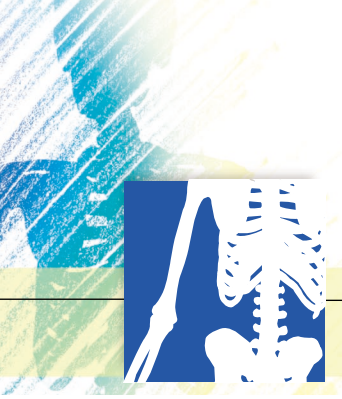
The Musculoskeletal System

11 Bones and Cartilage



Chapter Outline

BONES

Bone Fractures

Immediately after a fracture, the patient suffers severe local pain and is not able to use the injured part. Deformity may be visible if the bone fragments have been displaced relative to each other. The degree of deformity and the directions taken by the bony fragments depend not only on the mechanism of injury but also on the pull of the muscles attached to the fragments. Ligamentous attachments also influence the deformity. In certain situations—for example, the ileum—fractures result in no deformity because the inner and outer surfaces of the bone are splinted by the extensive origins of muscles. In contrast, a fracture of the neck of the femur produces considerable displacement. The strong muscles of the thigh pull the distal fragment upward so that the leg is shortened. The very strong lateral rotators rotate the distal fragment laterally so that the foot points laterally.

Fracture of a bone is accompanied by a considerable hemorrhage of blood between the bone ends and into the surrounding soft tissue. The blood vessels and the fibroblasts and osteoblasts from the periosteum and endosteum take part in the repair process.

Rickets

Rickets is a defective mineralization of the cartilage matrix in growing bones. This produces a condition in which the cartilage cells continue to grow, resulting in excess cartilage and a widening of the epiphyseal plates. The poorly mineralized cartilaginous matrix and the osteoid matrix are soft, and they bend under the stress of bearing weight. The resulting deformities include enlarged costochondral junctions, bowing of the long bones of the lower limbs, and bossing of the frontal bones of the skull. Deformities of the pelvis may also occur.

Epiphyseal Plate Disorders

Epiphyseal plate disorders affect only children and adolescents. The epiphyseal plate is the part of a growing bone concerned primarily with growth in length. Trauma, infection, diet, exercise, and endocrine disorders can disturb the growth of the hyaline cartilaginous plate, leading to deformity and loss of function. In the femur, for example, the proximal epiphysis can slip because of mechanical stress or excessive loads. The length of the limbs can increase excessively because of increased vascularity in the region of the epiphyseal plate secondary to infection or in the presence of tumors. Shortening of a limb can follow trauma to the epiphyseal plate resulting from a diminished blood supply to the cartilage.

Skull

Clinical Features of the Neonatal Skull

Fontanelles

Palpation of the fontanelles enables the physician to determine the progress of growth in the surrounding bones, the degree of hydration of the baby (e.g., if the fontanelles are depressed below the surface, the baby is dehydrated), and the state of the intracranial pressure (a bulging fontanelle indicates raised intracranial pressure).

Samples of cerebrospinal fluid can be obtained by passing a long needle obliquely through the anterior fontanelle into the subarachnoid space or even into the lateral ventricle.

Clinically, it is usually not possible to palpate the anterior fontanelle after 18 months, because the frontal and parietal bones have enlarged to close the gap.

Tympanic Membrane

At birth, the tympanic membrane faces more downward and less laterally than in maturity; when examined with the otoscope, it therefore lies more obliquely in the infant than in the adult.

Forceps Delivery and the Facial Nerve

In the newborn infant, the mastoid process is not developed, and the facial nerve, as it emerges from the stylomastoid foramen, is close to the surface. Thus, it can be damaged by forceps in a difficult delivery.

Fractures of the Skull

Fractures of the skull are common in the adult but much less so in the young child. In the infant skull, the bones are more resilient than in the adult skull, and they are separated by fibrous sutural ligaments. In the adult, the inner table of the skull is particularly brittle. Moreover, the sutural ligaments begin to ossify during middle age.

The type of fracture that occurs in the skull depends on the age of the patient, the severity of the blow, and the area of skull receiving the trauma. The **adult skull** may be likened to an eggshell in that it possesses a certain limited resilience beyond which it splinters. A severe, localized blow produces a local indentation, often accompanied by splintering of the bone. Blows to the vault often result in a series of linear fractures, which radiate out through the thin areas of bone. The petrous parts of the temporal bones and the occipital crests strongly reinforce the base of the skull and tend to deflect linear fractures.

In the **young child,** the skull may be likened to a table-tennis ball in that a localized blow produces a depression without splintering. This common type of circumscribed lesion is referred to as a "**pond**" **fracture.**

Fractures of the Anterior Cranial Fossa

In fractures of the anterior cranial fossa, the cribriform plate of the ethmoid bone may be damaged. This usually results in tearing of the overlying meninges and underlying mucoperiosteum. The patient will have bleeding from the nose (**epistaxis**) and leakage of cerebrospinal fluid into the nose (**cerebrospinal rhinorrhea**). Fractures involving the orbital plate of the frontal bone result in hemorrhage beneath the conjunctiva and into the orbital cavity, causing **exophthalmos.** The frontal air sinus may be involved, with hemorrhage into the nose.

Fractures of the Middle Cranial Fossa

Fractures of the middle cranial fossa are common, because this is the weakest part of the base of the skull. Anatomically, this weakness is caused by the presence of numerous foramina and canals in this region; the cavities of the middle ear and the sphenoidal air sinuses are particularly vulnerable. The leakage of cerebrospinal fluid and blood from the external auditory meatus is common. The seventh and eighth cranial nerves may be involved as they pass through the petrous part of the temporal bone. The third, fourth, and sixth cranial nerves may be damaged if the lateral wall of the cavernous sinus is torn. Blood and cerebrospinal fluid may leak into the sphenoidal air sinuses and then into the nose.

Fractures of the Posterior Cranial Fossa

In fractures of the posterior cranial fossa, blood may escape into the nape of the neck deep to the postvertebral muscles. Some days later, it tracks between the muscles and appears in the posterior triangle, close to the mastoid process. The mucous membrane of the roof of the nasopharynx may be torn, and blood may escape there. In fractures involving the jugular foramen, the ninth, tenth, and eleventh cranial nerves may be damaged. The strong bony walls of the hypoglossal canal usually protect the hypoglossal nerve from injury.

Bone Injuries of the Skull and Skeletal Development

The developing bones of a child's face are more pliable than an adult's, and fractures may be incomplete or greenstick. In adults, the presence of well-developed, air-filled sinuses and the mucoperiosteal surfaces of the alveolar parts of the upper and lower jaws means that most facial fractures should be considered to be open fractures, susceptible to infection and requiring antibiotic therapy.

Anatomy of Common Facial Fractures

Automobile accidents, fisticuffs, and falls are common causes of facial fractures. Fortunately, the upper part of the skull is developed from membrane (whereas the remainder is developed from cartilage); therefore, this part of the skull in children is relatively flexible and can absorb considerable force without resulting in a fracture.

Signs of fractures of the facial bones include deformity, ocular displacement, or abnormal movement accompanied by crepitation and malocclusion of the teeth. Anesthesia or paresthesia of the facial skin will follow fracture of bones through which branches of the trigeminal nerve pass to the skin.

The muscles of the face are thin and weak and cause little displacement of the bone fragments. Once a fracture of the maxilla has been reduced, for example, prolonged fixation is not needed. However, in the case of the mandible, the strong muscles of mastication can create considerable displacement, requiring long periods of fixation.

The most common facial fractures involve the nasal bones, followed by the zygomatic bone and then the mandible. To fracture the maxillary bones and the supraorbital ridges of the frontal bones, an enormous force is required.

Nasal Fractures

Fractures of the nasal bones, because of the prominence of the nose, are the most common facial fractures. Because the bones are lined with mucoperiosteum, the fracture is considered open; the overlying skin may also be lacerated. Although most are simple fractures and are reduced under local anesthesia, some are associated with severe injuries to the nasal septum and require careful treatment under general anesthesia.

