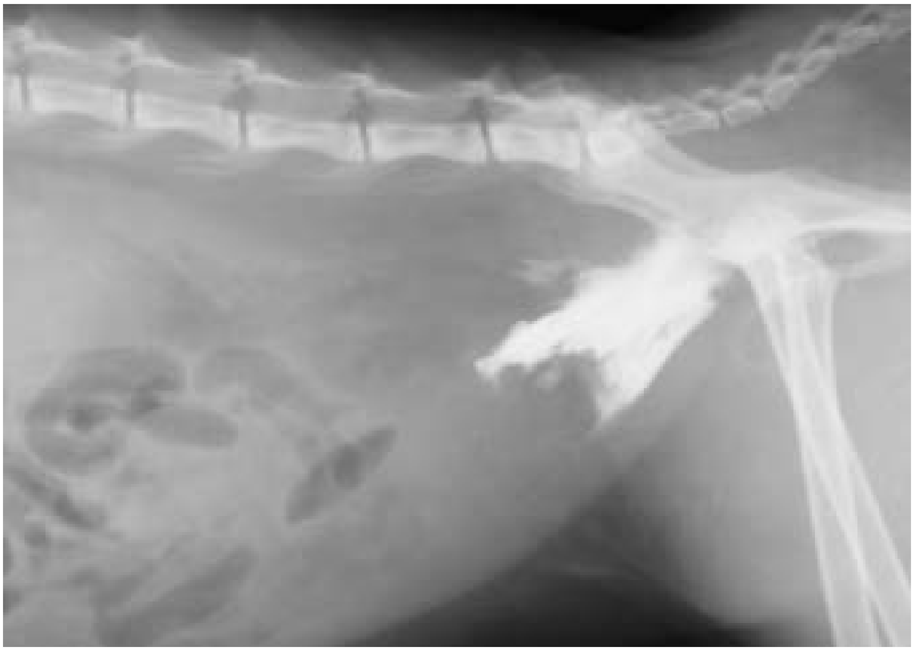


Retrograde urethrogram

Radiographic diagnosis (retrograde urethrogram): The retrograde study confirmed a urethral or bladder neck tear.

Treatment/Management: A more diagnostic study could have been made if the catheter tip had been positioned within the urethra, and if the study had been made immediately following injection of a minimal amount of contrast agent.

The owner refused treatment and the cat was euthanized without any further examination.

Case 3.31

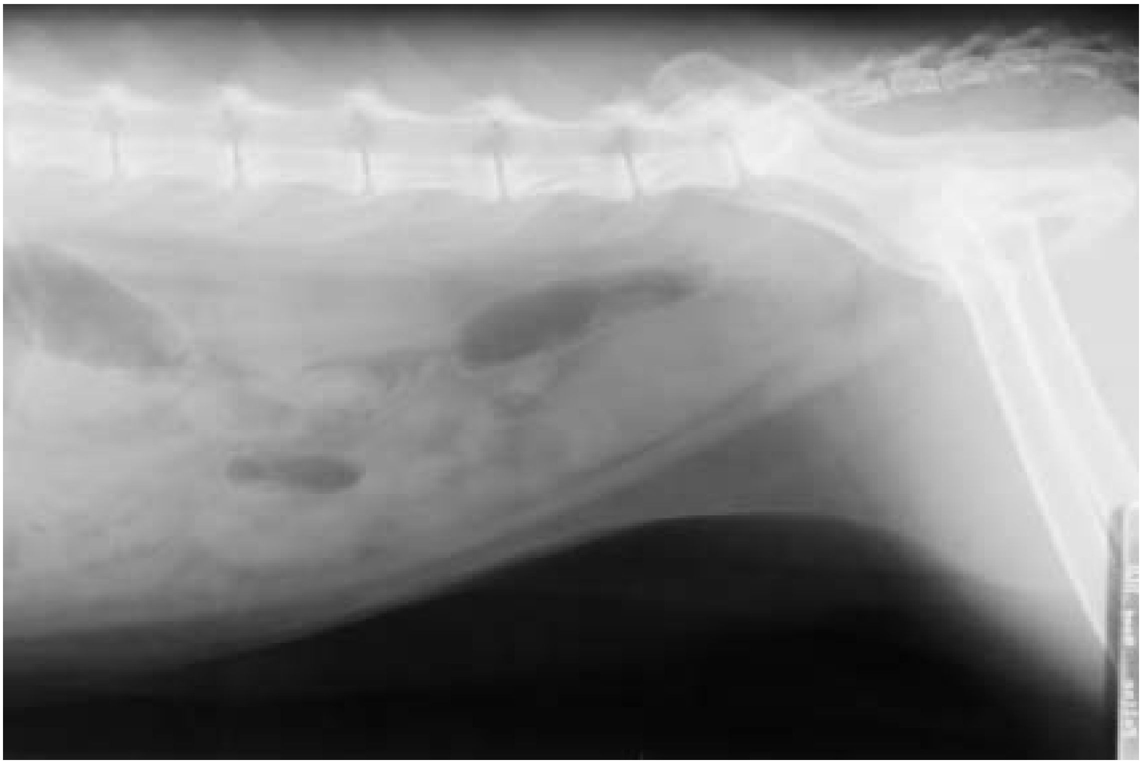
Signalment/History: "Natasha" was a 3-year-old, female DLH cat who had had an ovariohysterectomy two years earlier.

Physical examination: Abdominal masses had been palpated on a recent physical examination. They continued to be present at presentation.

Radiographic procedure: Abdominal radiographs were made.

Radiographic diagnosis: Two mummified feti occupied the midportion of the abdomen. A third mineralized mass was located just cranial to the feti on the abdominal floor and a fourth mass was located adjacent to the right abdominal wall.

Comments: The feti could have spilled from the uterus during the ovariohysterectomy or may have been present as an extra-uterine pregnancy.



Case 3.32

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Signalment/History: "Charlie" was a 2-year-old, male DLH cat with a history of hematuria and frequent urination.

Physical examination: The bladder did not move on palpation, but was fixed against the ventral abdominal wall.

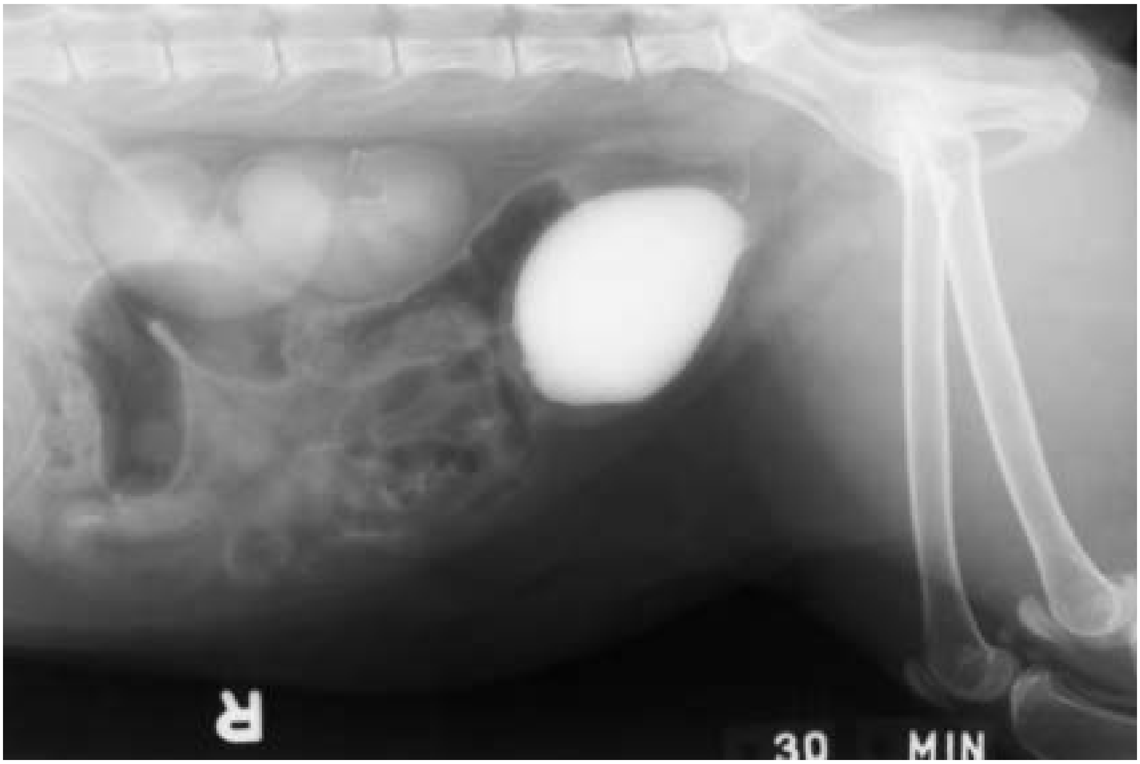
Radiographic procedure: A routine abdominal study was performed, followed by an intravenous urogram.

Radiographic diagnosis (abdomen): The urinary bladder was elongated and flattened with an unusual shape suggesting that a persistent urachus or adhesions from another cause had tied the bladder to the ventral abdominal wall.

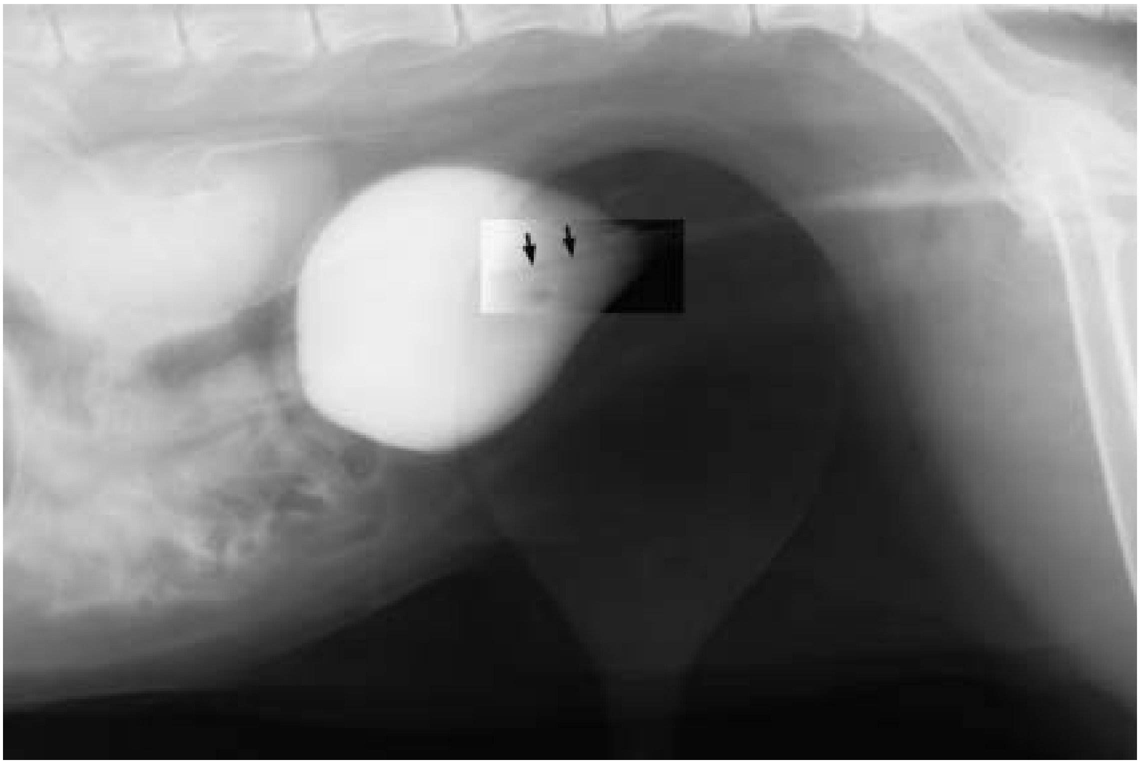
Radiographic diagnosis (intravenous urogram): Both kidneys functioned normally with contrast agent flowing into the urinary bladder. The cranial tip of the bladder had a thickened wall indicative of a chronic cystitis secondary to incomplete empting because of the uracheal remnant. The bladder neck was not normal in appearance. It had a ventral angulation and the gently tapering neck could not be seen. These findings lead to a special compression study being done.

Radiographic diagnosis (compression study): A compression view of the bladder neck showed a radiolucent line from a retained catheter that extended from the lumen of the bladder into the proximal urethra (arrows).

Treatment/Management: The owner was reluctant to reveal the complete medical history of the cat and chose to refuse to offer any explanation of the retained catheter.



Intravenous urogram



Compression study

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Case 3.33

Noncontrast

Signalment/History: "Blue" was a 3-year-old, female Great Dane with a history of surgical repair of a perianal fistula three months previously.

Physical examination: Drainage from a perianal tract was evident on presentation.

Radiographic procedure: Studies were made of the pelvic region and injection of the draining tract with a positive contrast agent was performed.

Radiographic diagnosis: The rectum was constricted 3 cm from the anus. No evidence of skeletal injury could be seen.

The positive contrast agent injected into the tract filled multiple saccules within the perianal tissue, principally on the right side. Importantly, the contrast agent identified a fistulous tract that entered the rectum (arrows), where it partially surrounded the fecal material.

Treatment/Management: The case was treated medically without good recovery. The owners rejected the offer of surgical correction feeling that the first surgery should have been successful.

Contrast

Case 3.34

Noncontrast

Signalment/History: "Nola" was a 4-year-old, female German Shepherd Dog being examined because of problems related to past pregnancies in which only a small number of puppies had been produced, some of which were nonviable.

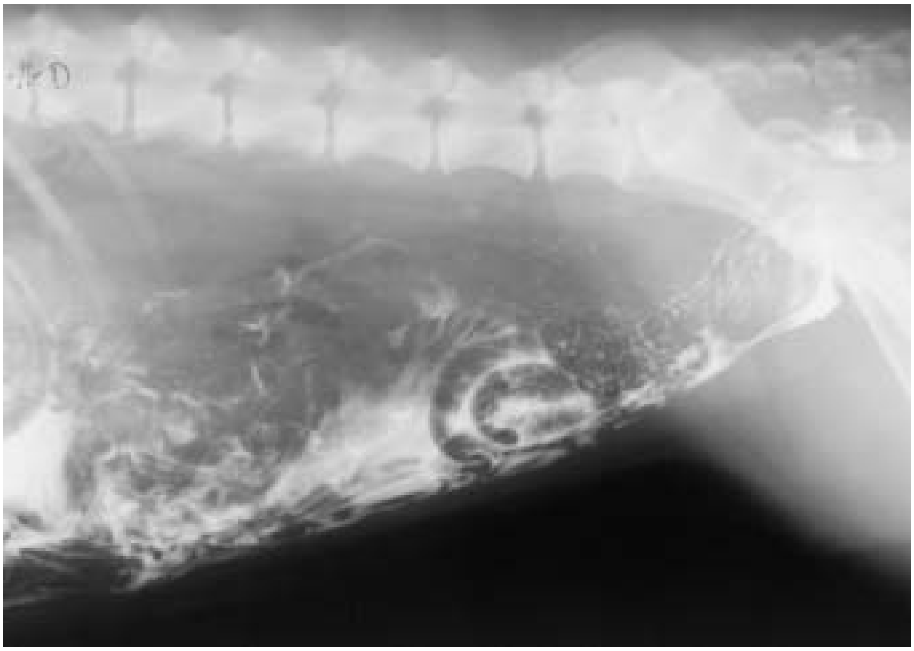
Radiographic procedure: Studies of the abdomen were made, followed by contrast studies of the uterus.

Radiographic diagnosis: Intraperitoneal air was noted in large pockets (arrows). An enlarged splenic shadow was seen.

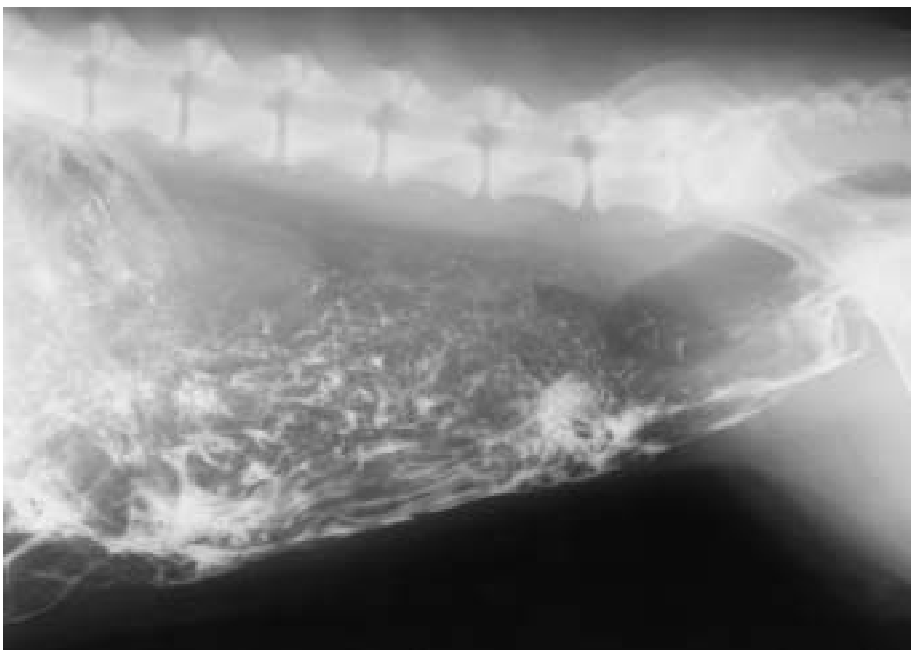
Radiographic diagnosis (contrast study): A catheter was placed into one uterine horn and an oily contrast agent was injected. The radiographs showed intraperitoneal spread of the contrast agent indicative of a uterine tear.

Radiographs made four days later showed a delay in the absorption of the contrast agent. An iodinated product in a water base such as used in urography would have more resorbed quickly.

Treatment/Management: The patient was treated medically. It is interesting that "Nola" delivered seven viable puppies three months following the detection of the uterine injury.

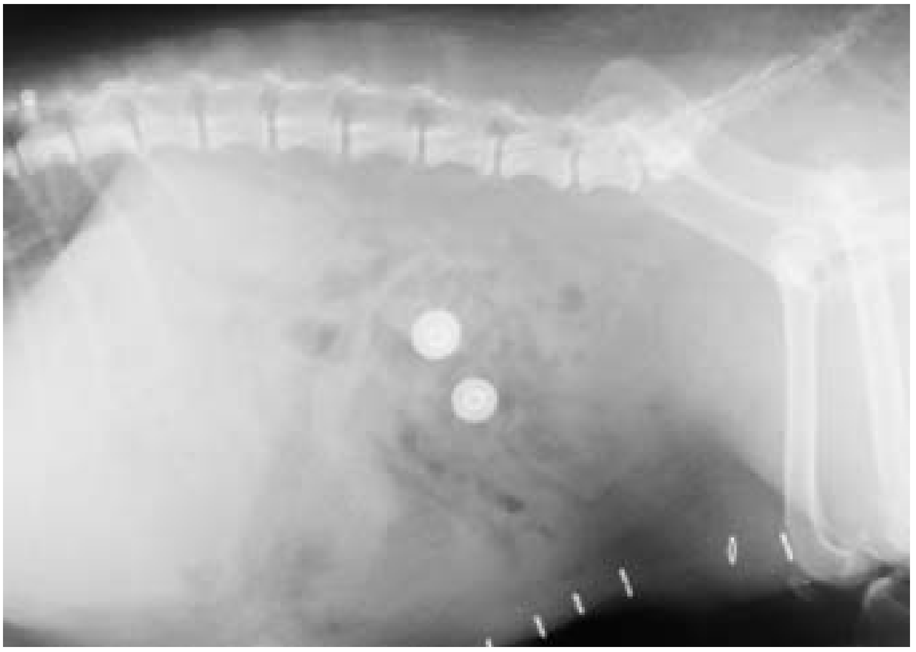


Contrast



3

3.2.8 Postsurgical problems



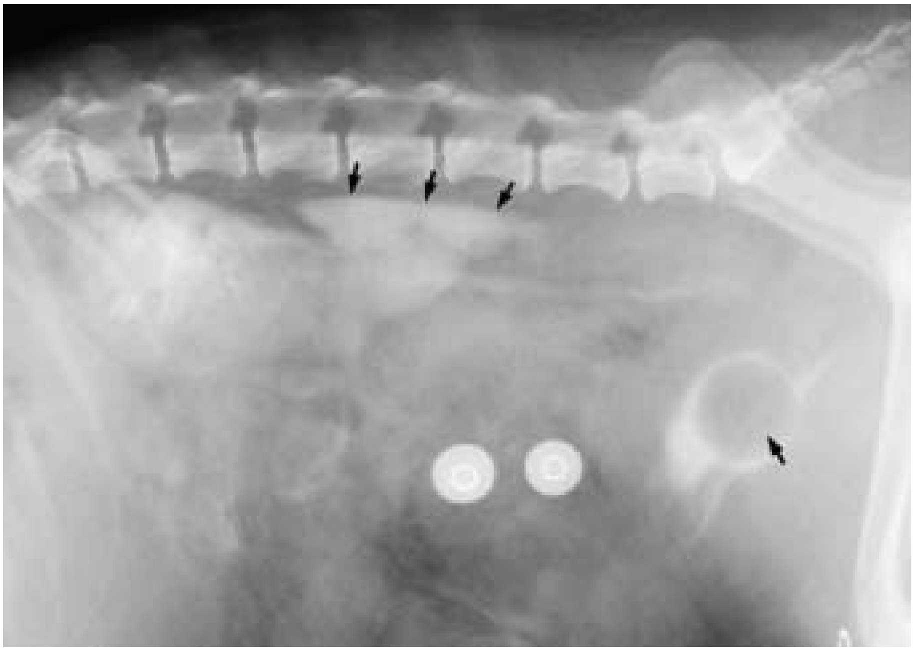
Case 3.35

Noncontrast

Signalment/History: "Tilly" was a 7-year-old, female Yorkshire Terrier. A post-dystocia ovariohysterectomy had been performed eight days earlier at the referring hospital. A second operation at the same hospital was performed four days afterwards and had been required to remove both incorrectly placed aortic and ureteral ligations. Normal renal function did not return and "Tilly" was referred for studies to evaluate her renal function.

Radiographic procedure: Radiographic studies of the abdomen were performed, followed by a urogram.

Radiographic diagnosis (noncontrast): An overall loss of serosal detail was thought to be secondary to postsurgical effusion, peritonitis, or urine leakage. Multiple, metallic staples were present along the ventral abdominal wall. ECG pads were noted on the lateral abdominal wall.



Urogram

Radiographic diagnosis (urogram): A hydronephrosis of the right renal pelvis and hydroureter of the right proximal ureter were probably a consequence of the ligated ureter. Leakage of contrast agent from the right mid-ureter into both the retroperitoneal and peritoneal spaces indicated a ruptured ureter (arrows). The left kidney and ureter appeared to have near-normal function. The persistent loss of serosal detail continued to suggest peritoneal fluid due to postsurgical effusion, peritonitis, or urine leakage. The balloon tip of a Foley catheter lay within the urinary bladder (arrow).

Treatment/Management: Because of the ureteral injury, a right nephrectomy was performed and "Tilly" was eventually discharged to her owners.

Case 3.36

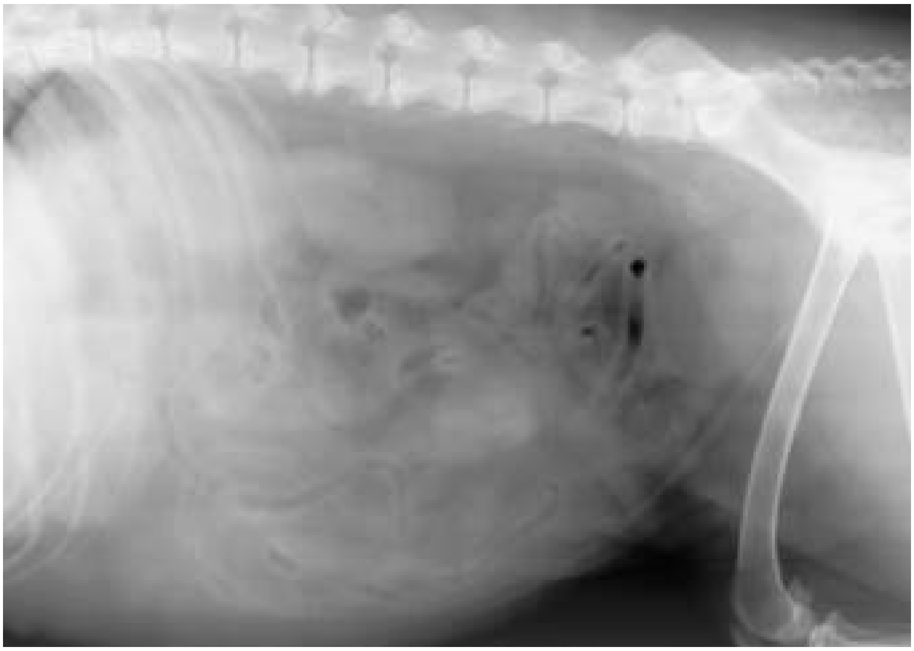
Day 1

Signalment/History: "Smokey" was a 12-year-old, female German Shepherd with abdominal pain.

Physical examination: A mid-abdominal mass was palpated.

Radiographic procedure: Abdominal radiographs were made.

Radiographic diagnosis (day 1): A 4-cm, right-sided, fluid-dense mass situated in the caudal abdomen had flecks of calcification scattered throughout it, suggesting a granuloma or tumor. The loss of contrast between the abdominal organs indicated a minimal fluid accumulation that might have been due to an effusion, hemorrhage, or peritonitis. No bowel distention was evident. The right renal shadow appeared smaller than expected.



Day 6

Radiographic diagnosis (day 6): The radiographic features were the same as on day 1. The mass lesion had stayed in the same location within the abdomen.

Treatment/Management: The mass lesion was removed surgically and was a retained surgery sponge incorporated within multiple adhesions.

Comments: Abdominal tumors in general do not contain mineralized tissue, which are more suggestive of a chronic inflammatory lesion.

Chapter 4

Radiology of Musculoskeletal Trauma and Emergency Cases

4

4.1 Introduction

Trauma is defined as a suddenly applied physical force that results in anatomic and physiologic alterations. The injury varies with the amount of force applied, the means by which it is applied, and the musculoskeletal organs affected. The event can be focal or generalized affecting a single bone or joint, or multiple sites. The effect of the injury to the musculoskeletal system can vary and result in a patient with apparently minimal injury characterized by lameness or inability to bear weight, a patient who is paralyzed, or a patient who is in severe shock. The patient may be presented immediately following the trauma or presentation may be delayed because of the absence of the animal from home or because of the hesitancy or inability of the owners to recognize the injury.

Most trauma cases are accidents in which the patient is struck by a moving object such as a car, bus, truck, or bicycle. The nature of the injury varies depending on whether the patient is thrown free, crushed by a part of the vehicle passing over it, or is dragged by the vehicle. Other types of trauma result from the patient falling with the injury depending on the distance of the fall and the nature of the landing. A unique injury occurs when dogs jumping from the back of a moving vehicle fall only a short distance, because the trauma results from the animal hitting the road at a high speed. This type of injury is severely complicated when the animal has been restrained by a rather long rope or leash in the back of the truck, which causes the patient to be dragged behind the vehicle and a form of "degloving" or "sheering" injury results. Other possibilities of trauma occur when the patient has been hit by a falling object, or is kicked or struck by something. Bite wounds constitute a frequent cause of injury in both small and large patients and can be complicated by a secondary osteomyelitis that develops later. Penetrating injuries are a separate classification of injury and can be due to many types of projectiles. Gunshots are a most common cause of trauma in certain societies (see Chap. 6). Abuse is a specific classification of trauma and should be suspected in certain type of injuries (see Chap. 7).

Emergency cases, i.e. those that are life threatening, are not frequently seen as the result of musculoskeletal injury. A special group consists of those patients with spinal injuries, where emergency treatment may be required and a specific method of movement of the patient is necessary in order to avoid additional injury to the spinal cord. Patients with head injuries are uncommon, though such traumas often result in the death of the animal. If the trauma only affects the more rostral portion of the head, it results in injury to the nasal or frontal portions and the injury, while obviously deforming, is not usually life threatening.

Musculoskeletal radiology can be performed relatively cheaply, quickly, and safely, thus providing rapid results on which to base the next set of decisions. Radiographic studies can usually be made on the non-sedated or non-anesthetized patient. When and how to use these techniques is often rather obvious (see Table 4.1).

Table 4.1: Use of radiographic examination in a traumatized or emergency patient suspected of having musculoskeletal injury

1. Radiograph permits selection of the area to study
   a. possible to survey the entire body:
      I. when a complete clinical history of the trauma is not available
      II. when a thorough physical examination cannot be conducted
      III. more accurately than is possible by physical examination alone
   b. possible to limit study to the area of suspected injury only
   c. use of comparison studies is helpful in skeletally immature patients
   d. nature of injury may limit the study to a single projection
2. Radiography can be performed
   a. in a non-traumatic manner
   b. within a few minutes
   c. with minimal cost to the client
   d. with relative ease in many patients
3. Radiographic diagnosis permits the detection of
   a. more than one lesion
   b. which lesions are of greatest clinical importance
4. Radiographic diagnosis enables decisions to be made about:
   a. the sequence of treatment
   b. the prognosis
   c. the expected time and cost of treatment
5. Radiography identifies complicating factors such as
   a. pre-existing
      I. non-traumatic lesions
      II. traumatic lesions
      III. arthrosis in the injured limb
   b. soft tissue injury
6. Radiography provides a permanent clinical record to enable:
   a. an owner to better understand
      I. the lesions
      II. the proposed treatment
   b. the clinician
      I. to evaluate the treatment
      II. to review the radiographs
      III. to seek further assistance by referral of the radiographs to an expert
7. Radiography permits
   a. assessment of the effectiveness of therapy in the event that clinical improvement is delayed
   b. determination of the time for removal of fixation devices
   c. determination of the time of discharge from the clinic
   d. determination of the time for a return to full physical activity

Radiology is the most commonly used method of examination of a traumatized patient with a suspected injury to either bone or joint. The use of radiology varies with the nature of the injury and ranges from a single survey radiograph to the use of a contrast study such as myelography in a suspected spinal injury. Radiology used in the evaluation of suspected injury to the appendicular skeleton is common and those patients constitute the major portion of this section.

The physical examination in fracture/luxation cases is informative and helps direct the radiographic examination. Bite and gunshot wounds have associated soft tissue lesions that are suggestive of those types of trauma. In certain patients unable to bear weight on a limb, attention is obviously directed toward that limb. In those patients with a less severe injury or chronic lameness, the role of trauma is not as obvious and many types of bone or joint disease could be the cause of a lameness incorrectly thought to be the result of trauma. Often, the physical examination in a trauma patient is compromised because of pain or non-cooperation, and errors in interpretation are frequent. The greatest error made in the examination of trauma patients is the tendency to direct all attention to the site of the most obvious injury and limit the examination of the remainder of the animal. For example, this can lead to the diagnosis of a pelvic fracture while ignoring a ruptured urinary bladder, or the treatment of a femoral fracture while ignoring a diaphragmatic hernia. The nature of the trauma can indicate the requirement for whole body radiographs. This need depends on the questionable nature of the clinical history and your failure to obtain adequate information from your physical examination. The positive value of whole body radiographs cannot be overstressed.

The most informative radiographic technique in the evaluation of suspected musculoskeletal injury includes two views and includes the joints both proximal and distal to the site of the suspected injury. In an examination performed on a skeletally immature patient, comparison radiographs of the opposite limb make the evaluation of the growth regions in a bone more accurate. Because of the trauma, positioning of a limb in the usual manner for radiography may be painful or damaging to the surrounding tissues and compromises are often required. It may be better medicine to rely on the radiograph of a malpositioned limb rather than having to fight with the patient in an effort to achieve a more acceptable radiographic positioning. Positioning errors are especially frequent with pelvic and femoral injuries, where the perfect VD view with the pelvic limbs extended is too painful and it has therefore often to be done with the limbs held in flexion with both in a similar position.

Radiographic diagnoses result from studying skeletal radiographs that present information in a single plane, and which includes only a descriptive gross image of the complex three-dimensional cortical and cancellous structures found in a bone. The radiographic image does not record the exact trabecular and cortical anatomic details, but instead depicts photographic patterns that are produced by overlay, groupings, and accumulations of large numbers of the fine and coarse trabeculae, as well as the enclosing cortical bone. In a bone with a complicated morphology, the radiographic interpretation of a lesion becomes more difficult.

In contrast to thoracic and abdominal trauma, radiographic diagnosis is more specific in trauma patients with musculoskeletal damage and may include a detailed description of the fracture and its location in a bone. In comparison, for example, the presence of fluid can be revealed in the thorax study of a patient, however, the type of fluid can only be speculated upon until further tests are undertaken.

Differential diagnosis is not often necessary in musculoskeletal trauma. However, it does become important when trauma is superimposed over previous bone or joint disease, or when the clinical history is incorrect and the bone lesions have not been induced by trauma. In certain patients when indicated, this section will include a full discussion of the differential diagnosis.

The treatment/management is often predictable in a trauma patient and has usually been kept brief in the text, consisting of a comment concerning the reduction and stabilization of a fracture. This part of the case discussion is not explored to any great depth in this book since it belongs more appropriately in an orthopedic text. In other patients, the handling of the patient includes specific comments that are thought to be of interest to the reader.

The outcome of the case is often known and a comment relative to this is made for the reader. When appropriate, the results of surgical biopsy or necropsy are included. In certain cases, additional clinical history is known and presented for the reader's interest. However, the specific time required for fracture healing is dependent on the particular injury, the status of the patient, and the type of the fracture and method of stabilization. Therefore, it is impossible to make specific statements about the expected time for fracture healing. Generally, if a time is offered, it only suggests the time expected for a fracture of a particular type.

Discussion of the case presented might include comments on specific changes in protocol that were of assistance in diagnosis, or it might include errors that were made in the manner in which the case was handled. Apparent errors in clinical judgment as seen in retrospect are actually often determined by the lack of freedom offered by an owner as treatment of the case progresses. Also included in the discussion are suggestions that might have provided additional information of value in diagnosis or treatment.

4

4.1.1 The order of case presentation

Presentation of trauma and emergency cases of the musculoskeletal system is most easily divided based on the portion of the skeletal system examined. Evaluation is easiest in bones of the appendicular portion because they are tubular, have sharp margins, and are projected free from overlying conflicting shadows within soft tissues. All of these factors make detection of injury relatively easy and consequently they are presented first. The appendicular skeleton has been further subdivided into the forelimb (Chap. 4.2.1.5) and pelvic limb (Chap. 4.2.1.6).

The pectoral girdle is composed of the clavicle and scapula. Since the forelimb has no articulation with the axial skeleton and supports the trunk by muscles only, the scapula is free to move widely and can be radiographed with the body in different positions. The scapula's attachment to the trunk is composed of muscles that do not fracture, though they can tear badly, and because of this, the scapula itself is not frequently traumatized. The shoulder joint attaches the scapula to the brachium, which is represented by the humerus. The elbow joint attaches the humerus to the antebrachium consisting of the radius and ulna. The antebrachiocarpal joint joins the radius and ulna to the forepaw or manus, which includes the carpal bones, metacarpal bones, phalanges, and the small sesamoid bones. Within the forepaw are the middle carpal joints, the carpometacarpal joints, the metacarpophalangeal joints, and the proximal and distal interphalangeal joints.

Each pelvic limb consists of its half of the pelvic girdle composed of the ilium, ischium, and pubis fused at the hipbone or os coxae and contains the acetabulum. The os coxae join the sacrum at the sacroiliac joint. The hip joint connects the hipbone to the thigh, represented by the femur. The stifle or knee joint connects the femur to the crus or that part of the hindlimb, which contains the tibia and fibula. The talocrural or ankle joint joins the tibia and fibula to the tarsal, metatarsal, phalangeal, and small sesamoid bones. The bones and joints within the hindpaw are similar to those found in the forepaw.

The axial skeleton with its unique morphology and high content of trabecular bone alters the manner of its response to trauma and makes radiographic diagnosis more difficult. The skull is the most complex and specialized part of the skeleton, and is basically divided into a facial plus palatal region, and the braincase. A radiograph of the head includes also the mandible. This region is indeed unique because of the variation in morphology that man has engineered in the creation of the various breeds of dog and cat, making the head the most difficult part of the body to radiograph or diagnose because of the question of what should be considered normal (Chap. 4.2.2.2).

The vertebral column consists of the multiple, irregularly shaped vertebrae divided into five groups: cervical, thoracic, lumbar, sacral, and caudal (coccygeal) (Chap. 4.2.2.3). The lumbosacral junction is of particular clinical importance. The pelvic limb joins the axial skeleton at the sacroiliac joints. Because of the clinically important spinal cord, subarchnoid myelography, epidural myelography, and sectional radiography may be necessary to completely understand the various causes of cord injury. Some lesions are limited to the pelvis alone, while others extend from the axial skeleton to the pelvis; because of this latter situation, some cases of pelvic trauma are included with the axial skeleton.

The ribs are attached to the spine and are therefore a part of the axial skeleton. Injury to the chest wall has been given considerable attention in the section on thoracic trauma. In the musculoskeletal section, it will be also considered though to a lesser degree in certain patients (Chap. 4.2.2.1).

4.1.2 Type of information gained by a radiographic evaluation of the skeleton in the trauma patient

Radiology is an important diagnostic tool in the investigation of traumatic skeletal disease because good radiographic contrast is naturally provided between the bone and the surrounding soft tissues, thus permitting the detection of even small but clinically important lesions. Radiology not only often confirms the presence of an injury suspected from the physical examination, but also enables an evaluation of the severity of the trauma and so assists in determining the most appropriate method of treatment and, importantly, making it possible to offer a more accurate prognosis. A simple transverse fracture of the midshaft of the femur can easily be differentiated from a badly comminuted fracture of the same bone that would require a different and more complex form of treatment with a questionable prognosis. Radiographs can be used to evaluate the success of treatment in the trauma patient by permitting an evaluation of the healing of the fracture. A fracture healing in an expected manner can be differentiated from one with an unsuspected superimposed infection leading to non-union, or one that involves delayed fracture healing associated with unstable fixation and potentially a non-union fracture.

A radiographic study can also reveal additional traumatic lesions that are clinically silent. Radiographic studies can be utilized to exclude a suspected diagnosis and instead, confirm a new diagnosis that is of either a traumatic or nontraumatic origin. Finally, it is possible that radiographs can fail to detect the cause of pain and lameness within a bone or joint, and so soft tissue injury can then be suggested to be the cause of the clinical signs.

Rarely are the radiographic features in an acute trauma patient with skeletal damage inconclusive; however, they can be ambiguous because of an acute trauma being superimposed over preexisting disease such as chronic trauma or infection. Certain combinations of lesions are common because of the high frequency of joint disease in some breeds as a result of developmental bone disease present prior to the trauma. In such cases, both the diagnosis and treatment are complicated and the prognosis is worsened.

A radiograph can offer information about critical features of a lesion that permit aging of the traumatic event. This can be a most important finding and can correct historical data received from the owner that was either accidentally or intentionally erroneous. Radiographs can also identify what I like to think of as "leave me alone" lesions in which treatment may not be indicated and only subsequent re-evaluation is recommended.

Radiographic examination also provides a temporal dimension that permits a more clear understanding of the clinical picture as you observe the progression of change in the radiographic features. This means that differences observed in the radiographic features over time can be used to determine the efficacy of treatment administered. Radiographs are used routinely to evaluate the success of fracture healing following the use of a specific method of orthopedic surgery; however, as stated before, this is generally beyond the scope of this atlas and can be found more completely discussed in orthopedic surgery texts.

4.1.3 Indications for radiography in suspected musculoskeletal trauma

Often, the indication for skeletal radiology is rather straightforward: the owner has seen the patient traumatized, or the patient is obviously lame, or non-weight bearing on one limb, or it has a prominent swelling on a limb. Other radiographic examinations are: (1) a part of a soundness examination, (2) made in the presence of known skeletal disease, (3) made to provide information prior to proposed surgery, (4) made to evaluate a postsurgical condition, or (5) of value in the general workup of a patient with generalized disease. Cases with these five types of clinical indication are not included in this atlas. The indications for appendicular skeletal radiography in trauma or emergency cases are listed (Table 4.2).

4.1.4 Factors influencing radiographic image quality

The quality of the radiographic image may limit your ability to reach a diagnosis or, more significantly, increase the likelihood of your making a wrong diagnosis. The quality can be influenced by errors in several elements: (1) patient positioning, (2) selection of machine settings that determine radiographic exposure, (3) selection of film-screen combinations, (4) selection of cassette size, (5) improper use of a grid, and (6) errors in film processing. There is a natural tendency to want to deny that non-diagnostic radiographs have been produced as a result of error in any of these elements. On evaluation of a poor-quality radiograph, it is relatively easy to call an artifact or normal anatomical variation a fracture resulting in a false-positive evaluation. More commonly, a technical error prevents visualization of a fracture, causing a false-negative evaluation.

Table 4.2: Indications for radiography in patients with suspected musculoskeletal trauma or emergency cases

1. Pain
   a. with or without heat
   b. with or without crepitation
2. Lameness
   a. painful (acute or chronic)
   b. mechanical (acute or chronic)
3. Palpable mass
   a. hard and firm suggesting fibrocartilaginous tissue
      I. fixed in position
      II. not fixed in position
   b. soft and possibly fluctuating suggesting soft tissue hemorrhage or edema
   c. in association with a draining tract suggesting infection
4. Abnormal findings on joint palpation
   a. abnormal movement
      I. excessive
         i) flexion or extension
         ii) medial or lateral angulation
         iii) rotational instability
      II. limited
   b. capsular thickness
   c. joint effusion
   d. crepitus
5. Postoperative evaluation of
   a. fracture fixation and stability
   b. fracture healing
   c. post-traumatic joint disease
   d. healing to determine time of removal of fixators

Correct patient positioning can be studied from textbooks, but its application is learned by experience. Breed variation strongly influences how positioning can be performed, with the radiographs of a short-limbed chondrodystrophic breed being more difficult to evaluate than those from a dog with long limbs. The nature of a specific trauma can prevent the use of recommended anatomical positioning and necessitate the use of another position. The use of a sedative can assist in achieving certain types of positioning and prevent patient motion during the exposure of the film, but this may be limited by the clinical status of the patient.

Positioning for the lateral view is easiest and in most studies of the dog and cat, the patient is recumbent and is positioned so that the affected part lies next to the tabletop. However, soft tissue injury may make it necessary for the affected limb to be uppermost and so further away from the tabletop with an increased object-film distance. Usually, the lateral radiographs made mediolaterally or lateromedially are similar in appearance.

The ease of positioning for the craniocaudal or caudocranial view of a limb varies with the portion of the limb examined. The proximal portions of the limb are more difficult to position in a manner that places the bone parallel to the tabletop and the limb may be extended or flexed to achieve a comfortable position The distal portions of the limb are relatively easy to place correctly.

Patient positioning influences the possibility of a superimposition of anatomical structures that create new radiographic patterns, which can make diagnosis of abnormalities difficult or compromise their visualization on the radiographs; i.e. the trachea or sternum may be positioned over the shoulders, or the os penis in the male dog may be superimposed over the stifle joint or femur if the hindlimb is flexed, or superimposition of the small bones in the feet can make the diagnosis of carpal and tarsal fractures difficult.

The inappropriate selection of exposure factors is rarely a technical problem in the radiographic diagnosis of trauma to the appendicular skeleton. The radiographic technique recommended for the axial skeleton is different from that used for thoracic and abdominal studies with the higher kVp technique thought to produce better diagnostic radiographs. High kVp technique, in the range of 70 to 90, produces a greater degree of contrast with additional shades of gray identifiable on the radiograph, which are thought to enhance its diagnostic quality. Selection of a high mA and short exposure times is less critical in radiography of the musculoskeletal system because movement of the patient and subsequent degradation of radiographic detail is less likely.

The best film-screen combination for use in the radiography of the limbs of dogs and cats involves the use of a combination of slow speed intensifying screens and film because of the consequent improvement in radiographic detail. Any increase in the mAs settings required in the use of the slower system rarely results in patient motion, because of the relative ease of patient positioning for studies of the limbs. The increase in thickness of the body when making axial skeleton studies can require the use of a faster speed/film-screen combination, if and when the mA capability of the machine is limited.

The cassette size selected should permit visualization of the region of interest dictated by the clinical examination. The entire bone and adjacent joints should be included on the radiograph. It is a good rule to "include both ends of the affected bone". If the lesion is articular, the beam should center on the affected joint and include the ends of the two adjacent bones. In studies of the spine, multiple views using a smaller cassette size are often more diagnostic than the use of one or two radiographs made using large cassettes.

The use of a grid results in removal of much of the scatter radiation that produces fogging of the film and loss of radiographic contrast; however, its use is not required for most studies of the appendicular skeleton of the dog or cat. If the use of a grid is limited to anatomical parts exceeding a thickness of 11 cm, it would only be required for the studies of the spine, pelvis, shoulder and hip joints in the larger dogs.

4.1.5 Enhancement of the diagnostic quality of a musculoskeletal radiograph

Use of stress views: Often the value of a study of a joint can be enhanced by making stressed views. The joint of interest is hyperflexed, hyperextended, rotated, or placed in external or internal angulation. These special views are of value in the determination of the nature and extent of joint injury, in which abnormal joint laxity or small fractures are present. Because of a probable failure to understand the absolute limits of joint motion, a comparison view made of the opposite unaffected joint in a similar stressed position is often of value in diagnosis. Stress views of the occipitoatlantoaxial and lumbosacral regions are extremely important in the diagnosis of suspected spinal injury, but they must be made with care in trauma patients where further spinal cord injury could result from stressing a vertebral instability.

Use of compression views: Compression views are made by placing a radiolucent paddle over the area to be examined forcing the bones next to the cassette. This technique must be used with care in trauma patients. It is of value in studies of the feet in the dog and cat, as it enables the phalanges to be forced into a position where the bones are parallel to the cassette. This technique can be used in spinal studies, but there a risk in its use in an abdomen in which there is possible organ rupture. So-called "paddle" studies enable placement of an assistant's hands further from the primary x-ray beam and are therefore also a factor in radiation safety.

Use of additional views: Skyline views made in a proximal to distal direction are valuable, but are usually limited to studies of the supraglenoid region of the shoulder, the olecranon process, the femoropatellar joint, the trochlea of the talus, and the os calcis. These views are always supplementary to the conventional views.

While two views comprise a study for most bones and joints in the dog and cat, additional oblique views are often of diagnostic value and are commonly used in studies searching for fractures in the feet.

Use of comparison studies: Frequently a radiographic feature or pattern of change is not familiar to the clinician and confusion exists as to whether it represents a fracture. This most often occurs in the skeletally immature patient, in whom the growth plates remain cartilaginous and therefore, create radiolucent lines suggestive of fractures. It is advisable to make a radiographic study of the opposite limb providing you with the opportunity to compare the two sets of radiographs and be more certain of your evaluation.

The appearance of the physeal or apophyseal growth plates changes so quickly during skeletal growth that in a suspected trauma patient, a comparison with the opposite normal limb is especially advisable. Special attention should also be given to the size and shape of the epiphyseal and apophyseal ossification centers. The epiphyseal center normally develops from a single ossification center, so the size of the ossified growth center increases with age and the margin of the ossified portion, which can at first be irregular in appearance, eventually develops a more distinct border. The "cut-back" zone in the metaphysis of the rapidly growing bones often appears indistinct, with a roughening of the cortical bone that has not had the opportunity to model. This pattern, which is frequently seen in larger dog breeds, is most prominent at the distal radius and ulna, and the proximal humerus, though fortunately, it has a bilateral symmetry.

Trauma patients can have Type 1 physeal fractures – physeal or avusion of apophyses with only minimal displacement of the centers of ossification. Evaluation is made easier when the opposite limb is radiographed and a comparison is made of the location and appearance of the ossification centers. In those patients with injury to a growth center resulting in a delay in growth, the effect on the length and shape of the bone can be assessed radiographically by making a comparison with a radiograph of the opposite limb. This is considered absolutely necessary prior to orthopedic correction. A film cassette of sufficient length to include the entire bone will provide the information required to assess an abnormality in bone length, curvature, and rotation. Often the error in growth occurs early and the altered length or shape of the bone is obvious. In a more subtle injury, the difference in length between two bones may be only in the range of 1 cm. In other cases, bone growth is unequally delayed causing growth in the physeal plate to be uneven, and bowing of the metaphysis/diaphysis results. This may lead to a less prominent change that can only be fully understood upon comparison with the appearance of the normal bones in the opposite limb.

Thus, the use of radiographs of the opposite limb for comparison is mandatory in trauma patients in which the physeal growth plates are still open: < 9 months of age in the dog; < 16 months of age in the cat. These studies should be made routinely at the time of the first study if the patient's condition permits and later if clinical conditions warrant it.

If trauma occurs in a mature patient in whom an error in physeal growth has occurred, the determination of the effect of the trauma on the size, shape, and length of the bone needs to be evaluated in addition to any new fracture from the recent trauma. Again, the differentiation of the chronic growth abnormality from the recent trauma can be more easily achieved when the opposite limb is radiographed, too.

4.1.6 Use of sequential radiographic studies

Sequential radiographic studies are used to evaluate the success of fracture stabilization and are commonly used to study the pattern of fracture healing (Table 4.3). In addition, the effectiveness of antibiotic therapy in a case of trauma-induced osteomyelitis can be monitored using successive radiographic studies. An improvement in clinical signs associated with a fracture often precedes an improvement in the radiographic appearance of the fracture healing. Changes in bone as noted on the radiograph occur after clinical signs of healing are noted. "Follow-up radiographic studies" are used to assist in determination of the time of removal of fixation devices.

Sequential radiographs need to be carefully standardized as to the positioning and radiographic technique if the maximum use is to be derived from such a comparison. One situation requires a variation in this standardization rule: chronic lameness associated with fracture fixation causes a rapid onset of atrophy of both the affected bone and muscle leading to a decrease in the associated tissue volume and density, thus necessitating a decrease in radiographic exposure. Without this change in technique, subsequent radiographs will appear overexposed making detection of early callus difficult and can result in a failure to correctly recognize early fracture healing.

Table 4.3: Sequential radiographic studies in trauma patients

1. Fracture cases (Cases 4.59, 4.68, 4.69, 4.70, 4.71, 4.117, 4.122, 4.133 & 4.135)
   a. evaluate quality of fracture reduction
   b. evaluate fixation stability
   c. evaluate callus formation
   d. evaluate healing
   e. predict appropriate time of removal of fixation devices
2. Bone or joint infection (Cases 4.58, 4.73, 4.101, 4.104, 4.136 & 4.137)
   a. evaluate the effect of therapy
   b. evaluate post-operative status
3. Joint disease (Cases 4.76, 4.78 & 4.132)
   a. evaluate the progression of arthrosis/arthritis
   b. evaluate post-operative status

Since this section of the book deals with trauma to the musculoskeletal structures, the series of radiographic features or patterns is much smaller, dealing often only with a deviation in the shape or the bone organ. However, identification of a pathological fracture requires the detection of a thinning of cortical thickness, which is a pattern, found away from the fracture.

4

4.2 Case presentations

4.2.1 Radiographic features of appendicular skeletal injury

Diagnostic radiology is conveniently used in clinical medicine for the diagnosis of fractures, evaluation of fragment reduction and stabilization, and for the determination of the prognosis of fracture healing. A fracture within a cortical bone is best defined as a lesion causing an interruption of the continuity of the bone resulting from stress that is beyond the capacity of the bone to withstand. The radiographic study should include not only the joints proximal and distal to the injury, but also two orthogonal views. Only on such a study is it possible to determine the full character of a fracture, something of the injury to the surrounding soft tissues, and the possible involvement of the adjacent joints. Evaluation of the soft tissues is important because that injury indicates the level of energy of the trauma and partially determines the healing potential of the fracture. With severe soft tissue injury, the new extra-periosteal blood supply that feeds the healing fracture fails to form as hoped for and delayed fracture healing or a non-union fracture can result. Information concerning soft tissue injury is supplied by noting the amount of swelling and hematoma formation as well as the displacement of the fracture fragments. Detection of interposed soft tissues that separate bony fragments is an indication of a potential delay to the fracture healing. Marked fragment over-riding or severe comminution of the fragments are also indicators of extensive soft tissue injury and a potential delay in healing. The radiograph, at best, offers only a clue to the extent of soft tissue injury, but despite this, it can provide valuable information in addition to that gained from the physical examination.

4.2.1.1 Fracture classification

Bone fracture is the most common traumatic injury in the appendicular skeleton. It is helpful to know the terminology used in the description of such fractures. Fracture classification is based on the completeness of the fracture line, the number of fracture lines, the location of the fragments, and the suspected energy level of the injury. In addition, the underlying character of the bone needs be evaluated to enable detection of pathologic fractures. Fractures in the long bones are usually more easily classified than those seen in small cuboidal bones. In addition, midshaft fractures are more easily classified than those that affect the epiphyseal/metaphyseal region of a bone. Fractures that disrupt the articular surface within a joint are an additional type of injury of especial clinical importance.

The classification of the fracture may be dependent on the energy level of the injury. A fracture resulting from a low energy injury might be incomplete or complete with good apposition and alignment of the fragments and little soft tissue injury. This type of fracture would be expected to heal readily, often with only minimal stabilization. A low energy fracture may also result in a complete fracture with a slight separation of the fragments; again with only a little soft tissue injury. A fracture resulting from a high-energy injury often has severe comminution and fragment displacement, as well as extensive soft tissue injury indicating a longer healing time. Very high energy fractures are usually caused by gunshot wounds in which both the soft tissue and bone injury is extensive and fragment alignment and stabilization is difficult or impossible.

Fractures seen in the skeletally immature bone include in addition to midshaft fractures, two clinically important groups: (1) physeal and (2) apophyseal.

4.2.1.2 Orthopedic fixation devices

After fragment reduction, a series of devices may be used to provide stability and maintain the alignment of the fragments during the healing process. Most are made of a type of metal alloy and are easily identified on a radiograph. These devices include cortical or cancellous screws that can function as lag or compression screws. The threads may be partial or complete. Plates serve to compress, neutralize, or buttress a fracture. Compression plates serve to place the fragments under compression. Neutralization plates only protect fracture surfaces from normal bending, rotational, and axial-loading forces. Buttress plates are used to support bone that is unstable.

Wires are unthreaded segments of extruded wire of variable thickness, which are drilled into the bone by placing them into a drill as if they were drill bits. Rotational stability is provided when more than one wire is used. Smooth wires can be placed across a physeal plate since they are smooth and the growing bone "slides" along the wire. The technique of placing a wire around fracture fragments to achieve stability is called cerclage wiring and is usually used in conjunction with another type of fixation device. Tension-band wiring is a special technique used to provide dynamic compression for the treatment of avulsion type fractures and for replacing osteotomized bone used to gain surgical exposure. Parallel wires are positioned to provide rotational stability and reduce shearing forces between the fragments. A figure-of-eight wire is placed on the tension side of the bone and is anchored by passing it around the bent ends of both wires and then passed through a drilled hole in the bone. When physiological forces pull on the bone, the wire carries the tensile force, which prevents separation of the fragments, and thus transmits any compressive forces to the bone.

Intramedullary pins have many sizes and shapes. They are placed the length of the shaft of a tubular bone, where they prevent angulation of the fragments. The pins may be used singularly or stacked, or can be used in conjunction with other devices to prevent rotational deformity. External fixation requires the use of pins that are joined externally after they are transfixed through both cortices. A combination of pins can be used to create a particular form of fixation. If the pins are intramedullary, they may become "lost" within the medullary cavity as a bone lengthens.

Any of these devices can be positioned with less than perfect placement, and this should be noted on the immediate post-operative radiograph. Following surgery, it is possible for any of the devices to bend, break, or loosen. The influence this has on the stability should be estimated from the "follow-up" radiographs. A final radiograph made after apparent healing helps to determine the appropriate time for removal of any or all of the fixation devices. The use of radiography in the evaluation of post-surgical status or healing status of a fracture is not explored to any great length in this book.

4.2.1.3 Post-traumatic aseptic necrosis

Post-traumatic aseptic necrosis is a characteristic lesion that can be found at specific anatomical sites, where it is possible for a bony fragment to be isolated and deprived of its blood supply following trauma. This type of lesion occurs most commonly in the capital epiphysis of the femur in the skeletally immature patient following physeal separation. The blood supply to the femoral head passes along the joint capsule and to a lesser degree through the cancellous bone of the neck, and an injury resulting in a separation of the femoral capital epiphysis plus tearing of the joint capsule leaves the epiphysis avascular. In this condition, it retains its bone density and shape for some time, while the surrounding femoral neck, and acetabulum can undergo marked remodeling associated with disuse. Although avascular necrosis is to be expected in injuries in the skeletally immature patient, it may uncommonly occur with an intracapsular femoral neck fracture in the mature patient.

While common in the proximal femur, aseptic necrosis does not frequently occur in the humeral head, although the epiphysis has a similar intracapsular anatomy. The carpal and tarsal bones may sometimes have a solitary blood supply that can be destroyed after trauma resulting in bone necrosis, but this is also uncommon.

4.2.1.4 Disuse osteoporosis (osteopenia)

Bone atrophy is a consequence of disuse. It is more prominent and occurs faster in the growing patient than in the mature one. The resorption of the bone tissue can be seen by making a comparison of bone density either with a radiograph of the bone made earlier or with the bone in the opposite limb. The most obvious change is in the thickness and density of the cortex. While the terminology suggests that this type of osteoporosis is subsequent to disuse, it must be noted that often in fracture cases, severe demineralization takes place most prominently only distal to the fracture. The loss of bone mineral does not result in early change in the size or shape of the bone, only in a loss of density within the cortex that, in severe examples, may lead to a remnant endosteal and periosteal line with a lack of bone density between them. This laminar appearance requires a long time to appear. Later, the width of the femoral neck can decrease.

An unexplained and more excessive loss of bone mineral occurs in some trauma cases and is referred to as post-traumatic osteoporosis (Sudeck's atrophy) and results in malformed bones that actually lose diameter and appear shrunken. A change of this type is often noted in the metacarpal and metatarsal bones of smaller dogs.

4.2.1.5 Forelimb injury

Scapula and shoulder joint

Injury to the scapula is uncommon, though fractures of the spine or blade can result from a car passing over the patient's body. Such fractures are often linear with fragments appearing to have been bent or folded because of the thin, flattened appearance of the bone. The radiographic diagnosis is difficult due to the absence of disruption of strong cortical shadows such as would be found in fractures in the long tubular bones.

Fractures involving the neck of the scapula are more important clinically because of the muscle attachments to this region and the possibility of fracture lines entering the shoulder joint (glenoid cavity). Radiography of the scapula is difficult as the VD views are compromised because positioning of the forelimbs places the scapula so it is projected "on end". The lateral views are compromised because of the overlying soft tissue and bony shadows from the opposite limb, the spine, the sternum, the air-filled trachea, and the contents of the cranial thorax.

One fracture of special importance is the avulsion of the supraglenoid tubercle. When found in the skeletally immature patient, it is an avulsion of the apophyseal center, while in the mature patient it is a result of excessive tension on the biceps tendon. A particular lesion found associated with chronic trauma to the muscles in the shoulder is mineralization of the biceps tendon and less commonly, the tendon of the supraspinatus muscle.

▶▶

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Case 4.1

Signalment/History: "Hash", a 2-year-old, male Brittany, had been hit by a car and was lame in the right forelimb.

Physical examination: Marked swelling was evident in the brachium and palpation was difficult.

Radiographic procedure: Two views were made of the shoulder area. The lateral one was made with the scapula displaced dorsally as far as possible.

Radiographic diagnosis: A comminuted fracture of the right scapula involved both the spine and blade with medial and caudal displacement of the proximal fragment. Fracture lines did not enter the shoulder joint and the humerus was unaffected.

Treatment/Management: Recovery in this patient was complicated by additional pelvic fractures. The scapular fractures were not treated surgically. Radiographs of the thorax were made because of the generalized trauma and were within normal limits.

Case 4.2

Signalment/History: "Hope" was a 5-year-old female Springer Spaniel with a history of lameness for two weeks.

Physical examination: The lameness was prominent in the left forelimb and examination indicated that the pain could be elicited by palpation in the region of the biceps tendon. Flexion of the left shoulder was painful. The right shoulder palpated without pain.

Radiographic procedure: Lateral views were made of both shoulder joints.

Radiographic diagnosis: On the left, a roughened periosteal surface extended through the supraglenoid tubercle up to the coracoid process with adjacent small, mineralized fragments and represented a chronic tearing or avulsion of the biceps tendon (arrow). A similar pattern was present on the right shoulder, however, with much less prominent changes.

Slight periarticular spurring on the caudal aspect of the humeral head where it meets the humeral neck was considered an early sign of arthrosis in both shoulders.

Treatment/Management: The biceps tendon was not thought to be ruptured in either shoulder and the owner was advised to control exercise hoping for satisfactory healing of the lesion.

Comments: In discussion with the owner, it was learned that the dog was aggressive during exercise and frequently pulled hard on the leash. To strengthen the shoulder muscles of their pets, some owners have been known to attach the leash to a car and have the dog "tow" the vehicle.

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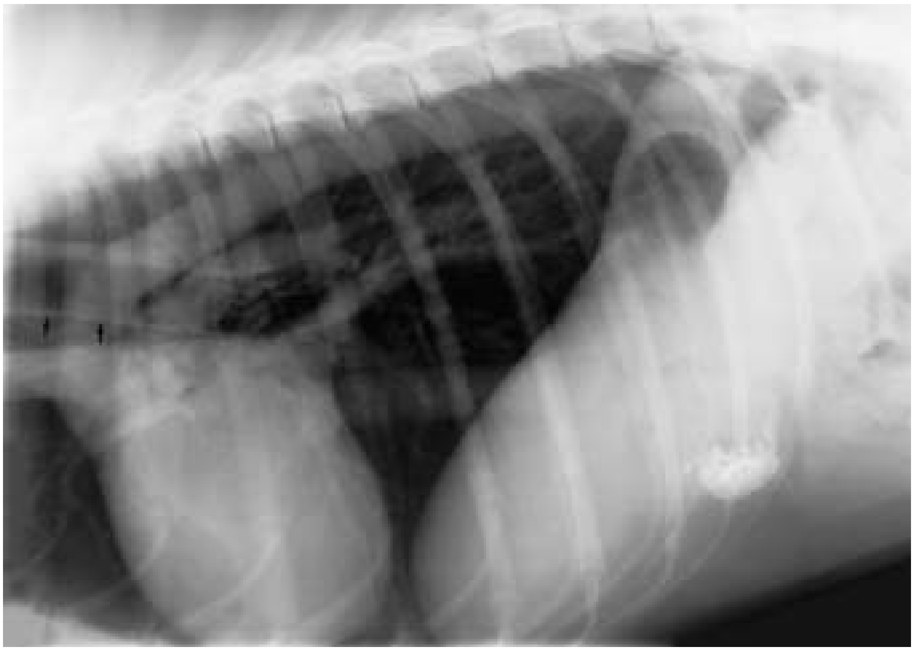
Case 4.3



Signalment/History: "Wendy" was a large 1-year-old, female Scottish Deerhound who had run into a tree the day before.

Physical examination: Crepitation was produced by palpation of the right shoulder. The dog was depressed with shallow breathing at the time of examination.

