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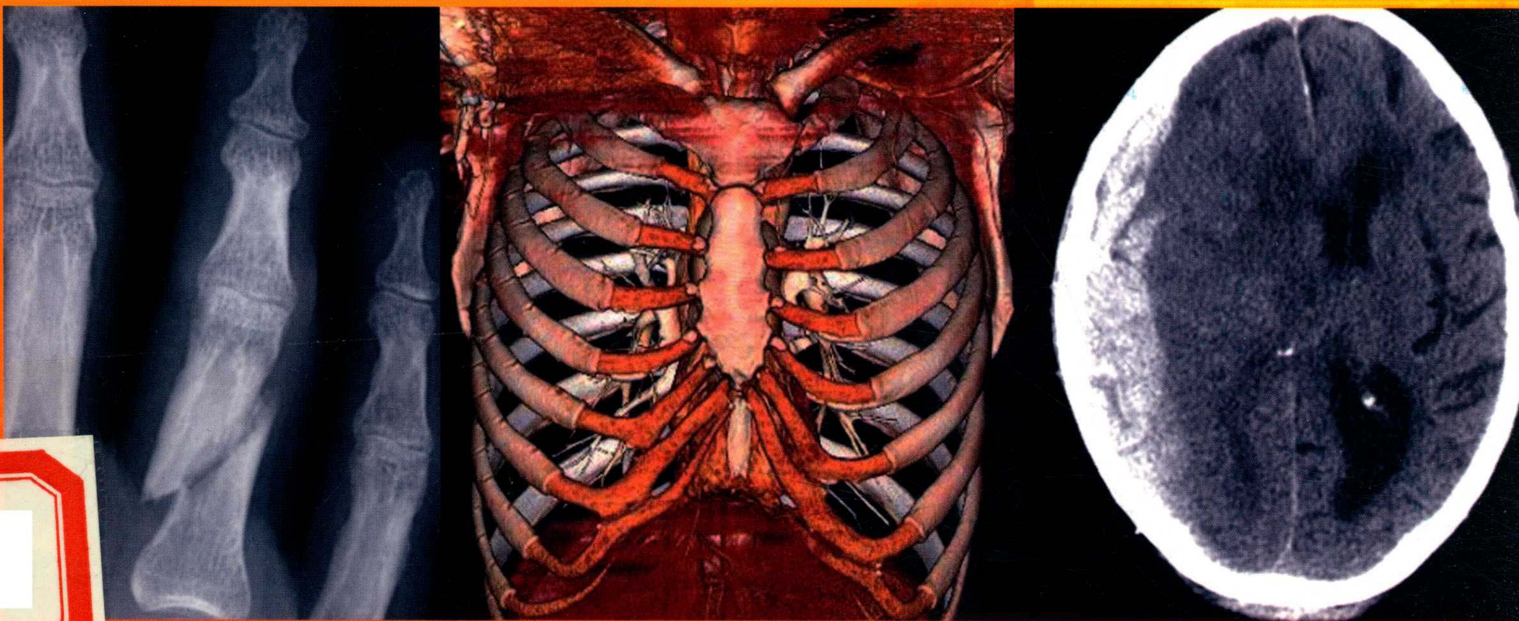
RECOGNIZING THE BASICS 3rd EDITION

William Herring



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Preface

I've checked, and most prefaces to a third edition or later start out with something like, "It's hard to believe that this is the third edition of..." Not this text. I know how much work it's taken, so I definitely **can** believe it. But thank you if you have contributed in any way, including reading this preface, to the success of this book.

In the first edition, I asked you to suppose for a moment that your natural curiosity drove you to wonder what kind of bird with a red beak just landed on your window sill. You could get a book on birds that listed all of them alphabetically from *albatross* to *woodpecker* and spend time looking through hundreds of bird pictures. Or you could get a book that lists birds by the colors of their beaks and thumb through a much shorter list to find that your feathered visitor is a cardinal.

This book is a red beak book. Where possible, groups of diseases are first described by the way they **look** rather than by what they're **called**. Imaging diagnoses frequently, but not always, rest on a recognition of a reproducible visual picture of that abnormality. That is called the ***pattern recognition approach*** to identifying abnormalities, and the more experience you have looking at imaging studies, the more comfortable and confident you'll be with that approach.

Before diagnostic images can help you decide what disease the patient may have, you must first be able to differentiate between what is normal in appearance and what is not. That isn't as easy as it may sound. Recognizing the difference between normal and abnormal probably takes as much practice, if not more, than deciding what disease a person has.

Radiologists spend their entire lives performing just such differentiations. You won't be a radiologist after you've completed this book, but you should be able to recognize abnormalities and interpret images better and, by so doing, perhaps participate in the care of patients with more assurance and confidence.

When pattern recognition doesn't work, this text will try wherever possible to give you a logical **approach** to reaching a diagnosis. By learning an approach, you'll have a method you can apply to similar problems again and again. An analytic approach will enable you to apply a rational solution to diagnostic imaging problems.

This text was written to make complimentary use of the platform on which radiologic images are now almost universally viewed: the digital display. Although digital displays may be ideal for looking at images, some people do not want to read large volumes of text from their digital devices. So we've joined the text in the printed book with photos, videos, quizzes, and tutorials—many of them interactive—and made them available online at StudentConsult/Inkling.com in a series of **web enhancements** that accompany the book. I think you'll really enjoy them.