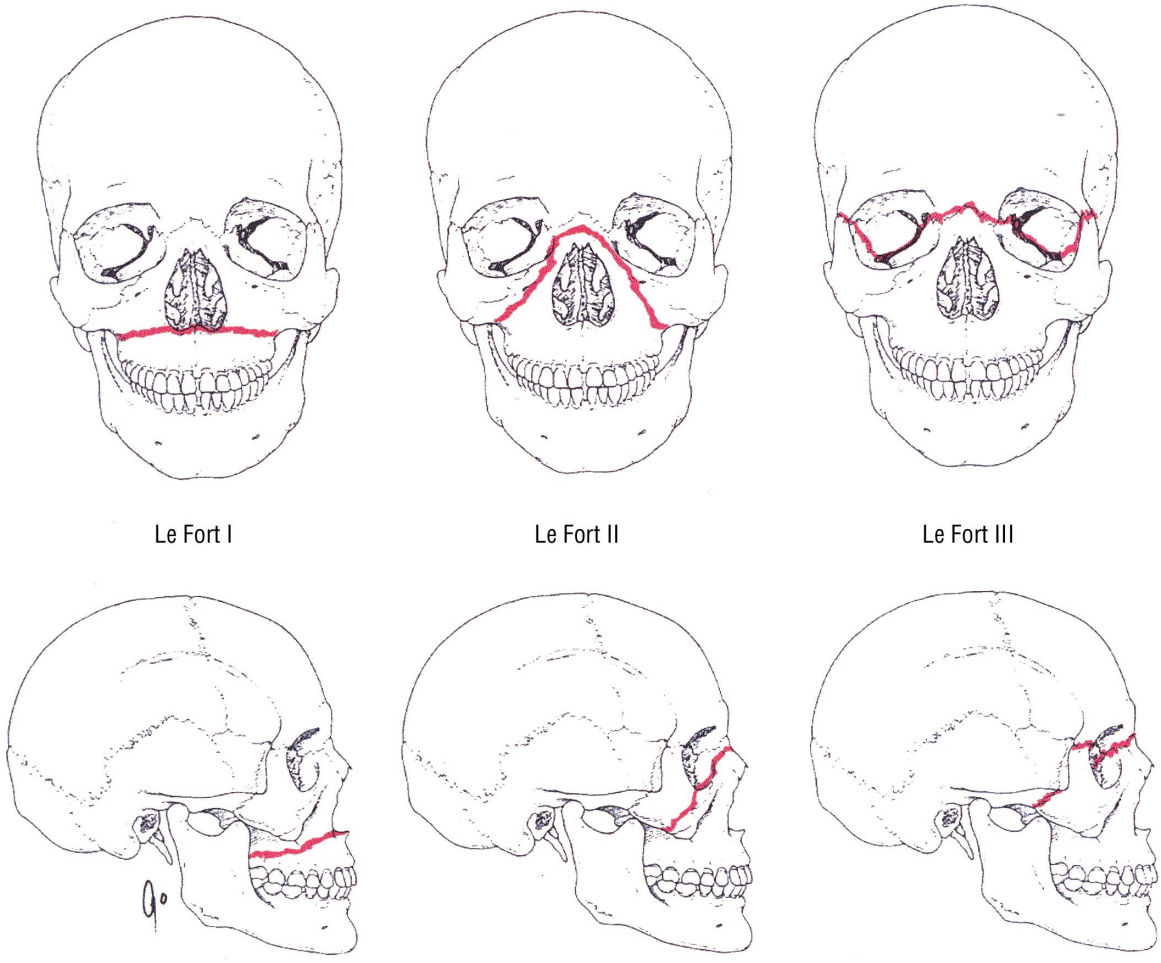
Maxillofacial Fractures

Maxillofacial fractures usually occur as the result of massive facial trauma. There is extensive facial swelling, midface mobility of the underlying bone on palpation, malocclusion of the teeth with anterior open bite, and possibly leakage of cerebrospinal fluid (cerebrospinal rhinorrhea) secondary to fracture of the cribriform plate of the ethmoid bone. Double vision (diplopia) may be present, owing to orbital wall damage. Involvement of the infraorbital nerve with anesthesia or paresthesia of the skin of the cheek and upper gum may occur in fractures of the body of the maxilla. Nose bleeding may also occur in maxillary fractures. Blood enters the maxillary air sinus and then leaks into the nasal cavity.

The sites of the fractures were classified by Le Fort as type I, II, or III; these fractures are summarized in CD Fig. 11-1.

Blowout Fractures of the Maxilla

A severe blow to the orbit (as from a baseball) may cause the contents of the orbital cavity to explode downward through



CD Figure 11-1 Le Fort classification of maxillofacial fractures. The *red line* denotes the fracture line.

the floor of the orbit into the maxillary sinus. Damage to the infraorbital nerve, resulting in altered sensation to the skin of the cheek, upper lip, and gum, may occur.

Fractures of the Zygoma or Zygomatic Arch

The zygoma or zygomatic arch can be fractured by a blow to the side of the face. Although it can occur as an isolated fracture, as from a blow from a clenched fist, it may be associated with multiple other fractures of the face, as often seen in automobile accidents.

Mandible

Fractures of the Mandible

The mandible is horseshoe shaped and forms part of a bony ring with the two temporomandibular joints and the base of the skull. Traumatic impact is transmitted around the ring, causing a single fracture or multiple fractures of the mandible, often far removed from the point of impact.

Vertebral Column

Examination of the Back

It is important that the whole area of the back and legs be examined and that the shoes be removed. Unequal length of the legs or disease of the hip joints can lead to abnormal curvatures of the vertebral column. The patient should be asked to walk up and down the examination room so that the normal tilting movement of the pelvis can be observed. As one side of the pelvis is raised, a coronal lumbar convexity develops on the opposite side, with a compensatory thoracic convexity on the same side. When a person assumes the sitting position, it will be noted that the normal lumbar curvature becomes flattened, with an increase in the interval between the lumbar spines.

The normal range of movement of the different parts of the vertebral column should be tested. In the cervical region, flexion, extension, lateral rotation, and lateral flexion are possible. Remember that about half of the movement referred to as flexion is carried out at the atlantooccipital joints. In flexion, the patient should be able to touch his or her chest with the chin, and in extension he or she should be able to look directly upward. In lateral rotation the patient should be able to place the chin nearly in line with the shoulder. Half of lateral rotation occurs between the atlas and the axis. In lateral flexion the head can normally be tilted 45° to each shoulder. It is important that the shoulder is not raised when this movement is being tested.

In the thoracic region the movements are limited by the presence of the ribs and sternum. When testing for rotation, make sure that the patient does not rotate the pelvis.

In the lumbar region, flexion, extension, lateral rotation, and lateral flexion are possible. Flexion and extension are fairly free. Lateral rotation, however, is limited by the interlocking of the articular processes. Lateral flexion in the thoracic and lumbar regions is tested by asking the patient to slide, in turn, each hand down the lateral side of the thigh.

Abnormal Curves of the Vertebral Column

Kyphosis is an exaggeration in the sagittal curvature present in the thoracic part of the vertebral column. It can be caused by muscular weakness or by structural changes in the vertebral bodies or by intervertebral discs. In sickly adolescents, for example, where the muscle tone is poor, long hours of study or work over a low desk can lead to a gently curved kyphosis of the upper thoracic region. The person is said to be "round-shouldered." Crush fractures or tuberculous destruction of the vertebral bodies leads to acute angular kyphosis of the vertebral column. In the aged, **osteoporosis** (abnormal rarefaction of bone) and/or degeneration of the intervertebral discs leads to **senile kyphosis,** involving the cervical, thoracic, and lumbar regions of the column.

Lordosis is an exaggeration in the sagittal curvature present in the lumbar region. Lordosis may be caused by an increase in the weight of the abdominal contents, as with the gravid uterus or a large ovarian tumor, or it may be caused by disease of the vertebral column such as spondylolisthesis. The possibility that it is a postural compensation for a kyphosis in the thoracic region or a disease of the hip joint (congenital dislocation) must not be overlooked.

Scoliosis is a lateral deviation of the vertebral column. This is most commonly found in the thoracic region and may be caused by muscular or vertebral defects. Paralysis of muscles caused by poliomyelitis can cause severe scoliosis. The presence of a congenital hemivertebra can cause scoliosis. Often scoliosis is compensatory and may be caused by a short leg or hip disease.

Partial Fusion of the Sacral Vertebrae

The first sacral vertebra can be partly or completely separated from the second sacral vertebra. Occasionally, on radiographs of the vertebral column, examples are seen in which the fifth lumbar vertebra has fused with the first sacral vertebra.

Fracture of the Sacrum in Trauma of the Pelvis

Trauma to the true pelvis can result in fracture of the lateral mass of the sacrum.

Fractures of the Coccyx and Coccydynia

Fractures of the coccyx are rare. However, **coccydynia** is common and is usually caused by direct trauma to the coccyx, as in falling down a flight of concrete steps. The anterior surface of the coccyx can be palpated with a rectal examination.

Thoracic Bones

Clinical Importance of the Sternal Angle (Angle of Louis)

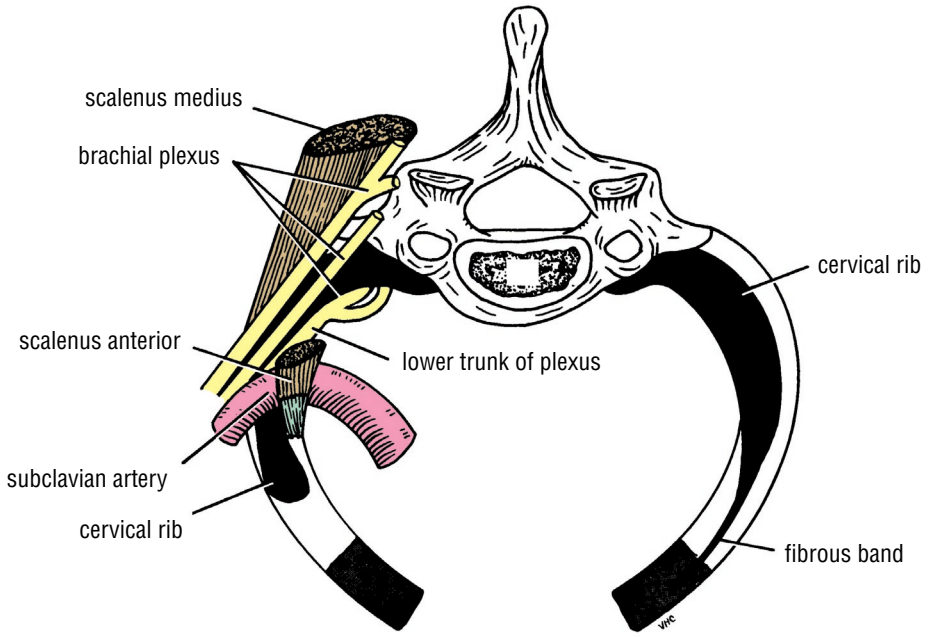
When one is examining the chest from the front, the **sternal angle (angle of Louis)** is an important landmark. Its position can easily be felt and can often be seen by the presence of a transverse ridge. The finger moved to the right or to the left passes directly onto the second costal cartilage and then the second rib. All other ribs can be counted from this point. The twelfth rib can usually be felt from behind, but in some obese persons this may prove difficult.

Sternum and Marrow Biopsy

Since the sternum possesses red hematopoietic marrow throughout life, it is a common site for **marrow biopsy.** Under a local anesthetic, a wide-bore needle is introduced into the marrow cavity through the anterior surface of the bone. The sternum may also be split at operation to allow the surgeon to gain easy access to the heart, great vessels, and thymus.

Cervical Rib

A cervical rib (i.e., a rib arising from the anterior tubercle of the transverse process of the seventh cervical vertebra) occurs in about 0.5% of humans (CD Fig. 11-2). It may have a free anterior end, may be connected to the first rib by a fibrous band, or may articulate with the first rib. The importance of a cervical rib is that it can cause pressure on the lower trunk of the brachial plexus in some patients, producing pain down



CD Figure 11-2 Thoracic outlet as seen from above. Note the presence of the cervical ribs (*black*) on both sides. On the right side of the thorax, the rib is almost complete and articulates anteriorly with the first rib. On the left side of the thorax, the rib is rudimentary but is continued forward as a fibrous band that is attached to the first costal cartilage. Note that the cervical rib may exert pressure on the lower trunk of the brachial plexus and may kink the subclavian artery.

the medial side of the forearm and hand and wasting of the small muscles of the hand. It can also exert pressure on the overlying subclavian artery and interfere with the circulation of the upper limb.

Rib Excision

Rib excision is commonly performed by thoracic surgeons wishing to gain entrance to the thoracic cavity. A longitudinal incision is made through the periosteum on the outer surface of the rib and a segment of the rib is removed. A second longitudinal incision is then made through the bed of the rib, which is the inner covering of periosteum. After the operation, the rib regenerates from the osteogenetic layer of the periosteum.