Radiographic procedure: Studies were made of the thorax with a special view of the scapula.

Radiographic diagnosis (thorax): The hyperlucent lung fields were possibly due to the dog's conformation in addition to the thin chest wall. All major midthoracic vessels plus both sides of the tracheal wall were easily identified as a result of a pneumomediastinum. Pulmonary vessels were easily identified without any abnormal lung density.

Radiographic diagnosis (scapula): The fractures of the right scapula extended through the lateral surface as well as through the spine and appeared to cause a bending of the bone. Fracture lines were not noted to enter the glenoid cavity.

Treatment/Management: The hyperlucent lung fields were the result of the conformation of the thorax; they made the evaluation of the pulmonary vessels easier. Because of "Wendy's" deep chest, caution was exercised in the evaluation of the cardiac silhouette, since minimal patient obliquity in positioning affected the appearance of the heart. The origin of the pneumomediastinum could not be ascertained from the radiographic study. A lateral view of the cervical region and thoracic inlet did not indicate any injury to the upper airway or to the esophagus. If the force of the trauma was severe, a tear in a major bronchial wall could have produced the pneumomediastinum. That etiology would not be clinically important since the injury to the bronchial wall would heal rather quickly. Due to this lack of knowledge of its specific etiology, it was thought to be important to continue to follow the progress of the pneumomediastinum radiographically hoping for its resolution.

The scapula fracture was treated conservatively.

Comments: Scapular fractures that do not invade the glenoid cavity are often not treated surgically.

Case 4.4

Signalment/History: "Rogue" was a 12-month-old, male Doberman Pinscher struck by a car and presented unable to walk on the right forelimb.

Physical examination: Crepitus was palpated in the right scapular region.

Radiographic procedure: Two radiographic views were made of the shoulder and scapula.

Radiographic diagnosis: An acute comminuted fracture of the scapula resulted in a marked displacement of the fragments. The spine was separated.

The shoulder joint, underlying ribs, and adjacent lung were radiographically normal.

Treatment/Management: The owners chose not to consider treatment for "Rogue".

Comments: The scapula in this patient was dense and the soft tissue mass was thin permitting easy visualization of the scapular fragments especially in comparison to a similar injury in a smaller dog who was obese.

Case 4.5

Signalment/History: "Buster" was a 21-month-old male Labrador Retriever found that morning unable to bear weight on the left forelimb.

Physical examination: Crepitus was palpated over the left scapula.

Radiographic procedure: Radiographic views of the shoulder and scapula were made.

Radiographic diagnosis: A recent transverse fracture through the neck and spine of the scapula resulted in marked medial angulation of the proximal fragment (arrows). The fracture through the spine extended proximally. The fracture did not involve the shoulder joint.

Treatment/Management: Radiographs were made of the thorax following identification of the traumatic lesion in the shoulder. Both pneumothorax and lung contusion were identified. "Buster" was hospitalized and kept under observation for several days. At the time of release, he remained lame, but his breathing was felt to be near normal. Since the fracture did not affect the adjacent joint, it was treated conservatively.

Comments: Fractures of the scapula are usually diagnosed on the basis of a marked angulation of the fragments since there are no prominent cortical shadows that can be disrupted.

Careful attention should be given to the glenoid cavity in a radiographic evaluation because fractures extending into the shoulder joint alter the clinical importance of the injury with the possibility of development of a post-traumatic arthrosis.

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Case 4.6

Signalment/History: "Domino", a 13-month-old, female Beagle, had been struck by a car five days earlier. She had had severe dyspnea and shock at that time and was treated with cage rest.

Physical examination: On presentation, the dog could not bear weight on the right thoracic limb, though she did not show any severe pain on palpation or movement of the limb. The elbow region was swollen and palpation of the shoulder joint was not thought to be normal. Injuries to both shoulder and elbow were suspected. Breathing was thought to be normal.

Radiographic procedure: Radiographs were made of the right forelimb plus the thorax.

Radiographic diagnosis (thorax): A moderate bilateral pneumothorax (arrows) was seen without pulmonary contusion and with no evidence of pleural fluid. The cranial mediastinum showed fluid density ventrally that was causing a displacement of the cranial lung lobes (arrows). In addition, a well-demarcated fluid density extended caudally from the base of the heart. These patterns of mediastinal fluid supported the diagnosis of hemomediastinum.

A complete luxation of the right shoulder joint was noted with the humeral head displaced cranially and medially (arrow).

Radiographic diagnosis (elbow): Avulsion fractures from the olecranon could be seen with proximal and distal bony fragments (white arrows). The small bone-like shadow just craniolateral to the radial head is a sesamoid bone (black arrows).

Treatment/Management: The pneumothorax and the hemomediastinum both indicated injury to the lungs and mediastinal organs; however, neither was excessive and they required no treatment other than cage rest.

Comments: The shoulder joint luxation required reduction in a dog of this size to avoid persistent forelimb lameness. The elbow injury suggested tearing of the tendons of the triceps with separation of the underlying bone tissue. The separation of the bony fragments from the parent bone plus their small size would complicate fragment repositioning.

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Case 4.7

Noncontrast

Arthrogram

Signalment/History: "Sting" was a 14-month-old male Rottweiler with left forelimb lameness, the owner believed had started following some form of trauma. Questioning failed to reveal what the owner meant by "some form of trauma".

Physical examination: Examination of the left forelimb produced pain, especially on flexion of the shoulder and on extension of the elbow.

Radiographic procedure: Radiographs were made of the shoulder and elbow. An arthrogram of the left shoulder was performed.

Radiographic diagnosis (shoulder): Studies of the shoulder showed a small bony ossicle off the caudal margin of the glenoid cavity (arrow). The contour of the humeral head was intact. The arthrogram revealed the ossicle to be a continuation of the glenoid cavity. It also showed the bicipital tendon to be normal.

Differential diagnosis: In retrospect, we know more about this type of patient today than we did on the day he was examined. First, the small ossicle formed from the articular surface of the scapula is a common finding in larger breeds representing an incomplete ossification of the glenoid cavity, and while undergoing some movement, is not always indicative of clinical signs. Second, the minimal changes in the elbows that were ignored are diagnostic of medial coronoid disease and belatedly were felt to have definite clinical importance.

Treatment/Management: No treatment was offered.

Comments: "Sting" probably continued life with a progressive arthrosis in the elbow secondary to the undiagnosed medial coronoid disease.

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Case 4.8

Signalment/History: "Rocky" was a 3-year-old, male Pit Bull Terrier struck by a car one month previously and had been lame on the left forelimb ever since.

Physical examination: Palpation of the shoulder was painful and movement of the shoulder joint was limited.

Radiographic procedure: Studies of the shoulder joint were conducted.

Radiographic diagnosis: A comminuted fracture line separated the supraglenoid tuberosity, entered the shoulder joint, and extended approximately 3 cm proximally along the cranial border separating the scapular notch. The larger fragment was displaced cranially by tension on the long tendon of origin of the biceps muscle. A single fragment was identified at the articular surface (black arrow). Callus formation was noted on the large fragment (white arrows), and between the large fragment and the parent bone. The appearance of the fracture was in agreement with the length of time since the injury.

Differential diagnosis: Older fractures develop a pattern of callus that results in fragment margins appearing indistinct. A radiographic pattern of this type invites a possible diagnosis of a pathologic fracture. The young age of the dog plus the absence of any clinical signs suggesting infection tended to rule out malignant disease or osteomyelitis. Still, the character of the fracture was unique and possibilities other than simple trauma were considered.

Treatment/Management: Because of the age and nature of the injury, it was thought not possible to reposition the fragment and it was left to heal as a malunion fracture. This was unfortunate because of the resulting persistent disruption of the articular surface of the scapula.

Humerus and elbow joint

Most fractures of the humerus involve the midshaft of the bone and the condylar region, as the proximal end seems to be well protected by the shoulder muscles. Midshaft fractures are typically spiral and can be easily examined radiographically on a lateral view, although positioning for the craniocaudal or caudocranial view may be painful and not easily performed due to the problem of extending or flexing the limb. Distal condylar fractures are often found in immature members of smaller breeds. In such cases, the opposite limb needs to be examined also, since the fracture may be associated with a persistent cartilage remnant that exists between the two condyles, and also such fractures may be bilateral. In the adult, the fractures may be linear and result in separation of the lateral condyle or may assume a "T" or "Y" configuration and separate both condyles. Oblique positioning may be helpful in these patients in determining the possible entrance of a distal fracture line into the elbow joint space.

Examination of the elbow is most often undertaken in the search for secondary arthrosis following dysplasia. Elbow luxation following trauma can occur with or without any associated fractures. Avulsion of the olecranon can occur in both immature and mature patients, while avulsion of the medial epicondyle only occurs in the skeletally immature, although this type of injury in a healed form may be seen on radiographs of a mature patient.

Case 4.9 #216936

Signalment/History: A 4-month-old, female Yorkshire Terrier had been bitten by a dog several days previously. She had been non-weightbearing on her left foreleg since that time.

Physical examination: Examination revealed crepitus in the upper left foreleg that suggested a humeral fracture.

Radiographic procedure: Radiographs were made of the left thoracic limb.

Radiographic diagnosis: A simple, slightly oblique fracture at the junction of the middle and distal thirds of the humerus had resulted in overriding of the fragments with marked instability. Both the shoulder and elbow joints were radiographically normal.

Treatment/Management: The fracture was treated with a single IM pin. Later, the distal fragment displaced cranially and the pin escaped from that fragment.

The owner would not spend any additional funds on treatment and they departed in an unhappy mood with an unstable fracture that at the best would become a malunion.

Comments: A fracture of this type without any degree of comminution is unique and represents a low energy fracture that, considering the age of the patient, would have healed easily had the stabilization been adequate.

Case 4.10

Signalment/History: "Cream" was a 20-year-old, female Siamese cat with lameness thought to be secondary to trauma that had occurred eight to ten weeks earlier.

Physical examination: The right elbow was painful on palpation and motion was limited. No soft tissue swelling was noted.

Radiographic procedure: Radiographs were made of the right elbow.

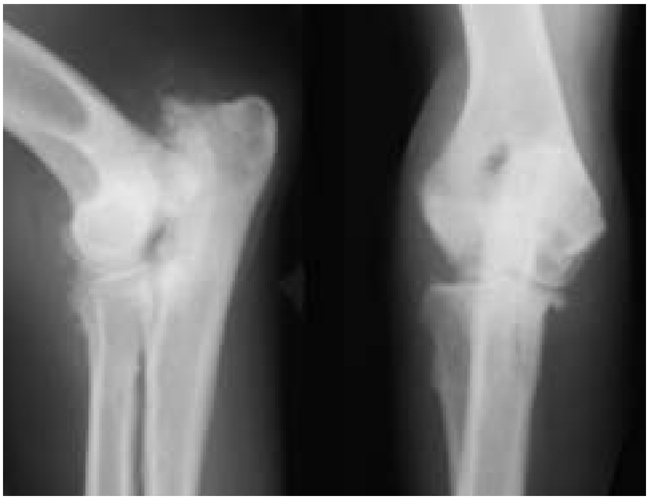
Radiographic diagnosis: Marked periarticular new bone was attached to the parent bone and was in the form of periarticular osteophytes as well as enthesophytes. The new bone was centered near the medial coronoid process of the ulna, as well as cranially at the humeral condyle and radial head. Note the modeling (flattening) of the articular surface of the humeral condyle.

Differential diagnosis: The pattern of new bone that characterized the chronic degenerative joint disease in this old cat was similar to that seen in dogs with medial coronoid disease. While a pattern such as this could have resulted from acute trauma, it is more likely that the trauma to the joint was minimal and repetitive. The lesion does not have the characteristics of inflammatory arthritis.

Treatment/Management: Little was offered in a way to treat this chronic arthrosis and "Cream" was not seen again after this visit to the clinic.

Comments: Patients such as this older cat with chronic arthrosis often are seen in the clinic following minimal trauma with an apparent acute lameness while the lesion, as identified radiographically, suggests a duration of months or years. Cats especially have the tendency to not show any clinical signs; i.e. pain, relative to chronic joint disease of this type until the time of a superimposed trauma.

On presentation



Six weeks postoperative

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Case 4.11

Signalment/History: "Mutley" was a 3-year-old male Labrador Retriever who had a luxation of the right elbow; the result of a dog bite nine months earlier. Radiographs were made at that time and demonstrated the luxation that was reduced by closed reduction.

Physical examination: On presentation the joint was swollen and the dog did not use the limb normally. Motion of the elbow joint was limited and a firm soft tissue swelling surrounded the joint.

Radiographic procedure: The elbow joint was re-radiographed to determine the status of the joint at this time.

Radiographic diagnosis: Destruction of the elbow joint was characterized by fragmentation of the anconeal process, flattening of the trochlear notch, periarticular lipping from the medial coronoid process, and periarticular soft tissue mineralization. The lesion was considered a severe post-luxation arthrosis.

Differential diagnosis: The new bone formation on the bone margins suggested the possibility of an inflammatory process, and both an osteomyelitis and infectious arthritis were considered. To see this lesion without a history of trauma, a diagnosis of malignant synovioma could also be considered. The bony features seen on the radiograph are typical for a chronic elbow dysplasia except for the periosteal new bone and the fragmented anconeal process

Treatment/Management: Surgical arthrodesis was performed. No evidence of infectious or neoplastic tissue was seen at surgery.

Outcome: Radiographs made six weeks post-operatively showed a successful joint arthrodesis and the dog could use the limb without pain.

Comments: This was an interesting patient with atypical elbow disease that necessitated surgical intervention to provide tissues to rule out the possibilities of either inflammatory or neoplastic disease. Surgical arthrodesis is thought to be a satisfactory treatment for a post-traumatic joint disease of this type.

Case 4.12

Signalment/History: "Woody" was a 10-year-old, female cat with a history of limping on the right forelimb for some weeks.

Physical examination: Neither crepitus nor pain were palpated and the cat did not show any lameness in the examination room.

Radiographic procedure: Both forelimbs were radiographed.

Radiographic diagnosis: The malformed medial epicondyles had enthesophytes originating at the origin of the carpal flexors and adjacent soft tissue mineralization probably the result of avulsion fractures (black arrows). The mineralization had a smooth margin and was adjacent to the enthesophyte formation. No joint disease was evident. All of the injury was chronic.

The sesamoid bones within the lateral collateral ligament were identified adjacent to the radial head bilaterally (white arrows), at the site where they blended with the annular ligament.

Differential diagnosis: While the clinical history suggested recent trauma, the radiographic features were those of chronic injury.

Treatment/Management: No treatment was considered in this patient.

Case 4.13

4

Signalment/History: "Issac" was a 2-year-old, male Irish Setter, who had injured his left elbow when struck by a car.

Physical examination: A severe laceration on the lateral aspect of the left elbow indicated marked soft tissue injury. The soft tissue swelling was severe.

Radiographic procedure: Studies were made of the left elbow.

Radiographic diagnosis: The debriding injury was not fully appreciated on the physical examination, but was obvious on the radiograph after noting that the lateral epicondyle was flattened after having been "ground away". Small fragments of bone or foreign material (black arrows) remained in the soft tissues lateral to and cranial to the joint. The three bones forming the elbow joint remained in their normal anatomical position; however, the soft tissue injury, at least, must have destroyed the lateral collateral ligament.

Treatment/Management: A shearing injury of this nature requires surgical skill to repair the soft tissue damage. The apparent absence of fracture fragments mistakenly suggests that this was an injury, which would heal without problems.

Unfortunately, the owners chose to take "Isaac" home and the nature of the natural, untreated, repair of the elbow joint was not known.

Comments: The use of stress radiographs would have shown other features of the soft tissue injury; however, care must be exercised in determining which patients should have stress studies to prevent further damage to the soft tissues.

4

Radius and ulna

Fractures of the radius are common because of its distal location on the forelimb and are found with associated fractures in the adjacent ulna. Dependent on the injury, the fractures may be within the same part of the radius and ulna. If the injury results in a rotational deformity to the limb, one fracture may be proximal and the other distal (Table 4.4).

Fractures of the ulna are uncommonly found alone, but are usually associated with a concomitant fracture in the radius. Because the ulna is the smaller of the two bones, treatment often is directed toward the larger bone and the ulna may be left untreated. In the mature patient, fracture lines through the olecranon appear differently from those seen in the more tubular-shaped portion of the bone. Injury to the proximal ulna can lead to an avulsion of the apophyseal growth center of the olecranon in the immature patient. Injury to the distal ulna in the adult can result in the fracture of the styloid process.

Physeal injury may result in either bone from a relatively minor, clinically unimpressive injury, with a subsequent effect on bone growth from either the proximal or distal growth plates. The trauma may result in premature closure or only delayed growth, either being of equal or unequal influence across the plate. Such injuries lead in the worst situation to a shortening or a marked angulation of the bone. This is usually associated with an injury to the elbow or antebrachiocarpal joints. The result of trauma to the distal ulna is unique and often causes injury to the cone-shaped physeal plate where lateral movement of the metaphysis occurs with a crushing injury to the physeal plate. Because 90% of the ulnar growth results from this distal growth plate, any injury at this location can markedly affect the subsequent length of the ulna. Often the disturbance in growth affects more than one growth plate and it may be difficult to ascertain, which was a primary effect from the acute trauma and which was the secondary effect from the disparity in length of the adjacent bone.

Table 4.4: Radiographic signs of trauma to the radius and ulna

1. pattern of fractures of the radius alone
   a. uncommon
   b. occurs with
      I. minimal trauma causing incomplete fractures (Case 4.18)
      II. gunshot injury
      III. degloving injury (Case 4.30)
2. pattern of fractures of the ulna alone
   a. uncommon
   b. occurs with
      I. fractures of the olecranon
      II. avulsion of the olecranon apophyseal growth center
      III. fracture of the styloid process (Case 4.19)
3. pattern of radial and ulnar fractures (Case 4.15)
   a. common
   b. midshaft spiral or comminuted with butterfly fragments
   c. fragment appearance dependent on type of trauma (Case 4.30)
4. abnormal post-traumatic growth (Case 4.125)
   a. proximal radial physis
      I. shortening of the radius
      II. widened humeroradial joint space
      III. destruction of the trochlear notch of the ulna (Cases 4.124 & 4.126)
   b. distal radial physis
      I. shortening of the radius (Case 4.126)
      II. widened radiocarpal joint space
      III. destruction of the radiocarpal joint space (Case 4.124)
   c. distal ulnar physis
      I. shortening of the ulna (Cases 4.100 & 4.127)
      II. proximal displacement of the styloid process
      III. lateral rotation of the foot
      IV. valgus deformity of the foot
      V. destruction of the antebrachiocarpal joint (Case 4.125)
   d. combination of growth anomalies (Case 4.17)
      I. proximal and distal radial physes
      II. distal radial and ulnar physes
4. non-union fracture (Cases 4.114 & 4.118)
5. pattern of soft tissue injury
   a. subcutaneous emphysema
   b. surface debris
   c. gunshot missile pattern

Case 4.14

Signalment/History: "Saul" was a 7-month-old, male Pug cross who had been limping for 24 hours.

Physical examination: Forelimb lameness was evident on observation and the dog only placed partial weight on the affected limb. Pain was evident on palpation of the left forelimb distally. No evidence of a malalignment of the bones was noted. No crepitus was noted. Soft tissue swelling was minimal if present at all.

Radiographic procedure: Two views were made of the distal part of both limbs.

Radiographic diagnosis: A break in the cortex at the junction of the middle and distal thirds of the left radius had resulted in a fracture with a slight cranial and lateral angulation of the distal fragment. This was an incomplete radial fracture. The ulna appeared unaffected. Both adjacent joints were within normal limits. All the growth plates were open. The right forelimb was normal in comparison.

Treatment/Management: Because of the incomplete nature of the fracture, it was treated by splinting.

Comments: The owner of a young patient with skeletal trauma should be advised to examine the limbs regularly after injury to determine the first display of growth abnormality, which probably will present as a lateral angulation of the foot. At the time of detection of any growth abnormality, radiographs can be made to determine the specific status of the physeal growth plates and a projected severity of the disparity in growth.

4

Right Left

Right Left

Case 4.15

Signalment/History: "Tar Baby" was a 14-month-old, male Greyhound who had suffered fractures in both forelimbs while playing.

Physical examination: The fractured limbs had been splinted and the extent of the examination was compromised by the presence of the splinting material.

Radiographic procedure: Both views were made of each forelimb.

Radiographic diagnosis: The fractures were simple and involved both the radius and ulna on each of the forelimbs. The fracture site on the left was midshaft, while the fractures on the right were more distal. Overriding at the fracture site resulted in an absence of any end-to-end apposition of the fragments. Soft tissue swelling was minimal. The quality of the radiographic studies was compromised only slightly by the overlying splint. Both the elbow and carpal joints were normal bilaterally.

Differential diagnosis: Because bones in both forelimbs were fractured, a search was made to detect a cause of bone weakness. However, the bone tissue was thought normal in density, with normal cortical thickness and pathologic fractures were not considered likely.

Treatment/Management: The radial fractures were stabilized with intramedullary pins achieving relatively good fragment alignment. Callus formation was exuberant indicating that the fixation was permitting some movement at the fracture site. Radiolucencies were noted around both IM pins and both movement of the pin or osteomyelitis were suspected.

Outcome: Subsequent radiographs made at ten weeks indicated that the fractures had healed, but certainly following secondary healing. The suspect radiolucencies identified around the pins were proven to be due to their movement and not a bone infection.

Case 4.16

Signalment/History: "Mimi" was an 8-month-old, female Pomeranian who could not walk on her forelimbs. Trauma was thought to have occurred several days before.

Physical examination: Crepitus and instability were easily palpated in each forelimb.

Radiographic procedure: Two views were made of each forelimb.

Radiographic diagnosis: The radial and ulnar simple oblique fractures on the left were at the junction of the middle and distal thirds of the bones. The fractures showed signs of modeling at the fragment ends although no bridging callus could be seen, indicating a somewhat longer time period since the trauma than the reported period of several days.

Almost identical fractures were present on the right; however, the fracture fragments in that limb were sharply marginated with no modeling indicating a more acute injury.

Differential diagnosis: Bilateral fractures without a clinical history of trauma always suggest the possibility of pathologic fractures. In this patient, the bone density and thickness appears relatively normal for the breed and the fractures were thought to be due to a minimal trauma of low energy such as jumping to the ground from a short distance.

Treatment/Management: The owner chose to return to their referring veterinarian for treatment and this interesting case was lost to follow-up.

Comments: The explanation of fractures in both limbs that appeared to be of different ages remained confusing at the time of first examination. However, prior to leaving the clinic, the owner did admit that "Mimi" had been lame on the left forelimb a period of several days before the injury to the right limb. This suggested two separate traumatic events and explained the difference in the appearance of the fractures.

Day 90 after trauma

Case 4.17

Signalment/Management: "Tory" was an 11-month-old, female Boxer with an uncertain past history of fractures in the forelimbs occurring three months before. Recently, the owner noticed that "Tory" was lame on the left forelimb after exercise.

Physical examination: A valgus deformity was noted in the left foot and cranial angulation of the right forelimb as the dog stood in the examination room. She could move easily and did not show any pain on walking. Palpation of the distal portion of each forelimb located several prominent hard, firm masses of uncertain etiology that were not painful and were not associated with any overlying soft tissue swelling.

Radiographic procedure: Radiographs were made of both forelimbs because of the patient's age and the clinical findings.

Radiographic diagnosis (day 90 after the presumed trauma): Cranial angulation of the distal radius and ulna was noted on the right forelimb at the site of the pedunculated bony mass. A valgus deformity of the left antebrachium was prominent and a pedunculated bony projection appeared to originate from the radius at a site where lateral angulation of the distal fragment occurred. The bony projections appeared to originate from the radius and to cause underlying cortical defects in the adjacent ulnae bilaterally. It was difficult to determine the presence of bony activity at this time. The extent of injury to the antebrachiocarpal joints could not be clearly determined, but was thought to be only minimal.

Differential diagnosis: The pedunculated bony masses had the appearance of benign tumors: multiple osteochondromas. While not seen frequently, these benign bony tumors may result in a growth abnormality in the parent bone especially when located near the end of a bone. The history of past trauma falsely suggested that the lesions could have been the result of malunion fractures. Fortunately, radiographs made at the time of the injury provided the answer.

Day of trauma

Radiographic diagnosis (day of presumed trauma): Subsequently, it was possible to review the radiographs that were made on the day of the presumed trauma. In these, transverse fractures in the radius and ulna in both forelimbs were obvious with an overriding of the fragments.

Comments: A review of the original radiographs clearly showed the patterns seen on presentation to be the result of malunion fractures. While the fractures had healed, the angulation in the bones created a clinically important problem for this dog.

Day 1

Week 3

Case 4.18

Signalment/History: "Scarlet" was a 6-month-old, female Irish Setter, who had been struck by a car earlier in the day and was presented non-weightbearing on the right thoracic limb.

Physical examination: The right forelimb was painful to touch especially in the distal portion; however, no crepitus was detected. Swelling was minimal. Movement of the joints appeared normal, but painful.

Differential diagnosis: A witness to the injury simplified the differential diagnosis and a fracture/luxation in the forelimb was strongly suspected.

Radiographic procedure: Two views were made of the injured forelimb.

Radiographic diagnosis (day 1): An incomplete, "greenstick", fracture extended through the midshaft of the right radius (black arrows). Apposition and alignment of the fragments remained anatomical. The right ulna was not fractured. Fracture lines did not enter the physeal growth areas. The adjacent joints were radiographically normal.

Note the heavy bony "cuff" that encircles the distal ulnar metaphysis, a normal finding in larger dogs at this stage of skeletal growth (white arrows).

Treatment/Management: Because of the patient's age and the incomplete nature of the fracture, the limb was only splinted.

A second set of radiographs was made three weeks later.

Radiographic diagnosis (week 3): The fracture was in a healing phase with the fracture line bridged with callus and not visible. Note the smooth periosteal callus (arrows). Also note the disuse osteopenia characterized by thin dense lines that indicate the cortical width especially around the small bones distally. The growth plates all remained open indicating that the injury had not affected bone growth.

Comments: Disuse osteopenia occurs quickly in the immature patient.

Postmortem

Nine years earlier

Case 4.19

Signalment/History: An 11-year-old, female colony Beagle was examined at necropsy for the possible spread of malignant disease.

Radiographic procedure: Radiographs were made of all the bones.

Radiographic diagnosis (postmortem): A distal ulnar lesion on the left forelimb showed evidence of cortical thickening with a radiolucent zone in the medullary cavity partially surrounded by bony tissue (black arrow). The periosteal surface was smooth. The soft tissues were not swollen when compared with the opposite limb.

Differential diagnosis: The lesion could be either an inflammatory or neoplastic lesion; however, the lesion showed no evidence of any activity as would have been indicated by new bone formation. The possibility of a healed fracture should be considered.

Radiographic diagnosis (9 years earlier): Radiographs made when the dog was 2 years of age showed a unique ulnar fracture (white arrow) at that time with a callus formation yet to bridge the fracture site.

Comments: This dog was a colony dog and was housed two to an enclosure. It is possible that the fracture was the result of a bite wound. The fence construction prevented a limb being caught with a resulting fracture. Stress fractures without displacement of fragments could be considered and it was known that the dogs spent many hours each day jumping against the fence.

The pattern of incomplete healing was probably due to a failure of normal stress lines at the time of healing.

Forefoot

The bony structures of the forefoot include the carpus, metacarpus, phalanges, and the small sesamoid bones. All of these bones are small and trauma can result in crushing or comminution, with the impaction preventing the easy detection of fracture lines. Luxation of the intact central carpal bone occurs in athletic dogs. Because of its morphology, multiple views are usually made of the foot to aid in diagnosis. Another helpful method of examination is the use of stress views in which the foot is placed in hyperextension or in hyperflexion, with medial or lateral stress, or in rotation. The injury to the soft tissues supporting the joints can be detected on these stress studies. In addition, corner fractures and avulsion fractures can be seen more clearly.

Determining the position of the accessory carpal bone is valuable in the detection of injury to the flexor retinaculum or the deep ligaments leading from the tip of the accessory carpal bone to the heads of metacarpals IV and V.

Two prominent sesamoid bones are embedded in the tendons of insertion of the interosseus muscles at each metacarpophalangeal joint on the palmar aspect and may be important in causing pain and lameness. Injury often affects the 2nd and 7th bones because of the angulation of those joints to the ground. The bones can be fractured and appear with two or more fragments, the sum of which approaches their original size and shape. Congenital anomaly of these small bones can be referred to as bipartite or tripartite sesamoid bones, in which the fragments are malformed, have a round smooth margin, and the sum of which is usually larger than the size of a normal bone. A third cause for apparent fragmentation of the sesamoid bones is chronic joint disease, usually traumatic in nature, and in which the bones become fragmented assuming multiple sizes and shapes. The nature of the onset of pain or lameness plus the appearance of the other sesamoid bones in the same foot and in the opposite foot does much in assisting the determination of the correct etiology.

The third phalanx is unique as its base contains the articular surface and the extensor tubercle. The distal part of the phalanx is a laterally compressed cone shielded by the horny claw, the root of which fits proximally beneath the ungual crest.

Because of the tendency for the dog to hold the first phalanx extended, the second phalanx flexed, and the third phalanx hyperextended, these bones are difficult to radiograph in a dorsopalmar direction. Flattening of the foot through the use of a compression paddle may be of assistance in radiography. Separation of the digits through the use of gauze tape or a small paddle device is helpful in taking a diagnostic lateral view.

Case 4.20

Signalment/History: “Shami” was a 3-month-old puppy with a suspected abnormality in the left forefoot.

Physical examination: It was difficult to determine pain on palpation, but the affected foot did have a valgus deformity.

Radiographic procedure: Dorsopalmar views were made of both forefeet.

Radiographic diagnosis: Non-union fractures in the mid-portion of the 2^{nd}, 3^{rd}, 4^{th}, and 5^{th} metacarpal bones permitted lateral angulation of the distal portions of the digits (arrow). Evidence of disuse was noted in the increased width of the metacarpophalangeal joints due to delayed epiphyseal growth and the increased length of the claws on the affected foot.

Differential diagnosis: The possibility of infection as a cause of the non-union was not considered because of the absence of any clinical signs pointing to an infectious lesion and the absence of any periosteal new bone.

More important clinically is the question of whether the fractures are delayed union or non-union. The callus is smooth and shows no activity supporting the diagnosis of non-union.

Treatment/Management: Because of the question of non-union, the foot was re-radiographed two weeks later. The fragments had remained in a non-union status. Small IM pins were inserted in the 3^{rd} and 4^{th} metacarpal bones and radiographs made two weeks following the surgery showed early bridging callus.

4

Right Left

Case 4.21

Signalment/History: "Bucklely" was a 1-year-old, male Wolf-Husky mix with a marked abnormality in the left fore-foot. The owner knew nothing of the origin of the abnormality, but admitted that it had been present for many months.

Physical examination: The marked deformity in the metacarpal bones could be palpated without pain. The soft tissue was firm with a prominence laterally and without heat or swelling. Only four digits were present.

Radiographic procedure: Multiple views of the affected foot were made with a single dorsopalmar view of the normal foot for comparison.

Radiographic diagnosis: Malunion fractures with cross healing were noted in the 3rd and 4th metacarpal bones proximally. The proximal portion of the 5th metacarpal bone was present with atrophic penciling of the distal tip. The remainder of the 5th digit has been amputated. On the lateral view, the marked cranial bowing of the affected metacarpal bones was evident.

Differential diagnosis: The etiology of the deformity was thought to be traumatic and was associated with the amputation of the 5th digit. Congenital anomalies have bones that are more orderly in their development.

Treatment/Management: No treatment was offered.

Comments: This dog was presented to the clinic with a new owner two years later with the same abnormality. The dog was entered as a German Shepherd Dog at this time. The radiographic changes in the left forefoot were identical to those noted on the first study.

Week 4

Day 2

Case 4.22

Signalment/History: "J.R." was a 6-month-old, male Bouves de Flanders, who had fallen a distance of 5 meters two days earlier and was acutely non-weight bearing on the left forelimb.

Physical examination: Palpation indicated a fracture of the scapula on the left and in addition, multiple fractures in the left hindfoot.

Radiographic procedure: Multiple radiographs were made of the left foot.

Radiographic diagnosis (day 2): Salter-Harris Type 1 fractures in the proximal physes of the first phalanx of all four digits. The fragments were displaced medially and angled laterally

Treatment/Management: The phalangeal fractures were treated conservatively by placement of the foot in a splint. Radiographs were made 4 weeks later

Radiographic diagnosis (week 4): The bony callus bridged the fracture in a malunion type of healing (arrow). The lateral angulation of the bones persisted. The scapular fracture was also healing.

Comments: Note the use of a "wooden spoon" on the second study to assist in positioning of the foot.

4

Case 4.23

Left

Right

Signalment/History: "Tug" was a 10-year-old, male Shetland Sheepdog who had been lame on the left forelimb for over one year. He had been "chewing" on the left carpus for the previous 30 days.

Physical examination: The antebrachiocarpal region on the left was swollen and firm without any evidence of heat. Pain was not noted on palpation.

Radiographic procedure: Radiographs were made of both forelimbs.

Radiographic diagnosis: The left carpus had misshapen carpal bones with lucent regions in the radiocarpal bone, possible fragmentation of the 1st, 2nd, and 3rd carpal bones, and marked periarticular new bone on the medial side including the distal radius. The space between the central and ulnar carpal bones was increased suggesting a luxation of the ulnar carpal bone. Other intercarpal joint spaces were difficult to evaluate. The accessory carpal bone appeared to be unaffected.

The right carpus was thought to be normal.

Differential diagnosis: The lesion was thought to be traumatic, but inflammatory sites as indicated by the radiolucent pockets were considered.

In such a case, a specific form of chronic trauma should be considered, i.e. that associated with the abductor pollicis longus muscle whose tendon inserts on the proximal end of the first metacarpal; although here the luxated ulnar carpal bone is not compatible with this diagnosis.

A final consideration in distal joint disease in smaller dogs is a polyarthritis. The radiographic features seen in "Tug" were focused on the medial aspect of the carpal region, which is a not typical presentation for that condition, and the lesions were only found in one joint which is not expected in polyarthritis.

Treatment/Management: Multiple joints taps were all without evidence of inflammation. "Tug" was placed on aspirin and reported to have lessened lameness. The diagnosis was post-traumatic arthrosis.

4

Case 4.24

Signalment/History: "Rocky", a 4-year-old, male German Shepherd, was lame on the right forelimb.

Physical examination: Prominent swelling of the 5th digit on the right forefoot was painful on palpation. No drainage was noted.

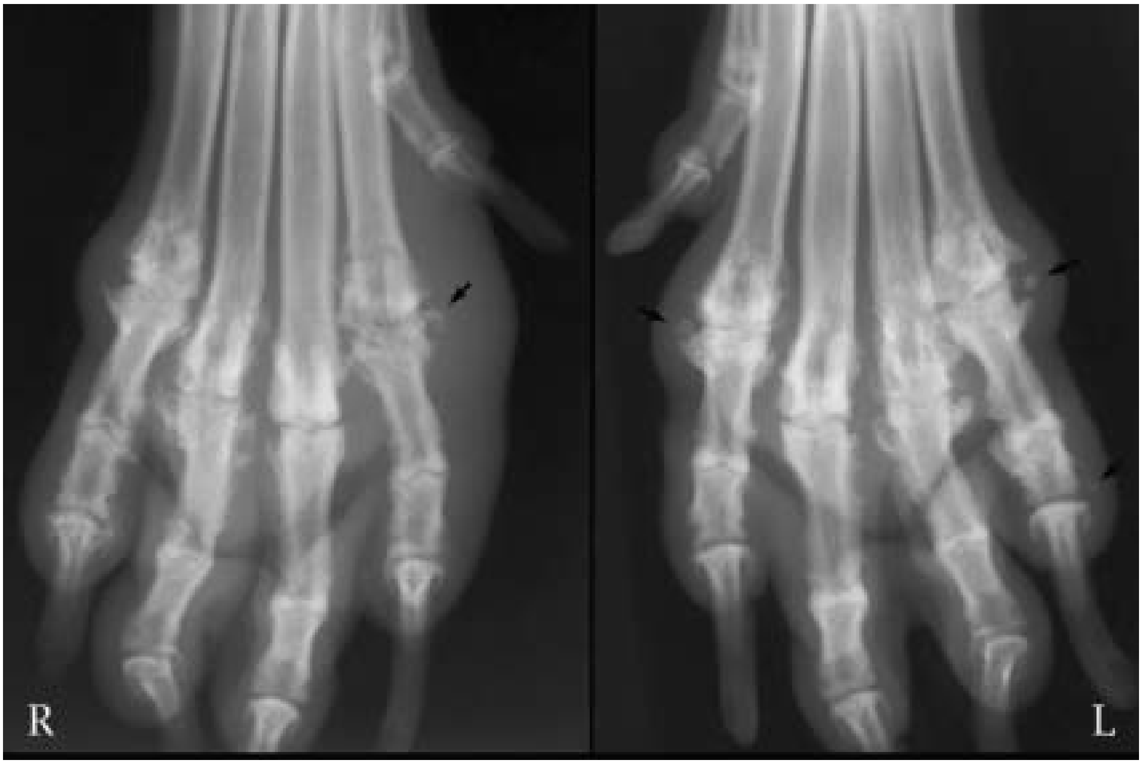
Radiographic procedure: Multiple radiographs were made of the foot.

Radiographic diagnosis: The ungal process of the third phalanx on the 5th digit was blunted (black arrows) and a fragment of mineralized tissue in the tip of the nail (white arrows) was thought to be a dissociated fragment that originated from the ungual process. The lesion had the appearance of being secondary to chronic trauma and had no radiographic changes to suggest either an inflammatory or neoplastic process. The lesion was diagnosed as a post-traumatic lesion. The small fragment of bone adjacent to the distal interphalangeal joint space was thought to have resulted from the traumatic event.

Differential diagnosis: A helpful diagnostic radiographic finding was the absence of inflammatory or neoplastic features such as periosteal new bone or amorphous soft tissue mineralization.

Treatment/Management: The lesion was treated conservatively with the option of amputation for sometime in the future.

Outcome: "Rocky" developed a severe cauda equina syndrome 10 months later and was retired from the police force.



Case 4.25

4

Signalment/History: "Hermann" was a 12-year-old, male German Shepherd cross, who had had swollen forefeet for several months. He had become noticeably lame three days earlier.

Physical examination: Both feet were swollen, more severely on the right, and were firm to palpation. Motion of the metacarpophalangeal joints was limited with some crepitus. No draining tracts were located.

Differential diagnosis: The bilateral involvement of both feet alters the differential diagnosis. Both acute and chronic trauma plus foreign body abscessation due to plant material were considered in this patient.

Radiographic procedure: Two views of both forefeet were made.

Radiographic diagnosis: The lesions were limited primarily to the metacarpophalangeal joints of the major digits. The joint spaces were collapsed, the subchondral bone was sclerotic, prominent enthesophytes had formed at the sites of attachment of the joint capsules, and some free joint bodies were present. Periarticular soft tissue swelling was prominent. The interphalangeal joints were normal with the exception of minimal change at the proximal and distal interphalangeal joints of the 5th digits on both feet. The nails were greatly overgrown. No destructive lesions were noted that might have been associated with an infectious disease. All of the changes were thought to be due to chronic trauma. The carpal regions were normal.

Treatment/Management: The dog was treated symptomatically in an effort to reduce the pain and discomfort from the chronic post-traumatic arthrosis.

Comments: The destructive changes associated with an inflammatory lesion superimposed over a chronic, non-inflammatory, post-traumatic joint disease would probably not be easily detected radiographically. In this dog, several exploratory incisions were made to learn more of the etiology and only granulation tissue was obtained. The pattern of injury is interesting in that the trauma was centered at the metacarpophalangeal joints. Also the small centers of ossified tissue interposed between enthesophytes (arrows) is a frequent finding associated with chronic arthrosis.

4

Case 4.26

At presentation

Right Left
Four months later

Signalment/History: "Butkkus" was a 7-year-old, male Boxer with a mild left forelimb lameness for four months.

Physical examination: Swelling was present on the medial aspect of the radiocarpal joint, associated with pain on palpation of that region.

Radiographic procedure: Multiple radiographs were made of both carpal joints.

Radiographic diagnosis (left carpus): A radiolucent line with irregular borders extended proximodistally through the center of the radiocarpal bone and suggested a chronic fracture as seen in primarily trabecular bone (black arrow). A small bony fragment was present dorsally at the radiocarpal joint (white arrow). The injury to the articular surfaces was difficult to see, but must have been rather extensive since the fracture line extended into the joint spaces both proximally and distally. Adjacent soft tissue swelling was noted.

The fracture was easiest seen when compared with a radiograph of the opposite limb.

Treatment/Management: The fracture was treated only through the use of a supportive wrapping.

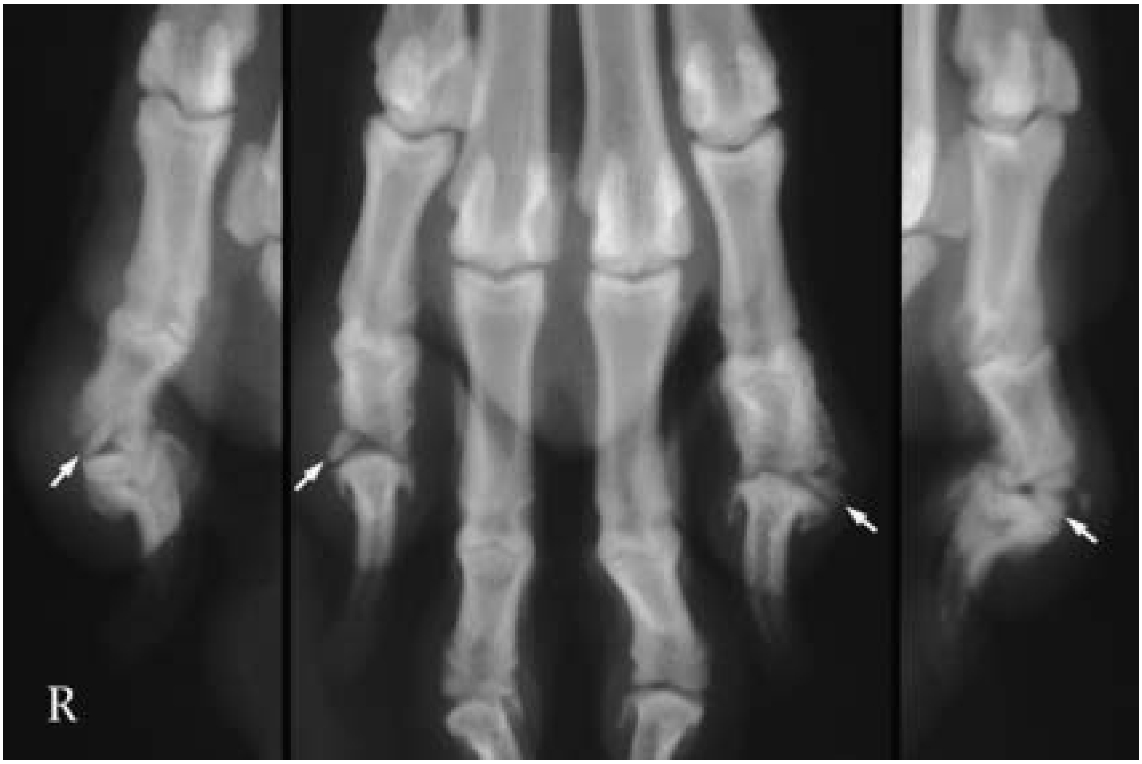
Comments: The fracture had not been detected radiographically at the time of original injury and as a result the injury was underdiagnosed as a traumatic arthrosis and undertreated.

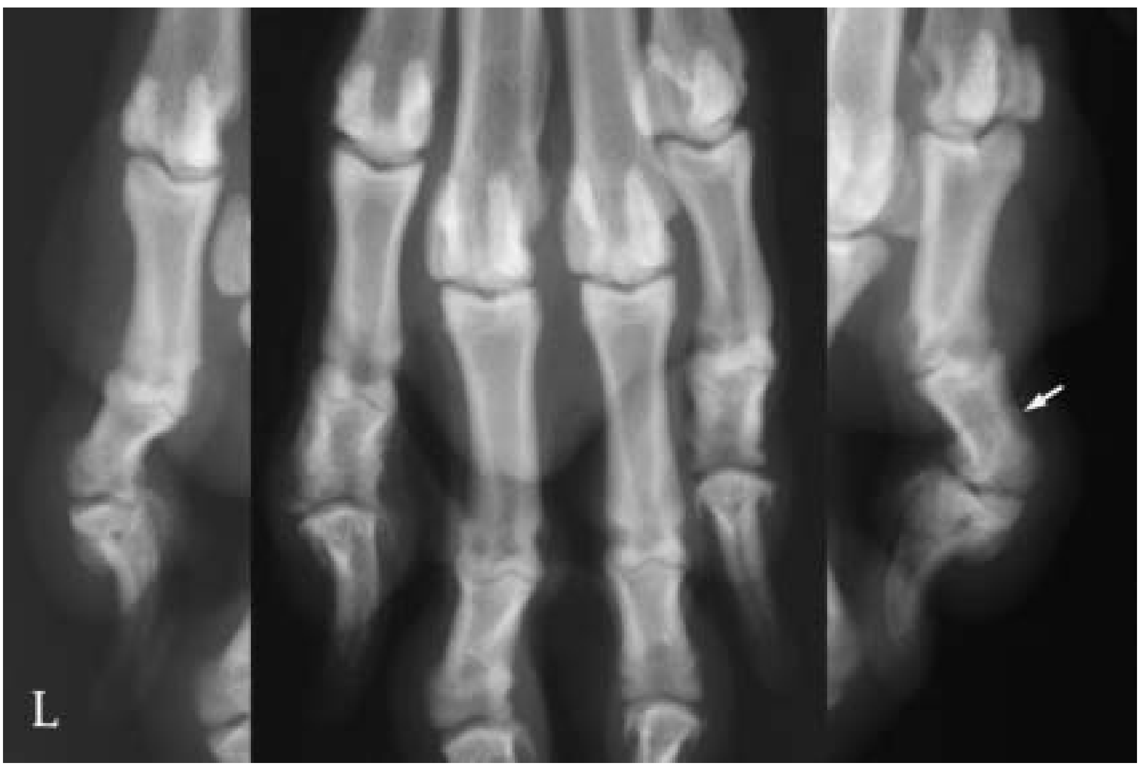
The age and complete nature of the fracture was difficult to determine on the study made four months after the suspected injury; however, with fragment displacement the fracture was complete and the indistinct appearance of the surface of the fracture fragments indicated it was old (arrow).

Fractures in small bones do not produce callus as easily as do long bones surrounded by a vascular soft tissue; thus, in this case this could either be a non-union fracture or a fracture healed with a fibrocartilaginous callus.

4

Case 4.27





Signalment/History: "George" was a 6-year-old, female Irish Setter with a history of unknown injury to the right foot.

Physical examination: Palpation of the digits showed firm soft tissue masses around the 2^{nd} and 5^{th} digits on the right foot.

Radiographic procedure: Radiographs were made of both feet.

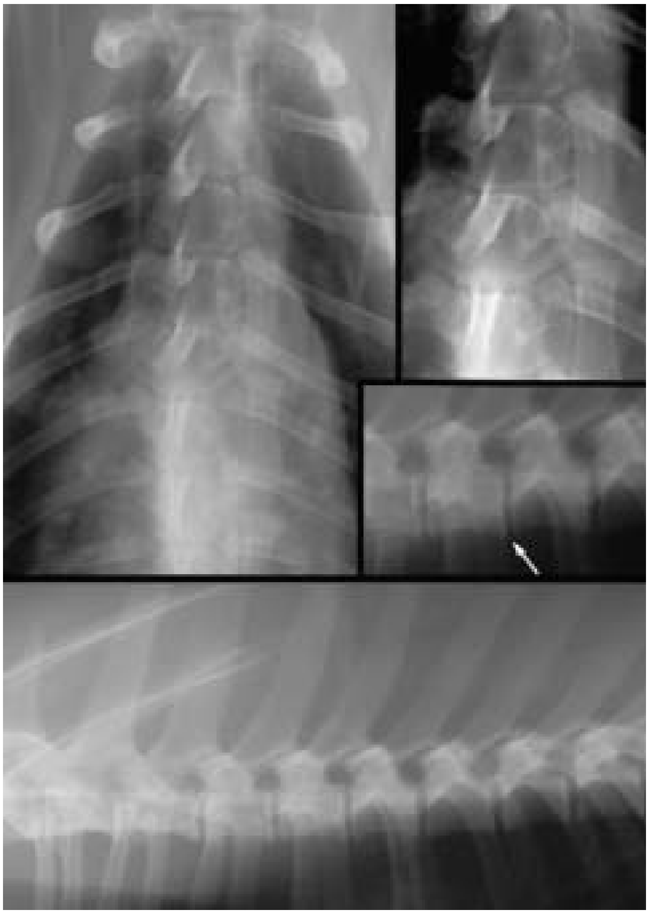
Radiographic diagnosis: On the right foot, chronic intra-articular fractures affected the distal interphalangeal joint of the 2^{nd} digit and the same joint on the 5^{th} digit. The fragments (white arrows) had a smooth border without any signs of active repair processes. The fracture lines were indistinct, an indication of chronic trauma. Periosteal new bone was especially prominent on the 2^{nd} digit. Soft tissue swelling was minimal.

A similar pattern of chronic change was noted on the left foot, though with much less severe change.

Differential diagnosis: Exclusion of infectious and neoplastic lesions was the main differential problem. In this dog, the features were rather specific for chronic trauma with the fracture lines and fracture fragments being identified. The periosteal response was adjacent to the injured joint and did not suggest either an inflammatory or neoplastic lesion.

Treatment/Management: Having found an injury due to old trauma, the choice of treatment was limited. Amputation could be considered if one of the lesions was causing a particular clinical problem for the dog.

Comments: Injury of this type is more likely in the 2^{nd} and 5^{th} digits.



Day 1

Case 4.28

Signalment/History: "Beaver", a 5-year-old, female Labrador Retriever, had fallen 4 meters from a roof onto the ground. Injury to both forefeet was evident. In addition, a pneumothorax required immediate treatment.

Physical examination: Palpation of the feet produced marked instability suggesting fracture/luxation. Dyspnea was pronounced.

Radiographic procedure: Radiographs of the thorax and the cranial portion of the thoracic spine were done at admission. The former were made because of the dyspnea and the latter because of a suspected segmental instability noted on the thoracic studies. After nine days in the clinic, the dog stabilized and both feet were radiographed including stress radiographs.

Radiographic diagnosis (day 1, cranial thoracic spine): A collapse of the T4–5 disc space with minimal malalignment of the segments was note on both projections.

Radiographic diagnosis (day 9, feet): Fracture/luxation of the carpometacarpal joints on the left caused extensive instability as evidenced by a palmar displacement of the head of the 2nd metacarpal bone. Also note the lateral displacement of the metacarpal bones indicating the severity of the injury.

Fracture/luxation of the intercarpal joints on the right resulted in a palmar displacement of the distal row of carpal bones and hyperextension. The fractures appeared to be limited to small chip and avulsion fragments.

Treatment/Management: Pancarpal arthrodesis and partial carpal arthrodesis were attempted.

Despite the collapse of the T4–5 disc space (arrow), the neurologic examination was thought to be normal and consequently, the spinal subluxation was not treated. The finding of the spinal injury did indicate the requirement for cage rest for a period of time after the trauma.

Outcome: Radiographs were made eight months following the corrective surgeries, at which time both surgeries were clinically and radiographically considered healed with the anticipated arthrodeses.

Comments: The minimal periosteal new bone seen on the distal aspect of the accessory carpal bones is compatible with time being nine days post-trauma.

Day 9

4

Case 4.29

Signalment/History: "O.J." was a 7-week-old, female Labrador Retriever puppy noticed by the owner to be lame on the right forelimb.

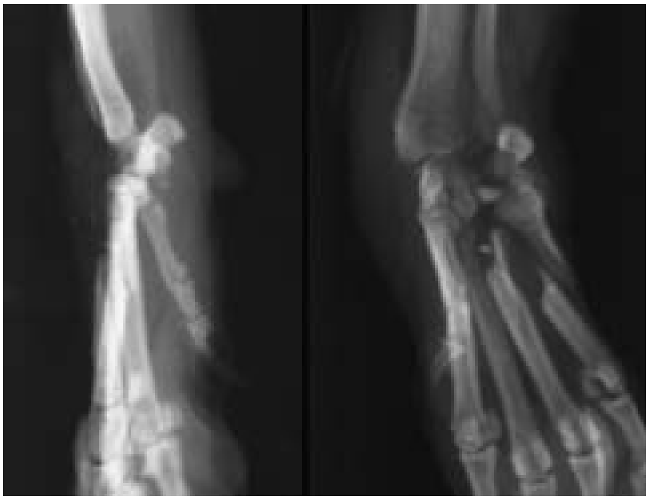
Physical examination: Pain was not evident on examination; however, she was an excited, hyperactive puppy. She was definitely lame when jumping around the examination room.

Radiographic procedure: A study was done of the right and left forefoot

Radiographic diagnosis: Complete fractures of the proximal portions of the 2nd and 3rd metacarpal bones were noted (arrows).

Treatment/Management: The fractures were treated by splinting.

Outcome: The metacarpal fractures healed within two weeks, which is within the expected time considering the apparent low energy of the trauma and the young age of the patient.



Day 1

Week 5

Case 4.30

Signalment/History: "Muffie" was a 7-year-old, female Miniature Poodle who had been struck by a car and injured her left forelimb.

Physical examination: Severe soft tissue injury characterized the open, comminuted fractures in the left foot.

Radiographic procedure: Two views were made of the distal left forelimb.

Radiographic diagnosis (day 1): The original radiographs were made with the foot in a thin bandage and were diagnostic of a severe "degloving" type of injury with the abrasion removing a portion of the distal radius and ulna, part of the carpal bones, and the proximal part of the metacarpal bones. The injury is on the dorsal surface and all of the soft tissues on the extensor surface are missing.

Differential diagnosis: Detection of bone infection cannot be made at the time of an injury, but such an open lesion must always be considered as being infected.

Treatment/Management: A second radiographic study was made five weeks later following only treatment of the soft tissue injury.

Radiographic diagnosis (week 5): At this time, the distal ulna had become atrophic as characterized by "penciling" (arrow). The remaining bones had less density, although the study was made with the splint in position somewhat compromising the determination of bone density. It remained difficult to identify any changes typical of bone infection, but it had to be assumed that it was present.

Treatment/Management: Carpal arthrodesis was performed with good results fusing the radius, carpal bones, and metacarpal bones.

Outcome: Unfortunately, a marked dorsal angulation plus varus deformity resulted leaving the dog with a leg that could be used for little more than a support.

Comments: Interestingly, infection was successfully controlled by antibiotic therapy and did not interfere with the arthrodesis.

4

4

Case 4.31

Signalment/History: "Kalu", a 1-year-old, male Labrador Retriever had suffered an acute lameness in the left forelimb six weeks previously. The limb had been splinted for ten days.

Physical examination: Point tenderness over the proximal sesamoid bones on the palmar surface of the 2nd digit on the left. Similar tenderness was noted in the same area of the 2nd and 3rd digits on the right

Radiographic procedure: Multiple views were made of both forefeet.

Radiographic diagnosis: Multiple non-union fractures of the proximal sesamoid bones on the plantar surface of the 2nd and 3rd digits on the right and the 2nd and 5th digits on the left were to be seen (arrows).

Differential diagnosis: The differential diagnosis for lesions of this type included three specific entities: (1) congenital bipartite sesamoid bones, (2) fractured sesamoid bones, and (3) degenerative changes resulting in fragmentation and soft tissue mineralization.

Treatment/Management: Because the clinical signs were on the left, that foot was operated and the fragmented sesamoid bones were removed from the 2nd and 5th digits.

Comments: The use of a plastic paddle to assist in positioning the foot resulted in a shadow of reduced tissue density across the feet.

4.2.1.6 Pelvic limb injury

Pelvis

The os coxae, or the hipbone, is composed of the ilium, ischium, pubis, and the acetabular bone. Fusion of these bones results in the creation of the os coxae including the acetabulum that ultimately receives the femoral head. The two hipbones join at the pelvic symphysis to form the pelvis. The pelvic symphysis consists of the pubic symphysis and the ischial symphysis. The ischial symphysis contains a separate small triangular ossification center caudally. With age, the ischial symphysis ossifies though in smaller dogs, the pubic symphysis often remains cartilaginous. The pelvis attaches to the sacrum at the sacroiliac joints. They are a combined synovial and cartilaginous joint; the cranial portion of which is radiolucent because of the presence of a fibrocartilage plate, whereas the caudal portion often undergoes bony fusion with age. The pattern of degeneration is breed/size dependent. Visualization of the sacroiliac joint on the ventrodorsal radiographs is dependent on the conformation of the iliac wings and often is not symmetrical as seen on radiographs made of a malpositioned patient.

Injuries of the pelvis are unique because of its anatomic structure (Table 4.5). The resulting pattern of injury to the bony pelvis can be thought of as that expected with a disruption of a "box" or "ring" in which one side has been fractured. To permit the displacement of one fragment, additional fractures must be present and three separate fractures are often identified as having occurred together. A common pattern of injury involves ipsilateral fractures of the body of the ilium, the body of the pubis, and the ischiatic table. This effectively frees a segment of the pelvis containing a hip joint. Another common pattern involves fractures of the body of the ilium on one side, the body of the opposite pubis, and the opposite ischiatic table. This also frees a segment of the pelvis including a hip joint. Often fractures affect the pelvic symphysis and these cannot be identified either on lateral radiographs due to a lack of fragment displacement or on the VD radiograph because of superimposed coccygeal segments and a rectum filled with fecal material. These are referred to as fractures in the "floor of the pelvis".

Injury to the sacroiliac joints is somewhat dependent on age, since the caudal portion of the joints ossifies with age and the joints become stronger. In the younger patient, the joints can luxate rather easily often resulting in luxation of one sacroiliac joint plus ipsilateral fractures in the pubis and ischium. A common injury in the cat is the luxation of both sacroiliac joints as the only injury freeing the bony pelvis to shift cranially, the result of pulling by the rectus abdominis muscles. Any injury to the sacroiliac joints should prompt a careful search for a fracture line that enters the sacrum; this is more commonly found in the older patient because of the bony fusion of the joints.

Careful inspection of the acetabulum and femoral head is important, since fractures that enter the hip joint affecting the articular surface have great clinical importance because if the fracture is not anatomically reduced, a post-traumatic arthrosis will develop. The fracture may only affect the margin of the acetabulum or may pass through the hipbone, or the fracture may involve the opposite articular surface with fragmentation of the femoral head.

Avulsion fractures in the pelvis can occur in the immature patient resulting in a separation of the centers of ossification in the ilial crest and in the ischiatic tuberosity. Because these fractures do not affect weightbearing bones and are not articular, they are not usually treated, though they are a source of pain.

Injuries to the tail can be assessed on the radiographs of the pelvis, though they are best seen on the lateral view, since the rectal contents often prevent the detection of fracture/luxations near the sacrococcygeal junction. The nature of the fracture uncommonly tells of the severity of the injury to the cauda equina contained within the segments.

Injury to the lumbosacral junction has a particular importance and is discussed with lesions of the lumbar spine (Chap. 4.2.2.3).

Table 4.5: Radiographic signs of pelvic trauma

1. pattern of fractures or luxations because of a "box" or "ring" configuration (Cases 4.34, 4.35, 4.36, 4.37 & 4.41)
   a. ilium, pubis, and ischium on the same side
   b. ilium on the one side, and pubis and ischium on the opposite side
   c. pelvic symphysis plus other fractures (Case 4.27)
   d. both sacroiliac joints with cranial displacement of the bony pelvis (Case 4.45)
   e. sacroiliac joint, pubis and ischium on the same side (Cases 4.32, 4.63 & 4.128)
   f. sacroiliac separation (Cases 4.195 & 4.107)
   g. sacroiliac joint on the one side, and pubis and ischium on the opposite side (Case 4.41)
2. avulsion of the ilial crest or ischial tuberosity (Cases 4.42, 4.106 & 4.132)
3. sacrococcygeal fracture/luxation (Case 4.38)
4. coccygeal fracture/luxation (Case 4.56)
5. unique patterns
   a. fracture pattern leading to a narrowing of the pelvic canal (Cases 4.33, 4.56, 4.99, 4.103, 4.102 & 4.112)
   b. pelvic injury including an acetabular fracture (Cases 4.34, 4.36, 4.37, 4.40 & 4.107)
   c. pelvic injury including a sacral fracture (Cases 4.39, 4.49 & 4.93)
6. patterns of soft tissue injury
   a. intrapelvic hemorrhage
   b. rupture of the urethra or bladder neck (Case 4.33)
   c. change in position of the feces- or air-filled rectum (Cases 4.108 & 4.112)
   d. failure to identify the prostate gland because of hemorrhage or urine (Case 4.104)
   e. failure to identify the urinary bladder because of rupture
   f. subcutaneous emphysema (Case 4.62)
   g. peritoneal fluid
   h. displaced urinary bladder (Case 4.108)
   i. rectal diverticulum (Case 4.108)

Case 4.32

Signalment/History: "Dog" was a 2-year-old, female mixed breed that had jumped from the back of a moving truck and was unable to walk normally after the accident.

Physical examination: She would not bear weight on the left pelvic limb in the examination room. Palpation of the pelvic region produced pain especially when moving the left pelvic limb. Crepitus was not detected.

Differential diagnosis: A pelvic fracture was suspected.

Radiographic procedure: Both VD and lateral views were made.

Radiographic diagnosis: Fractures of the left hemipelvis involved the pubis (black arrow) and ischium, and were located just caudal and medial to the acetabulum. The comminuted fracture entered the caudal aspect of the acetabular roof as viewed on the lateral projection (white arrow) with a single bony fragment being identified. Displacement of the fracture fragments caused only minimal narrowing of the pelvic canal.

Treatment/Management: Because of the slight displacement of fragments and involvement of the caudal, non-weight-bearing portion of the acetabular roof, "Dog" was successfully treated with cage rest.

Outcome: Fracture healing in a young dog occurs quickly and he was exercising normally within 3 weeks.

Comments: It appeared as though the rule of "three pelvic fractures" was broken in this case. The third site of trauma apparently was the undetected injury to the left sacroiliac joint that provided the movement necessary to free the hemipelvis. Often sacroiliac injury is extensive; however, in this patient, the injury was minimal and without displacement.