This text is not intended to be encyclopedic. Many wonderful radiology reference texts are available, some of which contain thousands of pages and weigh slightly less than a Mini Cooper. This text is oriented more toward students, interns, residents, residents-to-be, and other health care professionals who are just starting out.

This book emphasizes conventional radiography because that is the type of study most patients undergo first and because the same imaging principles that apply to reaching the diagnosis on conventional radiographs can frequently be applied to making the diagnosis on more complex modalities.

Let's get started. Or, if you're the kind of person (like I am) who reads the preface **after** you've read the book, I hope you enjoyed it.

William Herring, MD, FACR

Acknowledgments

I am again grateful to the many thousands of you whom I have never met but who found a website called Learning Radiology helpful, making it so popular that it played a role launching the first edition of this book, which itself was so popular that it led to this third edition.

For their help and suggestions, I thank David Saul, MD, one of our radiology residents, who made invaluable suggestions about how this edition could be changed. Daniel Kowal, MD, a radiologist who graduated from our program, did an absolutely wonderful job in simplifying the complexities of MRI again in the chapter he wrote. Jeffrey Cruz, MD, one of our residents, helped out with the online Radiation Safety and Dose module, and Sherif Saad, MD, contributed an illustration.

I thank Chris Kim, MD; Susan Summerton, MD; Mindy Horrow, MD; Peter Wang, MD; and Huyen Tran, MD, for supplying additional images for this edition. And thanks to Mindy Horrow, MD; Eric Faerber, MD; and Brooke Devenney-Cakir, MD, for reviewing chapters from this text.

I certainly want to recognize and again thank Jim Merritt and Katy Meert from Elsevier for their support and assistance.

I also acknowledge the hundreds of radiology residents and medical students who, over the years, have provided me with an audience of motivated learners, without whom a teacher would have no one to teach.

Finally, I want to thank my wonderful wife, Pat, who has encouraged me throughout the project, and my family.

William Herring, MD, FACR

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CHAPTER 1

Recognizing Anything

AN INTRODUCTION TO IMAGING MODALITIES

It's always exciting when a class starts out with a surprise quiz. No pencils are necessary. Here are six images with brief histories presented as unknowns. Each is diagnostic. If you don't know the answers, that is perfectly fine because that's what you are here to learn. The answers are at the very end of this book (Figs. 1-1 to 1-6).

- You are about to learn about each of the imaging modalities, about how to approach imaging studies, about the six diseases represented in the figures, and much more as you complete this text.

