Radiography of Pediatric and Geriatric Patients

Learning Objectives

At the conclusion of this chapter, you will be able to:

- Demonstrate appropriate levels of communication with children of any age
- Immobilize an infant or toddler for a radiographic examination
- Compare the characteristics of the developing skeleton with those of the mature skeleton
- Formulate exposures for pediatric radiographic techniques
- Identify pediatric radiographic examinations that vary in method from adult examinations
- List signs that suggest the possibility of nonaccidental trauma in children and in the elderly
- List considerations that improve communication and compliance when dealing with older patients
- Describe changes that occur to the skeleton and the soft tissues as a result of aging
- Adjust radiographic exposures appropriately for patients with osteoporosis and/or advanced age
- List and describe three pathologic conditions common to pediatric patients
- List and describe three pathologic conditions common to geriatric patients

Key Terms

Alzheimer disease
aspiration
battered child syndrome
decubitus ulcers
demineralization
diverticulitis
geriatrics
nonaccidental trauma (NAT)
organic brain syndrome
osteopenia
osteoporosis
Parkinson disease
pediatrics
valid choice

The term **pediatrics** refers to the care of children. **Geriatrics** is the term for the care of elder adults. This chapter is divided into two parts, one devoted to the special needs of infants and children and the other to the requirements of older adults. Pediatric and geriatric patients have the same needs as other patients: confidence and reassurance, safety and security, and comfort and competent care. It is in the ways these needs are met that their requirements differ.

This chapter offers strategies for effective communication with both pediatric and geriatric patients in the clinical setting. It also covers variations in the skeletons and soft tissues of these patients and the exposure adjustments required for successful radiography. Instructions are provided for immobilizing infants and small children. Pediatric procedures that vary from the methods used for adults are addressed as well. Pathologic conditions unique or especially common to the very young and the very old are also presented.

PEDIATRICS

Communication

Relating to a child can be difficult for those who have little experience with children. Even successful parents sometimes have problems relating to other people's children. This is a skill that improves with practice. If relating to children does not come easily for you, experience with children without the stress of the workplace may help. Consider spending an afternoon at the park with children of a relative or friend. Make it a point to get acquainted with a neighbor's child. When introduced to a child, make a special effort to relate in a comfortable way.

Children tend to be more intuitive than adults. They can usually sense when you really care about them. If your real concern is whether you will get off duty on time or whether your employer will be satisfied with the images, the child will not be fooled by your pretended interest. To gain a child's trust, your interest and concern must be genuine.

Effective communication is age appropriate and shows both respect and concern. We communicate both verbally and nonverbally. Research indicates that about 70% of communication received by adults is nonverbal. That is, we learn far more from posture, body language, facial expression, and tone of voice than from what is actually said. Positive touch is both firm and gentle and is also an important aspect of nonverbal communication. There are no available figures for the percentage of communication received by children that is nonverbal, but it is presumed to be even higher than for adults.

Children are more likely to have a positive attitude about radiography if they perceive your facility to be a child-friendly place. Some small furniture and an assortment of books and games (Fig. 18.1) will help them feel welcome and will keep them occupied if they must wait. At the very least, it is helpful to have a few toys or interesting objects that can capture the attention of children of different ages (Fig. 18.2). One inexpensive item that appeals to a wide age range is a variety of stickers. They may be used as a get-acquainted gift and/or a reward for good behavior.

Neonate and Infant (Birth to 1 Year)

The neonatal period includes the first month of life (Fig. 18.3). During this stage, infant behavior is mostly reflexive and is influenced by your face, voice, and touch.

Fig. 18.1 Children feel welcome when the clinic waiting room has an area in which they can play.

Fig. 18.2 Toys or other interesting objects may serve to distract a frightened child.

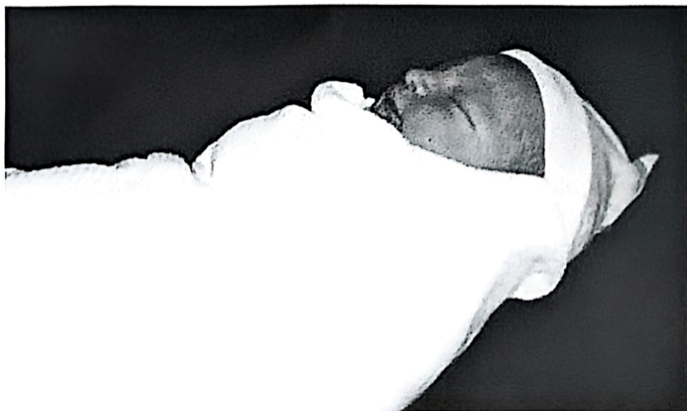


Fig. 18.3 Neonates feel most secure when wrapped snugly.

Some important things to remember when dealing with infants in the first month of life include the following:

1. They like to be bundled up. They feel more secure when they are warm and snugly wrapped.
2. They like to be held firmly and gently. It may help settle them if you rock them or walk around with them.
3. They relate to faces. They like eye contact, but they cannot focus very far away, so closeness is good.
4. They respond to the sound of voices long before they can understand words. Talk to them softly as you work.

The period from 1 month to 1 year of age is characterized by rapid physical growth and development. There is a ·rression from reflexive to more purposeful behavior. Two- and three-month-old infants smile because it elicits a response from others. Sucking, chewing, and vocalizing are important oral activities. By 8 months of age, infants begin to differentiate themselves from others. They recognize familiar persons, such as their parents, and they fear strangers and unfamiliar situations. At 9 months, infants experience separation anxiety. Keep infants and parents together as much as possible, limit the number of staff, and provide familiar objects, such as a blanket, toy, or pacifier. Employing familiar objects and incorporating play will serve to distract the infant during the exam.

Always provide a safe environment. Never leave an infant on a flat surface unattended, keep the crib rails up at all times, and immobilize the infant during the exam whenever it is necessary.

Toddler (1 to 2 Years)

Toddlers start walking between 10 and 14 months of age and start to communicate using two- and three-word sentences. They like to explore and manipulate their environment.

Strange adults are often intimidating to children because of their stature, so try to speak to children at their own eye level (Fig. 18.4). You will find that this is especially helpful when you approach the child to "make friends" before the radiographic procedure. If you are calm, cheerful, and unhurried, the toddler is much less likely to respond negatively to the strange surroundings and machines. Allowing the toddler to take a favorite blanket or toy to the radiology department can help promote a feeling of security. Talk to toddlers and play with them to

distract them during the exam and reduce their stress. Even if they do not understand all you say, a cheerful voice is reassuring. Prepare the toddler shortly before the procedure and use demonstration in addition to spoken instructions. When directions are given, keep them short and simple, giving one direction at a time, because toddlers have a short attention span. They need lots of reminders and lots of patience.

Toddlers are quite attached to their parents, but are also beginning to assert their independence because they are mobile and have the ability to do more for themselves. Resistance to control by parents or health care workers can result in negative behaviors, such as temper tantrums. Respond to these behaviors using a friendly but firm approach, and set limits by stating, "You must lie still." Allow the toddler choices when possible and, when necessary, explain to parents that immobilization techniques will need to be used to obtain the child's radiographic images.

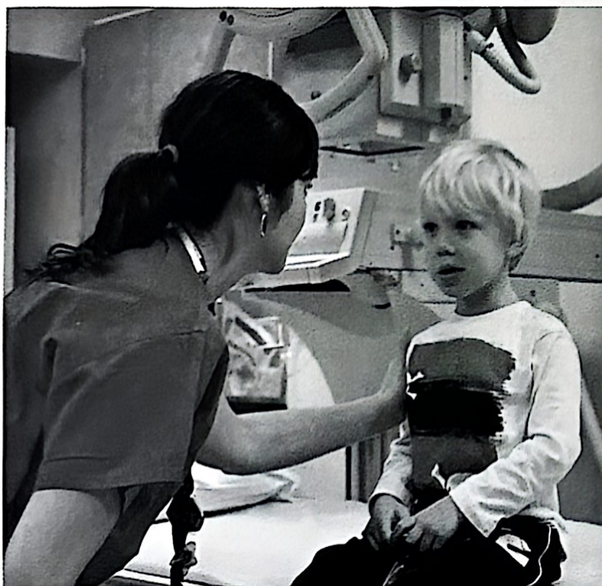


Fig. 18.4 Use positive touch and eye contact at the child's eye level.

Preschooler (3 to 5 Years)

Children at this age (Fig. 18.5) require somewhat different approaches to care and communication. They are demonstrating increasing independence, they are conversational and able to share information with you, and they can cooperate more fully, but they also fear a loss of self-control and need to make valid choices even more than adults do. A **valid choice** is one in which either alternative is acceptable to you. For example, you might ask, "Would you like to wear a blue gown or a red one?" or "Would you like to get up on the table by yourself or would you like me to help you?" Asking, "Would you like to lie down here?" is *not* a valid choice. If the child must lie down for the procedure, there is no choice involved, and if the child answers "No," you have placed yourself in an awkward position. Although children have no choice about submitting to the examination, they should be encouraged to cooperate as much as possible. Apprehensive children do not feel reassured by such statements as, "This won't hurt a bit." All too frequently, the only word they assimilate is "hurt," and they become even more frightened. Asking, "Have you ever had your picture taken by x-ray?" allows

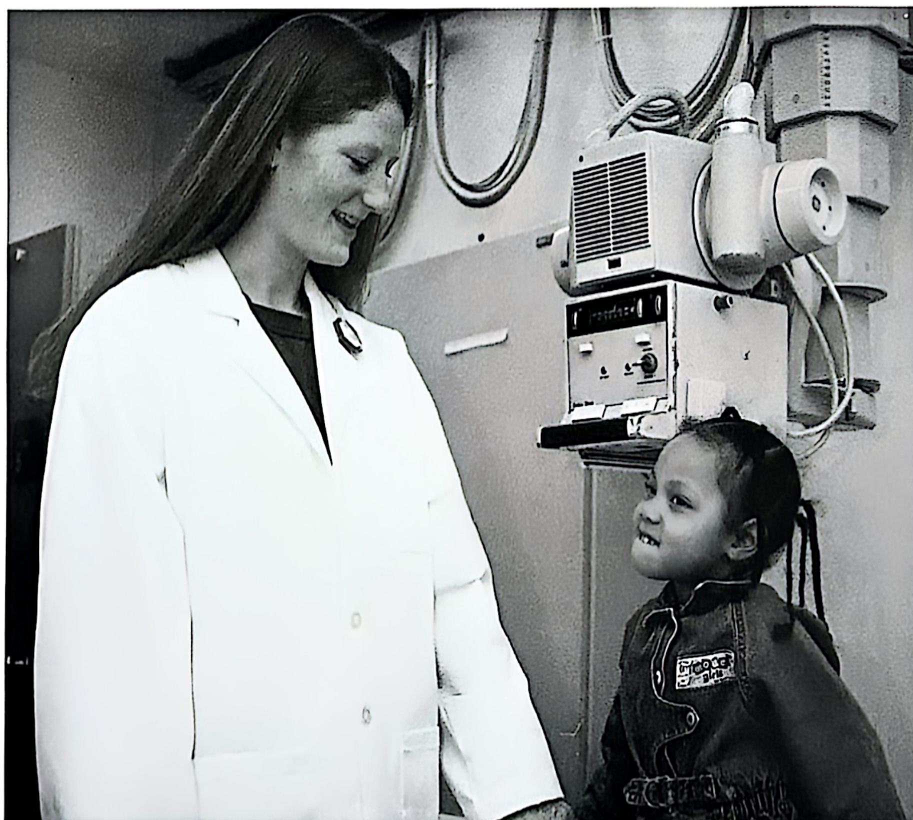


Fig. 18.5 Preschool children demonstrate increasing independence.

you to add whatever simple explanation is necessary. The statement "We're going to take a picture of your leg with this special big camera so your doctor can see why it hurts" is understandable to most children in this age group.

Preschoolers will want to understand what you are doing. They are curious and will probably ask questions. Keep your explanations simple, direct, and honest. Too much detail may be frightening or boring, especially if they do not understand all you say. Avoid stating how many pictures you plan to take. These children will count, and if additional images are necessary, you may lose credibility. Honest praise is a good motivator.