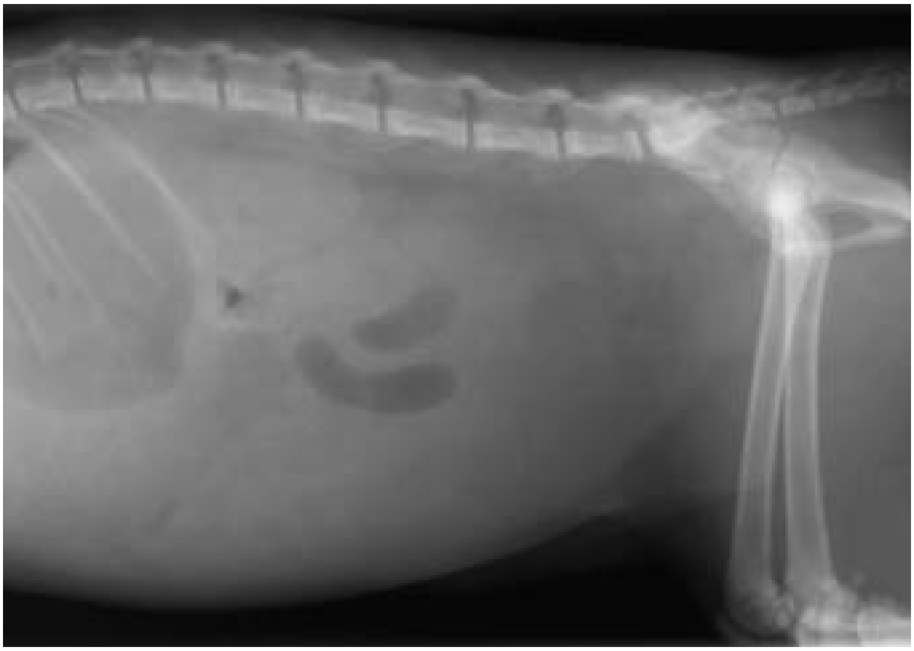
The flexed view for the pelvis was used in this case because it was much less painful to position the pelvic limbs in flexion than attempting to extend what may have been a limb with a fractured femur or move bony fragments associated with an injured hip joint.

Note how the left-sided fractures resulted in a medial displacement of the left hemipelvis and a collapse resulting in the obturator foramen appearing smaller on the radiograph.

4

4

Case 4.33



Noncontrast

Retrograde urethrogram

Signalment/History: "Scardy Cat", a 4-month-old female kitten, had been run over by the owner's car.

Physical examination: The cat was lame and could not walk on the left pelvic limb. Her abdomen was enlarged and the bowel loops palpated to be distended with fluid contents, i.e. the bowel felt fluid-filled.

Radiographic procedure: The radiographic study included both the abdomen and pelvis.

Radiographic diagnosis (abdomen and pelvis): The abdomen was fluid-filled with two gas-filled small bowel loops floating in the peritoneal fluid. The abdominal organs could not be identified. Pelvic injuries were generalized and included a right-sided sacroiliac separation, a left ilial fracture, and narrowing of the pelvic inlet. Left pubic and ischial fractures were not visualized, but were required to permit the medial displacement of the left hemipelvis. The fractures on the left side seemed to be just cranial to the acetabulum; however, this was difficult to evaluate.

Treatment/Management: As the use of a retrograde urethrogram/cystogram is indicated to determine the status of the urinary bladder in a patient with pelvic injuries, where there is an inability to identify the urinary bladder on an abdominal radiographic study, this procedure was done in "Scardy cat".

Radiographic diagnosis (retrograde urethrogram): Positive contrast was injected through a urethral catheter and resulted in a peritoneal flow of the agent indicative of a urethral or bladder neck rupture. The contrast agent against the serosal surface (black arrows) outlined the size, shape, and position of the urinary bladder.

Outcome: The patient was euthanized because of the projected expense of treating the injuries.

Day 1

Day 11

Note how the ileal fracture is compacted and that the fracture line is difficult to identify radiographically (white arrow)

Case 4.34

Signalment/History: "Augie" was an 8-month-old, female Doberman Pinscher who had fallen down a steep incline while hiking with her owner. She has been hesitant to walk since that time.

Physical examination: The dog was lame when examined and non-weightbearing on both pelvic limbs at the time of examination. Crepitus was palpated with movement of the left hip joint. Pain was elicited on rectal examination especially on the left side.

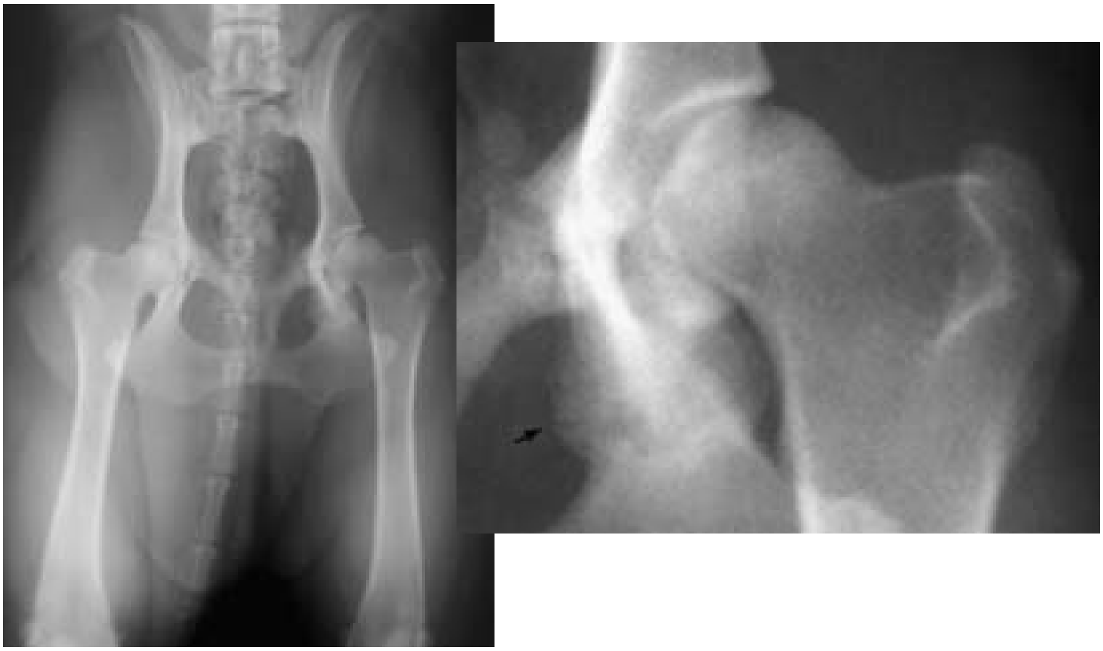
Radiographic procedure: Radiographs were made of the pelvis.

Radiographic diagnosis: Multiple fractures of the left hemipelvis involved the ileum, ischium and pubis. The acetabula appeared to be unaffected (day 1).

Treatment/Management: Because the hip joints appeared intact, the fracture was not treated surgically and the owner was instructed to severely limit the patient's physical activity.

Additional radiographs were made 11 days later and showed inward displacement of the left ileum and ischium opening the previously undetected acetabular fracture. A third study was made 50 days after the injury and showed a massive callus forming around the fracture sites. At that time the dog was showing no pain or lameness.

Comments: The rather good fragment positioning present at the time of the injury was lost by permitting the dog freedom to exercise. The lesion involved the acetabular cup more than was thought originally and a secondary arthrosis will be a sequela in this patient. The exuberant callus that formed around the acetabular fractures almost had a malignant appearance because of the rapid development of new bone in a skeletally young puppy.



Case 4.35

Signalment/History: "Bridgette" was a 2-year-old, female Labrador Retriever who had a history of falling from a truck two months previously and had had pain in the pelvic region since that time.

Physical examination: The dog was not painful on palpation, although she was somewhat tense from being in the clinic thus making examination difficult. Soft tissue atrophy was prominent around the left pelvic limb.

Radiographic procedure: Studies were made of the pelvis because of the clinical history.

Radiographic diagnosis: Healing fractures were noted in the left acetabular branch of the pubis, body of the left ischium, and left symphyseal branch of the ischium (arrow). Soft tissue atrophy in the muscles of the hind limbs was noted. The fractures involved the ischium just caudal to the left acetabulum, but did not seem to have actually entered the articular surfaces. The femoral head was slightly luxated, perhaps affected by the adjacent soft tissue atrophy or influenced by a pre-existing hip dysplasia.

The shape of the pelvis was not altered suggesting that the fractures were essentially without fragment displacement. This partially explained why the owners were late in bringing "Bridgette" for treatment.

Treatment/Management: A cautious prognosis was offered because of a questionable status of the hip joint. The owner was encouraged to use physiotherapy in an effort to help the dog to regain use of the left hindleg. The dog was discharged without a definitive treatment plan because of the partial healing of the fractures, but the owner was optimistic about the possibility of the dog being a happy pet.

Case 4.36

Signalment/History: "Ben" was a 14-month-old, male Great Dane who had probably been struck by a car approximately two weeks earlier. The owners finally brought him into the clinic because he "does not walk right". They also said he had not urinated since the accident.

Physical examination: The examination was difficult because of the dog's size, but crepitation was noted in the pelvic region more prominently on the left side. Rectal palpation was incomplete but no abnormalities were noted. No neurologic deficits were noted, except for the dog's unwillingness to use the pelvic limbs.

Radiographic procedure: Multiple views were made of the pelvis. The lateral view was directed at the abdomen because of the question of the status of the urinary bladder and was underexposed for a study of the pelvis.

Radiographic diagnosis (pelvis): Multiple pelvic fractures involved the right acetabulum, left ilium, the left acetabular branch of the pubis, the left ischiatic table, and an avulsion fragment from the left tuber ischii (arrow). The pubic symphysis was partially separated. The fragments were noted to move freely on comparison of the two VD views. A soft tissue mass was noted beneath the sacrum that probably represented a hematoma.

Treatment/Management: A greater trochanter osteotomy was performed to gain access to repair the right acetabular fracture using a five-hole bone plate held in position by five cortical screws. "Ben" was discharged 12 days post trauma and could walk, but he still showed signs of pain.

Comments: Studies of a giant breed are always compromised by the size of the dog.

4

Case 4.37

Signalment/History: "Duke" was a 2-year-old, male German Shepherd who had escaped from the yard and was absent for seven days. He had returned the evening before not able to bear weight on the left pelvic limb.

Physical examination: Crepitus was noted on palpation of the pelvis.

Radiographic procedure: Routine views were made of the pelvis.

Radiographic diagnosis: The fracture fragments in the left ischium were displaced and the fracture line angled caudoventrally. The femoral head was driven medially and impacted between the ilial fragment laterally and the ischial fragment medially. Fractures of the left pubis and ischium permitted complete separation of the caudal fragment on the left.

The right coxofemoral joint and iliosacral joints were normal in appearance.

Treatment/Management: An injury of this type requires surgical treatment to free the femoral head and restore some degree of joint architecture Because of the age of the fracture that suggested possible immobility of fragments due to early healing, the unwillingness of the owner to consider the cost of surgical treatment, and the presence of sacral canal stenosis, euthanasia was carried out.

Comments: Sacral canal stenosis assumes importance as a dog ages and can be one of the features causing a cauda equina syndrome and its presence complicated the prognosis in this dog. Sacral canal stenosis is a commonly inherited trait in this breed.

4

Case 4.38

Signalment/History: "Sam" was a 3-year-old, male Dachshund admitted with the sudden onset, two days previously, of urinary incontinence, pelvic limb ataxia, and straining at defecation.

Physical examination: He was ambulatory with probable decreased conscious proprioception in the right pelvic limb. The anus was flaccid. Crepitus could be detected on palpation of the pelvic limbs. Because of the breed, a disc protrusion was strongly considered.

Radiographic procedure: The spine and pelvis were radiographed.

Radiographic diagnosis: The presence of a sacrum with four segments made localization of the acute fracture/luxation confusing. The injury was centered at the junction of the 2nd and 3rd sacral segments with some displacement of the fragments. A free cortical fragment was located ventrally. The urinary bladder was distended.

Differential diagnosis: The injury site appears to be defined by a lucent zone in the sacrum with a slight collapse characterized by a dorsocranial displacement of the caudal segments. The lesion appeared to be more a pathologic fracture due to the folding and bending of the cortical bone (arrow). A pathologic fracture could involve either a benign or malignant bone lesion. The absence of recognized trauma supported a diagnosis of this type rather than one of pure trauma. Neurologic signs of a cauda equina syndrome may always be due to lesions such as a degenerated lumbosacral disc with dorsal protrusion and not due to the trauma, or both can play a role in the syndrome.

Treatment/Management: The owners chose to have the patient treated conservatively. The dog was discharged in a more comfortable state and was able to walk, but was lost to follow-up.

Comments: This patient is an example of neurologic deficits causing a cauda equina syndrome in a breed frequently affected by disc disease that has instead, radiographic evidence of atraumatic or pathologic fracture. This patient should have been followed radiographically to ascertain the exact nature of the fracture. A biopsy should have been taken to ascertain the nature of the abnormal tissue.

Case 4.39

Signalment/History: "Sophie" was a 1-year-old, female cat who was presented with incoordination in her pelvic limbs. The owners assumed trauma as the etiology.

Physical examination: The spinal reflexes were normal. Pain perception was present in the hindlimbs and tail. The hip joints palpated normally. No crepitus was evident.

Radiographic procedure: Ventrodorsal and lateral views were made of the pelvic region.

Radiographic diagnosis: Pubic, ischial and sacral fractures (arrows) permitted cranial displacement of the right hemi-pelvis. The sacral fracture entered the lumbosacral disc space with destruction of its lateral component. The hip joints were radiographically normal. The urinary bladder was seen to be normal in size, shape, and position.

Treatment/Management: The owners chose euthanasia.

Comments: The traumatic injury involved the sacrum and LS disc in a manner that is unusual for pelvic trauma.

Case 4.40

Signalment/History: "Wally" was a 2-year-old, male Spaniel who had jumped from a truck three days previously. He had been unable to walk normally after the accident and was treated at an emergency clinic and then referred.

Physical examination: Pain was evident on palpation of the right pelvic limb especially on movement of the hip joint.

Radiographic procedure: Radiographs were made of the pelvis.

Radiographic diagnosis: An unusual pattern of fracture lines involved the right ilium and then extended caudally over the acetabular roof into the ischium. Minimal displacement of the fragments was evident. The fracture lines definitely entered the acetabulum and resulted in subluxation of an otherwise normal femoral head.

Treatment/Management: A contoured reconstruction plate was used to repair the ilial and ischial fractures. "Wally" was discharged to the referring clinician and was lost to follow-up.

Case 4.41

Signalment/History: "Buster" was a 3-year-old, male cat who had been involved in a car accident one day before presentation.

Physical examination: Palpation of the pelvis suggested multiple pelvic fractures. The hip joints palpated normally; however, crepitus was noted on more aggressive movement of the pelvic limbs.

Radiographic procedure: Radiographs of the pelvis were made.

Radiographic diagnosis: A right sacroiliac separation (white arrow), left ilial fracture with overriding of the fragments (black arrows), left pubic fracture, and left ischial fracture permitted cranial displacement of the pelvis. Both hip joints appeared normal. The sacrum was unaffected.

Treatment/Management: Because of the lack of injury to the hip joints and the absence of collapse of the pelvic canal, "Buster" was treated with cage confinement for two weeks with the hope that the fractures would heal without malalignment.

Comments: Pubic and ischial fractures near the symphysis pubis are difficult to identify on either lateral or VD projections. Often the incomplete evaluation radiographically is accepted because surgical treatment of the fractures is not usually considered.

4

Case 4.42

Signalment/History: "Corky" was a 9-month-old, male mixed-breed dog who was presented with an acute onset of left pelvic limb lameness. The owners knew of no injury, but admitted that the dog was free to run in the garden and onto the adjacent highway.

Physical examination: Palpation of the pelvic region produced severe pain on the left side.

Radiographic procedure: Studies were made of the pelvis.

Radiographic diagnosis: A fracture of the ischium with fragment separation was noted (arrow). The hip joints were not affected.

Comments: This is a somewhat unique type of ischial fracture with the trauma apparently directed from behind the dog.

Note the open growth regions on the dorsum of the femoral neck where the lip of bone from the greater trochanter has yet to unite with the lip of bone that will grow down from the femoral head.

Case 4.43

Signalment/History: “Black Boy” was a 7-year-old, male German Shepherd with pain noted in the pelvic region after exercise. The owners did not know anything about the duration of the pain.

Physical examination: The dog was definitely limping on the left pelvic limb; otherwise, the physical examination contributed little information.

Radiographic procedure: Studies were made of the pelvis and pelvic limbs.

Radiographic diagnosis: Dorsocranial bilateral coxofemoral luxations appeared chronic with acetabular modeling and valgus deformity of the modeled femoral heads and necks. Disuse osteopenia in the femoral heads indicated that disuse of the limbs was chronic and present for a period of time.

Comments: It was remarkable that the bilateral coxofemoral luxation was not noted on the physical examination, especially considering the marked muscle atrophy and the probability of bilateral patellar luxation.

The differential diagnosis of chronic hip lesions should include the following possibilities: (1) bilateral congenital hip luxation with marked valgus deformity of the femoral necks, (2) bilateral hip luxation associated with hip dysplasia, and (3) bilateral traumatic luxation of the femoral heads. All could have been present when the dog was young and determination of the etiology was now clouded by the extensive secondary modeling that had occurred.

If the owner does not know the patient well, it is difficult to obtain a meaningful history relative to past lameness or pain. Often the clinical and radiographic examination in such cases provides the cause of the pain/lameness, but not their etiology.

4

Case 4.44

Signalment/History: "Ginger" was a 13-month-old, female Labrador Retriever who had been struck by a car that morning.

Physical examination: The patient was difficult to examine, but it was obvious that she had a stilted, guarded gait in the pelvic limbs.

Radiographic procedure: Radiographs were made of the pelvis.

Radiographic diagnosis: The floor of the pelvis was fractured free at the junction of the pubis and ilium on both sides and at the junction of the pubis with the ischium. A probable separation of the left sacroiliac joint was noted. Severe arthrosis of both hip joints secondary to hip dysplasia was also present. A congenital sacral spinal canal stenosis was detected (black line).

Comments: Frequently, larger dogs who have hip joint disease from dysplasia also sustain pelvic trauma and it is necessary to determine whether the presenting clinical signs are the result of injury to the joints with a resulting chronic arthrosis or are the result of an acute bone or joint injury. The presence of the arthrosis obviously complicates ambulation of the patient during the healing stage of the fractures. This factor needs to be explained to the owner. Also, the owner needs to understand that subsequent pain and lameness in the pelvic limbs is probably due to the arthrosis and not due to a problem in the treatment of the fractures.

The congenital canal stenosis has an important clinical significance since it can be associated with the development of a cauda equina syndrome. Again, this is not a problem associated with treatment of the fractures

Case 4.45

Signalment/History: "Puss" was an 11-month-old, female kitten who had been struck by an automobile several hours previously.

Physical examination: She was dyspneic with open-mouth breathing, and in shock. Examination was limited but it was obvious that the kitten could not bear continual weight on the right pelvic limb, although she could stand briefly. Crepitus was palpated over the right hip joint.

Radiographic procedure: Both thoracic and pelvic radiographs were made.

Radiographic diagnosis (thorax): Subcutaneous emphysema was identified on the right extending into the cervical region. Consolidation was noted of both lung lobes on the left. Pulmonary edema/hemorrhage was present in the right cranial lung lobe. A minimal pneumothorax was present. This was best seen where the free air contrasted with the partially atelectic lung lobes in the left hemithorax. No pleural fluid was seen. The cardiac silhouette was on the midline but not clearly identified because of the pulmonary fluid.

Radiographic diagnosis (pelvis): Bilateral sacro-iliac luxations caused cranial displacement of the bony pelvis. Pubic and ischiatic symphyseal fractures resulted in collapse of the pelvic canal caudally. A sacral fracture resulted in malalignment of the vertebral segments. Both hip joints were normal in appearance.

Treatment/Management: "Puss" unfortunately had no owner and was euthanized.

Case 4.46

Signalment/History: "Partner" was a 5-month-old, male Golden Retriever puppy who had been hit by a car five days previously and had remained lame after the injury.

Physical examination: The examination was difficult to perform because of the age of the puppy and the lameness on the left side.

Radiographic procedure: Studies were made of the pelvis.

Radiographic diagnosis: Fracture lines entered the left acetabulum resulting in some displacement of the fragments. A second fracture line was just caudal to the right acetabula. A pubic and ischial fracture resulted in a free segment from the floor of the pelvis. Of greater importance was the slippage of the capital epiphysis on the left (arrow).

Outcome: The owner refused to pay for treatment of the fractures and the patient was subsequently released. The fractures will all probably undergo malunion because of the young age of the patient. Unfortunately, the injury to the acetabulum will result in a post-traumatic arthrosis later in life. The healing of the slipped capital epiphysis is more problematic with the possibility of aseptic necrosis of the capital epiphysis leading to rather severe joint disease

Case 4.47

Signalment/History: A male Husky mixed breed was presented having been found by the roadside by a person who witnessed a car striking the dog. The dog was then kept at the new home for five days awaiting its original owner to claim it. After this period of time, the dog was presented by the new owner for treatment because of the persistent lameness of the right pelvic limb.

Physical examination: Pain was identified within the pelvic region, especially on palpation of the right hip joint. Crepitus was noted in that hip joint.

Radiographic procedure: Studies were made of the pelvis.

Radiographic diagnosis: Multiple pelvic fractures were identified with only minimal displacement of the fragments, as seen on the ventrodorsal view, but with marked ventral angulation of the ischial fragment as seen on the lateral view (arrow). The most important injury involved the right acetabulum; however, the important dorsocranial weight-bearing portion of the articular surface appeared not to be traumatized. Prepubic and ischiac fractures were identified (small arrows). The urinary bladder was distended and easily visualized. The prostate gland was enlarged.

Treatment/Management: Treatment was not considered because of failure to locate the original owner of the dog.

Hip Joint

The hip joint is a most important component of the pelvic limb and is often subjected to trauma. Radiography of the hips in the traumatized patient often requires positioning the patient in a VD view with the hindlimbs extended and this view may be very painful. It is much less traumatic to place the hindlimbs equally into a fully flexed position.

Luxations are the most common injury and the injury site needs to be carefully examined for avulsion fractures from the femoral head, fractures that split the femoral head, and fractures from the acetabular margin. All of these reduce the chance of a successful reduction of a luxated femoral head. Closed reduction of the femoral head in a joint affected by hip dysplasia is not often successful and the influence of the arthrosis needs to be recognized (Table 4.6).

In the immature patient, slippage of the capital epiphysis results in a loss of blood supply to the femoral head because of the intracapsular location of the physis. A subsequent necrosis of the femoral head will occur unless the reduction and fixation is immediate and anatomically successful. With a coxofemoral luxation, a tearing of the ligament of the femoral head may result in an avulsion fracture from the fovea of the femoral head or a fracture from the margin of the acetabulum. In an older patient with more severe trauma, a splitting of the femoral head can occur (Chap. Femur). The particular importance of physeal fractures that separate the capital epiphysis is also discussed in the section about the femur.

In larger dogs, the high frequency of arthrosis secondary to hip dysplasia often complicates the interpretation of the clinical signs of a traumatic injury. It also may complicate the interpretation of radiographs in such cases, where acute fractures can be masked by the reactive changes seen in a joint with chronic arthrosis. This is also true of older patients with chronic arthrosis associated with hip dysplasia. In suppurative arthritis, the destructive changes often cannot be identified because of the superimposed reactive new bone associated with the dysplasia.

Clinical signs thought to be due to injury to a hip joint may instead be actually associated with lumbosacral disease or stifle joint disease. A dog that shows pain when pressure is placed on its back may be telling you about the LS joint or stifle joint instead of the hip joint. For this reason, radiographic evaluation of the LS region and stifle joint may be as important as evaluation of the hip joint itself.

Table 4.6: Radiographic signs of trauma to the hip joint

1. Pattern of coxo-femoral luxation
   a. displacement of the femoral head is usually dorsal and cranial (Cases 4.50, 4.52, 4.53, 4.54, 4.57, 4.60, 4.61, 4.103 & 4.130)
   b. examine for associated fracture (Cases 4.60 & 4.73)
   c. examine for preexisting arthrosis (Case 4.67)
   d. chronic luxation (Cases 4.48, 4.50 & 4.57)
2. Pattern of acetabular fracture (Cases 4.32, 4.33, 4.34, 4.36, 4.40, 4.46, 4.47, 4.49, 4.69 & 4.99)
   a. often the detection of a fracture line into the acetabulum is difficult
   b. fracture lines often enter dorsocaudally and are not as clinically important
   c. pattern is often comminuted
   d. oblique or flexed limb studies often contribute to a full understanding of the fracture
   e. post trauma (Cases 4.61, 4.102, 4.103, 4.105 & 4.127)
3. Pattern of superimposed infection (Case 4.55)
   a. destructive lesions are present in the subchondral bone
   b. articular surfaces are roughened
   c. periosteal new bone is indistinct and superimposed over old osteophytes
4. Pattern of soft tissue injury
   a. examine for atrophy to indicate chronicity (Cases 4.32, 4.35, 4.43, 4.48, 4.57, 4.58, 4.61, 4.99 & 4.104)
   b. gunshot pattern may be present and is often not clinically important
5. Post-operative patterns (Case 4.58)
6. Post-operative arthrosis (Case 4.107)

Day 3

Day 45

Case 4.48

Signalment/History: "Harlow" was a 1-year-old, female Dalmatian who had been hit by a car and given emergency treatment for thoracic wall injury, mediastinal hemorrhage, pulmonary contusion, pleural hemorrhage, and minimal pneumothorax. She rapidly developed signs of severe abdominal blood loss and at surgery a torn uterine artery was ligated. Several days after the trauma, she was reluctant to use her right pelvic limb and on presentation, crepitus was palpated in a painful hip joint.

Physical examination: Examinations during hospitalization were difficult because of the original trauma and then because of the post-surgical status of the dog. Eventually it was possible to palpate the hip joints and a luxation was noted on the right side.

Radiographic procedure: Views were made of the pelvis.

Radiographic diagnosis (day 3 post presentation): A craniodorsal coxofemoral luxation was noted on the right with an avulsion fracture fragment that originated from the right femoral head.

Radiographic diagnosis (day 45 post presentation): A persistent, craniodorsal coxofemoral luxation was seen on the right with modeling of the bony fragments within the acetabulum (arrows). New bone had formed on the ilium at the site of pseudoarthrosis formation. Loss of bone density and loss of muscle mass were both indicative of disuse atrophy.

Comments: The extensive thoracic and abdominal injury was recognized and treated immediately following the trauma, while diagnosis and treatment of the luxated hip had been delayed. "Harlow" is an example of a patient with multiple trauma causing injuries to the thorax, abdomen, and a hip joint. The satisfactory treatment of the acute problems was remarkable, but failure to treat the hip joint injury more aggressively left "Harlow" with the likelihood of a chronic post-traumatic arthrosis in the right hip joint.

4

4

Case 4.49

Day 1

Signalment/History: "Jenny", a 7-month-old, female Pointer, had been struck by a car and was lame on the right pelvic limb.

Physical examination: Palpation suggested luxation of the right femoral head. Additional injury was not detected.

Radiographic procedure: Two views of the pelvis were made.

Radiographic diagnosis (day 1): A dorsocranial luxation of the right femoral head left bony fragments that were either chip fractures from the acetabular margin or avulsion fractures from the fovea capitus.

Treatment/Management: Closed reduction was attempted utilizing a DeVita pin to stabilize the femoral head. Additional radiographs of the pelvis made one month later.

Month 1

4

Radiographic diagnosis (month 1): These showed bony resorption within the femoral neck suggesting that a subcapital fracture had been present originally and had not been detected, perhaps because of the more obvious luxation. The periosteal response on the ilium was probably due to placement of the DeVita pin (arrows).

Comments: A review of the original radiographs suggested an oblique radiolucent line across the femoral neck on the VD view (white arrows) and a widened physeal plate as seen on the lateral view (black arrows). These findings suggested the possibility of an intracapsular femoral neck fracture that lead to the femoral neck resorption seen on the later radiograph.

The detection of fracture fragments within the acetabulum is an indication for open reduction.

Case 4.50

Signalment/History: “Duke” was a 2-year-old, male German Shepherd with a history of recent trauma (probably hit by a car).

Physical examination: The dog was in pain and lame in the right hip.

Radiographic procedure: Two views of the pelvis were made.

Radiographic diagnosis: A chronic right femoral head luxation was noted with a pseudoarthrosis formed dorsal to the acetabulum. The position of the right femoral head was dorsal to the acetabulum on the lateral view (arrows). All of the bony production noted around the right acetabulum on the VD view was dorsal to the acetabulum.

Comments: The location of the lesion in “Duke” was unique in that the pseudoarthrosis was directly dorsal to the hip joint instead of its usual location cranial to the acetabulum against the shaft of the ilium. Upon questioning, the owner admitted that the dog had been acutely non-weight-bearing on the right pelvic limb several weeks previously.

Case 4.51

Signalment/History: "Tiger" was an 8-year-old, male German Shepherd with a low-grade, chronic, progressive lameness in the pelvic limbs for the past several years. The owner had seen the dog fall some days previously and noted that he had become acutely lame.

Physical examination: Lameness of the pelvic limbs appeared to be bilateral. Some loss of proprioception was detected on neurological examination.

Radiographic procedure: A VD view of the pelvis with the limbs extended was made.

Radiographic diagnosis: Bilateral arthrosis was noted in both hip joints and was characterized by joint laxity and secondary modeling. This was thought secondary to hip dysplasia. The lumbosacral morphology was normal except for moderate spondylosis deformans. The heavy enthesophyte formation on the iliac crests and ischial arch was thought to be due to the age and size of the dog.

Comments: In the older patient, the pain associated with a chronic arthrosis such as commonly seen in a dog with hip dysplasia can become acute following minor trauma. As in "Tiger", this could have resulted in a marked change in the clinical signs suggesting an acute injury rather than being associated with the chronic disease that was present in the hips.

Also, it is possible for an infectious arthritis to be superimposed over the noninflammatory joint disease, such as would be found in a patient with chronic arthrosis secondary to hip dysplasia. An infection would also cause a similar abrupt change in pattern of the clinical signs. One of the purposes of radiographic examination in this patient was to rule-out an infectious process.

"Tiger" had neurological signs of a cauda equina syndrome and, in conjunction with the minimal radiographic findings of lumbosacral spondylosis deformans, indicated a requirement for continued clinical evaluation. The progression of the neurological signs would suggest the possible need for decompressive surgery with or without stabilization of the lumbosacral junction.

Case 4.52

Signalment/History: “Suma”, an 8-year-old, male German Shepherd mixed breed, was lame on the right pelvic limb. No history of trauma was available.

Physical examination: The right femoral head was luxated.

Radiographic procedure: Radiographs were made of the pelvis.

Radiographic diagnosis: The right femoral head was luxated in a cranial direction, although the right acetabulum appeared unaffected. The femoral head on the left remained within the acetabulum; however, an arthrosis secondary to hip dysplasia was characterized by a prominent thickening of the femoral neck.

The lumbosacral region was characterized by roughening of the endplates of the L7 segment and the sacrum. Marked osteophyte formation bridged the lumbosacral disc ventrally.

Differential diagnosis: The hip luxation was assumed to have been induced by trauma; however, it was not possible to determine if an arthrosis secondary to hip dysplasia might not have resulted in joint instability that could have played a role in permitting the luxation. The lumbosacral lesion was thought to be secondary to a chronic discospondylitis, a sacral osteochrondrosis, or the result of a severely degenerated LS disc. All of these would result in instability with formation of the peripheral spondylosis deformans.

Treatment/Management: The femoral head was reduced by closed reduction. The lumbosacral lesion was not treated at this time because of the absence of signs of a cauda equina syndrome; however, the owner was advised to be observant.

Comments: In the event of future examination of the lumbosacral disc, it would be difficult to perform a discogram in this dog because of the collapse of the disc space. An extradural contrast examination would be possible to evaluate the presence of a mass lesion within the spinal canal. These examinations were delayed awaiting the potential onset of neurologic signs. The dog was not returned for follow-up examination.

Case 4.53

Day 2

Year 6

Signalment/History: "Buffy" was a 1-year-old, female mixed breed, who had been hit by a car two days previously and had pain on the left pelvic limb.

Physical examination: On palpation, the left femoral head was thought to be luxated dorsally. Soft tissue swelling was noted in the left pelvic limb.

Radiographic diagnosis (day 2): A dorsocranial left coxofemoral head luxation was identified. A transitional sacrococcygeal vertebra was present as an incidental finding.

Comments: The preservation of bone density and lack of any responsive new bone suggest an acute injury. The absence of a fracture fragment within the acetabulum improves the prognosis for a successful closed reduction.

Radiographic diagnosis (year 6): Radiographic examination of the pelvis six years later revealed only minimal bony changes suggesting minimal secondary post-traumatic arthrosis within the left coxofemoral joint.

Case 4.54

Signalment/History: "Africa" was an adult, male Belgium Sheepdog who had been hit by a car nine days previously. The treating clinician had been unsuccessful in an attempt to reduce a suspected femoral head luxation.

Physical examination: Palpation of the right hip joint was more painful than expected and the possibility of injury additional to a femoral head luxation was considered.

Radiographic procedure: Studies were made of the pelvis.

Radiographic diagnosis: A dorsocranial luxation of the right femoral head was noted with comminuted fractures of the right ileum that extended into the dorsocranial aspect of the acetabular margin. An additional fracture extended obliquely through the sacrum dividing it into two major fragments (black arrow) and which resulted in a ventral angulation of the distal fragment (black lines). The lumbosacral disc space was wedge-shaped and suggested injury to the disc. Another simple fracture extended into the right ischium (white arrow). Bilateral arthrosis was characterized by thickened femoral necks and shallow acetabula, and was thought to be secondary to hip dysplasia.

Both stifle joints appeared normal.

Treatment/Management: The patient was treated in a conservative manner. The luxation was not reduced even though the owner understood that a pseudoarthrosis would form. The potential importance of the sacral fracture was not recognized at the time of treatment. Any neurological signs present when the dog was presented were masked by the painful character of the injury to the hip joint. The owner was advised upon discharge to observe the dog during convalescence for any signs of persistent pain or failure to develop a more normal gait, either of which could suggest the potential development of a cauda equina syndrome.

Case 4.55

Signalment/History: "Black Jack" was a 5-year-old, male Siberian Husky with a sudden onset of lameness on the left pelvic limb. He had had lameness as a puppy that resolved without treatment.

Physical examination: The left limb was swollen and the patient's temperature was elevated. Palpation of the right hip joint was not possible.

Radiographic procedure: Radiographs were made of the hip joints.

Radiographic diagnosis: Extensive chronic modeling changes were noted in the femoral head and neck, and in the acetabulum. Little remained of the original femoral head. The diagnosis was that of secondary arthrosis probably following a slipped femoral capital epiphysis. The right hip joint was normal.

Treatment/Management: An osteotomy was performed on the left removing the badly remodeled head and neck. The tissue was examined histologically.

A sample of joint fluid contained toxic neutrophils and bacterial cocci . Blood cultures grew a beta hemolytic *Streptococcus*. The synovium and attached soft tissues had moderate to severe inflammatory infiltrates comprised primarily of lymphocytes and plasma cells, with focal clusters of neutrophils.

Comments: This patient probably had had a traumatic fracture with severe joint damage at a young age, followed by the progressive development of a trauma-induced secondary arthrosis. Presumable a bacteremia had occurred recently with seeding in the damaged hip joint leading to the development of a septic arthritis superimposed over the non-inflammatory arthrosis. This changed the clinical signs abruptly.

The appearance of the joint space as seen radiographically deserved a more thorough attention than it had received on the first examination of the study. Chronic non-inflammatory joint disease presents with dense subchondral bone, but in this patient, the subchondral bone is less dense with lucent zones and the joint space is indistinct. This latter radiographic pattern is that expected with inflammatory, infectious arthritis.

Note that the left femur appears shorter than the right. This is the result of the dog preventing full extension of the painful left hip joint as compared with the normal right hip. In a patient such as this one, it is better to position both limbs in a similar manner so that more accurate comparison can be made between the two hips on the radiograph.

Did you notice the calculi within the penile urethra? This was a clinical problem that was not recognized and thus, not treated.

Case 4.56

Signalment/History: "Mac" was a five-month-old, female Ocelot who was unable to walk on the pelvic limbs.

Physical examination: Palpation of the entire body located numerous abnormalities in the limbs plus a marked lordosis at the junction of the spine with the pelvis. Marked bowing of the femurs was evident.

Radiographic procedure: Radiographs were made of the entire body.

Radiographic diagnosis: Malformed bones with both varus and valgus deformities were noted with the most extensive change affecting the lumbosacral junction, the pelvis, and the femurs. Collapse of the body of L5 was present (white lines). Sharp angulation suggested a fracture between the sacrum and first coccygeal segment (white lines). A decrease in cortical thickening was noted with double cortical shadows. Wedging of physeal growth plates was evident (black arrows). Note the flattening of the capital epiphyses.

Differential diagnosis: The generalized bone disease was probably due to nutritional secondary hyperparathyroidism with multiple pathologic fractures. The severity of the bony changes is attributed to the young age of the cat. A similar, but much less severe bone disease can be seen with phosphorous retention causing calcium removal from bones due to renal disease.

Treatment/Management: The owners admitted to feeding the cat on a diet that consisted exclusively of meat since the time of weaning. With a change in diet, "Mac" recovered to the point where he could walk without discomfort. The owners were cautioned that problems in defecation were likely to occur since the collapse of the pelvic canal remained.

Comments: With the use of balanced diets, patients such as "Mac" are not common nowadays.

Case 4.57

Signalment/History: "Heidi" was a 7-year-old, female German Shepherd with a history of chronic lameness. She was assumed to have hip dysplasia.

Physical examination: The hip joints did not palpate normally. Movement of the pelvic limbs was difficult and painful. Muscle atrophy was prominent in the hindquarters, but was more obvious on the right side.

Radiographic diagnosis: A chronic dorsal luxation of the right femoral head was noted and was complicated by a bony fragment missing from the head (arrow). Flattening of the right acetabulum suggested chronicity of the injury. The left coxofemoral joint was normal.

A transitional vertebral segment was located at the lumbosacral junction with marked reactive bony spurring. The L6 lumbar segment was shortened and malformed.

Comments: The exact nature of the original fractures was difficult to determine because of the chronicity. It was thought that the right hip joint was normal at the time of the original trauma; however, the L6 lesion could have been congenital/developmental as well as post-traumatic. The presence of the transitional segment as well as a sacrum with four segments supports a congenital/developmental etiology.


Pre-operative

Case 4.58


Post-operative


12 months

16 months

24 months

Signalment/History: "Taffy" was an 11-month-old, female Golden Retriever, who had had bilateral femoral head ostectomies as treatment for bilateral hip dysplasia.

Radiographic procedure: Radiographs were made to evaluate the outcome of the surgery. The original pelvic radiographs plus the immediate post-operative studies were available for comparison. It was thought the calcar was more prominent post-operatively than desired.

Radiographic diagnosis: Radiographic studies made 12, 16, and 24 months after surgery clearly showed the secondary flattening of the acetabular cups and remodeling of the femoral necks. While these changes were rather frightening in appearance, they were anticipated in surgery of this type in a large dog as bone atrophy and remodeling occur. Free mineralized fragments were probably synovial osteochondromas formed in association with the changes in the joint capsular remnants (arrows). Soft tissue atrophy suggested that the dog was having difficulty in regaining use of its pelvic limbs. The modeling pattern seen on the right side is more desirable than that seen on the left.

Comments: Radiographs made following trauma or in post-operative patients demonstrate bone in a healing phase and may have features that are rather remarkable in the demonstration of the patterns of modeling.

Day 1

Post-operative

Case 4.59

Signalment/History: "Chewy" was an 8-month-old, female Retriever mixed breed who had been hit by a car and was lame on the right pelvic limb.

Physical examination: Crepitus was detected in the right hip joint. Movement of the limb caused considerable pain to the dog.

Radiographic procedure: Radiographs of the pelvis were made with the limbs in flexion to reduce the pain.

Radiographic diagnosis (day 1): A physeal fracture left the right femoral head remaining within the acetabulum (arrow). The opposite hip joint was normal.

Treatment/Management: An attempt was made to stabilize the capital epiphysis using small wires. The resulting position of the head relative to the neck was not anatomical.

Radiographic diagnosis (day 30): The radiographs made one month later showed the "apple core" appearance of the femoral neck indicating acute bony resorption (arrow). The femoral head remained essentially unchanged indicating a lack of blood supply. The modeled neck appeared to have united with the head. The normal appearance of the acetabular roof suggested that it was weightbearing and was a good prognostic sign.

Comments: The speed of resorption of the femoral neck in slippage of the capital epiphysis in the young dog is always a frightening radiographic feature and though expected, it may incorrectly suggest infection or even malignant resorption.

Day 30

Case 4.60

Signalment/History: "Casey" was a 1-year-old, male German Shepherd mix who had been hit by a car several days previously and would not bear weight on his left pelvic limb. The referring clinician had diagnosed a femoral head luxation.

Physical examination: Palpation of the left hip suggested that the femoral head was luxated.

Radiographic procedure: Two views of the pelvis were made.

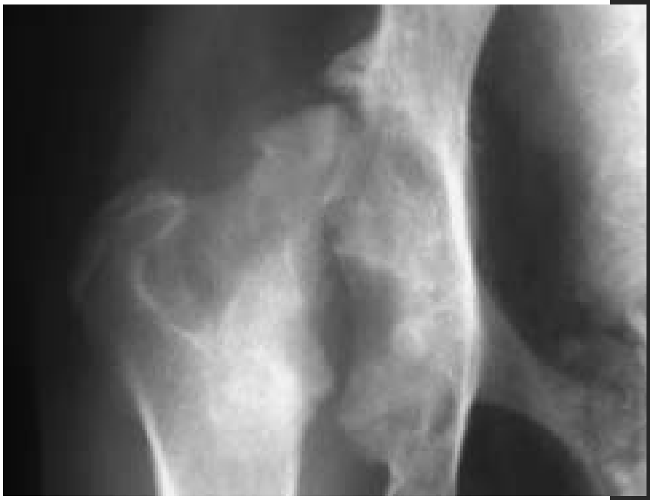
Radiographic diagnosis: A luxation of the left femoral head was associated with a fracture that had separated a large portion of the head (arrow). The femoral head was luxated dorsal to the acetabulum. The left acetabulum was normal except that the bony fragment remained within the acetabulum. The right hip joint was normal.

Treatment/Management: The owner was advised that closed reduction was not possible because the bone fragment prevented replacement of the femoral head. He refused surgical treatment and left with a dog that would be chronically lame

Comments: "Casey" is an example of the value of radiographic examination of a suspect trauma case. An uncomplicated coxofemoral luxation could have been reduced; however the femoral head in this case could not be reduced because of the bony fragment positioned in the acetabulum.

The airgun pellet in the soft tissues of the right hindlimb was an incidental finding and was unrelated to the current trauma.

4



Case 4.61

Signalment/History: "Duke" was a 1-year-old, male Samoyed who had been hit by a car several months previously. He had become progressively lame on his right pelvic limb with marked muscle atrophy.

Physical examination: Crepitus was noted on palpation of the right hip joint. The muscle atrophy was marked, but not painful. The right pelvic limb appeared shortened, suggesting the possibility of a coxofemoral luxation.

Radiographic diagnosis: The malshapened right femoral head and acetabulum were thought to be post-traumatic. The right femoral head luxation was dorsal and cranial. The muscle atrophy affected the right pelvic limb and indicated disuse. A healed fracture at the junction of the middle and distal thirds of the left femur was suggested by the thickened cortex (arrow).

Comments: This type of injury is common in a younger dog and apparently, the trauma had occurred just at the time of skeletal maturation. The fracture/luxation of the femoral head included a separation of a portion of the femoral head and fragmentation of the dorsocranial margin of the acetabulum. The femoral fracture had been treated with an IM pin and a suggestion of the pin tract was seen in the distal femur. Minimal callus formation remained around the fracture site. Why treatment was only directed toward the femoral fracture and the right hip joint injury was not treated, remained an unanswered question.

4

Femur

The femur is a long, tubular bone that frequently suffers the effects of being hit by a car with resulting midshaft fractures. In addition, the proximal femur is unique clinically with respect to injuries of the femoral head and neck, while fractures to the distal femoral condyles form another clinically important injury (Table 4.7).

Fractures of the midshaft are often spiral and contain a large butterfly fragment with marked displacement of the fragments, including overriding. If patient positioning in such cases includes a VD view of the pelvis, additional injury can occur to the soft tissues when attempts are made to extend the limb for this view. It is much less traumatic to place the hindlimb into a fully flexed position or if the patient is small, the body can be positioned in a "sitting position" with the limb extended.

Injury to the proximal femur includes the femoral head and neck, as well as both trochanters. In the immature patient, slippage of the capital epiphysis results in a loss of blood supply to the femoral head because of the intracapsular location of the physis. Subsequent femoral head necrosis will occur unless the reduction and fixation is immediate, and anatomically successful. With a coxofemoral luxation, a tearing of the ligament of the femoral head may result in an avulsion fracture from the fovea of the femoral head or a fracture from the margin of the acetabulum. In older patients with a more severe trauma, a splitting of the femoral head can occur.

Avulsion of the greater trochanter results from a tearing of the piriformis and middle gluteal muscles, while avulsion of the lesser trochanter results from a tearing of the tendon of the iliopsoas muscle

Distal fractures may result in physeal separation of the femoral condyles with their subsequent caudal and proximal displacement, the result of a contraction of the semimembranosus muscle. Distal fractures may extend into the femoral trochlea, where they interfere with the femoropatellar joint. Other injuries to the patella can occur following luxation with or without fracture.

Table 4.7: Radiographic signs of femoral trauma

1. Pattern of fracture of the femoral head and neck in the immature animal (Cases 4.46, 4.59, 4.105, 4.109, 4.128, 4.130, 4.132 & 4.133)
   a. physeal fracture of the femoral head (Cases 4.59, 4.105, 4.109 & 4.128)
   b. avulsion fracture from the fovea of the femoral head (Case 4.48)
   c. avulsion of the greater trochanter (Case 4.105)
   d. avulsion of the lesser trochanter (Case 4.130)
2. Pattern of fracture of the femoral head and neck in the mature animal
   a. femoral neck fracture
   b. femoral head fracture (Case 4.57)
   c. intertrochanteric fracture
3. Injury includes an acetabular fracture
4. Fracture patterns of the femoral shaft
   a. spiral
   b. with butterfly fragments (Cases 4.63, 4.64 & 4.68)
   c. comminuted (Cases 4.104 & 4.121)
   d. fragment over-riding (Cases 4.68 & 4.104)
5. Fracture patterns of the condylar area
   a. physeal separation of the femoral condyles (Case 4.131)
   b. fracture line into the trochlea (Case 4.62)
   c. injury causing traumatic patellar luxation (Case 4.43)
   d. pathologic fracture (Case 4.64)
   e. patellar fracture (Cases 4.65 & 4.135)
6. Patterns of soft tissue injury
   a. intramuscular hemorrhage
   b. subcutaneous emphysema
   c. muscle atrophy (Cases 4.32, 4.35, 4.43, 4.48, 4.57, 4.58, 4.61, 4.99, 4.104 & 4.124)

Case 4.62

Signalment/History: A young, female cat had been found by the roadside and was brought to the clinic unable to walk on the right pelvic limb.

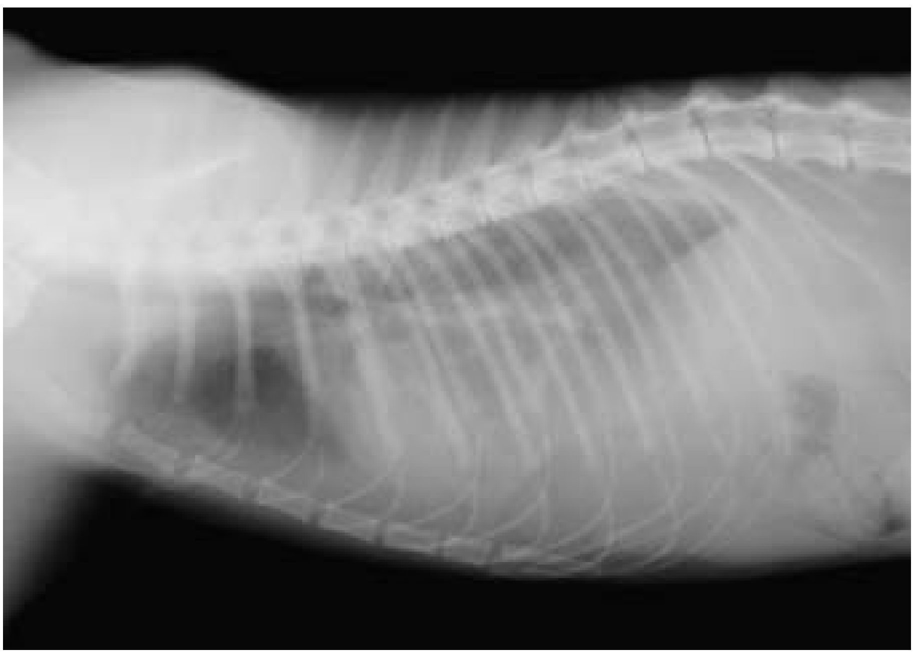
Physical examination: Crepitus and instability were noted in the right stifle joint and a fracture/luxation was suspected. An extensive laceration was present on the medial aspect of the upper limb.

Radiographic procedure: Radiographs were made of the right pelvic limb.

Radiographic diagnosis: An articular fracture extended from the distal medial femoral cortex into the intercondylar fossa destroying the trochlear of the femur. Distraction of the medial condyle was medial and caudal. The small, mineralized shadow cranial to the joint space within the thickened patellar tendon suggested a partial tear of its attachment to the tibial crest. The patella was intact but malpositioned. Joint effusion was extensive and the infrapatellar fat pad could not be identified. Subcutaneous emphysema was noted.

Treatment/Management: Two cancellous screws repositioned the condyle and healing was progressing nicely at one month post-trauma. The cat was lost to follow-up after that time.

Day 3



Day 33

Case 4.63

Signalment/History: "Pablo" was a 17-month-old, male Siamese cat, who had been hit by a car three days previously. A fragment of bone protruding through a wound in the hindlimb was cleaned and "replaced" by the referring veterinarian. The cat was referred for definitive treatment of the fracture.

Physical examination: The hind limb was swollen and discolored and the fracture was obvious.

Radiographic procedure: A lateral radiograph was made of the pelvic region.

Radiographic diagnosis (day 3, femur): An acute midshaft fracture of the femur was characterized by marked over-riding and separation of the major fragments with four large butterfly fragments at the fracture site.

Treatment/Management: The fracture was treated with internal fixation and the cat discharged.

One month later, the owner found the cat to be painful on handling and somewhat dyspneic. "Pablo" was returned to the clinic and radiographic studies made of the thorax.

Radiographic diagnosis (day 33, thorax): The increase in fluid density in the caudal thorax suggested pleural fluid. The cardiac silhouette had shifted dorsally and the diaphragm could not be identified. An oral contrast meal was administered and the displaced stomach and small bowel were diagnostic of a diaphragmatic hernia.

Comments: "Pablo" is an example of a case in which all the attention was directed toward the most obvious injury, the fractured femur. It is quite probable that the cat was maintained in the clinic awaiting surgery, underwent a surgical procedure, recovered and was returned to the client without anyone listening to the thorax. However, it is also possible that although the injury to the diaphragm occurred at the time of the original trauma, the cranial displacement of the bowel into the thoracic cavity did not occur until later, when the cat became dyspneic.

Outcome: The hernia was successfully repaired and "Pablo" returned home again.

4

4

Case 4.64

Signalment/History: "Caesar" was a 9-year-old, male Rottweiler who had experienced a short fall and became acutely non-weight-bearing on his left hindleg. He had been diagnosed as having bilateral hip dysplasia three years earlier.

Physical examination: Palpation of both hip joints was painful for the dog.

Radiographic diagnosis: A severe, deforming arthrosis of both hip joints was secondary to bilateral hip dysplasia. In addition, a highly destructive medullary lesion with a pathologic fracture in the distal left femur was thought to be due to a primary bone tumor. Soft tissue swelling was event around the distal femur.

Treatment/Management: "Caesar" presented a difficult diagnostic problem. He was known to have chronic pelvic limb lameness due to secondary arthrosis from hip dysplasia; however, the clinical signs had changed markedly following a minor trauma when he became non-weightbearing on his left hindlimb. The destructive nature of the lesion plus the pathologic fracture strongly suggested a primary bone tumor. Surgical biopsy examination following limb amputation proved the lesion to be a centrally located osteosarcoma.

Stifle joint

The stifle or knee joint is a frequently injured component of the pelvic limb (Table 4.8). It consists of three separate joints: (1) the femoropatellar joint, (2) the medial femorotibial joint, and (3) the lateral femorotibial joint. Trauma often damages the ligaments or tendons more often than it causes fracture or luxation of the bony structures of this joint. Radiographic diagnosis of femorotibial joint disease is often inaccurate because of the failure of the articular surfaces of the femur and tibia to meet closely. The two menisci separate these bones and take part in protecting the articular cartilage. Consequently, the pattern of arthrosis is altered and consists primarily of enthesophyte formation.

In many dogs, the high frequency of cranial cruciate ligament injury leads to chronic arthrosis and often enhances any acute traumatic injury. In the older patient, the pattern of radiographic features associated with cruciate or collateral ligament or meniscal disease often covers a more acute lesion such as a suppurative arthritis.

The patella and trochlear notch of the distal femur are of particular importance since they may be affected in any congenital/developmental diseases in which the patella tends to luxate. They are also the first to show enthesophytes associated with developing arthrosis. Skyline views are important in the evaluation of this articulation.

Fractures of the distal femur may involve the distal growth plate with caudal and proximal displacement of the epiphysis. In the mature dog, fractures may be a Salter-Harris type III and enter the joint space through the intercondylar space of the femur.

The tibial crest with its attachment to the patellar tendon suffers frequently from avulsion. The clinical importance is lessened because the injury does not involve the stifle joint. This is discussed later in the section on the tibia.

Clinical signs thought to be due to injury to the hip joint or lumbosacral joint may originate from stifle joint disease. A dog that shows pain when pressure is placed on the back may be telling you about its stifle joint instead of the hip joint or LS junction. For this reason, inclusion of the stifle joint in any radiographic evaluation may be important.

Table 4.8: Radiographic signs of trauma to the stifle joint

1. Pattern of stifle joint luxation
   a. uncommon
   b. patellar luxation (Cases 4.43 & 4.67)
   c. often with extensive ligamentous and tendenous injury
2. Pattern of articular fracture
   a. fracture line may enter through the intercondylar space (Case 4.62)
   b. patellar fracture is possible (Cases 4.65 & 4.135)
3. Pattern of superimposed infection
   a. uncommon in the stifle
4. Pattern of joint effusion
   a. infrapatellar fat pad is displaced or not seen clearly
   b. joint capsule is displaced caudally
   c. collateral ligaments are thickened and displaced abaxially
   d. possible joint capsule tear (Case 4.66)

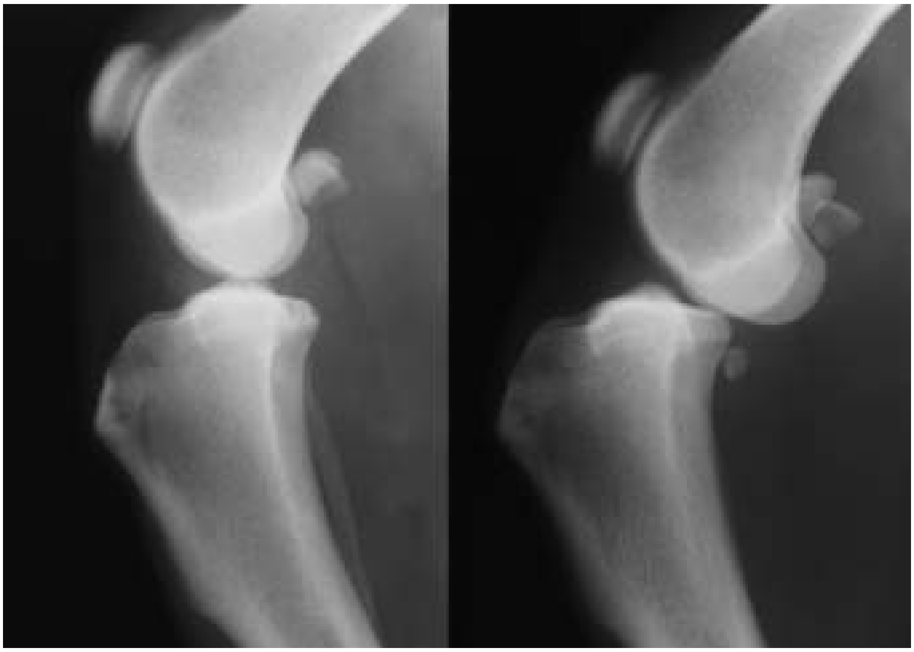
Case 4.65

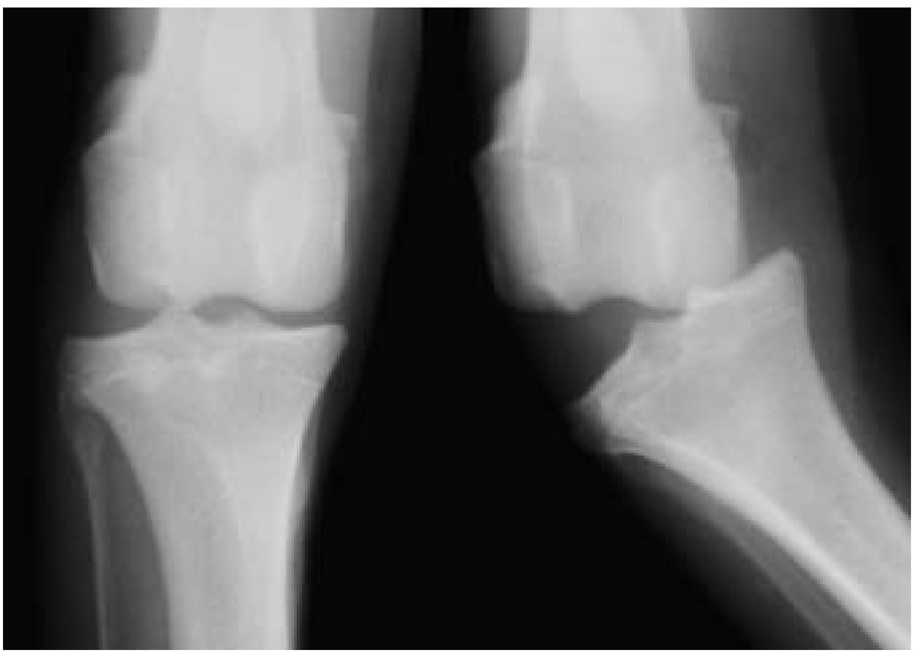
Signalment/History: "Poncho" was a 7-year-old, male German Shepherd mixed breed that had jumped out of a boat onto land four days previously and had not used his right pelvic limb since that time.

Physical examination: The stifle joint was swollen extensively making deep palpation impossible.

Radiographic diagnosis (day 4): A comminuted fracture of the patella had fragment separation. The soft tissue swelling included some joint effusion.

Comments: Because of his older age, with this type of trauma, "Poncho" could not avulse the tibial crest, but instead fractured the patella. The age of the comminuted fracture was difficult to ascertain, but some of the fragments had sharply defined margins indicating a recent injury as described by the owners.





Case 4.66

Signalment/History: “Moe” was a 3-year-old, male Afghan Hound who had got in a fight with other dogs and was subsequently acutely lame in the left pelvic limb.

Physical examination: The stifle joint was unstable with no evidence of crepitus.

Radiographic procedure: Studies of the stifle joint included stress views.

Radiographic diagnosis: Instability in the stifle joints suggested tearing of both the cranial cruciate and lateral collateral ligaments. No fracture fragments could be identified. A persistent infrapatellar fat pad suggests that the capsule was torn and joint fluid and or hemorrhage had escaped into the periarticular tissues.

Treatment/Management: The luxation was not treated.

Comments: Meniscal injury cannot be determined radiographically and its presence would further complicate treatment.

Case 4.67

Signalment/History: "Lisa" was a 1-year-old, female German Shepherd who had been hit by a car one week previously. She had been examined at an emergency clinic and no fractures were identified; any injury was assumed to be ligamentous.

Physical examination: At presentation, she was non-weightbearing on the left pelvic limb and showed pain on flexion and extension of the stifle and hock. The hips did not palpate in a normal manner.

Radiographic procedure: Radiographs were made of the pelvis and left stifle joint.

Radiographic diagnosis (hip joints): Both femoral heads were subluxated with thickened femoral necks. The neck on the right had a "Morgan's line" (white arrow) suggestive of early arthrosis associated with hip dysplasia. The positioning of the hip on the left prevented the same degree of radiographic evaluation. Bilateral hip dysplasia was present.

Radiographic diagnosis (stifle joint): The patella on the left was luxated laterally and a fracture line in the epiphysis extended from the area of the tibial crest through the lateral tibial cortex (white arrows). The fracture line had become indistinct because of the minimal displacement of the fragment and the time since the trauma. Massive soft tissue swelling with joint effusion was present. In conclusion, the tibial fracture was articular with a patellar luxation.

Treatment/Management: "Lisa" was not treated and was lost to follow-up with the knowledge that she would develop hip and stifle arthrosis.

Comments: The fracture, luxation and joint effusion were not detected on physical examination immediately after the accident nor were they noted on the original radiographs. It was assumed that the subluxation on the left was due to the dysplasia. Traumatic subluxation of a healthy hip joint is uncommon, if not impossible.

Tibia

Fractures of the tibia are common with spiraling, comminuted, midshaft fractures being the most common (Table 4.9). Distally, fractures of the medial malleolus are associated with tibiotarsal luxations. Fibular fractures occur in conjunction with the tibial fractures. Type II physeal fractures of the proximal epiphysis are rather common and may occur alone or with an avulsion of the tibial crest. Apparent Type I fractures of the distal tibial may often be actually a Type II. A separate injury may result from increased tension on the patellar tendon, which results in a proximal displacement of the tibial crest.

Table 4.9: Radiographic signs of tibial trauma

1. Pattern of fracture in the immature animal
   a. physeal fracture of the proximal tibial plateau (Cases 4.67, 4.121 & 4.122)
   b. avulsion fracture of the medial malleolus
   c. avulsion of the tibial crest (Cases 4.119, 4.123, 4.134, 4.135 & 4.136)
   d. physeal injury to the distal tibia (Cases 4.120, 4.128 & 4.140)
   e. injury to the tibial epiphysis (Case 4.62)
2. Pattern of fracture of the tibial shaft
   a. often long oblique or spiral fracture (Cases 4.69, 4.71 & 4.137)
   b. usually involves the fibula (Case 4.70)
   c. greenstick fracture (Case 4.70)
   d. with butterfly fragments (Case 4.73)
   e. malleolar fracture (Cases 4.75 & 4 76)
3. Pattern of soft tissue injury
   a. intramuscular hemorrhage
   b. subcutaneous emphysema

Case 4.68

Signalment/History: "Moonshine" was presented as an emergency case with a history of trauma. She was an 8-year-old, female mixed breed unable to walk on her right hindlimb.

Physical examination: Palpation indicated a midshaft fracture of the femur.

Radiographic procedure: Radiographs were made of the upper hindlimb.

Radiographic diagnosis: A transverse fracture at the junction of the middle and distal thirds of the femur had a single small butterfly fragment. Marked overriding of the fragment ends was noted.

Treatment/Management: The fracture was treated with placement of a ten-hole plate with an additional three screws placed as lag screws. A cancellous graft was used at the fracture site. The fracture healed in the expected manner with radiographs made after two months showing early healing of the fracture.

Comments: The unfortunate part of this case is that the severe arthrosis in the adjacent stifle joint was not appreciated by the clinician prior to fracture repair and the owners did not suggest any problems in walking prior to the trauma. As a result of non-locomotion during the fracture healing, motion of the previously diseased stifle joint became more limited. The fracture healed nicely, but "Moonshine" was left with severe lameness because of the pre-existing stifle joint disease.

Day 1

Day 14

Case 4.69

Signalment/History: "Not Yet" was a 4-month-old, male Samoyed who had caught his left pelvic limb in a fence several hours previously.

