Objectives

Cognitive

4-9.1 Describe the incidence, morbidity, and mortality of musculoskeletal injuries. (p 25.3)
4-9.2 Discuss the anatomy and physiology of the musculoskeletal system. (p 25.3)
4-9.3 Predict injuries based on the mechanism of injury, including:
   a. Direct
   b. Indirect
   c. Pathologic (p 25.12)
4-9.4 Discuss the types of musculoskeletal injuries:
   a. Fracture (open and closed)
   b. Dislocation/fracture
   c. Sprain
   d. Strain (p 25.14–25.17)
4-9.5 Discuss the pathophysiology of musculoskeletal injuries. (p 25.12)
4-9.6 Discuss the assessment findings associated with musculoskeletal injuries. (p 25.19)
4-9.7 List the six “P’s” of musculoskeletal injury assessment. (p 25.19)
4-9.8 List the primary signs and symptoms of extremity trauma. (p 25.19)
4-9.9 List other signs and symptoms that can indicate less obvious extremity injury. (p 25.19)
4-9.10 Discuss the need for assessment of pulses, motor and sensation before and after splinting. (p 25.24)
4-9.11 Identify the need for rapid intervention and transport when dealing with musculoskeletal injuries. (p 25.23)
4-9.12 Discuss the management of musculoskeletal injuries. (p 25.23)
4-9.13 Discuss the general guidelines for splinting. (p 25.23)
4-9.14 Explain the benefits of cold application for musculoskeletal injury. (p 25.23)
4-9.15 Explain the benefits of heat application for musculoskeletal injury. (p 25.23)
4-9.16 Describe age associated changes in the bones. (p 25.7)
4-9.17 Discuss the pathophysiology of open and closed fractures. (p 25.14)
4-9.18 Discuss the relationship between volume of hemorrhage and open or closed fractures. (p 25.18)
4-9.19 Discuss the assessment findings associated with fractures. (p 25.18)
4-9.20 Discuss the management of fractures. (p 25.23)
4-9.21 Discuss the usefulness of the pneumatic anti-shock garment (PASG) in the management of fractures. (p 25.25)
4-9.22 Describe the special considerations involved in femur fracture management. (p 25.27)
4-9.23 Discuss the pathophysiology of dislocations. (p 25.16)
4-9.24 Discuss the assessment findings of dislocations. (p 25.16)
4-9.25 Discuss the out-of-hospital management of dislocation/fractures, including splinting and realignment. (p 25.36)
4-9.26 Explain the importance of manipulating a knee dislocation/fracture with an absent distal pulse. (p 25.37)
4-9.27 Describe the procedure for reduction of a shoulder, finger or ankle dislocation/fracture. (p 25.36)
4-9.28 Discuss the pathophysiology of sprains. (p 25.16)
4-9.29 Discuss the assessment findings of sprains. (p 25.16)
4-9.30 Discuss the management of sprains. (p 25.17)
4-9.31 Discuss the pathophysiology of strains. (p 25.17)
4-9.32 Discuss the assessment findings of strains. (p 25.17)
4-9.33 Discuss the management of strains. (p 25.17)
4-9.34 Discuss the pathophysiology of a tendon injury. (p 25.17)
4-9.35 Discuss the assessment findings of tendon injury. (p 25.17)
4-9.36 Discuss the management of a tendon injury. (p 25.17)
4-9.37 Integrate the pathophysiological principles to the assessment of a patient with a musculoskeletal injury. (p 25.18)
4-9.38 Differentiate between musculoskeletal injuries based on the assessment findings and history. (p 25.18)
4-9.39 Formulate a field impression of a musculoskeletal injury based on the assessment findings. (p 25.20)
4-9.40 Develop a patient management plan for the musculoskeletal injury based on the field impression. (p 25.23)

Affective

4-9.41 Advocate the use of a thorough assessment to determine a working diagnosis and treatment plan for musculoskeletal injuries. (p 25.19)
4-9.42 Advocate for the use of pain management in the treatment of musculoskeletal injuries. (p 25.23)

Psychomotor

4-9.43 Demonstrate a clinical assessment to determine the proper treatment plan for a patient with a suspected musculoskeletal injury. (p 25.19)
4-9.44 Demonstrate the proper use of fixation, soft and traction splints for a patient with a suspected fracture. (p 25.27)
Chapter 25  Musculoskeletal Injuries

25.3  Introduction

Musculoskeletal injuries are one of the most common reasons that patients seek medical attention. Complaints related to the musculoskeletal system lead to almost 60 million visits to physicians annually in the United States, more than for any other reason. Approximately 1 in 7 Americans will experience some type of musculoskeletal impairment, leading to millions of missed days of work or school and costing hundreds of billions of dollars yearly. An estimated 70% to 80% of all patients with multiple system trauma have one or more musculoskeletal injuries. Some areas of public policy, legislative changes, and public education have been effective in reducing the injury problem. For example, efforts related to cell phone use by drivers, child safety seat use and availability, and falls in older people have had positive impacts.

Injuries related to the musculoskeletal system are usually easily identifiable because of the associated pain, swelling, and deformity. Although these injuries are rarely fatal, they often result in short- or long-term disability. By providing prompt temporary measures, such as splinting and analgesia, paramedics may help reduce the period during which patients are disabled. However, despite the sometimes dramatic appearance of these injuries, you should not focus on the musculoskeletal injury without first determining that no life-threatening injury exists. Never forget the ABCs!

Anatomy and Physiology of the Musculoskeletal System

The musculoskeletal system gives the body its shape and allows for its movement. It is essential that you understand its basic anatomy and physiology.

Functions of the Musculoskeletal System

The musculoskeletal system performs many important functions within the body. Bones help support the soft tissues of the body and form a framework that gives the human body its shape and allows it to maintain an erect posture. Movement is generated because muscles are attached to bones by tendons. (Reminder: Muscles-To-Bones [MTB] means Muscles–Tendons–Bones.) When a muscle contracts, the force generated by the muscle is transferred to a bone on the opposite side of the joint from the muscle, leading to motion. Bones also offer protection to the more fragile organs and structures beneath them—for example, the skull's protection of the brain, the rib cage's protection of the heart and lungs, and the spinal column's protection of the spinal cord.

Another important function of the musculoskeletal system is hematopoiesis—the process of generating blood cells. In adults, it most commonly occurs in the red bone marrow of the sternum, ribs, vertebral bodies, pelvis, and the proximal portions of the femur and humerus. Each day, the body produces new red blood cells, white blood cells, and platelets from the stem cells that are present in the bone marrow, thereby replacing those that have been lost or that are no longer functional.

The Body's Scaffolding: The Skeleton

The integrated structure formed by the 206 bones of the body is called the skeleton. It may be divided into two distinct portions: the axial skeleton and the appendicular skeleton. The axial skeleton is composed of the bones of the central part, or axis, of the body; its divisions include the vertebral column, skull, ribs, and sternum. The skull is composed of the cranial, basilar skull, face, and inner ear. The spine is composed of 33 spinal vertebrae: 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal. Moving anteriorly, the thorax is formed by the sternum and 12 pairs of...

You are the Provider Part 1

You are dispatched to a private residence for a man who has fallen off a ladder. En route to the scene, dispatch advises you that a neighbor witnessed the incident and estimated the fall to be 15” to 20”. The witness also reports the man appears to be awake and breathing and looks to be in great pain.

On arrival, you find a 63-year-old man on the ground next to a ladder that is leaning against the house. He complains of pain in his left leg and left wrist, is slow to respond to your questions, but remembers what happened.

1. What are your initial assessment and treatment priorities?
2. What other information should be obtained about the patient and the incident?
ribs. The appendicular skeleton is divided into the pectoral girdle, the pelvic girdle, and the bones of the upper and lower extremities.

**Shoulder and Upper Extremities**

The pectoral girdle, also referred to as the shoulder girdle, consists of two scapulae and two clavicles. The scapula (shoulder blade) is a flat, triangular bone held to the rib cage posteriorly by powerful muscles that buffer it against injury. The clavicle (collarbone) is a slender, S-shaped bone attached by ligaments at the medial end to the sternum and at the lateral end to the raised tip of the scapula, called the acromion. The clavicle acts as a strut to keep the shoulder propped up; however, because it is slender and very exposed, this bone is vulnerable to injury.

The upper extremity joins the shoulder girdle at the glenohumeral joint. The proximal portion contains the humerus, a bone that articulates proximally with the scapula and distally with bones of the forearm—the radius and ulna—to form the hinged elbow joint.
The radius and ulna make up the forearm. The radius, the larger of the two forearm bones, lies on the thumb side of the forearm. Distally, the ulna is narrow and is on the little-finger side of the forearm. It serves as the pivot around which the radius turns at the wrist to rotate the palm upward (supination) or downward (pronation). Because the radius and the ulna are arranged in parallel, when one is broken, the other is often broken as well.

The hand contains three sets of bones: wrist bones (carpals), hand bones (metacarpals), and finger bones (phalanges). The carpals, especially the scaphoid, are vulnerable to fracture when a person falls on an outstretched hand. Phalanges are more apt to be injured by a crushing injury, such as being slammed in a car door.

**Pelvis and Lower Extremities**

The pelvic girdle is actually three separate bones—the ischium, ilium, and pubis—fused together to form the innominate bone. The two iliac bones are joined posteriorly by tough ligaments to the sacrum at the sacroiliac joints; the two pubic bones are connected anteriorly by equally tough ligaments to one another at the pubic symphysis. These joints allow very little motion, so the pelvic ring is strong and stable.

The lower extremity consists of the bones of the thigh, leg, and foot. The femur (thigh bone) is a long, powerful bone that articulates proximally in the ball-and-socket joint of the pelvis and distally in the hinge joint of the knee. The head of the femur is the ball-shaped part that fits into the acetabulum. It is connected to the shaft, or long tubular portion of the femur, by the femoral neck. The femoral neck is a common site for fractures, generally referred to as hip fractures, especially in the older population.

The lower leg consists of two bones, the tibia and the fibula. The tibia (shin bone) forms the inferior component of the knee joint. Anterior to this joint is the patella (kneecap), a bone that is important for knee extension. The tibia runs down the front of
Characteristics and Composition of Bone

Bone Shapes

Bones may be classified based on their shape. Long bones are longer than they are wide; examples include the femur, humerus, tibia, fibula, radius, and ulna. Short bones are nearly as wide as they are long; they include the phalanges, metacarpals, and metatarsals. Flat bones are thin, broad bones; they include the sternum, ribs, scapulae, and skull. Irregular bones do not fit into one of the other categories but rather have a shape that is designed to perform a specific function, such as the bones of the vertebral column and the mandible. Round bones are generally found in proximity to a joint and help with movement. They are often referred to as sesamoid bones because of their location within a tendon. The patella is the largest of these bones.

Typical Long Bone Architecture

Long bones have several distinct regions and anatomical features. These bones can grow to such long lengths because of the presence of the growth plate, or physis, in children. Once a person reaches adulthood, the growth plate closes and the mature adult bone is complete. The long bone is divided into three regions: the diaphysis, the epiphysis, and the metaphysis.

The articular surfaces of a long bone come in contact with other bones to form articulations (joints). These regions of the bone are covered by articular cartilage, a substance that acts as a cushion to protect the bone from damage and wear. The portion of bone that is not covered by articular cartilage is, instead, covered by the periosteum. This dense, fibrous membrane contains capillaries and cells that are important for bone repair and maintenance. In the inner portion of the long bone, blood comes from the nutrient artery of the bone.
it penetrates the bone’s outer cortex, the artery enters the medullary canal, the hollow inner portion of the shaft that is lined by the endosteum (similar to the periosteum, but on the inside) and contains yellow (fatty) marrow in adults.

**Age-Associated Changes in Bone**

Bone ages just like any other tissue of the body, decreasing in density after the age of 35 years, leading to a loss of height, and producing changes in facial structure. In women, this decrease in density is further accelerated once menopause is reached because of the loss of estrogen, a hormone that helps promote bone formation. A significant decrease in bone density, called osteoporosis, is associated with a higher risk of fracture. People with osteoporosis are at risk for incurring a fracture, especially in the hip, spine, and wrist.

Other changes associated with aging of bone include aging of muscles, cartilage, and other connective tissues that may also lead to degradation of joints and disk herniation. For example, the water content of the intervertebral disks decreases, increasing the risk of disk herniation. In some joints, the cartilage may become degraded, leading to arthritis and pain; in others, the cartilage becomes calcified, leading to restricted motion.

**Joints**

When two bones come together, they articulate with one another to form a joint. Some joints are fused and allow for no motion, such as the joints of the skull. Other joints allow for motion by permitting movement between the two bones, typically within a certain plane of motion that is defined by the structure of the bones that form it. The various motions that a joint may allow include flexion, extension, abduction, adduction, rotation, circumduction, pronation, and supination.

**Types of Joints**

The three general types of joints are fibrous, cartilaginous, and synovial. Fibrous joints, also referred to as synarthroses or fused joints, contain dense fibrous tissue that does not allow for movement. Examples include the bones of the skull and the distal tibiofibular joint.

Cartilaginous joints, also called amphiarthroses, allow for very minimal movement between the bones. The pubic symphysis and the joints connecting the ribs to the sternum are examples of this type of joint.

Synovial joints, or diarthroses, are the most mobile joints of the body. They are surrounded by an extension of the periosteum called the joint capsule, with the bones that form them being held in place by very strong ligaments. Within the joint are the articular cartilage and the synovial membrane, which secretes synovial fluid into the joint cavity to lubricate it.
**Figure 25-10** Joints in the body.
Bursa
A bursa is a padlike sac or cavity located within the connective tissue, usually in proximity to a joint. It may be lined with a synovial membrane and typically contains fluid that helps reduce the amount of friction between a tendon and a bone or between a tendon and a ligament. Examples include the olecranon bursa of the elbow and the prepatellar bursa of the knee. Bursitis is inflammation of a bursa.

Skeletal Connecting and Supporting Structures
Tendons connect muscle to bone. These flat or cordlike bands of connective tissue are white and have a glistening appearance.

Ligaments connect bone to bone and help maintain the stability of joints and determine the degree of joint motion. These inelastic bands of connective tissue have a structure similar to that of tendons.

Cartilage consists of fibers of collagen embedded in a gelatinous substance. This flexible connective tissue forms the smooth surface over bone ends where they articulate, provides cushioning between vertebrae, gives structure to the nose and external ear, forms the framework of the larynx and trachea, and serves as the model for the formation of the skeleton in children. Cartilage has a very limited neurovascular supply—it receives nutrients through diffusion from the outer covering of the cartilage or from the synovial fluid—so it does not heal well if it is injured.