Bones of the Upper Limb

Bones of the Shoulder Girdle

Fractures of the Clavicle

The clavicle is a strut that holds the arm laterally so that it can move freely on the trunk. Unfortunately, because of its position, it is exposed to trauma and transmits forces from the upper limb to the trunk. *It is the most commonly fractured bone in the body*. The fracture usually occurs as a result of a fall on the shoulder or outstretched hand. The force is transmitted along the clavicle, which breaks at its weakest point, the junction of the middle and outer thirds. After the fracture, the lateral fragment is depressed by the weight of the arm, and it is pulled medially and forward by the strong adductor muscles of the shoulder joint, especially the pectoralis major. The medial end is tilted upward by the sternocleidomastoid muscle.

The close relationship of the supraclavicular nerves to the clavicle may result in their involvement in callus formation after fracture of the bone. This may be the cause of persistent pain over the side of the neck.

Compression of the Brachial Plexus, Subclavian Artery, and Subclavian Vein by the Clavicle

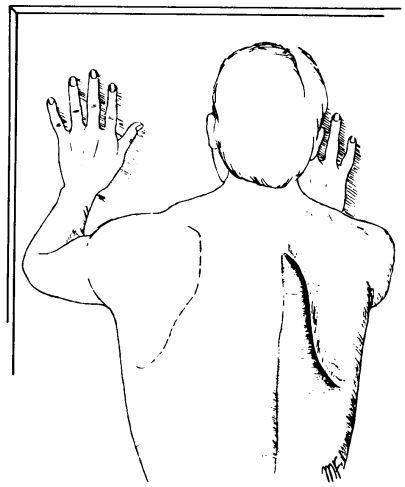
The interval between the clavicle and the first rib in some patients may become narrowed and thus is responsible for compression of nerves and blood vessels.

Fractures of the Scapula

Fractures of the scapula are usually the result of severe trauma, such as occurs in run-over accident victims or in occupants of automobiles involved in crashes. Injuries are usually associated with fractured ribs. Most fractures of the scapula require little treatment because the muscles on the anterior and posterior surfaces adequately splint the fragments.

Dropped Shoulder and Winged Scapula

The position of the scapula on the posterior wall of the thorax is maintained by the tone and balance of the muscles attached to it. If one of these muscles is paralyzed, the balance is upset, as in dropped shoulder, which occurs with paralysis of the trapezius, or winged scapula (CD Fig. 11-3), caused by paralysis of the serratus anterior. Such imbalance can be detected by careful physical examination.



CD Figure 11-3 Winging of the right scapula.

Bones of the Arm

Fractures of the Proximal End of the Humerus

Humeral Head Fractures

Fractures of the humeral head (CD Fig. 11-4) can occur during the process of anterior and posterior dislocations of the shoulder joint. The fibrocartilaginous glenoid labrum of the scapula produces the fracture, and the labrum can become jammed in the defect, making reduction of the shoulder joint difficult.

Greater Tuberosity Fractures

The greater tuberosity of the humerus can be fractured by direct trauma, displaced by the glenoid labrum during dislocation of the shoulder joint, or avulsed by violent contractions of the supraspinatus muscle. The bone fragment will have the attachments of the supraspinatus, teres minor, and infraspinatus muscles, whose tendons form part of the rotator cuff. When associated with a shoulder dislocation, severe tearing of the cuff with the fracture can result in the greater tuberosity remaining displaced posteriorly after the shoulder joint has been reduced. In this situation, open reduction of the fracture is necessary to attach the rotator cuff back into place.

Lesser Tuberosity Fractures

Occasionally, a lesser tuberosity fracture accompanies posterior dislocation of the shoulder joint. The bone fragment receives the insertion of the subscapularis tendon (see CD Fig. 11-4), a part of the rotator cuff.

Surgical Neck Fractures

The surgical neck of the humerus (see CD Fig. 11-4), which lies immediately distal to the lesser tuberosity, can be fractured by a direct blow on the lateral aspect of the shoulder or in an indirect manner by falling on the outstretched hand.

Fractures of the Shaft of the Humerus

Fractures of the humeral shaft are common; displacement of the fragments depends on the relation of the site of the fracture to the insertion of the deltoid muscle (see CD Fig. 11-4). When the fracture line is proximal to the deltoid insertion, the proximal fragment is adducted by the pectoralis major, latissimus dorsi, and teres major muscles; the distal fragment is pulled proximally by the deltoid, biceps, and triceps. When the fracture is distal to the deltoid insertion, the proximal fragment is abducted by the deltoid, and the distal fragment is pulled proximally by the biceps and triceps. The radial nerve can be damaged where it lies in the spiral groove on the posterior surface of the humerus under cover of the triceps muscle.

Fractures of the Distal End of the Humerus

Supracondylar fractures (see CD Fig. 11-4) are common in children and occur when the child falls on the outstretched hand with the elbow partially flexed. Injuries to the medial, radial, and ulnar nerves are not uncommon, although function usually quickly returns after reduction of the fracture. Damage to or pressure on the brachial artery can occur at the time of the fracture or from swelling of the surrounding tissues; the circulation to the forearm may be interfered with, leading to Volkmann's ischemic contracture.

The medial epicondyle (see CD Fig. 11-4) can be avulsed by the medial collateral ligament of the elbow joint if the forearm is forcibly abducted. The ulnar nerve can be injured at the time of the fracture, can become involved later in the repair process of the fracture (in the callus), or can undergo irritation on the irregular bony surface after the bone fragments are reunited.

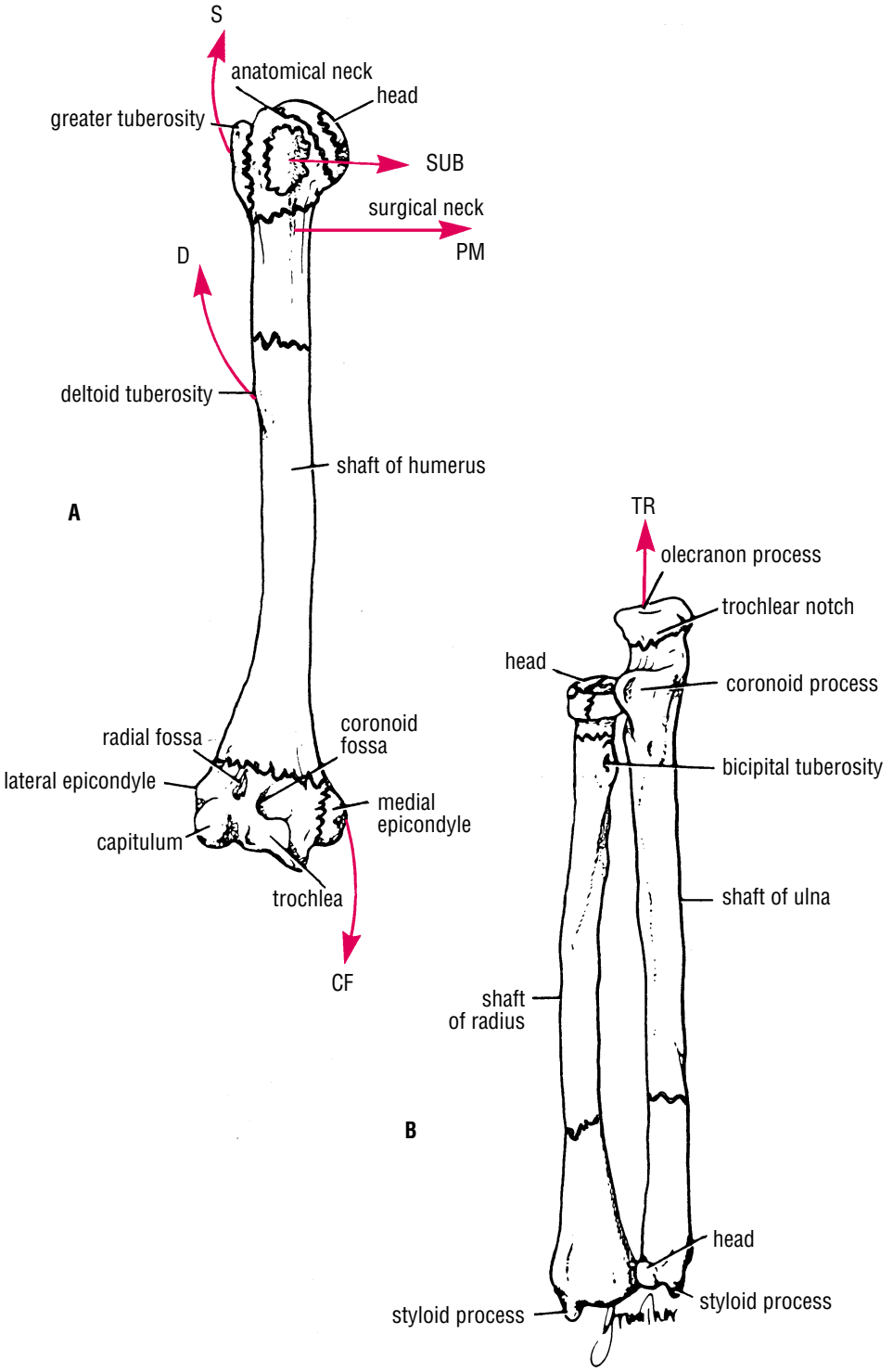
Bones of the Forearm

Fractures of the Radius and Ulna

Fractures **of the head of the radius** can occur from falls on the outstretched hand. As the force is transmitted along the radius, the head of the radius is driven sharply against the capitulum, splitting or splintering the head (see CD Fig. 11-4).

Fractures **of the neck of the radius** occur in young children from falls on the outstretched hand (see CD Fig. 11-4).

Fractures **of the shafts of the radius and ulna** may or may not occur together (see CD Fig. 11-4). Displacement of the fragments is usually considerable and depends on the pull of the attached muscles. The proximal fragment of the radius is supinated by the supinator and the biceps brachii muscles (see CD Fig. 11-4). The distal fragment of the radius is pronated and pulled medially by the pronator quadratus muscle. The strength of the brachioradialis and extensor carpi radialis longus and brevis shortens and angulates the forearm. In fractures of the ulna, the ulna angulates



CD Figure 11-4 **A.** Common fractures of the humerus. **B.** Common fractures of the radius and ulna. The displacement of the bony fragments on the site of the fracture line and the pull of the muscles. CF = pull of common flexure muscles, D = deltoid, PM = pectoralis major, S = supraspinatus, SUB = subscapularis, and TR = triceps.

posteriorly. To restore the normal movements of pronation and supination, the normal anatomic relationship of the radius, ulna, and interosseous membrane must be regained.