FIGURE 1-1 **A 56-year-old patient with abdominal pain.**

FIGURE 1-2 **A 49-year-old who fell off a ladder.**

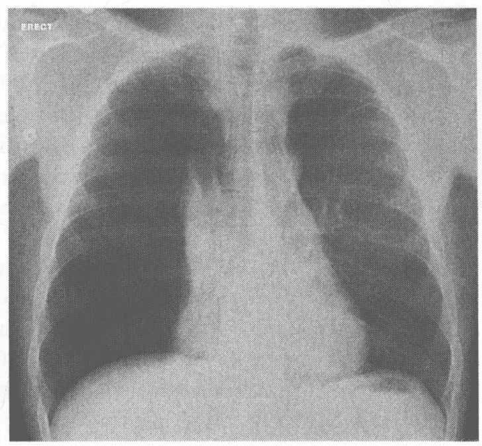

FIGURE 1-3 **A 22-year-old with sudden chest pain.**

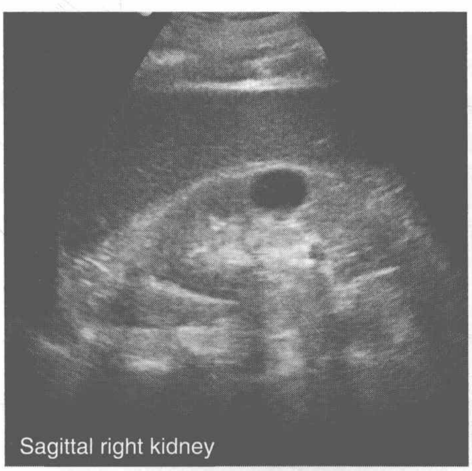

FIGURE 1-4 **Incidental finding on abdominal ultrasound.**

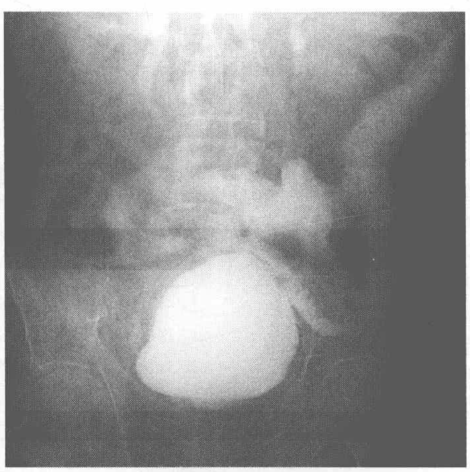

FIGURE 1-5 **Cystogram of a 56-year-old who was in an automobile accident.**

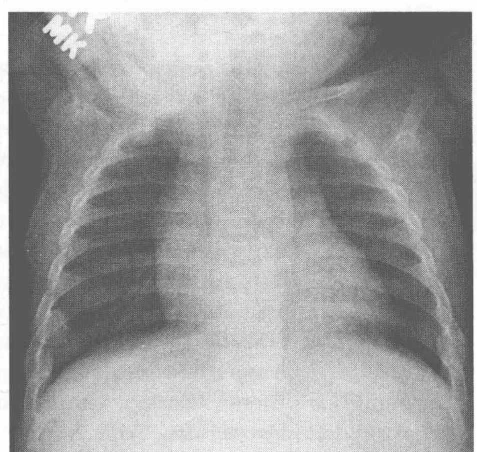

FIGURE 1-6 **A 4-month-old with irritability.**

FROM DARKNESS ... LIGHT

- In 1895, Wilhelm Röntgen (or Roentgen), working in a darkened laboratory in Würzburg, Germany, noticed that a screen painted with a fluorescent material in the same room, but a few feet from a cathode ray tube he had energized and made lightproof, started to glow (fluoresce). Sensing something important had happened, he recognized that the screen was responding to the nearby production of an unknown ray transmitted invisibly through the room. He named the new rays "x-rays," using the mathematical symbol "x" for something unknown. It didn't take long before almost everyone was taking x-rays of almost everything imaginable.
- For about 100 years after that, radiographic images survived their brief birth as a burst of ionizing radiation nestled comfortably on a piece of film. In some places, film is the medium still used, but it's much less common.
- Today, like in 1895, conventional radiographic images (usually shortened to **x-rays**) are produced by a combination of ionizing radiation and light striking a **photosensitive surface,** which, in turn, produces a **latent image** that is subsequently **processed.** At first, the processing of film was carried out in a darkroom containing trays with various chemicals; the films were then, literally, hung out and then up to dry.
  - When an immediate reading was requested, the films were interpreted while still dripping with chemicals, and thus the term ***wet reading*** for a "stat" interpretation was born.
  - Films were then viewed on lighted view boxes (almost always backward or upside-down if the film placement was being done as part of a movie or television show).
- This workflow continued for many decades, but it had **two major drawbacks:**
  - It required a great deal of **physical storage space** for the ever-growing number of films. Even though each film is very thin, many films in thousands of patients' folders take up a great deal of space (eFig. 1-1).
  - The other drawback was that the radiographic films could physically be in only **one place at a time,** which was not necessarily where they might be needed to help in the care of a patient.
- So, eventually, **digital radiography** came into being, in which the photographic film was replaced by a **photosensitive cassette** or **plate** that could be processed by an **electronic reader** and the resulting image could be stored in a **digital format.** This electronic processing no longer required a darkroom to develop the film or a large room to store the films. Countless images could be stored in the space of one spinning hard disk on a computer server. Even more important, the images could be viewed by anyone with the right to do so, anywhere in the world, at any time.
- The images were maintained on computer servers, where they could be **stored** and **archived** for posterity and from which they could be **communicated** to others. This system is referred to as ***PACS,*** which stands for **picture archiving, communications, and storage.**
- Using PACS systems, images created using all modalities can be stored and retrieved. Conventional radiography, computed tomography (CT), ultrasonography, magnetic resonance imaging (MRI), fluoroscopy, and nuclear medicine are examples of images that can be stored in this way.
- We will look briefly at each of these modalities in the sections that follow.

CONVENTIONAL RADIOGRAPHY

- Images produced through the use of ionizing radiation (i.e., the production of x-rays, but without added contrast material such as barium or iodine) are called ***conventional radiographs*** or, more often, **plain films.**
- The major advantage of conventional radiographs is that the images are relatively **inexpensive** to produce, can be obtained almost **anywhere** by using portable or mobile machines, and are still the most widely obtained imaging studies.
- They require a **source** to produce the x-rays (the "x-ray machine"), a method to **record** the image (a film, cassette, or photosensitive plate), and a way to **process** the recorded image (using either chemicals or a digital reader).
- Common uses for conventional radiography include the ubiquitous chest x-ray, plain films of the abdomen, and virtually every initial image of the skeletal system to evaluate for fractures or arthritis.
- The major disadvantages of conventional radiography are the **limited range of densities** it can demonstrate and that it **uses ionizing radiation.**

THE FIVE BASIC DENSITIES

- **Conventional radiography is limited to demonstrating five basic densities,** arranged here from **least** to **most** dense (Table 1-1):
  - **Air,** which appears the blackest on a radiograph
  - **Fat,** which is shown in a lighter shade of gray than air
  - **Soft tissue or fluid** (because both soft tissue and fluid appear the same on conventional radiographs, it's impossible to differentiate the heart muscle from the blood inside of the heart on a chest radiograph)
  - **Calcium** (usually contained within bones)
  - **Metal,** which appears the whitest on a radiograph
    - Objects of metal density are not normally present in the body. Radiologic **contrast media** and **prosthetic knees** or **hips** are **examples of metal densities** artificially placed in the body (Fig. 1-7).
- Although conventional radiographs are produced by ionizing radiation in relatively low doses, radiation has the potential

TABLE 1-1 FIVE BASIC DENSITIES SEEN ON CONVENTIONAL RADIOGRAPHY

Density	Appearance
Air	Absorbs the least x-ray and appears "blackest" on conventional radiographs
Fat	Gray, somewhat darker (blacker) than soft tissue
Fluid or soft tissue	Both fluid (e.g., blood) and soft tissue (e.g., muscle) have the same densities on conventional radiographs
Calcium	The most dense, naturally occurring material (e.g., bones); absorbs most x-rays
Metal	Usually absorbs all x-rays and appears the "whitest" (e.g., bullets, barium)

