CHAPTER 8

Musculoskeletal Trauma

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Upon completion of this topic, the student will be able to initially assess and manage patients with life-threatening and limb-threatening musculoskeletal injuries. Specifically, the doctor will be able to:

OBJECTIVES

1. Explain the significance of musculoskeletal injuries in patients with multiple injuries.
2. Outline priorities in the assessment of musculoskeletal trauma to identify life-threatening and limb-threatening injuries.
3. Explain the proper principles of initial management for musculoskeletal injuries.
Introduction

Injuries to the musculoskeletal system occur in 85% of patients who sustain blunt trauma; they often appear dramatic, but rarely cause an immediate threat to life or limb. However, musculoskeletal injuries must be assessed and managed properly and appropriately so life and limb are not jeopardized. The doctor must recognize the presence of such injuries, be familiar with the anatomy of the injury, protect the patient from further disability, and anticipate and prevent complications.

Major musculoskeletal injuries indicate that significant forces were sustained by the body. For example, a patient with long-bone fractures above and below the diaphragm has an increased likelihood of associated internal torso injuries. Unstable pelvic fractures and open femur fractures may be accompanied by brisk bleeding. Severe crush injuries cause the release of myoglobin, which may precipitate in the renal tubules and result in renal failure. Swelling into an intact musculoskeletal space may cause an acute compartment syndrome that, if not diagnosed and treated, may lead to lasting impairment and loss of use of the extremities. Fat embolism, an uncommon but highly lethal complication of long-bone fractures, may lead to pulmonary failure and impaired cerebral function.

Musculoskeletal trauma does not warrant a reordering of the priorities of resuscitation (ABCDEs). However, the presence of significant musculoskeletal trauma does pose a challenge to the treating doctor. Musculoskeletal injuries cannot be ignored and treated at a later time. The doctor must treat the whole patient, including musculoskeletal injuries, to ensure an optimal outcome. Despite careful assessment and management of multiple injuries, fractures and soft tissue injuries may not be initially recognized. Continued reevaluation of the patient is necessary to identify all injuries.

Primary Survey and Resuscitation

What impact do musculoskeletal injuries have on the primary survey?

During the primary survey, it is imperative to recognize and control hemorrhage from musculoskeletal injuries. Deep soft tissue lacerations may involve major vessels and lead to exsanguinating hemorrhage. Hemorrhage control is best effected by direct pressure.

Hemorrhage from long-bone fractures may be significant, and certain femoral fractures may result in up to 4 units of blood loss into the thigh, producing class III shock. Appropriate splinting of the fracture may significantly decrease bleeding by reducing motion and enhancing a tamponade effect of the muscle. If the fracture is open, application of a sterile pressure dressing usually controls hemorrhage. Aggressive fluid resuscitation is an important supplement to these mechanical measures.

Adjuncts to Primary Survey

Adjuncts to the primary survey of patients with musculoskeletal trauma include fracture immobilization and x-ray examination.

Fracture immobilization

The goal of initial fracture immobilization is to realign the injured extremity in as close to anatomic position as possible and to prevent excessive fracture-site motion. This realignment is accomplished by the application of in-line traction to realign the extremity and maintained by an immobilization device. The proper application of a splint helps control blood loss, reduce pain, and prevent further soft tissue injury. If an open fracture is present, the doctor need not be concerned about pulling exposed bone back into the wound because all open fractures require surgical debridement.

Major musculoskeletal injuries indicate that significant forces were sustained by the body.
session and Management, Skill XII-C: Realigning a Deformed Extremity.

Joint dislocations usually require splinting in the position in which they are found. If a closed reduction has successfully relocated the joint, immobilization in an anatomic position may be accomplished in a number of ways: prefabricated splints, pillows, or plaster. These devices will maintain the extremity in its unreduced position.

Splints should be applied as soon as possible, but they must not take precedence over resuscitation. However, splints may be very helpful during this phase to control hemorrhage and pain.

X-RAY EXAMINATION

X-ray examination of most skeletal injuries occurs as the part of the secondary survey. Which x-ray films to obtain and when to obtain them are determined by the patient’s initial and obvious clinical findings, the patient’s hemodynamic status, and the mechanism of injury. An anteroposterior (AP) view of the pelvis should be obtained early for all patients with multiple injuries for whom a source of bleeding has not been identified.