Physical examination: He was non-weight-bearing and the limb was painful on palpation. Swelling was not detected.

Radiographic procedure: Radiographs of the left tibia were made.

Radiographic diagnosis (day 1): A spiral fracture in the left tibia appeared to be recent with no callus formation and with little displacement of the fragments (arrow). Minimal soft tissue swelling was evident suggesting a low energy trauma. The growth plates were open and appeared normal. A generalized secondary osteopenia was present that could have had a nutritional or renal etiology.

Radiographic diagnosis (day 14): The fracture was seen in a healing stage.

Treatment/Management: The fracture was thought to heal more slowly than expected considering the young age of the dog and minimal trauma to the limb. The bones remained osteopenic without the cause having been determined.

Comments: The first study was performed with the limb wrapped in a supporting bandage. While this is a common practice in trauma patients, there is a danger that an important aspect of the injury may not be identified. Radiographs made following removal of the bandage, cast, or splint should be evaluated prior to any surgical procedure.

Case 4.70

Signalment/History: "Missy" was a 4-month-old, female Labrador Retriever puppy injured probably when hit by a car.

Physical examination: She was lame on the left pelvic limb that palpated as though there was a tibial fracture.

Radiographic procedure: Two views were made of the distal portion of the left pelvic limb.

Radiographic diagnosis: A comminuted midshaft fracture of the tibia was seen with cranial and lateral angulation of the distal fragment and minimal impaction of the fragments. An associated fibular fracture was present. Growth plates and adjacent joints appeared unaffected.

A simple fracture of the midshaft of the 4^{th} metatarsal bone and a comminuted fracture of the midshaft of the 3^{rd} metatarsal bone were noted (arrows). Soft tissue swelling was prominent.

Treatment/Management: All the fractures were treated by placement of the entire limb in a splint. The fractures were healed on follow-up radiographs made one month after the injury. The distal tibial fragment healed with cranial angulation and a 10-degree lateral angulation. The distal tibial physeal growth plate had closed.

Comments: In a puppy, the malalignment of the fragments will probably correct with further bone growth. In a case such as with this dog, the further growth of the tibia should be monitored.

4

Case 4.71

Signalment/History: "Baby" was a 17-year-old, female Pointer who had injured her right leg three weeks previously. Treatment had consisted of an external cast.

Physical examination: Examination was limited because of the cast.

Radiographic procedure: Radiographs were made of the right tibia with the cast in place.

Radiographic diagnosis: A long oblique fracture within the proximal half of the tibia contained one rather long fissure line in the distal fragment. The major fracture line extended to within 1–2 cm of the stifle joint. Apposition and alignment of the fragments was good with a 1-cm separation of all fragments. No callus was identified. The fibula had a delayed union midshaft fracture as well.

All the bones appeared to contain small lucent cavities, especially the proximal tibia and the femoral condylar region, which suggested a generalized destructive disease.

Differential diagnosis: First, it was strange that no callus had formed in a three-week-old fracture. The delay in healing was thought to be due to the severity of the soft tissue injury, the failure to stabilize the fragments, the older age of the patient, plus the possible formation of a radiolucent callus in unstable fractures. Secondly, the pattern of lucencies was correctly thought to be due to the overlying cast material. The answer to the problem was obtained by observation of the more healthy appearing bone tissue in the femur, an area not covered by the cast.

Treatment/Management: The fracture had a well-formed fibrocartilagenous callus that had fixed the fragments in position at the time of the radiographs, so treatment with the external cast was continued. Subsequent radiographs made at three months following injury showed the fragments in the same position as before and with minimal callus formation around both the tibial and fibular fractures.

Comments: Any change in the nature of the overlying soft tissues may influence how the bone tissue appears in a skeletal study. Metallic objects or gravel create a more opaque shadow, while air or gas creates a lucent pattern. Other objects such as bandage tape or wet hair create a pattern in the overlying density and alter the appearance of the bone possibly causing misdiagnosis as happened in this patient. The limit of the cast can be seen in the mid-femoral region.

Case 4.72

Signalment/History: "Mitsy" was a 3-month-old, female, mixed-breed puppy that had been stepped on by her owner. She was lame on her left hindleg.

Physical examination: She was unable to bear weight on the left pelvic limb. No crepitus was elicited; however, deep palpation of the tibia was painful.

Radiographic procedure: Both views were made of the tibia.

Radiographic diagnosis: A spiraling, incomplete (greenstick) fracture in the midshaft of the tibia was seen.

Differential diagnosis: Nutrient foramina can cause lucent lines that can appear as fractures.

Treatment/Management: Having learned the cause of the lameness, it was possible to confine the puppy to cage rest for a short time to permit healing of the fracture.

Comments: The diagnosis of the fracture eliminated a primary soft tissue injury as the cause of the lameness.

Case 4.73

Signalment/History: "Spurs" was a 2-year-old, male Border Collie who had been missing from home for four days and had returned with an injury to his right pelvic limb.

Physical examination: An open fracture of the right midshaft tibia appeared to be comminuted. Palpation of the pelvic region detected a left coxofemoral luxation.

Radiographic procedure: Radiographs were made of the pelvis and right pelvic limb.

Radiographic diagnosis: The severely comminuted open midshaft fracture of the tibia had multiple butterfly fragments. A fissure fracture line extended into the distal fragment to a distance 1 cm proximal to the end of the bone. Minimal overriding of the major fragments caused a cranial and proximal malposition of the distal fragment with slight lateral angulation.

A luxated left femoral head was seen with a small avulsion of bone from the fovea capitus femoris (white arrows). Avulsion of the ischiatic tuberosity (black arrows) was adjacent to debris on the skin that compromised visualization of the bony fragment.

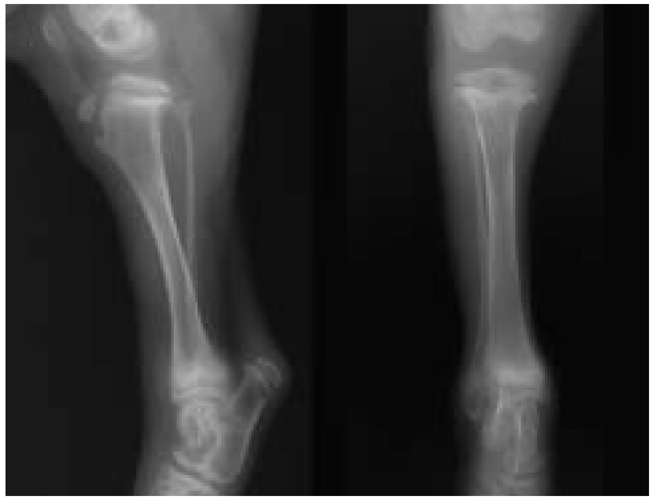
Treatment/Management: The tibial fracture was treated with an external KE apparatus. The coxofemoral luxation was reduced by open reduction.

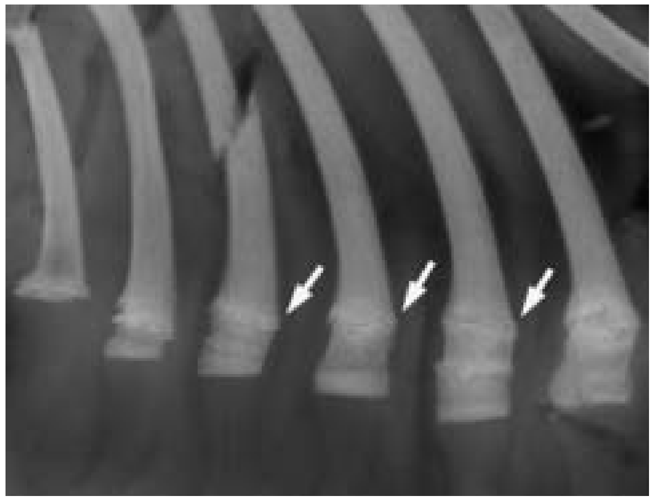
The tibial fracture site became infected. Multiple sequestra were identified and were removed surgically six weeks after the first treatment and a new KE apparatus was put into position.

Radiographs were made of the tibia five months after treatment.

Comments: The appearance of bones during healing following both trauma and surgery can be altered remarkably with confusion centering on whether the combination of lytic and productive changes at the fracture site are associated only with healing of the fracture or may be due to the presence of underlying osteomyelitis The decision of a secondary bone infection is best made utilizing the clinical status of the patient in conjunction with the radiographic patterns.

5 months





Case 4.74

4

Signalment/History: "Jed" was a 3-month-old, male Spaniel fed a diet of bitch's milk and commercial food. Despite this diet, he had a history of generalized weakness and inability to walk.

Physical examination: The left pelvic limb was particularly sensitive to palpation.

Radiographic procedure: Two views were made of each pelvic limb. Lateral views were made of the forelimbs.

Radiographic diagnosis: Generalized bone disease was evident and was characterized by thin cortices, epiphyses with lucent centers, while the metaphyseal bone was more dense than usual. Lateral angulation of the tibia on the left was secondary to a pathologic fracture in the proximal metaphysis.

Differential diagnosis: While the pathologic fracture was identified, the etiology was not easily determined.

The radiodense rings around the epiphyses are seen in scurvy or Barlow's disease and are called Wimberger's ring sign. While this is typical for vitamin C deficiency, there is no sign of subperiosteal hemorrhage in this patient, which is also a classic feature for this condition.

In hypothyroidism, the bones appear to develop normally, although at a delayed rate. In this dog, the size of the epiphyses is thought to be normal for its age.

Rickets is probably the most likely diagnosis except for the history of a healthy diet. Rickets can be vitamin D resistant, associated with a decreased intestinal absorption of calcium or phosphorus, or due to renal tubular disorder with a loss of calcium through the kidneys.

Treatment/Management: "Jed" was euthanized. However, a post-mortem examination of the bones failed to produce an etiology for the bone disease. Multiple pathologic fractures were seen at the costochondral junctions (white arrows) in addition to the long bone lesions.

Comments: Bone surveys may identify abnormal skeletal maturation, but often cannot determine the specific etiology. Also the histologic examination of the bone tissue is often not helpful.

Case 4.75

Signalment/History: "Tammy" was a 5-year-old, female Collie who had sustained multiple injuries after being struck by a car.

Physical examination: Fractures were noted in three limbs with severe soft tissue injury in the pelvic area. Because of the dog's inability to stand, injury to the right tarsal region was not noted at first. Later, palpation of the distal right pelvic limb indicated marked crepitus and instability, and a requirement for further examination.

Radiographic procedure: Radiographs were made of the right tarsus five days after the trauma.

Radiographic diagnosis (day 5): A bimalleolar fracture affected the medial and caudal malleolus (white arrows) with fracture lines entering the tibiotarsal joint resulting in injury to the articular surface.

Treatment/Management: Unfortunately, a fracture in another bone became infected and the attention of the clinicians was directed toward that limb ignoring the right tarsal injury.

All the other fractures eventually healed and "Tammy" was discharged; however, the right hock was left untreated with the certainty of development of a post-traumatic arthrosis.

Comments: The small sliver of bone adjacent to the calcaneus (black arrows) was at the site of attachment of the long part of the lateral collateral ligament and probably represents an avulsion fracture following tearing of that structure. Although not articular and not requiring re-attachment, this injury does further indicate the severity of the trauma.

Case 4.76

Signalment/History: “Phillip” was a 7-year-old, male Australian Shepherd who had injured his right hindlimb while playing with his owner.

Physical examination: The right hock region was swollen and painful to palpation.

Radiographic procedure: Two views of the tarsus were made.

Radiographic diagnosis: The tip of the medial malleolus was avulsed and the lateral malleolus was fractured free. Swelling surrounding the joint suggested a soft tissue injury associated with the sprain.

Treatment/Management: The lateral malleolar fracture was reduced by a tension band apparatus. The chip fragment from the medial malleolus was removed with an attempted soft tissue reattachment. The lateral malleolar fracture was healed in six weeks but the joint appeared unstable.

Comments: An injury of this type can be further evaluated pre- and postoperatively by the use of stress radiography to determine joint stability. The failure to treat the medial malleolar fracture with greater success may have left both the short and long part of the medial collateral ligament damaged and the joint unstable.

Hindfoot

The skeleton of the hindfoot includes the tarsus, metatarsus, phalanges, and the small sesamoid bones. All are small and trauma can result in crushing or comminution with the impaction preventing an easy detection of the fracture lines. Because of its morphology, multiple views are usually made of the foot.

Another helpful examination method is the use of stress views in which the foot is placed in hyperextension, hyperflexion, medial or lateral stress, or rotation. The injury to the soft tissues supporting the joints can be detected with these stress studies, while corner or avulsion fractures can be seen more clearly.

The calcaneous is unique as there is the possibility of separation of the calcaneal tuber in the skeletally immature patient and fracture through the body of the calcaneous in the mature one.

The proximal sesamoid bones are not as frequently injured in the hindfoot as in the forefoot.

The third phalanx is unique as its base contains the articular surface and the extensor tubercle. The distal part of the phalanx is a laterally compressed cone shielded by the horny claw, the root of which fits proximally beneath the ungual crest.

Case 4.77

Signalment/History: "Tiac" was a 3-year-old, female Akita with an injury of unknown origin to the right tarsal region resulting in a marked instability of the joint.

Physical examination: The tarsus was unstable on palpation and soft tissue swelling was prominent.

Radiographic procedure: Multiple radiographs of the tarsus were made including stress views.

Radiographic diagnosis: Proximal intertarsal joint luxation with small avulsion fractures (black arrow) probably represented a tearing of the plantar ligament, especially the band that leaves the caudolateral surface of the calcaneous and attaches to the base of metatarsal V. Actually, fragmentation was minimal considering the degree of malalignment generated by the hyperflexed view. The failure to produce displacement medially or laterally suggests that the collateral ligaments had received only minimal injury.

Treatment/Management: A bone plate was placed on the caudolateral aspect of the tarsus with the use of a cancellous graft to obtain an arthrodesis.

Radiographs were made three months later when "Tiac" was again lame. These showed that one of the screws was broken with the head having "backed out". However, the arthrodesis was thought complete at that time. Soft tissue swelling was apparent.

Comments: Stress studies are valuable in locating the exact location and extent of an injury. The soft tissue mineralization proximal to the tip of the calcaneous (white arrows) is probably not associated with the trauma.

Case 4.78

Signalment/History: "Rascal", an 11-year-old, female Spaniel, was in the hospital for an examination related to her diet when the clinician noted that the 2nd digit on her right pelvic limb was smaller than normal and the nail badly deformed. It was thought prudent to radiograph the foot.

Radiographic procedure: Multiple views were made of the foot.

Radiographic diagnosis: Atrophy of all three phalanges of the 2nd digit was marked. The 3rd phalanx was particularly malformed with only a small residual of the nail bed remaining (arrows). The distal end of the 2nd phalanx had undergone "penciling" and was luxated from the 3rd phalanx. No soft tissue swelling or mass lesions were noted. No pattern of aggressive bone destruction was noted.

The diagnosis was bone atrophy following a traumatic luxation of the 3rd phalanx.

Differential diagnosis: Lesions affecting a nail include those that are traumatic, inflammatory, or neoplastic. Determination of the etiology would assist in determining the appropriateness of amputation as a treatment.

Treatment/Management: In the absence of clinical or radiographic evidence suggesting either an inflammatory or neoplastic lesion, and since the malformed nail did not interfere with her walking, the lesion was not treated.

Comments: Suspect lesions of the 3rd phalanx should be studied diligently and are often amputated if thought to be due to a chronic inflammatory or malignant lesion. Diagnosis is then made from examination of the surgical specimen.

Case 4.79

Signalment/History: “Lady” was a 2-year-old, female cross breed whose owner noticed that she was not walking correctly on her left hindlimb.

Physical examination: Palpation detected crepitus within the left metatarsal bones. No soft tissue injury was evident.

Radiographic procedure: Views of the left hind foot were made.

Radiographic diagnosis: Comminuted fractures were noted in the proximal $^{1}/_{3}$ of the 2^{nd} and 3^{rd} metatarsal bones (arrows). Apposition and alignment of the fragments remained almost anatomical. Soft tissue swelling was minimal. The injury appeared recent.

Treatment/Management: Because of the good position of the fragments, the foot was heavily bandaged and the owner advised that if they restrict movement, healing should take place within a short time.

Comments: Because each fracture is unique as to the energy level of the trauma, the bone fractured, the nature of the fracture, the injury to the soft tissue, the method of fracture reduction, the compliance of both patient and owner during healing, as well as the health of the patient, it is difficult to predict an exact schedule of expected healing.

Case 4.80

Signalment/History: "Tiko", a 2-year-old, male Rottweiler, was presented with the primary complaint of acute lameness of the left pelvic limb, first noticed the previous morning.

Physical examination: The dog was bearing only partial weight on the left pelvic limb. Pain was elicited on palpation of the foot, especially around the swollen 5th digit.

Radiographic procedure: Multiple studies were made of the foot.

Radiographic diagnosis: An acute intraarticular oblique fracture (arrows) with minimal comminution extended the length of the 2nd phalanx. A transverse fracture (arrow) in the proximal portion of the 3rd phalanx was seen to extend into the ungal crest.

Treatment/Management: The foot was supported awaiting healing of the phalangeal fractures.

Comments: Note the multiple "string-like" film artifacts caused by hair inside the cassette.

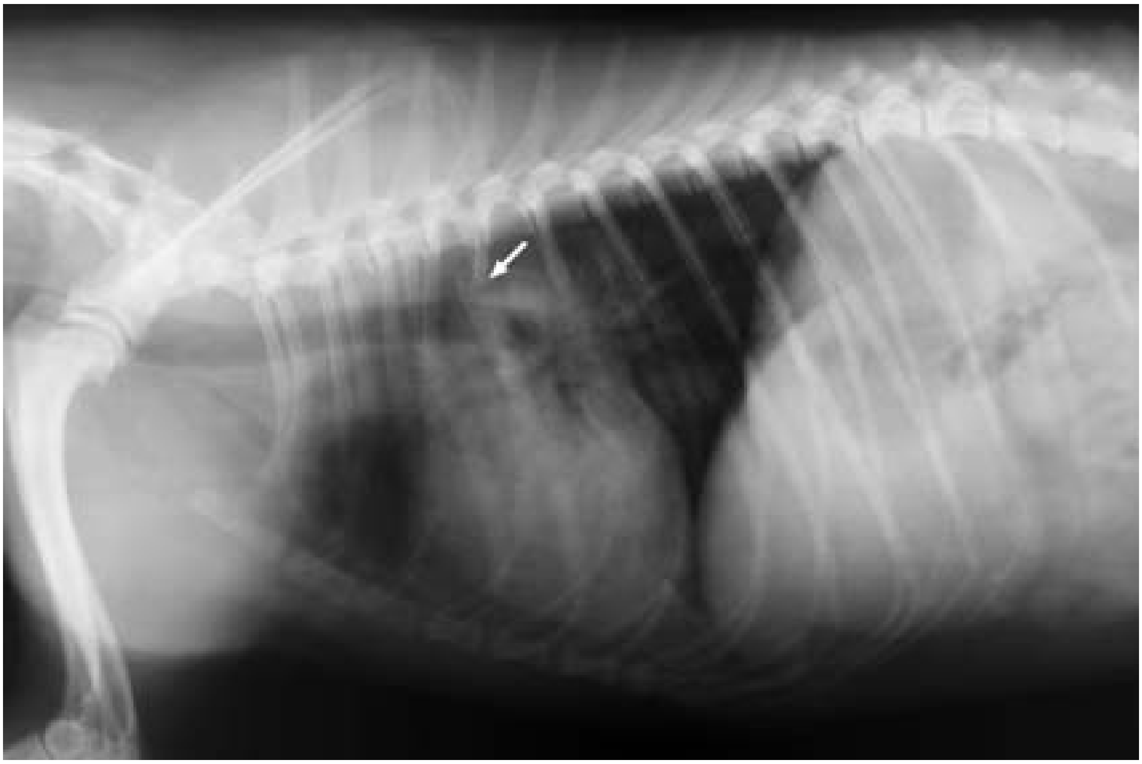
4.2.2 Radiographic features of axial skeleton injuries

The traumatized chest wall often has radiographic lesions revealing injury to the soft tissue and ribs (Table 4.10). Radiography defines and evaluates the extent of the underlying damage. Clinically, any injury of the chest wall results in a diminished efficiency in respiration and restricted expansion of the rib cage. The skeletal structures injured in the traumatized thorax include the vertebrae, ribs, costochondral junction, and sternebrae. Injury to the contents of the thoracic cavity is discussed fully in the section on thoracic injury (Chap. 2).

Table 4.10: Radiographic features of thoracic wall injury

1. Soft tissues
   a. swollen
   b. subcutaneous air (Case 4.81)
      I. pockets
      II. linear distribution
   c. debris on skin and within soft tissues
   d. soft tissues
      I. torn intercostal muscles
      II. injured skin and subcutaneous tissues
2. Ribs
   a. fractures
      I. undisplaced fragments (Case 4.81)
      II. malpositioned fragments
      III. multiple fragments ("flail chest") (Case 4.81)
   b. injury near the costovertebral joints (Case 4.82)
   c. injury near the costochondral joints (Case 4.74)
3. Sternal injury (Cases 4.82 & 4.83)

4.2.2.1 Disruption of the thoracic wall



Case 4.81

4

Signalment/History: "Dobie" was an 8-year-old, male mixed-breed Poodle who had been kicked by a horse several hours previously and was brought to the clinic because he was not breathing normally.

Physical examination: A depression type defect was noted in the left thoracic wall on palpation with a small break in the skin. The dog was open-mouth breathing and thoracic radiographs were ordered.

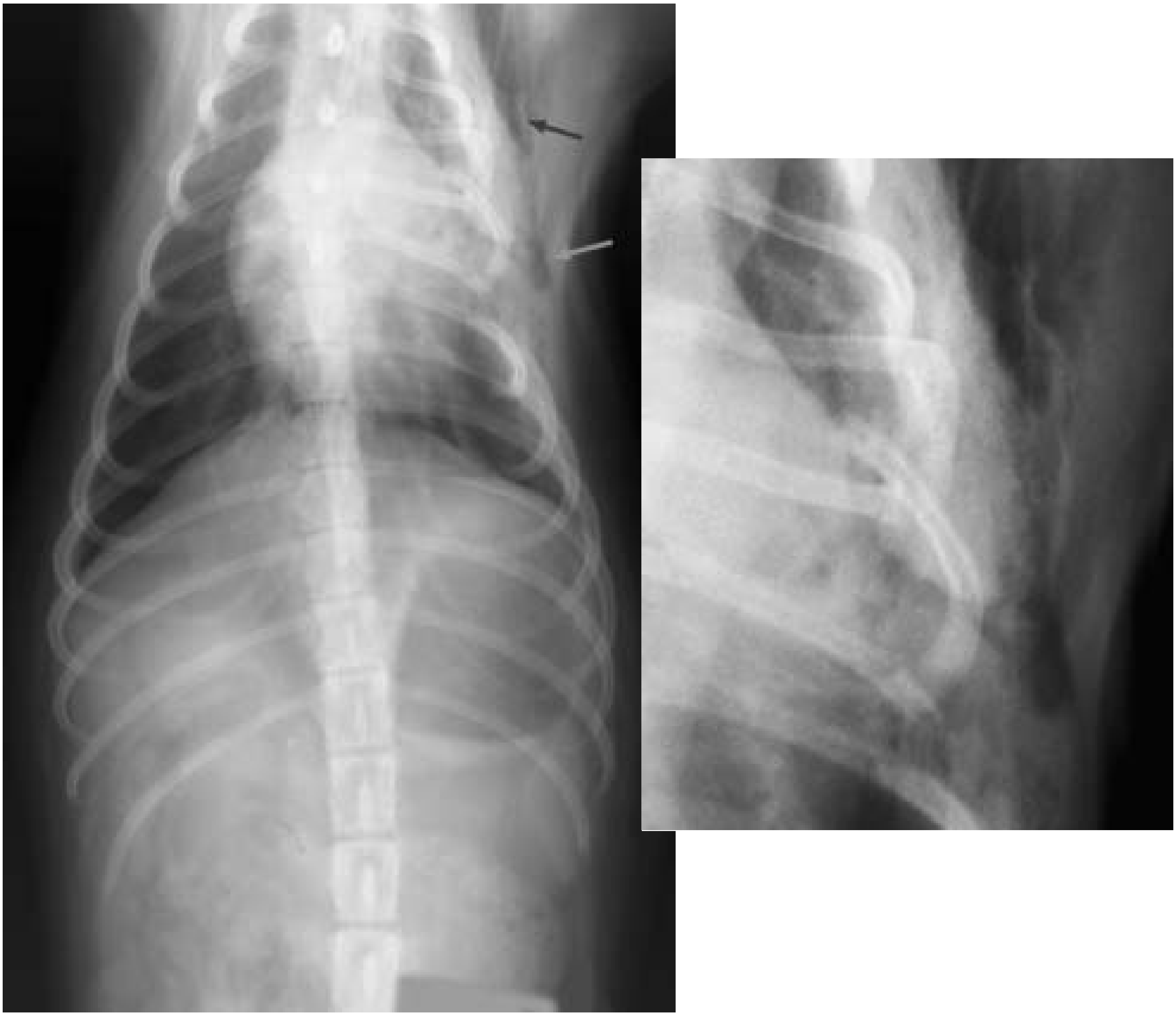
Radiographic procedure: Thoracic radiographs were made with as little distress to the patient as possible.

Radiographic Interpretation: Fractures of the left 4^{th}, 5^{th}, and 6^{th} ribs (white arrows) with free fragments caused a flail chest with collapse of the underlying left middle lung lobe. Subcutaneous emphysema was present on the left (black arrow). The only sign of pleural fluid was a thickening of the shadow of cardiophrenic ligament in the left hemithorax and suggested a possible hemothorax. The cardiac silhouette had shifted toward the left.

No evidence of pneumothorax was present and the mediastinum was of normal width. The right lung was normal in appearance. The diaphragm appeared intact.

Treatment/Management: "Dobie" was treated conservatively and discharged to the owner after three days.

Comments: Comparison of the two halves of the thoracic cavity on the DV or VD view provided useful information in diagnosis. The radiolucent lines on the right chest wall were due to fat and needed to be separated from the irregular radiolucent pattern due to the subcutaneous air on the left.



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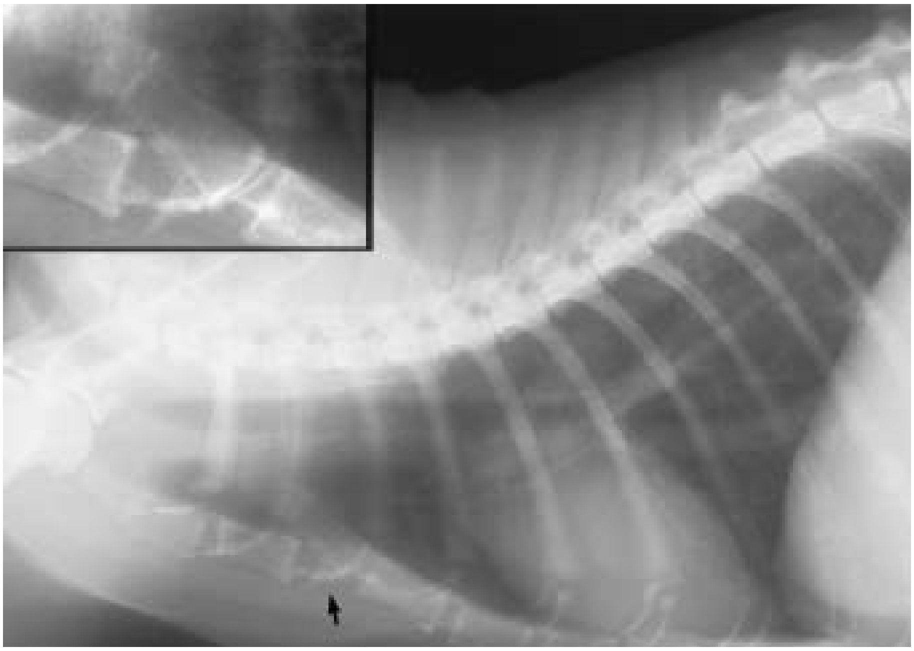


Case 4.82

Signalment/History: "Tom" was a mature male cat with a history of hemangiosarcoma, who was presented for examination for metastatic disease.

Radiographic procedure: Thoracic radiographs were made.

Radiographic diagnosis: The airway shadows were coarse with a pulmonary bulla positioned just cranial to the diaphragm on the right side. No metastatic nodules were noted.

A chronic sternal luxation had resulted in a displaced 3rd sternebrae, which had decreased bone density typical of disuse atrophy (arrow). Pleural thickening around the protruding bone was not evident.

Treatment/Management: No treatment was offered for the sternal lesion.

Comments: Often chronic traumatic lesions are noted as incidental findings. In this patient, repair had occurred and the luxation was stable. No signs of adjacent pleural or pulmonary lesions were present.

Case 4.83

Signalment/History: “Tom” was a 1-year-old, male cat with generalized muscle atrophy and weakness. The clinical history was non-contributory.

Physical examination: Palpation of the caudal ribs and sternum indicated a marked displacement of these structures.

Radiographic procedure: Routine thoracic radiographs were made because the palpable abnormality suggested the possibility of chronic trauma with rib fractures.

Radiographic diagnosis: The caudal portion of the sternum was deviated dorsally causing the cardiac silhouette to be shifted dorsally and to the left (arrows). The caudal sternebrae appeared fused and were deviated toward the right. The costal cartilages and ribs were severely deformed, but not fractured. The lung fields were of normal inflation and density.

Differential diagnosis: While an anomaly of this type could be post-traumatic, the sternebrae showed no signs of fracture or luxation, and the deformity of the ribs and costal arches appears much more to be a congenital anomaly.

Treatment/Management: “Tom” was tested positively for intestinal parasites and treated accordingly.

4

4.2.2.2 Head

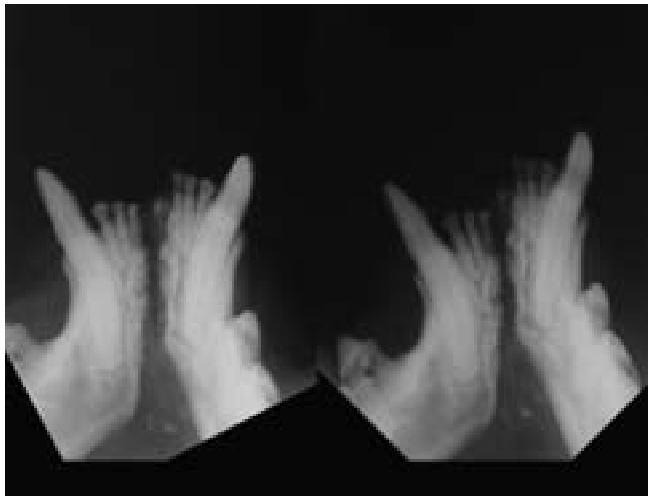
The head contains the skull, the brain, the mandible, the proximal portion of the respiratory system, the proximal portion of the digestive system including the teeth, and a part of the lymphatic system. Coverage of all of these parts is far beyond the scope of this presentation of trauma cases. The skull is the most complex and specialized part of the skeleton and is basically divided into a facial plus palatal region and a braincase. Both are indeed unique because of the variation in morphology that man has created in the various breeds of dog and cat. The determination of what constitutes normal is commonly the most difficult decision to make.

Most fractures involve the facial portion of the skull and the mandible (Table 4.11). These may be hit by many diverse types of moving objects, such as cars or bullets, and thus the nature of the injury can vary widely. Because of the lateral position of the zygomatic arches, they are often subjected to trauma. A fracture of mandible symphysis is common in the falling cat. If the trauma is sufficient to cause fractures in the braincase, death is often immediate.

Two different types of joints are present in the skull. The temporomandibular joint has clinical importance and its examination radiographically is of particular interest. Special positioning for the lateral views is possible, plus visualization on the DV or VD view. The other joint is the occipitoaxial joint. Occipital condyle dysplasia plus dysplasia of the foramen magnum is important in the smaller breeds of dog.

Table 4.11: Radiographic signs of trauma to the head

1. Fractures often affect
   a. zygomatic arches (Case 4.84)
   b. nasal, premaxillary, and maxillary bones
   c. frontal bones
   d. mandible
   e. mandibular symphysis (Case 4.84)
   f. temporomandibular joints (Case 4.84)
   g. teeth
2. Gunshot wounds
   a. affect bone
   b. affect nasal passages
   c. affect soft tissues in throat
3. Foreign bodies
   a. inhaled into nasal passages
   b. swallowed into oropharyngeal area



Case 4.84

Signalment/History: "Spot" was an adult, female cat who had been hit by a car several days previously. Following stabilization of the patient, she was referred for definitive radiographs.

Physical examination: A mandibular symphyseal separation was palpable. In addition, crepitus was noted upon careful palpation of the skull.

Radiographic procedure: Multiple radiographs of the head were possible because the cat was anesthetized.

Radiographic diagnosis: Multiple fractures were identified in the nasal, maxillary, and palatine bones, as well as in both zygomatic arches (arrows). Temporal bone fractures were near the mandibular fossa of the right temporomandibular joint. Separation of the mandibular symphysis was noted.

Treatment/Management: The only fracture treated was a stabilization of the mandibular symphysis.

Comments: A definitive radiographic study of the skull, especially of the cat, requires anesthesia, an experienced technician, and multiple views.

Case 4.85

Signalment/History: A 2-year-old, male Shih Tzu would not eat and appeared to have a "painful mouth".

Physical examination: Pain and crepitus were evident on palpation of the mandible.

Radiographic procedure: Multiple views were possible in this patient following anesthesia.

Radiographic diagnosis: A fracture of the mandible between the 3rd and 4th lower premolars of some duration as judged by the callus formation ventrally and medially. The fracture line entered the periodontal space of the 4th premolar (arrows).

Differential diagnosis: The gap at the fracture site as seen on the oblique view remained without any callus bridging indicating the possibility of a sequestrum and osteomyelitis.

Treatment/Management: The owner did not wish surgical treatment and the dog was discharged.

Comments: Note the malposition of the corner incisors.

4.2.2.3 Spine

The nature of the trauma may vary from the commonly seen patient struck by a car, to a patient who has run into a tree, to a small puppy with a congenitally weakened OAA region, who has been dropped from its owner's arms.

Because of the clinically important spinal cord, subarchnoid myelography, epidural myelography, stress radiography, and sectional radiography are of value in additional to routine non-contrast studies in completely understanding the various causes and severity of cord injury.

The nature of spinal fractures varies depending on the patient's age and the nature of the trauma. In the skeletally immature, fractures are often compressive because of the lack of strength in the vertebral body. In the older patient, the fracture often is of a transverse nature with the possibility of an associated luxation resulting in marked malalignment of the fragments. Other injuries result in separation of the dorsal arch with a type of decompressive trauma that may result in less injury to the spinal cord. Other fractures are subtler and affect only the dorsal elements especially the articular facets. Generally, the endplates are stronger than the trabecular bone and an injury may spare them. In other types of trauma, the fracture line passes through the endplate and the injury is a combination of fracture/luxation with involvement of the vertebral body including the endplate, the disc, and the dorsally located spinal joints. If the disc is injured and the lesion is more of a luxation, the only radiographic feature may be lateral, ventrodorsal, or rotational malalignment of the vertebral segments.

What of a trauma patient with no signs of vertebral fracture, but a protruding Type II disc seen on the myelogram. Traumatic disc herniation should be considered although it is not usual. The determination of a fracture fragment within the spinal canal on the non-contrast study is either difficult or virtually impossible to determine without CT studies (Table 4.12).

A trauma patient can have injury to both the thoracolumbar spine and the pelvis, although the prominent clinical signs caused by the pelvic injury prevent not only a thorough physical examination that might have shown a site of pain within the spine, but also a thorough neurological examination that might have shown an upper or lower motor neuron lesion in the pelvic limbs.

The concept of spinal radiography can be conveniently divided in to those done in the conscious patient and those done in an anesthetized patient. The severely injured patient should be carefully positioned on the table and lateral radiographs made of the entire spine in the form of a survey study. This has the purpose of detecting any major injuries only. This is important information so as to avoid the possibility of increasing the injury to the spinal cord by careless movement of the patient. Think of what happens to the spine when you "drape" the patient over your arms while carrying it to the examination table. The second type of study is made on the anesthetized patient in which stress radiographs plus VD and oblique radiographs can be made with the possibility of learning about segmental instability and/or malalignment. Contrast studies can be utilized in this second group of patients to determine more of the nature of the spinal cord injury by showing cord swelling from edema or hemorrhage, or show meningeal tearing.

In the event of a definite lesion seen on a noncontrast study, the determination of the magnitude of spinal cord injury can be more accurately made from the neurological examination. Be careful in assigning the level of injury to the spinal cord on the basis of the location of the fracture fragments or noting segmental malalignment on noncontrast studies. The extent of fragment or segmental displacement may have been excessive at the time of trauma causing extensive cord injury and yet the fragments or segments can then return to a near-normal position as seen on the noncontrast study. Use therefore the findings from the neurological examination to predict the extent of cord injury.

The spine can be subject to numerous congenital anomalies seen throughout the life of the patient. Degenerative changes, such as disc space collapse and the formation of spondylosis deformans can occur later in life. Visualization of these patterns on spinal radiographs can be rather obvious, however, determination of their role in a trauma patient can be difficult. The affect of trauma centered on a degenerated disc with spondylosis deformans and disc space collapse can be difficult to diagnose.

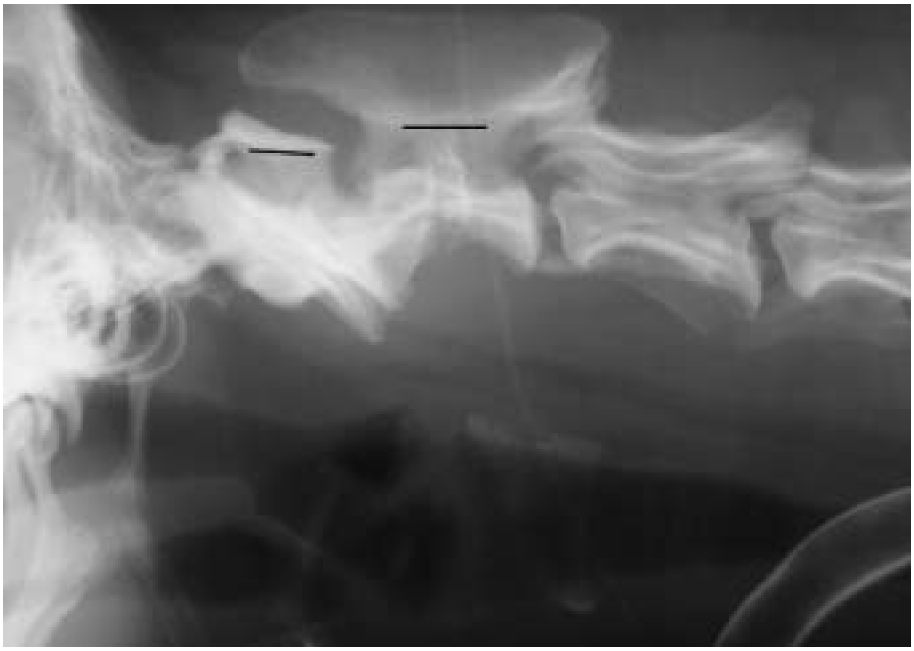
Table 4.12: Radiographic signs of spinal trauma

1. Pattern of fractures
   a. compressive fractures in immature animals
   b. simple fractures with or without malalignment
   c. comminuted fractures with or without malalignment
   d. fractures of the dorsal arch
   e. fracture/luxation
   f. fracture with herniated disc
2. Gunshot fracture
   a. B-B or airgun pellet lodged within the spinal canal
   b. shotgun pellets lodged within the spinal canal
   c. high energy bullet causing fracture
3. Fracture associated with congenital anomaly
   a. occipital condyles
   b. dens
   c. LS transitional segment

4

4

Cervical vertebrae



Case 4.86

Noncontrast

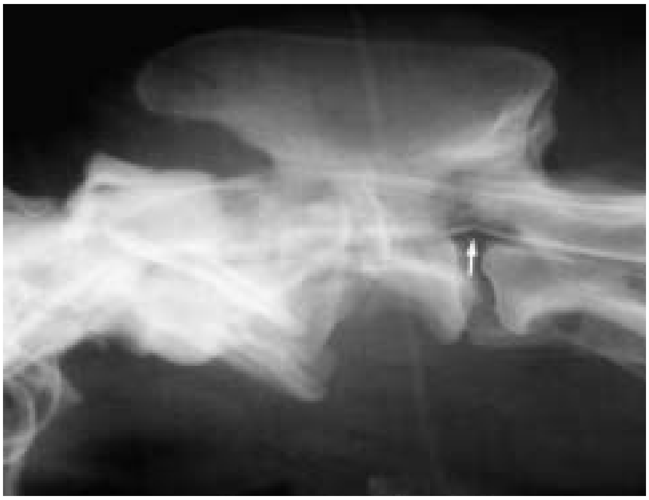
Signalment/History: "Arno" was a 2-year-old, male Giant Schnauzer who had been hit by a car one week previously. A paresis followed by quadriplegia developed during the ensuing week. A tracheostomy tube had been positioned because respiration was difficult.

Physical examination: A limited examination confirmed the possibility of a cervical fracture.

Radiographic procedure: Lateral radiographs were made of the entire spine with a single VD view of the cervical spine. Myelography was then performed to determine the prognosis and the course of treatment.

Radiographic diagnosis (noncontrast): A badly comminuted fracture of the body of C2 with rotation and angulation that caused extensive displacement of the fragments. The spinal canal appeared to be reduced in height. Malalignment of the roof of the canal was marked (black lines).

Note the tracheostomy tube.



Myelography

Radiographic diagnosis (myelography): The myelogram showed a badly distorted spinal cord; however, the extent of cord compression was minimal (arrows). Dural injury that would have permitted leakage of the contrast agent was not noted.

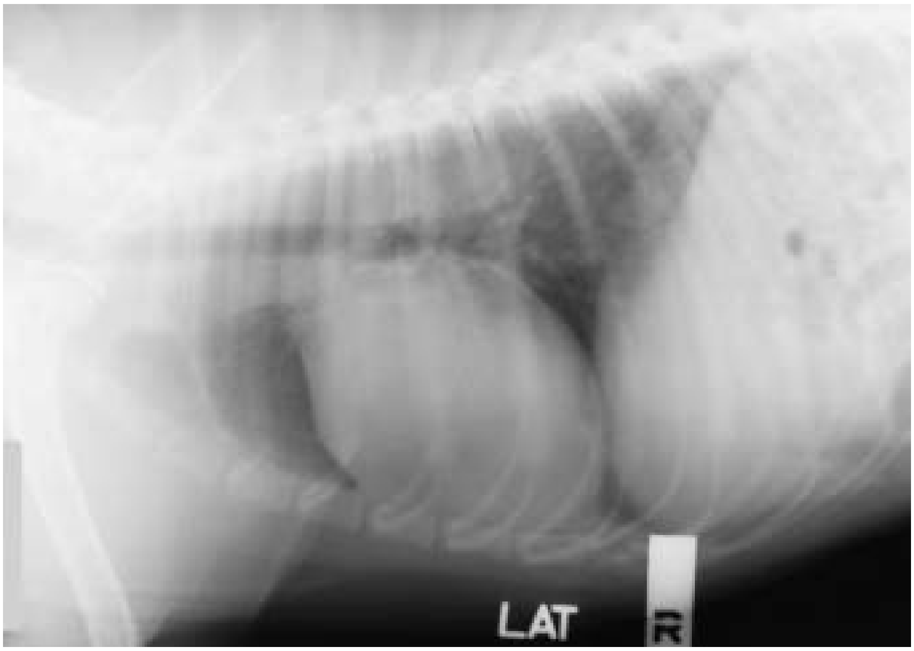
Treatment/Management: Loss of deep pain occurred soon after admission and the poor prognosis lead to euthanasia

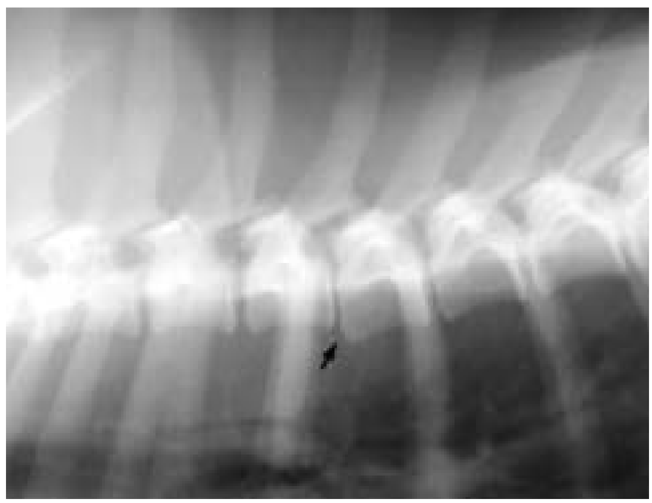
Comments: The use of myelography in cord trauma can provide useful information, but the manipulation of the patient during the examination may make its use questionable. "Arno" was thought to have a cervical fracture, and yet, the neck had not been placed in a protective brace during the week following trauma. The resulting motion of the bony fragments probably caused more cord injury.

4

Thoracic vertebrae

Case 4.87





Signalment/History: "Kila" was an 18-month-old, female Golden Retriever who had been hit by a car 24 hours earlier.

Physical examination: She could not walk when presented. She had superficial pain reflexes, a normal panniculus reflex, and normal patellar reflexes.

Radiographic procedure: Radiographs were made of the thorax with additional studies centered on the region of T5–6.

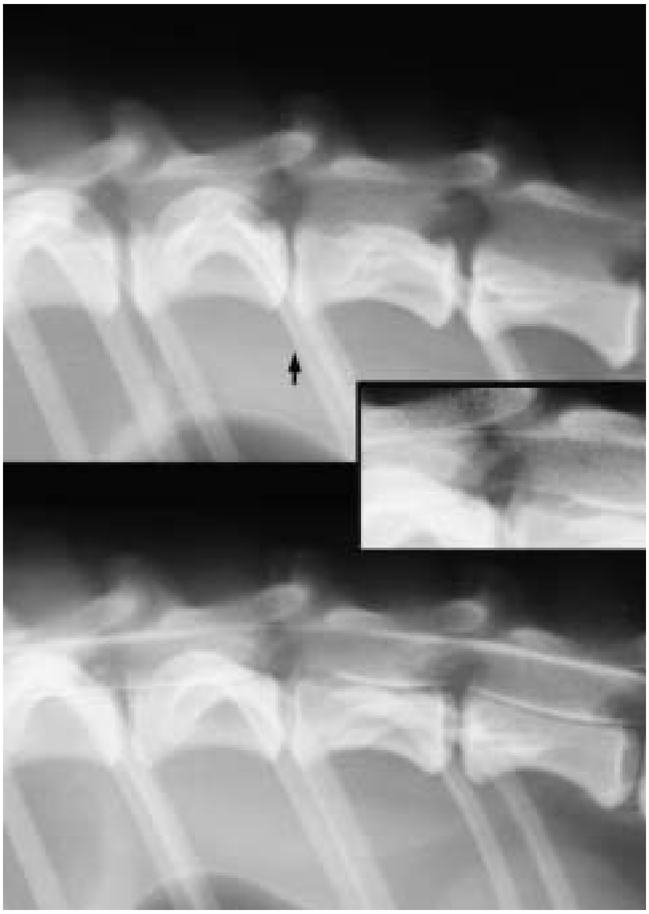
Radiographic diagnosis: A heavy pattern of alveolar fluid in the right lobes produced air-bronchogram patterns. The diaphragm was intact. No pleural fluid was noted. The chest wall was normal. The cranial mediastinum was thought to be widened.

A fracture-luxation of T5–6 was noted. The additional studies centered on this region showed a malalignment of the segments plus an increased width of the true vertebral joints (arrow).

Treatment/Management: Because of the minimal segmental displacement plus the persistent pain perception, "Kila's" fracture was approached with a positive prognosis. The location made placement of a vertebral plate difficult and conservative treatment was in the form of a body cast with the dog positioned beneath a "grate" in a cage that prevented movement. Later radiographs showed the affected vertebra to have remained in a stable position. The dog was discharged after four weeks in the clinic.

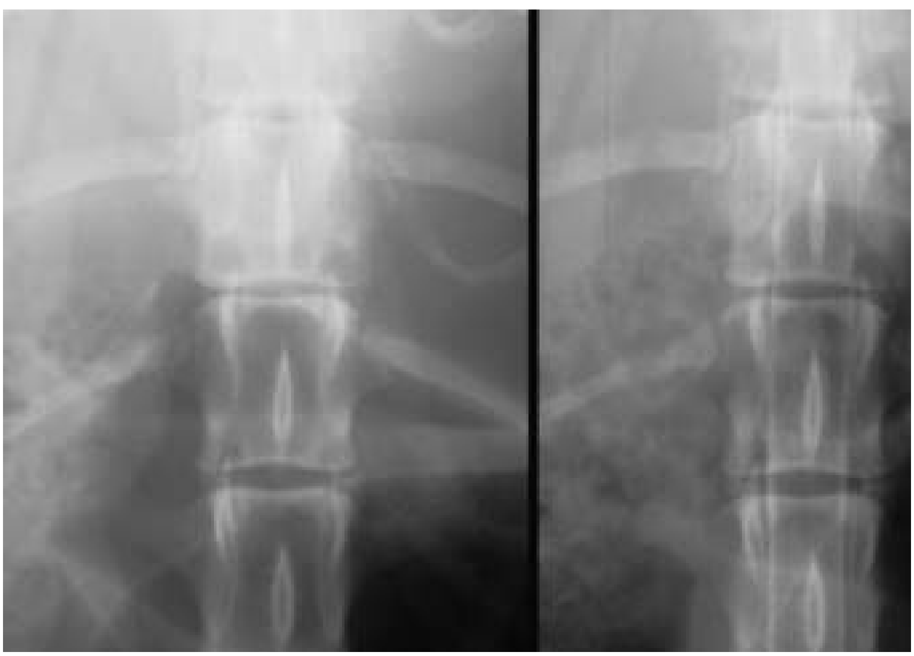
4

Case 4.88



Noncontrast

Myelogram



Noncontrast

Myelogram

Signalment/History: "Romeo" was a 3-year-old, male Toy Poodle with a history of having been struck by a car four days previously, resulting in an immediate pelvic limb paralysis.

Physical examination: Deep pain perception was present in both pelvic limbs. Patellar reflexes were hyperreflexic. The pannicular reflex was absent caudal to T11–12. Withdrawal reflexes in the pelvic limbs were normal.

Radiographic procedure: Spinal radiographs and myelography were made.

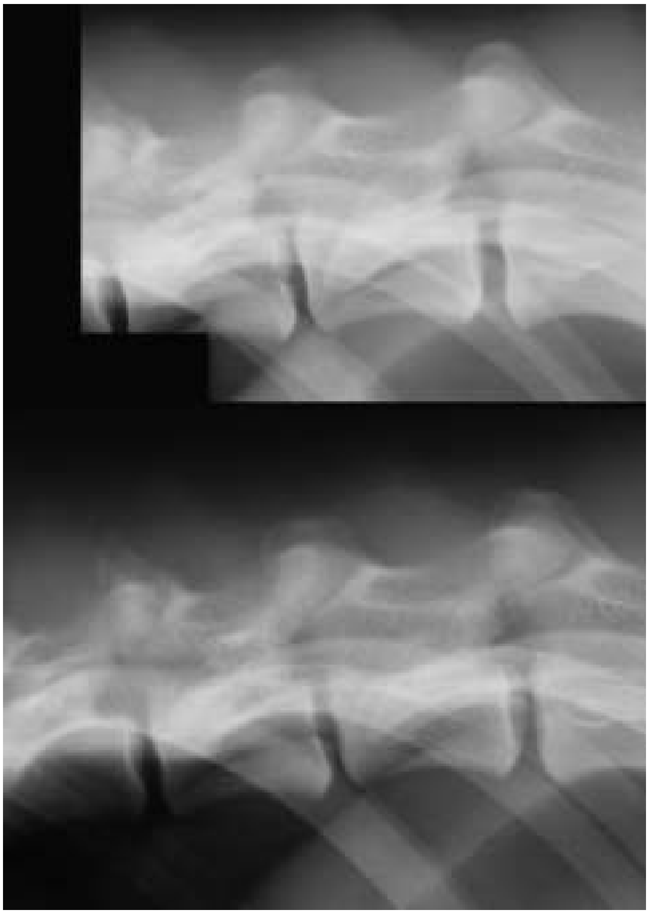
Radiographic diagnosis: On the noncontrast radiographs, the disc space at T12–13 was narrowed (arrow). The VD myelogram showed cord widening with narrowing of the subarachnoid columns. The lateral myelogram showed elevation of the narrowed ventral subarachnoid column at T12–13.

Differential diagnosis: The radiographic and myelographic findings were diagnostic of a fracture/luxation with an extradural lesion on the floor of the spinal canal at T12–13 that could be protruded disc tissue with or without extradural hemorrhage. The widened cord suggested minimal cord edema/hemorrhage as well. Changes of this type are due to the traumatic spontaneous acute disc protrusion plus the segmental malalignment at the time of the trauma.

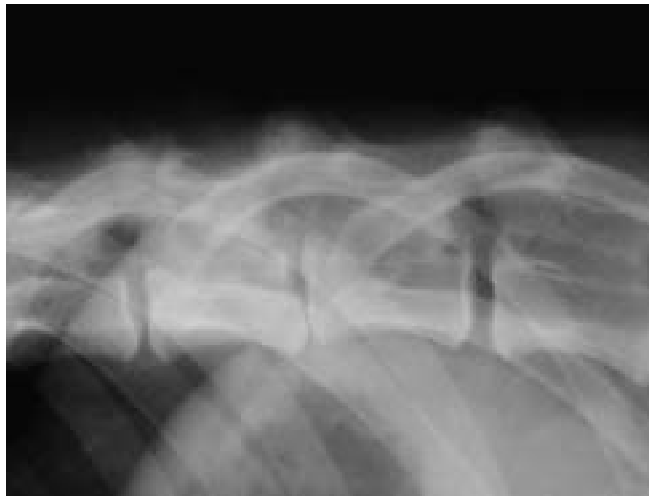
Treatment/Management: The owners chose not to treat the dog.

Comments: Without the clinical history of trauma, these radiographic and clinical findings could also be found in a patient with acute disc protrusion.

4



Day 1



Day 11

Case 4.89

Signalment/History: "Donner" was a 1-year-old, female German Shepherd cross with a history of running into a post and being unable to rise following the injury.

Physical examination: Because of the known trauma, spinal radiographs were ordered immediately.

Radiographic procedure: Spinal radiographs were made.

Radiographic diagnosis (day 1): A thin fracture line extended through the arch of T12 into the caudal end plate separating the arch and a part of the body from the larger fragment of T12. The fracture line extended craniodorsal to caudoventral. The larger fragment of T12 was displaced ventrally. The smaller fragment included the caudal articular facets. The disc space was narrowed.

Radiographic diagnosis (day 11): Radiographs made 11 days later showed a more complete collapse of the disc space with a slight ventral displacement of the body of T12.

Treatment/Management: The patient was kept under close control and the relatively nondisplaced fragments healed in a satisfactory manner with conservative treatment.

Case 4.90

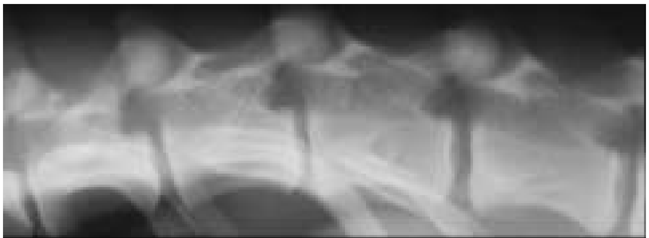
Signalment/History: A 1-year-old, male mixed-breed dog had been injured ten days earlier and had remained paraplegic since that time.

Physical examination: An abnormal malalignment at T12–13 was palpated. The neurologic examination indicated an upper motor neuron lesion in the pelvic limbs. Deep pain could be elicited.

Radiographic procedure: The study was centered at the thoracolumbar junction with great care being taken in positioning the dog for the VD view.

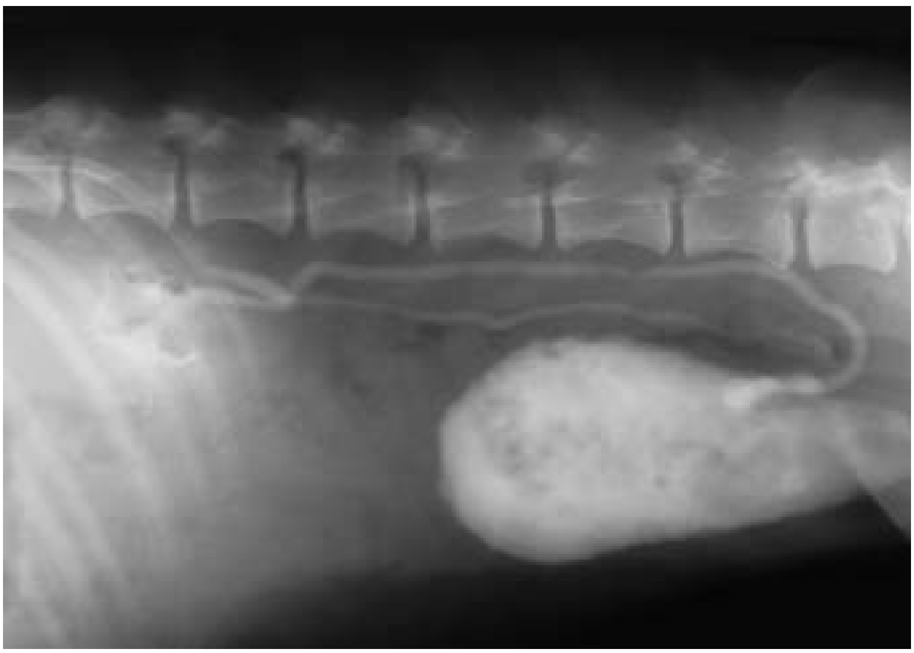
Radiographic diagnosis: The body of T12 was collapsed as seen on both views (large black arrow). The fragment representing the caudoventral portion of the T12 vertebral body was displaced to the left and ventrally. A luxation indicated destruction of the disc and permitted ventral displacement with lateral angulation of the caudal segments. The dorsal processes could be identified on the VD view (long thin arrows). On the lateral view, the vertebral malalignment was identified by noting the displacement of the roof of the spinal canal (long thin arrows).

Treatment/Management: The owner seemed only interested in determining the cause of the paraplegia and did not permit treatment.

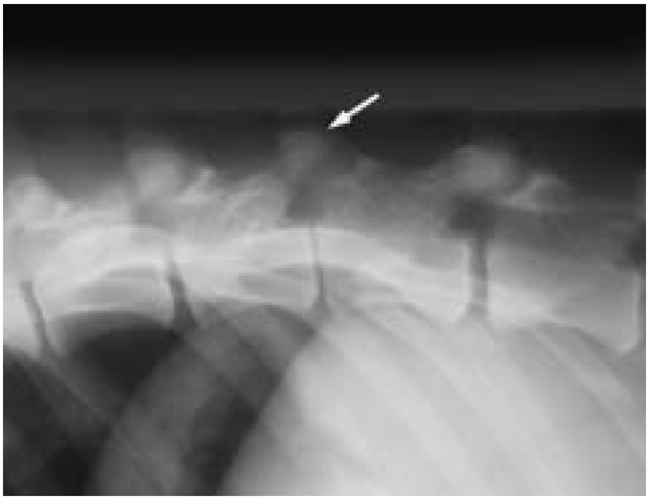


Noncontrast

Myelogram



Intravenous urogram



9 days later

Case 4.91

Signalment/History: "Tisza" was a 5-year-old, female Viszla who had been hit by a car 12 hours previously. She had been treated at an emergency clinic and diagnosed as having a T12–13 fracture.

Physical examination: Because a pneumothorax caused severe dyspnea, the examination was difficult to perform.

Radiographic procedure: A second series of spinal radiographs were made plus a myelographic study.

Radiographic diagnosis (noncontrast): Disc space narrowing at T12–13 with minimal ventral displacement of the body of T13 was noted.

Radiographic diagnosis (myelogram): This showed cord edema/hemorrhage extending the length of one vertebral segment. An extradural mass was not identified. The lesion was diagnosed as a fracture/luxation with traumatic disc collapse.

Treatment/Management: The vertebral fracture/luxation was decompressed and stabilized on the day of admission. The pneumothorax regressed almost immediately.

Nine days later the dog developed hematuria and radiographs taken at that time showed the T12–13 lesion to appear unchanged except for the expected post-surgical changes (white arrow); however, a distended urinary bladder was evident.

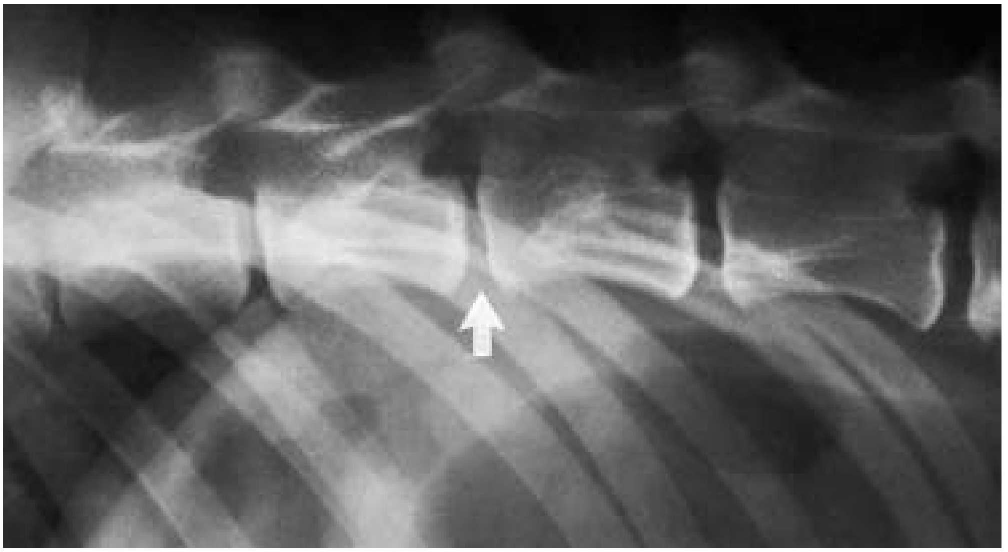
An intravenous urogram showed normal renal function with multiple filling defects in the bladder suggesting numerous blood clots. The bladder injury apparently resulted in delayed renal drainage and bilateral hydroureter was evident. The last radiographic study was made five months after the injury and showed that the fracture area had remained stable.

Comments: The absence of an extradural mass on the myelogram suggested that the herniating disc "exploded", with the disc material spreading along the spinal canal and traumatizing the cord. Another possibility, more likely in a 5-year-old, was that the disc had protruded laterally or ventrally and the cord injury was from being struck by the vertebral segments as they displaced.

4

4

Case 4.92



Noncontrast

Myelogram

Signalment/History: A 5-year-old, male German Shepherd was thought to have been hit by a car causing an sudden onset of pelvic limb paralysis.

Physical examination: Neurologic examination suggested an upper motor neuron lesion in the pelvic limbs. No malalignment of vertebral segments could be palpated.