The Moving Forces: Muscles
Muscles are composed of specialized cells that contract (shorten) when stimulated to exert a force on a part of the body. Three types of muscle are found in the body: smooth muscle, cardiac muscle, and skeletal muscle.

Skeletal Muscle
Skeletal muscle is also called voluntary muscle, because its contractions are largely under voluntary control, or striated muscle, because striations can be seen in it during microscopic examination. Skeletal muscle includes all of the muscles attached to the skeleton and forms the bulk of the tissue of the arms and legs. It is also found along the spine and buttocks. By maintaining a state of partial contraction, this type of muscle allows the body to maintain its posture and to sit or stand. It varies greatly in size and shape, from thin strands to the large muscles of the thigh and back. It also constitutes the muscles of the tongue, soft palate, scalp, pharynx, upper esophagus, and eye. About 40% to 50% of normal body
weight is skeletal muscle, as it has a high water content. In addition, because of its high metabolic rate and demand for energy and oxygen, skeletal muscle has a very rich blood supply, which causes it to bleed significantly when injured.

Skeletal muscles are profoundly affected by the amount of training and work to which they are subjected. Unused muscles tend to atrophy (shrink or waste away), whereas physical training promotes hypertrophy (increase in size).

Skeletal muscles are attached to bones by tendons. Tendons cross joints to create a pulling force between two bones when a muscle contracts. The biceps muscle, for example, has its origin on the scapula; the biceps tendon passes over the head of the humerus, where it fuses with the body of the biceps muscle; at the distal end of the biceps, a tendon passes over the anterior surface of the elbow and inserts on the radius. Thus, when the biceps muscle contracts, the force causes the elbow to bend (flex).

Muscle contraction requires energy. This energy is derived from the metabolism of glucose and results in the production of lactic acid (lactate). Lactic acid, in turn, must be converted
25. Musculoskeletal Injuries

25.1 Muscular Activity and Respiration

into carbon dioxide and water, a process that requires oxygen. For that reason, vigorous muscular activity is often followed by an increased respiratory rate, which increases oxygen delivery to and carbon dioxide removal from the tissues.

The sensation of muscle fatigue occurs when the energy supply to the muscle is inadequate to meet the energy demands. If muscle fatigue occurs as a result of excessive muscular activity, rest produces quick recovery. If it occurs from a lack of oxygen or essential nutrients or electrolytes (such as sodium or calcium), however, rest will not lead to such a quick recovery.

**Muscle Innervation**

Skeletal muscle is innervated by somatic motor neurons. These neurons transmit electrical stimuli to a muscle that cause it to contract. The combination of the muscle and the neuron that innervates it constitutes a motor unit. A motor unit that receives a signal to contract responds as forcefully as possible or does not contract at all. It is an all-or-nothing response. To generate a more forceful contraction, more neurons need to signal more muscle cells to contract, a process called recruitment.

Innervation of the upper extremities arises from the brachial plexus. The brachial plexus is formed by a network of nerves that originate from the spinal cord at the C5–T1 levels. After the fibers of these nerves network with one another, five distinct nerves are formed: the axillary, radial, musculocutaneous, ulnar, and median. Innervation of the lower extremities is provided by the lumbar and lumbosacral plexuses, which are formed by the spinal nerves that originate from L1–S4. The networking of nerves within these two plexuses leads to the formation of multiple distinct nerves, including the sciatic nerve, which branches in the popliteal fossa to form the peroneal and tibial nerves, and the femoral nerve.

**Musculoskeletal Blood Supply**

When a person has a musculoskeletal injury, the arteries that supply the injured region may also be damaged. Therefore, it is important to realize which arteries are present in each part of the extremity. Figure 25-14 A. Upper extremities. B. Lower extremities.
In the lower extremity, the blood supply originates from the external iliac artery. When the external iliac artery reaches the leg, it becomes the femoral artery. When it reaches the knee, the femoral artery turns posteriorly and laterally and is referred to as the popliteal artery. The popliteal artery divides into the anterior tibial artery and posterior tibial artery. The anterior tibial artery travels along the anterior and lateral surface of the tibia until it reaches the ankle, where it proceeds along the dorsal surface of the foot toward the great toe and becomes the dorsalis pedis artery. The posterior tibial artery travels along the posterior aspect of the tibia until it reaches the ankle, where it follows a path just behind the medial malleolus until it reaches the plantar aspect of the foot. Within the foot, arcades of arteries supply the various structures with blood and give off branches that form the digital arteries of the toes.

Patterns and Mechanisms of Musculoskeletal Injury

Skeletal injuries result from blunt and penetrating trauma. In some cases, a force that might not generally cause harm to normal healthy bone produces a fracture. Such a pathologic fracture occurs when a medical condition causes the bone to become abnormally weak. In adults and children, motor vehicle crashes, falls, and athletic activities are common causes of injury. Among children, intentional trauma or abuse is a common cause of fractures and musculoskeletal injuries.

Sports account for a significant number of musculoskeletal injuries.

Injury Forces and Motions

Direct Force

An object that strikes a person will transfer its energy to its point of impact. This energy is first absorbed by the soft tissues in the region of the impact. When the amount of force is so great that the soft tissues cannot fully dissipate it, a fracture occurs.

Penetrating injuries may also lead to a fracture or other musculoskeletal injury. A high-velocity injury, such as that caused by a high-power rifle, typically shatters bone and causes extensive soft-tissue damage.

An impalement injury commonly causes a soft-tissue injury similar to that seen in a low-velocity penetrating injury. If the impaled object happens to strike a bone, it may cause a fracture. In any case of impalement, it is essential to stabilize the object to protect the soft tissues from further injury.

Indirect Force

An indirect injury occurs when a force is applied to one region of the body but causes an injury in another region of the body. In this type of injury, the force is transmitted through the skeleton until, at some point, it reaches an area that is structurally weak in comparison with the other parts of the musculoskeletal system through which the force has traveled.

For example, a hip fracture may occur when a person's knee strikes the dashboard during a motor vehicle crash. In this case, the force is applied to the knee and travels proximally along the femur. When this force reaches the femoral neck, it causes the femoral neck to fracture.

Forces may be transmitted along the entire length of a bone or through several bones in series and may cause an injury anywhere along the way. Thus, a person falling on an outstretched hand may have one or more injuries as the result of forces transmitted proximally from the point of impact: (1) fracture of the scaphoid bone of the hand (direct blow); (2) fracture of the distal ulna and radius (Colles fracture); (3) fracture-dislocation of the elbow; (4) fracture-dislocation of the shoulder; or (5) fracture of the clavicle.

Twisting injuries, like those that commonly occur in football or skiing, result in fractures, sprains, and dislocations. Typically, the distal part of the limb remains fixed, as when cleats or a ski holds the foot to the ground, while torsion develops in the proximal section of the limb; the resulting force causes tearing of tendons and ligaments and spiral fractures of bone. Fatigue fractures, also called march fractures, are caused by repetitive stress and most commonly occur in the feet after prolonged walking.

Pathologic fractures are seen in patients with diseases that weaken areas of bone, such as metastatic cancer, and may occur with minimal force. Older people, particularly those with osteoporosis, also have weaker, more brittle bones and are more susceptible to fractures than younger people.
Some injuries are commonly encountered together because of the way the causative forces are transmitted; thus, if you find one, look for the others. Pain and swelling over the scaphoid (navicular) bone of the wrist, for example, means that the patient fell hard against an outstretched hand, so he or she may have other injuries anywhere along the axis from the hand to the shoulder.

## Fractures

A fracture is a break in the continuity of a bone. Fractures occur when the magnitude of the force applied to a bone (a single

### Documentation and Communication

Some services take digital or Polaroid pictures at crash scenes to include in reports to the receiving hospital. These images allow emergency department staff to better understand the forces involved.

<table>
<thead>
<tr>
<th>Table 25-1</th>
<th>Musculoskeletal Injuries That Commonly Occur Together</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>If You Find</strong></td>
<td><strong>Look For</strong></td>
</tr>
<tr>
<td>Scapular fracture</td>
<td>Rib fracture, pulmonary contusions, pneumothorax</td>
</tr>
<tr>
<td>Scaphoid fracture</td>
<td>Wrist, elbow, or shoulder fracture</td>
</tr>
<tr>
<td>Pelvic fracture</td>
<td>Lumbosacral spine and other long bone fractures, intra-abdominal or genitourinary injury</td>
</tr>
<tr>
<td>Hip dislocation</td>
<td>Fracture of the acetabulum or femoral head</td>
</tr>
<tr>
<td>Femoral fracture</td>
<td>Dislocation of ipsilateral hip</td>
</tr>
<tr>
<td>Patellar fracture</td>
<td>Fracture-dislocation of ipsilateral hip</td>
</tr>
<tr>
<td>Knee dislocation</td>
<td>Tibial fracture; distal pulse may be absent</td>
</tr>
<tr>
<td>Calcaneal fracture</td>
<td>Fracture of the ankle, leg, hip, pelvis, spine, and the other calcaneus</td>
</tr>
</tbody>
</table>

### You are the Provider Part 2

As you continue your initial assessment, an engine company arrives and assists with application of spinal precautions and high-flow supplemental oxygen. Soon afterward, the neighbor approaches and identifies himself. He says that the patient seemed to have lost his balance while painting and may have struck the air conditioner during his fall. On further assessment, you note that the patient appears to have an open fracture of his left arm, which is bleeding significantly.

<table>
<thead>
<tr>
<th>Vital Signs</th>
<th>Recording Time: 2 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of consciousness</td>
<td>A (Alert to person, place, and day)</td>
</tr>
<tr>
<td>Skin</td>
<td>Pink, warm, and slightly moist</td>
</tr>
<tr>
<td>Pulse</td>
<td>110 beats/min, full and regular</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>144/90 mm Hg</td>
</tr>
<tr>
<td>Respirations</td>
<td>42 breaths/min</td>
</tr>
<tr>
<td>SaO₂</td>
<td>96% with 15 L/min via nonrebreathing mask</td>
</tr>
</tbody>
</table>

3. What are the potential complications of an open fracture?
4. Why are open fractures prone to bleeding more than closed fractures?
5. Would your treatment priorities change if the patient complained of abdominal pain in the presence of hypotension?
application or an accumulation of repetitive applications) over-
comes the strength of the bone. The strength of a bone is affected
by age, osteoporosis, nutritional status, and disease processes.

**Fracture Classification**

**Fracture Type**
A fracture may be classified based on the direction that the
fracture line travels through a bone, number of fractures on the
bone, or number of cortices involved. Table 25-2

### Fracture Classification Based on Fracture Type

<table>
<thead>
<tr>
<th>Type of Fracture</th>
<th>Description</th>
<th>Common Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear fracture</td>
<td>Parallel to the long axis of the bone</td>
<td>Low-energy stress injuries</td>
</tr>
<tr>
<td>Transverse fracture</td>
<td>Straight across a bone at right angles to each cortex</td>
<td></td>
</tr>
<tr>
<td>Oblique fracture</td>
<td>At an angle across the bone</td>
<td>Direct or twisting force</td>
</tr>
<tr>
<td>Spiral fracture</td>
<td>Encircles the bone</td>
<td>Twisting injury</td>
</tr>
<tr>
<td>Impacted fracture</td>
<td>End of one bone becomes wedged into another bone</td>
<td>Fall from a significant height</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Fractures on One Bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comminuted fracture</td>
</tr>
<tr>
<td>Segmental fracture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of Cortices Injured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete fracture</td>
</tr>
<tr>
<td>Incomplete fracture</td>
</tr>
<tr>
<td>Greenstick fracture</td>
</tr>
<tr>
<td>Buckle fracture (torus fracture)</td>
</tr>
<tr>
<td>Bowing fracture</td>
</tr>
<tr>
<td>Fatigue fracture (stress fracture)</td>
</tr>
</tbody>
</table>

**Special Considerations**

Children with fractures may not want you to see, touch, or splint the injured extremity. You should always be honest with children about what you are doing and whether it will hurt. In particular, splinting is a necessary and sometimes painful intervention for a child with a fracture. Once the splint is in place, cold is applied, and analgesia is considered, the child will likely have less pain because the fracture is stabilized.
fracture, the increased interstitial pressure within the hematoma compresses the blood vessels, limiting the size of the hematoma. In a closed femur fracture, the blood loss may exceed 1 L before enough pressure develops to tamponade the bleeding. In contrast, open fractures allow much of the blood to escape, so tamponade does not occur as readily or at all.

**Signs and Symptoms of a Fracture**

The primary symptom of a fracture is pain that is usually well localized to the fracture site. In addition, the patient may report hearing a snap or feeling a break. Signs of fracture detected on physical examination include the following:

- **Deformity** is one of the most reliable signs of a fracture. The limb may be found in an unnatural position or show motion at a place where there is no joint. Compare the deformed limb with the extremity on the other side.
- **Shortening** occurs in fractures when the broken ends of a bone override one another. It is characteristic of femur fractures, for example, because the broken femur can no longer serve as a strut to oppose spasm in the powerful thigh muscles.

**In the Field**

The ends of a fractured bone are sharp. Use caution whenever bone ends are exposed to prevent a puncture injury to yourself, your crew, or the splint.

**Table 25-3 Fracture Classification Based on Displacement**

<table>
<thead>
<tr>
<th>Type of Fracture</th>
<th>Description</th>
<th>Common Causes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nondisplaced fracture</td>
<td>Bone remains aligned in its normal position, despite the fracture.</td>
<td>Low-energy injury</td>
</tr>
<tr>
<td>Displaced fracture</td>
<td>Ends of the fracture move from their normal positions.</td>
<td>High-energy injury</td>
</tr>
<tr>
<td>■ Overriding</td>
<td>Muscles pull the distal fracture fragment alongside the proximal one, leading them to overlap; the limb becomes shortened.</td>
<td>Only occurs when a fracture is fully displaced and there is no bone contact</td>
</tr>
<tr>
<td>■ Distraction injury</td>
<td>A powerful tensile force is rapidly applied to a bone, causing it to fracture—the bone ends are pulled apart.</td>
<td>Industrial equipment, machinery</td>
</tr>
<tr>
<td>■ Impacted fracture</td>
<td>A massive compressive force is applied to a bone, causing it to become wedged into another bone.</td>
<td>More likely to happen in cancellous bone</td>
</tr>
<tr>
<td>(impaction injury)</td>
<td>A powerful muscle contraction causes the insertion site of the muscle to be fractured off of the bone.</td>
<td>Sudden “jerking” of a body part</td>
</tr>
<tr>
<td>■ Avulsion fracture</td>
<td>Blunt trauma to a flat bone (such as the skull) causes the bone to be pushed inward.</td>
<td>Blunt injury</td>
</tr>
</tbody>
</table>
Limit, the bones that form a joint may break or become displaced and the supporting ligaments and joint capsule may tear.