A fracture of one forearm bone may be associated with a dislocation of the other bone. In **Monteggia's fracture,** for example, the shaft of the ulna is fractured by a force applied from behind. There is a bowing forward of the ulnar shaft and an anterior dislocation of the radial head with rupture of the anular ligament. In **Galeazzi's fracture,** the proximal third of the radius is fractured and the distal end of the ulna is dislocated at the distal radioulnar joint.

Fractures of the olecranon process can result from a fall on the flexed elbow or from a direct blow. Depending on the location of the fracture line, the bony fragment may be

displaced by the pull of the triceps muscle, which is inserted on the olecranon process (see CD Fig. 11-4). Avulsion fractures of part of the olecranon process can be produced by the pull of the triceps muscle. Good functional return after any of these fractures depends on the accurate anatomic reduction of the fragment.

Colles' fracture is a fracture of the distal end of the radius resulting from a fall on the outstretched hand. It commonly occurs in patients older than 50 years. The force drives the distal fragment posteriorly and superiorly, and the distal articular surface is inclined posteriorly (CD Fig. 11-5). This posterior displacement produces a posterior bump, sometimes referred to as the "dinner-fork deformity" because the forearm and wrist resemble the shape of that eating utensil. Failure to restore the distal articular surface to its normal position will severely limit the range of flexion of the wrist joint.

Smith's fracture is a fracture of the distal end of the radius and occurs from a fall on the back of the hand. It is a reversed Colles' fracture because the distal fragment is displaced anteriorly (see CD Fig. 11-5).

Olecranon Bursitis

A small subcutaneous bursa is present over the olecranon process of the ulna, and repeated trauma often produces chronic bursitis.

Bones of the Hand

Injuries to the Bones of the Hand

Fracture of the scaphoid bone is common in young adults; unless treated effectively, the fragments will not unite, and permanent weakness and pain of the wrist will result, with the subsequent development of osteoarthritis. The fracture line usually goes through the narrowest part of the bone, which because of its location is bathed in synovial fluid. The blood vessels to the scaphoid enter its proximal and distal ends, although the blood supply is occasionally confined to its distal end. If the latter occurs, a fracture deprives the proximal fragment of its arterial supply, and this fragment undergoes avascular necrosis. Deep tenderness in the anatomic snuffbox after a fall on the outstretched hand in a young adult makes one suspicious of a fractured scaphoid.

Dislocation of the lunate bone occasionally occurs in young adults who fall on the outstretched hand in a way that causes hyperextension of the wrist joint. Involvement of the median nerve is common.

Fractures of the metacarpal bones can occur as a result of direct violence, such as the clenched fist striking a hard object. The fracture always angulates dorsally. The "boxer's fracture" commonly produces an oblique fracture of the neck of the fifth and sometimes the fourth metacarpal bones. The distal fragment is commonly displaced proximally, thus shortening the finger posteriorly.

Bennett's fracture is a fracture of the base of the metacarpal of the thumb caused when violence is applied along the long axis of the thumb or the thumb is forcefully abducted. The fracture is oblique and enters the carpometacarpal joint of the thumb, causing joint instability.

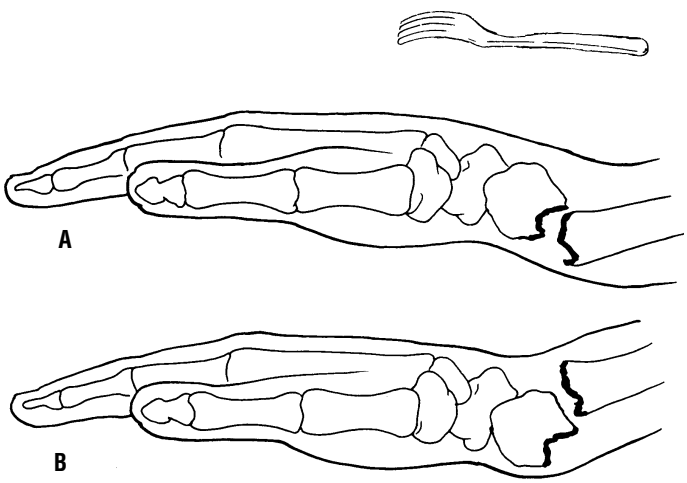
Fractures of the phalanges are common and usually follow direct injury.

Bones of the Lower Limb

Bones of the Pelvic Girdle

Clinical Concept: The Pelvis Is a Basin with Holes in Its Walls

The walls of the pelvis are formed by bones and ligaments; these are partly lined with muscles (obturator internus and piriformis) covered with fascia and parietal peritoneum. On



CD Figure 11-5 Fractures of the distal end of the radius. **A.** Colles' fracture. **B.** Smith's fracture.

the outside of the pelvis are the attachments of the gluteal muscles and the obturator externus muscle. The greater part of the bony pelvis is thus sandwiched between inner and outer muscles.

The basin has anterior, posterior, and lateral walls and an inferior wall or floor formed by the important levator ani and coccygeus muscles and their covering fascia.

The basin has many holes: The posterior wall has holes on the anterior surface of the sacrum, the **anterior sacral foramina,** for the passage of the anterior rami of the sacral spinal nerves. The **sacrotuberous** and **sacrospinous ligaments** convert the greater and lesser sciatic notches into the **greater** and **lesser sciatic foramina.** The greater sciatic foramen provides an exit from the true pelvis into the gluteal region for the sciatic nerve, the pudendal nerve, and the gluteal nerves and vessels; the lesser sciatic foramen provides an entrance into the perineum from the gluteal region for the pudendal nerve and the internal pudendal vessels. (One can make a further analogy here: For the wires to gain entrance to the apartment below, without going through the floor, they have to pierce the wall [greater sciatic foramen] to get outside the building and then return through a second hole [lesser sciatic foramen]. In the case of the human body, the pudendal nerve and internal pudendal vessels are the wires and the levator ani and the coccygeus muscles are the floor.)

The lateral pelvic wall has a large hole, the **obturator foramen,** which is closed by the **obturator membrane,** except for a small opening that permits the obturator nerve to leave the pelvis and enter the thigh.

Pelvic Measurements in Obstetrics

The capacity and shape of the female pelvis are of fundamental importance in obstetrics. The female pelvis is well adapted for the process of childbirth. The pelvis is shallower and the bones are smoother than in the male. The size of the pelvic inlet is similar in the two sexes, but in the female, the cavity is larger and cylindrical and the pelvic outlet is wider in both the anteroposterior and the transverse diameters.

Four terms relating to areas of the pelvis are commonly used in clinical practice:

- The **pelvic inlet** or **brim** of the true pelvis (CD Fig. 11-6) is bounded anteriorly by the symphysis pubis, laterally by the iliopectineal lines, and posteriorly by the sacral promontory.
- The **pelvic outlet** of the true pelvis (see CD Fig. 11-6) is bounded in front by the pubic arch, laterally by the ischial tuberosities, and posteriorly by the coccyx. The sacrotuberous ligaments also form part of the margin of the outlet.
- The **pelvic cavity** is the space between the inlet and the outlet (see CD Fig. 11-6).
- The **axis of the pelvis** is an imaginary line joining the central points of the anteroposterior diameters from the inlet to the outlet and is the curved course taken by the baby's head as it descends through the pelvis during childbirth (CD Figs. 11-6 and 11-7A).

Internal Pelvic Assessments

Internal pelvic assessments are made by vaginal examination during the later weeks of pregnancy, when the pelvic tissues are softer and more yielding than in the newly pregnant condition.

- **Pubic arch:** Spread the fingers under the pubic arch and examine its shape. Is it broad or angular? The examiner's four fingers should be able to rest comfortably in the angle below the symphysis.
- **Lateral walls:** Palpate the lateral walls and determine whether they are concave, straight, or converging. The prominence of the ischial spines and the position of the sacrospinous ligaments are noted.
- **Posterior wall:** The sacrum is palpated to determine whether it is straight or well curved. Finally, if the patient has relaxed the perineum sufficiently, an attempt is made to palpate the promontory of the sacrum. The second finger of the examining hand is placed on the promontory, and the index finger of the free hand, outside the vagina, is placed at the point on the examining hand where it makes contact with the lower border of the symphysis. The fingers are then withdrawn and the distance measured (CD Fig. 11-7B), providing the measurement of the **diagonal conjugate,** which is normally about 5 in. (13 cm). The anteroposterior diameter from the sacrococcygeal joint to the lower border of the symphysis is then estimated.
- **Ischial tuberosities:** The distance between the ischial tuberosities may be estimated by using the closed fist (CD Fig. 11-7D). It measures about 4 in. (10 cm), but it is difficult to measure exactly.

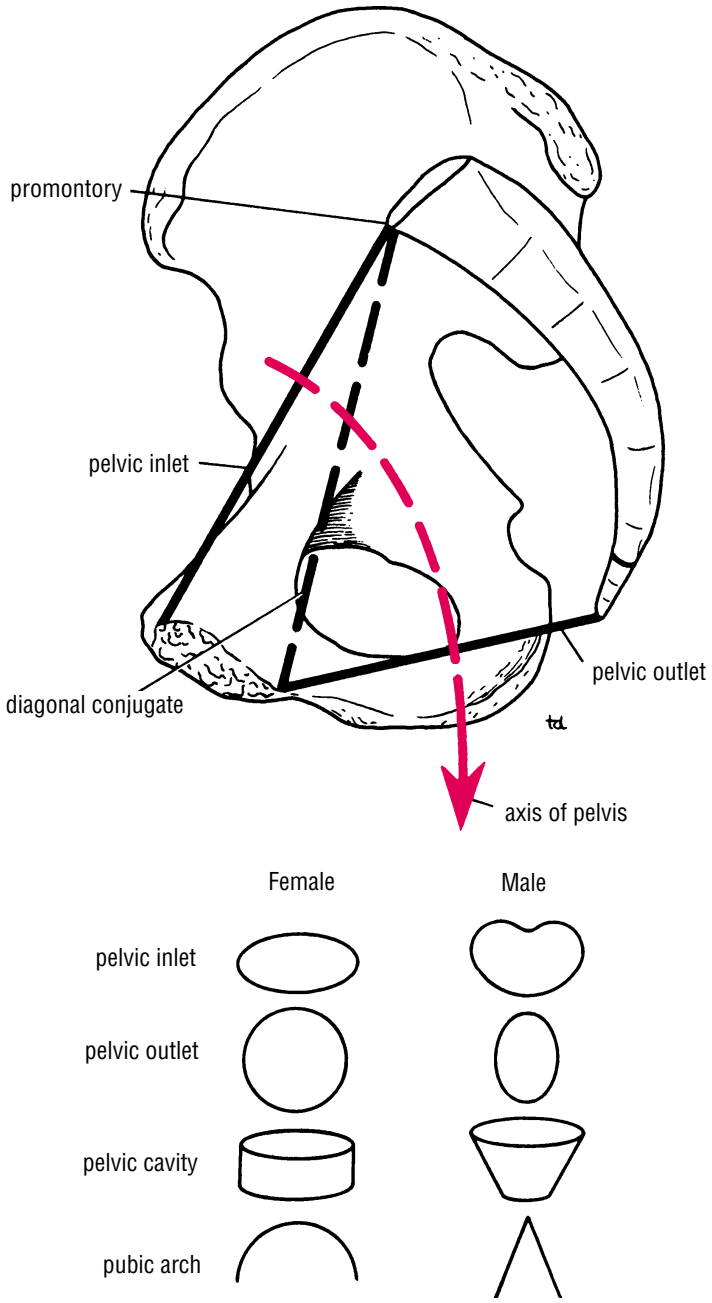
Needless to say, considerable clinical experience is required to be able to assess the shape and size of the pelvis by vaginal examination.