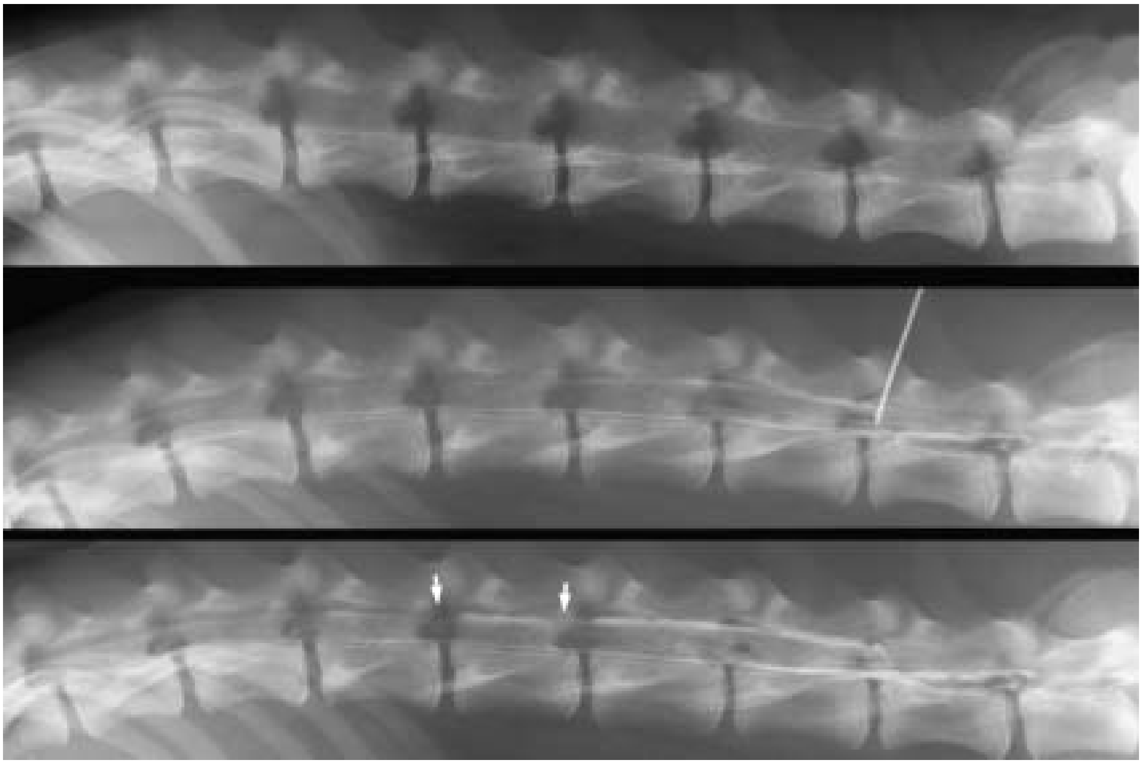
Radiographic procedure: Noncontrast spinal radiographs plus a myelogram were made.

Radiographic diagnosis: The collapse of the space at T12–13 was evident with an epidural mass on the floor of the canal was revealed by the myelogram (arrows).

Comments: In this patient, the nature of the trauma was not known and may have been something rather benign as could happen while playing in the garden or as the result of an automobile accident. The treatment for the epidural mass is the same regardless of the etiology of the disc protrusion and must include decompressive surgery.

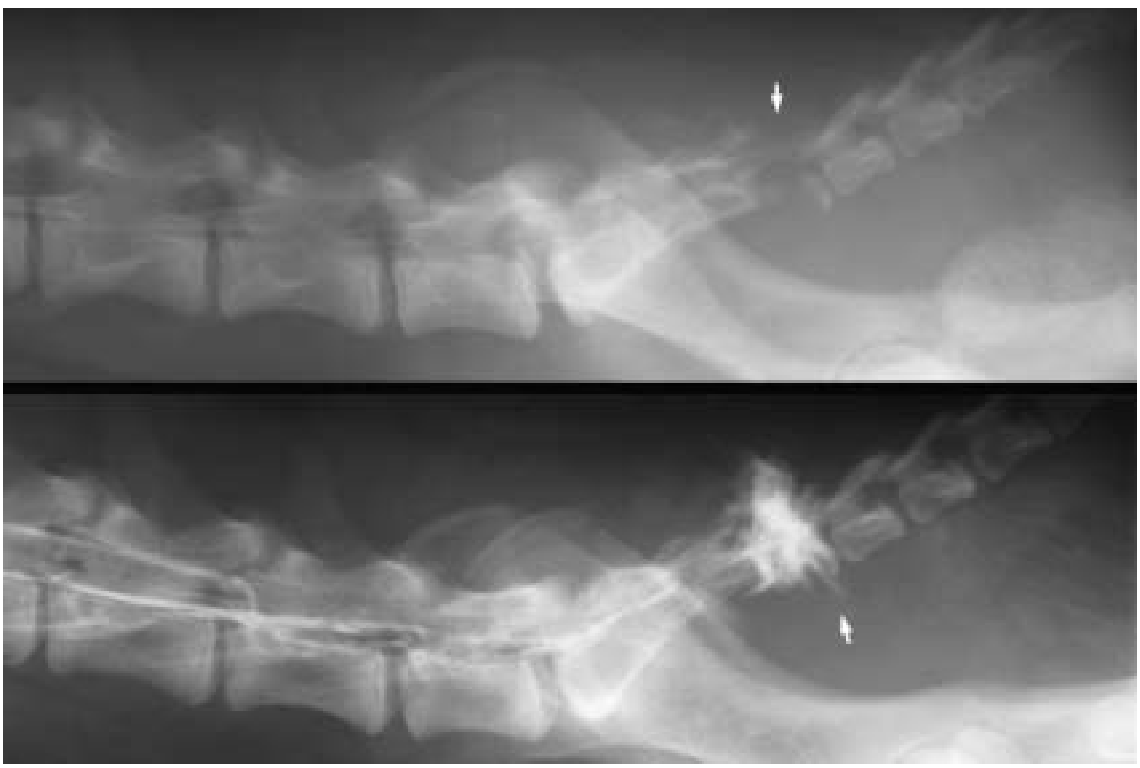
Lumbar vertebrae

Case 4.93



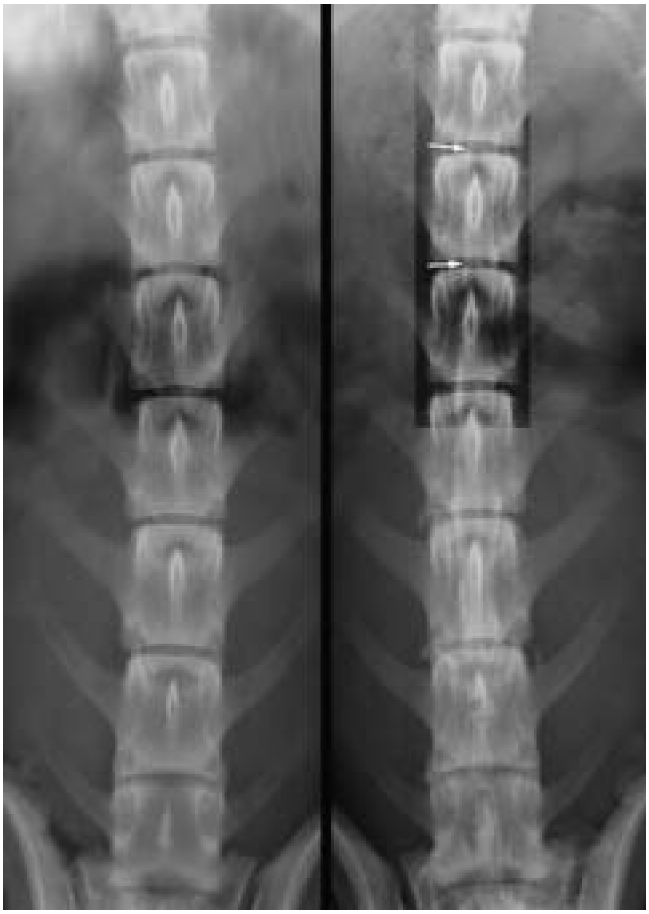
Noncontrast

Myelogram



Noncontrast

Myelogram



Noncontrast Myelogram

Signalment/History: "Sandy" was a one-year-old female Viszla who had been struck by a car several hours earlier. She had continued walking and then "went down".

Physical examination: The dog showed a Schiff-Sherrington sign in the forelimbs and had reduced pain perception in the pelvic limbs. She had no voluntary movement in her pelvic limbs, but she had normal reflexes in them. The tail was flaccid and she had a weak anal sphincter reflex. The reflexes in the forelimbs were normal.

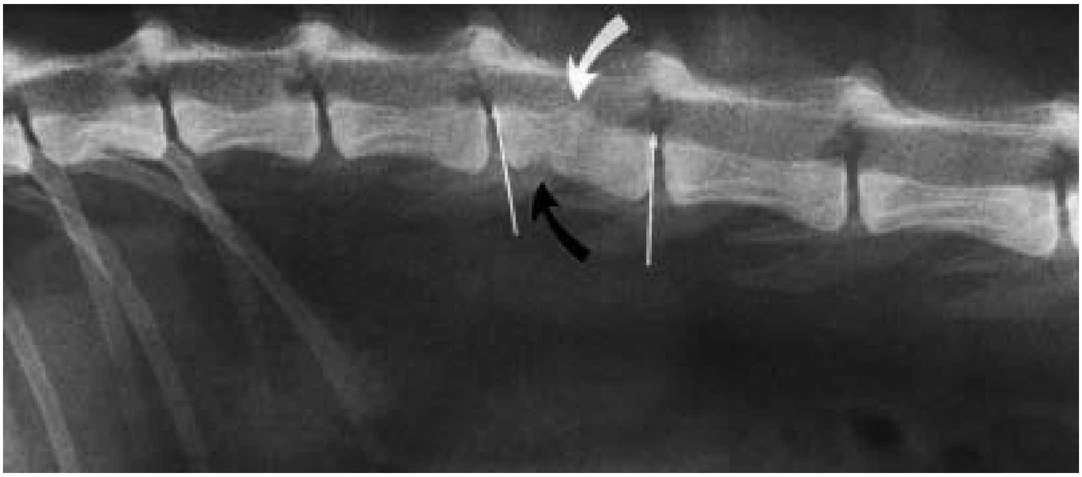
Radiographic procedure: The radiographs needed to include the region of the spine where a lesion would result not only in a cauda equina syndrome but also would cause an upper motor neuron lesion in the pelvic limbs. This included the spine caudal to T2. Myelography was performed.

Radiographic diagnosis (noncontrast): A fracture of the sacrum with avulsion of the caudal fragment and a soft tissue mass ventral to the injury were present (arrow); the latter probably representing a hemorrhage. The remainder of the spine was thought to be normal on the noncontrast studies.

Radiographic diagnosis (myelogram): Tearing of the meninges had resulted in a leakage of contrast agent at the site of the sacral fracture indicating a severe injury (arrow). The subarachnoid contrast columns showed narrowing from T12 to L3 with an associated narrowing of the spinal cord and a shift toward the left (arrows).

Differential diagnosis: The thoracolumbar epidural mass was most likely hemorrhage because of its continuing presence over five vertebral segments. No narrowing of a disc space or a focal mass that would indicate the presence of a localized disc protrusion was evident. Infectious or neoplastic lesions were not considered in a patient of this age and with this clinical history.

Treatment/Management: "Sandy" was treated conservatively without improvement and was euthanized following a lack in improvement in her neurologic status. The body was taken without permission for a necropsy.



Case 4.94

Signalment/History: This young female cat had been found by the roadside two weeks previously, but had just been brought in for examination.

Physical examination: The cat had caudal limb paralysis. Urinary incontinence was evident.

Radiographic procedure: Noncontrast radiographs were made of the thoracolumbar spine.

Radiographic diagnosis: A compression fracture involved the body of L3 and was identified by an inward folding of the ventral cortex (black arrows). A dense shadow was identified on the floor of the spinal canal and was thought to be a part of the trabeculae displaced by the fracture (white arrow). The distended urinary bladder was evident (arrows).

Differential diagnosis: A compression fracture always suggests a pathologic fracture, therefore the patient's diet and blood chemistry should be examined.

Case 4.95

Signalment/History: "Cisco" was a 2-year-old, male Irish Setter who had been in an automobile accident 12 hours previously.

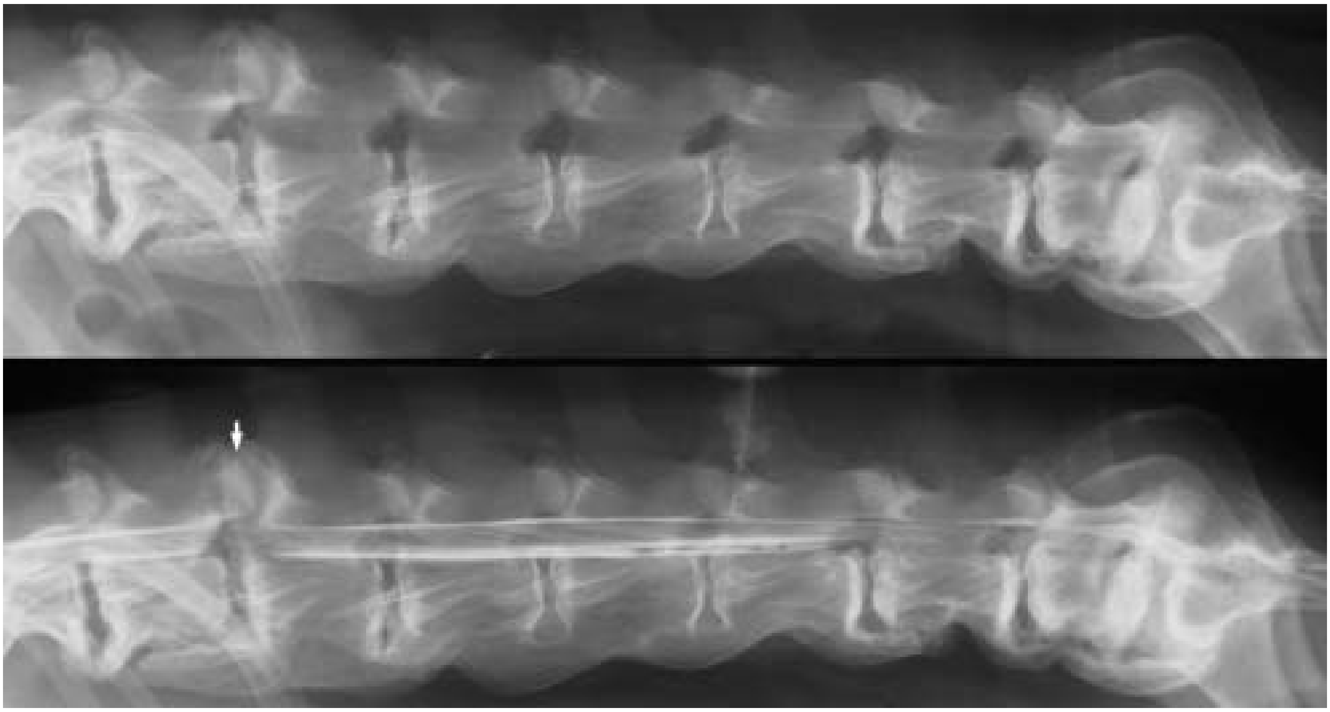
Physical examination: The dog was unsteady on his pelvic limbs when walking and was painful as evidenced by his trying to bite during the palpation of his pelvis.

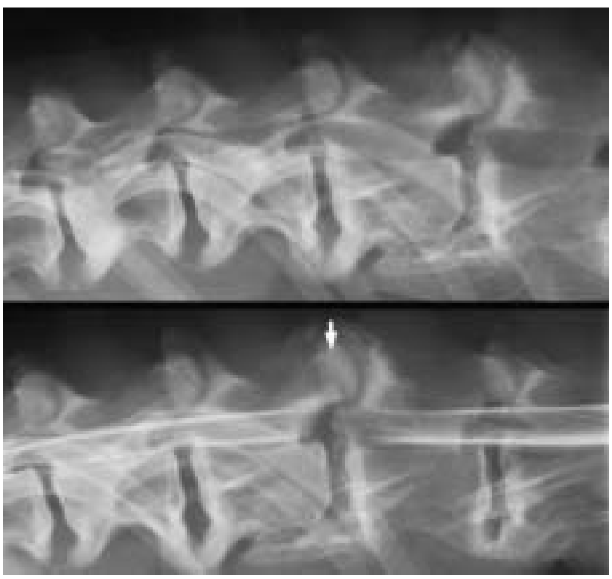
Radiographic procedure: Radiographs were made of the pelvis.

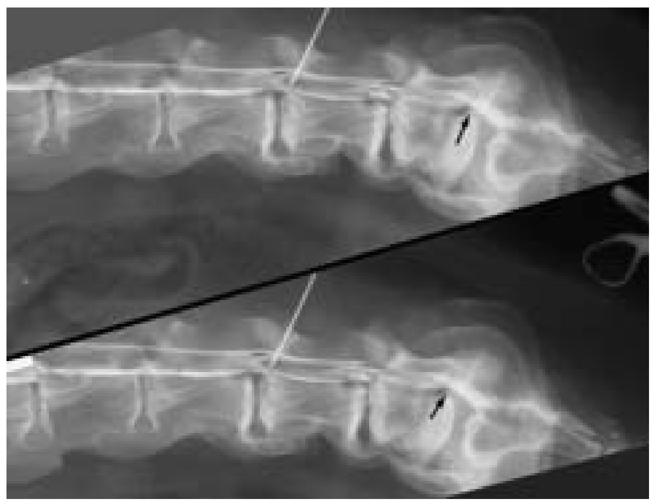
Radiographic diagnosis: Ventral displacement of a caudal sacral fragment was noted plus a left sacroiliac fracture/luxation (arrows). Spondylosis deformans was noted at L4–5 and L6–7. The lumbosacral junction and the hips were normal. The dense shadow superimposed over the left sacro-iliac junction was fecal material.

Treatment/Management: Detection of the sacroiliac injury explained why "Cisco" was so painful, and why he delayed using his pelvic limbs during the recovery period.

Note the use of the less painful, flexed position of the pelvic limbs for radiography. The radiolucent shadows seen dorsal to the right acetabulum on the lateral view represent gas within the rectum.







Case 4.96

Signalment/History: "Duchess" was a 6-year-old, female German Shepherd cross, who had collapsed 12 days previously and had been treated with steroids resulting in a slight improvement. Subsequently, she had another event of pelvic limb paresis and was referred for radiographic examination of the spine.

Physical examination: Because of her history, she was scheduled immediately for spinal radiographs.

Radiographic procedure: Both noncontrast and contrast studies were made.

Radiographic diagnosis: Severe spondylosis deformans in the lumbar region with segmental fusion resulted in a hypermobility of the adjacent discs (domino effect). All the studies showed a misalignment at L1–2, while the myelogram showed a short cord segment with edema/hemorrhage (white arrows).

A second site of potential cord injury at the LS disc showed both malalignment and dorsal disc protrusion (black arrows).

Differential diagnosis: The role of trauma in this patient was difficult to assess. The immobility of the lumbar segments apparently placed excessive stress on the adjacent discs so that minimal trauma could have resulted in the cord injury.

Treatment/Management: Decompressive surgery was performed. Because of the unexpectedly soft nature of the disc material taken from L1–2, surgical biopsy was utilized to confirm the presence of degenerated intervertebral disc material. Histological examination of the material suggested a more acute disc protrusion as would be associated with trauma.

"Duchess" was discharged with some improvement, but not totally recovered.

Comments: Spondylosis deformans of this extent with solid bridging extending over multiple segments is referred to as Disseminated Idiopathic Skeletal Hyperostosis (DISH) and often results in patients with a clinical picture such as seen in "Duchess".

4

4

Case 4.97

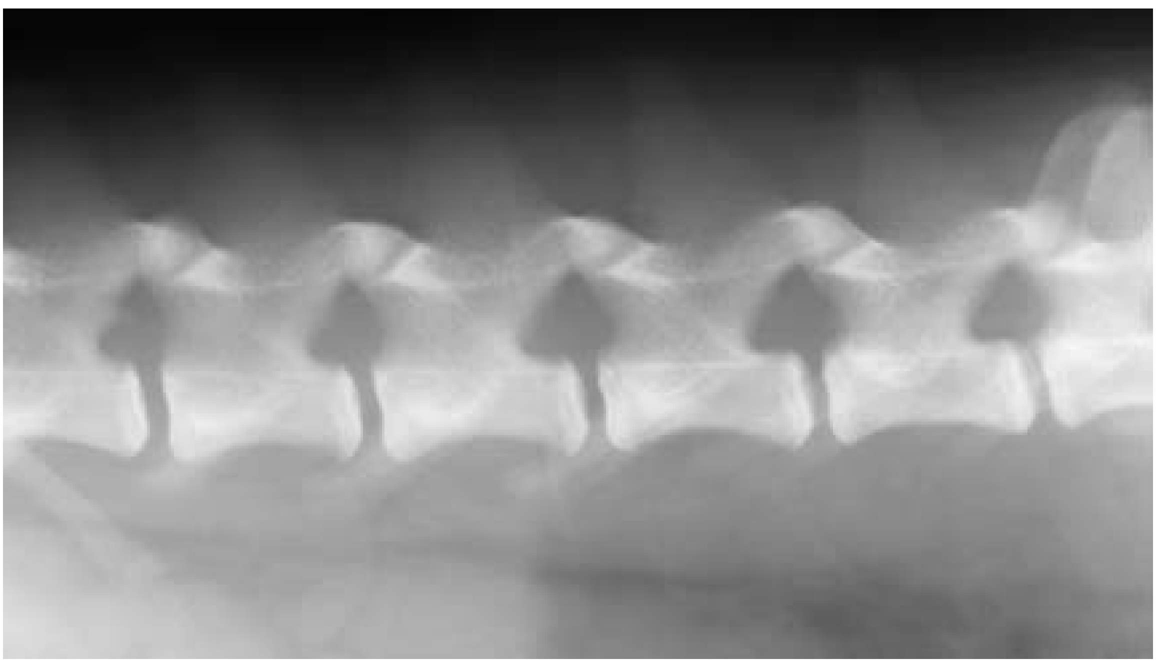
Signalment/History: "Nebraska" was an 8-month-old, female Chow Chow who had been run over by her owner's truck three days earlier. The left femur was fractured and had been treated surgically. After the surgery, the dog lost use of her right pelvic limb and had no reflexes or cutaneous sensation in that limb. However, the deep pain reflex was still present. The dog was referred with a suspected lumbosacral injury following treatment of the fracture.

Physical examination: Examination was difficult because of the injuries and the post-surgical status. Radiographs were made with the intention of performing a myelogram.

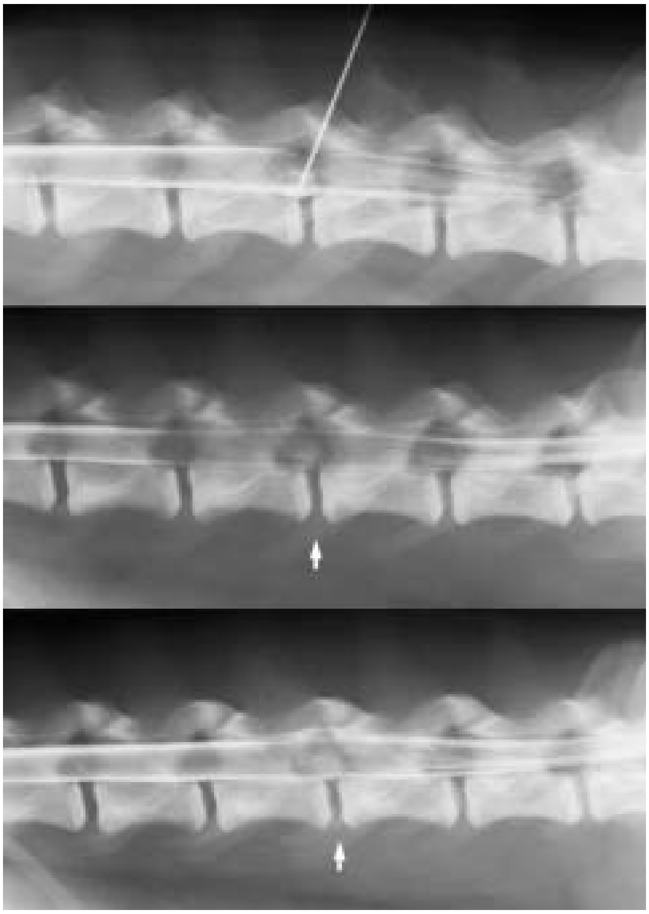
Radiographic diagnosis (femur): A single lateral view of the femur showed the reduction of a comminuted midshaft fracture by a single IM pin with two cerclage wires positioned at the fracture site. The proximal fragment was "bayoneted" into the distal fragment.

Radiographic diagnosis (lumbar spine): A single lateral view of the lumbar spine was selected from the complete spinal study. No evidence of abnormality was noted.

Femur



Lumbar spine



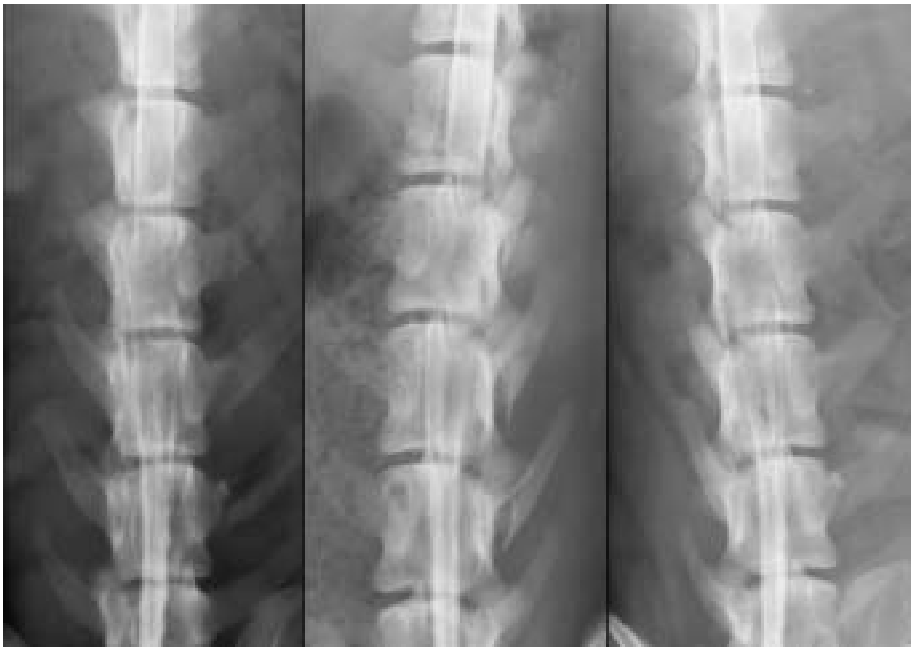
Radiographic diagnosis (myelogram): The first lateral view showed the spinal needle in position at L4–5 immediately after the trial injection. Extradural pooling of the contrast was noted around the needle tip along with a filling defect within the dorsal subarachnoid column. The defects in filling seen around the needle site were not fully appreciated and the remainder of the contrast agent was injected.

The next film showed thinning of both the dorsal and ventral subarachnoid columns with continued leakage of contrast agent into the extradural space. The last lateral film was made after the subarachnoid pressure had decreased and showed more contrast agent in the subarachnoid columns over L4–5 (arrows). A continued leakage into the extradural spaces was also evident. The VD and oblique views showed the same radiographic pattern with collapse of both subarachnoid columns and leakage into the extradural space on the left.

Treatment/Management: With the history of trauma and the neurological signs of a lower motor neuron lesion, the diagnosis of spinal hemorrhage or contusion with dural tearing was considered. Examination of the CSF showed an excess of cells indicating hemorrhage. On the basis of the suspected spinal cord injury, "Nebraska" was euthanized.

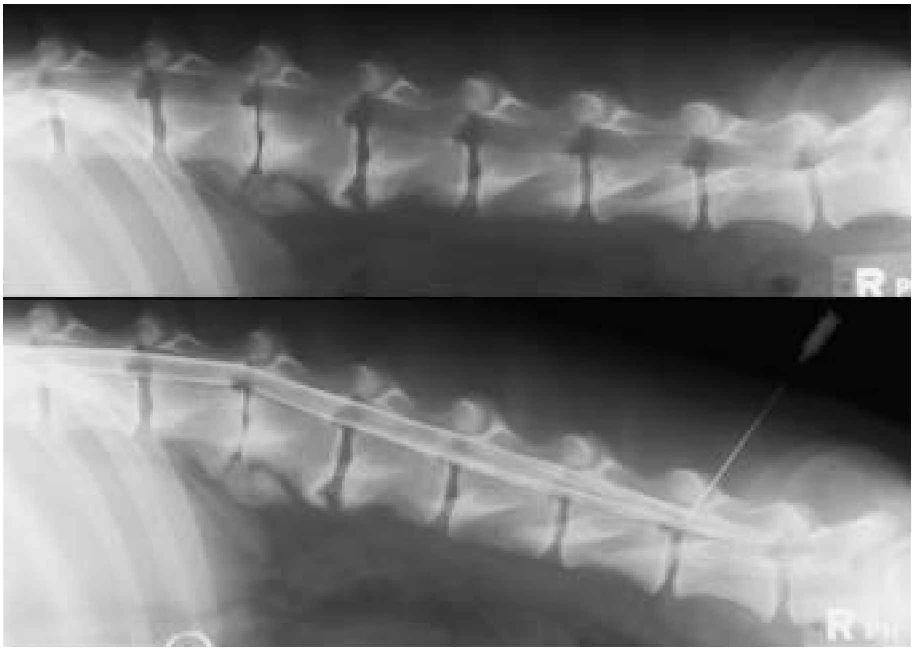
Outcome: Necropsy finding showed severe myelomalacia from L3–L6 secondary to trauma, with secondary severe Wallerian degeneration from T12–L8. The ventral spinal artery was thrombosed. All the lesions were more severe on the right.

Comments: Intramedullary swelling with narrowing of the subarachnoid columns were the primary features. The changes were noted at the site of the lumbar intumescence, which was also the site of the needle placement; both of which compromised interpretation of the myelogram.



Myelogram

Case 4.98



Noncontrast

Myelogram

Noncontrast Myelogram

Signalment/History: "Sundance" was a 5-year-old, male Doberman Pinscher with a sudden onset of caudal paresis thought to have been induced by trauma.

Physical examination: The neurological examination showed upper motor neuron signs in the pelvic limbs with crepitus palpated in the upper lumbar spine.

Radiographic procedure: Noncontrast spinal radiographs were made, followed by myelography.

Radiographic diagnosis (noncontrast): Collapse of the L1–2 disc space was present with some sclerosis of the end-plates and a large bony osteophyte ventrally. On the VD view, the collapse at L1–2 was associated with a lateral displacement of L2 to the right with some rotation to the left (arrows).

Spondylosis deformans was prominent at L3–4; however, that disc space appeared to be of normal width.

Hypoplasia of the ribs could be seen in the last thoracic segment. This is a form of transitional vertebral segment.

Radiographic diagnosis (myelogram): The elevation and slight shifting toward the left side of the spinal cord, and the mild narrowing of the subarachnoid columns were diagnostic of an extradural mass on the floor of the canal just over the disc space with minimal injury to the spinal cord (arrows). The diagnosis was a traumatic protrusion of the degenerating disc at L1–2.

Differential diagnosis: Malalignment of vertebral segments is an important radiographic feature. In the absence of such a malalignment, the radiographic features seen in this case were those frequently seen with chronic disc degeneration. The identification of the malalignment is more supportive of a change following trauma. Myelography was necessary to confirm that the trauma had played a role in the malalignment of the L1–2 segments.

Treatment/Management: Because of the minimal size of the extradural mass, "Sundance" was treated conservatively with strict cage rest. He recovered and was discharged after several weeks in the clinic.

Comments: A point of potential error in this patient was in the description of the location of the trauma. The presence of the hypoplastic ribs on the last thoracic segment made for a difficult determination of where the first lumbar segment was actually located.

4.2.2.4 Malunion fractures

Malunion is the joining together of fracture fragments that results in an abnormal bone organ, which is unacceptable to the patient and/or the owner because of: (1) bone shortening due to fragment over-riding, (2) angulation of the distal fragment, (3) rotation of the distal fragment, or (4) osteosynthesis between adjacent bones. The pattern of fracture healing is normal and a histological examination of the bridging callus or the resulting remodeled bone is normal. Only the gross bone organ is abnormal and the manner in which the limb functions is often unacceptable (Table 4.13).

Table 4.13: Radiographic signs of malunion fractures

1. Pattern of malunion
   a. overriding fragments with shortening of the bone
   b. fragment malalignment
      I. cranial or caudal angulation
      II. lateral or medial angulation
      III. rotational malalignment
   c. osteosynthesis with adjacent bone formation
   d. secondary to osteomyelitis
2. Secondary to gunshot fracture
3. Malunion resulting from fracture causing physeal growth anomaly
   a. delayed growth
   b. partial closure with angulation
   c. complete closure with shortening

Any fracture can heal as a malunion. The interpretation is based only on the bone having a morphology, in the eyes of the observer, other than that seen normally. The degree of abnormality can be extensive or minimal, and an evaluation must be made to determine its clinical importance. For example, minimal over-riding of fragments in the midshaft of the femur without rotation or angulation causes bone shortening that can be compensated for easily. However, if the same fracture heals with rotation, the stability of the hip joint may be affected and the femoral head may subluxate due to the resulting anteversion of the femoral head and neck, or the limb is used in an internal rotation position with resulting injury to the stifle joint. Any fracture that is articular and heals with malunion will result in secondary arthrosis and will be clinically important.

Physeal fractures that cause unequal growth, delayed growth, or premature closure can also be considered malunion. They are, however, treated separately in this book (Chap. 4.2.2.6).

Case 4.99

Signalment/History: "Skooter" was an 8-month-old, male Brittany with a history of having been struck by a car two months earlier. He had been limping on the right pelvic limb since that time.

Physical examination: Pain was elicited on palpation of the right hip joint. Muscle atrophy was marked. The hip palpated as though the femoral head was luxated.

Radiographic procedure: A VD radiograph of the pelvis was made in addition to a lateral view of the femur.

Radiographic diagnosis: A chronic malunion fracture of the right acetabulum was present, characterized by a marked medial displacement of the bony fragments causing a narrowing of the pelvic canal. The size and shape of the femoral head were preserved but the head fitted poorly into the malformed acetabulum. Radiographic signs of the secondary post-traumatic arthrosis were not as prominent as might have been expected.

Treatment/Management: No treatment was considered. The owner was advised of the possible continuing problems associated with progressive arthrosis and the problems associated with normal defecation that might result from the pelvic narrowing.

Comments: The fracture line had entered the acetabulum in such a manner that the important weight-bearing portion of the acetabular roof (cranial and dorsal) remained uninjured. The femoral head, therefore, was able to continue to articulate with the rather large and important portion of the articular surface that remained uninjured.

Early radiographs

Day of presentation

Case 4.100

Signalment/History: "Skipper" was a mature Cocker Spaniel with a history of forelimb injury seven years previously. The owners did not have an accurate memory of the nature of the injury, but thought that he had fractured his radius and ulna and some type of surgical repair had been utilized. They had brought "Skipper" to the clinic because they could feel something in his "skin" and because he had become slightly lame on this limb.

Physical examination: The patient was sensitive to deep palpation and a firm mass could be palpated cranially just distal to the elbow joint. Motion of the antebrachiocarpal joint and rotation of the foot was limited. The use of the limb was also limited and the dog seemed to use it hesitantly.

Early radiographs: The original radiographs were obtained from another clinic and revealed the original premature closure of the distal ulna and the surgical repair.

Radiographic procedure: Two views of the forelimb were made on the day of presentation to evaluate the soft tissue mass.

Radiographic diagnosis: Osteosynthesis between the radius and proximal ulnar fragment was identified with an intramedullary pin remaining partially within the distal radius. The proximal tip of the pin extended through the cortex into the soft tissue by a distance of 1 cm. The alignment of the radial fragments was near anatomical.

Treatment/Management: The treatment recommended was only symptomatic because of the chronicity of the arthrosis, the limited nature of the lameness, and the older age of the dog. However, the owner was "unhappy" with the protruding pin and asked for its removal. This was done without incidence and "Skipper" was discharged a happy dog, although there was little improvement in his gait.

Differential diagnosis: Any bone or joint disease could have caused the signs evident in this dog. The role of the IM pin was suspect even though there were no clinical or radiographic signs of associated infection. Secondary joint disease in the antebrachiocarpal joint was high on the list because of the history of earlier trauma and because of the dog's age. As the Cocker Spaniel is not a breed which is highly susceptible to malignant bone or joint disease, and does not regularly have osteochondrosis/osteochondritis dissecans, these diagnoses were positioned lower on the differential list. Any soft tissue

24 months later

lesion could have been a cause of the lameness. An inflammatory lesion could have been considered although no history of a bite wound or draining tract was offered.

Second presentation

Signalment/History: "Skipper" was presented 24 months later with a more acute lameness and a large swelling on the distal antebrachial region that was obvious to the owner and was thought to have formed within the previous two weeks.

Physical examination: A firm mass was palpated on the distal limb with the majority of the mass lying cranial and lateral. Pain was elicited on firm palpation. Movement of the distal joints was limited partially because of the mass, partially because of chronic arthrosis, and partially because of pain.

Differential diagnosis: The suddenly presenting mass was suggestive of a malignant process and this was first on the list of differential diagnoses. The absence of any history of recent trauma tended to exclude a fracture/luxation or an infection following an injury.

Radiographic procedure: Two views were made of the distal limb centering on the mass.

Radiographic diagnosis: A highly productive bony lesion originated from the distal radius, where a radiolucent center approximately 1–2 cm in diameter was located. The periosteal new bone was rather well formed and had a sharp border. The new bone effectively covered the distal tip of the ulna making any determination of the degree of involvement of that bone by the lesion difficult. The soft tissue mass extended around the new bone. Involvement of the radial carpal bone was possible, although the new bone created a cuff that extended distally, covering the carpus, and preventing the exact determination of progression distally. It almost appeared that the bony lesion "grew" along the new bone that formed the osteosynthesis between the radius and ulna. The zone of transition between the lesion and normal bone was indistinct and rather long.

The diagnosis reached was that of a primary bone tumor, probably osteosarcoma, following malignant transformation at an old fracture site.

Treatment/Management: Because of the older age of the dog and the presence of a suspect malignant process, "Skipper" was euthanized.

The necropsy finding was that of an osteosarcoma. No spread of the malignancy was noted in the lungs.

Comments: Malignant transformation following a fracture often follows an incorrectly utilized metallic implant or a chronic, concurrent inflammatory process. In this patient, the fracture treatment appeared satisfactory and without any history of a persistent inflammatory process, with the exception of the protruding tip of the IM pin proximally. It is also possible that the primary bone tumor occurred unrelated to the earlier fracture or surgery. However, this breed has a low frequency of primary bone tumor making a malignant transformation at the surgical site more likely.

Case 4.101

Signalment/History: "Smokey" was the name given to a young male cat who had been brought to the clinic as a "stray". He was lame, but the nature of any trauma was unknown.

Physical examination: The left hip joint palpated abnormally and a fracture was evident in the left distal tibia with severe soft tissue swelling.

Radiographic procedure: Radiographs were made of the distal limb.

Radiographic diagnosis: The distal tibial fracture was badly comminuted with rather large butterfly fragments. A single fracture of the fibula was present. The fragments were impacted and the soft tissue injury was thought to be severe.

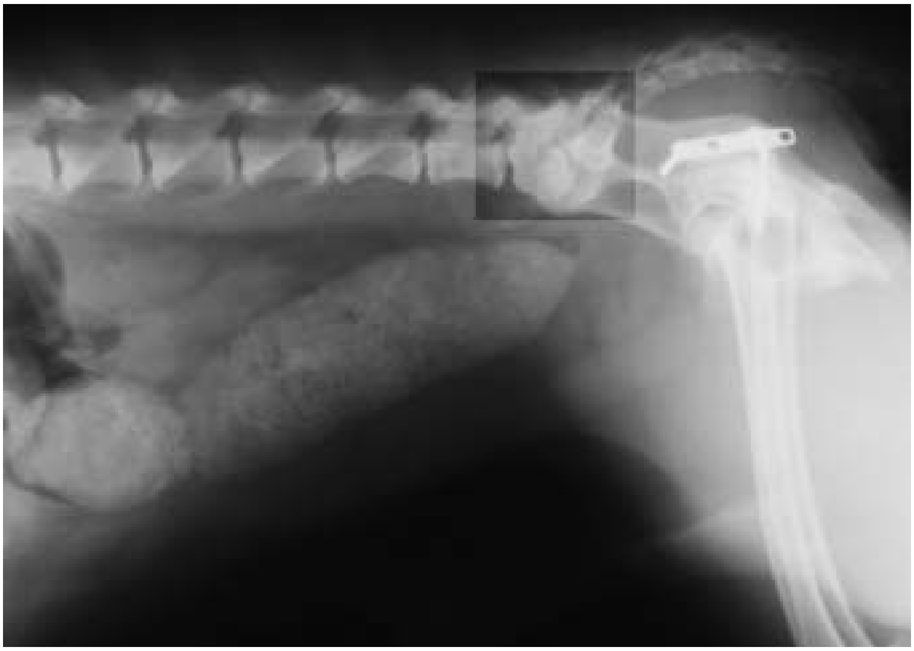
Joint disease at the antebrachiocarpal and intercarpal joints was characterized by subchondral bone cysts and periosteal new bone especially on the accessory carpal bone. Cranial rotation of the distal radial fragment had altered the plane of the articular surfaces of that joint contributing to the secondary arthrosis.

The elbow joint was radiographically normal. The soft tissues were thought to be unremarkable

Differential diagnosis: The cause of the trauma was unknown, if it were due to a bite wound, the possibility of secondary infection would have been considered likely.

Treatment/Management: The tibial fracture was treated with a full Kirschner apparatus (Type II splintage). Healing of the tibial fracture was delayed and a cancellous graft was added after two months.

Radiographs made at three months showed the Kirschner apparatus to still be in place. A small strip of bone joined the two major tibial fragments (white arrows). Another pointed "peak" of new bone extended from the distal fragment, but had failed to meet the proximal fragment (black arrows). The fibula had healed with a rather strong appearing union. Both stifle and tarsal joints were still normal in appearance. The tibial malunion was weak and resulted in the problem of deciding how to stage the removal of the external apparatus to permit further strengthening of the healing callus without overstressing it and causing a pathologic fracture.



Case 4.102

Signalment/History: "Yamo" was a 4-year-old, male German Shepherd mixed breed with a history of lower bowel obstruction. He had been straining to defecate over the previous three days.

Physical examination: The dog was depressed and appeared to be uncomfortable. A large firm tubular mass was palpated in the abdomen.

Radiographic procedure: Abdominal studies were made including the pelvic region.

Radiographic diagnosis: A distended colon with an apparent constriction cranial to the pelvis was filled with inspisated fecal material. A soft tissue mass was positioned between the pelvic rim and the distended colon, and probably represented the prostate gland. The urinary bladder could not be identified.

The badly deformed left hemipelvis resulted in at least a 50% occlusion of the pelvic inlet. The left femoral head was seated within the malformed acetabulum. A small surgical plate was positioned on the acetabular margin. The small pin in the greater trochanter probably indicated the site of a trochanteric osteotomy. The malformed body of L7 and the heavy spondylosis deformans suggested a malunion fracture in this region.

Treatment/Management: Multiple enemas were administered and resulted in two small "onions" being retrieved in addition to the hard fecal material.

Comments: Later, the owner offered the history that "Yamo" had been struck by a car as a puppy and had had a surgically corrected pelvic fracture. They had not been informed of the LS fracture.

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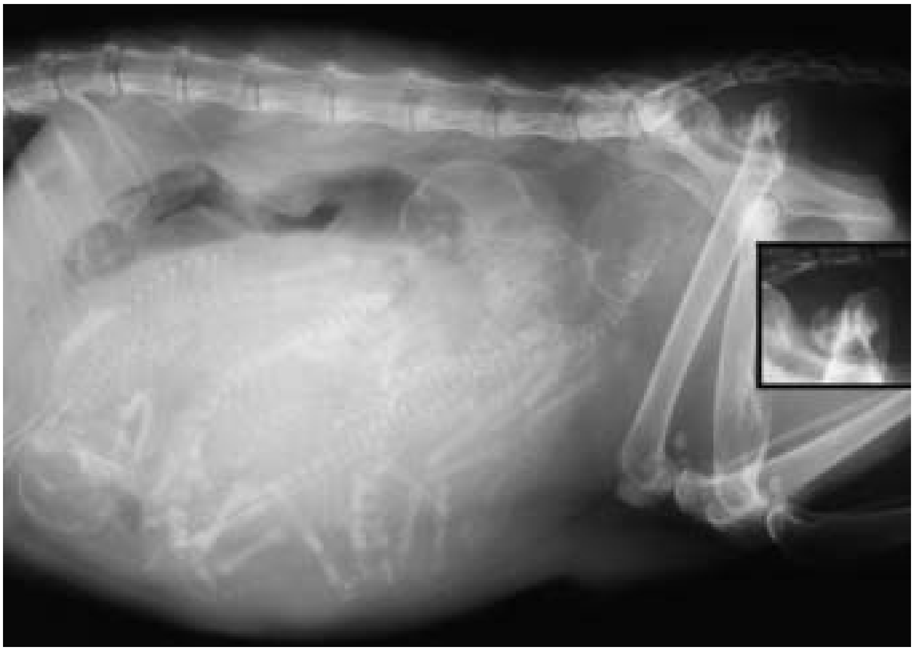

Case 4.103

Signalment/History: "Rose" was a 1-year-old, female kitten who had been found by the owner three weeks previously. She had been brought to the clinic because the owners thought she was pregnant and in labor. No kittens had been born.

Physical examination: Palpation of the abdomen suggested a gravid uterus and the cat was straining as though in labor.

Radiographic procedure: Radiographs were made of the abdomen and pelvis.

Radiographic diagnosis: Abdominal radiographs showed the gravid uterus with four fully developed fetal skeletons. No abnormal gas accumulation was associated with the skeletons and there was no collapse of the skeletal structures suggesting that the feti were dead.

Malunion fractures of the left ilium and ischium had resulted in the destruction of the acetabulum and a narrowing of the pelvic inlet. A chronic subcapital non-union epiphyseal fracture had lead to a dorsal luxation of the left femoral head. The right femur had a malunion fracture distally resulting in shortening of the bone. The right femoral head was normal and was seated within the acetabulum.

Treatment/Management: The kittens were removed by cesarean section some days after the radiographic examination and were all dead. The surgical incision became infected and because she had been a stray, the owners elected not to continue treatment but to have the cat euthanized. At necropsy, the vaginal stump of the uterus was infected along with the suture line.

Comments: The determination of fetal death on a radiographic study is only accurate after fluid absorption has resulted in collapse of the skeletal structures or if gas accumulation has occurred within the fetus. Ultrasound examination is the technique of choice in evaluation of fetal viability.

On presentation

Case 4.104

Signalment/History: A mature female German Shepherd was found and brought to the clinic because of an obvious mechanical lameness in the left pelvic limb.

Physical examination: Shortening of the limb plus the detection of a large firm mass around the midshaft of the femur suggested a healing fracture or a malunion fracture. The lesion was not painful tending to rule out an infectious or malignant lesion.

Radiographic procedure: Radiographs were made of the pelvis and both femurs.

Radiographic diagnosis: On the left, there was a chronic, comminuted, oblique midshaft femoral fracture in a healing phase, with marked separation and over-riding of the fragments. A massive exuberant callus had started to bridge between the two bones. The stifle joint appeared normal; however, the proximal fragment had assumed an anteversion position and caused a partial luxation of the femoral head (arrow). The fracture had the appearance of being more than one month old. Soft tissue atrophy around the affected limb was prominent.

2 months later

Treatment/Management: The dog was treated conservatively. Radiographs made two months later showed healing of the fracture with apposition and alignment of the fragments remaining unchanged. Note the femoral head appeared to be seated deeply, the result of the limb being in partial abduction.

Comments: Often it is important to determine the age of an injury to assist in the determination of treatment. In this dog, the fracture callus and modeling of the fragments suggested a stage of healing that would have made it nearly impossible to attempt a repositioning of the fracture fragments. The possibility of injury to tendon, ligament, or nerve was described to the owner in an explanation of the problems that the dog might have in walking. Note the transitional lumbosacral segment, which is a common congenital anomaly in this breed. It is more accurate to measure the length of the femur on the lateral view, because it is parallel to the tabletop, than on the VD view in which position the femur may be at an angle to the surface.

Case 4.105

Signalment/History: "Gray Ling Cry" was an adult male cat with a history of a slight lameness in the left pelvic limb. The owners wanted to know more about the injury and its clinical importance.

Physical examination: The cat could walk on the affected limb suggesting a mechanical lameness rather than a lameness due to pain. A comparison of the length of the pelvic limbs indicated that the shortening of the left limb was indicative of a dorsocranial coxofemoral luxation. Movement of that limb produced marked crepitus. Soft tissue atrophy was slight.

Radiographic procedure: Radiographs were made of the pelvis and hip joints.

Radiographic diagnosis: While the lateral radiograph of the pelvis was relatively normal in appearance, the VD view showed an extensive pseudoarthrosis of the left coxofemoral joint. The new acetabular roof extending from the ilium was very prominent. The acetabulum was shallow with the appearance that the dorsocranial acetabular margin had fractured free. The femoral head and neck were severely deformed suggesting that the capital epiphysis had fractured free and had subsequently undergone a malunion healing to the femoral neck. The free bony fragment adjacent to the bony spur attached to the right ilium was probably an avulsion from the greater trochanter. The right hip joint was normal.

Outcome: The owners chose not to consider a femoral head and neck ostectomy that was offered as a way to diminish the lameness and pain.

Comments: The exact explanation of the nature of the original trauma was an academic exercise that played only a minor role in either the clinical condition of the patient at the time of presentation in this case or the expected prognosis. The lesion is definitely post-traumatic with formation of a pseudoarthrosis following injury to the left hip joint.

Case 4.106

Signalment/History: "Rhonda" was a 2-year-old, female German Shepherd undergoing routine radiographs of the pelvis to determine the status of her hip joints. She had no history of injury or lameness.

Radiographic procedure: Routine VD studies were made of the pelvis for a hip dysplasia study.

Radiographic diagnosis: Both hip joints were radiographically normal with the femoral heads well formed and seated deeply in well-formed acetabula. A bony lesion involved the ischiatic tuberosity of the right ischium was characterized by a loss of the normal trabecular pattern, a displaced cortical segment, and an area of increased bone density.

Differential diagnosis: The dog was young and had no history of trauma. The diagnosis of a malunion/non-union fracture was considered first as a bone tumor or an osteomyelitis would have been associated with more reactive bone and would be more painful. Also, this lesion had a smooth border which suggested a chronic benign process.

Treatment/Management: Palpation of the tuberosity failed to produce any pain or discomfort and the lesion was not treated.

Comments: The discovery of what is assumed to be a chronic traumatic event is rather common in skeletal radiography. Often the finding is of no clinical importance, but in some patients it explains chronic lameness or may suggest the possibility of future clinical importance.

Case 4.107

Signalment/History: "Freta" was a 5-year-old, female German Shepherd mixed breed who was presented with muscle atrophy in the left pelvic limb.

Physical examination: The left limb lameness was more mechanical than painful. The stifle joint was enlarged but was non-painful and firm on palpation. The right tibia was thickened and deformed with a valgus deformity and slight caudal angulation.

Radiographic procedures: Studies were made of the pelvis and right pelvic limb.

Radiographic diagnosis (pelvis): A malunion left acetabular fracture, malunion pelvic fractures of the left ischium and ilium, and a post-traumatic fusion following a luxated right sacroiliac joint were noted. The severity of the post-traumatic arthrosis in the left hip joint was difficult to determine. The subluxation of the right femoral head could have been secondary to hip dysplasia or influenced by the malposition of the pelvis following the trauma. Generalized muscle atrophy was more pronounced on the right.

Radiographic diagnosis (tibia): A malunion fracture in the midshaft of the right tibia had resulted in a nonanatomic restoration with caudal and lateral angulation of the distal tibia resulting in a valgus deformity. Osteosynthesis of tibia and fibula had occurred. The persistent cavitary pattern (arrows) at the site of malunion suggested a chronic bone infection, whose state of activity could not be determined on the radiographs.

The post-traumatic joint disease in the stifle and tibiotarsal joints was important clinically.

Comments: What was rather confusing on physical examination became apparent through the radiographic studies. The biggest question as to the continued use of the left limb was the degree of severity of the arthrosis in the left hip joint and what was the resulting limitation of movement of the pelvic limb. The contour of the femoral head appeared near normal suggesting that a femoral head or neck fracture was not a part of the injury. The question of why the muscle atrophy was more prominent on the right was answered by evaluation of the radiographs of the right tibia. The nature of that malunion fracture was influenced by the presence of chronic osteomyelitis. The original radiographs did not clearly show the severity of the joint injuries, which were possibly a major cause of the dog's inability to use its limbs normally at the time of examination. A lateral malleolar fracture was suggested as well.

This was a difficult case, since the original injuries involved the left hip joint, the right stifle joint, and the right tibiotarsal joint. The joint injuries had a greater clinical importance at presentation than the malunion pelvic and tibial fractures. Superimposed on these injuries was the suspected chronic bone infection in the tibia.

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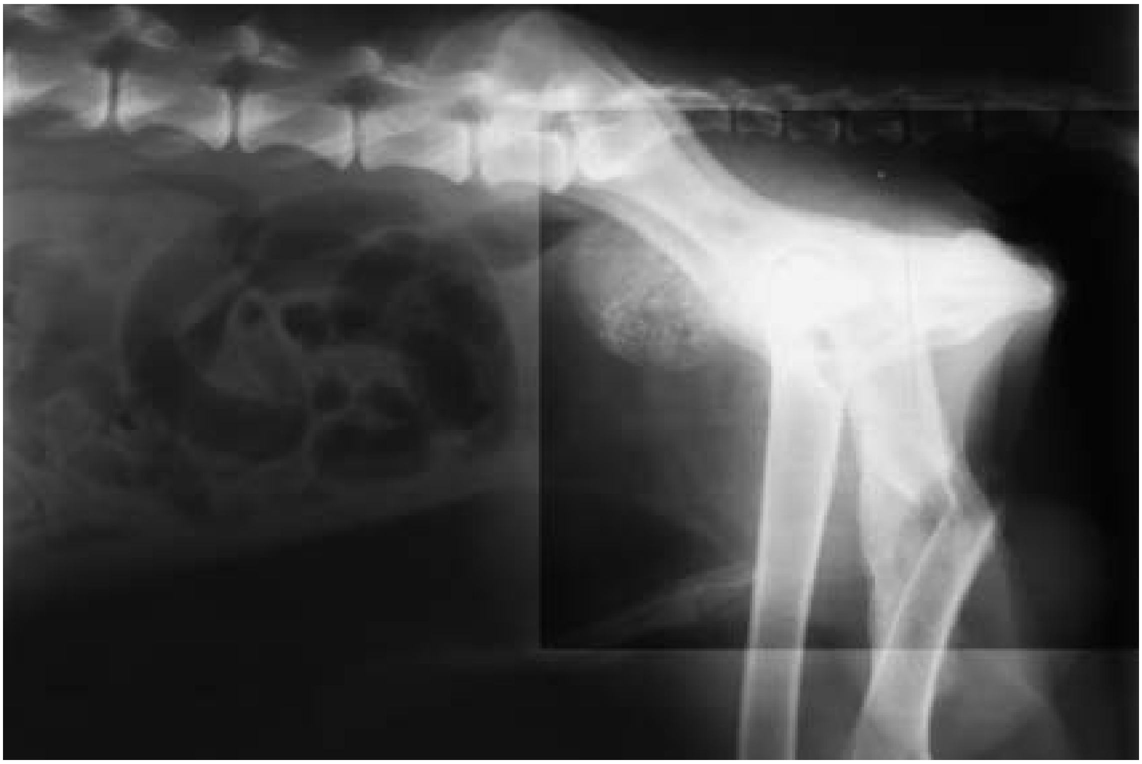
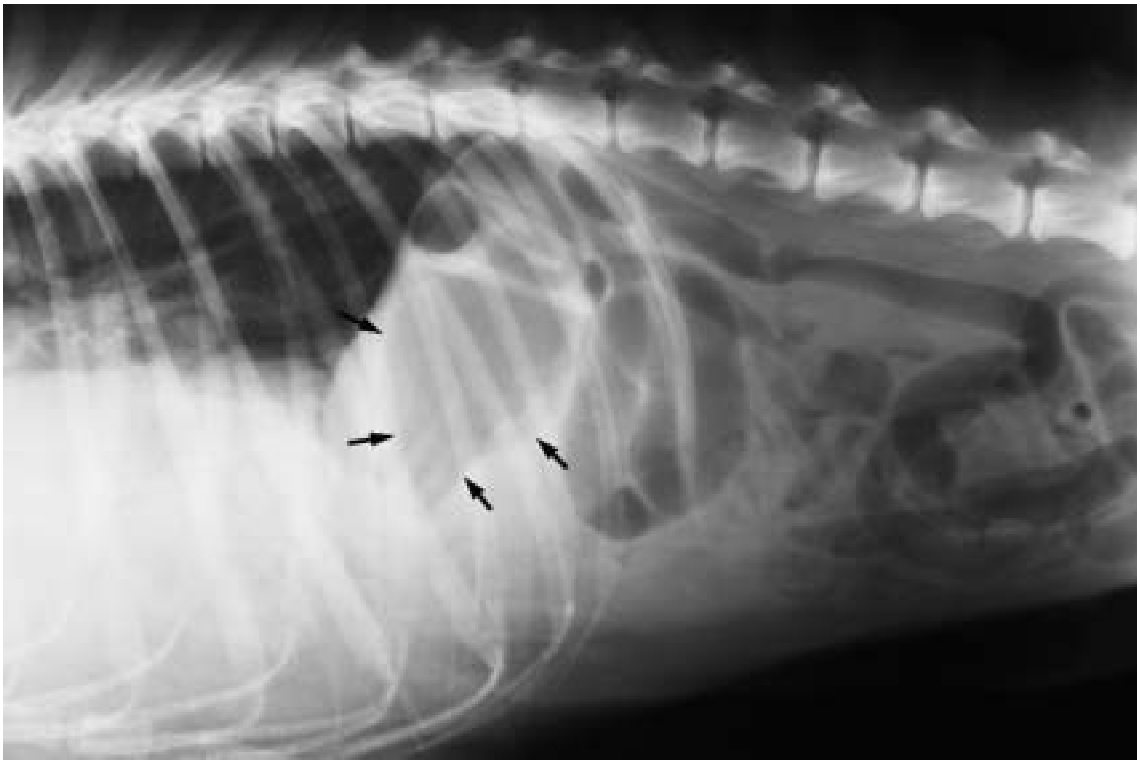
Case 4.108



Pelvis

Barium enema



Body

Signalment/History: "Sable" was a 10-year-old, male Collie with a history of chronic diarrhea and a report by the owner that he had not eaten for eight weeks.

Physical examination: "Sable" was thin, but had probably been eating some food during the previous couple of weeks. He was dyspneic, dehydrated, and attempted to vomit during the examination. He had a palpable deformity in the right hind limb, which also had limited motion and marked muscle atrophy. In addition, there was an inguinal hernia on the right side

Radiographic procedure: A single lateral view was made of the pelvis because of difficulty in positioning the dog due to the deformity of the right hindleg. This was followed by a low barium enema and a second lateral radiograph was made. Because of the dyspnea and attempts at vomiting, a single lateral radiograph of the body was made.

Radiographic diagnosis (pelvis): A malunion midshaft fracture of the right femur had resulted in a cranial displacement of the proximal fragment and an anteversion of the femoral head. Subluxation of the femoral head was noted. In addition, a 4- to 5-cm circular mass containing material resembling impacted feces was located on the floor of the pelvic inlet. A second circular mass was located dorsal to the os penis. The ventral abdominal wall could not be seen at its attachment to the pelvis.

Radiographic diagnosis (barium enema): The rectum was displaced dorsal to the mass. The mass was thought to represent inspisated feces or a calcified hematoma.

Radiographic diagnosis (body): A cranial malposition of the gastric air bubble (arrows) and a pleural density that represented fluid and probably an abdominal organ herniation could be seen. The cardiac silhouette and the ventral diaphragm were not identified. Healed fractures of the 6^{th}–8^{th} ribs were noted.

Treatment/Management: The diagnosis was that of: (1) malunion fractures with a probable rectal diverticulum or calcified hematoma, (2) an inguinal hernia that contained the urinary bladder, and (3) a diaphragmatic hernia.

The owners were questioned further concerning the clinical history of the dog and admitted that "Sable" had been struck by a car two years earlier, had been chronically lame since that time, and was presumed to have had a fractured femur. Because of the poor condition of the dog, the owners chose euthanasia.

At necropsy, a centrally placed diaphragmatic hernia was noted associated with a cranial displacement of the liver lobes. The urinary bladder was positioned laterally in an inguinal hernia. The rectal diverticulum contained inspisated fecal material. The malunion fracture of the right femur was as seen on the radiograph. An unsuspected finding at necropsy was that of a generalized mesothelioma present on the pleural and peritoneal surfaces.

Case 4.109

Signalment/History: "Rusty" was a 9-month-old, male kitten with a history of being struck by a car three weeks previously. He had been dysuric and hematuric at that time. At presentation, he was lame in the right pelvic limb.

Physical examination: Crepitus was palpated on movement of the right hip joint. Motion of that limb was limited. Palpation of the abdomen demonstrated a large tubular mass occupying most of the abdominal cavity.

Radiographic procedure: Radiographs were made of the pelvis and also of the abdomen because of the unexpected findings on palpation.

Radiographic diagnosis (abdomen): The colon was markedly distended and filled with dense fecal material. A large diverticulum projected ventrally just proximal to the pelvic inlet. A hernia in the abdominal wall was present, apparently associated with a tear of the prepubic tendon. No bowel loops were seen within the hernial sac. The urinary bladder was in its normal position.

Radiographic diagnosis (pelvis): A malunion fracture of the right ilium was most prominent. The pubic and ischial fractures were located near the symphysis and were seen in a non-union state. A subcapital femoral epiphyseal fracture had resulted in resorption of the femoral neck. The capital epiphysis remained within the acetabulum and had a normal bone density.

Treatment/Management: The owner was not interested in spending any money on corrective surgery and was advised to use enemas and strictly control the kitten's diet to control the fecal impaction.

Comments: Hemoclips were evident within the abdomen and are probably associated with earlier surgery. In a young patient, such a finding would suggest the necessity of reassessing the reported sex of the kitten.

Case 4.110

Signalment/History: "Katie", a 8-month-old, female Collie, was presented with a badly malformed left pelvic limb. An injury had occurred when she was four months of age.

Physical examination: The bony abnormalities in the limb were easily palpated. The foot was rotated laterally. Both the stifle and talocrural joints had limited movement.

Radiographic procedure: The distal portion of the pelvic limb was radiographed.

Radiographic diagnosis: Malunion fractures of the tibia and fibula with cross-healing between these bones and lateral rotation of the distal fragments were noted. Just as important was the injury to the talocrural joint with crushing of the 4th tarsal bone resulting in the lateral rotation of the foot. The intertarsal joints appeared to be ankylosed (arrow).