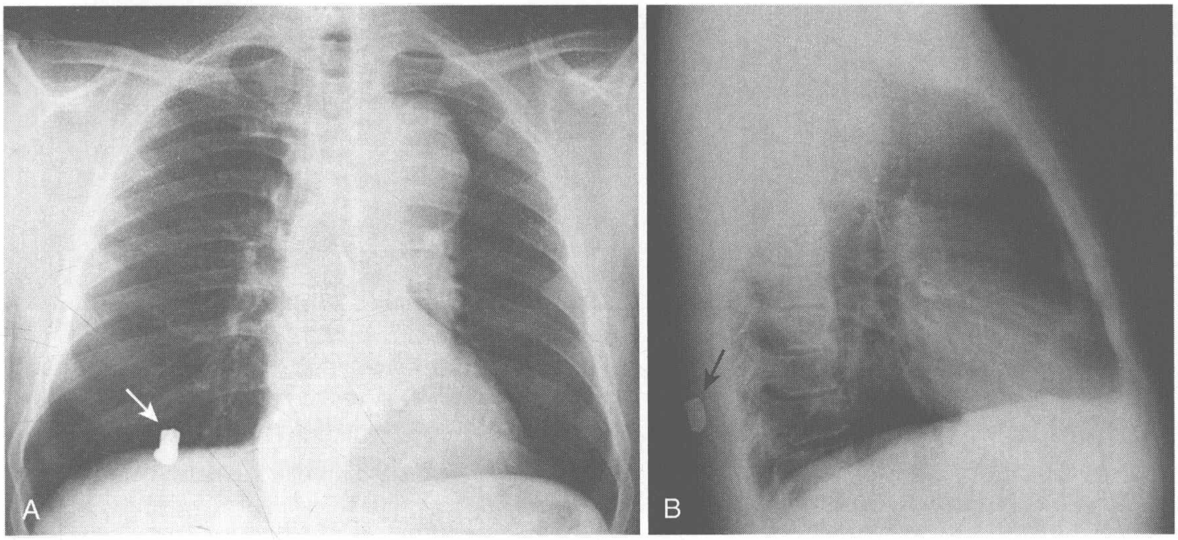

FIGURE 1-7 Bullet in the chest. A, The dense (white) metallic foreign body overlying the right lower lung field (*white arrow*) is a bullet. It is much denser (whiter) than the bones (calcium density), represented by the ribs, clavicles, and spine. Fluid (such as the blood in the heart) and soft-tissue density (such as the muscle of the heart) have the same density, which is why we cannot differentiate the two using conventional radiography. The air in the lungs is the least dense (blackest). **B,** Two views at 90° angles to each other, such as these frontal and lateral chest radiographs, are called ***orthogonal*** views. With only one view, it would be impossible to know the location of the bullet. On the lateral view, the bullet can be seen lying in the soft tissues of the back (*black arrow*). Orthogonal views are used throughout conventional radiography to localize structures in all parts of the body.

to produce cell mutations, which could lead to many forms of cancer or anomalies. Public health data on lower levels of radiation vary with regard to assessment of risk, but it is generally held that only medically necessary diagnostic examinations should be performed and that imaging using x-rays should be avoided during potentially teratogenic times, such as pregnancy. (More information about radiation dose and safety is available at StudentConsult.com.)

COMPUTED TOMOGRAPHY

- CT (or "CAT") scanners, first introduced in the 1970s, brought a quantum leap to medical imaging.
- Using a gantry with a rotating x-ray beam and multiple detectors in various arrays (which themselves rotate continuously around the patient), along with sophisticated computer algorithms to process the data, a large number of two-dimensional, slicelike images (each of which is millimeters in size) can be formatted in multiple imaging planes (Video 1-1).
- **A CT scanner** is connected to a **computer** that processes the data though various **algorithms** to produce **images** of diagnostic quality.
- A CT image is composed of a matrix of thousands of tiny squares called ***pixels,*** each of which is computer-assigned a **CT number** from −1000 to +1000 measured in **Hounsfield units (HUs),** named after Sir Godfrey Hounsfield, the man credited with developing the first CT scanner (for which he won the Nobel Prize in Medicine in 1979 with Allan Cormack).
  - The CT number will **vary according to the density of the tissue** scanned and is a **measure of how much of the x-ray beam is absorbed** by the tissues at each point in the scan. By convention, **air is assigned a Hounsfield number of −1000 HU** and **bone about 400 HU to 600 HU. Fat is −40 to −100 HU, water is 0,** and **soft tissue is 20 HU to 100 HU.**
- CT images are displayed or viewed using a range of Hounsfield numbers preselected to best demonstrate the tissues being studied (e.g., from −100 to +300), and anything within that range of CT numbers is displayed over the levels of density in the available gray scale. This range is called the ***window.***

➡ **Denser substances** that absorb more x-rays have **high CT numbers,** are said to demonstrate **increased attenuation,** and are displayed as **whiter densities** on CT scans.