**Dislocations, Subluxations, and Diastases**

In a dislocation, a bone is totally displaced from the joint. Typically, at least part of the supporting joint capsule and some of the joint’s ligaments are disrupted. Dislocations occur when a body part moves beyond its normal range of motion and the articular surfaces are no longer intact. The dislocated bones are then locked in place by muscle spasms. Evaluation of the patient usually reveals an obvious and significant deformity, a significant decrease in the joint’s range of motion (ROM), and severe pain. In all cases of a dislocation, a fracture should be suspected until ruled out by radiographs.

The partial dislocation of a joint is a subluxation. In this type of injury, the articular surfaces of the bones that form the joint are no longer completely in contact. In some cases, part of the joint capsule and supporting ligaments may be damaged. Despite the subluxation, the patient may be able to move the joint to some degree. Failure to recognize and treat a subluxation may lead to persistent joint instability and pain.

When the ligaments that hold two bones in a fixed position with respect to one another are disrupted and the space between them increases, a situation known as a diastasis occurs. An example of this would be an injury to the ligaments that hold the pubic symphysis together, causing the width of the joint to increase (diastasis of the pubic symphysis).

The principal symptom of a dislocation is pain or a feeling of pressure over the involved joint, plus loss of motion of the joint. A patient with a posterior dislocation of the shoulder, for example, is unable to raise the arm but holds it against the side instead. Sometimes the joint will seem “frozen.” The principal sign of dislocation is deformity.

A dislocation is considered an urgent injury because of its potential to cause neurovascular compromise distal to the site of injury. If the dislocated bone presses on a nerve, there may be numbness or weakness distally; if an artery is compressed, there may be absent distal pulses (such as in a knee dislocation). For these reasons, you should always assess the patient’s neurovascular status distal to the site of dislocation (check pulse and motor and sensory functions [PMS]).

**Sprains**

Sprains are injuries in which ligaments are stretched or torn. They usually result from a sudden twisting of a joint beyond its normal range of motion that also causes a temporary subluxation. The majority of sprains involve the ankle or the knee because most occur after a person misjudges a step or landing. Evasive moves, like those done during a sporting event, commonly cause sprains in athletes. Sprains are typically characterized by pain, swelling, and discoloration over the injured joint and unwillingness to use the limb. In contrast with fractures and dislocations, sprains usually do not involve deformity and joint mobility is usually limited by pain, not by joint incongruity.

Because it may be difficult to differentiate among the various types of injuries in the field, it is best to err on the side of caution: If you suspect a fracture or dislocation, treat it as such. Even if a dislocation is ruled out by radiographs, always check surrounding joints for evidence of injury. In cases of a suspected dislocation or fracture, you must control the pain and swelling and immobilize the injury.
Musculoskeletal Injuries

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caution and treat every severe sprain as if it were a fracture. General treatment of sprains is similar to that of fractures and includes the following (numbers 1 through 4 form the mnemonic RICE):

1. **Rest**. Immobilize or splint injured area
2. **Ice** or cold pack over the injury
3. **Compression** with an elastic bandage (usually applied at the hospital once radiography rules out a fracture)
4. **Elevation**
5. Reduced or protected weight bearing
6. Pain management as soon as practical

**Muscle and Tendon Injuries**

**Strains**

A **strain** (pulled muscle) is an injury to a muscle and/or tendon that results from a violent muscle contraction or from excessive stretching. Often no deformity is present and only minor swelling is noted at the site of injury. Some patients may complain of increased pain with passive movement of the injured extremity.

**Achilles Tendon Rupture**

A rupture of the Achilles tendon usually occurs in athletes older than 30 years who are involved in start-and-stop sports such as basketball or football. The most immediate indications are pain from the heel to the calf and a sudden inability for **plantar flexion** of the foot. As time passes, the calf muscles begin to contract proximally and a deformity within the calf may develop. The **Thompson test** can be performed in the field to identify an Achilles tendon rupture. To perform this test, have the patient assume a prone position and then squeeze the calf muscles of the injured leg. If the foot plantar flexes while squeezing, the tendon is most likely intact. If there is no movement of the foot, the Achilles tendon has likely been torn. Management of an Achilles tendon injury includes RICE and pain control. These injuries are treated with surgery or multiple casts and can require up to 6 months for recovery.

**Inflammatory Processes**

When a muscle is subjected to frequent and repetitive use, its tendon or nearby bursa are at risk for becoming inflamed. When inflammation of the tendon causes pain, the patient is said to have **tendinitis**. There will typically be point tenderness on the inflamed tendon with pain often increasing if the person performs the movement that led to the inflammation. When a bursa becomes painful and inflamed, it is called **bursitis**. Patients with bursitis often complain of pain in the region of the inflamed bursa, especially with motions that cause the space where the bursa sits to become smaller. Examination of the site may reveal tenderness, swelling, erythema, and warmth. Tendinitis and bursitis are treated with RICE, pain relievers, and, in many cases, steroid injections.

**Arthritis**

**Arthritis** means inflammation of a joint. The three most common types of arthritis are osteoarthritis, rheumatoid arthritis, and gouty arthritis.

**Osteoarthritis (OA)** is a disease of the joints that occurs as they age and begin to wear. It is characterized by pain and stiffness, which typically get worse with use, and “cracking” or “crunching” of the affected joints. The spine, hands, knees, and hips are the most commonly affected sites. In general, the risk of developing OA increases with age, but other factors also include...
increase the risk, such as obesity and prior joint injury. Treatment of OA involves low-impact physical therapy, pain control, anti-inflammatory medications, joint injections, and, in severe cases, joint replacement surgery.

Rheumatoid arthritis (RA) is a systemic inflammatory disease that affects joints and other body systems. In RA, significant bone erosion at the affected joints makes them more susceptible to fractures and dislocations. Of particular concern is the cervical spine, which is at high risk of subluxating following trauma or during intubation. Give extra attention to the cervical spine of a patient with RA to prevent further injury.

Gout is a condition in which the body has difficulty eliminating uric acid. When the concentration of uric acid in the blood becomes too great, the uric acid may crystalize within a joint. The patient will then have a hot, red, swollen joint with decreased range of motion. Prehospital treatment involves immobilization, pain relief, and transportation to an emergency department (ED) where the fluid in the joint can be aspirated to search for the characteristic crystals of gouty arthritis.

**Injuries That May Signify Fractures**

**Amputations**

An amputation is the separation of a limb or other body part from the remainder of the body. The amputation may be incomplete, leaving only a small segment of tissue connecting the part, or it may be complete, causing the part to be fully separated. Hemorrhage from complete or incomplete amputations can be severe and life threatening. Fractures may also be present with amputations. Amputations are discussed in more detail in Chapter 19.

**Lacerations**

A laceration is a smooth or jagged cut caused by a sharp object or a blunt force that tears the tissue. The depth of the injury can vary, extending through skin and subcutaneous tissue and even into the underlying muscles and adjacent nerves and blood vessels. Lacerations involved in damaged arteries or veins may result in severe bleeding. The presence of lacerations may also be a sign of an underlying fracture. Deep lacerations may injure the muscle nerves, or vasculature, so distal PMS functions should always be evaluated.

**Vascular Injuries**

When blood vessels are damaged following a musculoskeletal injury, devascularization of the body part that is supplied by the vessel may occur. The types of injuries that a vessel may sustain include a contusion of the vessel wall, laceration, kinking or bending, and formation of pseudoaneurysms. In addition, a blood vessel may thrombose (become occluded by a clot) when the injury causes blood flow to become very slow. Regardless of the type of vascular injury involved, it is important to assess and reassess pulses, control bleeding, and maintain adequate intravascular volume by using intravenous (IV) fluid.

**General Principles of Assessment and Management**

When assessing an injured patient, do not be distracted by visually impressive injuries! It is essential to complete the initial assessment of the patient before focusing on the extremities. In cases of musculoskeletal injuries, patients may be classified based on the presence or absence of associated injuries:

- Life- or limb-threatening injury or condition, including life- or limb-threatening musculoskeletal trauma
- Life-threatening injuries and only simple musculoskeletal trauma
- Life- or limb-threatening musculoskeletal trauma and no other life-threatening injuries
- Isolated, non-life- or non-limb-threatening injuries

**Volume Deficit Due to Musculoskeletal Injuries**

Fractures may lead to significant blood loss from damage to vessels within the bone and musculature around the bone and, in some cases, from damage to large blood vessels in the region of the fracture. When caring for patients with fractures, undertake interventions such as applying direct pressure, splinting,
and administering IV fluids to prevent hypotension and unstable condition of the patient. Table 25-4 lists the potential blood loss from various fracture sites and may serve as a guideline for estimating the amount of resuscitation required. The goal of prehospital management should be to keep the patient's volume, vital signs, and mental status normal.

**Principles of Assessment**

As with all patients, you should conduct a scene size-up, focusing on safety and body substance isolation precautions and then proceed to an initial assessment focusing on the patient's mental status, ABCs, and priority. If the initial assessment indicates that the patient has no immediately life-threatening condition and only localized musculoskeletal trauma, continue with a focused history and physical exam. If the patient has a significant mechanism of injury, complete a rapid trauma assessment and perform a detailed physical exam en route to the ED. The priorities throughout the assessment and management of musculoskeletal injuries should include identifying the injuries, preventing further harm or damage to the injured structures and surrounding tissues, supporting the injured area, and administering pain medication if necessary.

**History of Present Injury**

Obtain information about the incident that led to the injury from the patient and any bystanders who witnessed it. In particular, determine the condition of the patient immediately before the incident, the details of the incident, and the patient's position after the incident. Also, ask the patient for a subjective description of the injury: How did this happen? Did you hear a pop? Do you have pain? What functional limitations do you now have?

**Medical History**

Obtain the patient's medical history using the standard SAM-ple format. This history should also identify any preexisting musculoskeletal disorders and attempt to learn more about the injury. Some information obtained will be very relevant to the injury (such as the patient is taking anticoagulant medications).

<table>
<thead>
<tr>
<th>Fracture Site</th>
<th>Potential Blood Loss (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pelvis</td>
<td>1,500–3,000</td>
</tr>
<tr>
<td>Femur</td>
<td>1,000–1,500</td>
</tr>
<tr>
<td>Humerus</td>
<td>250–500</td>
</tr>
<tr>
<td>Tibia or fibula</td>
<td>250–500</td>
</tr>
<tr>
<td>Ankle</td>
<td>250–500</td>
</tr>
<tr>
<td>Elbow</td>
<td>250–500</td>
</tr>
<tr>
<td>Radius or ulna</td>
<td>150–250</td>
</tr>
</tbody>
</table>

**Examination**

When examining the patient, obtain a baseline set of vital signs. The focus can then shift to evaluating the injured extremity. One of the simplest ways to assess an extremity is to compare one side with the other, noting any discrepancy in length, position, or skin color. Next, complete an exam noting DCAP-BTLS (Deformity, Contusions, Abrasions, Penetrating injury--Burns, Tenderness, Lacerations, Swelling) as you observe and palpate the soft tissue from head to toe and assess the patient for limitations, such as inability to move a joint. While performing the exam, be sure to cover the 6 Ps of musculoskeletal assessment: Pain, Paralysis, Parasthesias (numbness or tingling), Pulselessness, Pallor (pale or delayed capillary refill in children), and Pressure.

**Pain**

A person experiences acute pain when peripheral pain receptors (nocioceptors) convert painful stimuli into electrical impulses that are transmitted via the peripheral nerve fibers to the spinal cord. The signal ascends along the spinal cord to the pain-sensing region of the brain. When a tissue is injured, various chemical mediators are released that facilitate the conduction of the painful stimulus to the brain.

When assessing a patient's pain, remember the OPQRST mnemonic: Onset of the pain; Provoking or Palliating factors; Quality of the pain (such as sharp, pressure, crampy); Region of the pain, including its primary location and areas where pain radiates or refers; Severity of the pain; and the Time (duration) that the patient has been experiencing pain. It is also useful to have the patient quantify the severity of the pain by using a scale of 1 to 10 or with visual images such as faces that appear to be happy or in pain.

**Inspection**

When inspecting an injured extremity, always evaluate the joint above and the joint below the site of injury because the injuring force may have affected these sites as well. In particular, compare the injured side with the uninjured side. While inspecting a patient's injuries, look for the following signs:

- Deformity, including asymmetry, angulation, shortening, and rotation
- Skin changes, including contusions, abrasions, avulsions, punctures, burns, lacerations, and bone ends
- Swelling
- Muscle spasms
- Abnormal limb positioning
- Increased or decreased range of motion
- Color changes, including pallor and cyanosis
- Bleeding, including estimating the amount of blood loss

**Palpation**

Palpation of an injured extremity should include the injury site and the regions above and below it. Regions of point tenderness should be identified. Reassess any tender areas frequently to determine whether there are changes in the location or severity of the pain or tenderness. Note that while point tenderness is one of
the best indicators of an injury, it may be absent in patients who are intoxicated or who have an injury to the spinal cord.

When palpating an injured site, attempt to identify instability, deformity, abnormal joint or bone continuity, and displaced bones. Feel for crepitis, which is commonly found at the site of a fracture. Palpate distal pulses on all extremities, with special attention to comparing the strength of the pulses in the injured extremity with those in a normal one.

On occasion, an arterial injury may be identified while palpating an extremity. Signs of an arterial injury include a pulsatile expanding hematoma, diminished distal pulses, a palpable thrill (vibration) over the site of injury that correlates with the patient’s heartbeat, and difficult-to-control bleeding.

The purpose of palpating the pelvis is to identify instability and point tenderness. Apply pressure over the pubic symphysis to evaluate for tenderness and crepitis. Next, press the iliac wings toward the midline and then posteriorly. Any gross instability found during this examination should be reported to hospital personnel because it may indicate a severe pelvic injury. Do not repeatedly examine the pelvis if instability is found because the manipulation may disrupt blood clots and cause further bleeding.

The upper and lower extremity exam should include palpation of the entire length of each arm and leg to identify any sites of injury. The most efficient way to accomplish this is to place your hands around the extremity and squeeze. Repeat this procedure every few centimeters until you reach the end of the extremity. When evaluating the upper extremities, always examine the cervical spine and shoulder because complaints within the arm may be caused by a more proximal disorder. Likewise, with the lower extremities, always conduct an exam of the pelvis and hip if the patient complains of pain in the leg.

**Motor Function and Sensory Exam**

It is essential to assess a patient’s distal pulse, as well as motor and sensory function, in the case of a musculoskeletal injury. A motor function exam should be performed whenever a patient has an injury to an extremity, provided the patient does not also have a life-threatening injury. When assessing motor function, consider the preinjury level of function. In some cases, weakness or motor deficits may be due to prior injuries or medical problems. For this reason, you should perform a careful review of the patient’s history whenever a patient complains of being weak or unable to move an extremity.