Treatment/Management: No treatment could be offered.

Case 4.111

Signalment/History: "Barney" was a 2-year-old, male Springer Spaniel with a history of injury to the right tarsus six months previously. The pelvic limb had been placed in a plaster cast at that time. The cast was removed and the owner was interested in an evaluation of his using "Barney" as a field trial dog.

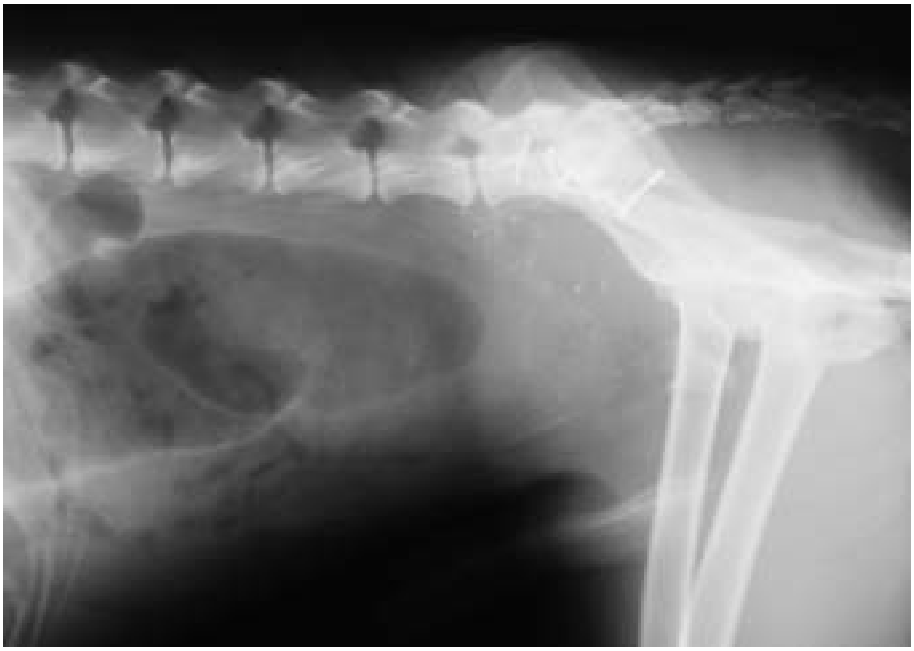
Physical examination: Firm swelling was palpated around the tarsus. No pain was evident. Motion of the tibiotarsal and intertarsal joints was thought to be limited.

Radiographic procedure: Multiple studies were made of the tarsus.

Radiographic diagnosis: A fracture-luxation at the tibiotarsal joint had resulted in a non-union fracture of the medial malleolus (white arrow). In addition, a displaced osteochondritis dissecans fragment was positioned just medial to the malleolus (black arrow). A stress radiograph suggested minimal joint instability. Soft tissue swelling was evident.

Treatment/Management: The owner was advised of the non-union status of the fracture plus the possibility that the dog had an osteochondritis dissecans lesion as well. The injury to the joint plus the resulting instability indicated that "Barney" would not be able to tolerate heavy athletic activity.

Comments: Two concurrent but different etiologies are not common, but must be considered. The combined effect makes the joint injury more important clinically. The diagnosis of a developmental lesion that is inheritable may be of interest to the owner.



Case 4.112

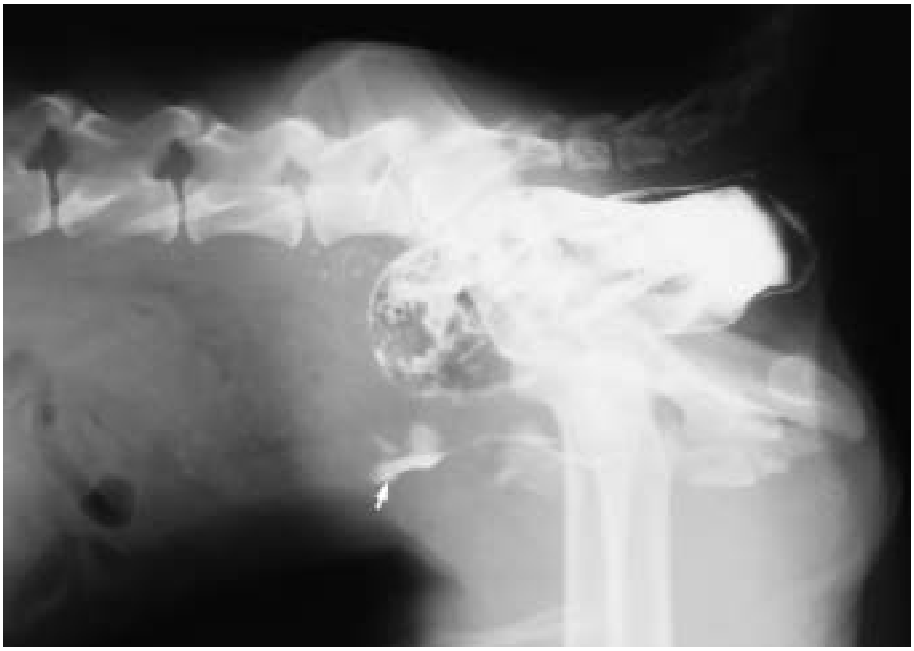
Noncontrast

Signalment/History: "Fin" was a 2-year-old, male German Shepherd mixed breed, who had been hit by a car one month previously. A right ilial fracture was stabilized at that time. He was presented because of persistent diarrhea associated with straining. The question was whether or not the trauma had caused some injury to the colon.

Physical examination: The pelvic canal was narrow and the rectum was distended and filled with soft feces. Proctoscopy indicated a possible colonic stricture 9 cm cranial to the anus. Ultrasound examination was not helpful in the diagnosis.

Radiographic procedure: Studies of the pelvis were made, including a barium enema to evaluate the pelvic soft tissues.

Radiographic diagnosis (noncontrast): The right hemipelvis was displaced cranially and medially with healing malunion fractures of the right ilium and pubis. Three wire sutures held the iliac fragments in position. The hip joints were unaffected by the trauma. A soft tissue pelvic mass was thought to represent the clinically detected distended intrapelvic rectum. A second soft tissue mass was located just cranial to the pelvic inlet. A third structure was filled with gas and probably represented a distended descending colon.



Barium enema

Radiographic diagnosis (barium enema): The contrast agent mixed with feces in a 6-cm-long, distended rectal segment. The barium sulfate flowed cranially and ventrally in a narrow stream (arrow). The contrast agent remained within the bowel and was not thought to be peritoneal. The cause for the redundant and strictured intrapelvic portion of the rectum could not be determined.

Treatment/Management: Surgical exploration located a surgical sponge just cranial to the pelvic inlet with massive adhesions that had caused the stricture of the colon and resulting dilatation. Some improvement was noted in the ease of defecation following the surgery; however, the narrowing of the pelvic inlet remained, and both the soft tissue and bony strictures caused continued chronic problems.

4

4.2.2.5 Non-union or delayed union fractures

The determination of a non-union fracture in its early stages is a subjective evaluation. The surgeon would prefer to recognize this type of fracture as one requiring only a longer period for healing and would suggest that "a non-union fracture is one evaluated by an overly anxious radiologist". At a later stage of fracture healing, it is then possible to be specific about the absence of any healing activity at the fracture site and the presence of a non-union situation (Table 4.14).

One particular form of fracture healing is difficult to judge: the healing of a physeal or apophyseal fracture in which a large component of the tissue around the fracture site is cartilage. In general fracture healing, the identification of bony callus formation is the radiographic sign that is used to judge the stage and rate of healing. However, if a physeal fracture is to heal and the cartilage growth plate activity preserved, a healing callus should not be seen, especially not a bridging callus. For, if it is identified, it means that bony tissue is bridging the growth plate and further growth will be prevented from occurring. Healing of an apophyseal avulsion fracture is a different matter clinically, since the length of the bone is not dependent on the apophysis. Bony union when it occurs, unites the apophyseal center to the parent bone providing an attachment for a muscle, ligament, or tendon.

Delayed healing is seen with unstable fixation, but can also be seen in the older patient in which the stability of the fracture is good. The decision of what to do with a case of delayed healing is usually answered by the particular conditions of the fracture. If the fragments appear to remain in good apposition and alignment, there may be no problem in waiting another four weeks before making a definite decision concerning the healing.

Non-union is usually recognized when there is no evidence radiographically of any activity at the fracture site and is characterized by: (1) smooth fragment cortices, (2) uniform fragment density, (3) no periosteal new bone with roughened margins, (4) callus with a uniform density, (5) smooth callus margins, and (6) no "fluffy" or early callus formation. It looks like "nothing is happening" at the fracture site.

Two forms of non-union are recognized. One is the hypertrophic form indicating that a reasonable blood supply to the fracture site was present, while stabilization of the fracture fragments was probably lacking. The ends of the fragments tend to form "knob-like" endings or those with a flattened surface. These patterns may be described as those acquired in the development of a pseudoarthrosis. Any active fracture healing may cease before formation of the pseudoarthrosis, in which case, the activity centering around the fracture site appears to have "been turned off" and no signs of additional bridging callus formation are present. Actually, the early callus of woven bone that has formed becomes smooth as it matures and the borders of the existing callus become sharp and are clearly identifiable when compared with the less dense immature callus in an active healing environment. The medullary cavity at the end of the fragment tends to fill with bony tissue creating a rounded appearance called an "elephant foot", because of the expanded appearance of the bone end. Remodeling activity takes over until the ends of the fragments have become shaped so that they are lying "comfortably" adjacent to each other, at which time activity stops and the pseudoarthrosis has formed.

The other form of non-union is one of atrophy in which the fragments become osteopenic and assume a tapered appearance referred to as "penciling". It seems this is more commonly seen in the smaller dog breeds, perhaps because of the limited blood supply from the soft tissues in the distal portion of their limbs.

It is possible to have features of hypertrophic non-union in concert with those of atrophic non-union. This is especially possible in the event of fractures of paired bones, i.e. the radius and ulna. The proximal fragments atrophy and taper, while the distal fragments form a "cup" in which the proximal fragment sits and the pseudoarthrosis develops.

A third form of non-union is one that is seen in fracture healing influenced by osteomyelitis. The centrally located infection causes the callus to widely bridge the infected fracture site. If the external blood supply is adequate, this type of fracture will eventually heal, assuming more the characteristics of a malunion.

Table 4.14: Radiographic signs of non-union or delayed union

1. Features of delayed union
   a. callus formation is
      I. absent
      II. minimal
      III. delayed
   b. fragments
      I. fail to lose bone density
      II. fail to show any new bone production
   c. fixation device permits motion
   d. osteomyelitis present at fracture site
      I. callus attempts to bridge infected site
      II. callus attempts to bridge sequestra
2. Features of non-union
   a. atrophic type
      I. penciling of fragment ends
      II. loss of bone density
      III. absence of callus formation
   b. hypertrophic type
      I. no bridging callus
      II. modeling of fragment ends
         i) "elephant foot" formation
         ii) pseudoarthrosis formation
   c. associated with osteomyelitis
      I. callus attempts to bridge infected site
      II. sequestra influence callus formation

Case 4.113

Signalment/History: "Brandy" was a 6-month-old, female German Shepherd cross, who was noted to be limping on the right pelvic limb. She had shown signs of pain several weeks earlier and had sat down and cried.

Physical examination: Examination showed a happy, active puppy who ran around the examination room; however, she had a shortened right pelvic limb.

Radiographic procedure: Two views were made of the affected limb and only a lateral view was made of the opposite limb.

Radiographic diagnosis (lateral views only): A generalized cortical thickening was noted in the mid shaft of the right tibia at the site of cranial angulation of the distal fragment. The thickening was more prominent cranially and laterally (arrows). The medullary cavity was normal in appearance. A comparison was made with the normal limb and it was noted that the left tibia was longer and did not have the pattern of cortical thickness in its midshaft.

Comments: The radiographic changes were diagnostic of a fracture undergoing healing at the junction of the proximal and middle thirds of the tibia. The healed bone was shorter than the opposite tibia. The physeal growth plates remained open in both limbs suggesting that the shortening was the effect of injury to a growth plate with only a delay in growth or due to over-riding of the fracture fragments. Because the fracture had not been treated, it is difficult to think that the fracture had been complete with over-riding fragments.

Case 4.114

Signalment/History: "Barbara" was a 7-year-old, female German Shepherd mixed breed with a history of trauma to the right forelimb three months previously. The fractures in the right forelimb had been treated by casting. The cast had been changed twice, but the limb had not been radiographed.

Physical examination: The cast was removed to permit examination. The foot had cranial and medial angulation with movement felt with palpation at the suspected fracture site. Pain was not evident. Soft tissue atrophy was present.

Radiographic procedure: Two views of the traumatized limb were made.

Radiographic diagnosis: A non-union fracture of the distal radius and ulna was characterized by atrophic changes (penciling) of the fragment ends. An effort to form a pseudoarthrosis between the overlapping radial fragments was evident. Marked disuse osteopenia was evident in the distal fragments. The elbow joint appeared normal and the distal joints appeared to not have been affected by the trauma.

Note the more prominent disuse osteoporosis in the distal fragments. A pattern of soft tissue density remained in the carpal area following removal of the cast.

Treatment/Management: The owner was informed about the possibilities of attempting to surgically correct the non-union fractures. "Barbara" was lost to follow-up.

Case 4.115

Signalment/History: "Deacon" was a 12-year-old, male German Shepherd cross with a history of lower limb amputation of the right pelvic limb nine years earlier. The skin overlying the stump had begun to dry and develop cracks with drainage tracts.

Physical examination: The amputation stump was swollen and warm with a question of soft tissue infection and/or osteomyelitis.

Radiographic procedure: The remainder of the right limb was radiographed.

Radiographic diagnosis: Bone atrophy was evident with penciling. The cortices were thin. No reactive bone was noted. The pattern seen was thought to be due to disuse and as expected. The absence of any periosteal new bone or destructive pattern suggested the absence of osteomyelitis or any secondary malignant process. A fistulous tract was seen (arrow).

Differential diagnosis: Normal bone atrophy was seen without evidence of underlying bone disease.

Treatment/Management: Drainage was established and the patient treated with antibiotics.

Comments: An understanding of the radiographic features of non-weightbearing or disuse of a limb is important to prevent the overdiagnosis of a destructive bone lesion from another etiology. Also, the presence of disuse osteopenia helps in the estimation of the duration of time since a traumatic event or the duration of disuse.

Case 4.116

Signalment/History: "Re-Wrap" was a 14-month-old, female Labrador Retriever with a history of a fracture six weeks previously. Since that time the pelvic limb had remained in a cast and the dog had not supported weight on the limb.

Physical examination: The cast was removed. A firm, nonpainful thickening of the soft tissues was evident around the lower limb. No draining tracts were present and the limb was not hot. Movement of the foot failed to cause motion at the suspected site of fracture. The affected limb was shorter when compared with the opposite limb.

Radiographic procedure: Studies of the lower limb were made.

Radiographic diagnosis: A healing comminuted fracture, which was evident in the proximal one-half of the tibia with malalignment of the ununited butterfly fragments. Slight cranial angulation of the distal fragment was noted. The stifle and tibiotarsal joints appeared normal on examination.

Treatment/Management: The dog had a healing fracture and had reached the stage where the deposition of a large extracortical fibrocartilaginous callus had made movement of the fragments limited and nonpainful. The heavy callus seen at presentation made fragment repositioning nearly impossible were surgery to be attempted.

Radiographic examination of the limb at a later date showed formation of a healing callus, but the fragments remained in an overriding position and resulted in a permanent shortening of the limb.

Case 4.117

Signalment/History: "Rascal" was a 3-year-old, male Shetland Sheepdog who had been struck by a car ten weeks earlier. A resulting right midshaft femoral fracture was treated with an IM pin and multiple cerclage wires. The original repair had failed and the same form of fracture treatment was repeated. The second IM pin migrated and had been finally removed several days previously by the owner.

Physical examination: Soft tissue atrophy was prominent in the right pelvic limb. The non-union midshaft femoral fracture was palpated. No draining tracts could be detected.

Radiographic procedure: Radiographs were made of the right femur with views of the normal left femur.

Radiographic diagnosis: A non-union midshaft femoral fracture was seen with four cerclage wires at the fracture site. The distal fragment was angled caudally on the lateral view, and laterally on the VD view; however, the fragment seemed free to shift in position. Only minimal early callus had formed at the fracture site. The four cerclage wires had shifted toward the fracture site. Small resorption sites on the periosteal surface represented the original position of the cerclage wires before their movement. Disuse osteoporosis was evident.

Differential diagnosis: Although the non-union status of the fracture could be established, the question of the presence of osteomyelitis was more difficult to determine. The absence of a reactive periosteal response suggested that infection was not present, but this was probably better determined clinically.

Treatment/Management: The fracture was plated. Radiographs made five months later showed a satisfactory healing of the femoral fracture.

Case 4.118

Signalment/History: "Bucky" was a 8-month-old, male Poodle mixed breed with a history of injury to his left forelimb several months previously. The dog had not been presented for treatment at that time even though he was acutely lame.

Physical examination: The affected limb appeared shorter than the opposite limb. Despite not bearing full weight on the limb, the dog actually showed only little pain on palpation. The midshaft of the radius/ulna palpated thicker than expected, with a definite mass laterally and caudally. Flexion and extension were possible in both the elbow and antebrachiocarpal joints.

Radiographic procedure: The forelimb was radiographed.

Radiographic diagnosis: A non-union fracture was noted in the midshaft of the radius and ulna with overriding of the fragments. The fragment ends showed both atrophic and hypertrophic patterns typical of non-union fractures. A pseudoarthrosis had developed between the proximal radial and distal ulnar fragments. No signs of healing activity were evident. The adjacent joints were within normal limits radiographically. Note the degree of cortical thinning from disuse.

Treatment/Management: Because of the absence of pain and "Bucky's" ability to ambulate, the owners chose to not consider treatment at this time.

Comments: If surgical treatment is to be undertaken, it is always helpful to have radiographs of the opposite limb to determine the correction in the length of the bones that should be attempted.

The differential diagnosis in this patient was not difficult, although it must include an explanation for the shorter limb in a young dog, the unusual findings on palpation, plus the history of trauma, as all of these suggest a problem associated with fracture healing.

Case 4.120

4

Signalment/History: "Jodi", a 6-month-old, female Great Pyrenees, was presented lame on the left pelvic limb. The owner had just acquired the dog and knew no relevant clinical history.

Physical examination: The stifle joint was painful on palpation and muscle atrophy was prominent. Joint effusion and/or a thickened joint capsule was palpated.

Radiographic procedure: Lateral studies of both stifle joints were made because of the age of the dog.

Radiographic diagnosis (lateral views only): A chronic, non-union avulsion fracture of the tibial crest on the left with thickening of the patellar ligament (arrow). The stifle joint on the right was normal.

Comments: This injury was chronic as evidenced by the absence of any sharply defined bony fragments and by the presence of an early bridging callus. The patellar fat pad on the injured limb could not be identified because of hemorrhage or edema.

The location of the patella is almost normal when compared with the opposite limb, as would be expected in a lesion in which the tibial crest is displaced only a short distance.

4.2.2.6 Traumatic injuries to growing bones

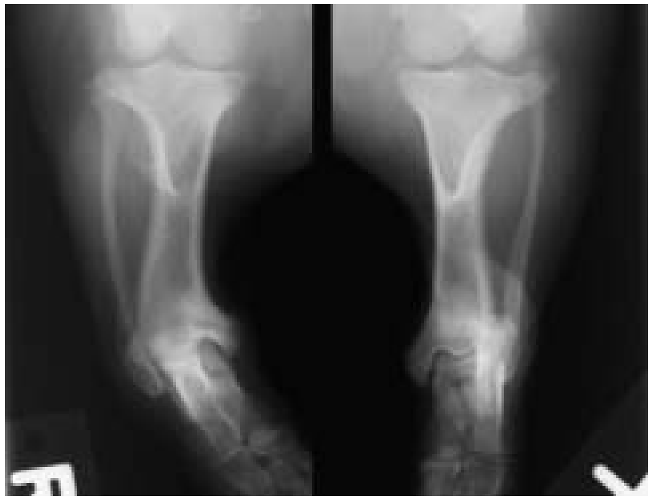
Fractures seen in the skeletally immature bone that affect growth areas are divided into those that are physeal and those that are apophyseal. Of particular importance are the physeal injuries, which ultimately affect the length and shape of the radius and ulna. In the pelvic limb, slippage of the capital epiphysis often results in necrosis of the proximal epiphysis and results in injury to the hip joint. Apophyseal injury to the tibial crest has the possibility of causing chronic injury to the femoropatellar articulation.

Physeal growth injuries

Physeal fractures affect those growth plates that provide the length of the long bones. Physeal fractures have been conveniently divided into Salter Harris type I, in which the fracture remains within the cartilaginous growth plate; type II in which the fracture escapes from the cartilaginous growth plate and enters the metaphysis; type III in which the fracture escapes from the cartilaginous growth plate and enters the epiphysis; type IV in which the fracture is directed more longitudinally with the fracture line passing through the epiphysis, across the physis, and through the metaphysis; and type V in which a crushing or sheering injury results in a bony bridging of the growth plate. A type VI has also been described, in which peripheral injury results in formation of a bony callus that bridges the growth plate and prevents lengthening of the bone. Of the physeal fractures, only Types III and IV enter the joint space.

Injury to the physeal growth plates can result in growth disturbance of several types. It can terminate growth across the entire plate and result in what is frequently referred to as "premature closure" with cessation of bone growth. The injury may also only center on a portion of the growth plate and result in an unequal injury, and subsequent unequal growth. If the injury is less severe, the growth may only be delayed or lessened and this pattern may be equal across the growth plate or affect only a portion of the plate. Thus, it is possible to have a range of results following injury. This range is also affected by whether the long bone is solitary or paired. The radius and ulna have the most commonly described growth problems. If one bone has closure to growth, the continued growth of the paired bone will result in marked bowing. It is also possible for the adjacent joint to be destroyed as a result of the unequal growth of paired bones. Thus, radiographic examination must include both the elbow joint and the antebrachiocarpal joint in such cases.

Injury to the growth plate of the proximal femur is intra-articular and may result in destruction of the blood supply to the capital epiphysis and subsequent avascular necrosis. This type of injury is often seen in association with other pelvic injuries.



Case 4.120

Signalment/History: "Peete" was a 5-month-old, male Dachshund with an abnormally shaped right pelvic limb. This included a varus deformity centering on the distal tibia.

Physical examination: Palpation failed to identify any site of pain or swelling. The varus deformity was easily seen and the affected limb was slightly shorter. The pads on the foot had worn unevenly.

Radiographic diagnosis: The abnormal growth of the distal tibia was characterized by cranial and medial angulation of the distal portion causing a varus deformity. The shortening of the affected bone was noted in addition to a marked angulation of the tibiotarsal joint space. A malunion physeal fracture was the most likely cause of the deformity.

Outcome: The owner did not want to pay for any reparative surgery. "Peete" was discharged and not seen again.

Comments: Physeal injury often occurs in the forelimb. However, this patient had an injury to the distal physeal plate in the tibia that had resulted in uneven growth with delayed growth medially. The injury must have been minimal because of the absence of any clinical signs.

4

Case 4.121

Signalment/History: "Rufus" was a 6-month-old, male Labrador Retriever who had fallen down a flight of stairs 24 hours earlier and had become non-weight-bearing on the left pelvic limb.

Physical examination: Palpation of the limb did not elicit pain and no evidence of soft tissue swelling was noted.

Radiographic diagnosis: A Type 1 Salter-Harris fracture was seen in the proximal tibia with only minimal displacement of the fragments. The metaphysis was shifted slightly in a medial direction (white arrow). An associated incomplete fracture of the proximal fibula was detected (black arrow).

Comments: Generally, this type of physeal injury does not affect bone growth if the fragments are maintained in a good position during healing.

Case 4.122

Signalment/History: "Cindy" was a 4-month-old, female Fox Terrier who had fallen and become lame on her left forelimb.

Physical examination: Crepitus was palpated in the left elbow joint.

Radiographic procedure: Multiple radiographs were made of the elbow.

Radiographic diagnosis: An oblique Type IV Salter-Harris fracture separated the lateral condyle with marked proximal and lateral displacement.

Treatment/Management: A single bone screw and short Steinman pin were used for reduction and stabilization.

A follow-up radiograph four months after the injury showed healing of the humeral fracture.

Comments: A fracture of this type in smaller breeds dog is often associated with the failure of complete closure of the growth area between the two condyles. Therefore, the opposite limb should be radiographed to ascertain whether or not the persistence of the cartilage plate is bilateral, thereby forming a zone of weakness in the opposite limb.

Case 4.123

Signalment/History: "Samantha" was a 6-month-old, female puppy who had become lame after "playing with the children".

Physical examination: She was non-weightbearing on the right pelvic limb and the stifle region was swollen and painful.

Radiographic procedure: Both views were made of the tibia including the stifle joint.

Radiographic diagnosis: A combination of injuries to the growth plate of the tibial crest and the proximal tibial growth plate was noted. The fracture line started from the physeal plate and extended into the metaphysis making this a Salter-Harris Type II injury. This combination of apophyseal and physeal injury is not common. The fibula was fractured without fragment displacement (arrows). Joint effusion, probably hemorrhagic, was evident.

Treatment/Management: The tibial crest and proximal epiphysis remained united and the entire fragment was reduced by the use of K wires.

Comments: Fractures of this type usually heal quickly in a puppy and a possible delay in growth of the tibia would be compensated for by a slight change in the angulation of the stifle joint during walking.

Comparison views of the normal limb would have been helpful. Follow-up radiographs would have assisted in recognizing any problem in bone growth.

Case 4.124

Signalment/History: "Bear" was an 8-month-old, male German Shepherd mix who had been limping on his right forelimb for several months. The foot was in a valgus deformity. He seemed to be without pain while walking.

Physical examination: Muscle atrophy was obvious throughout the right forelimb. The valgus deformity was centered at the radiocarpal joint. Movement of the elbow joint was without pain, but was not normal. Movement of the foot showed the angulation of the paw. The nature of the injury could not be determined during the physical examination. The left limb appeared normal on examination.

Radiographic procedure: Two views of both forelimbs were made.

Radiographic diagnosis: In the right forelimb, shortening of the radius had lead to a luxation of the humeroradial joint, destruction of the trochlear notch, and luxation of the humeroulnar joint, which essentially destroyed the elbow joint. Unequal growth at the distal radial physeal plate had caused a marked valgus deformity of the foot. The degree of injury to the radiocarpal joint could not be clearly identified.

This deformity was secondary to closure of the proximal radial physeal plate and unequal growth of the distal radial physeal plate.

Note that the distal ulnar physeal plate on the affected limb remained open. The affected radius was 2.7 cm shorter and the affected ulna was 1 cm shorter than in the left forelimb. The opposite limb was normal by comparison with all its growth plates open.

Treatment/Management: Surgical osteotomy of the ulna permitted a slight reduction in the degree of elbow joint luxation. A radial osteotomy fixed with an IM pin partially corrected the valgus deformity and lateral rotation of the foot.

Even with excellent reduction of the elbow joint luxation, the articular surfaces could not be made normal and the persistence of joint incongruity (arthrosis) continued to exist.

Comments: The etiology in lesions of this type usually remains a question. It is assumed that a traumatic event influenced the disruption of the blood supply to the growth areas; however, evidence of the trauma is often not included in the clinical history and is not seen on the radiographs.

Left

Right

Case 4.125

Signalment/History: "Bruiser" was an 8-month-old, male Saint Bernard with abnormal curvature of both fore limbs. The owners had only recently acquired the dog and knew of no history that might have been helpful.

Physical examination: The left limb had a valgus deformity centered at the carpus and the limb appeared shorter than the right. Palpation of the elbow and carpal region on the affected limb was abnormal, while palpation of the right limb was thought to be normal. The foot on the right was externally rotated and the carpus dropped almost to the ground.

Differential diagnosis: Because of the age of the dog and the breed, a growth abnormality was considered.

Radiographic procedure: Views of both forelimbs were made.

Radiographic diagnosis: The radius was 4 cm shorter on the more severely affected limb, and the ulna was 3.8 cm shorter. Both the elbow and antebrachiocarpal joints were severely damaged in this limb. The distal radius was angled laterally and the distal one third of this bone was wider than normal with uneven cortical thickness and strong "struts" extending between the cortices. The trochlear notch was malformed and displaced proximally with increase in the width of the humeroulnar joint space. The medial coronoid process was badly damaged. The humeroradial joint space was widened. The proximal radial growth plate remained partially open. The radiocarpal joint surfaces were angled distomedial to proximolateral resulting from the unequal growth of the adjacent growth plate. This caused the valgus deformity of the foot. The distal radial and ulnar physeal plates were closed. The distal ulna was displaced proximally and angled cranially. A severe deforming arthrosis was present in the proximal and distal joints.

The bones and joints of the right forelimb were within normal limits with the exception of a slight lateral angulation of the foot.

The etiology of the growth deformity on the left was premature growth plate closure of unknown etiology.

Treatment/Management: The owner wanted to have corrective surgery on the forelimb performed. Additional radiographs showed the dog to also have severe arthrosis secondary to hip dysplasia. and the dog was euthanized.

Comments: Skeletal growth abnormalities are much more difficult to treat successfully in giant breeds and careful examination of the entire skeleton is suggested before treatment of one region is considered.

4


Right


Left

Case 4.126

Signalment/History: "Sami" was a 5-month-old, male Beagle, whose right forelimb had been stepped on when he was six weeks of age. A progressive lameness had developed in the right forelimb over the previous month.

Physical examination: Movement of the right elbow was not normal and the right forelimb appeared slightly shorter than the left. Lateral rotation of the foot was evident.

Radiographic procedure: Both forelimbs were radiographed.

Radiographic diagnosis: A marked separation was noted between the humeral condyle and the radial head in the right forelimb. The trochlear notch was displaced proximally causing an increase in the width of the right humeroulnar joint space. The proximal radial growth plate was partially closed. Rotation of the distal radial epiphysis had injured the radiocarpal joint. The distal radial growth plate was closed. The radius and ulna remained straight, but the foot was externally rotated. The radius was 1 cm shorter than the radius on the left. The diagnosis was delayed physeal growth in the right radius resulting in a destructive elbow luxation and external rotation of the foot.

Treatment/Management: Midshaft ulnar ostectomy was attempted. The dog's clinical status improved greatly, but the humeroulnar subluxation remained causing a continued lameness.

Comments: Treatment must consider the status of the adjacent joints in addition to attempting to restore the length of the bones.

Right

Left

Case 4.127

Signalment/History: "Shemi" was a 2-month-old, female Collie with a right forelimb that was not "straight". The limb had been normal at birth.

Physical examination: The right thoracic limb appeared shorter than the opposite limb and the right foot was deviated laterally. No pain was evident on palpation although the puppy was difficult to examine.

Radiographic procedure: Two views were made of each forelimb.

Radiographic diagnosis: Physeal injury to the distal radius and ulna resulted in a marked valgus deformity of the foot (arrows). The radius was 1 cm shorter, and the ulna 1.5 cm shorter than the bones in the opposite limb. The modeling and malalignment in the distal radial metaphysis suggested a possible Type 1 physeal slippage that had not been recognized. The injury may have delayed radial growth; however, ulnar shortening had resulted in an apparent overgrowth of the radius with the radial metaphysis displaced medially. This displacement had protected the radiocarpal joint.

Note the increase in width of the ulnar physis suggesting a persistent blood supply to the epiphysis that permitted continued cartilage production. In comparison, there was obviously a lack of blood supply to the metaphysis that delayed mineralization of the cartilage and growth of the bone. The resulting dissimilarity of growth of the two bones caused them to appear as an "X" when viewed on the craniocaudal view instead of two parallel bones. The bones and joints in the left limb were normal.

Treatment/Management: The puppy was treated with a splint to correct the valgus deformity with the hope that the remaining growth potential in the bones would result in some correction of the deformity. The puppy was lost to follow-up.

4

Case 4.128

Signalment/History: "D'Artagnan" was a 10-month-old, male Irish Setter whose name had not protected him from some type of trauma. The injury had occurred three months previously and the owners had been waiting for him to "improve" in the ensuing time. When this did not occur, they brought him to the clinic for treatment.

Physical examination: The left pelvic limb was obviously abnormal with severe soft tissue atrophy. Movement of the hip joint was painful and limited.

Radiographic procedure: Only a VD view of the pelvis was made.

Radiographic diagnosis: The misshapen left femoral head and neck appeared to be subsequent to a chronic physeal fracture. The malshapen left acetabulum was secondary to attempted repair of the femoral physeal fracture. The muscle atrophy in the left pelvic limb was extensive. Obliquity of the pelvis made diagnosis difficult, but healing of a left sacroiliac joint luxation, left pubic fracture, and left ischial fracture were all suspected.

Note the wide white shadow cast by a skin fold extending across the left hip joint

Comments: The injury was most probably a subcapital physeal fracture plus fractures at three locations in the pelvis which had occurred at the time of the trauma three months earlier. A portion of the avascular capital epiphysis remained yet to be resorbed. The femoral neck had undergone osteoclastic modeling because of disuse. The acetabulum may have been fractured, but that would be uncommon with a physeal fracture. More likely, the acetabulum had simply remodeled and become flattened because of disuse.

4

Case 4.129

Signalment/History: "Angelo", a 7-month-old, male Irish Setter, had had a suspected trauma two months previously. A coxofemoral luxation was diagnosed on physical examination.

Physical examination: Generalized soft tissue atrophy was noted in the pelvic region. Palpation of the right hip joint was abnormal and either a fracture or luxation was suspected.

Radiographic diagnosis: A chronic physeal fracture of the right femoral neck had resulted in avascular necrosis of the right femoral head with marked resorption of the right femoral neck, and prominent remodeling of the right acetabulum. The femoral head remained essentially unchanged. The fracture probably had remained a non-union, although this was difficult to ascertain on this single view. The soft tissue atrophy suggested that the dog had not used the limb since the time of injury.

Comments: The radiographic findings were typical of those following a subcapital physeal fracture of the femoral head in a skeletally immature dog. The femoral neck quickly resorbed due to disuse and because it retained its blood supply. The capital epiphysis contained its original bone content because the destruction of its blood supply had prevented a rapid demineralization. The acetabulum had flattened because of disuse. The sclerosis in the subtrochanteric region of the femur reflected the increased stress through that part of the bone.

Case 4.130

Signalment/History: "Schwartz" was a 9-month-old, female Labrador Retriever who had been struck by a car two weeks earlier. A luxated hip had been reduced twice without any success.

Physical examination: A painful right hip joint with abnormal motion was noted with a suspected luxated femur.

Radiographic procedure: Multiple views of the pelvis were made for the right hip.

Radiographic diagnosis: The luxated right hip had a subcapital physeal fracture and an avulsion of the lesser trochanter (black arrows). The minimal soft tissue mineralization was probably early callus formation as would be expected around an unstable fracture in a skeletally immature patient two weeks post-trauma. The soft tissue atrophy was commensurate with the clinical history of two weeks duration.

Note the small ossification center at the caudal aspect of the symphysis pubis.

Case 4.131

Signalment/History: “Sidney” was a 9- or 10-month-old, male cat who had been found lame by his owner.

Physical examination: The right pelvic limb was swollen and crepitus could be palpated.

Radiographic procedure: Radiographs were made of the pelvic limb.

Radiographic diagnosis: A Salter-Harris Type I distal femoral physeal fracture was noted with typical caudal and proximal displacement of the epiphysis. There was no evidence of an intracondylar fracture.

Treatment/Management: The thorax was radiographed because of the presumed traumatic etiology and was within normal limits.

Two Kirschner wires were placed in a crossing fashion and the reduction was satisfactory.

Comments: Typically, physeal fractures at this location have a small triangular fragment of caudally located metaphyseal bone still attached to the epiphysis resulting in a classification of Salter-Harris Type II. This does not seem to have been present in this patient.

4

Case 4.132

At presentation

Signalment/History: "Goldie" was a 6-month-old, female Retriever cross breed who had been hit by a car two days earlier. The dog had been treated in an emergency clinic, where a splint had been placed on the fractured left tibia. She was then referred.

Physical examination: The fracture in the midshaft of the left tibia could be palpated and was studied on the referral radiographs. In addition, crepitus was noted in the right hip and movement of the right pelvic limb was painful.

Radiographic procedure: Radiographs were made of the pelvis.

Radiographic diagnosis (at presentation): The slipped right capital epiphysis remained within the shallow acetabulum and had lost subchondral density. Minimal soft tissue calcification (early callus) was noted within the soft tissues surrounding the femoral neck. These features suggested an injury of more than two days duration.

In addition, an undisplaced fracture in the right ischium (black arrows) was present and the ischiatic tuberosity was avulsed (white arrows), indicating torn attachments of the biceps femoris or semitendinosus muscles.

Month 2

The opposite femoral head was positioned loosely within the acetabulum, but the hip joint was felt to be otherwise normal.

Treatment/Management: An attempt was made to surgically stabilize the capital epiphysis through placement of four small Kirschner wires. The limb was placed in an Ehmer sling after surgery. The tibial fracture was incomplete and the fibula was unaffected, so this region of the limb was only splinted. Additional radiographs were made two months later.

Radiographic diagnosis (month 2): Resorption of the femoral neck had occurred with beginning resorption of the femoral head. The head had slipped along the pins and had impacted on the neck, where it could be seen to be healing. The change in the contour and shape of the femoral head, the acetabular modeling as to accept the reshaped femoral head, and the marked sclerosis of the subchondral bone suggested development of a post-traumatic arthrosis that will be of clinical importance in a dog of this size.

Comments: Owners often do not admit that they have delayed treatment of trauma patients.

Case 4.133

Signalment/History: "Heidi" was a 7-month-old, female German Shepherd who was brought to the clinic because of not walking "quite right". The only history that the owners could offer was that she was "run over by a truck" when she was eight weeks old. She had received no treatment at that time.

Physical examination: Both hip joints palpated in an abnormal manner with limited motion. Soft tissue atrophy was evident bilaterally, more prominent on the left.

Radiographic procedure: Radiographs were made of the pelvis.

Radiographic diagnosis: Chronic bilateral hip joint injury had resulted in a partial resorption of both femoral necks and remodeling of the acetabulae leading to a marked flattening. The subchondral sclerosis was more severe on the right. Both capital epiphyses had lost bone density, were partially resorbed, and were not reunited with the femoral necks. The femoral cortices were thin suggesting either a generalized disuse or perhaps nutritional disease.

Malunion fractures of the pubis and ischium plus fusion of the right sacroiliac joint had resulted in a marked cranial displacement of the right hemipelvis.

The most likely diagnosis was capital physeal fractures in a puppy with marked post-traumatic resorption and non-union of the femoral heads, and severe secondary arthrosis.

Treatment/Management: Bilateral femoral head ostectomy was performed. "Heidi" had delayed recovery during the postoperative period, probably because of the ineffective use of physiotherapy and never regained a good use of her pelvic limbs.

Comments: A major problem in this patient was that the injury had occurred prior to the formation of the hip joints. As a consequence, the severe injury to the joints was only partially due to the trauma. It was really largely due to the fact that the hip joints were only partially developed at the time of the trauma.

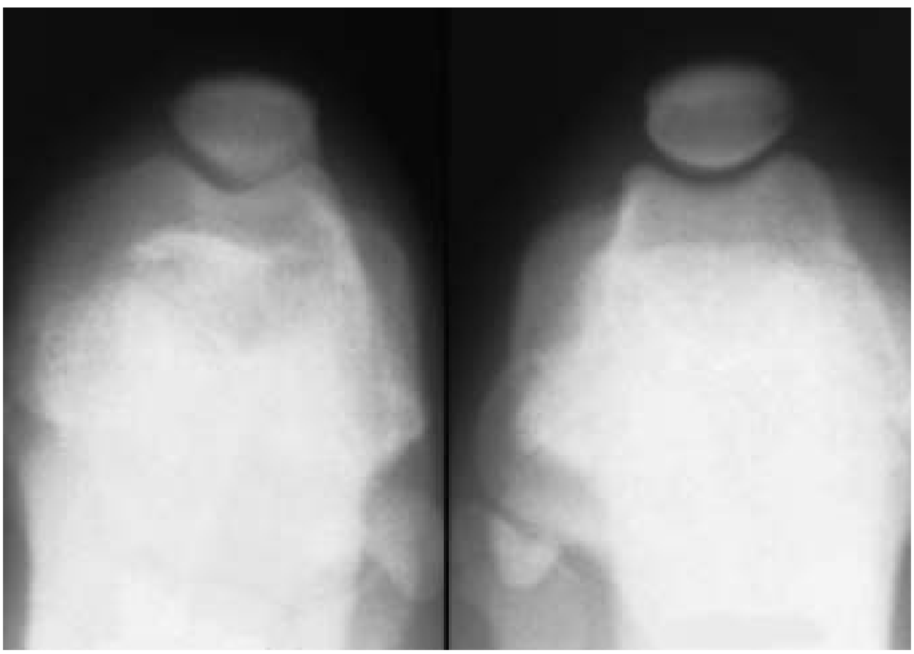
Apophyseal fractures

Skeletally immature bone may suffer apophyseal fractures that are of an avulsion nature, with separation of the apophyseal growth center. These have a characteristic appearance with a "pulling away" of the growth center from the parent bone and can obviously occur only in specific anatomic locations. The sites most commonly affected are the supraglenoid tuberosity, the greater trochanter of the femur, the tibial crest or tuberosity, the calcaneal tuber, and the ossification center for the olecranon process. Additional sites include the tubercles of the proximal humerus, the crest of the ilium, the ischiatic tuberosity, the lesser trochanter of the femur, and the tip of the accessory carpal bone.

In fractures of this type, the bony fragment usually separates from the parent bone with the fracture line located within the cartilaginous growth plate. Because the apophyseal growth regions do not contribute prominently to the length of the bone, the secondary affects of the injury are not as severe as in physeal fractures. Perfect repositioning of the avulsed fragment that insures renewed physeal growth is not required. Separation of the tibial crest is somewhat unique since avulsion alters the attachment of the patellar ligament and, in that way, the fit of the patella in the femoral trochlea may be altered resulting in a secondary arthrosis.

Another group of avulsion fractures in the developing skeleton occur at sites that actually do not have a separate apophyseal growth center, but are only sites for the attachment of muscle tendons, such as the medial or flexor epicondyle of the distal humerus. Because this type of injury occurs in the developing bone, they have clinical and radiographic features in common with the apophyseal fractures.

Left Right



Case 4.134

Signalment/History: "Rusty" was a 7-month-old, male Brittany who had fallen from the seat of a car onto the ground. He was immediately lame on the left pelvic limb. The limb was then placed in a cast for two weeks. On removal of the cast, he continued to show lameness and was brought to the clinic for evaluation.

Radiographic procedure: Studies were made of the stifle joint in both limbs.

Radiographic diagnosis (day 66): A chronic avulsion fracture had separated the tibial crest ossification center on the left and could now be seen with a partial bony union of the tibial crest to the parent bone. The patella was more proximally positioned than seen on the normal limb. The "skyline" views showed the patella resting in the trochlear groove in a near-normal manner. The right limb was normal in comparison.

Comments: A number of etiologies could have been involved in this case. Is it a case of delayed bony healing over a two-month period because the limb had not been stabilized well, so that the continued motion of the fragment delayed the healing process? Or, was the fragment stabilized by the formation of a fibrocartilaginous callus and that explains the lucency between the fragment and parent bone? Or, was "Rusty" only showing a mechanical lameness, the result of the limb being immobilized for two months and the fracture was actually well stabilized?

Case 4.135

Left Right

Signalment/History: "Brandy" was a 4-month-old, female German Shepherd who had fallen a distance of 1.5 meters the previous evening and had been lame since.

Physical examination: Pain and swelling were obvious around the left stifle joint.

Radiographic procedure: Radiographs were made of both stifles.

Radiographic diagnosis: An acute avulsion of the tibial crest on the left was noted with the right normal in comparison. Evaluation of the acute nature of the injury was supported by the clinical history and a failure to note any bridging callus. The tibial crest was seen displaced proximally on the caudocranial view (arrows).

Treatment/Management: The tibial crest was repositioned using two K wires. Radiographs made postoperatively showed more clearly the small avulsion from the distal aspect of the patella indicating a tendenous tearing at that location.

Radiographs of the injury three weeks later showed the fracture to have healed with the formation of a bridging bony callus.

Comments: It may be difficult to determine the healing of an apophyseal fracture since the separation created by the avulsion is filled with cartilaginous tissue and presumably will remain cartilage until growth ceases. The filling of this space with a bony callus suggests that the healing has hastened the closure of the cartilage growth plate. An early closure should not result in skeletal anomaly of clinical importance.

The comparison radiographs made the changes in the injured limb easier to understand and are a "must" in the examination of skeletal pain or lameness in the skeletally immature patient.

4

4.2.2.7 Radiographic changes of osteomyelitis

The radiographic changes associated with bone infection are varied (Table 4.15). Traumatically induced bone infection can be secondary to a bite wound that has resulted in a soft tissue infection, which ultimately spreads to the bone causing an osteomyelitis. In this situation, the infected bone often does not cause clinical signs nor is it evident on the radiograph until days or weeks after the trauma. Consequently, the soft tissue wound will have healed and been long forgotten by the time the patient presents with pain or lameness.

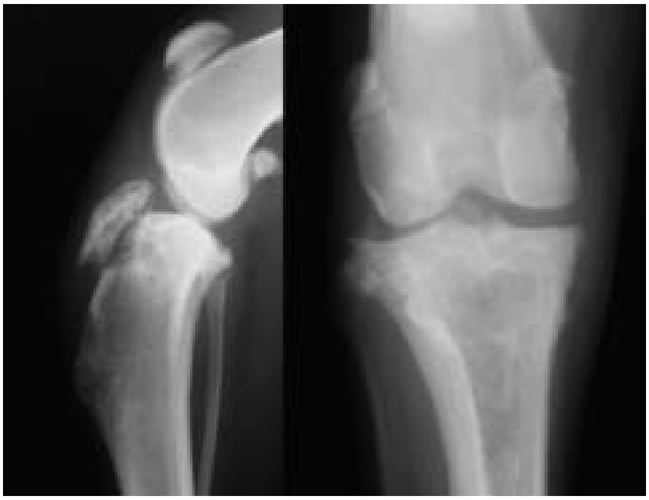
Another way in which osteomyelitis can occur, is in conjunction with an open fracture in which the contaminated wound results in bone infection. This direct implantation of the infectious organism can also be the result of a puncture wound, e.g. a bite wound. A third form of osteomyelitis occurs following the open reduction of a fracture with resulting hematogenous infection at the site of the traumatized soft tissue.

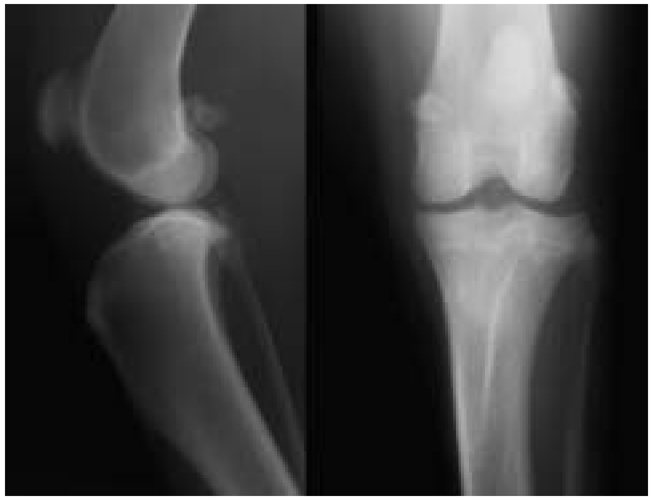
The pattern of radiographic change associated with a soft tissue infection extending into bone is characterized early by periosteal new bone formation. Later destructive changes can be identified within the bone. Radiographically, the pattern of bone infection following a deep bite wound is relatively easy to recognize especially if it is near the midshaft of the bone. The features of periosteal new bone, involucrum formation, and sequestration are all possible. If the infection is associated with a fracture, detection of the osteomyelitis is difficult because the features of the infection are superimposed over the callus formation and bone modeling associated with fracture healing. Radiographic patterns can extend from one of a resulting non-union without any signs of reactive bone to one in which a fracture fragment assumes the role of a sequestrum, and bony callus forms and bridges the site of osteomyelitis. If fixation devices have been positioned to aid in fragment stabilization, the osteomyelitis may center around the metallic plates or screws. Often bone lysis occurs with loosening of these devices. That lysis may be the only indication of the underlying osteomyelitis evident on the radiographs.

For these reasons, the diagnosis of osteomyelitis in association with a fracture and subsequent healing is best made on the basis of the clinical signs of a non-union or delayed union fracture with heat, swelling, and the presence of a draining tract. The wide variety of radiographic patterns present in association with bone infection secondary to trauma means that identification of a sequestrum with concurrent involucrum formation is rather infrequent.

Table 4.15: Radiographic features of osteomyelitis

1. Extensive soft tissue infection
   - a. soft tissue edema and swelling
   - b. minimal periosteal new bone formation
2. Deep bite wound
   - a. periosteal new bone formation
   - b. soft tissue edema and swelling
   - c. region of bone lysis
   - d. uncommon for a visible sequestrum to develop
3. Associated with an open fracture
   - a. soft tissue signs may persist from the original injury
     - I. subcutaneous emphysema
     - II. edema and swelling
   - b. failure of callus formation as expected
   - c. periosteal new bone may be present
     - I. has no pattern of formation as normal callus would
     - II. pattern is indistinct
     - III. pattern may be away from the fracture site
     - IV. eventually could form an involucrum
   - d. bone lysis
     - I. difficult to separate from resorption at a fracture site
     - II. eventually could form a resorption cavity
   - e. sequestrum
     - I. can form eventually
4. Associated with a surgically reduced fracture
   - a. soft tissue swelling is confused with post-surgical swelling
   - b. early periosteal new bone is confused with early callus
     - I. formation away from fracture site may be suggestive of infection
   - c. failure of callus formation is confused with delayed healing
   - d. avascular fragment
     - I. suggested by persistence of sharp margination
     - II. suggested by persistence of original bone density
   - e. sequestrum
     - I. can form eventually





Case 4.136

Signalment/History: "Molly" was an 18-month-old, female mixed-breed dog with a history of generalized disease characterized by a disseminated pneumonia complicated by the development of a pneumothorax. During treatment of this condition, she was noticed to be lame on the right pelvic limb.

Physical examination: The stifle joint was swollen.

Radiographic procedure: Studies were made of both stifle joints.

Radiographic diagnosis: A chronic avulsion fracture of the tibial crest was noted with a destructive pattern within the avulsed fragment and the adjacent tibia. Soft tissue swelling was noted plus effusion within the stifle joint.

Treatment/Management: The history made us suspicious that this was not just a traumatic avulsion fracture in a healthy bone. Both the avulsed fragment and the parent bone contained a destructive pattern and bridging callus could not be identified. Further examination of "Molly" indicated ulcerative skin lesions, eye lesions, and the previously diagnosed persistent pneumonia. A biopsy of bone tissue taken from the proximal tibial metaphysis was evaluated as inflammatory and distinctive organisms with unstained and double-contoured walls were diagnosed as *Blastomyces dermatitidis.*

At presentation

Week 2

Case 4.137

Signalment/History: "Morgan" was a 1-year-old, male Newfoundland with a history of trauma to a pelvic limb.

Physical examination: The limb was severely swollen and the examination was limited.

Radiographic diagnosis (at presentation): A spiral fracture of the tibia with marked overriding of the fragments resulted in protrusion of the distal tip of the proximal fragment into the soft tissues adjacent to the medial malleolus. The tarsus appeared not be affected by the trauma.

Treatment/Management: The fractured tibia was reduced by the placement of interfragmentary screws and a single metallic pin placed within the medullary cavity of the tibia.

Radiographic diagnosis (week 2): The first postoperative radiographic study was made two weeks after surgery and showed early callus formation in several locations along the distal tibial shaft. The borders of the fracture fragments had become difficult to identify suggesting a healing process. Good apposition and alignment of the fragments remained as at the time of surgery.

Month 2

Radiographic diagnosis (month 2): The second postoperative study made 8 weeks after surgery showed lucent cavities around the screws with a long lucent cavity at the site of the fracture line. Lucency was seen around the distal portion of the intramedullary pin. Apposition and alignment of the fragments remained as before.

Outcome: The form of fixation used was not sufficient to stabilize the fragments in the face of the bone infection. The owner refused further treatment in spite of being advised that the fixation would weaken, probably collapse, and the fracture end as a malunion at the best.

Comments: The presence of reactive periosteal new bone on the first postoperative study at a distance from the major fracture site suggests that it is secondary to infection and not a pattern expected with callus formation. The second postoperative study clearly shows the destructive pattern of bone infection with the osteomyelitis causing weakness of the metallic implants at the site of fracture healing.

4

At presentation

Case 4.138

Signalment/History: "Riley" was a 7-year-old, male Irish Setter with a history of having been in a dogfight two months previously. The left forelimb became swollen four weeks after the trauma and the dog was treated with antibiotics without improvement. The earlier radiographs were not available for examination, but osteomyelitis had been diagnosed on the study.

Physical examination: The left forelimb was swollen and painful to palpation. The adjacent joints palpated normally.

Radiographic procedure: Two views of the left antebrachium were made.

Radiographic diagnosis: Periosteal new bone affected both the left radius and ulna and assumed two patterns: the first pattern was that of an intact smooth elevation, while the second pattern was that of roughened spicules directed laterally and caudally (white arrows). The sclerotic pattern noted within the medullary cavities was probably summation due to the external cuff of new bone. The zone of transition was rather short. No evidence of cortical destruction was noted.

The radiographic signs were compatible with the tentative diagnosis of osteomyelitis following a bite wound. The level of activity of the bony changes was difficult to ascertain, but the pattern of new bone forming spicules suggested the lesion was active.

Differential diagnosis: The diagnosis of osteomyelitis remained high on the list because of: (1) the clinical history, (2) the interpretation made from the first radiographic study, and (3) the features on the radiographs made two months after the injury. The bony changes were progressive but remained benign in nature.

11 months later

Treatment/Management: The patient was treated with antibiotics and showed some improvement. Two weeks later, the radiographic appearance of the lesion remained the same. After a further two weeks, the lesion was curetted in an effort to hasten healing of the suspected bone infection. The surgical biopsy obtained at that time was that of a "fibrosing periostitis" with the tissues suggestive of an old inflammatory lesion in a stage of resolution with a low-grade smoldering inflammatory component. The patient showed periodic lameness during the subsequent healing of the lesion.

Outcome: Radiographs were made eleven months later because of the dog's continued failure to use the limb normally and showed persistent non-active smooth periosteal new bone secondary to the chronic osteomyelitis and surgical curettage. Note the new bone forming in the interosseous ligament (black arrow). The lesion was thought to be in a healing phase at this time.

Comments: The diagnosis in this case was rather easy because of the clinical history of a bite wound and the interpretation of the earlier radiographs. The differential diagnoses for a bony lesion of this radiographic appearance lying adjacent to the nutrient foramina should include: hematogenous osteomyelitis, hematogenous fungal bone infection, metastatic spread of malignant tumor, bony callus around an incomplete radial and ulnar fracture, and even a bizarre form of panosteitis. Diagnosis is made easier by the use of radiographs of the opposite limb as well as follow-up radiographic studies of the injured limb.

4

Case 4.139

Signalment/History: "Rusty" was a 2-year-old, male Viszla with a history of acute lameness of the right thoracic limb. He had a history of fighting with other dogs.

Physical examination: Pain was elicited upon deep palpation of the antebrachium. No other signs of abnormality were noted.

Radiographic procedure: Studies were made of the right forelimb.

Radiographic diagnosis: Radiolucent cavities with sharp margins were present in the right radius and ulna surrounding the nutrient foramina (arrows). Features of secondary reactive bone were not present.

Differential diagnosis: Lameness in a 2-year-old dog could be due to a variety of etiologies including inflammation, neoplasm, or even a developmental lesion such as a bone cyst with a pathologic fracture. If the lesion was inflammatory, it could have been either the result of a puncture wound, been hematogenous, or have been spread to the bone from the adjacent soft tissue.

Treatment/Management: The lesions were curetted in an effort to determine the etiology as well as to be possibly curative. A cancellous bone graft was implanted in the region. The surgical biopsy was evaluated as "containing necrotic bone with no evidence of active inflammation" and the lesion was treated as a sterile abscess.

The use of the cancellous bone graft plus rather deep curettage created a radiographic pattern that was somewhat confusing. Two months later the dog could bear weight on the limb. The slow clinical improvement suggested the presence of an active bone infection; however, no draining tract was present. Three months following surgery, the dog remained slightly lame on the limb, but with no soft tissue swelling or heat, and no draining tract. Recovery after that time was progressive and uneventful.

Comments: The lesions were thought to be hematogenous not only because of the absence of any positive history of bite wound or other injury, but also because of its location at the entrance of the nutrient vessels to the bone. This etiology was also supported by the absence of any periosteal new bone that would have characterized spread of an infectious lesion from the surrounding soft tissues. Lesions characterized by bone destruction at the site of the nutrient foramina need to be thoroughly evaluated for both inflammatory and neoplastic lesions.

Case 4.140

Signalment/History: A 1-year-old, male kitten was presented following a catfight, where he had sustained bite wounds in the distal left pelvic limb. The owners said that he had been non-weightbearing over the whole week since the injury.

Physical examination: The left hindlimb was swollen, warm, and painful to palpation. Draining tracts were present in the tibial region.

Radiographic procedure: Multiple views were made of the left pelvic limb.

Radiographic diagnosis: A destructive pattern was centered on the distal tibial physeal growth plate with the suggestion of collapse around the growth plate (left, arrows). A combination of periosteal new bone and some medullary new bone surrounded the destructive portion. The tibiotarsal joint appeared swollen; probably due to a joint effusion. Injury to the subchondral bone was difficult to evaluate.

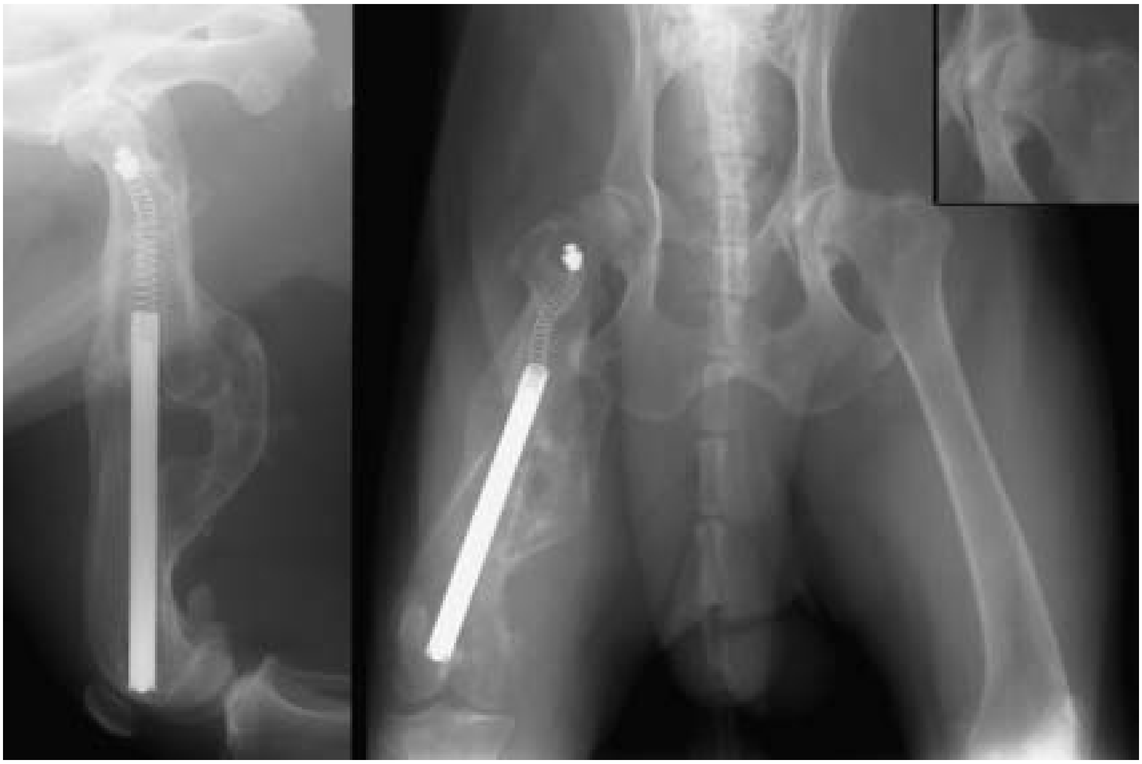
In addition, a primarily destructive lesion was present in the proximal tibial metaphysis that extended into the subchondral bone. A similar lesion was also present in the lateral condyle of the femur (right, white arrows). Stifle joint effusion was noted. Soft tissue swelling was evident throughout the limb.

Differential diagnosis: The destructive patterns in the tibia and femur suggested multicentric osteomyelitis: (1) secondary to direct implantation into the bone from two separate bite wounds, (2) secondary to one bite wound with the second lesion occurring after spread into the medullary cavity, (3) secondary to soft tissue infection with direct extension into the bone, or (4) secondary to soft tissue infection with hematogenous spread to the bone. The joint effusion suggested an infectious arthritis in both the stifle and tibiotarsal joints.

Two destructive lesions in one bone in a one-year-old cat with a history of fighting rules out most other diagnoses other than osteomyelitis.

Treatment/Management: Radiographs made six weeks later, after treatment with antibiotics, showed healing of the bone lesions. The cat was gaining weight and using the limb near-normally. All the soft tissue tracts had healed at that time with one exception.

Comments: The “cord-like” dense lesions in the proximal tibia (black arrows) suggested bone infarcts providing support for the idea that the lesions were at least partially due to hematogenous spread.



Case 4.141

Signalment/History: "Red" was a 3-year-old, male German Shepherd mixed breed with a history of a surgically treated femoral fracture some months earlier. He was presented at this time because of a draining tract near the stifle joint. According to the owner, he had not used the limb normally since the fracture.

Physical examination: Muscle atrophy of the right pelvic limb was prominent. Palpation of the thigh indicated a hard mid-shaft mass. Movement of both hip joints was abnormal with a feeling of joint laxity. The opening of the draining tract was medial to the stifle joint.

Radiographic procedure: Two views of the pelvis and femurs were made.

Radiographic diagnosis: A Jonas splint had been used to reduce the midshaft femoral fracture. The sleeve, spring, and pin could be identified. The spring had escaped the sleeve proximally instead of driving the pin distally from the sleeve. Apparently some stability had been achieved by this device, since the fracture had healed; however, the cavity at the fracture site and the persistent cortical shadows outlining the partially resorbed sequestrum were indicative of a chronic osteomyelitis. The laxity in the right hip joint was most likely secondary to hip dysplasia, disuse of the limb, and anteversion secondary to the femoral fracture. The malunion fracture resulted in a valgus deformity of the proximal femur that negatively influenced the development of the hip joint. The dog carried the limb abducted forcing the femoral head into the acetabulum despite the valgus deformity.

The subluxation of the left femoral head plus the remodeling of the femoral head and neck are features of joint disease secondary to chronic hip dysplasia.

Treatment/Management: The fracture site was explored surgically and the intramedullary device and the sequestrum were removed. The wall of the involucrum was curetted. The lesion healed satisfactorily although a mechanical lameness persisted because of the bilateral joint disease influenced by the trauma and the hip dysplasia.