  - On conventional radiographs, these substances (e.g., **metal** and **calcium**) would also appear whiter and would be said to have **increased density** or to be **more opaque.**
- **Less dense substances** that absorb fewer x-rays have **low CT numbers,** are said to demonstrate **decreased attenuation,** and are displayed as **blacker densities** on CT scans.
  - On conventional radiographs, these substances (e.g., **air** and **fat**) would also appear as blacker densities and would be said to have **decreased density** (or **increased lucency**).
- CT scans can also be windowed in a way that optimizes the visibility of different types of pathology **after** they are obtained, a benefit called ***postprocessing,*** which digital imaging, in general, markedly advanced. Postprocessing allows for additional manipulation of the raw data to best demonstrate the abnormality **without repeating a study** and without reexposing the patient to radiation (Fig. 1-8).
- Traditionally, CT images were viewed mostly in the axial plane. Now, because of volumetric acquisition of data, CT

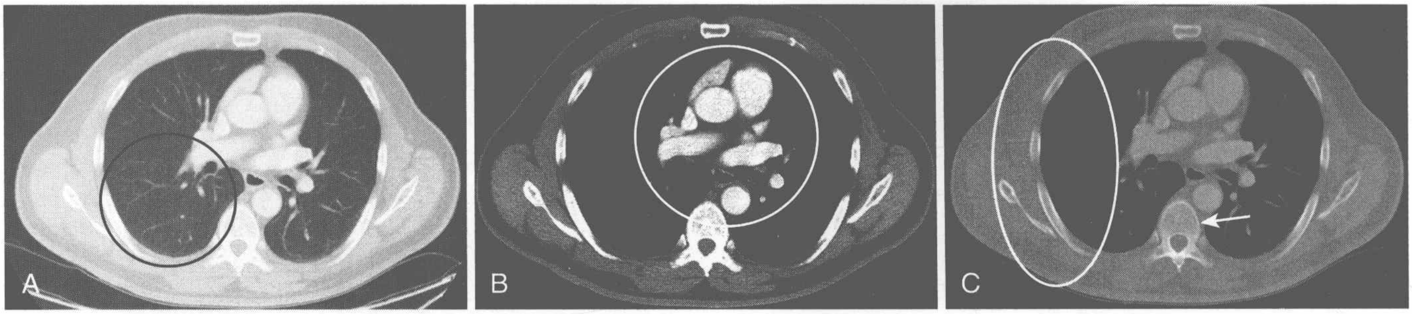

FIGURE 1-8 Windowing the thorax. Chest computed tomography scans are usually "windowed" and displayed in several formats to optimize anatomical definition. **A,** Lung windows are chosen to maximize the ability to image abnormalities of the lung parenchyma and to identify normal and abnormal bronchial anatomy *(black circle)*. **B,** Mediastinal windows are chosen to display the mediastinal, hilar, and pleural structures to best advantage *(white circle)*. **C,** Bone windows are utilized as a third way of displaying the data to visualize the bony structures to their best advantage *(white oval and arrow)*. It is important to recognize that the displays of these different windows are manipulations of the data obtained during the original scan and do not require rescanning the patient.

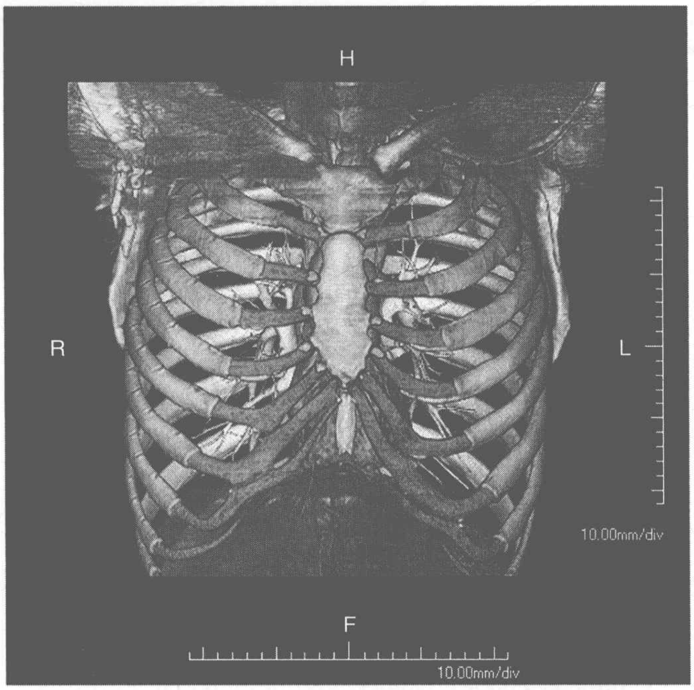

FIGURE 1-9 Three-dimensional computed tomography rendering of normal rib cage. This grayscale version (color online) of a three-dimensional surface rendering of the rib cage is made possible by the acquisition of multiple, thin computed tomographic sections through the body. These sections can then be reconstructed to demonstrate surface anatomy, as in this illustration. The same data set could have been manipulated to show the heart or lungs (which are digitally removed here) and not the rib cage. Such renderings are especially helpful in demonstrating the exact anatomic relationships of structures, especially for surgical planning. *F,* Foot; *L,* left; *H,* head; *R,* right.

scans can be shown in any plane: axial, sagittal, or coronal. Volumetric data consist of a series of thin sections that can be **reassembled** for a three-dimensional reconstruction. Surface and volume rendering in three dimensions can produce CT images of amazing, realistic quality (Fig. 1-9).