School Age (6 to 12 Years)

Children in this age group can think logically about anything that can be touched and seen. Give specific information about the examination (Fig. 18.6); be explicit about the body areas or parts that will be involved. Be honest and let them know whether or not they will experience any pain or discomfort. Although they have an increased attention span and reasoning skills, continue to use demonstrations or models to explain the examination. They want to be brave and are usually willing to help (Fig. 18.7). Most respond readily to humor. If pain or fear causes them to revert to the behavior of a younger child, the techniques for dealing with younger children may be applied. Valid choices, positive expectations, and honest praise will usually ensure success.

Adolescent (13 to 18 Years)

Special sensitivity is required to deal with the emotional needs of younger adolescents. Although they may act quite adult under normal circumstances, they can become frightened and confused and may revert to childlike behavior when ill or in stressful situations. Show empathy if the adolescent loses control of his or her emotions. Adolescents fear threats to their physical appearance, and they fear loss of control and independence. Avoid using an authoritarian approach and involve them in as much decision making as possible.

You can establish rapport and reduce adolescents' anxiety about the procedure by talking with them about their hobbies, favorite sports, school, or friends before beginning the exam. Prepare the adolescent for the procedure away from parents and peers, if possible. If parents are present, involve them, but do not talk to parents "about" the adolescent, and include the patient in all discussions. This age group has moved past the physical or concrete properties of a situation and is capable of understanding abstract principles. Provide thorough explanations and the rationale for procedures using proper medical terminology.

Young teens usually behave much like adults, but the hormonal changes of puberty can make them subject to mood swings. When hurt or frightened, they may behave somewhat like toddlers; they may act self-centered and their attention span may be short. When this happens, appropriate praise and/or disapproval are effective strategies. One important characteristic of most young teens is an exaggerated sense of modesty. They are in the process of coming to terms with the physiologic changes of puberty and can be easily embarrassed by any attention to their bodies. Girls may feel "naked" if asked to remove their bras. The x-ray may be perceived as an "all-seeing eye," ready to reveal their innermost secrets. Special sensitivity

Fig. 18.6 Keep explanations simple, direct, and honest.

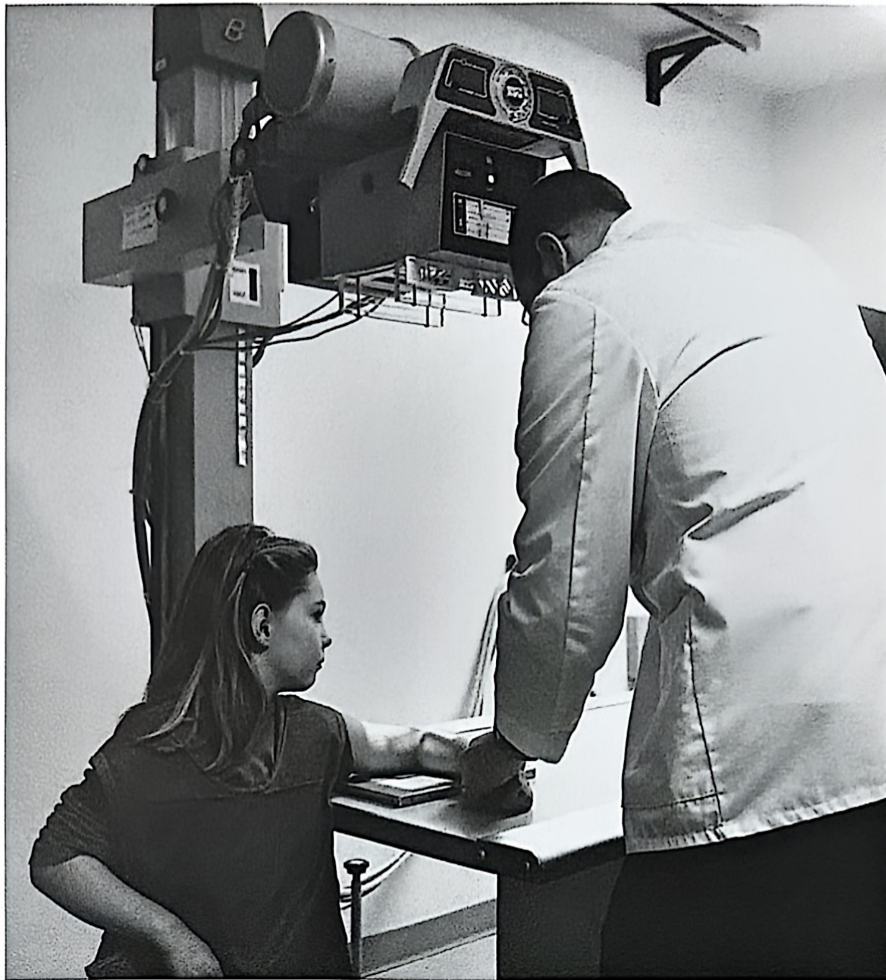


Fig. 18.7 When a positive relationship is established, children are more likely to cooperate.

Fig. 18.8 Sensitivity to privacy improves relationships with young teens.

is needed. If undressing is required, provide one or more gowns (Fig. 18.8) so that the patient is modestly covered during the examination. If you must inquire about sensitive subjects, such as bowel habits or menstrual periods, discuss these topics in a matter-of-fact way and do it privately.

A professional approach, coupled with warm reassurance, promotes a more positive attitude in both children and adolescents. Many of the poor attitudes toward health care displayed by adults can be traced to a lack of sensitivity in the care given by health professionals during their formative years.

Parents in the X-Ray Room

One question that limited operators must answer when small children are radiographed is whether or not to allow parents in the x-ray room. Experts disagree on this subject, and there are good arguments on both sides of the issue.

The principal argument in favor of a parent's presence is that separating parent from child creates anxiety in both the child and the parent. Having the parent close may be reassuring to the child. In addition, parents often have skills for calming their children and gaining their cooperation. If help is needed to hold a child in position during an exposure, a parent is the logical person to assist.

The opposing argument holds that a parent's presence may create anxiety for both parent and child. The child may appeal to the parent for "rescue" from the procedure, creating a dilemma for the parent: rescue and comfort the child or support the continuation of the procedure. This

argument tends to support the idea that if the parent is not visible, the child is more likely to accept the procedure. If the child is distressed and must be immobilized, the parent will be less upset if waiting out of sight and out of earshot. The parent can comfort the child as soon as the procedure is completed.

Each approach has merit under certain circumstances. The duty of the limited operator is to evaluate the circumstances and make a judgment call. Consider the age of the child. Babies may be calmed by hearing the mother's voice nearby. Toddlers that usually get their way with their parents may behave better if taken into the x-ray room alone. Consider the state of mind of both the parent and the child. Even the best parents sometimes behave irrationally when their children are sick or injured. The parent may feel helpless and have a strong need to control everything. The presence of a parent who is not calm is likely to upset the child. When both parents are present, it is usually best for only one to accompany the child into the x-ray room. If you choose to have a parent present, try to select the one with the most matter-of-fact attitude.

At this point, there are two important things to remember, and both should be reassuring to you. You can change your mind, and you can ask for help. Whatever you decide, if you make the wrong decision, it is reversible. If a parent is a problem in the room, you can say, "I think little Sara and I can work this out by ourselves. Please wait in the waiting room, and I'll bring her out just as soon as we're finished." And if you begin without the parent and change your mind, you can say, "I think Jason needs his mommy. Would you mind giving me a hand?" Finally, if the situation seems unmanageable, do not hesitate to ask for help. A more experienced staff member can sometimes save the day. As a last resort, consult the physician, who may decide to postpone the procedure or to sedate the patient.

Immobilization

Infants and small children can be immobilized for most examinations without the need for someone to hold them. Whenever possible, mechanical immobilization of some type is the best answer. This section introduces some of the commercial devices available for this purpose. If pediatric patients are frequently seen in your facility, it is wise to invest in commercial immobilization devices to meet your needs. Noncommercial devices and the use of items commonly found in the x-ray room or the clinic are also illustrated in this section.

When circumstances require that someone hold a child during an exposure, remember that this *must not* be done by a limited x-ray machine operator. Occupationally exposed persons such as radiographers are prohibited from holding either patients or image receptors (IRs) during exposures. A non–occupationally exposed person must be recruited for this duty, and the best candidate is usually the child's parent, provided that person is not pregnant. Provide a lead apron.

Fig. 18.9 Take appropriate precautions for radiation safety when holding is required.

Lead gloves should be worn if the hands will be in the radiation field. Demonstrate precisely how the child should be held and how to sit or stand to minimize exposure of the holding person to primary radiation. Using extended arms so that the holder's body is at arm's length from the child will reduce exposure from scatter radiation (Fig. 18.9). To avoid the need for repeat exposures, take care to ensure that the holder has a comfortable and *firm* grip on the child in the correct position.

Commercial Immobilization Devices

Table restraints are common accessories for radiographic tables. These wide bands attach to the sides of the table and may be adjusted for placement at various locations along its length. Wide strips of Velcro secure the bands around the patient. Similar devices called *compression bands* consist of a single band of cloth that is secured to rails on both sides of the table. The band is tightened using a ratchet roller. Although originally designed to provide abdominal compression for specific procedures, compression bands are also useful to provide immobilization and security from falls.

Many radiographic devices designed for pediatric immobilization are modifications of the original designs for circumcision boards. They are frames to which the child is attached by Velcro straps at strategic locations. Figs. 18.10–18.12

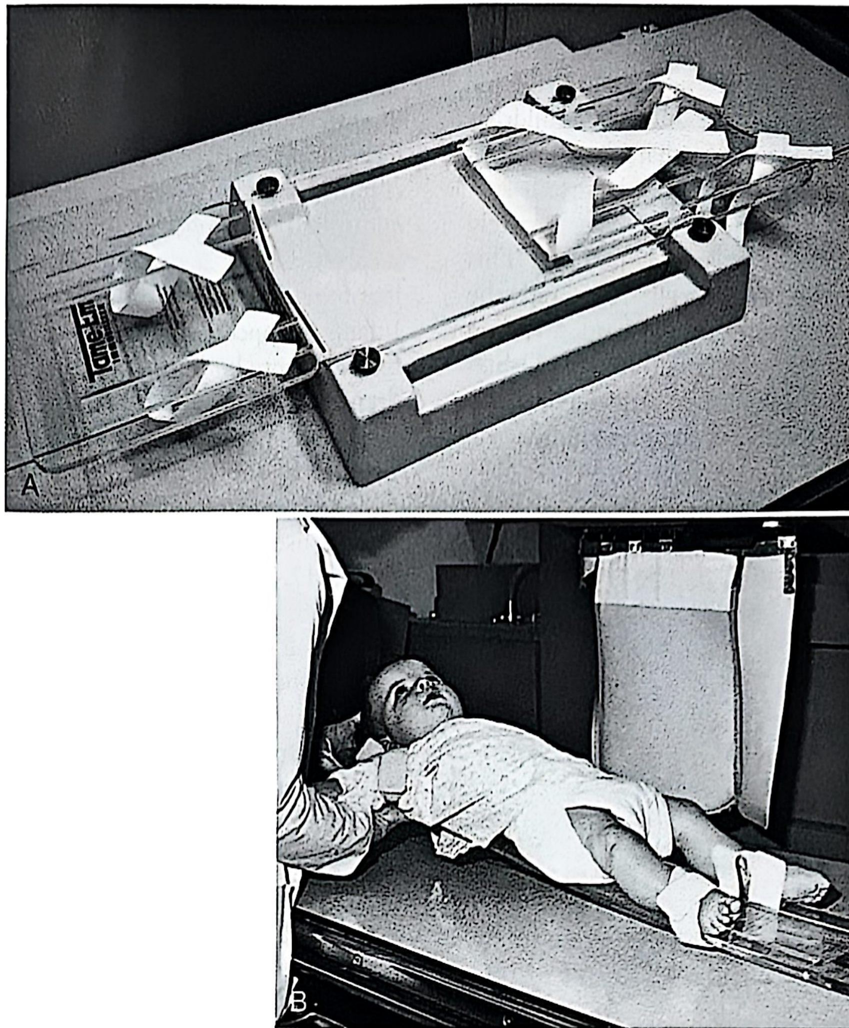


Fig. 18.10 Tame-Em adjustable infant restraining device. (A) Device is made of Lucite with Velcro straps. (B) Device in use.