The Female Pelvis

Deformities of the pelvis may be responsible for **dystocia** (difficult labor). A contracted pelvis may obstruct the normal passage of the fetus. It may be indirectly responsible for dystocia by causing conditions such as malpresentation or malposition of the fetus, premature rupture of the fetal membranes, and uterine inertia.

The cause of pelvic deformities may be congenital (rare) or acquired from disease, poor posture, or fractures caused by injury. Pelvic deformities are more common in women who have grown up in a poor environment and are undernourished. It is probable that these women suffered in their youth from minor degrees of rickets.

In 1933, Caldwell and Moloy classified pelves into four groups: gynecoid, android, anthropoid, and platypelloid



CD Figure 11-6 Pelvic inlet, pelvic outlet, diagonal conjugate, and axis of the pelvis. Some of the main differences between the female and the male pelvis are also shown.

(CD. Fig. 11-7C).The **gynecoid** type, present in about 41% of women, is the typical female pelvis, which was previously described.

The **android** type, present in about 33% of white females and 16% of black females, is the male or funnel-shaped pelvis with a contracted outlet.

The **anthropoid** type, present in about 24% of white females and 41% of black females, is long, narrow, and oval shaped.

The **platypelloid** type, present in only about 2% of women, is a wide pelvis flattened at the brim, with the promontory of the sacrum pushed forward.

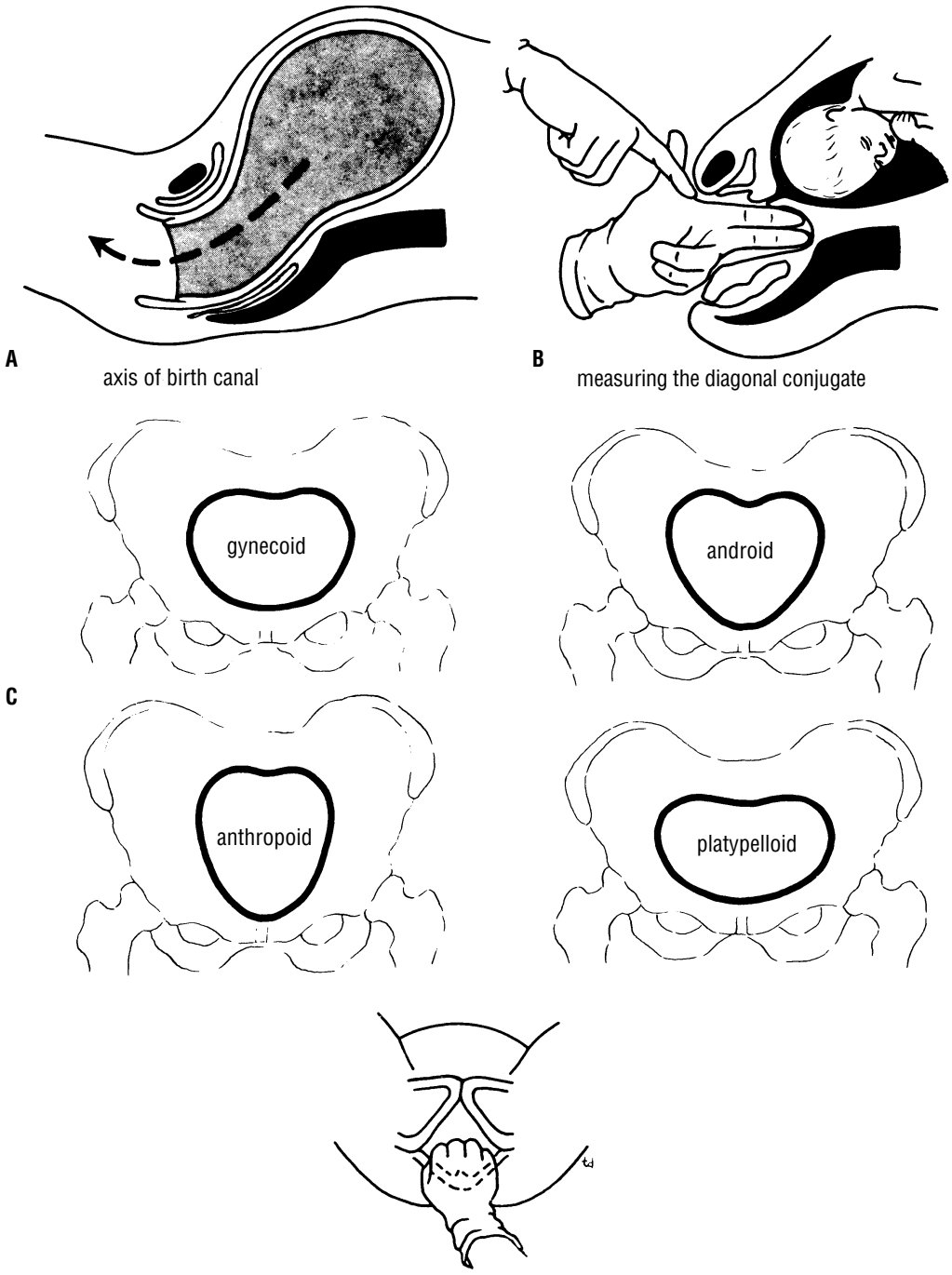
Fractures of the Pelvis

Fractures of the False Pelvis

Fractures of the false pelvis caused by direct trauma occasionally occur. The upper part of the ilium is seldom displaced because of the attachment of the iliacus muscle on the inside and the gluteal muscles on the outside.

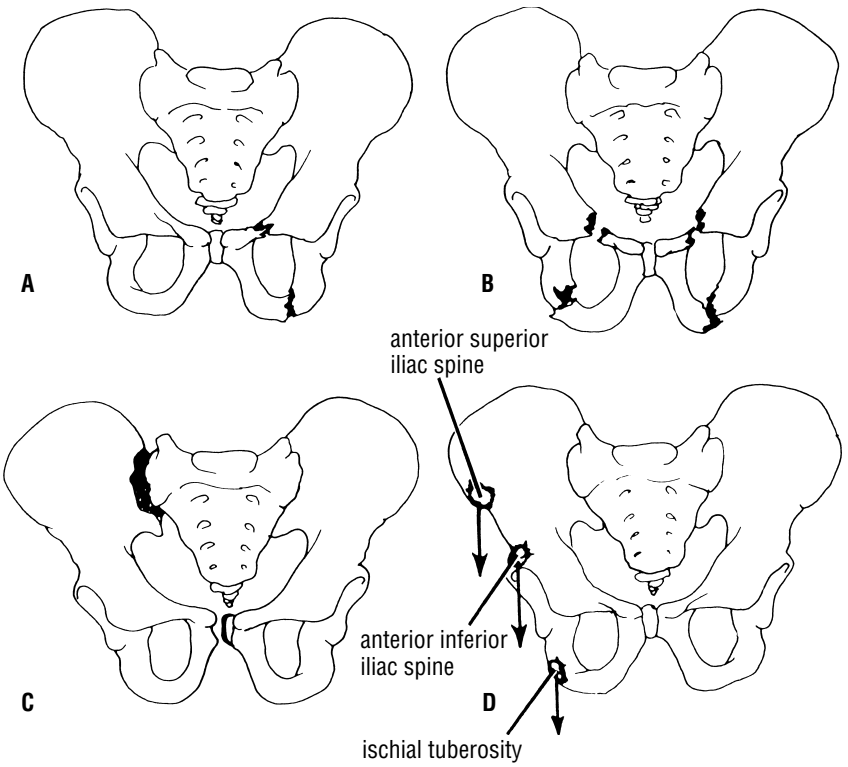
Fractures of the True Pelvis

The mechanism of fractures of the true pelvis can be better understood if the pelvis is regarded not only as a basin but also as a rigid ring (see CD Fig. 11-8). The ring is made up



CD Figure 11-7 **A.** Birth canal. *Interrupted line* indicates the axis of the canal. **B.** Procedure used in measuring the diagonal conjugate. **C.** Different types of pelvic inlets, according to Caldwell and Moloy. **D.** Estimation of the width of the pelvic outlet by means of a closed fist.

of the pubic rami, the ischium, the acetabulum, the ilium, and the sacrum, joined by strong ligaments at the sacroiliac and symphyseal joints. If the ring breaks at any one point, the fracture will be stable and no displacement will occur. However, if two breaks occur in the ring, the fracture will be unstable and displacement will occur, because the postvertebral and abdominal muscles will shorten and elevate the lateral part of the pelvis (see CD Fig. 11-8). The break in the ring may occur not as the result of a fracture but as the result of disruption of the sacroiliac or symphyseal joints. Fracture



CD Figure 11-8 **A–C.** Different types of fractures of the pelvic basin. **D.** Avulsion fractures of the pelvis. The sartorius muscle is responsible for the avulsion of the anterior superior iliac spine; the straight head of the rectus femoris muscle, for the avulsion of the anterior inferior iliac spine; and the hamstring muscles, for the avulsion of the ischial tuberosity.

of bone on either side of the joint is more common than disruption of the joint.

The forces responsible for the disruption of the bony ring may be anteroposterior compression, lateral compression, or shearing.