While performing a motor exam, carry out each test with and without resistance because some patients may be too weak to overcome any outside resistance. Also, perform the test on both sides of the body simultaneously so that each extremity can be compared.

A sensory exam should be performed on all patients who have an injury or complaint related to an extremity, assuming that it does not take attention away from a potentially fatal condition. The sensory exam and history should attempt to identify any pre-existing deficits in function or other disorders, including diabetes and nerve disorders that may cause changes in sensation. It is important to assess not only for the presence or absence of sensation, but also for the quality and symmetry of sensation.

To perform a sensory exam, first ask the patient if he or she feels any abnormal sensations, such as numbness, tingling, or burning. Next, conduct a gross sensory exam by lightly touching the injured extremity and the unaffected side simultaneously; have the patient report whether the two sides feel the same or different. In some cases, a patient may complain of an abnormally severe sensation of pain when just lightly touched. Such hyperesthesia may be a sign of an injury to the spinal cord.

To perform a motor function and sensory exam, follow the steps shown in Skill 25-1:

1. Have the patient abduct his or her arms at the elbow to test axillary nerve motor function.
2. Evaluate the patient’s ability to extend the arms at the elbow to test musculocutaneous nerve motor function.
3. Have the patient extend the thumbs (thumbs up) to test radial nerve motor function.
4. Assess the patient’s ability to make an “okay” sign to test median nerve motor function.
5. Check the patient’s ability to spread his or her fingers apart to test ulnar nerve motor function.
6. Instruct the patient to extend his or her legs at the knee to test femoral nerve motor function.
7. Have the patient plantarflex his or her feet to test tibial nerve motor function.
8. Assess the patient’s ability to dorsiflex the feet to test peroneal nerve motor function.
9. Check light touch over the lateral surface of the shoulder (over the deltoide) to test axillary nerve sensory function.
10. Evaluate light touch on the anterolateral surface of the forearm to test musculocutaneous nerve sensory function.
11. Assess light touch on the anterolateral surface of the web space of the thumb to test radial nerve sensory function.
12. Lightly touch the volar surface of the distal thumb, index, and middle fingers to test median nerve sensory function.
13. Lightly touch the distal volar surface of the small finger to test ulnar nerve sensory function.
14. Examine the patient’s sense of light touch over the anteromedial surface of the thigh to test femoral nerve sensory function.
15. Evaluate light touch on the plantar surface of the toes to test tibial nerve sensory function.
16. Assess light touch in the web space between the great toe and the second toe to test peroneal nerve sensory function.

**Documentation and Communication**

Always document the findings of a neurovascular exam, even if they are normal. When an abnormality is identified, document the specific deficit—for example, the patient was unable to extend the thumb or the wrist.
Skill Drill 25-1: Performing a Motor Function and Sensory Exam

Step 1: Have the patient flex his or her arms at the elbow.

Step 2: Have the patient extend the arms at the elbow.

Step 3: Have the patient extend the thumbs (thumbs up).

Step 4: Have the patient make an “okay” sign.

Step 5: Have the patient spread his or her fingers apart.

Step 6: Instruct the patient to extend his or her leg at the knee.

Step 7: Have the patient flex his or her feet and ankles downward.

Step 8: Instruct the patient to flex the ankles upward.

Step 9: Check light touch over the lateral surface of the shoulder (over the deltoid).
Skill Drill 25-1: Performing a Motor Function and Sensory Exam (continued)

Step 10
Evaluate light touch on the anterolateral surface of the forearm.

Step 11
Assess light touch on the dorsal surface of the web space of the thumb.

Step 12
Lightly touch the volar surface of the distal thumb, index, and middle fingers.

Step 13
Lightly touch the distal volar surface of the small finger.

Step 14
Examine the patient’s sense of light touch over the anteromedial surface of the thigh.

Step 15
Evaluate light touch on the plantar surface of the toes.

Step 16
Assess light touch in the web space between the great toe and the second toe.
**General Interventions**

The overall goal in the treatment of a musculoskeletal injury is to identify the type and extent of the injury and to create a biologic environment that maximizes the normal healing process of the injured structure. This process begins in the field with a thorough assessment of the patient and proper immobilization of injuries to prevent further harm.

**Pain Control**

A patient who has sustained a musculoskeletal injury may experience pain for a number of reasons. Pain may be caused by a fracture or continued movement of an unstable fracture, muscle spasm, soft-tissue injury, nerve injury, or muscle ischemia. Orthopedic injuries are often extremely painful, so the goal of prehospital pain control should be to diminish the patient's pain to a tolerable level.

A number of interventions may be performed in the field to control pain from a musculoskeletal injury. The first step is to assess the level of pain. Establishing a baseline level of pain and reassessing it after each intervention allow you to determine the effectiveness of the treatment being provided. Simple methods for controlling pain include splinting, resting and elevating the injured part, and applying ice or heat packs.

When simple procedures do not effectively control a patient's pain, consider the administration of an analgesic or antispasmodic agent. Analgesics used in the field include narcotics, such as fentanyl and morphine, and nitrous oxide; antispasmodic agents include diazepam and lorazepam. These agents should be reserved for patients in hemodynamically stable condition who have an isolated musculoskeletal injury. It is important to obtain vital signs before and after administering any medication for pain and spasm and to monitor the patient's respiratory status for signs of respiratory depression. After pain medication is administered, reassess the patient's pain to ensure that pain relief is adequate.

Administering pain medication before splinting may allow the extremity to be immobilized more effectively. Remember, it hurts to have an injured extremity held in the proper position for splinting. Pain medication may make it possible for the patient to tolerate that position longer and allow the splint to be applied properly.

**Cold and Heat Application**

Cold packs are useful for treating patients during the initial 48 hours following an injury and are very effective at decreasing pain and swelling. Cooling the injured area causes vasoconstriction of the blood vessels in the region and decreases the release of inflammatory mediators. As a result, swelling and inflammation are reduced when ice packs are used during the acute stage of an injury.

Conversely, heat therapy should not be used during the initial 48 to 72 hours following an injury because it may actually increase pain and swelling during this period. Once the acute phase of the injury ends and the damaged blood vessels become clotted, heat is useful for increasing blood flow to the region to decrease stiffness and to promote healing. As a consequence, heat packs may be beneficial for patients who report an injury several days before contacting paramedics.

**Splinting**

Splinting is intended to provide support to and prevent motion of the broken bone ends. Correctly splinting an injured extremity not only decreases the pain a patient experiences, but also reduces the risk of further damage to muscles, nerves, blood vessels, and skin. In addition, splinting helps to control bleeding by allowing clots to form where vessels were damaged. When a patient with multiple orthopedic injuries must be transported immediately, you will not have time to splint each fracture one by one. The best way to stabilize multiple fractures when the patient's overall condition is critical is to splint the axial skeleton by using a long backboard and straps or an alternative device, such as a vacuum air mattress. This will serve two purposes: (1) It will protect against a spinal injury. (2) It will reduce the movement of injured extremities by securing them to the board.

**Principles of Splinting**

Splinting is one of the most crucial skills to learn when caring for patients with musculoskeletal injuries. Failure to properly splint an injured extremity leads to unnecessary discomfort and the possibility of further injury or harm. Allowing a closed fracture in the distal tibia to become an open fracture owing to
misunderstanding or improper splinting will result in the need for surgery and a hospital stay and may increase the patient's rehabilitation time. Keep the following points in mind when applying a splint:

1. The injured area must be adequately visualized before splinting. Remove clothing as necessary so that you can inspect the area thoroughly.
2. Assess and record distal PMS functions before and after splinting.
3. Cover all wounds with a dry, sterile dressing before applying the splint. Do not attempt to push exposed bone ends back under the skin.
4. Do not move the patient before splinting unless an immediate hazard exists.
5. For fractures, the splint must immobilize the bone ends and the two adjacent joints. For dislocations, the splint must extend along the entire length of the bone above and the entire length of the bone below the dislocated joint.
6. Pad the splint well to prevent local pressure and to provide optimal motion restriction.
7. Support the injured site manually with one hand above and one hand below the injury, and minimize movement until the splint is applied and secured.
8. If a long bone fracture is severely angulated, gently apply longitudinal traction (tension) to attempt to realign the bone and improve circulation. Use a smooth, firm grip to apply manual traction, and take care to avoid any sudden, jerky movements of the limb. Do not attempt to straighten fractures involving joints without first obtaining medical direction. In fact, there is no need to straighten or manipulate the joint unless it has no distal pulse.
9. Splint the knee straight if not directly injured and angulated; splint the elbow at a right angle. (The patient may not be able to tolerate this procedure, and rapid transport should be initiated.)
10. If the patient complains of severe pain or offers resistance to movement, discontinue applying traction, splint in the position of deformity, and carefully monitor the distal neurovascular status (PMS).
11. Splint firmly, but not so tightly as to occlude the distal circulation.
12. If possible, do not cover fingers and toes with the splint to allow for monitoring of skin CTC (color, temperature, and condition).
13. If possible, apply cold packs and elevate the splinted limb to minimize swelling.

**Notes from Nancy**

Always check the pulses, strength, and sensation distal to a musculoskeletal injury.

14. When the patient has a life-threatening injury, individual splint application for possible fractures must not delay transportation and might not be accomplished.
that are used to secure it to the extremity, this step is not required.) Leave the fingers or toes out of the bandage so that distal circulation can be monitored.

**Sling and Swath**

An arm sling may be fashioned from a triangular bandage and is useful to immobilize injuries that involve the shoulder or as an adjunct to a rigid splint of the upper extremity. The sling holds the injured part against the chest wall and takes some of the weight off the injured area.

To apply a sling, place the splinted extremity in a comfortable position across the chest and lay the long edge of a triangular bandage along the patient’s side opposite the injury. Bring the bottom edge of the bandage up and over the forearm, and tie it at the side of the neck to the other end. Tie or pin the pointed end of the sling, at the elbow, to form a cradle. Secure the sling so that the hand is carried higher than the elbow and the fingers are visible for checking peripheral circulation.

An arm that is splinted with a sling can be further immobilized by adding a swath. Create a swath by using one or more triangular bandages to secure the arm firmly to the chest wall. This technique is particularly useful for injuries to the clavicle and for anterior dislocations of the shoulder. Do not use a sling if the patient has a neck injury.

**Pneumatic Splints**

Pneumatic splints (also known as air splints or inflatable splints) are useful for immobilizing fractures involving the lower leg or forearm. They are not effective for angulated fractures or for fractures that involve a joint because they will forcefully attempt to straighten the fracture or joint. Likewise, air splints should not be used on open fractures in which the bone ends are exposed.

Air splints offer two distinct advantages: They can help slow bleeding and minimize swelling by applying pressure over fracture sites to decrease small-vessel bleeding. For injuries involving the pelvis or femur, the pneumatic antishock garment (PASG) may be used as an air splint and can potentially tamponade bleeding from larger vessels. If a PASG is used for this purpose, it is necessary to use high pressure in the device (106 mm Hg or until the pop-off valves for the compartments blow off).

The method of application for an air splint depends on whether it is equipped with a zipper. If it is not, gather the splint on your own arm so that its proximal edge is just above your wrist. Grasp the patient's hand or foot while an assistant maintains proximal countertraction, then slide the air splint over your hand and onto the patient's extremity. Position the air splint so that it is free of wrinkles. Then, while you continue to maintain traction, instruct your assistant to inflate the splint with a commercially available device that is compatible with the splint system—do not use a compressed air tank to inflate an air splint. If the air splint has a zipper, apply it to the injured area while an assistant maintains traction proximally and distally; then zip it up and inflate. In either case, inflate the splint just to the point at which finger pressure will make a slight dent in the splint’s surface.

You must watch air splints carefully to ensure that they do not lose pressure or become overinflated. Overinflation is particularly
likely when the splint is applied in a cold area and the patient is subsequently moved to a warmer area because the air inside the splint will expand as it gets warmer. Air splints will also expand when going to a higher altitude if the patient compartment is unpressurized, a factor that must be considered when patients are transported by air ambulance.

**Vacuum Splints**

A vacuum splint consists of a sealed mattress that is filled with air and thousands of small plastic beads. The mattress is laid out on the stretcher, and the patient is placed on top of it and allowed to settle into a comfortable position. A suction pump attached to the mattress is then used to evacuate the air from inside the mattress. The resulting vacuum inside the mattress compresses the beads in such a way that the whole splint becomes rigid, much like a plaster cast that has been molded to conform to the contours of the patient’s entire posterior surface.

The vacuum mattress is an excellent splint, but there are a few factors that may limit its broad appeal. The splint is quite bulky, so it not only takes up a lot of storage room in the vehicle, but also can be difficult to work with in cramped quarters. Furthermore, like all vacuum splints, it requires a mechanical suction pump, yet another piece of equipment to grab.

A smaller vacuum splint is available to splint individual limbs. This type of splint is applied by positioning the injured limb on the splint and then evacuating the air from inside of it. The result is a splint that is molded to the extremity. This type of vacuum splint requires less space than a mattress-style vacuum splint but is still relatively expensive compared with standard rigid splints.

**Pillow Splints**

A pillow is an effective means to immobilize an injured foot or ankle. Simply mold an ordinary pillow around the affected foot and ankle in a position of comfort, then secure the pillow in place with several cravats. Pillows can also be molded around an injured knee or elbow and are invaluable for padding backboards when they are used to immobilize patients with dislocated hips.

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**You are the Provider Part 3**

You have assessed the patient’s airway, breathing, and circulation and have controlled significant bleeding found on the left arm. During this time, your partner has inserted a large-bore IV catheter in the right arm. She has also noted that the patient’s lung sounds are clear and initiated a bolus of 200 mL normal saline.

As you continue your rapid trauma exam, you find that the left pedal pulse is absent. When you expose the leg, you see significant deformity of the knee consistent with a posterior dislocation. The patient has difficulty feeling his foot and moving his toes. This is a true emergency. With your patient immobilized on the backboard, you decide to move him to the ambulance as per your local protocols.

### Reassessment Recording Time: 7 Minutes

| Reassessment |  
|-------------|---|
| Skin        | Pink, warm, and slightly moist; pale and cool left foot |
| Pulse       | 110 beats/min, full and regular |
| Blood pressure | 140 by palpation |
| Respiration | 40 breaths/min |
| SaO2        | 100% on 15 L/min via nonrebreathing mask |
| ECG         | Sinus tachycardia with no ectopy |

6. Why would this dislocation be considered a true emergency?

7. What is an important consideration before manipulating a dislocation?
Chapter 25  Musculoskeletal Injuries

25.27  Traction Splints

Following a femur fracture, the strong muscles of the thigh go into spasm and often lead to significant pain and deformity. Traction splints provide constant pull on a fractured femur, thereby preventing the broken bone ends from overriding as a result of unopposed muscle contraction. In addition, these splints help maintain alignment of the fracture pieces and provide effective immobilization of the fracture site. As a result, patients are likely to experience less pain.