Fig. 18.11 Octastop restraint board. Device features octagonal end plates and Velcro restraining straps to hold child securely in oblique position, shown here, plus seven other positions.

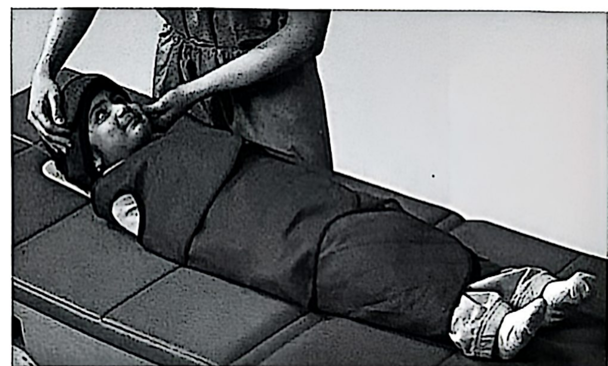


Fig. 18.12 Olympic Papoose Boards come in several sizes to provide selective immobilization for infants, children, and adults. Wide fabric straps with Velcro secure the patient's torso and legs.

illustrate a variety of these products. Some come in several different sizes; others are adjustable in size. Each has some advantages and disadvantages. For example, the Octastop restrainer has octagonal end pieces that allow the child to be placed in eight different positions. Once the child is secured in the device, anteroposterior (AP), posteroanterior (PA), right and left lateral, and four oblique positions of the torso are obtainable without readjustment of the attachments. The disadvantage of this device is that object–image receptor distance (the distance between the patient and the imaging plane) is greater than usual.

Radiography of the skull, face, and neck requires precise immobilization of the head. The devices described earlier have head straps that aid in this process, but specific devices for head immobilization can be very helpful if they

are available. Fig. 18.13 illustrates head clamps for this purpose.

The Pigg-O-Stat (Fig. 18.14) is a unique device for upright chest radiography of infants and small children. Its saddle-like seat is mounted in a disk that rotates for various projections. An adjustable clear plastic sheath surrounds the child's upper body and is fastened securely with leather straps behind the waist and the head. This plastic portion supports the body upright and holds the arms overhead. The unit incorporates gonad shielding and a holder for the image receptor (IR). The Pigg-O-Stat is not inexpensive, but it is a worthwhile investment where there is a high volume of pediatric chest radiography.

Fig. 18.13 Adjustable head clamp secures skull positions with cushioned contacts.

Noncommercial Devices and Methods for Immobilization

The principal objective of most immobilization is to prevent motion from flailing arms and kicking legs. When the extremities are under control, it is nearly impossible for a child to turn over or move about. In the absence of a commercial immobilization device, the extremities can be controlled by using a "mummy wrap." A sheet is used to secure the arms at the sides of the body and to hold the legs together. This technique is illustrated in Fig. 18.15. Infants wrapped in this way, with a lead apron placed over the pelvis, are both immobilized and shielded. Older children may still be able to "buck," flexing their knees and necks to bounce the torso up and down. Fig. 18.16 shows the use of the mummy wrap in conjunction with the table restraint strap across the knees, which is very effective.

The use of tape to maintain position is illustrated in Fig. 18.17. Note that the adhesive surface of the tape is not in contact with the patient's skin. The tape can be twisted so that the nonadhesive side is against the skin, or a gauze pad may be placed between the tape and the skin. Tape is not effective if applied to the tabletop or the flat surface of the IR. It must be wrapped around the edge of the IR or table so that lifting pressure does not loosen it.

Stockinet is a tubular knitted fabric placed on extremities before the application of a cast. It is also useful for securing arms or legs together (Fig. 18.18). Velcro straps may also be used to hold the legs together and in position. Sandbags, too, can be used to hold extremities in place. A convenient way for the holding person to keep an extremity positioned correctly is to use a flexible sheet of

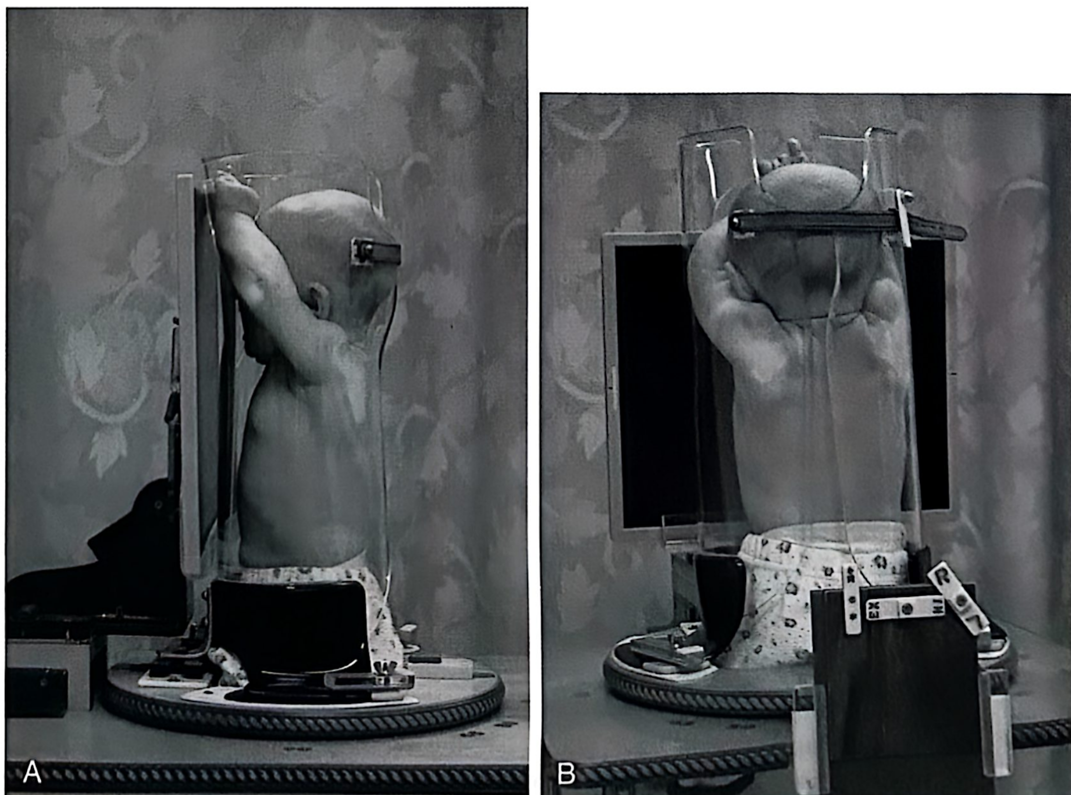


Fig. 18.14 Pigg-O-Stat positioning chair for upright pediatric chest radiography.

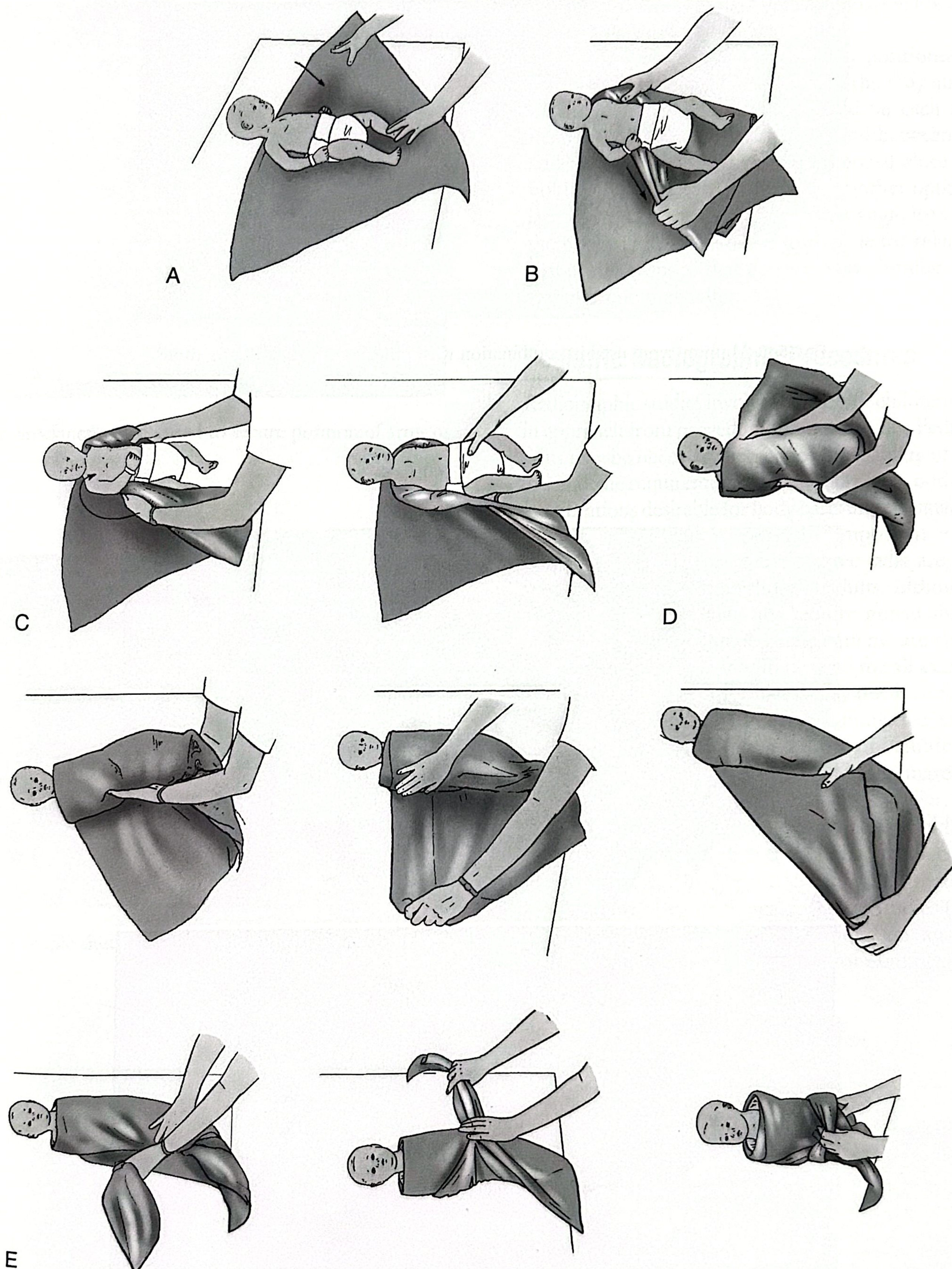


Fig. 18.15 Mummy wrap technique. (A) Fold the sheet on the diagonal to make a triangle. Place the child on the sheet with wide edge under neck. (B) Wrap one corner up over an arm, tuck it under the body, and pull it through. (C) Wrap the first corner over the second arm and tuck it under the body. (D) Wrap the second corner over the chest and secure it under the body. (E) Complete mummy wrap by securing the second corner around the child.

Fig. 18.16 Mummy wrap used in combination with other immobilization methods.