- One of the major benefits of CT scanning over conventional radiography is its ability to **expand the gray scale,** which enables differentiation of many more than the five basic densities available on conventional radiographs.
- Because of increasingly sophisticated arrays of detectors and acquisition of hundreds of slices simultaneously, **multislice CT scanners permit very fast imaging** (from head to toe in less than 10 seconds), which has allowed the development of new applications for CT, such as **virtual colonoscopy** and **virtual bronchoscopy, cardiac calcium scoring,** and **CT coronary angiography** (Video 1-2).
- CT examinations can contain 1000 or more images; therefore the older convention of filming each image for study on a viewbox is impractical, and such scans are almost always viewed on computer workstations.
- **CT scans are the cornerstone of cross-sectional imaging** and are widely available, although not as yet truly portable. Production of CT images requires an expensive scanner, a space dedicated to its installation, and sophisticated computer processing power. Like conventional x-ray machines, CT scanners utilize ionizing radiation (x-rays) to produce their images.

ULTRASONOGRAPHY

- Ultrasound probes utilize acoustic energy above the audible frequency of humans to produce images, instead of using x-rays as both conventional radiography and CT scans do (see Chapter 21).
- An ultrasound **probe** or **transducer** both produces the ultrasonic signal and records it. The signal is processed for its characteristics by an onboard computer. Ultrasound images are recorded digitally and are easily stored in a PACS system. Images are displayed either as static images or in the form of a movie (or "cine") (Video 1-3).
- Ultrasound scanners are relatively **inexpensive** compared with CT and MRI scanners. They are **widely available** and can be made **portable** to the point of being handheld.
- Because ultrasonography utilizes no ionizing radiation, it is particularly useful in obtaining images of children and women of **childbearing age** and **during pregnancy.**
- **Ultrasonography is widely used in medical imaging.** It is usually **the study of first choice** in imaging the female pelvis and in pediatric patients, in differentiating cystic versus solid lesions in patients of all ages, in noninvasive vascular

imaging, in imaging of the fetus and placenta during pregnancy, and in real-time, image-guided fluid aspiration and biopsy.

- Other common uses are evaluation of cystic versus solid breast masses, thyroid nodules, and tendons and in assessment of the brain, hips, and spine in newborns. Ultrasonography is used in settings ranging from intraoperative scanning in the surgical suite to the medical tent in the battlefield and in locations as remote as Antarctica.
- Ultrasonography is generally considered to be **a very safe imaging modality** that has no known major side effects when used at medically diagnostic levels.

MAGNETIC RESONANCE IMAGING

- MRI utilizes the potential energy stored in the body's **hydrogen atoms.** The atoms are manipulated by very strong magnetic fields and radiofrequency pulses to produce enough localizing and tissue-specific energy to allow highly sophisticated computer programs to generate two- and three-dimensional images (see Chapter 22).
- MRI scanners are **not as widely available** as CT scanners. They are **expensive** to acquire and require careful site construction to operate properly. In general, they also have a relatively **high ongoing operating cost.**
- However, they utilize **no ionizing radiation** and produce much higher contrast between different types of soft tissues than is possible with CT.
- MRI is widely used in neurologic imaging and is particularly sensitive in imaging soft tissues such as the muscles, tendons, and ligaments.
- There are **safety issues** associated with the extremely strong magnetic fields of an MRI scanner, both for objects within the body (e.g., cardiac pacemakers) and for ferromagnetic projectiles in the MRI scanner environment (e.g., metal oxygen tanks in the room). There are also known side effects from the radiofrequency waves that such scanners produce and possible adverse effects due to some MRI contrast agents.

FLUOROSCOPY

- Fluoroscopy (or "fluoro") is a modality in which ionizing radiation (x-rays) is used in performing **real-time visualization** of the body in a way that allows for evaluation of the motion of body parts, real-time positioning changes of bones and joints, and the location and path of externally administered barium or iodine contrast agents through the gastrointestinal and genitourinary tracts and blood vessels. Images can be viewed as they are acquired on video screens and captured as either a series of static images or moving (video) images (Video 1-4).
- Fluoroscopy requires an x-ray unit specially fitted to allow for controlled motion of the x-ray tube, as well as the imaging sensor and the patient, to find the best projection to demonstrate the body part being studied. To do this, fluoroscopic tables are made to tilt and the fluoroscopic tube can be moved freely back and forth above the patient (Fig. 1-10).
- Instantaneous "snapshots" obtained during the procedure are called ***spot films.*** They are combined with other images obtained by using an overhead x-ray machine in multiple projections (usually by both the radiologist and the radiologic technologist) during the performance of barium studies for whatever part of the gastrointestinal tract is being studied, depending on the nature of the abnormality and the mobility of the patient.