Traction splints also reduce blood loss. Normally, the thigh is shaped like a cylinder. In a femur fracture, the thigh is shortened and becomes spherical. The volume of a sphere can be substantially greater than that of a cylinder, so a person with an untreated femur fracture can accumulate more blood in the thigh than a person whose thigh is pulled out to length by a traction splint.

Traction splints are indicated for the treatment of most femur fractures. They should not be used when the patient has an additional fracture below the knee on the same extremity. The most commonly used traction splints are the Sager and the Hare traction splints. The basic principles of application are the same for both. After assessing the injured extremity for distal PMS functions, place the splint next to the uninjured leg to determine the proper length. The traction splint should extend 6” to 10” beyond the foot.

Support and stabilize the leg to minimize movement while another rescuer applies the ankle hitch. When the hitch is secure, the second rescuer will apply gentle longitudinal traction using enough force to realign the extremity. The initial rescuer can then place the splint into position and connect the upper attachment point of the splint and then the ankle hitch . After applying the splint, reassess PMS functions before securing the patient and splint for transport.

Buddy Splinting

Buddy splinting is used to splint injuries that involve the fingers or toes. With this technique, an adjacent uninjured finger or toe serves as a splint to the injured one. To buddy splint, tape the injured digit to an uninjured one. Place a gauze pad between the digits that are taped together, and ensure that the tape does not pass over joints.

Complications of Musculoskeletal Injuries

Musculoskeletal injuries can lead to numerous complications—not just those involving the musculoskeletal system, but also systemic changes or illness. It is essential to not focus all of your attention on the musculoskeletal injury: Keep in mind that there is a patient attached to the injured extremity!

The likelihood of having a complication is often related to the strength of the force that caused the injury, the injury’s location, and the patient’s overall health. Any injury to a bone, muscle, or other musculoskeletal structure is likely to be accompanied by bleeding. In general, the greater the force that caused the injury, the greater the hemorrhage that will be associated with it.

Following a fracture, the sharp ends of the bone may damage muscles, blood vessels, arteries, and nerves, or the ends may penetrate the skin and produce an open fracture. A significant loss of tissue may occur at the fracture site if the muscle is severely damaged or if the bone’s penetration of the skin causes a large defect. To prevent infection following an open fracture, you should brush away any obvious debris on the skin surrounding an open fracture before applying a dressing. Do not enter or probe the open fracture site in an attempt to retrieve debris because this may lead to further contamination.

Long-term disability is one of the most devastating consequences of a musculoskeletal injury. In many cases, a severely injured limb can be repaired and made to look almost normal. Unfortunately, many patients cannot return to work for long periods because of the extensive rehabilitation required and because of chronic pain. Paramedics have a critical role in mitigating the risk of long-term disability. By preventing further injury, reducing the risk of wound infection, minimizing pain by the use of cold and analgesia, and transporting patients with musculoskeletal injuries to an appropriate medical facility, they help reduce the risk or duration of long-term disability.

Neurovascular Injuries

The skeletal system normally protects the neurovascular structures within the limbs from injury. These critical structures typically lie deep within the limb and close to the skeleton. For example, the brachial plexus is situated within the axilla and the inner aspect of the arm, shielded from injury by the shoulder girdle. When the shoulder girdle or proximal humerus is fractured, displaced fracture fragments may lacerate or impale...
the nerves of the plexus, leading to a neurologic deficit. Neurovascular injuries are also likely to occur following a joint dislocation because the nerves and vessels in the region of a joint tend to be more securely tethered to the soft tissues and are less likely to escape injury.

**Compartment Syndrome**

Within a limb, groups of muscles are surrounded by an inelastic membrane called fascia. Thus, the muscles are confined to an enclosed space, or compartment, that can accommodate only a limited amount of swelling. When bleeding or swelling occurs within a compartment as the result of a fracture or severe soft-tissue injury, the pressure within it rises. Too-high pressure may impair circulation and lead to pain, sensory changes, and progressive muscle death. This condition, known as **compartment syndrome**, is one of the most devastating consequences of a musculoskeletal injury.

External and internal factors can lead to the development of compartment syndrome. External factors include bandages, splints, casts, and a PASG that are applied too tightly and restrict circulation. A number of internal factors can also increase the amount of material within a compartment. For example, bleeding within a compartment may occur because of a fracture, dislocation, crush injury, vascular injury, soft-tissue injury, or bleeding disorder. Alternatively, fluid leakage or edema may occur secondary to ischemia, excessive exercise, trauma, burns, or any condition associated with the leakage of proteins and fluid from vessels into the interstitial space. A common misconception is that open fractures are safe from compartment syndrome—a notion that is not true.

Signs and symptoms of compartment syndrome include early and late findings. Typically, the first complaint will be of a searing or burning pain that is localized to the involved compartment and out of proportion to the injury. This pain is often severe and typically not relieved with pain medication, including narcotics. When examining the patient, passive stretching of an ischemic muscle will result in severe pain. In the lower extremities, test for this condition by flexing and extending the great toe and by dorsiflexion and plantar flexion of the foot. In the upper extremity, use finger and hand flexion and extension.

During examination of the patient, the affected area may feel very firm and there may be skin pallor. Typical neurologic changes include paresthesias, such as a burning sensation, numbness, or tingling, and paralysis of the involved muscles, which occurs late in the condition. Another late sign of compartment syndrome is pulselessness. By the time the pressure within the compartment reaches the point where it totally occludes the artery passing through it, significant muscle necrosis has probably occurred.

The goal of prehospital care is to deliver the patient to an emergency facility before the extremity is pulseless. Thus, management should include elevating the extremity to heart level (not above!), placing ice packs over the extremity, and opening or loosening constrictive clothing and splint material.

**Crush Syndrome**

**Crush syndrome** occurs because of a prolonged compressive force that impairs muscle metabolism and circulation—actually, following the extrication or release of an entrapped limb. This condition happens not only in trauma patients, but also in patients who have been lying on an extremity for an extended period (4–6 hours of compression)—for example, when a drug overdose or stroke victim is not found for an extended period.

After a muscle is compressed for 4 to 6 hours, the muscle cells begin to die and release their contents into the localized vasculature. When the force compressing the region is released, blood flow is reestablished and the material from the cells that was released into the local vasculature quickly returns to the systemic vasculature. The primary substances that are of concern are lactic acid, potassium, and myoglobin. In particular, the return of myoglobin is likely to result in decreased blood pH, hyperkalemia, and renal dysfunction.

Treatment of crush syndrome, which aims to prevent complications due to toxin release, should always be performed with medical direction. A number of steps must be taken before releasing the compressing force. As with all patients, assess the ABCs in case of suspected crush syndrome. Ensure that the patient is being given high-flow supplemental oxygen, and then administer a bolus of crystalloid solution to increase the intravascular volume and to protect the kidneys from the forthcoming myoglobin load. Establish cardiac monitoring to evaluate for electrocardiographic (ECG) changes related to hyperkalemia (such as peaked T waves, widening QRS complex, prolonged P-R interval, dysrhythmia). To protect against the surge of potassium, a nebulizer treatment with albuterol may be given during extrication (beta-2 agonists promote the movement of potassium into cells). Once the patient is freed, if the ECG shows changes consistent with hyperkalemia, administer calcium to stabilize the myocardium; also give sodium bicarbonate to promote the intracellular shift of potassium. Insulin may also be given intravenously with dextrose, in the hospital, to facilitate the intracellular movement of potassium. Compressive devices such as a PASG should not be applied.

**Thromboembolic Disease**

**Thromboembolic disease**, including deep vein thrombosis (DVT) and pulmonary embolism, is a significant cause of death following musculoskeletal injuries, especially injuries to the pelvis and lower extremities that lead to prolonged immobilization.

Signs and symptoms of DVT include disproportionate swelling of an extremity, discomfort in an extremity that worsens with use, and warmth and erythema of the extremity.
When a DVT dislodges, it may cause a pulmonary embolism—a blood clot that occludes a portion or all of the pulmonary arteries. Signs and symptoms of a pulmonary embolism include a sudden onset of dyspnea, pleuritic chest pain, dyspnea, tachypnea, tachycardia, right-sided heart failure, shock, and, in some cases, cardiac arrest.

In addition to the risk of DVT, patients with long bone or pelvic fractures are at risk for developing a fat embolism. In this condition, fat droplets become lodged in the vasculature of the lungs. Affected patients have inflammation of the vasculature of the lungs and other blood vessels where fat is deposited. Generally, symptoms begin within 12 to 72 hours of injury; they include tachycardia, dyspnea, tachypnea, pulmonary congestion, fever, petechiae, change in mental status, and organ dysfunction.

Treatment for thromboembolic disease in the field is limited to maintaining an airway, adequate oxygenation, and intravascular volume and rapid transportation to an ED.

### Specific Fractures

#### Shoulder Girdle

**Clavicle**

Clavicle fractures are very common and often occur in children. In most cases, the clavicle fractures in the middle third of the bone, typically from a fall onto an outstretched hand or from direct lateral trauma to the shoulder (as in contact sports, snowboarding, and cycling). Patients have pain in the region of the shoulder, swelling, unwillingness to raise the arm, and tilting of the head toward the injured side.

**Shoulder**

Fractures of the shoulder include those that involve the glenoid fossa of the scapula, the humeral head, and the humeral neck. Most shoulder fractures are caused by a fall onto an outstretched hand and usually occur in elderly patients (younger patients tend to dislocate the shoulder because they have stronger bones). Patients with a shoulder fracture rarely have evidence of a significant deformity, but instead have considerable swelling, ecchymosis, and pain with movement of the arm. In some cases, an associated injury to the brachial plexus may be identified during the neurologic examination.

**Scapula**

Injuries to the scapula usually result from violent, direct trauma. Therefore, when a scapular injury is suspected, it is essential to look for associated injuries—particularly intrathoracic injuries, such as pneumothorax, hemothorax, and fractured ribs. Signs and symptoms of a scapular fracture include pain that increases with arm abduction and swelling in the region of the scapula. Potential complications include axillary artery or nerve injury, brachial plexus injury, pulmonary contusion, and clavicle fractures.

#### Midshaft Humerus

Fractures of the shaft of the humerus usually occur in younger patients secondary to high-energy injuries, such as motor vehicle crashes. Unlike fractures that occur more proximally, these
injuries typically have substantial deformity. Examination of the extremity usually reveals a significant amount of swelling, ecchymosis, gross instability of the region, and crepitus. If the force that caused the injury is severe enough, the nerves and blood vessels in the upper arm may also be damaged. Of particular concern is the radial nerve, which may be injured by the force itself or could become entrapped within the fracture site. The classic sign of a radial nerve injury is wrist drop.

**Treatment of Midshaft Humerus Fractures**
If the fracture is angulated, longitudinal traction may be applied to correct the deformity; but efforts should be halted if the patient's pain is too severe or if neurovascular status worsens. Once the extremity is in the desired position, apply a rigid splint that extends from the axilla to the elbow. Next, apply a sling and swath to immobilize the arm to the chest wall, and place cold packs over the fracture site to decrease the patient's pain and swelling.

**Elbow**

**Distal Humerus**

*Supracondylar fractures* of the humerus occur most often in children. The typical mechanism is a fall onto an outstretched hand with the elbow in extension, thereby breaking the distal humerus; as a result, the distal fragment of the humerus is pushed posteriorly and the humeral shaft is pulled anteriorly, where it compresses the brachial artery and the radial and median nerves. If the brachial artery is compromised, the patient could develop compartment syndrome in the forearm. When this complication occurs, the patient is at risk for a *Volkmann ischemic contracture*, a condition in which muscles of the forearm degenerate from prolonged ischemia. The patient's muscles that allow for movement of the fingers become contracted and nonfunctional, and the patient loses the ability to use the hand. Patients with a distal humerus fracture will complain of pain in the area of the elbow and typically have a significant degree of swelling and ecchymosis.

**Proximal Radius and Ulna**

Radial head fractures may result from a fall onto an outstretched hand or from a direct blow to the bone. This injury causes the patient to have significant pain when he or she attempts supination or pronation. In either case, the patient is likely to have pain and ecchymosis in the region of the injury. Similar to distal humerus fractures, these injuries may lead to an injury of the nerves or blood vessels in proximity to the fracture site. Therefore, a careful neurovascular examination should be performed.

**Treatment of Elbow Fractures**
Treatment of injuries in the region of the elbow is the same regardless of the exact location of the injury. The injured extremity must be repeatedly assessed for evidence of compartment syndrome. Before splinting the extremity, it is mandatory to document a neurovascular exam. The injured extremity should be splinted in the position that it is found if the patient has a strong distal pulse, and ice packs should be used only if there is no evidence of compartment syndrome. If the patient has an absent distal pulse or neurologic deficits, consult with the appropriate medical facility to determine whether you should attempt fracture reduction. In any event, the patient must be transported urgently to the closest appropriate medical facility for definitive treatment.

**Forearm**

Fractures of the forearm may involve the radius, the ulna, or, more commonly, both. Injury may result from a direct blow to the bone, the classic example of which is the nightstick fracture of the ulna. In other cases, injury occurs because of a fall onto an outstretched hand, as in the case of a Colles fracture. This fracture typically occurs in older patients with osteoporosis who have fallen but may be found in younger patients as well. A patient with a Colles fracture usually has a dorsally angulated deformity of the distal forearm (the “silver fork deformity”) and pain and swelling near the injured site.

**Treatment of Forearm Fractures**
A variety of splints may be used to secure a forearm fracture. Regardless of the type, the splint should provide immobilization of the entire forearm and, in cases of more proximal fractures, the elbow. Apply cold packs to the injury site to decrease pain and swelling. Frequent neurovascular exams are warranted to monitor for evidence of compartment syndrome and acute carpal tunnel syndrome.

**Wrist and Hand**

Injuries to the wrist and hand may lead to significant long-term disability, especially in people who rely on the use of their hands to earn a living. Sometimes these injuries occur while working at the job or at home; in other cases they result from a fall or during a sporting event. Careful splinting of the injured site is essential to help reduce the risk of long-term disability.

**Scaphoid**
The scaphoid, also called the carpal navicular, is located just distal to the radius. It may be injured from a fall onto an outstretched hand, for which the classic finding is pain and tenderness in the anatomic snuffbox. To identify the anatomic snuffbox on yourself, extend your thumb. Two tendons will be visible at the base of the thumb on the radial aspect of the wrist. The region between these two tendons is the *snuffbox*.