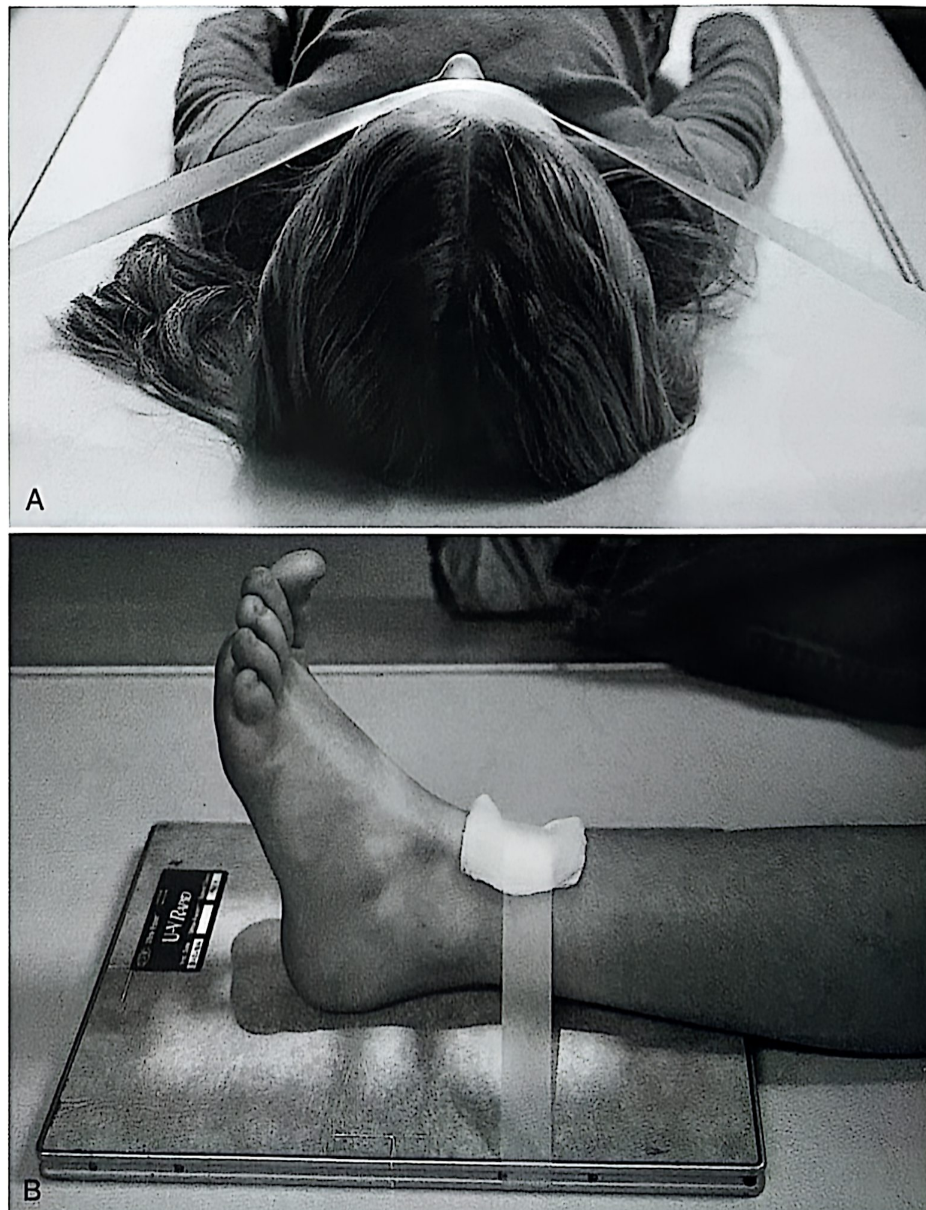


Fig. 18.17 Tape is often used to maintain pediatric positions. (A) Tape is twisted to avoid adhesive contact with skin. (B) Gauze is used to prevent adhesive contact with skin.

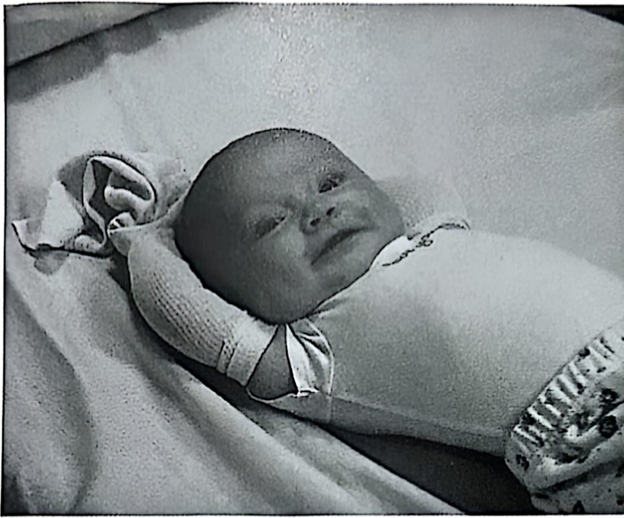


Fig. 18.18 Stockinet may be used to secure position of arms or legs.

Fig. 18.19 A simple sheet of clear Plexiglas aids in immobilizing a child's hand.

Plexiglas (Fig. 18.19). This plastic material is available at reasonable cost from plastics dealers.

When the head must be precisely positioned and head clamps are not available, tape is not the only answer. Two or three large books may be placed on each side of the head. Radiolucent sponges are placed between the books and the head, and the books are moved close enough to hold the head firmly (Fig. 18.20). Another option is to use large, heavy "bookends" made from angle iron in place of the books. These can be custom made for relatively small cost at metal shops that do iron work. Similar devices are available commercially.

Pediatric Radiographic Procedures

Radiographic studies involving infants or children often differ in approach from procedures used for adults. Pediatric variations may be necessary because of the inability of the patient to stand, the requirements of immobilization, or the technical modifications desirable for body parts that are small.

Gonad shielding is especially important in pediatric radiography. Immature reproductive cells are more vulnerable to mutation than those of adults. Although studies of the head or foot may not require gonad shielding on adults, all body parts on pediatric patients are closer to the gonads, and shielding should be used for all examinations. Children with chronic problems may need many examinations, and because gonad dose is cumulative, shielding is imperative. Small shields for infants and children may be cut from lead rubber or lead vinyl stock material. They may also be purchased from your x-ray supplier.

The sizes of the image and the radiation field for pediatric studies are smaller than those for adults because of the smaller size of the body parts. Select an IR that is slightly larger than the area of clinical interest. Studies that would involve several different examinations on an adult are sometimes combined for children. For example, the entire

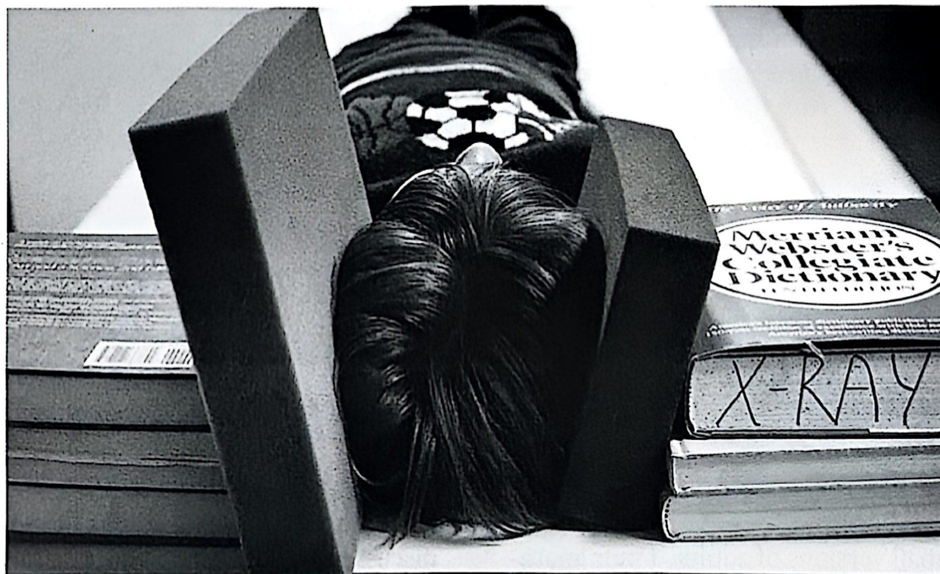


Fig. 18.20 Books and sponges may be used to secure a child's head position.

lower extremity might be included in a single exposure on an infant, whereas a study of the lower extremity would involve separate exposures of the femur and the lower leg on an adult.

Bilateral studies of extremities are often done on children. Comparison of the two sides is frequently helpful in determining whether variations in the growth centers of young bones are the result of injury or of normal development. Sometimes bilateral involvement of a pathologic condition is a significant diagnostic feature. Years ago it was routine to take bilateral comparison views for all extremity examinations on children under age 12. With the exception of hip and clavicle examinations, comparison views of the unaffected extremity are now taken only when they are necessary, and only on the specific order of the physician. This practice prevents unnecessary radiation exposure to the patient.

Many examinations that are done with a grid or Bucky on adults can be done better without the grid on small children. The deciding factor with respect to grids is the thickness of the body part. When the part thickness is less than 12 cm, a grid is not required. It is advantageous to avoid using a grid whenever possible for several reasons. Because grid use requires more exposure, non-grid exposures lower patient dose and permit shorter exposure times. When dealing with an active child, it is helpful to have the IR on the tabletop so that you can clearly see that the body part is correctly centered.

Chest radiographs on children do not require a grid. Unless you have a Pigg-O-Stat, infant chest radiographs will probably be done with the child recumbent at 40 or 48 inches source–image receptor distance (SID) (Fig. 18.21). Older children who are cooperative may sit or stand at an upright non-grid IR holder (see Fig. 18.9) or may sit at the end of the radiographic table and hold the IR (Fig. 18.22). These methods allow for upright projections at 72 inches SID.

Clavicle radiography differs significantly between adults and children. Adult studies involve only one clavicle and are usually done in the PA projection using the Bucky, often upright. Pediatric clavicle studies are usually bilateral and are done recumbent in the AP projection with the IR on the tabletop (Fig. 18.23). An axial projection may be taken in the same position with the central ray angled cephalad. This pediatric examination is frequently done because clavicle fractures are quite common in children.

Hip studies also are done bilaterally. The routine examination consists of AP and frog-leg lateral projections of the pelvis and proximal femurs (Fig. 18.24). Congenital hip dislocation is a fairly common condition that requires radiography for diagnosis and for continued evaluation until treatment is complete.

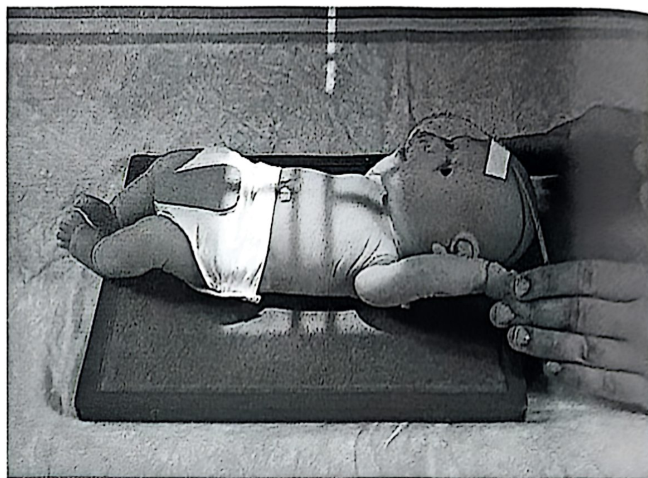


Fig. 18.21 Chest and abdomen studies on infants may be done on the tabletop at a 40-inch or 48-inch source–image receptor distance. (In practice, image receptor should be covered with a soft, warm blanket.)

Fig. 18.22 When an image receptor holder is not available, a cooperative child can hold the IR.

Pediatric Anatomy

Children are not just small versions of adults. Their anatomy is similar, but there are some definite differences. An infant's head is much larger in relation to body size than that of an adult. Adult spines have multiple curvatures, as discussed and illustrated in Chapter 15. An infant spine forms a C-shaped curve. The curve straightens and then recurves as the child grows.