A heavy fall on the greater trochanter of the femur may drive the head of the femur through the floor of the acetabulum into the pelvic cavity.

Fractures of the Sacrum and Coccyx

Fractures of the lateral mass of the sacrum may occur as part of a pelvic fracture. Fractures of the coccyx are rare.

Minor Fractures of the Pelvis

The anterior superior iliac spine may be pulled off by the forcible contraction of the sartorius muscle in athletes (see CD Fig. 11-8). In a similar manner the anterior inferior iliac spine may be avulsed by the contraction of the rectus femoris muscle (origin of the straight head). The ischial tuberosity can be avulsed by the contraction of the hamstring muscles. Healing may occur by fibrous union, possibly resulting in elongation of the muscle unit and some reduction in muscular efficiency.

Anatomy of Complications of Pelvic Fractures

Fractures of the true pelvis are commonly associated with injuries to the soft pelvic tissues.

If damaged, the thin pelvic veins—namely, the internal iliac veins and their tributaries—that lie in the parietal pelvic fascial beneath the parietal peritoneum can be the source of a massive hemorrhage, which may be life threatening.

The male urethra is often damaged, especially in vertical shear fractures that may disrupt the urogenital diaphragm.

The bladder, which lies immediately behind the pubis in both sexes, is occasionally damaged by spicules of bone; a full bladder is more likely to be injured than is an empty bladder.

The rectum lies within the concavity of the sacrum and is protected and rarely damaged. Fractures of the sacrum or ischial spine may be thrust into the pelvic cavity, tearing the rectum.

Nerve injuries can follow sacral fractures; the laying down of fibrous tissue around the anterior or posterior nerve roots or the branches of the sacral spinal nerves can result in persistent pain.

Damage to the sciatic nerve may occur in fractures involving the boundaries of the greater sciatic notch. The peroneal part of the sciatic nerve is most often involved, resulting in the inability of a conscious patient to dorsiflex the ankle joint or failure of an unconscious patient to reflexly plantar-flex (ankle jerk) the foot.

Bones of the Thigh

Tenderness of the Head of the Femur and Arthritis of the Hip Joint

The head of the femur—that is, that part that is not intraacetabular—can be palpated on the anterior aspect of the thigh

just inferior to the inguinal ligament and just lateral to the pulsating femoral artery. Tenderness over the head of the femur usually indicates the presence of arthritis of the hip joint.

Blood Supply to the Femoral Head and Neck Fractures

Anatomic knowledge of the blood supply to the femoral head explains why avascular necrosis of the head can occur after fractures of the neck of the femur. In the young, the epiphysis of the head is supplied by a small branch of the obturator artery, which passes to the head along the ligament of the femoral head. The upper part of the neck of the femur receives a profuse blood supply from the medial femoral circumflex artery (see text Fig. 12-25). These branches pierce the capsule and ascend the neck deep to the synovial membrane. As long as the epiphyseal cartilage remains, no communication occurs between the two sources of blood. In the adult, after the epiphyseal cartilage disappears, an anastomosis between the two sources of blood supply is established. Fractures of the femoral neck interfere with or completely interrupt the blood supply from the root of the femoral neck to the femoral head. The scant blood flow along the small artery that accompanies the round ligament may be insufficient to sustain the viability of the femoral head, and ischemic necrosis gradually takes place.

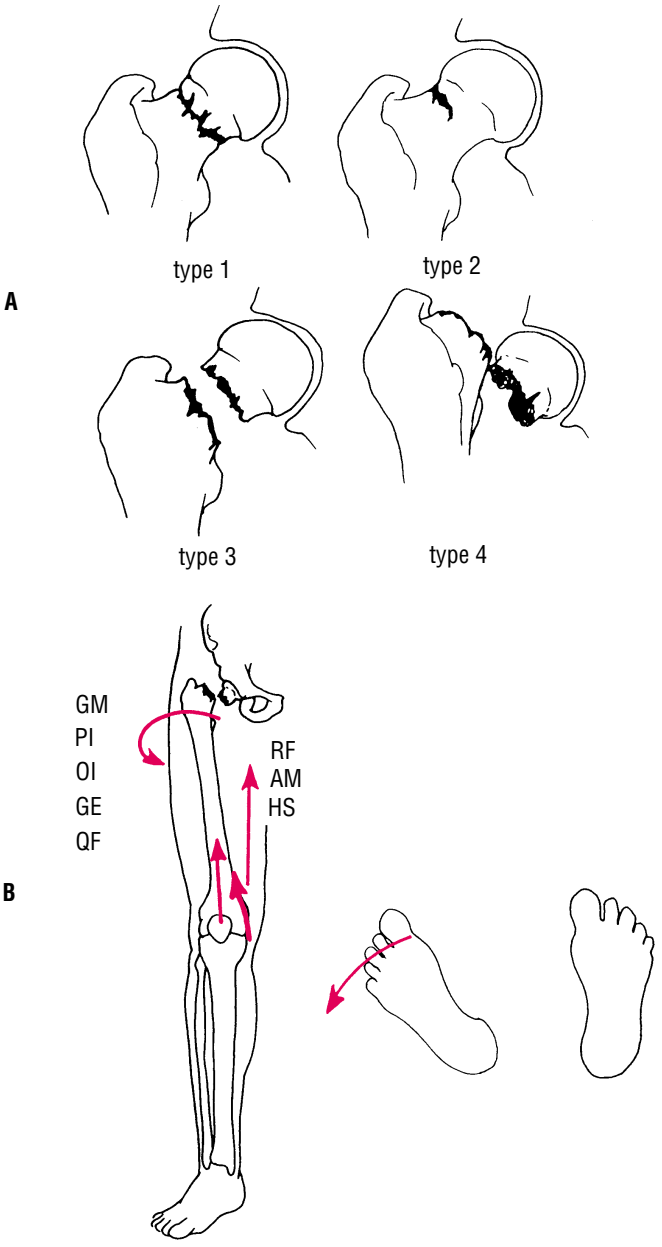
The Neck of the Femur and Coxa Valga and Coxa Vara

The neck of the femur is inclined at an angle with the shaft; the angle is about 160° in the young child and about 125° in the adult. An increase in this angle is referred to as **coxa valga,** and it occurs, for example, in cases of congenital dislocation of the hip. In this condition, adduction of the hip joint is limited. A decrease in this angle is referred to as **coxa vara,** and it occurs in fractures of the neck of the femur and in slipping of the femoral epiphysis. In this condition, abduction of the hip joint is limited. Shenton's line is a useful means of assessing the angle of the femoral neck on a radiograph of the hip region (see text Fig. 11-66).

Fractures of the Femur

Fractures of the neck of the femur are common and are of two types, subcapital and trochanteric. The **subcapital fracture** occurs in the elderly and is usually produced by a minor trip or stumble. Subcapital femoral neck fractures are particularly common in women after menopause. This gender predisposition is because of a thinning of the cortical and trabecular bone caused by estrogen deficiency. Avascular necrosis of the head is a common complication. If the fragments are not impacted, considerable displacement occurs. The strong muscles of the thigh (CD Fig. 11-9), including the rectus femoris, the adductor muscles, and the hamstring muscles, pull the distal fragment upward, so that the leg is shortened (as measured from the anterior superior iliac spine to the adductor tubercle or medial malleolus). The gluteus maximus, the piriformis, the obturator internus, the gemelli, and the quadratus femoris rotate the distal fragment laterally, as seen by the toes pointing laterally.

Trochanteric fractures commonly occur in the young and middle-aged as a result of direct trauma. The fracture



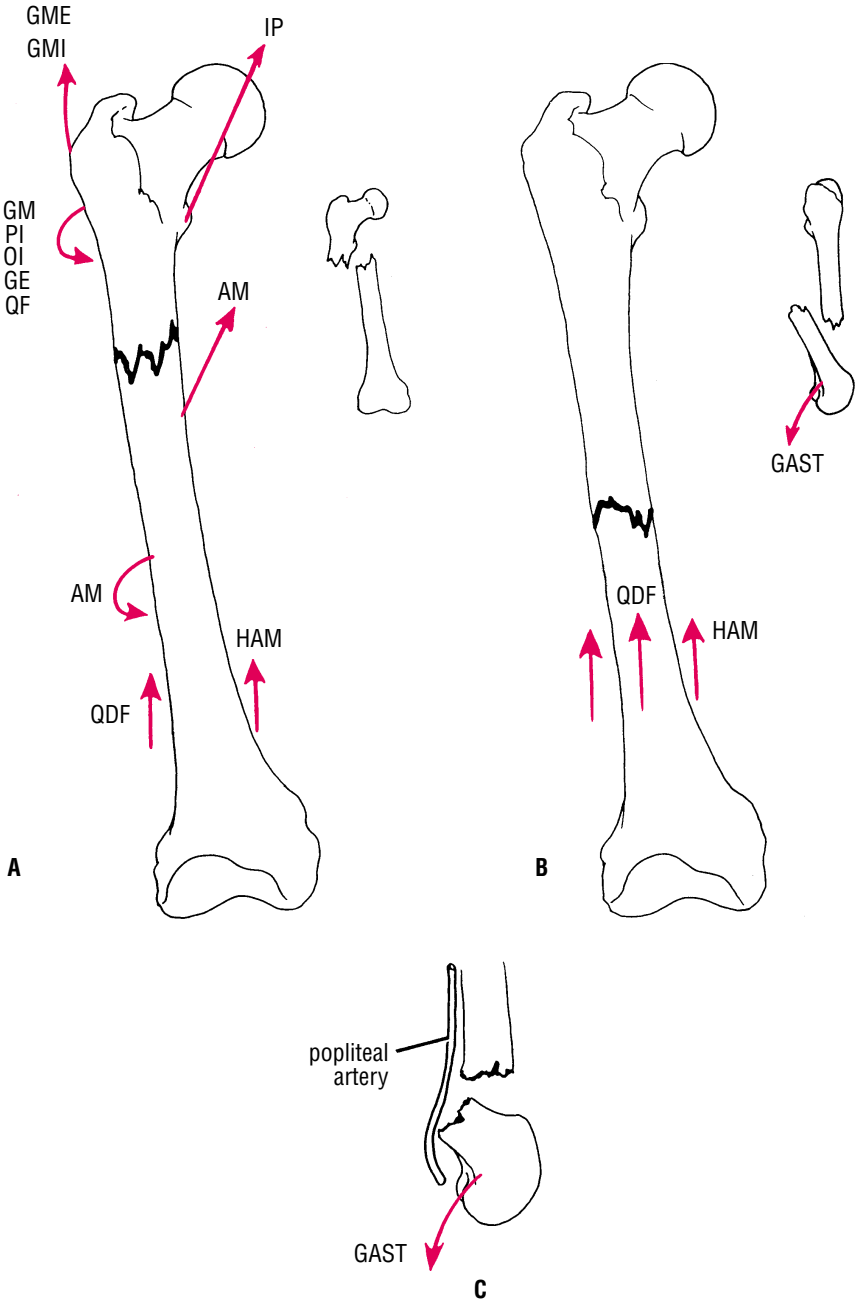
CD Figure 11-9 **A.** Fractures of the neck of the femur. **B.** Displacement of the lower bone fragment caused by the pull of the powerful muscles. Note in particular the outward rotation of the leg so that the foot characteristically points laterally. GM = gluteus maximus, AM = adductor muscles, GE = gemelli, HS = hamstring muscles, OI = obturator internus, PI = piriformis, QF = quadratus femoris, RF = rectus femoris.

line is extracapsular, and both fragments have a profuse blood supply. If the bone fragments are not impacted, the pull of the strong muscles will produce shortening and lateral rotation of the leg, as previously explained.