Secondary Survey

Elements of the secondary survey of patients with musculoskeletal injuries are the history and physical examination.

HISTORY

Key aspects of the patient history are mechanism of injury, environment, preinjury status and predisposing factors, and prehospital observations and care.

Mechanism of Injury

Information obtained from the transport personnel, the patient, relatives, and bystanders at the scene of the injury should be documented and included as a part of the patient’s medical record. It is particularly important to determine the mechanism of injury, which may arouse suspicion of injuries that may not be immediately apparent. See Appendix B: Biomechanics of Injury. The doctor should mentally reconstruct the injury scene, identify other potential injuries that the patient may have sustained, and determine as much of the following information as possible:

1. In a motor vehicle crash, what was the precrash location of the patient in the vehicle—driver or passenger? This fact can indicate the type of fracture—for example, lateral compression fracture of the pelvis resulting from a side impact in a vehicle collision.

2. What was the postcrash location of the patient—inside the vehicle or ejected? Was a seat belt or airbag in use? This information may indicate patterns of injury. If the patient was ejected, determine the distance the patient was thrown and the landing conditions. Ejection generally results in increased injury severity and unpredictable patterns of injury.

3. Was there external damage to the vehicle—for example, deformation to the front of the vehicle from a head-on collision? This information raises the suspicion of a hip dislocation.

4. Was there internal damage to the vehicle—for example, bent steering wheel, deformation to the dashboard, or damage to the windscreen? These findings indicate a greater likelihood of sternal, clavicular, or spinal fractures or hip dislocation.

5. Was the patient wearing a restraint? If so, what type (lap or three-point safety belt)? Was the restraint applied properly? Faulty application of safety restraints may cause spinal fractures and associated intrabdominal visceral injuries. Was an air bag deployed?

6. Did the patient fall? If so, what was the distance of the fall, and how did the patient land? This information helps identify the spectrum of injuries. Landing on the feet may cause foot and ankle injuries with associated spinal fractures.

7. Was the patient crushed by an object? If so, identify the weight of the crushing object, the site of the injury, and duration of weight applied to the site. Depending on whether a subcutaneous bony surface or a muscular area was crushed, different degrees of soft tissue damage may occur, ranging from a simple contusion to a severe degloving extremity injury with compartment syndrome and tissue loss.

8. Did an explosion occur? If so, what was the magnitude of the blast and what was the patient’s distance from the blast? An individual close to the explosion may sustain primary blast injury from the force of the blast wave. A secondary blast injury may occur from debris and other objects accelerated by the blast effect (eg, fragments), leading to penetrating wounds, lacerations, and contusions. The patient also may be violently thrown to the ground or against other objects by the blast effect, leading to blunt musculoskeletal and other injuries (tertiary blast effect).

9. Was the patient involved in a vehicle-pedestrian collision? Musculoskeletal injuries may follow predicted patterns (eg, bumper injury to leg) based on the size and age of the patient.
Environment
Ask prehospital care personnel for information about the environment, including:

- Patient exposure to temperature extremes
- Patient exposure to toxic fumes or agents
- Broken glass fragments (which may also injure the examiner)
- Sources of bacterial contamination (e.g., dirt, animal feces, fresh or salt water)

This information can help the doctor anticipate potential problems and determine the initial antibiotic treatment.

Preinjury Status and Predisposing Factors
It is important to determine the patient's baseline condition prior to injury, because this information may alter the understanding of the patient's condition, treatment regimen, and outcome. The AMPEL history also should include information about the patient's exercise tolerance and activity level, ingestion of alcohol and/or other drugs, emotional problems or illnesses, and previous musculoskeletal injuries.

Prehospital Observations and Care
Findings at the incident site that may help the doctor identify potential injuries include:

- Position in which the patient was found
- Bleeding or pooling of blood at the scene, including the estimated amount
- Bone or fracture ends that may have been exposed
- Open wounds in proximity to obvious or suspected fractures
- Obvious deformity or dislocation
- Presence or absence of motor and/or sensory function in each extremity
- Delays in extrication procedures or transport
- Changes in limb function, perfusion, or neurologic state, especially after immobilization or during transfer to the hospital
- Reduction of fractures or dislocations during extrication or splinting at the scene
- Dressings and splints applied, with special attention to excessive pressure over bony prominences that may result in peripheral nerve compression injuries, compartment syndromes, or crush syndromes.