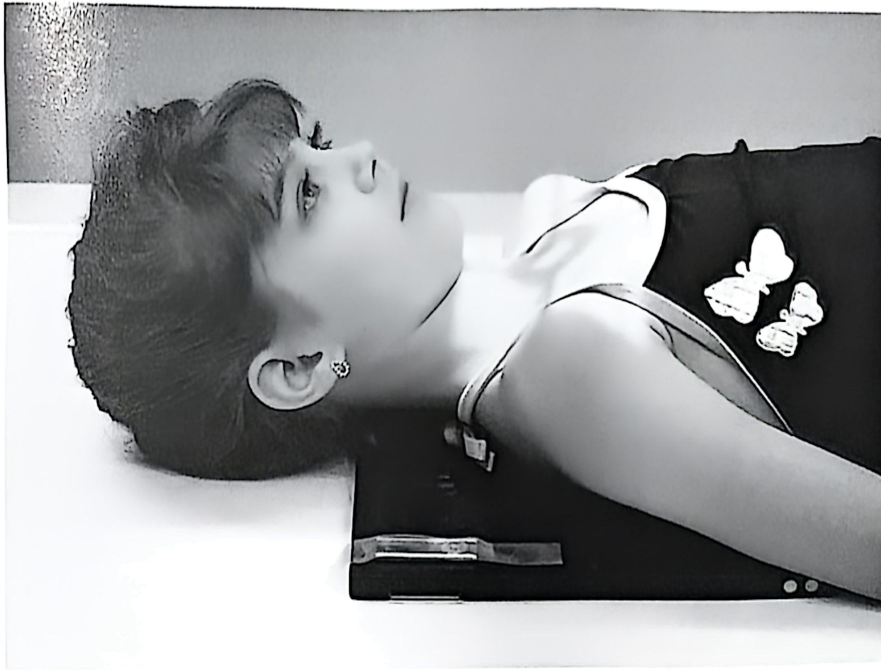
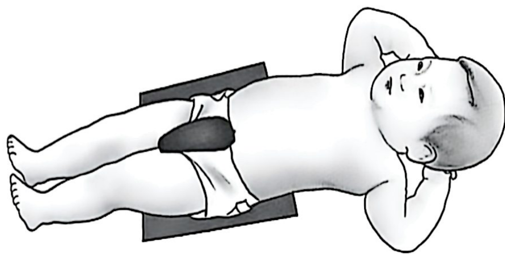
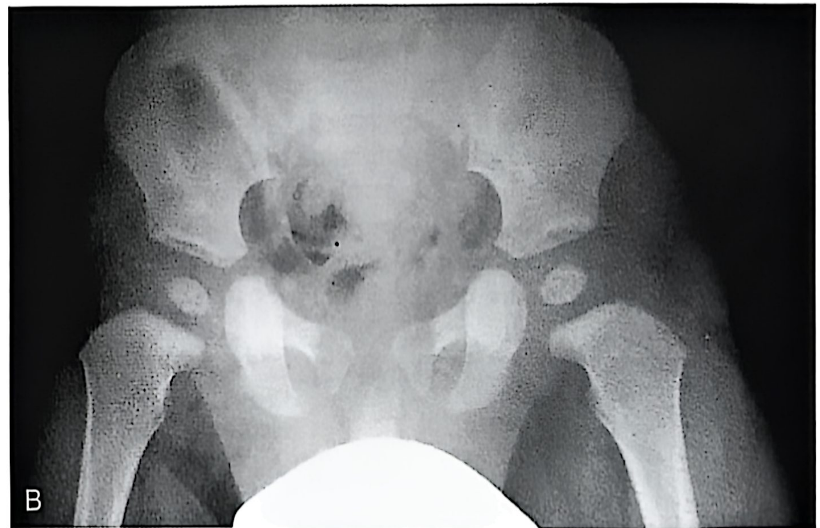
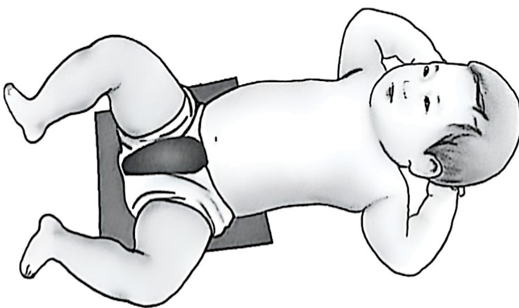


Fig. 18.23 Position for bilateral clavicle examination on a child.







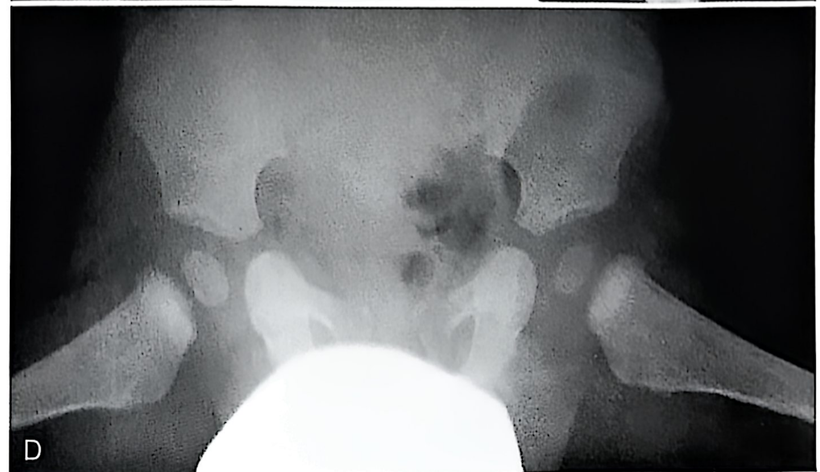


Fig. 18.24 Positions for bilateral hip examination on a small child. (A) Anteroposterior (AP) position. (B) AP radiograph. (C) Frog-leg position. (D) Frog-leg radiograph.

Fig. 18.25 illustrates an infant skeleton. Note that the skull and the joints are not completely ossified. With the exception of the anterior rib cage, the dark areas in this illustration, which represent cartilage, will become bone as the child develops. For this reason, the radiographic appearance of children's bones and joints is much different from that of adults. Fig. 18.26 is a typical example. It provides a radiographic comparison of the ankle and heel of a small child with those of an adult.

The structure of children's bones is less solid than that of adults' bones and is more easily penetrated by the x-ray beam. Note the difference in bone density in the two radiographs in Fig. 18.26. Children's soft tissues also differ from those of adults. "Baby fat" is a thick layer of subcutaneous (under the skin) fat that develops in the first 4 months of life and begins to disappear between the ages of 3 and 4. Children with baby fat are more easily penetrated than older children who have similar measurements because more of their soft tissue is fat, which is easily penetrated, and less is muscle, which is more radio-dense.

There is an exception to this rule, however, with respect to chest radiography. Babies and toddlers have smaller lungs and more fat in the chest. When the chest measurements are similar, a 5-year-old child will generally require less exposure for a chest radiograph than a 3-year-old child. This is because the older child's chest has little fat and is almost entirely made up of air-containing lung.

Even after the baby fat has disappeared, children's muscles tend to be small and underdeveloped. Their soft tissues are softer and more easily penetrated than those of an adult. This is true even when the child appears to be very strong. Dense musculature begins to develop in puberty.

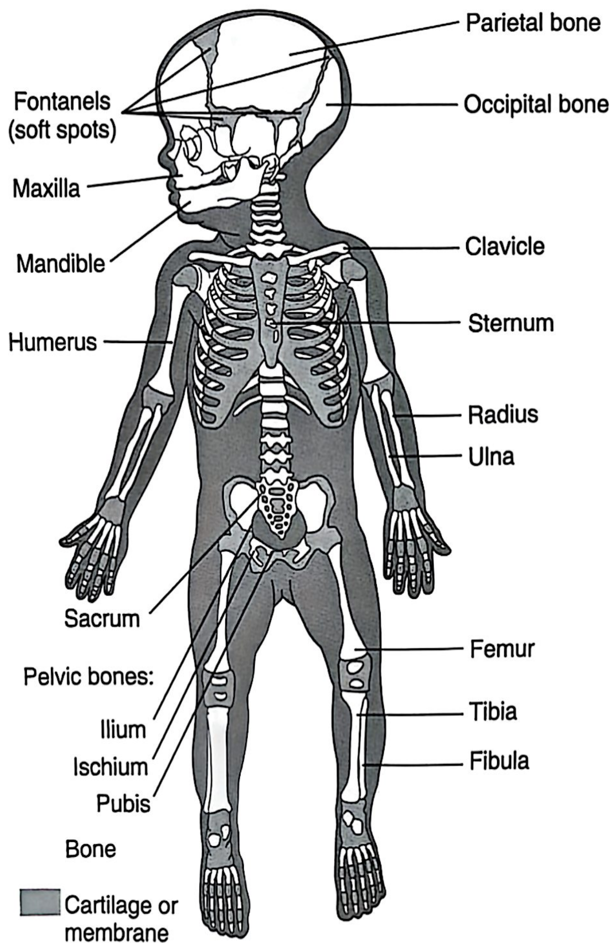


Fig. 18.25 An infant's skeleton has many bones that are not completely ossified.

Formulation of Techniques for Pediatric Exposures

Unless you work in a children's hospital or a pediatrician's office, you are unlikely to have a comprehensive pediatric x-

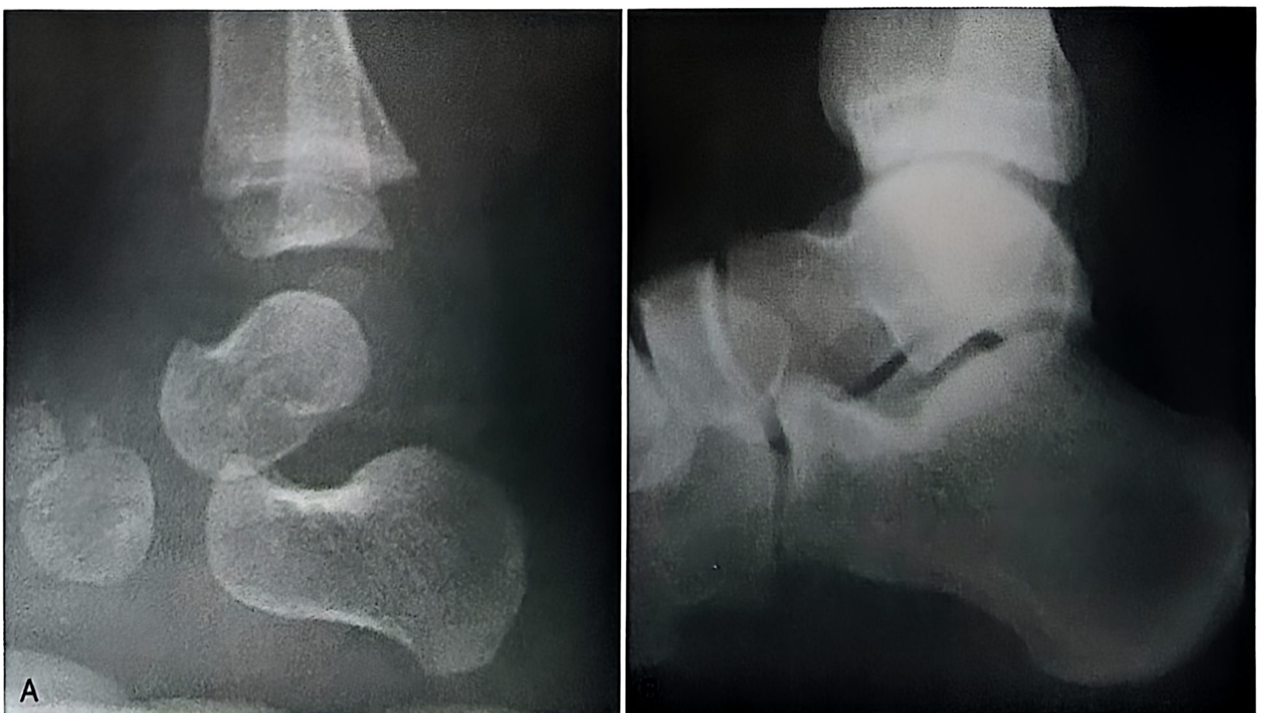


Fig. 18.26 Ankle radiographs show anatomic changes that occur with skeletal maturation. (A) Three-year-old child. (B) Adult.

ray technique chart. Pediatric exposure references often consist of a few penciled notes in the margins of an adult chart.

One method of arriving quickly at a pediatric technique is to compare the body part size with parts of similar size on an adult. For example, a child's wrist might be about the same thickness as an adult finger, or a baby's pelvis might be similar in thickness to an adult elbow. Using an adult technique for a body part of similar size is usually successful provided that the same IRs, SID, and grid or non-grid techniques are used. This method provides a starting point for deriving pediatric exposures, especially for examinations of the extremities.

Another method of calculating pediatric exposures is also based on an adult technique chart. This method presumes that the same speed of IR and the same grid or non-grid technique is used for the child as is specified in the adult chart. This formula uses the exposure for the smallest adult listing on the chart and modifies it as follows:

- Reduce kilovoltage (kVp) by 2 kVp for each centimeter of difference between the chart measurement and the patient measurement.
- Use 80% of the milliampere-seconds (mAs) suggested on the adult chart.

