

Joe P. Morgan · Pim Wolvekamp

Atlas of Radiology of the Traumatized Dog and Cat

The Case-Based Approach

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Second Edition

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schlütersche

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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.

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.

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 accu-

rate 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 com-

pressed, 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 under-exposed 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 pro-

cessing 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 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 device consisting of alternating strips of lead and a radiopaque 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 used 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 created 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 result-

ing 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.