Comments: The use of the Jonas splint was included in the text only as a historical feature. A stabilization of this type would not be used today. However, the consequences of a combination of different metal types in orthopedic devices were not recognized in the early 1960's.

Case 4.42

Signalment/History: “Max”, a 3-year-old, male Cocker Spaniel, was presented with a history of being bitten in the shoulder five months previously. The lameness resolved, only to recur two months after the injury. The soft tissue lesion initially healed and then a drainage track developed one month prior to presentation (four months post trauma).

Physical examination: “Max” showed no signs of pain or lameness during examination at the clinic. The drainage tract was present medial to the left shoulder.

Radiographic procedure: Radiographs were made of the left shoulder.

Radiographic diagnosis: The 1-cm-in-diameter, radiolucent lesion in the proximal metaphysis was characterized by dense surrounding reactive bone, which had a sharp, intact border. The lucent center of the lesion had probably contained a sequestrum at one time. The reactive periosteal new bone showed little sign of activity and suggested chronicity. The involucrum showed a defect medially without sclerotic bone that was a part of the cloaca (white arrow). The diagnosis was a chronic osteomyelitis with a resorbed sequestrum.

Differential diagnosis: In a 3-year-old dog, a primary bone tumor, a metastatic malignant tumor to bone, a hematogenous osteomyelitis, or a fungal bone infection needed also to be considered.

Treatment/Management: Because of the absence of clinical signs, surgery was delayed until the soft tissue lesion had healed. Even though the sequestrum could not be identified on the radiographs, curettage to remove the lining of the involucrum enabled the lesion to heal more quickly. Subsequent radiographs made three weeks later showed the bony lesion beginning to heal.

Comments: A chronic osteomyelitis in this location has features that strongly suggest a malignant lesion.

4

Case 4.143

Signalment/History: A 1-year-old, male Great Dane had a draining tract on its left antebrachial region following a dog-fight two months previously.

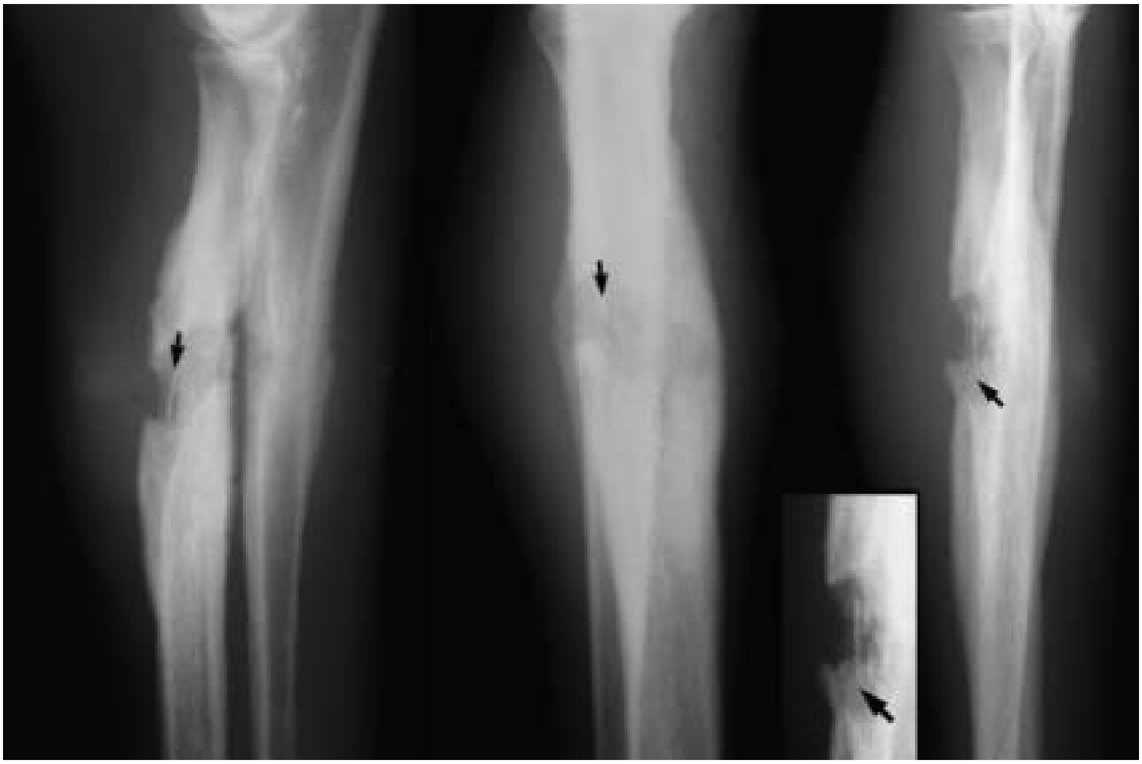
Physical examination: The draining tract was evident in the distal portion of the left antebrachium. Soft tissue swelling was prominent with heat and pain on palpation. Motion of the antebrachiocarpal joint was slightly painful, but full motion was possible.

Radiographic procedure: Studies were made of the left forelimb.

Radiographic diagnosis (at presentation): The lytic zone was centered on the lateral cortex and was surrounded by a sclerotic bony mass that included intramedullary new bone plus periosteal new bone. The bony response around the lucent site was mature and nonreactive at that time. The zone of transition was considered short. A radiographic pattern of this nature was thought to be diagnostic of an osteomyelitis with an involucrum and cloaca (white arrows). The sequestrum could not be identified. The inflammatory lesion had not spread to the adjacent radius.

Treatment/Management: The lesion was curetted, resulting in the removal of the involucrum and a sequestrum. Radiographs were made eight days later.

Radiographic diagnosis (day 8 after presentation): These showed a large saucer-shaped defect in the cortical bone.



Case 4.144

4

Signalment/History: "Chico" was a 10-month-old, female Labrador Retriever mixed breed with a history of being in a dogfight two weeks previously.

Physical examination: A large warm swelling was present over the proximal antebrachial region. Two draining tracts on the medial aspect of the limb exuded a hemorrhagic discharge. The patient could bear weight on the limb, but was definitely lame.

Radiographic procedure: Studies were made of the affected forelimb.

Radiographic diagnosis: The three radiographic views were all made at the time of admission and clearly showed a sequestrum within the involucrum (black arrows). Development of a cloaca was prominent. Soft tissue inflammation had lead to the development of reactive periosteal new bone on the adjacent ulna. The radiographic pattern was typical of that seen with a chronic osteomyelitis and sequestration following a bite wound.

Treatment/Management: The lesion was curetted with removal of the sequestrum. "Chico" was discharged much improved and able to walk more comfortably on the limb.

4

Case 4.145

Signalment/History: "Whompon", a 5-year-old, female Great Dane, was presented with a mass on her left forefoot. The foot had been swollen for three weeks, but she had been limping on this limb for a longer period. The dog had been treated briefly with antibiotics with a resulting decrease in the swelling; however, upon withdrawal of the medication, the swelling recurred and drainage was noted.

Physical examination: Swelling was limited to the terminal phalanges of the 3rd digit on the left forefoot. The draining tracts were also located on that digit.

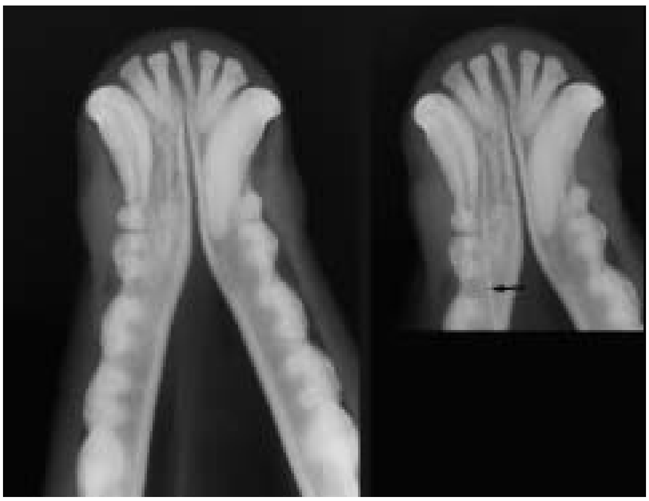
Radiographic procedure: Multiple views of the left forefoot were made with an attempt to separate the swollen portion of the 3rd digit from the more normal digits.

Radiographic diagnosis: Subluxation of the distal interphalangeal joint of the 3rd digit was noted along with marked destruction of the subchondral bone of the 2nd phalanx. The destructive lesion extended into the 2nd phalanx with a dense involucrum forming around the lytic area. Periosteal new bone was minimal; however, a pattern of mineralization within the soft tissues was noted. The 3rd phalanx did not appear to be involved in this process. The soft tissue swelling extended to involve most of the 2nd digit.

Differential diagnosis: This destructive lesion that extended to the subchondral bone, but did not cross the joint space was considered to be malignant. The fragmentation of the subchondral bone and the amorphous appearance of the new bone in the soft tissues were also strongly suggestive of malignancy. In comparison, the formation of a distinct involucrum suggested a more slowly expanding lesion and one that was benign, possibly inflammatory. The limitation of the lesion to one bone is more suggestive of malignancy than an inflammatory lesion. The identification of even one malignant feature in a radiographic pattern should make you strongly consider malignancy for a diagnosis.

Treatment/Management: The entire digit was removed surgically. The surgical biopsy revealed "an intense inflammatory reaction throughout much of the tissue with neutrophilic exudation and tissue necrosis". Dissecting tracts were noted grossly suggesting suppuration. The lesion appeared to be an acute suppurative inflammation that had resulted in an osteomyelitis and inflammatory arthritis. No evidence of neoplasia was present.

Comments: Treatment of a lesion in the 3rd phalanx often results in surgical removal. Therefore, it was thought to be appropriate to make the radiographic diagnosis of malignancy if there was any suggestion of an aggressive lesion. The failure of the inflammatory lesion to cross over to the third phalanx simply showed that not all lesions have "read the textbook" and follow instructions on how they should typically behave.



Case 4.146

Signalment/History: "Duke" was an 11-year-old, male Brittany that was presented with a chronic draining tract ventral to the mandibular incisor region. This tract may have been present for over a year.

Physical examination: The mandibular region was swollen and the lower canine tooth on the right appeared loose.

Radiographic procedure: Studies were centered on the lower incisor region.

Radiographic diagnosis: The area of soft tissue swelling was noted with the canine tooth "floating" so that it was misplaced laterally and was without any apparent bony attachment. A catheter (black arrow) was placed into a tract and advanced until the tip was located just medial to the canine tooth. Alveolar bone was missing. No reactive new bone was present, This pattern suggested a diagnosis of periapical osteomyelitis.

Treatment/Management: Surgical exploration produced a grass awn (foxtail) as the etiology of the chronic infectious lesion.

Comments: A destructive lesion should always be considered as possibly the result of a malignant process. In this patient, on the other hand, the chronic drainage strongly suggested a diagnosis of osteomyelitis.

Case 4.147

4

Signalment/History: "Damon" was an 11-year-old, male Doberman Pinscher who had run off 12 days previously. When the owner retrieved him from the authorities, he was noted to be lame in both pelvic limbs. Trauma was the suspected cause of the lameness.

Physical examination: Muscle wasting was evident in the pelvic region and the hip joints were painful on palpation and the extent of motion was limited. These findings suggested a more chronic lesion.

Radiographic procedure: Studies were made of the pelvis and hip joints.

Radiographic diagnosis: A destructive pattern was noted bilaterally in the femoral heads and necks, as well as within the flattened acetabulae. Collapse of the joint space was noted with marked destruction of the subchondral bone. Rather indistinct, generalized, reactive new bone surrounded the hip joints. These features were supportive of a diagnosis of osteomyelitis and infectious arthritis. Generalized muscle wasting indicated the chronic nature of the disease.

A transitional sacrococcygeal vertebral segment was present.

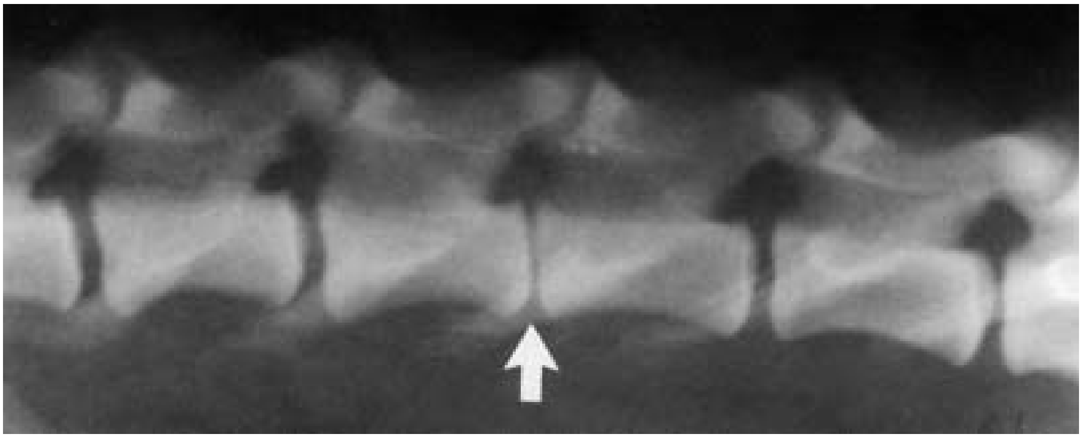
Treatment/Management: A joint tap was unsuccessful. A biopsy of one femoral neck produced tissue with many neutrophils suggestive of a suppurative osteomyelitis.

The dog was euthanized. At necropsy, both coxofemoral joints contained turbid sanguineous fluid with yellow floccules. Extensive loss of articular cartilage was characterized by adjacent cavitary lesions. The inflammatory pattern extended into the muscles surrounding the joint. No bacterial growth was obtained from samples taken from the hip joints; however, *Staphylococcus aureus* was grown from blood cultures. The diagnosis was a chronic suppurative arthritis.

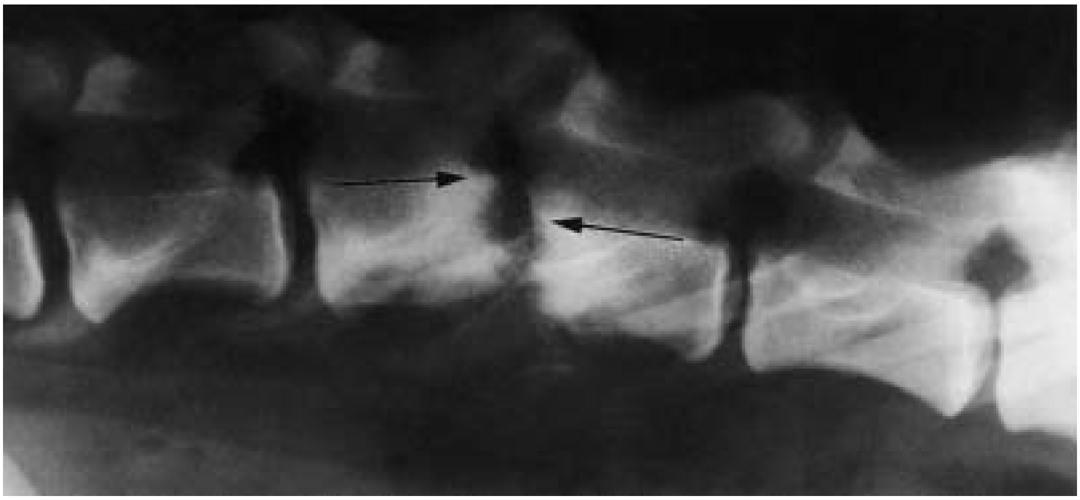
Comments: "Damon" was typical of many patients in whom trauma was suspected as the cause of lameness. Pets are often "carefully" examined following an absence from their home and the pelvic limb lameness was first noted following the return from being incarcerated. The owners thought the lameness was associated with the recent events. The radiographic changes indicated that the inflammatory process was chronic with severe destruction of both hip joints. Hematogenous seeding was thought to be possible because of the diseased syovium secondary to chronic arthrosis from hip dysplasia.

4

Case 4.148



Day 1



Week 4

Signalment/History: A 4-year-old, male Retriever had been struck by a car and was immediately brought to the clinic.

Physical examination: The dog could not walk. He was in great pain and would not permit a thorough examination. Pain was palpated in the midlumbar region.

Radiographic procedure: Lateral views of the thoracolumbar spine were made.

Radiographic diagnosis (day 1): Collapse of the disc space at L3–4 was prominent.

Differential diagnosis: Without any of the radiographic features of degenerative disc disease, the collapse was thought to be traumatic in etiology.

Treatment/Management: He was discharged having received corticosteroids.

When the dog was presented four weeks later, it was ambulatory on its forelimbs only and the muscle wasting in the caudal half of the dog's body was severe. He had increased patellar tendon reflexes, but no positive pain perception in the pelvic limbs. Additional radiographs of the L3–4 region were made.

Radiographic diagnosis (week 4): The widened disc space was characterized by marked end plate destruction and surrounding reactive new bone. The vertebral segments were malaligned. The diagnosis changed from a traumatic luxation to one of discospondylitis that was probably hematogenous in origin.

Treatment/Management: Cultures of urine, blood, and tissue obtained from the disc space under fluoroscopic control all grew a penicillin-sensitive *Staphylococcus aureus.* The peripheral white cell count was increased.

The dog was treated with 1 gram oxacillin TID and remained on that dosage for one month. This seemed to control the spondylitis; however, the segmental malalignment remained and the dog was eventually euthanized.

Chapter 5

Radiographic Features of Soft Tissue Injuries

5.1 Introduction

The value of soft tissue radiography associated with traumatic events is limited, but still remains rather interesting. An increase in the size of soft tissue shadows can assume several forms with either a generalized or focal swelling due to edema or hemorrhage. The distribution of the fluid is generalized when a distinct margin cannot be identified, and focal when a sharply marginated soft tissue structure can be identified. A decrease in the size of the soft tissue compartment is often identified due to the disuse of a limb that has resulted in muscle atrophy. If the accumulation of fluid is within a joint space, a particularly well-defined margin is created by the distended joint capsule. This is particularly evident adjacent to the femorotibial joint.

Increases in density in the soft tissues are caused by the presence of soft tissue mineralization of various types ranging from early calcification to mature bony tissue. Radiopaque foreign bodies may have differing densities, but usually have a specific shape and margination that permits them to be differentiated from the variety of soft tissue mineralizations. Debris on the skin may appear to be located deeply within the muscle of the limb on one radiographic view, but its true location can be better determined by examination of the opposite view as well. A physical examination of the limb prior to radiography may save an erroneous radiographic diagnosis of penetrating foreign bodies. The adherence of wet hair results in a rather dense shadow on a radiograph. The application of a bandage, cast, or splint generates shadows that are often specific and a glance at the animal itself will offer an explanation of their radiographic appearance.

The terms used in the description of soft tissue mineralization can be confusing. Most post-traumatic lesions can be referred to as dystrophic calcification or mineralization implying the deposition of mineral within a damaged tissue. Calcinosis circumscripta is a term used to describe a particular form of ectopic mineralization. It is found as a focal lesion within the subcutaneous tissues adjacent to joints, especially around the feet, where it is thought to result from repetitive trauma leading to a dystrophic mineralization of the injured tissues. A specific form, tumoral calcinosis is characterized by the presence of single or multiple, periarticular loculated cystic masses containing chalky material thought also to result from repeated trauma.

The quality of a radiograph taken for the identification of soft tissue lesions can be improved by utilizing a lower kVp setting, thereby making the study have a bit more contrast. It may help to study the radiograph carefully with a bright light to insure that the soft tissue portion is completely examined.

The most common foreign bodies in trauma patients in some societies are those resulting from a gunshot wound and assume a pattern typical for the gun that was used. The metallic missiles range from "B-Bs" and airgun pellets, to multiple shotgun pellets, to the tract left by a rifle bullet in soft tissues. If any of these projectiles strikes bone, the shape of the missile as well as that of the bone can be markedly altered (see Chap. 6). The metallic devices used for surgical reduction are expected foreign bodies, but they should be studied to see whether they have been properly implanted.

Puncture wounds into soft tissues caused by plant material or wood can not be identified on a noncontrast study because the foreign material has the same radiopacity as the surrounding tissues The foreign material can often be identified on a radiograph following the use of a contrast study of an associated sinus tract. If the foreign body results in a tract formation, either air or an iodinated contrast liquid can be injected into the tract to permit its visualization on the radiograph. This may then also identify the causative foreign body as well.

The identification of air within the soft tissues creates a less radiodense shadow and attracts attention to the site of the injury. It may be helpful in the identification of a foreign body or a deeply seated injury, such as a soft tissue rupture or a fracture.

5.2 Case presentations

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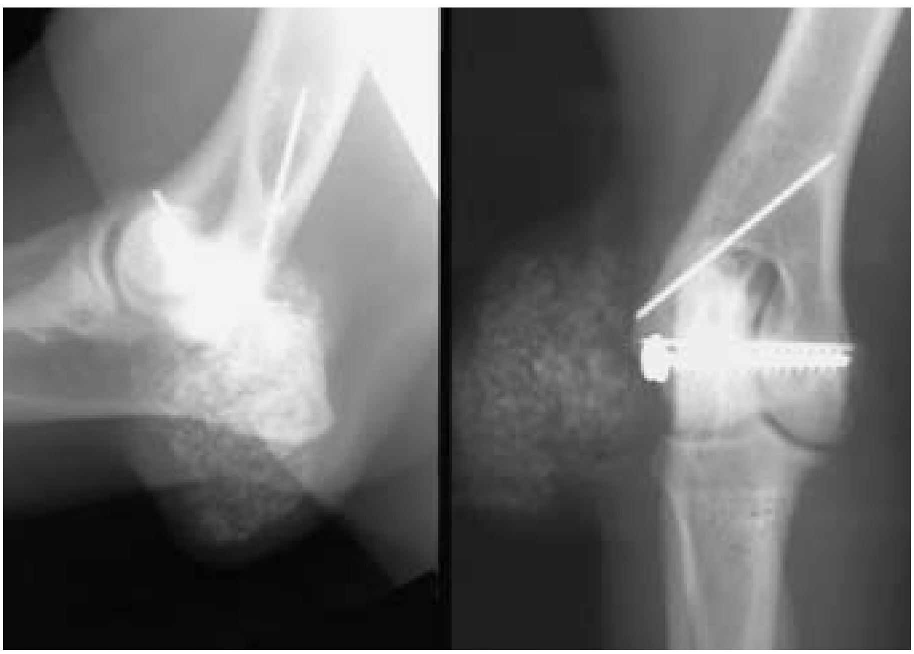
Day 1



Month 10

Case 5.1

Signalment/History: "Kelsey" a 3-month-old, female Labrador Retriever was presented with a complaint of non-weightbearing on the right thoracic limb. She had been running in a field and stepped into a hole and had been acutely non-weightbearing since then.

Physical examination: Crepitus was noted on movement of the right elbow joint. Marked swelling was present around the distal humerus.

Radiographic procedure: Radiographs were made of the elbow joint.

Radiographic diagnosis (day 1): Radiolucent lines separated the lateral condyle of the humerus with the fracture lines extending into the elbow joint.

Treatment/Management: The Salter-Harris Type IV fracture was repaired using a screw and 2 small Steinmann pins. Anatomic alignment of the fragment was obtained.

Radiographic diagnosis (month 10): Radiographs made ten months later showed the metallic implants to have remained in the same position with satisfactory healing of the fracture without any apparent injury to the growth of the bone.

A 3-cm-in-diameter, irregularly mineralized mass arose from the lateral aspect of the elbow. The mass seemed to be related to the head of the large bone screw, but no periosteal new bone could be seen. The mass appeared to be flocculated as though many pockets of calcified tissue were present. This would fit the diagnosis of tumoral calcinosis.

Case 5.2

Signalment/History: "Red" was a 7-year-old, male German Shepherd who had suffered a shotgun injury to his distal left forelimb.

Physical examination: The dog was lame on the left forelimb. His left elbow was swollen and painful on palpation. No crepitus was noted and near full motion was possible.

Radiographic procedure: Radiographs were made of the left elbow, the antebrachium, and the foot.

Radiographic diagnosis: Two patterns of increased soft tissue density were noted. One was a heavier pattern of small calcified foci that was located lateral, caudal, and proximal to the elbow joint. This pattern had sharp borders and all the foci appeared rounded and were of uniform density. No bone or joint injury was evident in connection with this pattern.

A more discrete second pattern of exactly the same size and density was the result of the gunshot injury. It was distal and was not associated with any fractures.

Differential diagnosis: The gunshot wound was thought to be the cause of the lameness. The soft tissue mineralization was chronic as evidenced by the discrete, well-marginated pattern. Gravel or dirt if mixed with the hair coat or incorporated within the skin following a "grinding" type of injury, might have caused such a radiographic pattern.

Treatment/Management: No treatment was considered for the shotgun wounds except to bandage the limb. Deep palpation of the skin and subcutaneous tissues around the elbow joint identified the lesions seen on the radiograph. A careful examination of the skin and subcutis indicated no debris of any type.

Treatment of the soft tissue wounds resulted in their healing and the case was lost to follow-up. Any clinical significance associated with the elbow lesions was not recognized.

Comments: The nomenclature for the type of chronic injury seen in the soft tissues of the elbow is not well defined. Dystrophic calcification may be a good term since it suggests a chronic injury with the development of multiple mineralized nodules. Mineralization of a tendon can occur, although the pattern seen in this elbow does not follow a tendon but remains more subcutaneous. In comparison, myositis ossificans suggests an injury leading to bone formation and is usually situated deeper in the muscle. Metastatic mineralization is more generalized and is associated with chronic renal disease, hyperthyroidism, or hypervitaminosis D.

5

Case 5.3

Signalment/History: "Rommell" was a large, 8-year-old, male mixed-breed dog with a history of having had a "traumatic" incident involving the tarsus one year earlier. The limb had been placed in a cast for one month after the injury because of persistent lameness and pain. The owners presented the dog for reexamination because of the continued lameness.

Physical examination: On presentation, "Rommell" was definitely "favoring" his hindlimb. On palpation, the tarsal region had a firm swelling and was painful on both palpation and on movement of the joint.

Radiographic procedure: A series of radiographs was made of the tarsal region.

Radiographic diagnosis: A pattern of soft tissue mineralization on the dorsal aspect of the calcaneous in the region of the attachment of the Achilles tendon created a cuff just proximal to the bone (arrows). A pattern of periosteal new bone, probably enthesophytes, was noted as well. The joints were all normal in appearance.

Differential diagnosis: The pattern of mineralization within the soft tissue and attached to the bone was typical of that seen in a post-traumatic situation. The margination was sharp and the density of the separate sites of mineralization was uniform. These two features suggested that the pattern not was related to either an acute or malignant process.

Treatment/Management: It was not thought that the changes seen on these radiographs were the cause of the clinical signs and radiography of the other major joints in the pelvic limb was recommended as there was the possibility that additional damage had occurred at the time of the injury one year previously. The owner chose not to spend any additional money, and "Rommell" was discharged without a definite diagnosis and with no specific treatment recommended.

Case 5.4

Signalment/History: A 14-year-old, female Beagle who had been a member of a colony was necropsied and radiographed following death.

Radiographic procedure: Radiographs of the forelimbs were a part of the total body radiographic study.

Radiographic diagnosis: Examination of the radiographs indicated a soft tissue swelling on the dorsal and medial aspect of the radiocarpal joint (arrows). Enthesophytes extending from the distal radius were typical of those reported as a part of the syndrome of stenosing tenosynovitis of the abductor pollicis longus (APL) muscle. The changes were bilaterally symmetrical.

Differential diagnosis: A single traumatic event might cause enthesophyte formation. The finding of exactly the same pattern of new bone on both forelimbs suggests a more chronic repetitive movement possibly dictated by the manner of the dog's physical activities while being caged in the colony.

Comments: The most important pathogenic factors in the etiology of a stenosing tenosynovitis of the APL are repetitive movement and a sharp angulation of the tendon at the radial styloid process. Overstraining of the tendon was probably due to an overuse of the joint particularly as the colony dogs spent a great portion of their day jumping against the enclosure's fence. While the primary radiographic feature was the bony proliferation just proximal to the styloid process, it was the inflammation and stenosis of the tendon sheath that would have impaired the free gliding movement of the tendon.

Chapter 6

Radiographic Features of Gunshot Injuries

6

6.1 Introduction

Gunshot injuries can result from the patient being shot either intentionally or accidentally. The frequency of gunshot wounds is variable depending on the culture of the society. In many patients, lead fragments or pellets are seen as incidental findings and indicate previous trauma; however, animals may be presented with acute gunshot trauma being the primary complaint. The type of gunshot wound is variable. In rural or hunting areas, shotgun and long-rifle injuries are encountered with the greatest frequency. In metropolitan areas, handgun and small-caliber gunshot injuries are more common. Guns discharging a small pellet may be found in the hands of children throughout the world.

The nature of the bullet or pellet varies with respect to size and shape, the number of pellets, and the velocity of projectile. The lowest velocity and the smallest pellet is the B-B and consequently, it is the least damaging and is usually only an incidental finding without clinical importance. However, if the range is short, these pellets can cause fractures in the cat and interestingly, can find their way into the spinal canal causing serious injury to the spinal cord. A slightly larger pellet is used in the air gun in which the velocity is greatly increased to such a level that these pellets often cause fractures. A shotgun injury varies depending on the size of the individual shot and the distance from the muzzle of the gun to the patient. Usually, these are injuries of minimal severity; however, at short distances they can be highly destructive to both soft tissues and to bone/joint. A rifle bullet can vary not only in size or caliber, but also with respect to the type of metallic coating, whether the ”nose” of the bullet in pointed or flattened, and its velocity.

The extent of tissue damage inflicted by a bullet depends on its velocity, mass, shape, composition, deformation (breakup), aerodynamic stability (yaw), hydrodynamic stability (“tumbling” characteristic), and on the mass and blood supply of the tissue traversed. Aerodynamic and hydrodynamic stability alter the impartable energy. If the bullet loses its stability as it travels through the tissue and begins to tumble rather than maintain a longitudinal flight, the amount of energy imparted to the tissue is increased. With low-velocity bullets, this increase is small; however, with high-velocity missiles the energy transmitted is markedly increased over a short distance.

The energy available to inflict injury from a moving object is related to the mass of the object times the velocity squared. The velocity of the missile as it strikes and passes through tissue is so important in influencing the wounding potential that some researchers believe it alone may serve as an indicator of the expected damage to the tissues. Traditionally, velocity has been used to classify expected injury from bullet wounds into high- or low-velocity injuries. A high-velocity bullet is classified as one that moves at a minimum rate of 600 to 750 m/sec. Many handguns/pistols ranging from .22 to .45 caliber have average velocities of 200 to 400 m/sec and are therefore considered low-velocity missiles.

The kinetic energy of high-velocity missiles is of such a large magnitude that on striking a tissue they impart tremendous energy to that tissue. When a bullet strikes a solid object such as a bone, all or part of its kinetic energy is immediately transmitted to the tissue. The resulting particles of bone accelerate forward and act as secondary missiles. One of the primary features of all missile wounds is cavitation. Within milliseconds after a high-velocity missile impacts and perforates, a pulsating undulating temporary cavity is formed. The surrounding tissue is subsequently explosively pushed and compressed laterally to enclose the temporarily formed cavity. The maximum diameter of this temporary cavity may be approximately 30 times the size of the original missile track. Therefore, tissues at a distance from the original wound may be damaged and adjacent bones may be fractured without ever having been struck directly by the missile or any secondary missile. In contrast, lower-velocity missiles create a direct pathway of destruction, with little injury to the surrounding tissues.

Bullet composition and design influence the extent of injury. Bullets that undergo mushrooming expand to several times their original caliber upon impact and establish a wound track with a frontal area far exceeding 30 to 40 times that of a fully jacketed, nonexpansile bullet, thereby increasing the wound volume.

A bullet track can be identified on a radiograph through the deposition of variously sized metallic fragments as the bullet passes through the soft tissues. If the bullet is steel-coated or has a hard coating of another type, there may be no fragmentation and the soft tissue track cannot be identified on the radiograph. A bullet tract may also be traced by a pattern of small bone fragments that reflect the fractures that have occurred. Clinically, it is important to determine the bullet track through the patient’s body either radiographically or by physical examination, so that all organs suspected of being injured can be identified and evaluated.

Classification of wounds can be made dependent on the velocity of the missile. Low velocity wounds are common and result from handguns or shotguns with velocities below 700

Table 6.1: Radiograph features of gunshot injuries

1. B-B gun pellet
   a. single pellet
   b. remains spherical when striking soft tissues
   c. deforms or breaks up when striking bone
   d. low velocity
   e. tissue injury
      I. minimal
      II. usually limited to soft tissues
2. Airgun pellet
   a. single pellet
   b. retains shape when striking soft tissues
   c. deforms when striking bone
   d. low velocity
   e. tissue injury
      I. usually limited to soft tissue
      II. can fracture a small diameter bone when fired at close range
3. Shotgun pellets
   a. multiple pellets
      I. dispersion based on distance of the patient from gun
      II. variation in size of pellets
   b. coating
      I. pellets remain spherical if steel-coated
      II. pellets deform when they strike bone if they are lead
   c. low velocity
   d. tissue injury
      I. based on size of pellet
      II. based on pattern size (distance from muzzle of gun)
      III. usually limited to soft tissue
      IV. if dispersion is minimal can cause severe comminuted fractures
4. Rifle bullet
   a. single bullet
   b. appearance of bullet can
      I. remain nearly unchanged
      II. tumble or fragment
      III. deform and fragment on striking bone
      IV. expand and mushroom
      V. leave a tract of small metallic fragments in soft tissue
   c. velocity of missile ranges from high to very high
   d. tissue injury
      I. missile creates a direct pathway of destruction
      II. high-velocity missile can
         i) cause massive secondary injury due to cavitation
         ii) accelerate bone fragments that act as secondary missiles

m/sec, while high-velocity wounds occur with velocities above 700 m/sec and propagate stress waves and cavitation. A penetrating wound is often the result of low-velocity missile that is retained in the tissue and has a typically small and ragged entry wound. A perforating wound is the result of a low- to high-velocity missile, with the missile passing completely through the patient. The exit wound is often considerably larger than the entry wound. Elastic tissue such as fascia and skin and spongy tissue such as lung show little devitalization when traumatized by even high-velocity missiles. Soft, bulky, homogeneous solid tissue such as muscle bellies, liver and spleen are violently disorganized and devitalized by missile wounds. Major vessel damage with a resultant compromising of blood supply and expanding hematoma enhance the extent of damage and the possibility of delayed healing.

Despite the potential for contamination associated with gunshot trauma, the results of a study have indicated a low prevalence of preoperative fracture contamination and postoperative osteomyelitis. These results implied either a low contamination rate or treatable contamination of the perifracture area (Doherty and Smith 1995).

Gunshot injuries and their radiographic features are uniquely dependent on the nature of the weapon (Table 6.1). An injury resulting from a bullet from a high-powered rifle is very different from that resulting from a shotgun loaded with small shot used for hunting birds. The distance of the dog from the gun also obviously affects the severity of the injury. Usually, these patients are presented as emergency cases and the owner knows what type of injury it is. However, there can be a delay in presentation if the owner is uncertain of the severity or nature of the trauma; in such cases, learning of a gunshot injury can come as a surprise.

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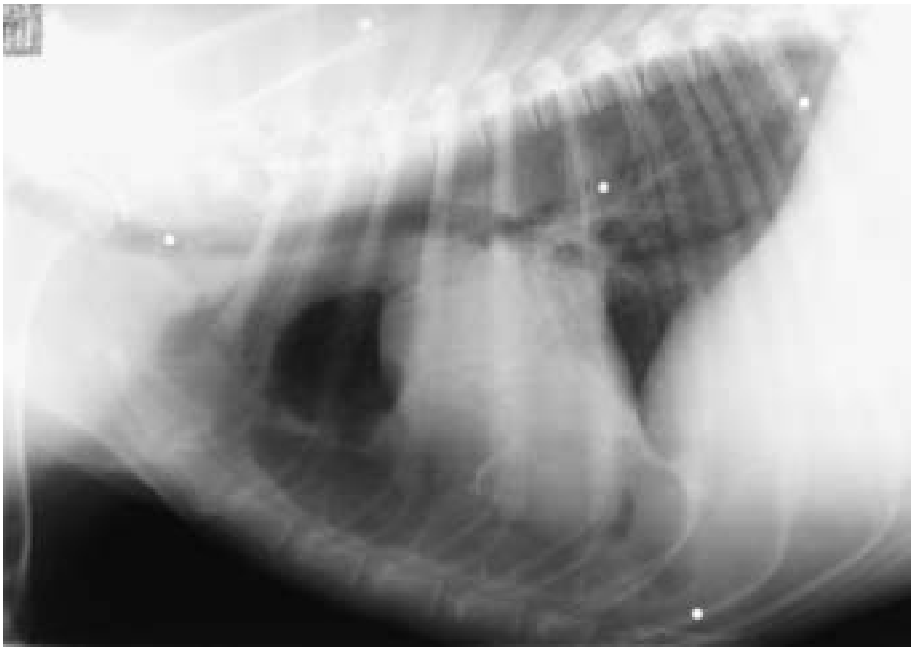
6.2 Case presentations

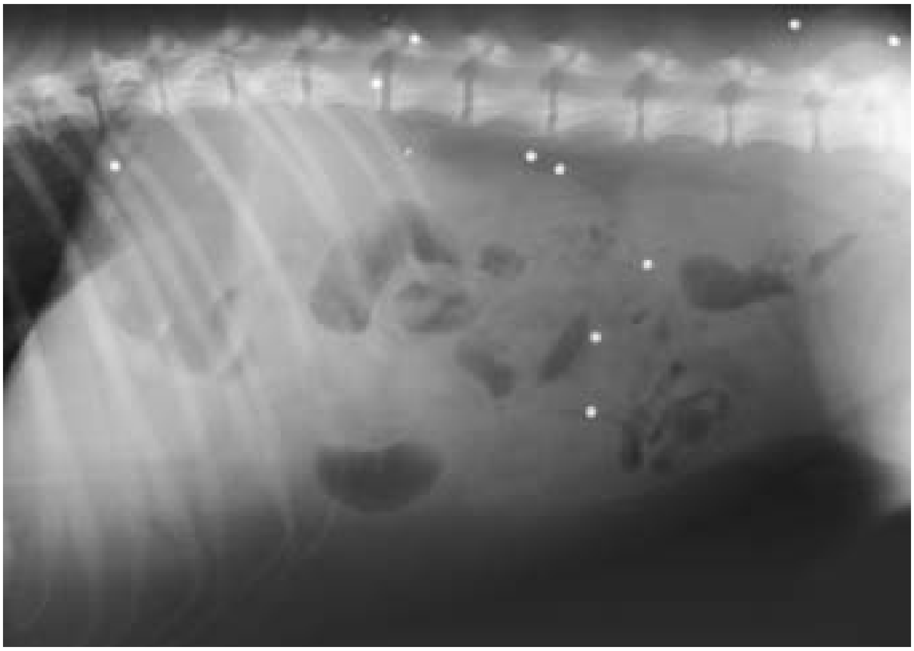


Case 6.1

Signalment/History: "Sadie" was a 4-year-old, female mixed-breed Retriever with a habit of chasing sheep in the neighbor's pasture. When the owner found "Sadie", she had severe skin injuries on the right side of her body.

Radiographic procedure: Both the thorax and abdomen were radiographed to determine the extent of the injury.

Radiographic diagnosis (thorax): A pulmonary infiltrative pattern was located primarily in the cranial lung lobes. A pneumothorax was bilateral with air that appeared to be both free in the pleural space as well as being trapped. Separation of the cardiac silhouette from the sternum was the result of the pneumothorax. Pleural fluid was prominent and was assumed to be the result of hemorrhage. Two intrathoracic metallic pellets were identified. The pulmonary vessels were small, suggesting shock. Subcutaneous emphysema was evident within the right chest wall.



Radiographic diagnosis (abdomen): Poor serosal contrast was assumed to be due to peritoneal fluid, most likely peritoneal hemorrhage. Free peritoneal air was within small cranioventral pockets and in the midabdomen. Multiple metallic pellets were identified; some fragmented. The subcutaneous emphysema extended along the right abdominal wall. A suspected fracture in the right 13th rib was near the costovertebral joint.

Differential diagnosis: The peritoneal fluid in a gunshot would could have been: (1) hemorrhage, (2) infectious peritonitis associated with perforated bowel, (3) bile peritonitis associated with liver and/or ball bladder injury, or (4) urine associated with rupture of the bladder. The small pockets of peritoneal air suggested bowel perforation with the probability of peritonitis.

A pattern of pellets from a shotgun could be seen in both the thorax and abdomen. Note how one of the pellets fragmented because it had struck the spine at L1–2.

Hemorrhage in both the pleural and peritoneal cavities was seen in association with both pleural and free peritoneal air.

Treatment/Management: "Sadie" underwent an exploratory laparotomy and 40 cm of small bowel with its accompanying mesentery were removed. Seven sites of intestinal perforation were located. "Sadie" was released from the hospital several days postsurgery.

Case 6.2

Signalment/History: "Shadow" was a 5-year-old, male Labrador Retriever who had had bilateral pectinotomy surgery two years previously in an effort to relieve the pain from bilateral hip dysplasia. He was presented at the clinic because right pelvic limb lameness had persisted.

Physical examination: Palpation of both hip joints was painful and showed limited motion of the joints.

Radiographic procedure: A single VD pelvic radiograph was made.

Radiographic diagnosis: Bilateral femoral head subluxation and remodeling of the acetabulae, and the femoral heads and necks were diagnostic of severe secondary joint disease due to hip dysplasia. Superimposed over the joint disease were multiple metallic densities indicative of a shotgun injury due to small "bird shot". The dispersion of the shot was small indicative of close range and was primarily on the left side.

Treatment/Management: Secondary arthrosis of this degree in a 5-year-old was not thought to be amenable to surgical correction except through the use of a total hip replacement. The owner chose that the dog be treated with conservative therapy instead.

Comments: The clinical signs of pain and lameness were due to the arthrosis. While the shotgun injury made an impressive radiographic pattern, it was considered an incidental finding, especially considering the small size of the pellets.

The lead shield was placed over the gonads to provide protection from the primary radiation.

6

Case 6.3

Signalment/History: "Tanker" was a 1-year-old, male Doberman Pinscher who had been shot the previous evening. The owner said that the dog was very close to the gun at the time of the shooting.

Physical examination: The left elbow appeared to have been almost destroyed by the injury.

Radiographic procedure: Radiographs were made of the left forelimb.

Radiographic diagnosis: A fracture of the distal humerus included a 2- to 3-cm-long butterfly fragment. Fracture lines were not identified entering the elbow joint. The metallic fragments were grouped medially around where the soft tissue injury appeared the most severe. No apposition of the bone fragments was present.

Treatment/Management: The fracture was first treated with an external K-E apparatus that was followed by placement of a bone plate. Healing was complicated by chronic osteomyelitis. The last study was done nine months after the injury. At that time, the elbow had undergone bony fusion and heavy callus formation was evident around the fracture site. Osteomyelitis was evident and several of the bone screws had loosened. The patient was lost to further follow-up.

Comments: Typically, a shotgun causes a low-energy injury. However, if the distance is short as in this patient, the concentration of the pellets creates a high-energy type of injury. Note that the fracture is proximal to the site of entry of the pellets. This is more typical of the type of injury seen with a very high velocity rifle bullet.

Case 6.4

6

Signalment/History: "Star" was an 11-month-old, male English Pointer who had suffered an injury to the head and left forelimb from being accidentally shot by his owner.

Physical examination: The injury to the head was easily detected. The fractures of the radius and ulna could be palpated.

Radiographic procedure: The dog was anesthetized and radiographs were made of the head, since it was thought that that injury was of greater clinical importance. Radiographs of the forelimb were delayed.

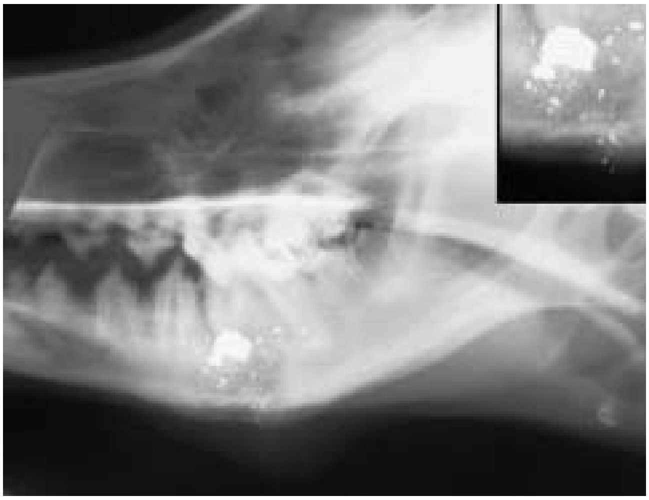
Radiographic diagnosis (head): Multiple metallic pellets were scattered within the nasal region without evidence of fracture. One pellet was within the left periorbital space as identified on the open-mouth view and several pellets were within the tongue. Many of the pellets were malformed, indicating that they had struck bone, while others left a trail of small metallic debris suggesting that the pellets were made of soft metal.

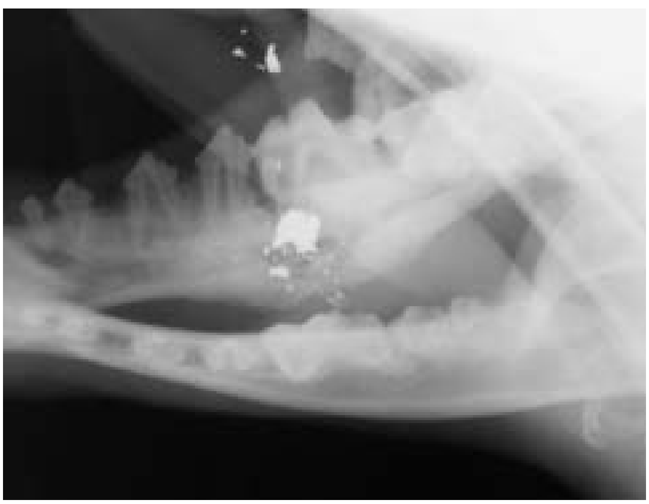
An increase in fluid density in the left nasal passages suggested hemorrhage at this location. The frontal view was especially important in the evaluation of the frontal sinuses showing that they were clear and without hemorrhage. Note the string adjacent to the canine teeth on the open-mouth view used to position the head on the tabletop.

Treatment/Management: None of the metallic pellets in the head were in a location suggesting the need for surgical removal. Examination of the eye was considered especially important as one of the pellets was in the periorbital space; however, no signs of injury to the eye were noted on clinical examination. The injuries to the head were treated in a conservative manner. The forelimb fractures were successfully reduced and stabilized and the dog discharged.

The fractures healed slowly because of the extensive soft tissue damage, but "Star" was eventually able to work in the field again.

Comments: The injury was typical of that resulting from being shot by a shotgun. The major force of the trauma was to the left forelimb, with the head located at the periphery of the shot pattern. Multiple views were required to access the head completely, and the study required use of an anesthetic.





Case 6.5

Signalment/History: "Skinny" was an 11-month-old, male Doberman Pinscher who was presented with a swelling around the horizontal ramus of the left mandible of unknown origin. The swelling had remained the same size for the previous four weeks. He was able to eat, although the owners admitted that they fed the dog outside and did not watch him closely while he was eating.

The lesion had been treated surgically with placement of a seton to encourage drainage. Antibiotic therapy had been tried. It was assumed that the lesion was subsequent to some type of trauma or plant awn (fox tail) migration.

Physical examination: On external palpation at the time of admission, the lesion was firm and not painful. The gingiva were intact and all the teeth appeared to fit tightly in the alveoli. The dog did not permit the mouth to be opened fully.

Radiographic procedure: Radiographs were made of the head with special views of the left mandible centered on the site of swelling.

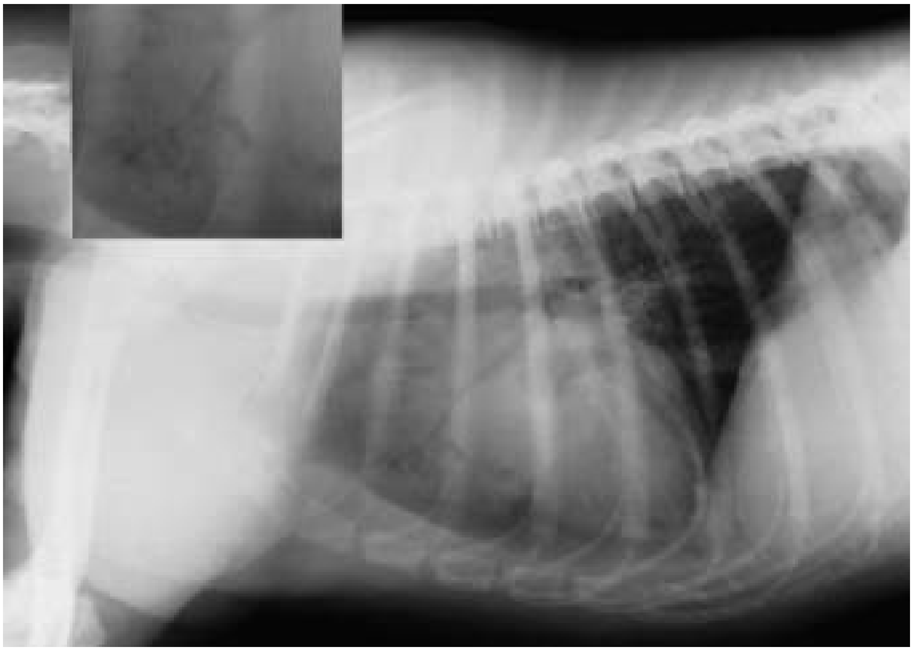
Radiographic diagnosis: A healing fracture of the horizontal ramus of the left mandible at the level of the first molar had a large bridging callus orally and ventrally. The fracture was chronic and thought to be the result of a gunshot wound on the basis of identification of the tract of metallic fragments at the fracture site, plus a single centrally located large metallic fragment. The fracture line remained open with a central radiolucent zone that was presumed to be infected with the area of osteomyelitis surrounded by a heavy involucrum (callus). Small bony fragments were presumed to be sequestra. Additional metallic fragments were present within the adjacent gingival tissues and within the tongue.

Differential diagnosis: The differentiation between a delayed union of a fracture because of a lack of stabilization of the major fragments and the presence of the metallic fragments, and a potentially non-union fracture because of a superimposed infection was not possible. The radiolucent zone strongly suggested an osteomyelitis.

Treatment/Management: Even though the lesion was solid at the time of surgery, the center was curetted, removing what appeared to be dead bony tissue and the large metallic fragment. Subsequent radiographs showed bony healing across the fracture site.

Comments: Treatment of the delayed-union fracture as if it was infected was the safest route, and it was thought that the surgical curettage would be beneficial in achieving rapid fracture healing.

This case is most interesting in that the owners admitted to knowing nothing about the injury and little about the dog's eating habits during the period of time after the trauma suggesting that clinical histories that accompany the patient to the clinic are often questionable in their accuracy.



Case 6.6

Day 1, thorax

6

Signalment/History: "Rex" was a 1-year-old, male Labrador Retriever with a gunshot wound in his right axilla and left pectoral region, as well as a fracture in the left antebrachium.

Physical examination: The examination was limited because of the injuries; however, the fractures in the left forelimb were easily noted.

Radiographic procedure: The thorax was radiographed to show the extent of the injury from the gunshot, and especially included the thoracic inlet. A study was also made of the left antebrachium.

Radiographic diagnosis (day 1, thorax): An extensive pulmonary hemorrhage within the cranial lung lobes had a superimposed pattern characterized by patchy air-filled cavities in the tip of the right cranial lobe that were suggestive of severe lung parenchymal damage, similar to that seen following trauma-induced pneumatoceles. A marked air-bronchogram pattern was seen in the cranial lobes.

A right-sided pneumothorax could be seen between the collapsed cranial and middle lobes and the thoracic wall. The pneumothorax also resulted in elevation of the cardiac silhouette. Minimal pleural fluid probably representing hemorrhage was seen throughout the thoracic cavity. Note how the fluid within the lung plus the pleural fluid created a fluid-like density that caused silhouetting with the heart shadow cranially.

Day 5, thorax

Radiographic diagnosis (day 5, thorax): Marked clearing of the pulmonary hemorrhage was noted on this study; however, persistent air-bronchograms in the peripheral lung lobes cranially, indicated a slower healing of the more severely damaged lung. Resolution of the pneumothorax and the pleural hemorrhage was noted.

▶▶

Day 1, antebrachium

Day 6, antebrachium

Radiographic diagnosis (day 1, antebrachium): A mid-shaft, complete, transverse fracture of the left radius plus an incomplete, mid-shaft fracture of the left ulna had associated bullet fragments in the surrounding soft tissue of the left antebrachium. Subcutaneous air was present in the left antebrachium plus a soft tissue pattern due to a wet hair coat. The elbow joint and antebrachiocarpal joint were normal.

Radiographic diagnosis (day 6, antebrachium): Reduction of the radial fracture using a five-hole bone plate was carried out on day 6. The ulnar fracture was now complete without fragment apposition. The larger metallic fragment had been removed. The placement of a rubber drain caused a prominent water-dense shadow dorsally and medially.

Day 90, antebrachium

Radiographic diagnosis (day 90, antebrachium): The healed radial fracture and a malunion healing of the ulnar fracture were noted. Small metallic fragments remained adjacent to the fracture site.

Comments: The injury to the lungs and delay in healing was typical of a bullet wound and different from that expected from blunt trauma seen when a dog has been struck by a car.

Interestingly, the bullet had entered the body near the right axilla, passed through the cranial thorax where it caused injury to the right lung lobe. It then exited the left chest wall cranioventrally and entered the left forelimb fracturing the radius and ulna.

Note how the bullet had lost most of its energy upon entering the forelimb and the large metallic bullet remained adjacent to the fractured bones. The radiographic features of healing of the well-stabilized radial fracture can be compared to the features of delayed healing seen in the ulnar fracture in which the fragments were left unapposed and without solid fixation.

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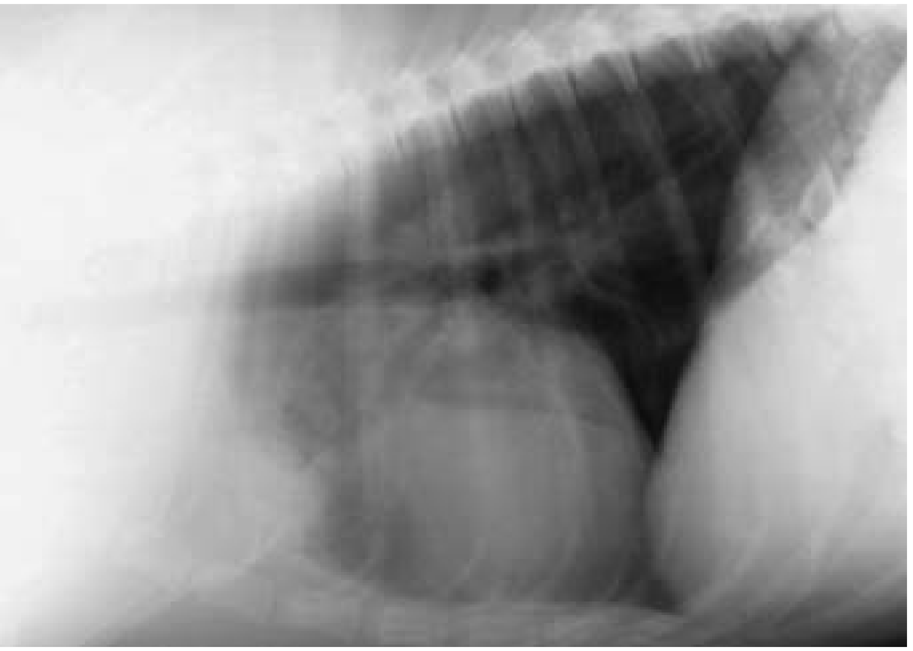
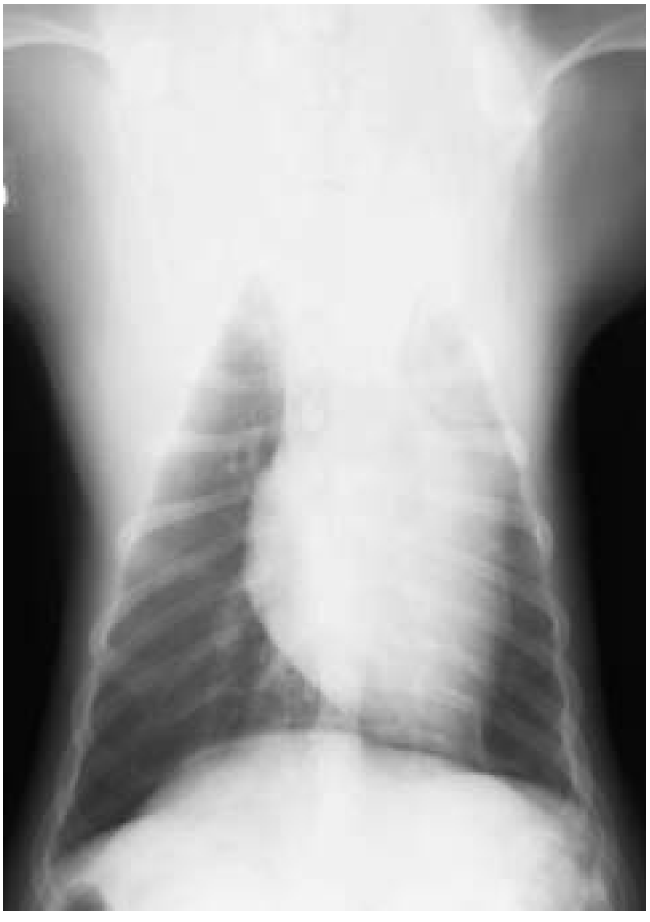


Case 6.7

At time of admission

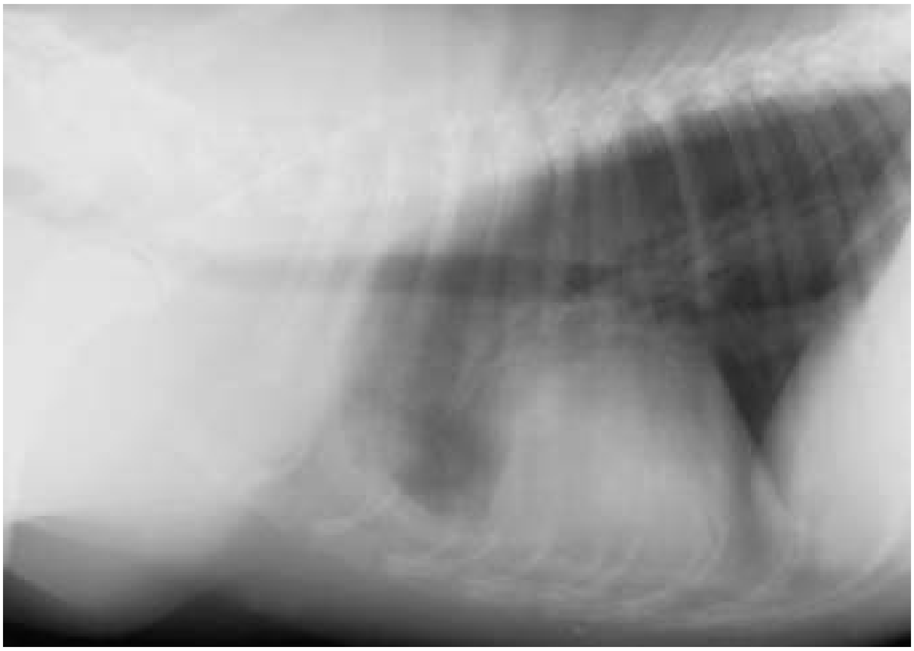


Signalment/History: "Roscoe" was a 5-year-old, male Labrador Retriever who had been injured in the morning by either being struck by a car or shot.

Physical examination: He was in shock on presentation.

Radiographic procedure: A series of thoracic radiographs were made to show the progression of changes associated with the trauma.

Radiographic diagnosis (at time of admission, thorax): The injury had caused hemorrhage within the left cranial lung lobe resulting in a prominent air-bronchogram pattern along with mediastinal widening suggestive of hemomediastinum. No injury was noted in the thoracic wall. The pleural space was normal with no free air or fluid. Soft tissue swelling around the right shoulder could be seen. The injury was more suggestive of a puncture wound such as might follow a gun shot injury rather than that following blunt trauma.



3 hours post admission

Radiographic diagnosis (3 hours post admission, thorax): A second set of thoracic radiographs were made three hours later and showed a minimal clearing of the fluid from the left lung; however, air bronchograms persisted. The volume of mediastinal hemorrhage had decreased slightly. Minimal pleural fluid was now noticeable.

▶▶

6

6 hours post admission

Radiographic diagnosis (6 hours post admission, thorax): A third set of thoracic radiographs made after another three hours showed a persistence of the mediastinal hemorrhage. The pleural hemorrhage had increased in volume. Air bronchograms persisted in the left cranial lobe.

Treatment/Management: Bullet entry and exit wounds were identified on both fore limbs. The dog was treated with blood transfusions. Pressure bandages were placed in the right axilla. The injury was thought to involve the right brachial plexus.

Day 6

Radiographic diagnosis (day 6, thorax): Radiographs made five days later showed persistent mediastinal hemorrhage. The left cranial lung lobe had re-inflated and had regained normal tissue density. A lesser amount of pleural fluid was evident.

Treatment/Management: The patient was discharged and not seen on follow-up.

Comments: The pattern of hemorrhage within the mediastinum and lung was typical of that seen in a patient shot by a rifle. The bullet did not strike bone so a pattern of metallic fragments could not be identified. The cardiac silhouette was slightly enlarged on all the studies and the possibility of hemopericardium was considered.

Case 6.8

Signalment/History: "Blue" was a 3-year-old, female German Shepherd who had been found that morning with a severe injury to the distal portion of her left pelvic limb thought to be from a gunshot.

Physical examination: Examination was limited because of the extensive tissue injury. Palpation suggested that the foot was attached to the upper limb by soft tissues alone, since no crepitus was noted.

Radiographic procedure: Two views were made of the pelvic limb.

Radiographic diagnosis: A gunshot injury from a very high energy bullet had destroyed a segment of the distal tibia, and a large portion of the soft tissue was missing, too. The comminuted fracture extended proximally to the midshaft of the bone and distally just proximal to the apparently unaffected tibiotarsal joint. No apposition of the fragments was present.

The very high energy bullet had a coating that had not fragmented and no metallic fragments could be identified within the soft tissues.

Treatment/Management: The owner was advised that the limb could not be salvaged and amputation would be necessary. The owners did not want a "Blue" with only three limbs and she was euthanized.

Case 6.9

Signalment/History: "Russell" was a 5-year-old, male mixed-breed Labrador Retriever, who had received a gunshot injury some months previously. He had been lame at that time, but was not presented for treatment and the owner admitted knowing little about the trauma. On the day of presentation, the pelvic limb lameness had recurred. It was more severe in the mornings and after resting. He seemed to "warm-out" of the lameness.

Physical examination: Palpation of the hips produced signs of joint laxity bilaterally, but the extent of motion of the pelvic limbs was thought to be normal. No evidence of muscle atrophy was noted. Pain was not detected, although dogs of this age and breed are often stoic.

Radiographic procedure: Ventrodorsal and lateral views were made of the pelvis with a special view of the left hip joint after review of the first radiographs.