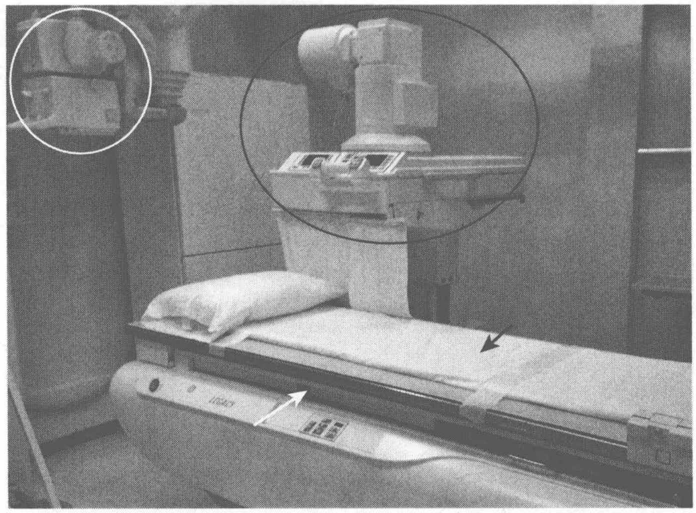

FIGURE 1-10 A standard radiology room equipped for both conventional radiography and fluoroscopy. The patient lies on the table *(black arrow),* which has the capacity to tilt up or down. Images can be obtained using the tube on the fluoroscopic carriage *(black oval),* which can be moved over the patient by the operator and then manipulated more or less freely to follow the barium column. Static images can be obtained using the overhead x-ray tube *(white circle).* The x-ray tube can be moved into place over an x-ray cassette, which would be located under the patient *(white arrow).*

- In **interventional radiology,** iodinated contrast is selectively injected into blood vessels or other ducts that can be imaged fluoroscopically to demonstrate normal anatomy, pathology, or the position of catheters or other devices (Video 1-5).
- Fluoroscopy units can be made **mobile,** although they are still relatively large and heavy. They carry the same warnings regarding exposure to radiation as any other modality using ionizing radiation.
- Radiation doses in fluoroscopy can be **substantially higher** than those used in conventional radiography because so many images are acquired for every minute of fluoroscopy time. Therefore the dose is reduced by using the **shortest possible fluoroscopy time** to obtain diagnostic images.

NUCLEAR MEDICINE

- A **radioactive isotope (radioisotope)** is an unstable form of an element that emits radiation from its nucleus as it decays. Eventually, the end product is a stable, nonradioactive isotope of another element.
- Radioisotopes can be produced **artificially** (most frequently by neutron enrichment in a nuclear reactor or in a cyclotron) or may occur **naturally.** Naturally occurring radioisotopes include **uranium** and **thorium.** The **vast majority of radioisotopes** used in medicine are produced **artificially.**

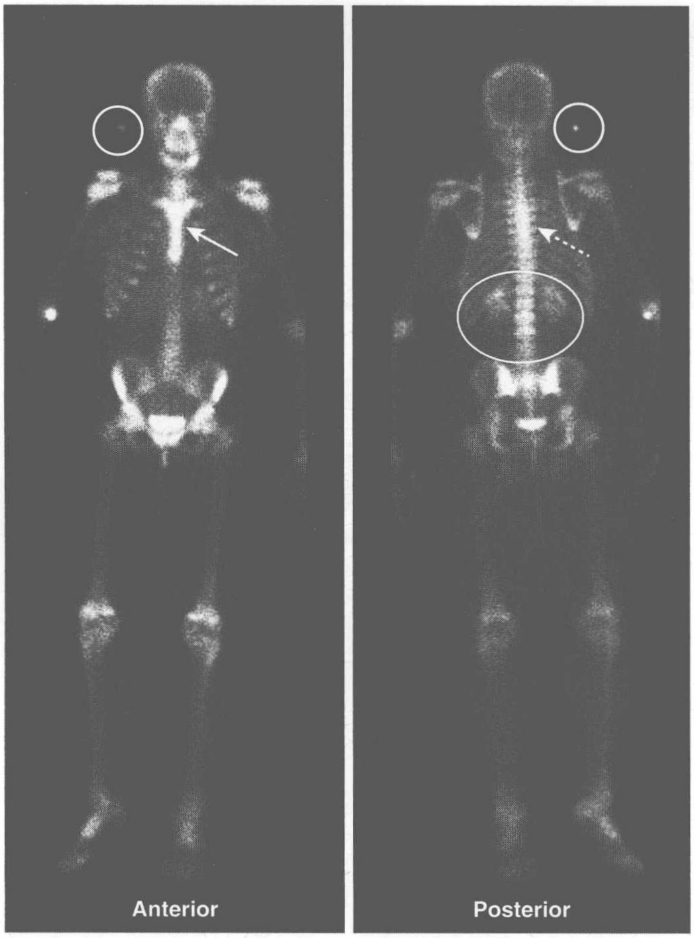

FIGURE 1-11 Bone scan. Anterior and posterior views are frequently obtained because each view brings different structures closer to the gamma camera for optimum imaging, such as the sternum on the anterior view *(solid white arrow)* and the spine on the posterior view *(dotted white arrow)*. Notice that the kidneys are normally visible on the posterior view *(white oval)*. Unlike the convention used in viewing other studies in radiology, the patient's right side is not always on your left in nuclear medicine scans. On posterior views, the patient's right side is on your right. This can be confusing, so make sure you look for the labels on the scan. In many cases, a white marker dot will be located on the patient's right side *(white circles)*.