Fractures of the shaft of the femur usually occur in young and healthy persons. In **fractures of the upper third of the shaft** of the femur, the proximal fragment is flexed by the iliopsoas; abducted by the gluteus medius and minimus; and laterally rotated by the gluteus maximus, the piriformis, the obturator internus, the gemelli, and the quadratus femoris (CD Fig. 11-10). The lower fragment is adducted by the adductor muscles, pulled upward by the hamstrings and quadriceps, and laterally rotated by the adductors and the weight of the foot (see CD Fig. 11-10).

In **fractures of the middle third of the shaft** of the femur, the distal fragment is pulled upward by the hamstrings and the quadriceps (see CD Fig. 11-10), resulting in considerable shortening. The distal fragment is also rotated backward by the pull of the two heads of the gastrocnemius (see CD Fig. 11-10).

In **fractures of the distal third of the shaft** of the femur, the same displacement of the distal fragment occurs as seen in fractures of the middle third of the shaft. However, the distal fragment is smaller and is rotated backward by the



CD Figure 11-10 Fractures of the shaft of the femur. **A.** Upper third of the femoral shaft. Note the displacement caused by the pull of the powerful muscles. **B.** Middle third of the femoral shaft. Note the posterior displacement of the lower fragment caused by the gastrocnemius muscle. **C.** Lower third of the femoral shaft. Note the excessive displacement of the lower fragment caused by the pull of the gastrocnemius muscle, threatening the integrity of the popliteal artery. AM = adductor muscles, GAST = gastrocnemius, GE = gemelli, GM = gluteus maximus, GME = gluteus medius, GMI = gluteus minimus, HAM = hamstrings, IP = iliopsoas, OI = obturator internus, PI = piriformis, QDF = quadriceps femoris, QF = quadratus femoris.

gastrocnemius muscle (see CD Fig. 11-10) to a greater degree and may exert pressure on the popliteal artery and interfere with the blood flow through the leg and foot.

From these accounts it is clear that knowledge of the different actions of the muscles of the leg is necessary to understand the displacement of the fragments of a fractured femur. Considerable traction on the distal fragment is usually required to overcome the powerful muscles and restore the limb to its correct length before manipulation and operative therapy to bring the proximal and distal fragments into correct alignment.

Patellar Dislocations

The patella is a sesamoid bone lying within the quadriceps tendon. The importance of the lower horizontal fibers of the vastus medialis and the large size of the lateral condyle of the femur in preventing lateral displacement of the patella have been emphasized. Congenital recurrent dislocations of the patella are caused by underdevelopment of the lateral femoral condyle. Traumatic dislocation of the patella results from direct trauma to the quadriceps attachments of the patella (especially the vastus medialis), with or without fracture of the patella.

Patellar Fractures

A patella fractured as a result of direct violence, as in an automobile accident, is broken into several small fragments. Because the bone lies within the quadriceps femoris tendon, little separation of the fragments takes place. The close relationship of the patella to the overlying skin may result in the fracture being open. Fracture of the patella as a result of indirect violence is caused by the sudden contraction of the quadriceps snapping the patella across the front of the femoral condyles. The knee is in the semiflexed position, and the fracture line is transverse. Separation of the fragments usually occurs.

Bones of the Leg

Fractures of the Tibia and Fibula

Fractures of the tibia and fibula are common. If only one bone is fractured, the other acts as a splint and displacement is minimal. Fractures of the shaft of the tibia are often open because the entire length of the medial surface is covered only by skin and superficial fascia. Fractures of the distal third of the shaft of the tibia are prone to delayed union or nonunion. This can be because the nutrient artery is torn at the fracture line, with a consequent reduction in blood flow to the distal fragment; it is also possible that the splint-like action of the intact fibula prevents the proximal and distal fragments from coming into apposition.

Fractures of the **proximal end of the tibia,** at the tibial condyles (tibial plateau), are common in the middle-aged and elderly; they usually result from direct violence to the lateral side of the knee joint, as when a person is hit by the bumper of an automobile. The tibial condyle may show a split fracture or be broken up, or the fracture line may pass between both condyles in the region of the intercondylar eminence. As a result of forced abduction of the knee joint, the medial collateral ligament can also be torn or ruptured.

Fractures of the **distal end of the tibia** are considered with the ankle joint.

Intraosseous Infusion of the Tibia in the Infant

The technique may be used for the infusion of fluids and blood when it has been found impossible to obtain an intravenous line. The procedure is easy and rapid to perform, as follows:

1. With the distal leg adequately supported, the anterior subcutaneous surface of the tibia is palpated.
2. The skin is anesthetized about 1 in. (2.5 cm) distal to the tibial tuberosity, thus blocking the infrapatellar branch of the saphenous nerve.
3. The bone marrow needle is directed at right angles through the skin, superficial fascia, deep fascia, and tibial periosteum and the cortex of the tibia. Once the needle tip reaches the medulla and bone marrow, the operator senses a feeling of "give." The position of the needle in the marrow can be confirmed by aspiration. The needle should be directed slightly caudad to avoid injury to the epiphyseal plate of the proximal end of the tibia. The transfusion may then commence.

Bones of the Foot

Fractures of the Calcaneum

Compression fractures of the calcaneum result from falls from a height. The weight of the body drives the talus downward into the calcaneum, crushing it in such a way that it loses vertical height and becomes wider laterally. The posterior portion of the calcaneum above the insertion of the tendo calcaneus can be fractured by posterior displacement of the talus. The sustentaculum tali can be fractured by forced inversion of the foot.

Fractures of the Talus

Fractures occur at the neck or body of the talus. Neck fractures occur during violent dorsiflexion of the ankle joint when the neck is driven against the anterior edge of the distal end of the tibia. The body of the talus can be fractured by jumping from a height, although the two malleoli prevent displacement of the fragments.

Fractures of the Metatarsal Bones

The base of the fifth metatarsal can be fractured during forced inversion of the foot, at which time the tendon of insertion of the peroneus brevis muscle pulls off the base of the metatarsal.

Stress fracture of a metatarsal bone is common in joggers and in soldiers after long marches; it can also occur in nurses and hikers. It occurs most frequently in the distal third of the second, third, or fourth metatarsal bone. Minimal displacement occurs because of the attachment of the interosseous muscles.

Clinical Problem Solving Questions

Read the following case histories/questions and give the best answer for each.

A 19-year-old boy was suspected of having leukemia. It was decided to confirm the diagnosis by performing a bone marrow biopsy.

1. The following statements concerning this procedure are correct **except** which?
   A. The biopsy was taken from the lower end of the tibia.
   B. Red bone marrow specimens can be obtained from the sternum or the iliac crests.
   C. At birth, the marrow of all bones of the body is red and hematopoietic.
   D. The blood-forming activity of bone marrow in many long bones gradually lessens with age, and the red marrow is gradually replaced by yellow marrow.

A 45-year-old man with extensive maxillofacial injuries after an automobile accident was brought to the emergency department. Evaluation of the airway revealed partial obstruction. Despite an obvious fractured mandible, an attempt was made to move the tongue forward from the posterior pharyngeal wall by pushing the angles of the mandible forward. This maneuver failed to move the tongue, and it became necessary to hold the tongue forward directly to pull it away from the posterior pharyngeal wall.

2. The **most likely** reason the physician was unable to pull the tongue forward in this patient is which?
   A. The hypoglossal nerves were damaged on both sides of the neck.
   B. Spasm of the styloglossus muscles
   C. The mandibular origin of the genioglossus muscles was floating because of bilateral fractures of the body of the mandible.
   D. The presence of a blood clot in the mouth
   E. The resistance of the patient

A 46-year-old man was seen in the emergency department after being knocked down in a street brawl. He had received a blow on the head with an empty bottle. On examination, the patient was conscious and had a large dough-like swelling over the back of the head that was restricted to the area over the occipital bone. The skin was intact, and the swelling fluctuated on palpation.

3. The following statements concerning this patient are correct **except** which?
   A. The hematoma, although large, did not extend forward to the orbital margins and did not extend laterally as far as the temporal lines.
   B. The hematoma was located just beneath the scalp and was superficial to the periosteum of the occipital bone.
   C. The swelling did not occupy the subcutaneous tissue of the scalp.
   D. The hematoma was restricted to one skull bone and was situated beneath the periosteum.

A 45-year-old woman visited her physician because of a low back pain of 3 months' duration. She was otherwise very fit. On examination of her back, nothing abnormal was discovered. The physician then listened to her chest, examined her thyroid gland, and finally examined both breasts. A large, hard mass was found in the left breast.

4. The following facts supported the diagnosis of carcinoma of the left breast with secondaries in the vertebral column **except** which?
   A. The lump in the breast was painless and the patient had noticed it while showering 6 months previously.
   B. Several large, hard, pectoral lymph nodes were found in the left axilla.
   C. A lateral radiograph of the lumbar vertebral column showed extensive metastases in the bodies of the second and third lumbar vertebrae.
   D. The lump was situated in the upper outer quadrant of the left breast and was fixed to surrounding tissues.

E. Although the cancer had spread by the lymph vessels, no evidence of spread via the bloodstream was present.

A 65-year-old man and a 10-year-old boy were involved in a severe automobile accident. In both patients the thorax had been badly crushed. Radiographic examination revealed that the man had five fractured ribs but the boy had no fractures.