The major complication of a scaphoid fracture is *avascular necrosis* of the bone, or poor fracture healing because of the limited blood supply to this bone.

**Boxer’s Fracture**

A *boxer’s fracture* is a fracture of the neck of the fifth metacarpal (small finger). It commonly occurs after punching a hard object, such as a wall or a door. The patient typically has pain over the ulnar aspect of the hand and may have noticeable swelling.
Metacarpal Shaft
Fractures of the metacarpals may result from a crush injury or from direct trauma. Assessment of the injured hand may reveal abnormal rotation or alignment of the fingers, swelling of the palm, and pain and tenderness in the region of injury. You should assess the neurovascular function of the hand and fingers following a crush injury, because development of compartment syndrome is possible within the hand.

Mallet Finger (Baseball Fracture)
A mallet finger occurs when a finger is jammed into an object, such as a baseball or basketball, resulting in an avulsion fracture of the extensor tendon. The patient will not be able to extend the distal phalynx of the finger and will maintain it in a flexed position.

Treatment of Wrist and Hand Fractures
Splint the injured hand in the position of function by placing the wrist in about 30° of dorsiflexion with fingers slightly flexed (a roll of gauze approximately 2˝ to 3˝ in diameter accomplishes this nicely). Next, secure the extremity to an armboard or other rigid splint that extends proximally to the elbow and is slightly elevated to help reduce swelling. For injuries that are isolated to the digits, use a foam-padded flexible aluminum splint to splint the injured digit, if available. In the case of penetrating injuries, regardless of whether a fracture is present, apply bulky dressings to the site of injury and splint the injured hand in the position of function.

Pelvis
Pelvic fractures are relatively uncommon injuries, accounting for fewer than 3% of all fractures. Despite their low incidence, these injuries are responsible for a significant number of deaths in blunt trauma patients. The risk of death following a pelvic fracture ranges from 8% to 50%, depending on the severity of the injury; when the fracture is open, the mortality rate rises to 25% to 50%. Death after a pelvic fracture commonly results from massive hemorrhage caused by damage to the arteries and veins of the pelvis.

Disruptions of the pelvic ring occur secondary to high-energy trauma such as crush injuries, motorcycle crashes, and falls from a significant height. A number of structures within the pelvis are at risk for injury when it is fractured—the bladder, urethra, rectum, vagina, and sacral nerve plexus. The blood vessels that are most prone to damage are the veins within the pelvis, but there may be damage to the internal or external iliac and arteries in the lumbar region. The nerves at greatest risk of injury are those in the lumbar and sacral regions and the sciatic and femoral nerves.

Patients with pelvic ring disruptions who have a stable injury, such as a minimal lateral compression injury, may complain of pain in the pelvis and difficulty bearing weight. Patients with a more severe injury may show evidence of profound shock, gross pelvic instability, and diffuse pelvic and lower abdominal pain. There may also be bruising or lacerations in the perineum, scrotum, groin, suprapubic region, and flank and hematuria (blood in the urine) or blood coming from the meatus of the penis, vagina, or rectum.

Lateral Compression Pelvic Ring Disruptions
Lateral compression injuries result from an impact on the side of the body (such as being struck by a car from the side or falling from a significant height and landing on one side of the body). The side of the pelvis that sustains the impact becomes internally rotated around the sacrum, and the actual volume within the pelvis decreases. Although this injury is not commonly associated with massive hemorrhage into the pelvis, it is often associated with injuries in other regions of the body.
Anterior–Posterior Compression Pelvic Ring Disruptions

These injuries may occur following a head-on motor vehicle crash, motorcycle crash, or fall or in a pedestrian who is struck head-on by a vehicle. The force of the impact compresses the pelvis in the anterior-to-posterior direction, causing the pubic symphysis and posterior supporting ligaments to be disrupted and tear apart. The pelvis then spreads apart and opens like a book—hence the name open book pelvic fracture. Such an injury has the potential for massive blood loss because the volume of the pelvis is greatly increased.

Vertical Shear

Vertical shear injuries occur when a major force is applied to the pelvis from above or below, such as when a person falls from a significant height and lands on the feet. On landing, the force is transmitted through the legs to the pelvis, leading to the complete displacement of one or both sides of the pelvis toward the head. Thus, this kind of injury has anterior and posterior components. The anterior component involves a fracture of the rami or disruption of the symphysis pubis. The posterior component involves a fracture of the ilium or sacrum or a disruption of the sacroiliac joint. The patient is likely to have significant shortening of the limb on the affected side and is at risk for massive hemorrhage into the pelvis.

Straddle Fracture

A straddle fracture occurs after a fall when a person lands in the region of the perineum and sustains bilateral fractures of the inferior and superior rami. This injury does not interfere with weightbearing, but it does carry a risk owing to its associated complications, particularly those of the lower genitourinary system.

Open Pelvic Fractures

Open pelvic fractures are life-threatening injuries. Such an injury is defined by the presence of a laceration of the skin in the pelvic region, vagina, or rectum. This uncommon fracture is caused by a high-velocity injury with subsequent massive hemorrhage and has a mortality rate of 25% to 50%. Even small amounts of blood found during a vaginal or rectal exam should raise your suspicion for an open fracture.

In the Field

Controlling bleeding from a severely injured pelvis is a major challenge, even to the most experienced trauma surgeon. Nevertheless, reducing the volume of an unstable pelvis can decrease bleeding and be a lifesaving intervention. This may be accomplished by using a PASG, applying a commercially made pelvic binder, or applying a sheet. When a sheet or pelvic binder is used, place it around the iliac wings and secure it while a provider on each side of the patient applies medially directed pressure. Emergency workers often make the mistake of placing this device too low on the pelvis, which decreases its effectiveness in reducing the pelvic volume.

Figure 25.32 A lateral compression injury to the pelvis.

In the Field

Controlling bleeding from a severely injured pelvis is a major challenge, even to the most experienced trauma surgeon. Nevertheless, reducing the volume of an unstable pelvis can decrease bleeding and be a lifesaving intervention. This may be accomplished by using a PASG, applying a commercially made pelvic binder, or applying a sheet. When a sheet or pelvic binder is used, place it around the iliac wings and secure it while a provider on each side of the patient applies medially directed pressure. Emergency workers often make the mistake of placing this device too low on the pelvis, which decreases its effectiveness in reducing the pelvic volume.

Treatment of Pelvic Fractures

Assessment of the patient with a possible pelvic fracture should begin as in any other trauma patient—with an initial assessment of the mental status and ABCs, taking spinal precautions. During the rapid trauma exam of the patient, you should search for injuries typically associated with pelvic fractures. Assess the pelvis for bleeding, lacerations, bruising, and instability. To assess for instability, apply pressure over the iliac wings in a medial direction and in a posterior direction. Once instability of the pelvis is identified, the pelvis should not be reassessed for instability to avoid causing increased bleeding.

Treatment should include careful monitoring of the ABCs, spinal immobilization, and IV access with at least one (if not two) large-bore catheters. Management of the pelvic injury is aimed at reducing the amount of bleeding and decreasing the degree of instability. It is often appropriate to seek medical direction for the management of these patients, especially for determining how to best stabilize the pelvis. Methods used to accomplish this may include application of a PASG or pelvic binder or simply tying a sheet around the pelvis. Applying pressure to the iliac wings and forcing them to shift toward the midline reduces the potential space within the pelvis, which may allow for tamponade of the bleeding vessels. Once packaged, the patient should be rapidly transported to a trauma center, and IV fluid should be administered to maintain adequate tissue perfusion but avoiding hypertension.

Hip

A hip fracture involves a fracture of the femoral head, femoral neck, intertrochanteric region, or proximal femoral shaft. Fractures of the femoral head are uncommon injuries that are usually associated with a hip dislocation. Femoral neck and intertrochanteric fractures typically occur in older patients with osteoporosis who have fallen and sustained direct trauma to the hip. They may occur in younger patients with healthy
bone, typically as the result of a high-energy mechanism. Proximal femoral shaft fractures can occur in patients of any age and result from a high-energy mechanism.

Patients with a hip fracture will complain of pain in the affected hip, especially with attempts at movement, and report an inability to bear weight. They may also report hearing or feeling something snap. If the fracture is displaced, the patient almost always has an externally rotated and shortened leg. If there is no displacement, the leg may appear normal. Examination of the injury site usually finds tenderness to palpation, and there may be noticeable swelling, deformity, or ecchymosis.

**Treatment of Hip Fractures**

The treatment of hip fractures depends on the mechanism of injury. Hip fractures in older patients who sustained a low-energy injury, such as a fall from a standing position, do not require traction splints. Treat these injuries by supporting the injured extremity in the position in which it is found. This may be accomplished by placing pillows or blankets under the affected extremity and securing them in place.

In younger patients and in those with high-energy injuries, place the injured extremity in a traction splint to reduce the amount of bleeding. For patients who have multiple lower extremity injuries, use a PASG. In either case, treat the patient as you would any other trauma patient: Fully immobilize the patient, establish vascular access, monitor for shock, and transport to a trauma center.

**Special Considerations**

A hip fracture in an elderly patient can be a debilitating and life-altering injury. In many cases, these injuries occur in the home after slipping on a throw rug, tripping over an object that extends into the walkway, or stumbling because of poor lighting. To help prevent this injury and other fall-related problems, you should point out any safety hazards in the home to the patient or a family member. It takes only a minute, and most patients and families appreciate the advice.

Definitive treatment of a hip fracture almost always requires surgery. If possible, the bone is repaired with plates, rods, or screws. Sometimes, however, the hip must be replaced.

**Femoral Shaft**

Femoral shaft fractures occur following high-energy impacts. Thus, the presence of a fracture of the femoral shaft should alert you to the risk of other injuries. Patients with femoral shaft fractures will complain of severe pain. The fracture may be severely angulated or lead to significant limb shortening, or it may be open. Examination may identify significant thigh edema, bruising, crepitus, and muscle spasm.

There is often significant blood loss (perhaps 500–1,500 mL) at the fracture site. In addition, damage to the neurovascular structures of the thigh is possible. Femoral shaft fractures also place the patient at risk for fat emboli.

**Treatment of Femoral Shaft Fractures**

Management of femoral shaft fractures includes monitoring for evidence of shock, full spinal immobilization, and establishing vascular access. Place the injured extremity in a traction splint, and use a PASG, if necessary, for further stability and hemorrhage control. Because these injuries may be extremely painful, consider the administration of pain medication.

**Knee**

Fractures of the knee may involve the distal femur, proximal tibia, or patella. An injury to this region may result from a direct blow to the knee, an axial load of the leg, or powerful contractions of the quadriceps. Assessment of the patient generally reveals significant pain in the knee, decreased range of motion, pain with movement and weightbearing, ecchymosis, swelling, and, in the case of displaced fractures, deformity.

**Treatment of Knee Fractures**

Management of knee fractures depends on the position of the leg and the status of distal pulses. If the patient has a good distal pulse, splint the extremity in the position that it is found. If there is no distal pulse, seek medical consultation to determine whether you should attempt manipulation before transportation. In all cases, elevate the leg to the heart level and apply cold packs. Frequent neurovascular checks are mandatory, given the high incidence of compartment syndrome and neurovascular injury in cases of knee fracture.

**Tibia and Fibula**

Fractures of the tibia and/or fibula may result from direct trauma to the lower leg or from application of rotational or
compressive forces. These injuries often present with significant deformity and soft-tissue injury. Complications may include compartment syndrome, neurovascular injury, infection, poor healing, and chronic pain.

**Treatment of Tibia and Fibula Fractures**

Apply a rigid, long leg splint, and administer pain medication as necessary. If there is gross angulation, attempt to align the leg after giving pain medication, documenting the premanipulation and postmanipulation neurovascular status. Monitor the patient for evidence of compartment syndrome, elevate the extremity to heart level, and apply cold packs.

**Ankle**

Fractures of the ankle usually result from sudden and forceful movements of the foot that damage the malleoli and sometimes produce dislocation (called a fracture-dislocation). In other cases, an axial load is transmitted through the foot and causes the talus (the bone of the foot that articulates with the tibia) to impact the distal tibia, leading to a fracture. Signs and symptoms of an ankle fracture include pain, deformity, and swelling. Ankle fractures may lead to damage of the nerves and blood vessels that supply the foot, the development of compartment syndrome, and chronic ankle pain and arthritis.

**Treatment of Ankle Fractures**

All ankle fractures should be immobilized using a commercially available splint or a pillow splint. The toes should be exposed to allow for frequent checks of distal neurovascular function. Elevate the extremity to the heart level, and apply cold packs to reduce swelling.

If an ankle fracture-dislocation is associated with a pulseless foot, medical direction may recommend that you attempt reduction. To reduce a fracture-dislocation of the ankle, first relax the calf muscles to allow the foot to move more freely by flexing the patient’s leg at the knee. With the leg flexed, grasp the heel and the foot just proximal to the toes and apply gentle traction. Next, rotate the foot back into its normal position without forcing it. If this procedure is successful, reassess the distal neurovascular status and splint the extremity in the reduced position, using care not to allow the ankle to dislocate again. If the fracture-dislocation cannot be reduced, notify medical control and expedite transport.

**You are the Provider Part 4**

You have set the IV of normal saline at a “keep vein open” rate. After consulting with medical direction, you receive an order to administer 0.5 mg of midazolam (Versed) and 50 μg of fentanyl to take the edge off the pain and permission to carefully attempt manipulation of the knee to restore its circulation. After movement of the tibia, PMS functions are restored distal to the knee. You carefully splint the leg and notice improvement of local skin signs. You reassess the splint on the left arm and note no changes. The patient tells you his pain is much less, and he thanks you for taking care of him. You place blankets on the patient and continue to monitor him throughout transport.

<table>
<thead>
<tr>
<th>Reassessment</th>
<th>Recording Time: 15 Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin</td>
<td>Pink, warm, and dry</td>
</tr>
<tr>
<td>Pulse</td>
<td>90 beats/min, full and regular</td>
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<tr>
<td>Blood pressure</td>
<td>134/76 mm Hg</td>
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<tr>
<td>Respiration</td>
<td>28 breaths/min</td>
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<td>Sao₂</td>
<td>100% while breathing 10 L/min via nonrebreathing mask</td>
</tr>
<tr>
<td>ECG</td>
<td>Sinus rhythm with no ectopy</td>
</tr>
</tbody>
</table>

8. Why should a joint that has just been manipulated be splinted immediately?
9. What facts should be relayed to the emergency department staff in your radio report?
transportation after splinting the ankle in the position in which it was found.

**Calcaneus**
The calcaneus may be fractured when a patient jumps from a height and lands on the feet or when a powerful force is applied directly to the heel. These injuries present with foot pain, swelling, and ecchymosis and should alert providers to the possibility of injuries in the knee, pelvis, and spine.