- **Radiopharmaceuticals** are combinations of **radioisotopes** attached to a **pharmaceutical** that has binding properties that allow it to concentrate in certain body tissues, such as the lungs, thyroid, or bones. Radioisotopes used in clinical nuclear medicine are also referred to as ***radionuclides, radiotracers,*** or, sometimes, simply ***tracers.***
- Various body organs have a specific affinity for, or absorption of, different biologically active chemicals. For example, the thyroid takes up **iodine;** the brain utilizes **glucose;** bones utilize **phosphates;** and **particles** of a **certain size** can be trapped in the lung capillaries (Fig. 1-11).
- After the radiopharmaceutical is carried to a tissue or organ in the body, usually via the bloodstream, its radioactive emissions allow it to be measured and imaged using a detection device called a ***gamma camera.***
- **Single-photon emission computed tomography (SPECT)** is a nuclear medicine modality in which a gamma camera is used to acquire several two-dimensional images from **multiple angles,** which are then reconstructed by computer into a **three-dimensional data set** that can be manipulated to produce thin slices in any projection. To acquire SPECT scans, the **gamma camera rotates around the patient.**
- **Positron emission tomography (PET)** is used to produce three-dimensional images that depict the body's biochemical and metabolic processes at a molecular level. It is performed using a **positron (positive electron)**-producing radioisotope attached to a targeting **pharmaceutical.**
- PET scanning is most often used in the **diagnosis and treatment follow-up of cancer.** It is frequently used **to locate hidden metastases** from a known tumor or to **detect recurrence.** Oncologic PET scans make up about 90% of the clinical use of PET. Some tumors take up more of the radiotracer than others and are referred to as ***FDG-avid*** tumors, with *FDG* referring to the contrast agent fluorodeoxyglucose (Video 1-6).
- Unlike other modalities that use ionizing radiation, the patient can briefly be the **source** of radiation exposure to others (e.g., technologists) in nuclear medicine studies. To limit exposure to others, the principles of **decreasing the time** in close proximity to the patient, **increasing the distance** from the source, and **appropriate shielding** are used (see online section on Radiation Dose and Safety).
- Compared with CT and fluoroscopy, nuclear medicine studies, in general, produce less patient exposure. The types of scans that deliver the highest dose relative to other nuclear scans are cardiac studies and PET examinations. (An additional online chapter on nuclear medicine is available to registered users at StudentConsult.com.)

CONVENTIONS USED IN THIS BOOK

- And now, a word from our sponsor. **Bold type** is used liberally throughout this text to **highlight important points,** and because this is a book filled with a large number of extraordinarily important points, **there is much bold type.**
- **Diagnostic pitfalls,** potential false-positive or false-negative traps on the sometimes perilous journey to the correct interpretation of an image, are signaled by this icon:
- **Important points** that are so important that not even **boldface** type does them justice are signaled by this icon:
- Online-only content is listed throughout the chapter (as eFigures, eTables, Videos, and so forth). Also, additional or complementary instructional material available on the *StudentConsult/Inkling.com* website for registered users is listed at the end of each chapter. Web-only extras include quizzes, imaging anatomy modules, expanded text and an additional chapter on nuclear medicine, color photos, and videos.
- **"Take-home" points** are listed at the end of each chapter in a Take-Home Points table.
    - You may use these points anywhere, not only in your home.

TAKE-HOME POINTS

RECOGNIZING ANYTHING: AN INTRODUCTION TO IMAGING MODALITIES

Today, almost all images are stored electronically on a picture archiving, communications, and storage system called *PACS*.

Conventional radiographs (plain films) are produced using ionizing radiation generated by x-ray machines and viewed on a monitor or light box.

Such x-ray machines are relatively inexpensive and widely available, and they can be made portable. The images are limited as to the sensitivity of findings they are capable of displaying.

There are five basic radiographic densities, arranged in order from *that which appears the whitest to that which appears the blackest:* metal, calcium (bone), fluid (soft tissue), fat, and air.

Computed tomography (CT) utilizes rapidly spinning arrays of x-ray sources and detectors and sophisticated computer processing to increase the sensitivity of findings visible and display them in any geometric plane.

CT scanners have become the foundation of cross-sectional imaging. They are moderately expensive and also use ionizing radiation to produce their images.

Ultrasonography produces images using the acoustic properties of tissue and does not employ ionizing radiation. It is thus safe for use in children and in women of childbearing age and during pregnancy. It is particularly useful in analyzing soft tissues and blood flow.

Ultrasonography units are less expensive, are in widespread use, and have been produced as small as handheld devices.

Magnetic resonance imaging (MRI) produces images based on the energy derived from hydrogen atoms placed in a very strong magnetic field and subjected to radiofrequency pulsing. The data thus derived are analyzed by powerful computer algorithms to produce images in any plane.

MRI units are relatively expensive, require site construction for their placement, and are usually relatively high in cost to operate. They have become the cornerstone of neuroimaging and are of particular use in studying muscles, ligaments, and tendons.

Fluoroscopy utilizes ionizing radiation to produce real-time visualization of the body that allows for evaluation of motion, positioning, and the visualization of barium or iodine contrast agents moving through the gastrointestinal and genitourinary tracts and blood vessels.

Nuclear medicine utilizes radioisotopes that have been given the property to "target" different organs of the body to evaluate the physiology and anatomy of those organs. Unlike other modalities that use ionizing radiation, the patient can briefly be the source of radiation exposure in nuclear medicine studies.

WEBLINK

Visit StudentConsult.Inkling.com for videos and more information.

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