Example: Suppose you wish to take an AP lumbar spine radiograph on a 9-year-old patient who measures 13 cm. Your technique chart states that an adult measuring 18 cm would require 18 mAs and 80 kVp. The difference in measurement is 18 − 13, or 5 cm. Multiply this number by 2 to obtain the kVp change:

$$5\ \text{cm} \times \text{kVp/cm} = 10\ \text{kVp}$$

Subtract the change in kVp from the original kVp:

$$80\ \text{kVp} - 10\ \text{kVp} = 70\ \text{kVp}$$

Now multiply the mAs by 80%:

$$20\ \text{mAs} \times 0.8(80\%) = 16\ \text{mAs}$$

The new technique is 16 mAs at 70 kVp.

Another method of formulating pediatric techniques is to use the Supertech calculator (Supertech, Elkhart, IN) introduced in Chapter 10. This slide rule has separate windows for both adult and pediatric measurements. It produces appropriate exposures for all body parts for children under age 12, as well as for adults. It also provides multiple options for pediatric chest radiography: grid and non-grid, 40 inches and 72 inches SID. The Supertech calculator may be used to create an entire technique chart or may be kept in the x-ray room to derive individual exposures as necessary.

When formulating pediatric techniques, a short exposure time is always an advantage. A high milliampere (mA) setting that permits the least possible exposure time will help to prevent repeat exposures because of patient motion. If there is any likelihood that the patient will move during the exposure, do not lengthen the exposure time by using the small focal spot or the slow-speed detail IRs for pediatric studies. Even slight motion defeats these efforts to provide fine detail.

Pediatric Pathology

Children tend to put things in their mouths, so it is not unusual for them to swallow foreign bodies. Although swallowed objects may be alarming to parents, smooth objects such as coins do not often cause a serious problem. They are likely to be located radiographically in the stomach (Fig. 18.27) or the intestines and will pass without incident in a few days. When the child is in distress and has difficulty swallowing, the object may be lodged in the upper esophagus (Fig. 18.28). AP and lateral projections to include the neck and chest area are indicated in these cases.

The term **aspiration** refers to the inhalation of a substance or object. Foreign bodies in the mouth or nose may also be aspirated, that is, inhaled into the trachea or a bronchus. Fig. 18.29 illustrates an opaque foreign body in the left main bronchus. Nonopaque items, such as plastic beads or peanuts, may also be aspirated and are more difficult to locate. Frontal chest radiographs taken on both inspiration and expiration are sometimes used to demonstrate failure of a lung segment to expand. This helps to identify the location of a bronchial blockage, even when the aspirated object cannot be seen on the radiographic image.

Children's long bones are more flexible than those of adults, so they are far more likely to sustain incomplete

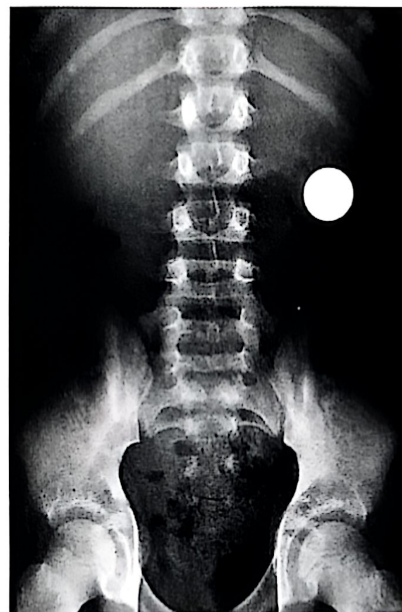


Fig. 18.27 Anteroposterior radiograph of the abdomen shows foreign body (coin) in child's stomach.

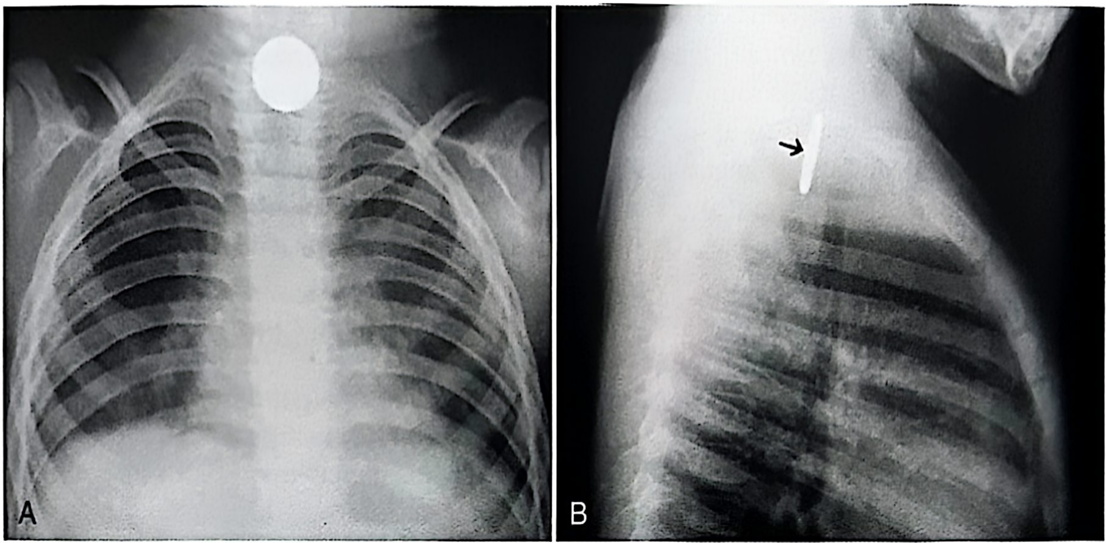


Fig. 18.28 Chest radiographs demonstrate foreign body (coin) in child's lower cervical esophagus. (A) Frontal projection. (B) Lateral projection.

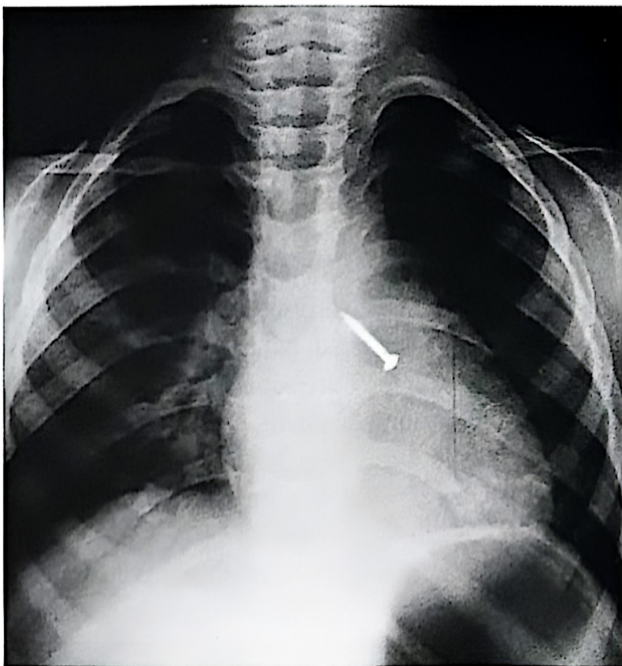


Fig. 18.29 Posteroanterior chest radiograph shows foreign body (nail) aspirated into left main bronchus.

fractures. The periosteum ruptures, and the cortex separates on one side of the bone, but the other side remains intact. This is called a *greenstick fracture*. Fig. 18.30 illustrates a greenstick fracture of the humerus in a 3-year-old girl.

Problems with the endocrine glands may affect the growth of a child. When pathologic conditions of the endocrine system are suspected, x-rays may be used to evaluate the degree of maturity of the skeleton. This is often referred to as a *bone age study*. Different sites may be radiographed, depending on the actual age of the child, but the wrist is common because it has many different growth centers that mature at different ages. Fig. 18.31 illustrates the wrist of a child with severe hypothyroidism. The skeletal maturity is typical of a child 2 to 3 years old, but this child's chronologic age was 11 years.

Fig. 18.32 is an example of a condition known as *slipped capital femoral epiphysis*. The growth plate of the femoral head has separated, and the epiphysis is displaced medially. This condition usually occurs in overweight children,

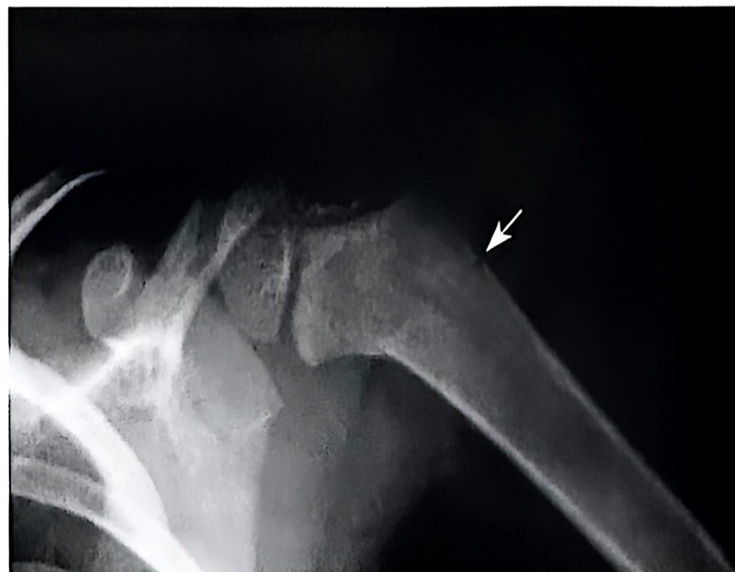


Fig. 18.30 Greenstick fracture of the humerus *(arrow)* in a 3-year-old girl.

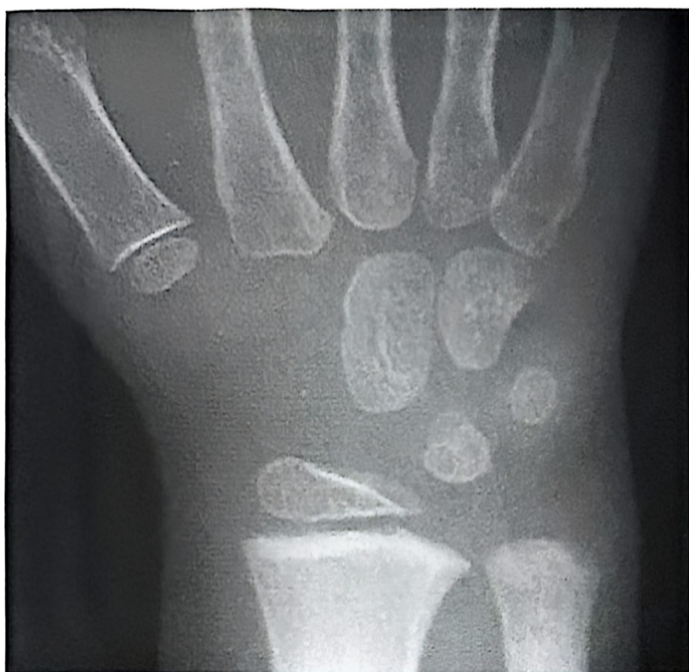


Fig. 18.31 Bone age study of the wrist in an 11-year-old child reveals severely retarded skeletal maturation caused by hypothyroidism. This wrist radiograph resembles that of a 2-year-old child.