**Treatment of Calcaneus Fractures**
When a calcaneus fracture is suspected, splint the injured extremity with a pillow and apply ice packs to help decrease swelling. Any patient with a suspected calcaneus fracture requires spinal immobilization given the high risk of an associated spine injury.

**Joint Injuries and Dislocations**

**Shoulder Girdle Injuries and Dislocations**

**Acromioclavicular Joint Separation**
Separation of the acromioclavicular (AC) joint usually occurs from a direct blow to the superior aspect or point of the shoulder, as may happen during contact sports and falls. Patients generally complain of pain and tenderness in the region of the AC joint, and the prominence of the distal clavicle may lead to a noticeable protrusion.

**Posterior Sternoclavicular Joint Dislocation**
Posterior dislocation of the clavicle at its junction with the sternum most often occurs as a result of a direct blow to the clavicle but is sometimes seen after strong pressure is applied to the posterior shoulder (as when a football player ends up at the bottom of a pile-up). This injury is rarely difficult to identify because there is pain and swelling at the sternoclavicular joint. What makes this a potentially dangerous and even potentially fatal injury is not the dislocation itself, but the possible damage to underlying structures—specifically, the trachea, esophagus, jugular vein, subclavian vein and artery, carotid artery, and other vascular structures. Any symptoms that suggest such underlying injury—such as dyspnea, pain on swallowing, a sensation of choking, loss of pulses, or a sensory deficit in the upper extremity on the same side—are danger signals and should prompt rapid transport of the patient to the hospital.

**Shoulder Dislocation**
Roughly 90% of shoulder dislocations are anterior dislocations. Usually, anterior shoulder dislocations are caused by a fall onto an outstretched arm that is abducted and externally rotated. Patients complain of severe pain and have significantly decreased range of motion at the shoulder. The arm is usually abducted and externally rotated, and any efforts at moving it result in extreme pain. A prominent bulge from the acromion is often noted on the anterior surface of the shoulder, the humeral head may be palpable, and the patient may experience frequent and painful muscle spasms.

Posterior shoulder dislocations are much less common and are often caused by massive muscle contractions such as those...
seen with electrical shocks and seizures. These injuries present with the same complaints of pain and limited motion, but the arm is maintained in internal rotation and adduction.

In some patients, a shoulder dislocation will produce a tear of the rotator cuff or a fracture of the glenoid. Some patients may have a concomitant injury to the brachial plexus, axillary artery, or axillary vein. The axillary nerve is also prone to injury during a shoulder dislocation; assess sensation over the deltoid muscle to determine whether there is a sensory deficit in the distribution of this nerve. Patients with a shoulder dislocation are also at risk for future dislocations, especially during the first 2 years following the injury and if the patient is young.

**Treatment of Joint Injuries Involving the Shoulder Girdle**

In cases of an AC joint separation, a sling and swath will often provide significant pain relief. In case of a posterior sternoclavicular joint dislocation, position the patient supine with the arm on the affected side abducted and place a rolled towel under the shoulder blade, a position that may take some of the pressure off the structures beneath the sternoclavicular joint. Pay close attention to the patient's airway, and keep airway equipment readily available.

For a dislocated shoulder, splint the injured extremity in the position in which it was found by using blankets, pillows, and, when possible, a sling and swath. When applying the swath, it may be necessary to connect two cravats together so as to encircle the patient's body, extremity, and pillows or blankets. Given the likelihood of muscle spasm and pain, use of pain medication and antispasmodic agents may be necessary. Perform neurovascular assessments frequently to monitor for changes in function.

**Elbow Dislocation**

Elbow dislocations are medical emergencies because of the high risk of neurovascular injury. The vast majority of elbow dislocations are posterior injuries that result from a fall onto an outstretched hand or from hyperextension of the elbow joint. Patients usually complain of significant pain in the region of the elbow and may have a large degree of swelling and ecchymosis. A palpable deformity may be present at the elbow from the prominence of the olecranon process, and there is typically locking or resistance to movement of the joint. Major complications of an elbow dislocation include an associated fracture in the region of the joint, brachial artery injury, median nerve injury, and injury to the ulnar nerve.

**Radial Head Subluxation**

Subluxation of the radial head is also referred to as nursemaid's elbow. It commonly occurs in children younger than 6 years and is caused by a sudden pull on the child's arm. Clinically, the injured arm is held in flexion and the child will often refuse to move the hand or elbow on the injured side. In general, there is only mild swelling in the region of the elbow.

**Treatment of Elbow Dislocation**

When you suspect a dislocation or subluxation in the elbow, splint the injured extremity in the position in which it was found. A sling and swath may be applied to provide additional stabilization to the injured elbow.

**Finger Dislocation**

Finger dislocations are caused by a sudden “jamming” force or from extension of the fingers beyond the normal range of motion. There is generally pain and deformity at the affected joint, and there may be compromise of the neurovascular structures of the digit, leading to paresthesias.

**Treatment of Finger Dislocation**

Manage the dislocated finger by splinting the entire hand in the position of function and using soft dressings as needed to support the digit. Do not attempt to relocate the injured digit in the field unless you are directed to do so by medical control. To reduce a dislocated digit, if the digit is dislocated to the dorsal side, extend the digit; if it is dislocated to the volar side, flex the digit. Next, use gentle longitudinal traction to bring the
digit back into its normal position. It may be helpful to apply pressure at the dislocated joint to push the distal part into position. Following reduction, the neurovascular status of the digit should be reassessed and the digit should be fully immobilized to prevent it from dislocating again.

**Hip Dislocation**

More than 90% of all hip dislocations involve posterior dislocation. The majority of these occur due to deceleration injuries, in which a flexed knee strikes an immobile object with a great degree of force. When a patient has a posterior hip dislocation, the leg of the affected side is typically found in flexion, adduction, and internal rotation, and it is noticeably shorter. Patients complain of severe pain and inability to move the leg, and significant soft-tissue swelling may be evident. Complications arising from such injuries include sciatic nerve injury, avascular necrosis of the hip, and associated fractures of the acetabulum.

Anterior hip dislocations usually follow a forceful spreading injury that occurs while the hip is flexed. The affected leg is usually flexed, abducted, and externally rotated, and the patient complains of severe pain. Major complications of this type of injury include injury to the femoral artery or nerve and avascular necrosis of the hip.

**Treatment of Hip Dislocation**

Because the majority of hip dislocations are associated with a high-energy mechanism, a full trauma assessment should be conducted and the patient fully immobilized. Splint the injured extremity in the position in which it is found by using blankets and pillows. Perform and document frequent neurovascular checks on your PCR. Once at the hospital, the patient generally requires sedation and muscle relaxants to allow the hip to be reduced.

**Knee Dislocation**

Dislocations of the knee are true emergencies that may threaten the limb. When the knee is dislocated, the ligaments that provide support to it may be damaged or torn. The knee may be dislocated by high-energy trauma (as in motor vehicle crashes), or it may dislocate secondary to powerful twisting forces (as when athletes attempt to avoid another player). In most cases, the knee will spontaneously reduce following the injury and there may be no obvious evidence of injury.

The direction of dislocation refers to the position of the tibia with respect to the femur. Anterior knee dislocations, which result from extreme hyperextension of the knee, are the most common, occurring in almost half of all cases. Commonly, the anterior and posterior cruciate ligaments are damaged, but there is also a high risk of injury to the popliteal artery.

In posterior dislocations, a direct blow to the knee forces the tibia to shift posteriorly. There is also the possibility of damage to the cruciate ligaments and injury to the popliteal artery.

Medial dislocations result from a direct blow to the lateral part of the leg. Because the deforming force causes the medial aspect of the knee to stretch apart, there is a high likelihood of injury to the medial collateral and cruciate ligaments. When the force is applied from the medial direction, a lateral dislocation occurs and the lateral part of the knee is stretched apart, injuring the lateral collateral ligament. Lateral and medial dislocations happen less commonly and have a lesser risk of injuring the popliteal artery.

Patients with a knee dislocation will typically complain of pain in the knee and report that the knee “gave out.” If the knee did not spontaneously reduce, there may be evidence of significant deformity and decreased range of motion. Complications may include limb-threatening popliteal artery disruption; injuries to the popliteal, peroneal, and tibial nerves; and joint instability. Do not confuse this injury with a relatively minor patella dislocation.

**Treatment of Knee Dislocation**

In all cases of knee dislocation, distal neurovascular function must be assessed frequently and will often guide the management. If a pulse is palpable in the foot, splint the knee in the position in which it is found. If there is no palpable pulse, you may need to reduce the knee to restore circulation. A number of factors, including time to the hospital and duration of dislocation, will affect this decision, so you should always seek medical direction before reducing a dislocated knee.

To reduce a dislocated knee, apply longitudinal traction to the tibia in the direction of the foot. While the first rescuer is applying traction, a second provider should apply pressure to the distal femur and proximal tibia. If the knee is dislocated anteriorly, apply pressure to the femur in the anterior direction and to the tibia in the opposite direction. In the case of a posterior dislocation, apply pressure in the opposite manner, with the tibia pressed anteriorly and the femur pressed posteriorly. Once the reduction has been accomplished, check the patient’s neurovascular status and splint the leg securely. If the attempt at reduction fails, splint the knee in the position in which it is found and undertake rapid transportation to an appropriate facility.
You are the Provider Summary

1. What are your initial assessment and treatment priorities?
As with any trauma patient, after assuring that the scene is safe, the initial assessment priorities for this patient are the mental status, the ABCs, and prioritizing the patient. Then proceed with a rapid trauma exam to identify the patient’s injuries. Because this patient fell from a significant height, it is also important to protect his spine. During the initial assessment, you note that he has a site of bleeding from his arm; this bleeding should be controlled. Once this is accomplished, IV access should be obtained and the assessment should continue in a systematic and orderly manner.

2. What other information should be obtained about the patient and the incident?
Obtain information about the events that led the patient to fall, such as how he felt before falling and why he thought he fell. It is also important to learn details about the fall, such as how his extremities were positioned when he landed or whether he struck any other objects while falling. Obtain any other information related to the patient’s status after the fall, such as loss of consciousness, mental status, and movement of extremities, from the patient or anyone who witnessed the fall. Also obtain information about any allergies the patient may know he has, any medication he takes, and the last time he had anything to eat or drink.

3. What are the potential complications of an open fracture?
One of the most significant complications following an open fracture is infection of the bone or soft tissues. To reduce the risk of infection, do not probe open fractures, brush away any debris on the surface of the skin, and cover the wound with a sterile dressing. Other complications of open fractures include poor healing of the fracture, soft-tissue loss, neurovascular injury, and long-term disability.

4. Why are open fractures prone to bleeding more than closed fractures?
In general, open fractures are higher-energy injuries than closed fractures, so they are likely to have more soft-tissue damage and, hence, more bleeding. Also, because the fracture is open, the blood that would normally accumulate within the closed fracture site is allowed to escape, so there is no tamponade of the bleeding vessels.

5. Would your treatment priorities change if the patient complained of abdominal pain in the presence of hypotension?
If the patient were found to be in unstable condition with evidence of an intra-abdominal injury, immediate and rapid transportation to a trauma center would be warranted. For a trauma patient in unstable condition who has a fracture, place the patient on a long backboard and fully immobilize the patient. While immobilizing the spine, the injured extremities may be immobilized as well by securing them to the board. The result is a compromise: The injured extremity is secured in place and protected from further movement without dedicating precious time to applying a formal splint.

6. Why would this dislocation be considered a true emergency?
When a patient with a dislocated knee has a pulseless foot, medical direction should be obtained and consideration should be given to manipulating the dislocation. Some paramedics may have a standing order to deal with this type of situation. Factors that will influence this decision include the duration of the dislocation, time to the hospital, the patient’s vital signs, and the patient’s overall condition.

7. What is an important consideration before manipulating a dislocation?
If the patient has no contraindications (such as hypotension), sedation should be considered before attempting manipulation of the extremity. This can be a very painful procedure, and without determining the appropriateness of analgesics such as morphine, you will not be addressing an important patient care issue—comfort.

8. Why should a joint that has just been manipulated be splinted immediately?
A dislocation is often associated with damage to the ligaments and capsule that support the affected joint, making it susceptible to recurrent dislocations. Once a dislocated joint has been manipulated, it should be splinted to prevent movements that may allow for it to once again dislocate.

9. What facts should be relayed to the emergency department staff in your radio report?
The presence of a dislocation and/or fracture with compromised neurovascular status should be relayed immediately to the receiving facility. Any attempts to correct the impairment should be explained, along with any changes or responses to treatment. Paint a clear picture of the mechanism of injury and the patient’s condition. Remember, the only information the emergency department staff have to plan for your arrival is based on your brief radio report.
Injuries and complaints related to the musculoskeletal system are one of the most common reasons that patients seek medical attention.

Musculoskeletal injuries are sometimes very dramatic, but attention should not be focused on them until life-threatening conditions have been excluded.

You have a vital role in reducing the complications associated with musculoskeletal injuries by promptly and effectively splinting injured extremities.

Assume the existence of a fracture whenever a patient who complains of a musculoskeletal injury has deformity, bruising, decreased range of motion, or swelling.

Always perform and record an accurate neurovascular examination before and after splinting an injured extremity.

When a dislocation is associated with absent distal pulses, obtain medical direction to determine whether the injury should be reduced.

Look for injuries to the chest and abdomen, and fully immobilize the spine when patients have evidence of a high-energy injury, such as a femoral shaft or scapular fracture.

Because fractures may be associated with significant blood loss, resuscitation with IV fluid may be necessary.

Pelvic fractures are potentially lethal injuries owing to the massive potential for blood loss.

Never forget the ABCs! Do not become distracted; the fracture can wait, if airway, breathing, or circulation problems are noted.