5. What is the **most likely** explanation for this difference in medical findings?
   A. The patients were in different seats in the vehicle.
   B. The boy was wearing his seat belt and the man was not.
   C. The chest wall of a child is very elastic, and fractures of ribs in children are rare.
   D. The man anticipated the impact and tensed his muscles, including those of the shoulder girdle and abdomen.

An 18-year-old woman was thrown from a horse while attempting to jump a fence. She landed heavily on the ground, striking the lower part of her chest on the left side. On examination in the emergency department she was conscious but breathless. The lower left side of her chest was badly bruised, and the ninth and tenth ribs were extremely tender to touch. She had severe tachycardia, and her systolic blood pressure was low.

6. The following statements are possibly correct **except** which?
   A. There was evidence of tenderness and muscle spasm in the left upper quadrant of the anterior abdominal wall.
   B. A posteroanterior radiograph of the chest revealed fractures of the left ninth and tenth ribs near their angles.
   C. The blunt trauma to the ribs could not result in injury to the underlying spleen.
   D. The presence of blood in the peritoneal cavity had irritated the parietal peritoneum, producing reflex spasm of the upper abdominal muscles.
   E. The muscles of the anterior abdominal wall are supplied by thoracic spinal nerves.

A 15-year-old girl, while demonstrating to her friends her proficiency at standing on her hands, suddenly went off balance and put all her body weight on her left outstretched hand. A distinctive cracking noise was heard, and she felt a sudden pain in her left shoulder region. On examination in the emergency department, the smooth contour of her left shoulder was absent. The clavicle was obviously fractured, and the edges of the bony fragments could be palpated.

7. The following statements concerning this case are correct **except** which?
   A. The clavicle is one of the most common bones in the body to be fractured.
   B. Anatomically, the weakest part of the clavicle is the junction of the medial and middle thirds, and this is where the fracture commonly occurs.
   C. The lateral bony fragment is depressed downward by the weight of the arm.
   D. The lateral fragment is pulled forward and medially by the pectoral muscles.
   E. The medial fragment is elevated by the sternocleidomastoid muscle.
   F. The supraclavicular nerves or a communicating vein between the cephalic and internal jugular vein may be damaged by the bone fragments.

A 22-year-old medical student fell off her bicycle onto her outstretched hand. She thought she had sprained her right wrist joint and treated herself by binding her wrist with an elastic bandage. Three weeks later, however, she was still experiencing pain on moving her wrist and so decided to visit the emergency department. On examination of the dorsal surfaces of both hands, with the fingers and thumbs fully extended, a localized tenderness could be felt in the anatomic snuffbox of her right hand. A diagnosis of fracture of the right scaphoid bone was made.

8. The following statements concerning this patient are correct **except** which?
   A. The fracture line on the scaphoid bone may deprive the proximal fragment of its arterial supply.
   B. A bony fragment deprived of its blood supply may undergo ischemic necrosis.
   C. Because the scaphoid bone articulates with other bones, the fracture line may enter a joint cavity and become bathed in synovial fluid, which would inhibit repair.
   D. The scaphoid bone is an easy bone to immobilize because of its small size.
   E. Fractures of the scaphoid bone have a high incidence of nonunion.

A heavily built, middle-aged man running down a flight of stone steps misjudged the position of one of the steps and fell suddenly onto his buttocks. Following the fall, he complained of severe bruising of the area of the cleft between the buttocks and persistent pain in this area.

9. The following statements concerning this patient are correct **except** which?
   A. The lower end of the vertebral column was traumatized by the stone step.
   B. The coccyx can be palpated beneath the skin in the natal cleft.

C. The anterior surface of the coccyx cannot be felt clinically.
D. The coccyx is usually severely bruised or fractured.
E. The pain is felt in the distribution of dermatomes S4 and S5.

An elderly woman was run over by an automobile as she was crossing the road. Radiographic examination of the pelvis in the emergency department of the local hospital revealed a fracture of the ilium and iliac crest on the left side.

10. The following statements about fractures of the pelvis are correct **except** which?
A. Fractures of the ilium have little displacement.
B. Displacement is prevented by the presence of the iliacus and the gluteal muscles on the inner and outer surfaces of this bone, respectively.
C. If two fractures occur in the ring forming the true pelvis, the fracture will be unstable and displacement will occur.
D. Fractures of the true pelvis do not cause injury to the pelvic viscera.
E. The postvertebral and abdominal muscles are responsible for elevating the lateral part of the pelvis should two fractures occur.
F. A heavy fall on the greater trochanter of the femur may drive the head of the femur through the floor of the acetabulum and into the pelvic cavity.

A pregnant woman visited an antenatal clinic. A vaginal examination revealed that the sacral promontory could be easily palpated and that the diagonal conjugate measured less than 4 in. (10 cm).

11. The following statements concerning this examination are correct **except** which?
A. Normally it is difficult or impossible to feel the sacral promontory by means of a vaginal examination.
B. The normal diagonal conjugate measures about 10 in. (25 cm).
C. This patient's pelvis was flattened anteroposteriorly, and the sacral promontory projected too far forward.
D. It is likely that this patient would have an obstructed labor.
E. This patient was advised to have a cesarean section.

On a routine anteroposterior radiographic examination of a patient's right hip joint, the long axis of the neck of the femur was found to be at an angle of 160° with the long axis of the femoral shaft.

12. Is this angle normal in a 5-year-old child? In a 35-year-old man? What is the clinical condition called in which the angle is smaller than normal? Which movement of the hip joint is limited by this condition?

13. Fracture of the neck of the femur in the adult commonly results in avascular necrosis of part of the femoral head. Can you explain this on anatomic grounds? Trochanteric fractures are never accompanied by avascular necrosis. Why?

A 37-year-old woman was involved in a light plane accident. She and her husband were flying home from a business trip when they had to make a forced landing in a field due to fog. On landing, the plane hit a tree and came to rest on its nose. Her husband was killed on impact and she was thrown from the cockpit. She was evaluated in the emergency department with multiple injuries. Radiographic examination of her pelvis showed a fracture of her left ilium and iliac crest.

14. From your knowledge of anatomy, would you expect much displacement of the bony fragments?

A 25-year-old man was running across a field when he caught his right foot in a rabbit hole. As he fell, the right foot was violently rotated laterally and overeverted. On attempting to stand, he could place no weight on his right foot. On examination by a physician, the right ankle was considerably swollen, especially on the lateral side. After further examination, including a radiograph of the ankle, a diagnosis of severe fracture dislocation of the ankle joint was made.

15. The following statements concerning this patient are correct **except** which?
A. This type of fracture dislocation is caused by forced external rotation and overeversion of the foot.
B. The talus is externally rotated against the lateral malleolus of the fibula, causing it to fracture.
C. The torsion effect on the lateral malleolus produces a spiral fracture.
D. The medial ligament of the ankle joint is strong and never ruptures.
E. If the talus is forced to move farther laterally and continues to rotate, the posterior inferior margin of the tibia will be sheared off.

16. A 32-year-old woman was rock climbing when she decided to jump from a ledge down to a flat rock some five feet below. On landing she maintained her balance but experienced a severe pain in her right foot in the region of the heel. On examination later in the emergency department of the local hospital, the physician's assistant noted the extreme tenderness felt over the sides and inferior surface of the right calcaneum. She also noted that the right calcaneum appeared wider than the one on the left. Using your knowledge of anatomy, make the diagnosis.

Answers and Explanations

1. **A** is the correct answer. In a 19-year-old boy, the bone marrow at the lower end of the tibia is yellow.
2. **C** is the correct answer. The genioglossus muscle arises from the superior mental spines behind the symphysis menti of the mandible (see text Fig. 11-10).
3. **B** is the correct answer. The hematoma was located deep to the periosteum of the occipital bone.
4. **E** is the correct answer. The carcinoma of the left breast was in an advanced stage and had spread by way of the lymph vessels to the axillary lymph nodes and by the bloodstream to the bodies of the second and third lumbar vertebrae. Carcinoma of the thyroid, bronchus, breast, kidney, and prostate tend to metastasize via the bloodstream to bones.
5. **C** is the correct answer. The chest wall of a child is very elastic, and fractures of ribs in children are rare.
6. **C** is the correct answer. Trauma to the lower part of the woman's left chest could easily severely damage the spleen in the abdomen, resulting in hemorrhage into the peritoneal cavity.
7. **B** is the correct answer. Anatomically, the weakest part of the clavicle is the junction of the middle and lateral thirds, and that is where the fracture occurred in this patient.
8. **D** is the correct answer. The scaphoid bone is a difficult bone to immobilize because of its position and small size.
9. **C** is the correct answer. The anterior surface of the coccyx can be palpated with a gloved finger placed in the anal canal.
10. **D** is the correct answer. Fractures of the true pelvis are commonly associated with injuries to the soft pelvic viscera, especially the bladder and the urethra.
11. **B** is the correct answer. The normal diagonal conjugate measures about 5 in. (11.5 cm) (see CD Fig. 11-6).
12. This angle is within normal limits in a 5-year-old child. It is too great in a 35-year-old man; the condition is called coxa valga, in which adduction of the hip joint is limited. When the angle of the femoral neck is smaller than normal (coxa vara), abduction of the hip joint is limited.
13. Fractures of the neck of the femur in the adult commonly result in avascular necrosis of part of the femoral head. The femoral head receives its blood supply from two sources—a small artery, a branch of the obturator artery, that runs with the round ligament of the femoral head and a profuse blood supply from the medial femoral circumflex femoral artery, branches that ascend the femoral neck beneath the synovial membrane. Fracture of the femoral neck may deprive the femoral head of part or all of the blood from the medial femoral circumflex femoral artery, and avascular necrosis will occur. In trochanteric fractures, both fragments have a profuse blood supply.
14. Most fractures of the upper part of the ilium have little displacement of the bone fragments. This is because the iliacus muscle is attached to the inner surface and the gluteal muscles are attached to the outer surface (see text Fig. 11-54). Splinting the bones is unnecessary because of the attachment of these muscles.
15. **D** is the correct answer. Although the medial ligament of the ankle joint is strong, extreme force can result in rupture of the ligament, or the ligament can be torn from the medial malleolus, or the pull on the ligament can fracture the medial malleolus.
16. This woman had suffered a compression fracture of the right calcaneum as a result of the fall from a height. The weight of the body drives the talus downward into the calcaneum, crushing it in such a way that it loses vertical height and becomes wider laterally. The diagnosis was confirmed on an anteroposterior and a lateral radiograph of the right ankle.