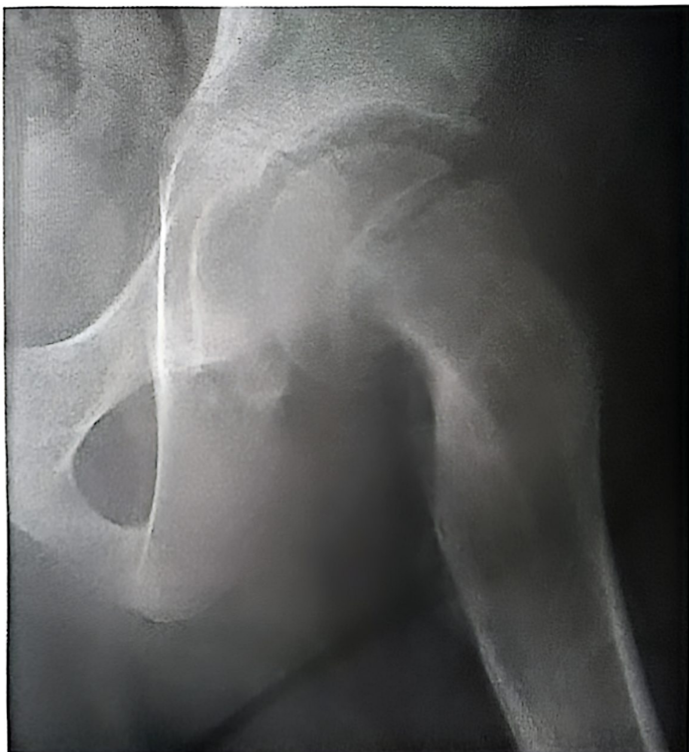


Fig. 18.32 Slipped capital femoral epiphysis in an overweight boy, aged 11.

who place too much stress on the growth plate before it is strong enough to support the excess weight.

Whenever an injured child is brought for treatment, physicians and other health care personnel should be alert for indications of **battered child syndrome**, the characteristics of physical abuse. Battered child syndrome is also referred to as **nonaccidental trauma (NAT)**. The incidence of child abuse is remarkably high. The total abuse rate is 25.2 cases per 1000 children. The majority of these cases are attributable to neglect, but these statistics also include sexual, emotional, and physical abuse, with considerable overlap among the categories. Approximately one-fourth of abused children suffer physical abuse or battering. Any of the following signs should raise concern about this possibility:

- Multiple injuries
- Evidence of chronic or repeated injury with no other explanation
- Injuries that are not consistent with the parents' report of the trauma
- Failure to seek prompt treatment for serious injury
- Bruise marks shaped like hands, fingers, or objects (such as a belt)
- Specific patterns of scalding (seen when a conscious child is immersed in hot water)
- Burns from an electric stove, radiator, heater, or other hot objects on the child's hands or buttocks
- Cigarette burns on exposed areas or the genitals
- Black eyes in an infant
- Human bite marks
- Lash marks
- Choke marks around the neck
- Circular marks around the wrists or ankles (twisting)
- Separated skull sutures or bulging fontanel in infants
- Unexplained unconsciousness in an infant

The last two items on this list are evidence of possible brain injury. Because of the difference in size and strength between adults and children, the abused child can be severely injured or killed unintentionally. Shaking an infant, for example, can cause bleeding over the brain (subdural hematoma), which can cause permanent brain damage or death. This condition is called *shaken baby syndrome*.

Fig. 18.33 illustrates a classic case of battered child syndrome. The radiographs of the lower legs show periosteal reaction from repeated bruising of the bone. This type of injury is sometimes referred to as *classic metaphyseal lesion (CML)*. Because abuse was suspected, a skeletal survey was done. That is, radiographs were taken of the skull, extremities, and thorax. The chest and rib study showed highly suspicious fractures of five ribs, which had partially healed. Four months after the skeletal survey, the child was again treated, this time for a fracture of the forearm. The parent stated that this injury had occurred on the previous day, but the radiographs showed evidence of healing at the fracture site, indicating that this injury had been present for a longer time. CML was also noted at the wrist. The diagnosis of battered child syndrome was undeniable.

GERIATRICS

Over the next decade, the size of the geriatric population will increase dramatically in the United States. The oldest

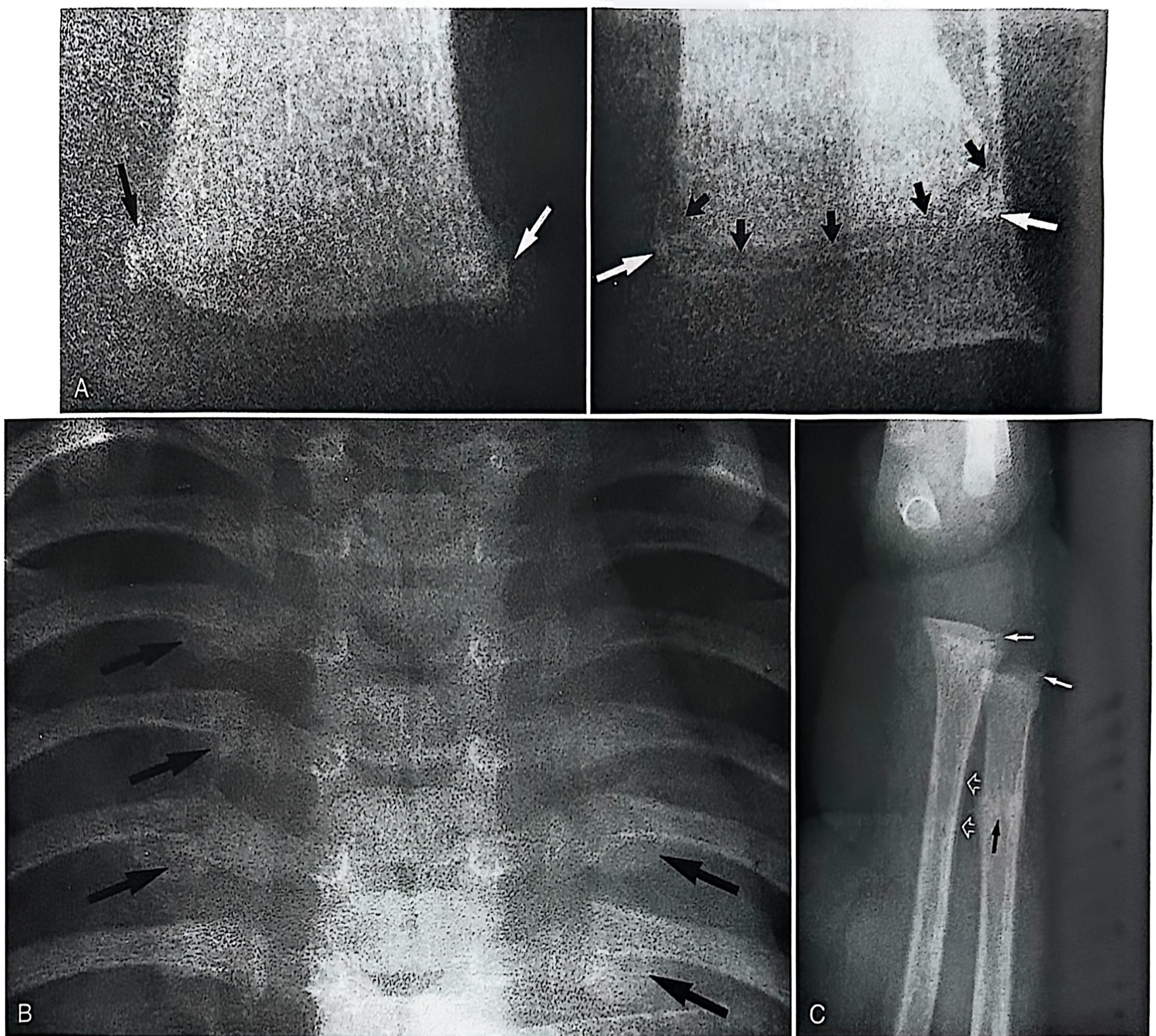


Fig. 18.33 Nonaccidental trauma. (A) Distal tibias revealed periosteal reaction from repeated bruising of the bone. (B) Skeletal survey revealed five healing rib fractures *(arrows)*. (C) Four months later, the patient was treated for fracture of the forearm. Radiographs revealed evidence conflicting with the parent's report of trauma.

members of the Baby Boom generation reached the age of retirement (65) in the year 2010. It is common for persons in this age group to begin experiencing health problems associated with aging and for the level and frequency of health care to increase. This generation is better educated and more self-directed than the generation it follows and will place ever-increasing demands on the health care system.

Communication

Most older adults are mentally alert and have little sensory impairment. Treated with respect, they present few problems for health care workers. On the other hand, aging is sometimes accompanied by the gradual loss of hearing, vision, mobility, or mental acuity, and limited operators must be alert to the possibility of these problems. It is important to evaluate the needs of older patients on an individual basis (Fig. 18.34).

A typical attribute of aging is a tendency to proceed at one's own pace, which is often slower than that of younger adults. Most older patients do not respond well to being pushed or hurried.

Hearing Loss

Patients with hearing loss may display levels of impairment that vary from the need to use a high-intensity hearing aid to a mild difficulty hearing voices in a high or low register. Do not assume that patients who are hard of hearing cannot communicate. Expecting others to listen and speak for them may be offensive. Some older adults deny that their hearing is failing or are embarrassed to admit that they cannot hear clearly. They may guess at what is being said or pretend to understand, so it is important for you to validate

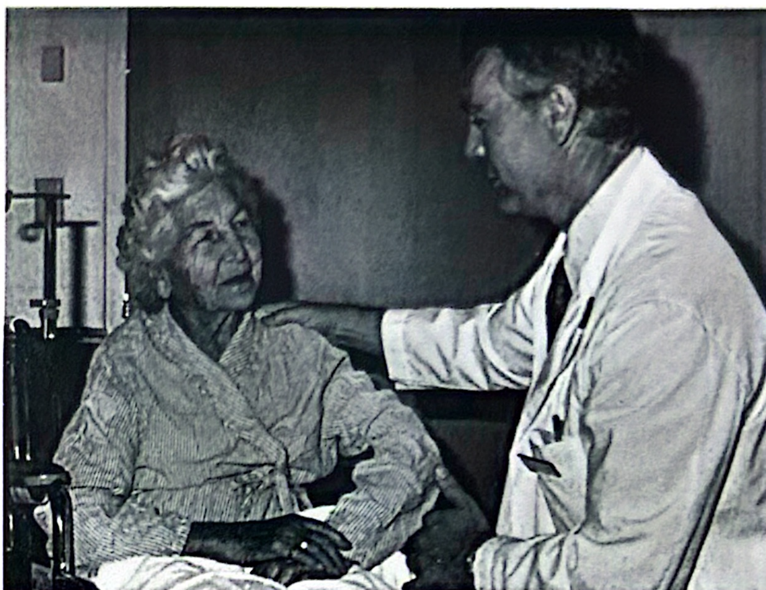


Fig. 18.34 Evaluate the needs of older patients on an individual basis.

that you have been understood correctly. The following list of suggestions will help to improve communication with patients whose hearing is impaired:

- Have the person's attention before you begin to speak.
- Face the person, preferably with light on your face. Lip reading may be an important supplement to hearing.
- Hearing loss is frequently in the upper register, so speak lower and louder. Do not shout.
- Speak clearly at a moderate pace.
- Avoid noisy background situations.
- Rephrase when you are not understood.
- Avoid potential misunderstandings by asking open-ended questions.
- Validate understanding by asking the patient to repeat instructions.
- Be patient.

When in doubt, ask the patient for suggestions to improve communication. Allow the patient who wears a hearing aid to retain it as long as possible. When a hearing aid must be removed for an examination, give all instructions before placing the aid in a safe location. Because visual clues are more important when hearing is impaired, do not remove the patient's glasses until necessary.

Failing Vision

Persons with failing vision usually see better in bright light. They may be able to walk about and to recognize faces but be unable to read fine print. Offer to read written material without waiting for the patient to request this assistance. Patients who manage quite well with glasses may become disoriented and unable to walk around safely when their glasses are removed. Allow these patients to retain their glasses as long as possible, and stand by to assist when they must move about without them.

Impaired Mental Function

Loss of mental function is a part of the aging process for some individuals. **Organic brain syndrome** is a term that refers to a large group of disorders associated with brain damage or impaired cerebral function. In older persons the cause is often either **Alzheimer disease** or circulatory impairment. Alzheimer disease is a specific type of brain tissue deterioration that causes memory loss and gradual deterioration of mental function. It is often indistinguishable from other forms of organic brain syndrome. Circulatory impairment may be caused by a major stroke or a series of small strokes. Mental impairment may involve orientation, memory, intellect, judgment, and/or insight. Mood and personality may also be affected. Medication, illness, or injury can cause similar symptoms. Patients over the age of 60 who have urinary tract infections may demonstrate confusion and loss of memory. This may be the only symptom they have, so the association between the symptoms and their cause is easily overlooked. The symptoms disappear when the infection is treated.