**Vital Vocabulary**

6 Ps of musculoskeletal assessment  Pain, Paralysis, Parasthesias, Pulselessness, Pallor, and Pressure.

abduction Movement away from the midline of the body.

acetalabulum The cup-shaped cavity in which the rounded head of the femur rotates.

acromion Lateral extension of the scapula that forms the highest point of the shoulder.

adduction Movement toward the midline of the body.

amputation Severing of a part of the body.

angulation The presence of an abnormal angle or bend in an extremity.

anterior tibial artery The artery that travels through the anterior muscles of the leg and continues to the foot as the dorsalis pedis.

appendicular skeleton The part of the skeleton comprising the upper and lower extremities.

arthritis Inflammation of the joints.

articulations The locations where two or more bones meet; joints.

atrophy Wasting away of a tissue.

avascular necrosis Tissue death resulting from the loss of blood supply.

avulsion fracture A fracture that occurs when a piece of bone is torn free at the site of attachment of a tendon or ligament.

axial skeleton The part of the skeleton comprising the skull, spinal column, and rib cage.

axilla The armpit.

axillary artery The artery that runs through the axilla, connecting the subclavian artery to the brachial artery.

bowing fracture An incomplete fracture typically occurring in children in which the bone becomes bent as the result of a compressive force.

boxer’s fracture A fracture of the head of the fifth metacarpal that usually results from striking an object with a clenched fist.

brachial artery The artery that runs through the arm and branches into the radial and ulnar arteries.

bucket fracture A common incomplete fracture in children in which the cortex of the bone fractures from an excessive compression force.

buddy splinting Securing an injured digit to an adjacent uninjured one to allow the intact digit to act as a splint.

bursa A fluid-filled sac located adjacent to joints that reduces the amount of friction between moving structures.

bursitis Inflammation of a bursa.

calcaneal The heel bone; the largest of the tarsal bones.

 cancellous bone Trabecular or spongy bone.

carpals The eight small bones of the wrist.

cartilage Tough, elastic substance that covers opposable surfaces of moveable joints and forms part of the skeleton.

cartilaginous joints Joints that are spanned completely by cartilage and allow for minimal motion.

clavicle The collar bone.

closed fracture A fracture in which the skin is not broken.

comminuted fracture A fracture in which the bone is broken into three or more pieces.

compartment syndrome An increase in tissue pressure in a closed fascial space or compartment that compromises the circulation to the nerves and muscles within the involved compartment.

complete fracture A fracture in which the bone is broken into two or more completely separate pieces.

compound fracture An open fracture; a fracture beneath an open wound.

crepitus A grating sensation felt when moving the ends of a broken bone.

crush syndrome A condition that arises after a body part that has been compressed for a significant period is released, leading to the entry of potassium and other metabolic toxins into the systemic circulation.

department syndrome An increase in tissue pressure in a closed fascial space or compartment that compromises the circulation to the nerves and muscles within the involved compartment.

depression fracture A fracture in which the broken region of the bone is pushed deeper into the body than the remaining intact bone.

devascularization The loss of blood to a part of the body.

diaphysis The shaft of a long bone.

diastasis An increase in the distance between the two sides of a joint.

digital arteries The arteries that supply blood to the fingers and toes.

dislocation The displacement of a bone from its normal position within a joint.

distraction injury An injury that results from a force that tries to increase the length of a body part or separate one body part from another.

dorsal Referring to the back or posterior side of the body or an organ.

dorsiflex To bend the foot or hand backward.
endosteum The inner lining of a hollow bone.
fascia A strong, fibrous membrane that covers, supports, and separates muscles.
fatigue fractures Fractures that result from multiple compressive loads.
femoral artery The main artery supplying the thigh and leg.
femoral shaft fractures A break in the diaphysis of the femur.
femur The proximal bone of the leg that extends from the pelvis to the knee.
fibrous joints The joints that contain dense fibrous tissue and allow no motion.
fibula The smaller of the two bones of the lower leg.
flat bones Bones that are thin and broad, such as the scapula.
fracture A break or rupture in the bone.
qlenoid fossa Socket in the scapula in which the head of the humerus rotates.
gout A painful disorder characterized by the crystallization of uric acid within a joint.
greenstick fracture A type of fracture occurring most frequently in children in which there is incomplete breakage of the bone.
hematopoiesis The generation of blood cells.
humerus The bone of the upper arm.
hypertrophy An increase in size.
ilium The broad, uppermost bone of the pelvis.
impacted fracture A broken bone in which the end of one bone becomes wedged into another bone, as could be the case in a fall from a significant height.
indirect injury An injury that results from a force that is applied to one region of the body but leads to an injury in another area.
intertrochanteric fractures Fractures that occur in the region between the lesser and greater trochanters.
irregular bones Bones with unique shapes that allow them to perform a specific function and that do not fit into the other categories based on shape.
ischium The lowermost dorsal bone of the pelvis.
joint The point at which two or more bones articulate, or come together.
joint capsule A saclike envelope that encloses the cavity of a synovial joint.
lactic acid A metabolic end product of the breakdown of glucose that accumulates when metabolism proceeds in the absence of oxygen.
lateral compression A force that is directed from the side toward the midline of the body.
ligaments Tough bands of tissue that connect bone to bone around a joint or support internal organs within the body.
linear fracture A fracture that runs parallel to the long axis of a bone.
long bones Bones that are longer than they are wide.
malleolus The large, rounded bony protuberance on either side of the ankle joint.
mallet finger An avulsion fracture of the extensor tendon of the distal phalanx caused by jamming a finger into an object.
march fractures See fatigue fractures.
medullary canal The hollow center portion of a long bone.
meteracarpals The five bones that form the palm and back of the hand.
memptyxis The region of the long bone between the epiphysis and diaphysis.
meteratarsals The five long bones extending from the tarsus to the phalanges of the foot.
muscle fatigue The condition that arises when a muscle depletes its supply of energy.
neurovascular compromise The loss of the nerve supply, blood supply, or both to a region of the body, typically distal to a site of injury; characterized by alterations in sensation, including numbness and tingling, or by a loss or decrease of motor function; vascular compromise is indicated by weak or absent pulses, poor skin color, and cool skin.
nondisplaced fracture A break in which the bone remains aligned in its normal position.
nursemaid’s elbow The subluxation of the radial head that often results from pulling on an outstretched arm.
oblige fracture A fracture that travels diagonally from one side of the bone to the other.
olecranon The proximal bony projection of the ulna at the elbow; the part of the ulna that constitutes the “funny bone.”
open book pelvic fracture A life-threatening fracture of the pelvis caused by a force that displaces one or both sides of the pelvis laterally and posteriorly.
open fracture Any break in a bone in which the overlying skin has been damaged.
osteoarthrosis (OA) The degeneration of a joint surface caused by wear and tear that leads to pain and stiffness.
osteoporosis A condition characterized by decreased bone density and increased susceptibility to fractures.
overriding The overlap of a bone that occurs from the muscle spasm that follows a fracture, leading to a decrease in the length of the bone.
paresthesias Abnormal sensations such as burning, numbness, or tingling.
patella The kneecap.
pathologic fracture A fracture that occurs in an area of abnormally weakened bone.
pectoral girdle The shoulder girdle.
pelvic girdle The large bone that arises in the area of the last nine vertebrae and sweeps around to form a complete ring.
periostium The fibrous tissue that covers bone.
phalanges The bones of the fingers or toes.
physis The growth plate in long bones.
plantar Referring to the sole of the foot.
plantar flexion Bending of the foot toward the ground.
point tenderness The tenderness that is sharply localized at the site of the injury, found by gently palpating along the bone with the tip of one finger.
popliteal artery The artery in the area or space behind the knee joint.
posterior tibial artery The artery that travels through the calf muscles to the plantar aspect of the foot.
**pronation** The act of turning the palm of the hand backward or downward, performed by internal rotation of the forearm.

**pubic symphysis** The midline articulation of the pubic bones.

**pubis** One of two bones that form the anterior portion of the pelvic ring.

**pulmonary embolism** Obstruction of a pulmonary artery or arteries by solid, liquid, or gaseous material swept through the right side of the heart into the lungs.

**radial artery** The artery pertaining to the wrist.

**radius** The bone on the thumb side of the forearm.

**range of motion (ROM)** The arc of movement of an extremity at a joint in a particular direction.

**recruitment** The process of signaling additional muscle fibers to contract to create a more forceful contraction.

**rheumatoid arthritis (RA)** An inflammatory disorder that affects the entire body and leads to degeneration and deformation of joints.

**round bones** The small bones that are found adjacent to joints that assist with motion.

**sacrolilac joints** The points of attachment of the ilium to the sacrum.

**scaphoid** The wrist bone that is found just beyond that most distal portion of the radius.

**scapula** The shoulder blade.

**segmental fracture** A bone that is broken in more than one place.

**short bones** The bones that are nearly as wide as they are long.

**silver fork deformity** The dorsal deformity of the forearm that results from a Colles fracture.

**skeletal muscle** Muscle that is attached to bones and usually crosses at least one joint; striated or voluntary muscle.

**snuffbox** The region at the base of the thumb where the scaphoid may be palpated.

**somatic motor neurons** The nerve fibers that transmit impulses to a muscle.

**spiral fracture** A break in a bone that appears like a spring on a radiograph.

**sprains** Injuries, including a stretch or a tear, to the ligaments of a joint that commonly lead to pain and swelling.

**straddle fracture** A fracture of the pelvis that results from landing on the perineal region.

**strain** Stretching or tearing of a muscle by excessive stretching or overuse.

**stress fracture** A fracture that results from exaggerated stress on the bone caused by unusually rapid muscle development.

**striated muscle** Skeletal muscle that is under voluntary control.

**subclavian artery** The artery that travels from the aorta to each upper extremity.

**subluxation** A partial or incomplete dislocation.

**supination** To turn the forearm laterally so that the palm faces forward (if standing) or upward (if lying supine).

**supracondylar fractures** Fractures of the distal humerus that occur just proximal to the elbow.

**synovial joints** Joints that permit movement of the component bones.

**synovial membrane** The lining of a joint that secretes synovial fluid into the joint space.

**talus** The bone of the foot that articulates with the tibia.

**tarsals** The ankle bones.

**tendinitis** Inflammation of a tendon that most commonly results from overuse.

**tendons** The fibrous portions of muscle that attach to bone.

**Thompson test** Squeezing of the calf muscle to evaluate for plantar flexion of the foot to determine whether the Achilles tendon is intact.

**thromboembolic disease** The condition in which a patient has a DVT or pulmonary embolism.

**tibia** The shin bone.

**torus fracture** See buckle fracture.

**transverse fracture** A fracture that runs in a straight line from one edge of the bone to the other and that is perpendicular to each edge.

**twisting injuries** Injuries that commonly occur during athletic activities in which an extremity rotates around a planted foot or hand.

**ulna** The larger bone of the forearm, on the side opposite the thumb.

**ulnar artery** The artery of the forearm that travels along its medial aspect.

**vertical shear** The type of pelvic fracture that occurs when a massive force displaces the pelvis superiorly.

**volar** Pertaining to the palm or sole; referring to the flexor surfaces of the forearm, wrist, or hand.

**Volkmann ischemic contracture** Contraction of the fingers and, sometimes, the wrist, with loss of muscular power, that sets in rapidly after severe injury around the elbow joint.

**voluntary muscle** Muscle that can be controlled by a person.
Assessment in Action

You are dispatched to the home of a 13-year-old boy with pain in his foot. When you arrive, the boy is sitting in his mother’s car complaining of severe pain in his left foot, ankle, and leg. On assessment, he has a distal pulse; his foot is cold and has limited range of motion. There is swelling noted in ankle region. There is no discoloration or obvious deformity. The remainder of his vital signs are within normal limits.

He tells you that he was in the mountains and was snowboarding. He went down a hill when suddenly, a tree was in the way. He struck the tree with the bottom of his left foot (traveling approximately 20 mph). He felt immediate pain in his foot and then began to feel a burning sensation up his left leg. His mother drove him back to their house, approximately 45 minutes away. He had no pain while traveling, but when he attempted to step out of the vehicle, the pain soared through him. You provide comfort care for the young man and transport him to the hospital. He tells you that his pain is about 7 on a 1 to 10 scale. You follow-up at the hospital and are told that he has a comminuted fracture in his heel and a fractured ankle.

1. What type of injury force did this young man sustain?
   A. Tapping injury force
   B. Crush injury force
   C. Penetrating injury force
   D. Indirect injury force

2. With the complaint of pain in his left leg, what other type of injury should have been suspected?
   A. Indirect injury
   B. Direct injury
   C. Twisting injury
   D. March fracture

3. The foot consists of three classes of bones. Which are they?
   A. Tarsals, metatarsals, and calcaneus
   B. Tarsals, metatarsals, and phalanges
   C. Tarsals, calcaneus, and tibia
   D. Tibia, fibula, and malleolus

4. Signs and symptoms of extremity trauma that have a high urgency include which of the following?
   A. Absent distal pulses
   B. Crepitus
   C. Decreased range of motion
   D. Swelling and deformity

5. Flexion, extension, abduction, and circumduction are all movements allowed by what type of joint?
   A. Hinge
   B. Synovial
   C. Saddle
   D. Ball and socket

6. Muscles are composed of specialized cells that contract when stimulated to exert a force on a part of the body. Three types of muscles found in the body are:
   A. Smooth, cardiac, and skeletal.
   B. Smooth, cardiac, and striated.
   C. Ligaments, cartilage, and smooth.
   D. Cardiac, skeletal, and cartilage.

7. When a person sustains a musculoskeletal injury, the arteries that supply the injured region may be damaged as well. What arteries supply the ankle and the foot?
   A. Tibial artery; anterior tibial artery
   B. Popliteal artery; anterior tibial artery
   C. Anterior tibial artery; posterior tibial artery
   D. Popliteal artery; posterior tibial artery

8. What is the primary symptom of a fracture?
   A. Pain
   B. Deformity
   C. Shortening
   D. Loss of use

9. When assessing the patient’s pain, you should use the mnemonic:
   A. PQRST
   B. OPQRST

Challenging Questions

You are dispatched to the home of a 60-year-old man found by neighbors. On your arrival, you find the man in a right lateral recumbent position and he is moaning. You’re not sure how long he has been on the ground, but there is 4 days worth of mail in the mailbox. You apply a backboard and cervical collar because you are not sure of the reason the patient is on the ground. His blood pressure is 100/60 mm Hg and the heart rate is 120 beats/min with sinus tachycardia, he has strong radial pulses, and his respirations are 12 breaths/min. He is verbally responsive by moaning. He is unable to tell you what happened or if anything hurts.

You provide supportive and comfort care en route to the hospital. His body is very stiff and you have difficulty manipulating his extremities. When you perform an assessment, you note that there is a nickel embedded in his head. There are large areas of ecchymosis along his right pelvic area and his right leg. His right shoulder has open wounds. He is incontinent of urine and feces. This man was admitted to the intensive care unit with a diagnosis of acute sepsis and crush syndrome.

10. What signs and symptoms would you recognize for the crush syndrome?

11. How would you treat this type of injury?

12. What will be the concerns of the hospital staff for this patient?
Points to Ponder

You are responding to a call at an assisted care facility for an older woman who has fallen out of bed while attempting to get up. When you arrive, the woman is still on the floor next to her bed. She tells you that her left leg and back hurt, but she is mentally alert and denies any other symptoms. She is sitting up, and it does not seem that she has bumped her head or injured herself in any other way besides the fall. Your physical exam reveals tenderness and pain in her left leg and crepitus and instability in her left hip. The staff tells you that the woman has osteoporosis but no other major medical problems.

How would you best treat this patient?

Issues: Thorough Assessment of Musculoskeletal Injuries, Pain Management.