Radiographic diagnosis: The radiographs showed bilateral femoral head subluxation (hip dysplasia) with no evidence of secondary bony changes. A rifle bullet was lodged in the soft tissues adjacent to the lesser trochanter on the left. The lesser trochanter was fragmented. An adjacent 2-cm-in-diameter fragment of bone density was thought to represent a fracture fragment or a soft tissue calcification that had remodeled, resulting in a smooth margin suggestive of chronicity.

Treatment/Management: The left hip joint had not been injured by the bullet. The metallic foreign body was not intraarticular and thus thought not to be clinically important at this time. Replacement of the fracture fragment was not considered possible nor required.

The pain from the hip dysplasia and from the soft tissue injury was not treated. The owner was advised to carry out limited exercise and control the dog's weight. The owner was also told that minimal trauma to hip joints of this character can produce pain and so cause clinical signs.

Comments: The injury to the lesser trochanter produced sufficient soft tissue injury to cause a secondary pattern of calcification and subsequent ossification. The absence of muscle atrophy suggested that no limitation of usage of the limb existed. The femoral head luxation was thought to be a part of bilateral hip dysplasia; however, the absence of secondary bony changes in a 5-year-old patient with dysplasia was thought to be unusual.

6

Case 6.10

Signalment/History: "Claire" was an 8-month-old, female Labrador Retriever who was presented with bleeding from wounds in the right pelvic limb. Two sites of injury were identified suggesting an entry and an exit wound.

Physical examination: The patient was in hypovolemic shock, but her breathing was thought normal. The pelvic limb wounds were easily identified and radiographs were ordered.

Radiographic procedure: Radiographs were made of the pelvis and both femurs.

Radiographic diagnosis: The soft tissue injury in the pelvis was on the right. It was severe, with swelling and a disseminated pattern of gas within the soft tissues. Several small metallic fragments could be seen lying deep within the muscles and suggested a high-energy gunshot injury. No fractures were identified and neither the hip nor stifle joints had been injured by the gunshot.

Abdominal radiographs were made and the bullet was identified within the right cranial abdomen.

Differential diagnosis: Often debris on the skin creates soft tissue patterns in trauma patients. In "Claire", the location of the metallic fragments and gas was not on the surface, but deep within the muscle mass; a pattern more typical for a puncture wound such as a gunshot wound. The additional radiographs located the bullet.

Treatment/Management: Exploratory surgery of the abdomen surprisingly confirmed a healthy status of the bowel without excessive peritoneal hemorrhage.

The injury to the arterial supply of the femoral limb was of concern, but the patient healed successfully and was released from the clinic.

Case 6.11

Signalment/History: A 2-year-old, male mixed-breed dog was presented because he could not walk normally. The owners knew nothing concerning the cause of the lameness.

Physical examination: The limb was swollen with skin lesions around the carpus. Palpation of the distal antebrachium was painful and crepitus was detected.

Radiographic procedure: Radiographs were made of the antebrachium.

Radiographic diagnosis: A comminuted fracture of the distal radius with associated metallic fragments suggested injury from a high energy rifle bullet (arrows). Cavitation had occurred at the time of the injury. The fracture was distant from the bullet tract, with one fracture line entering the radiocarpal joint. The radial carpal bone was displaced medially resulting in a radiocarpal luxation suggesting destruction of the medial collateral ligament. The lateral portion of the articular surface could not be identified, but was thought to be injured.

A clinically unimportant airgun pellet in the soft tissues lay adjacent to the cranial radial epiphysis.

Treatment/Management: The owners chose not to have the patient treated.

Case 6.12

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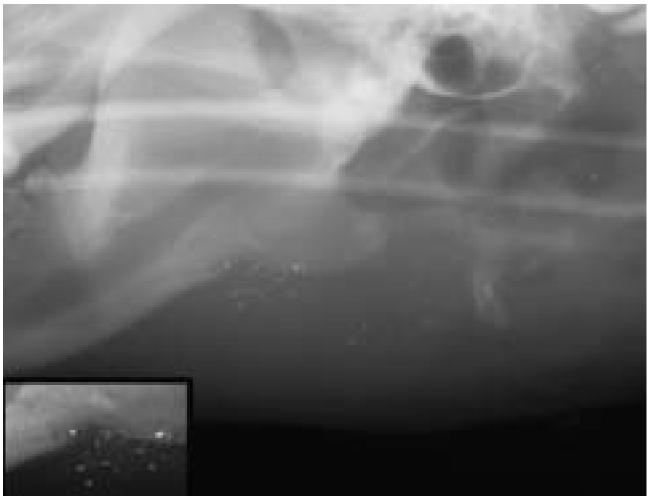


Signalment/History: "Buddy" was a 6-month-old, male German Shepherd unable to open his mouth to eat.

Physical examination: Swelling in the region of the left mandible was evident, however, a site of soft tissue injury was not noted. The mandible was painful on palpation, but no crepitus was detected. No abnormalities were evident on oral examination.

Radiographic procedure: Radiographs were made of the head with special oblique views of the site of swelling on the mandible.

Radiographic diagnosis: A gunshot wound characterized by the deposition of small metallic fragments along the bullet tract had caused an incomplete fracture of the left mandible just cranial to the angular process. The tract continued laterally causing soft tissue injury in the laryngeal region. The metallic pattern could be identified more clearly on the enlarged figures.

Treatment/Management: The fracture was not complete and required no fixation. The full importance of the soft tissue wound could not be determined from the radiographs. The dog was examined and found to be able to swallow normally. He was kept on a liquid diet for some days and subsequently released to his owner.

Comments: The fracture was typical of one resulting from an injury due to a high-energy rifle bullet. The tract could be identified along with the fragments that had resulted when the bullet struck the mandible. Removal of the metallic fragments was not required.

Case 6.13

6

Signalment/History: "Jinx" was a 4-year-old, female German Shepherd with bleeding around the head. The owners thought it was from a gunshot because they had heard shooting just before finding the dog injured.

Physical examination: The soft tissues on the right side of the head including the external ear were badly damaged. No effort was made to palpate deeply to determine the presence of bony lesions.

Radiographic procedure: Routine lateral and VD studies were made of the head with the dog awake.

Radiographic diagnosis: The metallic fragments associated with the bullet tract were located on the right side of the head and neck dorsally. The caudal portion of the zygomatic arch had been destroyed by the bullet. The normally air-filled external ear canal on the right could not be identified. The bullet tract appeared to be just dorsal to the temporomandibular joint, which was unaffected. The largest metallic fragment was located in the soft tissues dorsal and to the right of the second cervical segment.

Treatment/Management: The owners chose not to have the dog treated.

Comments: The radiographic presentation of the injury was typical of that resulting from a gunshot wound from a rifle bullet. When, as in this case, the path of the bullet is unknown, it is advisable to radiograph a larger area than usual to insure location of the bullet and detection of the entire bullet tract.

Case 6.14

Signalment/History: A mature Siamese cat had been found lying in the street unable to walk and was brought to the clinic.

Physical examination: The right forelimb was fractured.

Radiographic procedure: Radiographs were made of the right forelimb.

Radiographic diagnosis: A gunshot wound in the right forelimb had caused a comminuted fracture in the midshaft of the humerus with marked overriding of the bone fragments. The injury appeared acute. Some metallic fragments were at the fracture site, but the largest part of the bullet lay within the cranial thorax ventrally (arrows).

Treatment/Management: After the diagnosis of a gunshot injury, additional thoracic radiographs were made to evaluate the full damage caused by the bullet. Although it was lying on the floor of the thoracic cavity, it did not appear to have caused any injury to the surrounding organs. The humeral fracture was treated successfully.

Comments: The gunshot wound was typical of that seen with a rifle bullet; however, it must have been fired at a great distance since the bullet passed through only a minimal tissue thickness before coming to rest in the thoracic cavity. An air-gun pellet does not deform, as has this bullet.

Aging this bullet wound was difficult because it was impossible to know if the indistinct appearance at the fracture site was because of the comminution or because of an early callus formation.

6

Case 6.15

Signalment/History: "Gabriel" was a 3-year-old, male Labrador Retriever with a history of having been shot in the pelvic region four months previously. The hip had been operated on at that time, although the exact nature of the surgical procedure was not known.

Physical examination: Marked soft tissue atrophy was evident around the pelvis on the right without any evidence of skin lesions. Crepitus was prominent upon movement of the right pelvic limb. The lameness was not associated with pain and neurologic injury to the limb was thought possible.

Radiographic procedure: Two views of the pelvis were made.

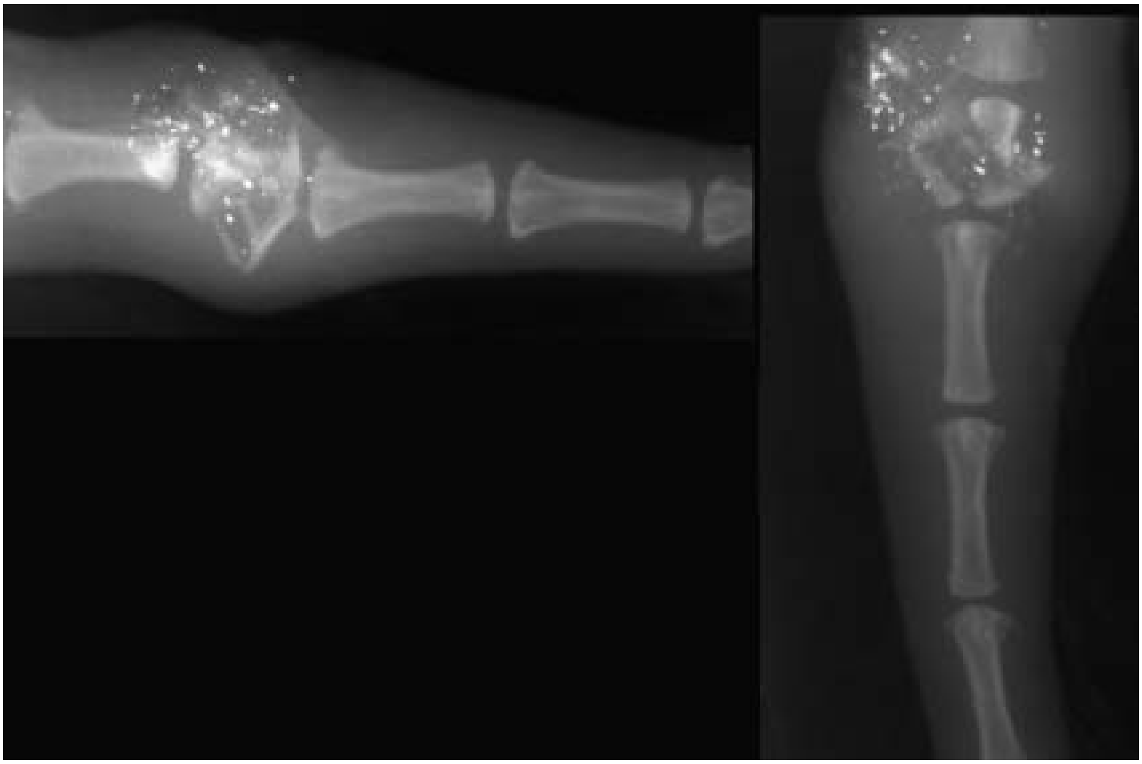
Radiographic diagnosis: A gunshot injury from a high-energy rifle bullet had resulted in fragmentation of the right femoral head with bony fragments evident within the acetabulum. Metallic fragments surrounded the hip joint. The right femoral head was luxated dorsally and was forming a pseudoarthrosis. A portion of the femoral head was missing presumably having been removed surgically.

The left femoral head sat well within the acetabulum; however, an enthesophyte was present on the femoral neck. The stifle joint was normal.

Radiopaque suture material indicated earlier soft tissue repair.

Treatment/Management: Surgery was scheduled to explore possible injury to the sciatic nerve. The nerve injury was identified but the attempted repair of the sciatic nerve proved to be unsuccessful.

Comments: Radiographs of a post-traumatic injury with a superimposed surgical trauma are difficult to evaluate. Osteolysis of the bone fragments and the remaining portion of the femoral head could have been the result of disuse or could have represented bone infection.



Case 6.16

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Signalment/History: "Shilow" was a 2-year-old, male mixed-breed dog, who lived in the foothills and was free to roam. He returned home one evening with a depressed expression and did not want to move his tail.

Physical examination: Swelling was noted around the right stifle joint with pain on palpation. Movement of the tail indicated a questionable region that had excessive movement and possible crepitus.

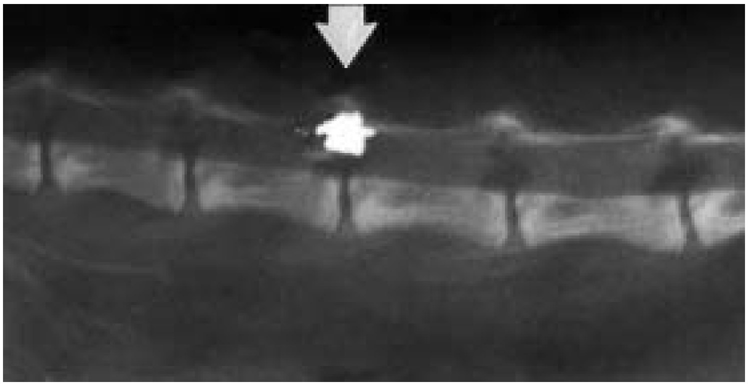
Radiographic procedure: Two views were made of the tail.

Radiographic diagnosis: A comminuted fracture of the 8th coccygeal vertebra was compressed with marked shortening of the segment. Multiple metallic fragments surrounded the fracture site suggesting a gunshot wound. The trabecular fragments were indistinct and it was not possible to determine the age of the fracture, the presence of early callus, or the presence of bone infection. The distal endplate was fractured probably indicating injury to that disc while the cranial disc appeared within normal limits. Soft tissue swelling was prominent.

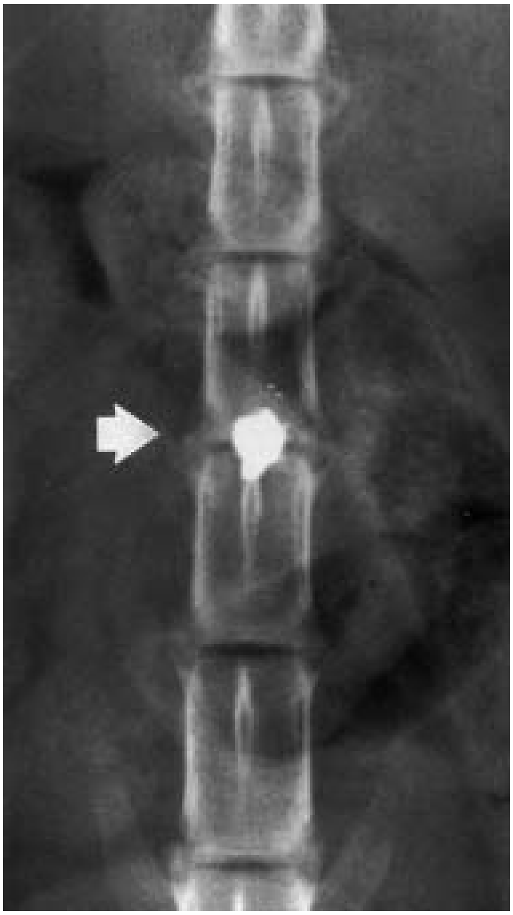
Radiographs of the stifle joint showed the presence of a single metallic shot in the soft tissues lateral to the joint.

Treatment/Management: The largest metallic fragment was removed surgically from the tail, although this was probably not necessary. It was not possible to stabilize the fracture and, in fact, palpation suggested that the fracture site was rigid and was of some duration with formation of an early callus.

Radiographs made two weeks later showed further callus formation and no evidence of destructive changes suggestive of bone infection.



Case 6.17



Signalment: A 10-month-old male Siamese cat was received in the clinic with a shoulder wound of 5 days duration that was of unknown origin.

Physical examination: The soft tissue wound in the region of the shoulder was complicated by the detection of pelvic limb paresis with exaggerated spinal reflexes and reduced response to pain sensation. Discussion with the owner suggested that the neurological signs were progressive during the 5 days.

Radiographic Procedure: Lateral and ventrodorsal views were made of the spine. (Views of the lumbar spine were included.)

Radiographic Diagnosis: A radiopaque foreign body (arrows)was clearly identified in the lumbar spine. Examination of both orthogonal views proved that the gunshot pellet was lodged within the spinal canal. Careful examination indicated that bone fragments originating from the dorsal laminae were located adjacent to the bullet within the spinal canal.

Comment: Loss of deep pain sensation occurred shortly following the examination and the cat was euthanized.

Case 6.18

Signalment: An 8-year-old male Labrador Retriever was presented having been accidentally shot by the owner.

Physical examination: The neurological signs were indicative of a cauda equina syndrome and radiographic studies were ordered.

Radiographic procedure: Two views of the lumbosacral region were made.

Radiographic diagnosis: Major bony disruption was not evident. However, what was important was a pathway made by a bullet leaving small metallic fragments that extended laterally at the level of the lumbosacral disc and at the level of the spinal canal (arrows). The result was destruction of the contents of the spinal canal at the level of the lumbosacral junction. Incidental findings were hip joints thought to be near-normal in conformation and minimal spondylosis deformans at the LS disc. The dilated status of the rectum was in agreement with the neurological injury.

Comments: The owner refused treatment and the dog was euthanized.

Chapter 7

Radiographic Features in Cases of Abuse

7.1 Introduction

The following narrative explains somewhat the change in attitude that has taken place since the first realization that abuse could be associated with some of the so-called trauma cases seen in a veterinary clinic.

"I remember the radiographs of the dog, his name was "Bobby", because we used the study every year for the annual spring university picnic. The Veterinary School furnished a radiographic exhibit of cases that would be of interest to kids. What could be more interesting than a dog that had "swallowed" a large metallic spoon? Later, we added to the exhibit other cases of interest. One was the cat with a needle embedded in the caudal nasopharynx. It was rusty and you could see the roughened surfaces. Then we added lateral radiographs of the thorax and abdomen of a large lion that had over 300 air-gun pellets within and under its skin. Two cases of cats with rubber bands around a foot and around the mandible were not as attractive, since they only caused a focal osteomyelitis, where the foreign body had cut through the soft tissue and come to lie next to the bone. We didn't include the radiographs of the pelvis of hunting dogs that had been shot in the course of their field activities because these cases were so common. Another case that was of interest to the rodeo fans was the young bull calf that had wire wrapped around its foot to generate pain, so the animal was easier to control. The only problem was that everyone had forgotten about the wire, and it was soon covered with hair and skin. All that remained was a huge, hard, swollen pastern joint with a massive periosteal new bone formation and periarticular ankylosis of the joint plus the wire."

Unfortunately, the veterinarian is faced with cases of this type rather frequently and they constitute several distinct problems. The first, and easiest to handle, is characterized by the owner of a large cat; who, by the way, did have a state permit to have such animals in a "private zoo". He readily admitted having shot the cat repeatedly, using it as a technique to "attract the cat's attention". He was somewhat embarrassed to realize that the pellets did not just bounce off the skin, but actually embedded and were probably painful. The hunters whose dogs are frequently shot are usually a group, who in anger or frustration, fire the gun with the thought that they may thereby correct aberrant behavior on the part of the dog. The owners of the young bull calf were just forgetful. Adults can usually be talked to and shown how their animal or pet has been injured. What may be of greater importance is the bringing to the attention of the owner of a patient in which the injury is more likely to be malicious and may be performed by a child within the household.

A recent article in *The Forensic Examiner* was entitled "Kids Who Kill". It stressed the relationship of attachment disorder, antisocial personality, and violence. "Cruelty to animals is one of the most disturbing manifestations of attachment disorder. It ranges from annoyance of family pets (e.g., tail pulling, kicking) to severe transgressions (e.g., strangulation, mutilation)." These children lack the capacity to give and receive affection with pets, lack the motivation to provide appropriate care, and delight in venting their frustrations and hostilities on helpless creatures to compensate for their own feelings of powerlessness and inferiority. Studies have found that children who abuse animals are five times more likely to commit violent crimes as adults (Levy and Orlans 1999). A majority of individuals who have committed multiple murders have also admitted to cruelty to animals during childhood (Cannon 1997). It should also be borne in mind that children who are sadistic are usually themselves the victims of cruel treatment (Fromm 1973).

What are the solutions open to the veterinary clinician, who during the examination of a pet, finds evidence of animal abuse (radiology is obviously only one method of making this determination). Remember that the clinician may only be suspicious of abuse, certainly does not know if it was committed by a family member, and does not want to risk losing a client by making a suggestion that may be totally rejected. However, the clinician may be the only person who is in a position to identify a disturbed child and interrupt what might be a pathway to further cruelty to animals. Remember that children with severe attachment disorders commonly manifest the three symptoms that are also found in the childhood histories of adult psychopaths: cruelty to animals, enuresis, and fire setting (Levy & Orlans 1999).

Please consider the following: talk to the owner of the pet and suggest that their animal may have been the subject of abuse. Let them know that this is not just a childish prank. Ask for their support. Make a report to child protective services if this option is open.

References

Cannon A. Animal/human cruelty linked. Denver Post, August 10, 1997.

Fromm E. The anatomy of human destructiveness. New York: Holt, Rinehart and Winston, 1973.

Levy TM/Orlans M. Kids who kill. The Forensic Examiner pp 19–24, March/April 1999.

7.2 Case presentations

Case 7.1

Signalment/History: "Geben", was a 1-year-old, male, German Shepherd mixed breed, who was radiographed after having been hit by a car three days earlier. He was lethargic, dehydrated, and icteric upon physical examination.

Physical examination: The dog was lame in the hindlimbs; however, no pain was detected on palpation and the hip joints palpated easily.

Radiographic procedure: Radiographs were made of the pelvis because of the dog's breed and the lameness noted in the examination room.

Radiographic diagnosis: A metallic foreign body (arrow) was noted dorsal to the right hip joint (a broken needle). The hip joints were not positioned perfectly, but no signs of dysplasia were noted.

Treatment/Management: "Geben" was treated for the systemic signs and recovered. The needle was not painful on deep palpation over the hip joint and no effort was made to remove it.

Comments: The origin of the metallic foreign body was unknown, but its location plus the fact that it was broken suggested that this was an example of abuse to a dog.

Case 7.2

Signalment/History: "Lassie" was a 14-month-old, female Collie with a history of sneezing both mucus and blood from both nostrils. The duration of the signs was not known by the owners. This was surprising to the clinician considering that the owners admitted that the dog was in the household regularly and the sneezing would have caused the surroundings to be rather badly soiled.

Physical examination: The nasal discharge was evident. No abnormality was noted during the examination of the head and neck, although it was limited because the dog was uncooperative.

Radiographic procedure: Studies were made of the head primarily for the nasal passages; however, open mouth studies could not be made.

Radiographic diagnosis: A metallic needle was clearly demonstrated within the turbinates. A little inflammatory response could be identified surrounding the foreign body.

Note the shadow cast by the clasp on the dog's identification band.

Case 7.3

Signalment/History: "Tiger" was a 3-year-old, male Pointer with a history of "pawing" at his face for the previous few days.

Physical examination: He refused to permit a thorough examination of his head; however, no nasal discharge was noted.

Radiographic procedure: Radiographs were made of the head including special views of the nasal cavity.

Radiographic diagnosis: A metallic foreign body (sewing needle) was located in the right nasal cavity. It had obviously been forced through the hard palate where the head of the needle still remained. The study shown here includes the placement of an intraoral location needle (arrow).

Comments: The second needle was positioned intraorally as a location needle prior to an attempted surgical removal.

Case 7.4

Signalment/History: "Schlutzie" was a 7-year-old, male Dachshund who had had a sudden onset of dysphagia 12 hours previously, refusing food and making frequent swallowing efforts.

Physical examination: He was uncomfortable in the examination room and made grunting sounds. He refused to eat food when it was offered and would not open his mouth widely. Sub-mandibular soft tissue swelling was evident. A complete oral examination was difficult and was delayed until the radiographs were made.

Radiographic procedure: Routine lateral and DV radiographs were made of the head and neck as a survey study. The radiographic exposure was decreased slightly so that the soft tissues could be evaluated better.

Radiographic diagnosis: A slightly bent metallic sewing needle was located within the oropharyngeal region slightly to the right and appeared to lie within the base of the tongue or epiglottis. The soft palate was swollen as was the retropharyngeal region, causing ventral displacement of the nasopharynx.

Treatment/Management: An unsuccessful effort was made to surgically remove the foreign body. The swelling reduced and the patient was discharged on a soft diet that he could eat. The owners were told to return if the dysphagia reoccurred.

Outcome: "Schlutzie" was seen in the clinic two years later having been just found by the owner bleeding from the ears. In addition, his left elbow was swollen and painful with a soft tissue lesion laterally. Radiographs of the elbow joint showed soft tissue swelling caudal to the proximal ulna without bony abnormality.

Comments: A history with repeated incidences of this type strongly suggested that this dog was being abused.

Case 7.5

7

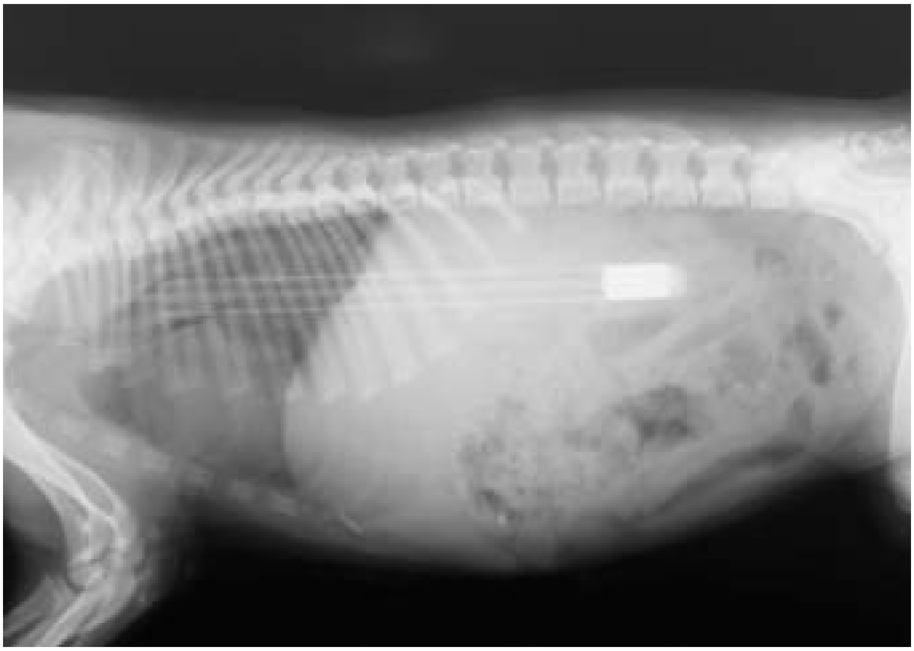
Signalment/History: "Charlie" was a male, Rottweiler puppy who refused to eat and when he did attempt to drink water, he experienced difficulty in swallowing.

Physical examination: Marked soft tissue swelling was evident ventrally from the caudal part of the submandibular region. An indistinct soft tissue mass could be palpated on the right side of the neck.

Radiographic procedure: Studies were made of the head and neck.

Radiographic diagnosis: A thin radiopaque metallic foreign body (needle) lay lateral to the larynx with a prominent soft tissue swelling on the right.

Comments: Note the "eye" of the needle was lateral suggesting that it had been pushed into the neck from the right side. The location of the eye of the needle made it unlikely for the dog to have been playing with thread and have accidentally swallowed the needle.



Case 7.6

Signalment/History: A female Boston Terrier puppy would not eat. The anorexia had developed acutely.

Physical examination: The abdomen was painful on palpation.

Radiographic procedure: Whole body radiographs were made.

Radiographic diagnosis: A linear gastroesophageal foreign body was identified.

Comments: It is unlikely that this type of foreign body could accidentally be swallowed by a puppy. This is an example of animal abuse. (Many thanks to Dr. W.J. Zontine.)

7

Case 7.7

At presentation

Signalment/History: “Rover” was a 4-year-old, male German Shepherd cross that was presented with a draining tract in the ventral cervical region, which had been evident for the previous week. The soft tissue lesion had been explored surgically several times without a foreign body being located.

Physical examination: The draining tract and associated soft tissue swelling were obvious.

Radiographic procedure: Studies of the thorax were made.

Radiographic diagnosis (at presentation): The lateral view showed a foreign body of metallic density just ventral to the heart (arrows). In addition, fluid was noted between the sternum and the heart. The cardiac silhouette was elevated. The dorsal aspect of the thorax appeared normal. Air was present in the esophagus just cranial to the hilus.

The pleural fluid was not noted on the DV view because it had shifted ventrally to the midline. The foreign body lay just to the right of the midline. The only other abnormal finding was a malunion fracture of the 6^{th} rib on the left.

Differential diagnosis: The radiographic findings were those of an intrathoracic foreign body (metal tip of an arrow with the assumption that a portion of the wooden or plastic shaft was still attached) and associated fluid that was loculated within the pleural space ventrally and/or possibly within the ventral mediastinum. Considering the history, the fluid was probably septic. Ventral mediastinal adhesions probably caused the loculation of the fluid ventrally.

Treatment/Management: The foreign body (arrow) was removed successfully from the thoracic cavity, where it was located within the ventral mediastinum.

▶▶

Month 3

7

Radiographic diagnosis (month 3 after presentation): Final thoracic radiographs were made three months after surgery, when the dog was continuing to have drainage from a lesion at the thoracic inlet. On the lateral view, the changes were limited to the ventral mediastinum, where the residual ventral mediastinal density was decreased in size but remained persistent. The cardiac silhouette was more normal in position than before. The lungs were normal in appearance except for a scalloping of their edges cranial to the heart suggesting pleural adhesions.

The DV view showed pleural thickening on the right side caudally that caused a separation of the lung from the chest wall. Widening of the cranial mediastinum was probably secondary to the chronic mediastinitis and/or pleuritis. The healed rib fracture was noted as before.

Comments: The persistent clinical signs were supportive of an active mediastinitis possibly associated with retention of a foreign body (probably arrow shaft). It was impossible to determine from the radiographs the activity of the mediastinal lesion. Considering the chronicity of the lesion prior to the surgery, the scarring and adhesions resulting from the wound and surgery probably healed leaving shadows of this nature. The clinical signs, however, suggested that this remained a chronic active mediastinitis.

The etiology was relatively easy to determine in this patient; however, the status of the mediastinal/pleural fluid could not be determined. Historically, the mediastinitis/pleuritis was chronic and probably remained active.

Case 7.8

Signalment/History: "O.J." was a 7-week-old, female Labrador Retriever puppy noticed by the owner to be lame.

Physical examination: Pain was not evident on examination; however, she was an excited, hyperactive puppy. She was definitely lame on more than one limb.

Radiographic procedure: A skeletal survey was performed with comparison films.

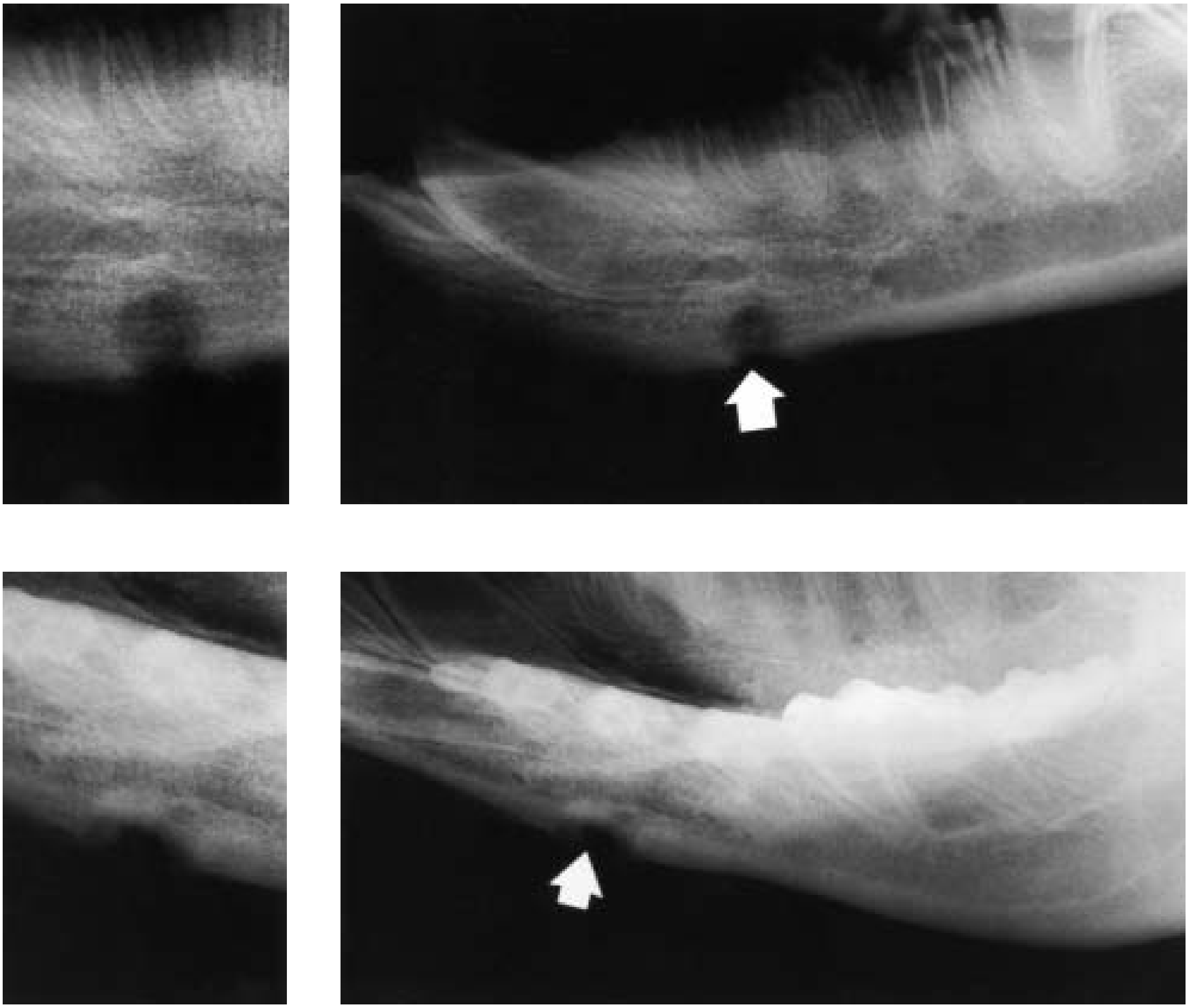
Radiographic diagnosis: A greenstick fracture of the mid-shaft of the right ulna (arrow), complete fractures of the proximal portions of the 2nd and 3rd metacarpal bones on the right (arrows), a transverse fracture of the right tibia, and a fracture of the right fibula were noted.

Differential diagnosis: In the absence of any explanation of how the multiple fractures occurred, the possibility of abuse should be considered.

Treatment/Management: The fractures were treated by splinting.

Outcome: The radial and ulnar and metacarpal fractures healed within two weeks. The complete tibial fracture was delayed because of movement at the fracture site. "O.J." was presented twice again, four months and 6 months later, both times for lameness. This history is suggestive of continued abuse.

Comments: Note the two prominent artifacts on the radiographs of the forelimbs. The tape holding the "R" marker extends across the toes on the right foot, while a large "hair" makes a curious arc across the 5th digit on the left foot (arrow).



Case 7.9

Signalment/History: "Tralee" was a 6-month-old, female Irish Wolfhound with a firm, hard swelling on the mandible at the level of the canine teeth. It had been present for two weeks and was becoming larger.

Physical examination: The mass was easily palpated, was hard and firm and not painful. The submandibular lymph nodes were enlarged. The dog permitted an oral examination, which was unremarkable.

Radiographic procedure: Lateral and oblique studies were centered on the mass lesion.

Radiographic diagnosis: A 0.8-cm-in-diameter lucent cavity was present in the ventral cortex at the level of the 2nd premolar (arrows). A periosteal response created a smooth border to the lesion. No sequestrum could be identified. The teeth were normal in appearance and no evidence of fracture was noted.

Differential diagnosis: A destructive lesion of this type may have been the result of a primary bone tumor or an infectious lesion secondary to a foreign body, or a puncture wound such as would occur due to a bite. The age of the dog and the absence of any clinical history of a soft tissue lesion excluded these etiologies. A focal osteomyelitis of this type is often found in association with an encircling devise such as a rubber band or string.

Treatment/Management: Surgical excision revealed a chronic irritative type lesion without evidence of an active osteomyelitis.

A surgical biopsy was taken from the tissue and submitted for examination. The curetted bone contained fibrous connective tissue and uncalcified bony matrix. It was diagnosed as active periosteal new bone without evidence of osteomyelitis. The soft tissue was immature and was heavily infiltrated with neutrophils and macrophages. An adjacent lymph node showed a diffuse increase in fibrous connective tissue. The lesion was compatible with a chronic irritation due to a foreign body.

Comments: The location and appearance of the lesion was typical for that seen with a rubber band or string foreign body placed around the lower jaw.

Case 7.10

Noncontrast

Signalment/History: "Sky", a 6-year-old, female Australian Blue Heeler, was presented with a history of having a large stick forced into her pharynx with possible entry into the esophagus.

7

Physical examination: It was not possible to palpate the cervical region. An open mouth examination was attempted, but the dog resisted.

Radiographic procedure: Lateral views were made of the cervical region followed by a barium sulfate swallow.

Radiographic diagnosis (noncontrast study): Free air was found within the retrolaryngeal space with a thickened epiglottis and soft palate suggesting a traumatic edema. No radiopaque foreign body was noted. No skeletal abnormalities were seen.

Contrast

Radiographic diagnosis (contrast study): The barium sulfate swallow was a simple radiographic technique to perform and revealed near-normal swallowing function with no leakage of the contrast agent into the surrounding soft tissues. However, the soft tissue air remained.

Treatment/Management: The diagnosis was made by the history furnished by the owner. The exact nature of the pharyngeal or laryngeal injury could not be determined and "Sky" was released to the owner after two days of hospitalization.

Comments: Patients such as "Sky" should be considered as having suffered from deliberate abuse.

The cervical region is difficult to evaluate on a DV or VD view, and oblique views are often of greater value. Increased size of the retropharyngeal space caused by soft tissue swelling secondary to trauma is difficult to evaluate because positioning of the head influences the size of the space, with its thickness being increased with the head in flexion and decreased with the head in extension. A lateral view of the head results in superimposition of the lateral processes of the atlas over the odontoid process; however obliquity of the head does permits good visualization of the odontoid process.

Chapter 8

Poisoning

8.1 Case presentations

8.1.1 Rodenticide poisoning

Radiographic examination following possible exposure to a rodenticide can be of value in determining the severity and location of the hemorrhage. While coagulation disorders have many causes, the occurrence of hemorrhage in a previously healthy patient should suggest inquiry into the possibility of poisoning. Of course, an acute traumatic event can also result in severe hemorrhage.

In the case of exposure to a rodenticide, many factors affect the radiographic appearance of the lesions. The amount of rodenticide, the time from poisoning until radiography, and the influence of therapy all exert a major affect. Still, as can be seen in the following patients, the location of the hemorrhage can vary markedly. It is obvious that both thoracic and abdominal centesis play a major role in determining the nature and volume of the fluid.

▶▶

Case 8.1

8

Signalment/History: "Buster" was a 7-month-old, male Lhasa Apso with primary complaints of inappetence, abdominal pain, and lethargy. Possible exposure to a rodenticide could have occurred 24 hours earlier.

Physical examination: His mucous membranes were pale and he had tachycardia.

Radiographic procedure: Studies of the thorax were made to establish a database for treatment of the patient. Thoracocentesis was also performed.

Radiographic diagnosis: An extensive pleural effusion was present, but more severe on the right with a mediastinal shift to the left. The trachea was parallel to the spine indicating slight elevation of the mediastinal contents. The cardiac silhouette could not be evaluated well. The nature of the lung parenchyma was not clearly visible, but the right lung may have been atelectic. The diaphragm was caudal and flattened, though it could not be definitely identified ventrally. A small pneumothorax on the right was located between the 7^{th} and 8^{th} ribs and was probably secondary to the attempted thoracocentesis.

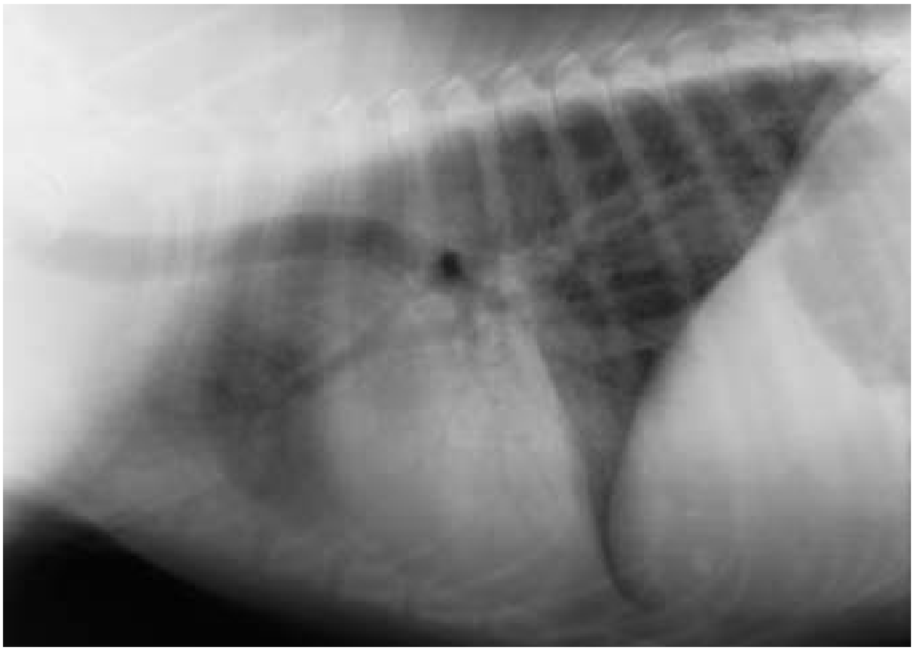
Differential diagnosis: The thoracocentesis revealed a bloody effusion with a PCV of 16 and total proteins of 5. A coagulation disorder with hemothorax can be due to a thrombocytopenia that is hereditary, acquired, or due to a platelet dysfunction secondary to rodenticide poisoning. In this patient, the owners acknowledged likely exposure to Warfarin. The major bleeding appeared to be pleural; however, mediastinal and pulmonary hemorrhage could not be clearly evaluated on this study.

Treatment/Management: Treatment of the poisoning with Vitamin K, plus treatment of the pneumonia with Baytril and Amoxicillin enabled "Buster" to be discharged two days following admission.

Subsequent radiographs of this patient suggested clearing of the pleural fluid with detection of a suspected pneumonia having developed in the left caudal lung lobe.

Comments: A differential radiographic diagnosis at the time of the first study might include any form of thoracic mass expected to produce a pleural effusion. The normal position of the gastric air bubble tends to rule out a diaphragmatic hernia.

8



Case 8.2

Day 1

Signalment/History: "Bridget" was a 2-year-old, female German Shepherd with a history of coughing associated with the production of a small amount of blood.

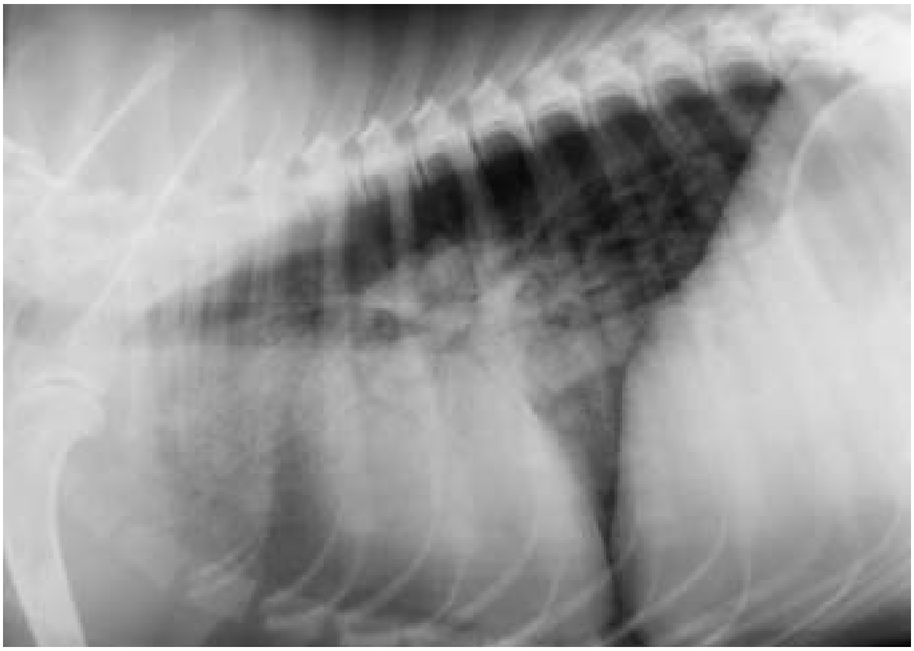
Physical examination: She was febrile with abnormal lung sounds and it was assumed that she had pneumonia. However, the PT and PTT were both prolonged, and it was thought that she could have a clotting problem.

Radiographic procedure (day 1): A marked increase in fluid density throughout the lung fields was most prominent on the left side. The prominent air-bronchogram pattern suggested alveolar flooding. Typical for many types of pulmonary disease, a collapse of the right middle lobe was noted. No pleural fluid was evident. A mediastinal shift was not evident.

Day 16

Radiographic procedure (day 16): Clearing of the lung field was noted with residual peribronchial markings that were thought to be more prominent than expected at this age.

Treatment/Management: The clinical history suggested the possibility of a rodenticide poisoning. The extent of the alveolar fluid seemed to be excessive for pneumonia in a dog that was not showing severe respiratory signs. The clearing of the pulmonary fluid was prolonged. The fever, plus the residual peribronchial markings in a young dog suggest a superimposed pneumonia and antibiotic therapy was incorporated in the treatment. Gram-negative rods were found repeatedly on tracheal washings taken throughout the time the dog was in the clinic. The extended hospital stay was due to the delay in clearing of the pneumonia.



Case 8.3

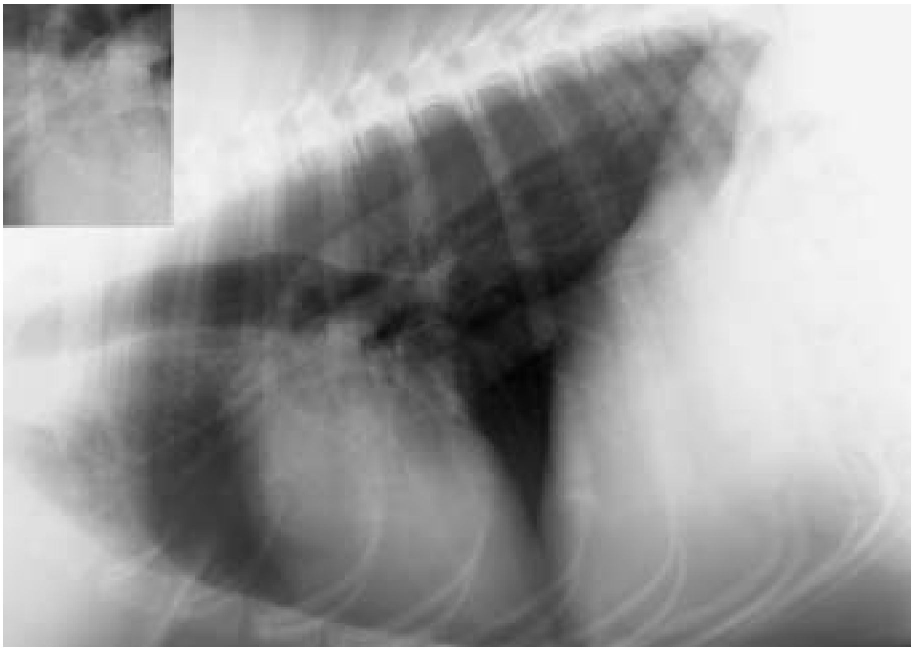
Day 1

Signalment/History: "Thor", a 1-year-old, male German Shepherd, was presented with a one-day history of hematuria, lethargy, anorexia, and coughing.

Physical examination: The lung sounds were harsh, the dog's mucous membranes were pale, and he was dehydrated.

Radiographic procedure: Studies of the thorax were made.

Radiographic diagnosis (day 1): Extensive alveolar infiltrates with prominent air-bronchogram patterns were present in all lobes except the right caudal and accessory lobes. The heart remained on the midline. The diaphragm was intact. No pleural fluid could be seen. A prominent skin fold was noted on the right. Air in the cranial esophagus created a "tracheal strip sign".



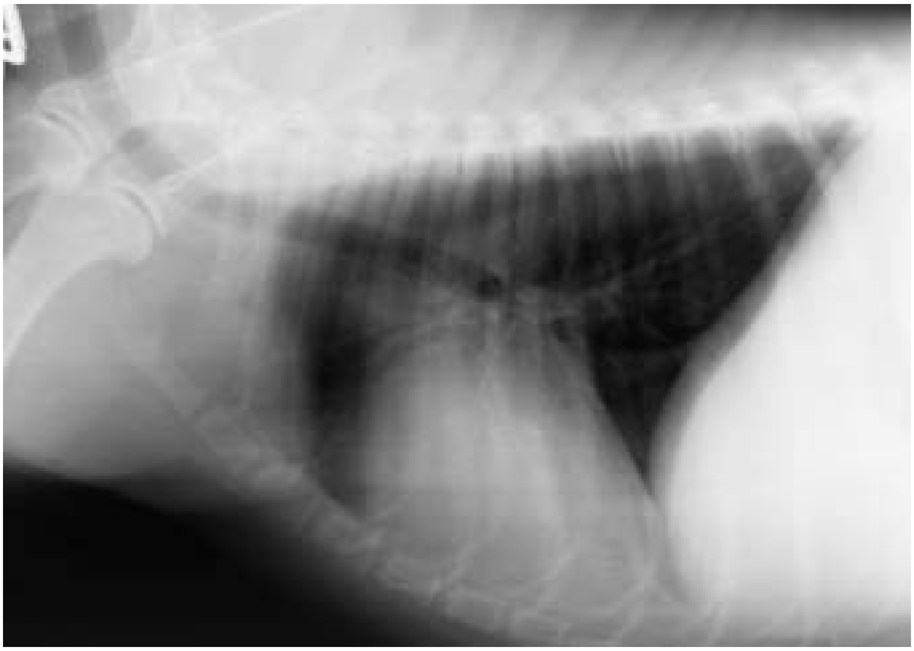
Day 10

Radiographic diagnosis (day 10): The study was considered to be radiographically normal.

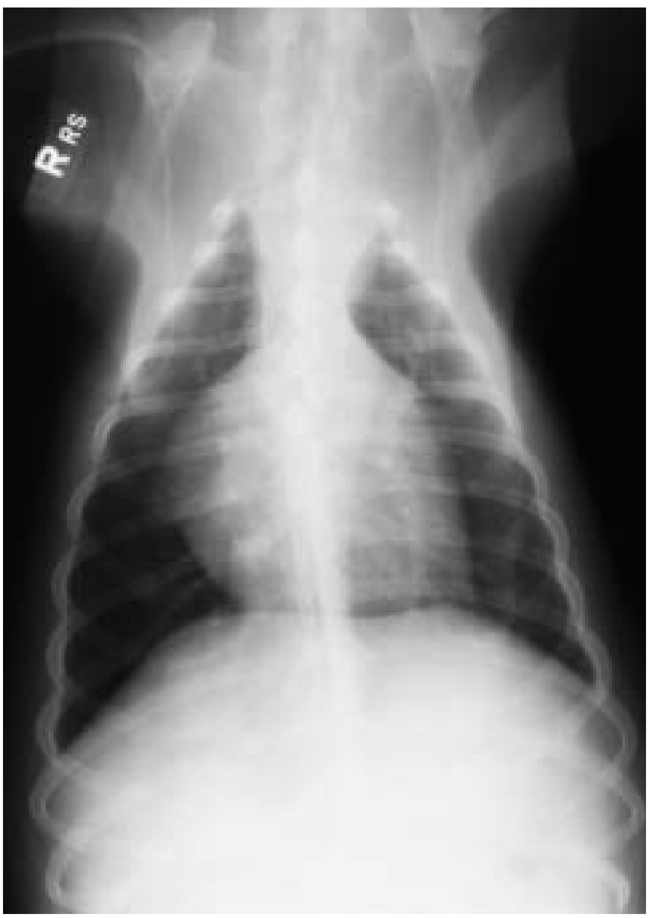
Treatment/Management: The PCV was decreased to 21.1%, RBCs were decreased to 1.93 M/µl, and the platelets were decreased to 109,000. The diagnosis was a coagulopathy, probably due to vitamin K antagonism. Complete resolution of the pulmonary hemorrhage followed treatment with Vitamin K1 for 30 days.

Comments: Note the abnormal location of the bronchus to the right cranial lung lobe as it coursed cranially only to make an abrupt turn. This was noted on both studies and was highly suggestive of an early or partial lung torsion initiated by an increased weight in a diseased lung lobe in such a deep-chested dog. The partial torsion could have delayed the clearing of the pneumonia. "Thor" was discharged and lost to follow-up, so the clinical importance of this finding could not be determined.

Case 8.4



Day 10



Signalment/History: "Jill" was an 8-year-old, female Pointer who had been treated with vitamin K for a suspected Warfarin poisoning. She was referred after the acute phase of the poisoning because of a suspect cranial thoracic mass.

Radiographic procedure: Studies of the thorax were made.

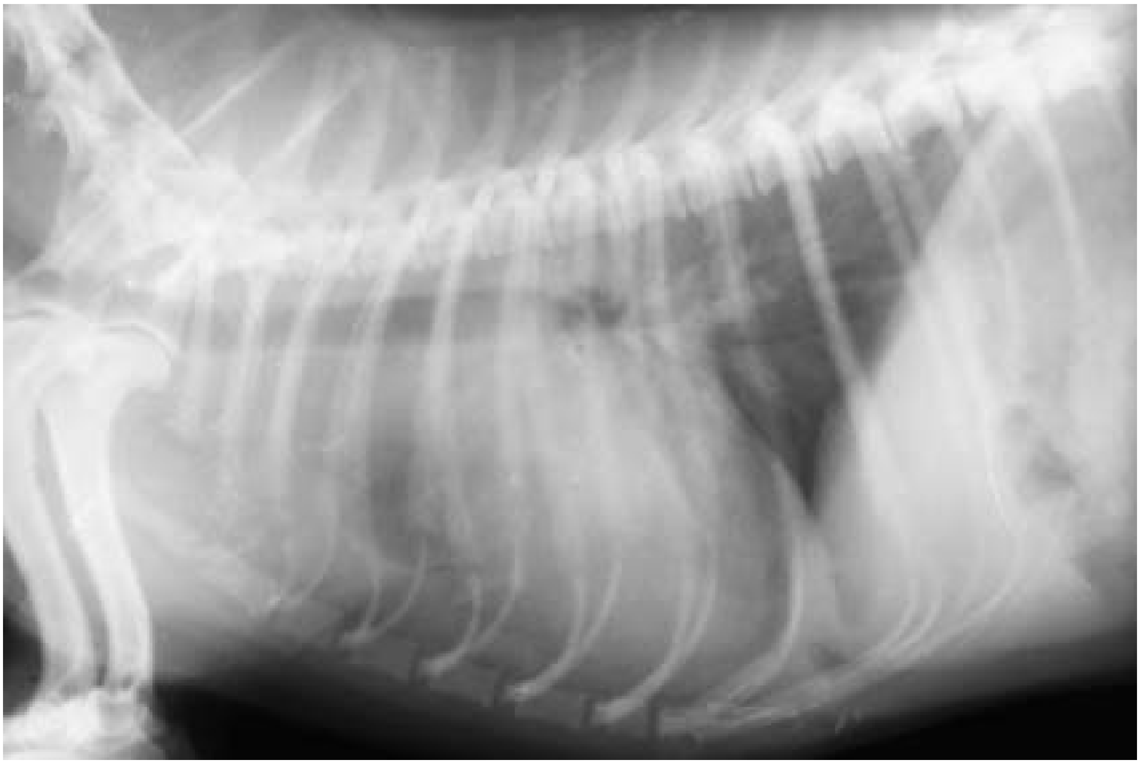
Radiographic diagnosis (day 10): A ventral cranial thoracic density on the midline had a rather distinct margin suggesting a cranial mediastinal mass. The enlarged cardiac silhouette suggested a probable pericardial hemorrhage. A loss of contrast in the abdomen suggested peritoneal fluid.

Day 40

Radiographic diagnosis (day 40): The mediastinal mass/fluid had disappeared and there was a decrease in the width of cardiac silhouette on the VD view.

Treatment/Management: "Jill" had been treated correctly prior to the time of referral and any pulmonary or pleural hemorrhage had cleared by that time. The mediastinal fluid was much slower to resorb and the referring clinician thought that because of her older age, she had an additional lesion, possibly a tumor. The mediastinal fluid had cleared by the time of the second radiographic study disproving that tentative diagnosis.

Case 8.5



Day 1, referral

Day 3

Day 6

Signalment/History: "Tasha' was a 4-year-old, female Terrier mix with a history of induced vomiting following suspected diphacinone intoxication. Clinically, she was improving at the time of admission to the clinic.

Radiographic procedure: Thoracic radiographs were made. Only the lateral views are shown.

Radiographic diagnosis (day 1, referral radiograph): Pleural fluid and pulmonary fluid were uniformly spread throughout the lungs and thorax. Mediastinal fluid was evident cranially, where it caused elevation of the trachea.

Radiographic diagnosis (day 3): Marked clearing of the pulmonary hemorrhage was evident except cranially, in what was thought to be a region of mediastinal hemorrhage. Clearing of the pleural fluid was evident.

Radiographic diagnosis (day 6): Radiographs made 3 days later showed a radiographically normal thorax except for a persistent thickening of the cranial mediastinal shadow.

Comments: "Tasha" was a typical coagulopathy patient except for the question of aspiration pneumonia, resulting from the owner attempting to induce vomition. The radiographs did not show any changes typical of aspiration pneumonia. The subsequent clearing of the hemorrhage was more rapid in the lungs than in the mediastinum. This was to be expected.

Case 8.6

Day 5

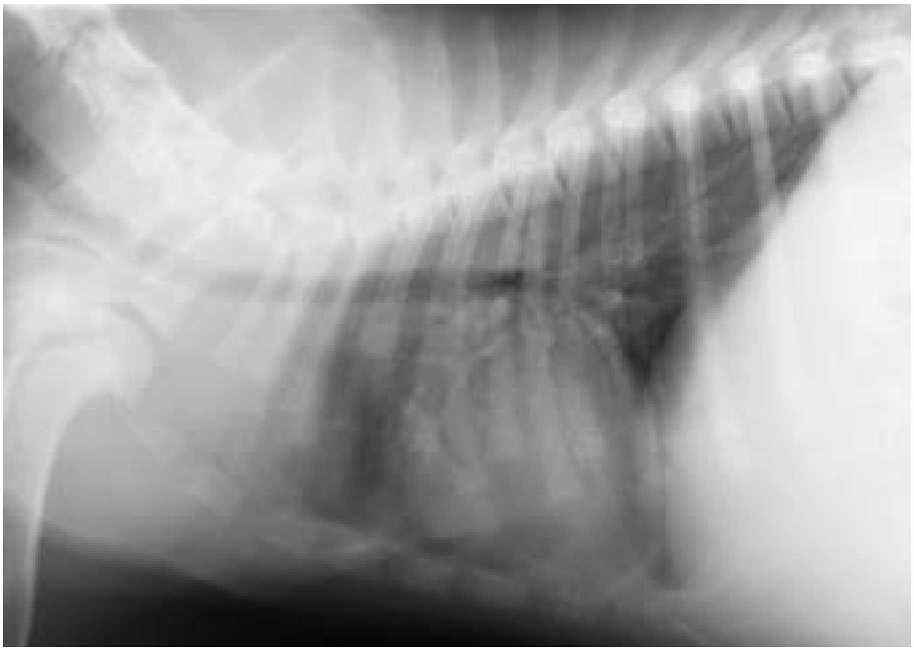
8

Signalment/History: "Boobie" was a 4-month-old, male Brittany with possible exposure to a rodenticide and had been on treatment for five days when presented for examination.

Physical examination: He was listless, febrile, with occasional lameness, and hematuria.

Radiographic procedure: Thoracic radiographs were made.

Radiographic diagnosis (day 5): A bilateral generalized alveolar pattern was apparent. Widening of the cranial mediastinum caused a mass-like lesion.



Day 8

Radiographic diagnosis (day 8): Partial clearing of the alveolar effusion was noted as well as a partial resolution of the cranial mediastinal mass-like lesion.

Comments: The possibility of secondary pneumonia can always influence the manner of hemorrhage clearing within the lung as seen on the radiographs in this case.

The clinical response of a patient usually shows improvement prior to the complete clearance of the pulmonary fluid as seen on the radiographs in this case. Radiographic examination following possible exposure to a rodenticide can be of value in the determination of the extent of the hemorrhage. While coagulation disorders have many causes, the occurrence of hemorrhage in a previously healthy patient should suggest inquiry into the possibility of poisoning. Of course, an acute traumatic event can also result in severe hemorrhage, but this is less common.

8.1.2 Herbicide poisoning

Case 8.7

Day 1

8

Signalment/History: "Pooper" was an 8-year-old, female Labrador Retriever with a history of high fever for 24 hours, rapid shallow respiration, and abdominal pain. She was referred for a diagnostic laparotomy. The surgery was delayed because of an absence of definite clinical signs to support the requirement for surgery. Two days later, she was in definite respiratory distress.

Radiographic procedure: Radiographs were made of the thorax.

Radiographic diagnosis (day 1): A minor increase in interstitial lung changes was present. This is not atypical for the dog's age; such changes were also suggestive of a pulmonary effusion. Malunion healing of the 7th and 8th ribs on the right was indicative of an old trauma. In addition, thickened pleura were adjacent to the malunion rib fractures. The heart was normal, no pleural fluid was seen and the diaphragm was intact.

Day 3

Radiographic diagnosis (day 3): A marked increase in fluid density in all the lung lobes along with an air-bronchogram pattern suggested an increase in diffuse alveolar fluid. No pleural fluid was evident.

Comments: The distribution of diffuse alveolar fluid was not hilar as would be seen with cardiogenic edema. The distribution was not lobar as expected with airway-oriented pneumonia and was not characterized by disseminated focal lesions as expected with hematogenous pneumonia. The acute onset of clinical signs complicated the determination of the diagnosis.

In this case, paraquat toxicity could only be proven on the basis of the owner's information.

Paraquat is a popular and effective herbicide; however, it is a harsh gastrointestinal irritant and in addition, has a most destructive impact on the respiratory tract. Poisoning can occur with oral, parenteral, aerosol, or dermal exposure. The symptoms in man are gastrointestinal pain and vomiting within 24 hours of exposure, followed by respiratory failure. The cause of the acute interstitial lung disease is unknown. The generation of toxic oxygen radicals is sufficient to damage normal pulmonary parenchyma and cause a secondary alveolitis. The pulmonary lesions can be classified as belonging to the group of Interstitial Lung Diseases of Unknown Etiology or within the group of Adult Respiratory Distress Syndrome or Respiratory Distress Syndrome.

Subject index

Numbers in bold type refer to tables with case references.