Although patients may be confused about where they are or why they have come, their memory of the past may be quite clear. It sometimes helps them to focus if you converse with them about their early life. Short-term memory is often diminished, so you may need to repeat instructions. Keep the instructions simple and give them one at a time. Using valid choices and treating elderly patients with the respect due any adult will help them maintain their sense of identity.

Physical Changes That Accompany Aging

As the skeleton ages, the bones tend to lose their calcium content, becoming porous and more radiolucent. Early

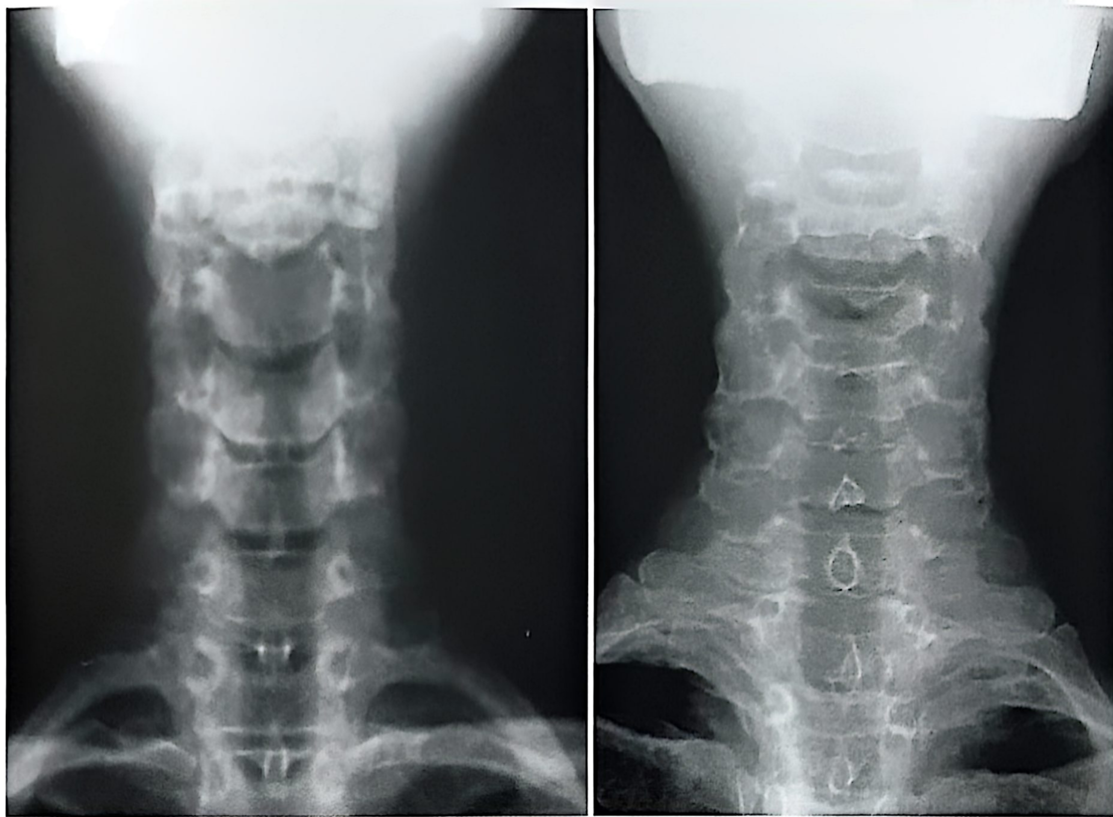


Fig. 18.35 Compare the bone density of these two cervical spine images. *Left:* A 26-year-old patient. *Right:* A 66-year-old patient. Note also the loss of cervical disc space on the older patient.

loss of bone calcium content is called **demineralization.** As this process progresses, it is called **osteopenia**. The more advanced stage is referred to as **osteoporosis** (Fig. 18.35).

The soft tissues also undergo change with age. The muscle tissues tend to atrophy and become fatty, which causes them to be more radiolucent than the muscles of younger adults. The subcutaneous fat layer that cushions the skin of younger persons is gradually lost with age and may be nonexistent in the elderly. The skin also loses its elasticity. Loss of both subcutaneous fat and skin elasticity causes the skin of older persons to be very fragile, and any shear pressure may injure it. For example, sliding across the table surface may cause the skin to tear and bleed, so it is best to place a sheet on the table and slide the sheet to move the patient. The skin of the feet and legs is especially delicate on patients whose circulation is compromised.

Veins also become fragile, which causes older patients to bruise easily. Pay special attention to avoid bumping the extremities as you position the patient and avoid wearing jewelry on your hands or wrists that could harm a patient during the process of moving or positioning.

Older or debilitated patients may develop ulcerated areas over bony prominences when pressure is exerted for even a short period of time, especially on the hard surface of a radiographic table. These lesions are called **decubitus ulcers** or *bedsores*. They are caused when pressure on a limited area inhibits circulation, depriving the cells of oxygen and nutrition. When pressure is not relieved and circulation restored promptly, the cells in the central portion may die, which causes the beginning of ulcer formation.

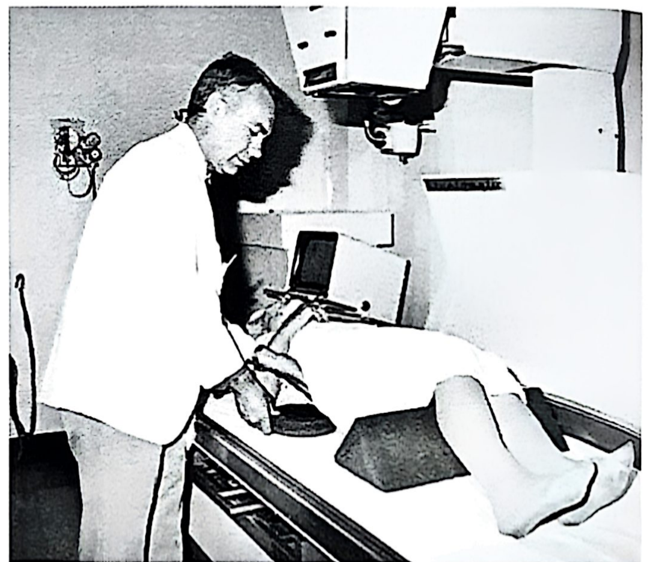


Fig. 18.36 Positioning with radiolucent sponges under bony prominences provides both comfort and safety.

Pressure for as little as 10 minutes may be sufficient to initiate this process in a high-risk patient. Over the course of a few days, the tissue breaks down and the ulcer becomes apparent on the skin surface. Because the damage is not visible immediately, the true origin of these lesions may not be recognized. High-risk patients who are weak or debilitated may be in a poor nutritional state with impaired circulation. When this is the case, the ulcers do not heal well and may even require skin grafting.

Decubitus ulcers can be prevented by padding bony prominences with radiolucent sponges (Fig. 18.36). Pay particular attention to the mid-thoracic area, the sacrum,

and the heels when the patient is supine. In the lateral position, provide cushioning under the trochanters, knees, and ankles. Alternatively, a full-size table pad may be used. Radiolucent pads with plastic covers are available to fit radiographic tables and should always be used when the procedure is likely to be prolonged. Failure to protect the skin increases the likelihood of decubitus ulcer formation.

Formulation of Techniques for Geriatric Exposures

Because the bones and soft tissues of elderly persons are more easily penetrated than those of younger adults, exposures must be adjusted to allow for these differences in tissue density. Demineralization of the bone produces less subject contrast on radiographic images, so the best result is obtained by reducing the kVp. A reduction of 4 to 6 kVp is usually appropriate for patients older than 70 years of age. Thin patients beyond the age of 80 may require a reduction of up to 10 kVp.

Geriatric Pathology

The aging process is generally accompanied by aches and pains. Osteoarthritis was discussed in Chapters 13, 14, and 15 and illustrated in Figs. *13.116*, *14.92*, and *15.91*. This condition is very common in the elderly, causing joints to be stiff and painful. There is no cure for osteoarthritis, and the usual treatment is a nonprescription pain medication, such as acetaminophen (Tylenol) or ibuprofen (Advil). But pain may also have other causes that require different treatments, so complaints of pain must be investigated to rule out other possibilities. Radiography is often a significant part of this evaluation process.

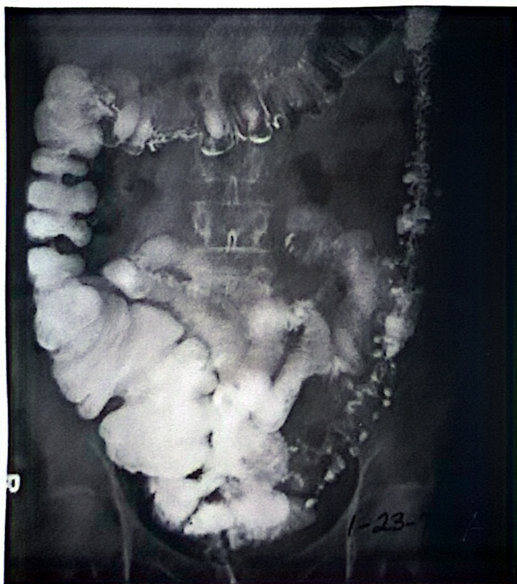


Fig. 18.37 Diverticulitis is demonstrated here in a barium enema study of the colon.

Heart disease is seen frequently in older patients. Chest radiography is an important aspect of the diagnosis and continued evaluation of patients with heart conditions as well as chronic conditions of the lung, such as emphysema.

Many older patients have gastrointestinal complaints. A common cause is **diverticulitis**, a degenerative inflammatory disease of the colon (Fig. 18.37). Small sacs or pouches called *diverticula* form in the walls of the colon, and feces tend to stagnate within them, causing inflammation. The symptoms of this condition are constipation and/or diarrhea with abdominal pain or cramping. The radiographic diagnosis of diverticulitis requires fluoroscopy with a contrast medium instilled rectally. This examination is called a *barium enema* or *lower gastrointestinal series* and is beyond the scope of this text because it is not usually performed by limited operators. Severe, chronic diverticulitis may lead to sufficient thickening of the colon walls to cause bowel obstruction. Also, diverticula may rupture, which allows gas and intestinal content to leak into the peritoneal cavity, causing peritonitis. These conditions cause acute abdominal pain and may be diagnosed by images of the abdomen without contrast agents. The procedure for radiography of acute abdominal conditions is discussed in Chapter 16.

Parkinson disease is a degenerative condition of the nervous system that sometimes attacks in middle age but is far more common in the elderly. The characteristic symptom is a fine tremor, which may begin in a hand or foot and gradually spreads to involve all parts of the body. As the disease advances, the body becomes weak and rigid; the patient has a peculiar gait and a lack of facial expression. Parkinson disease is not evaluated with radiography, but patients with this condition may require radiography for other reasons. The tremors complicate radiography because these patients may be unable to hold still during exposures. Patients with Parkinson disease will be better able to relax and minimize motion if they are resting comfortably in a recumbent position. Providing a solid object for them to grip may help to reduce hand tremors. A high mA setting with a short exposure time will help to avoid motion blur on the images.

SUMMARY

Compared with young adults, both pediatric and geriatric patients may exhibit limitations in their ability to cooperate with radiography. Respectful and age-appropriate communication will help to smooth the way, especially when accompanied by a generous amount of patience. It is important not to make assumptions based on age stereotypes, young or old. Each patient has a unique personality and abilities. Patients will respond best when approached with a genuine interest and concern for them as individuals.

Because of their smaller size and differing diagnostic requirements, infants and children often require protocols that differ from those for adults. Immobilization of infants and small children without the aid of human hands is highly desirable and usually possible. A variety of excellent commercial devices is available for this purpose, but creative use of available equipment and supplies will allow you to improvise when such devices are not available.

Because of differences in bone and soft tissue density, both pediatric and geriatric patients require modification of the exposures found on typical adult technique charts. Guidelines based on the adult chart are provided in this chapter, and the Supertech calculator provides suitable exposures as well.

An understanding of the special requirements of pediatric and geriatric patients will help you to function confidently and competently when radiography of these patients is needed. Working with the very young and the very old will provide some of your most delightful and satisfying experiences as a radiographer.