The time of the injury also should be noted, especially if there is ongoing bleeding and delay in reaching the hospital. All prehospital observations and care must be reported and documented.

PHYSICAL EXAMINATION
The patient must be completely undressed for adequate examination. Obvious extremity injuries are often splinted prior to the patient's arrival in the emergency department (ED). There are three goals for the assessment of trauma patients' extremities:

1. Identification of life-threatening injury (primary survey)
2. Identification of limb-threatening injuries (secondary survey)
3. Systematic review to avoid missing any other musculoskeletal injury (continuous reevaluation)

Assessment of musculoskeletal trauma may be achieved by looking at and talking to the patient, as well as by palpation of the patient's extremities and performance of a logical, systematic review of each extremity. The four components that must be assessed are: (1) skin, which protects the patient from excessive fluid loss and infection; (2) neurovascular function; (3) circulatory status; and (4) skeletal and ligamentous integrity. Using this evaluation process reduces the risk of missing an injury. *See Skill Station XII: Musculoskeletal Trauma: Assessment and Management, Skill XII-A: Physical Examination.*

Look and Ask
Visually assess the extremities for color and perfusion, wounds, deformity (angulation, shortening), swelling, and discoloration or bruising.

A rapid visual inspection of the entire patient is necessary to identify sites of major external bleeding. A pale or
white distal extremity is indicative of a lack of arterial inflow. Extremities that are swollen in the region of major muscle groups may indicate a crush injury with an impending compartment syndrome. Swelling or ecchymosis in or around a joint and/or over the subcutaneous surface of a bone is a sign of a musculoskeletal injury. Extremity deformity is an obvious sign of major extremity injury (see Table 8-1).

Inspect the patient’s entire body for lacerations and abrasions. Open wounds are obvious unless they are located on the dorsum of the body. The patient must be carefully logged to assess for an injury or skin laceration. If a bone protrudes or is visualized in the wound, an open fracture exists. Any open wound to a limb with an associated fracture also is considered an open fracture until proven otherwise by a surgeon.

Observe the patient’s spontaneous extremity motor function to help identify any neurologic and/or muscular impairment. If the patient is unconscious, absent spontaneous extremity movement may be the only sign of impaired function. With a cooperative patient, active voluntary muscle and peripheral nerve function may be assessed by asking the patient to contract major muscle groups. The ability to move all major joints through a full range of motion usually indicates that the nerve-muscle unit is intact and the joint is stable.

**Feel**

Palpate the extremities to determine sensation to the skin (neurologic function) and identify areas of tenderness (fracture or deep muscle injury). Loss of sensation to pain and touch demonstrates the presence of a spinal or peripheral nerve injury. Areas of tenderness or pain over muscles may indicate a muscle contusion or fracture. Pain, tenderness, swelling, and deformity over a subcutaneous bony surface usually confirm the diagnosis of a fracture. If pain or tenderness is associated with painful abnormal motion through the bone, fracture is diagnosed. However, attempts to elicit crepitus or demonstrate abnormal motion are not recommended.

At the time of logrolling, palpate the patient’s back to identify any lacerations, palpable gaps between the spinous processes, hematomas, or defects in the posterior pelvic region that are indicative of unstable axial skeletal injuries.

Closed soft tissue injuries are more difficult to evaluate. Soft tissue avulsion may shear the skin from the deep fascia, allowing for significant accumulation of blood. Alternatively, the skin may be sheared from its blood supply and undergo necrosis over a few days. This area may have local abrasions or bruised skin that are clues to a more severe degree of muscle damage and potential compartment crush syndromes. These soft tissue injuries are best evaluated by knowing the mechanism of injury and palpating the specific component involved.

Joint stability may be determined only by clinical examination. Abnormal motion through a joint segment is indicative of a ligamentous rupture. Palpate the joint to identify any swelling and tenderness of the ligaments as well as intraarticular fluid. Following this, cautious stressing the specific ligaments can be performed. Excessive pain may mask abnormal ligament motion because of guarding of the joint by muscular contraction or spasm; this condition must be reevaluated later.

**Circulatory Evaluation**

Palpate the distal pulses in each extremity and assess capillary refill of the digits. If hypotension limits digital examination of the pulse, the use of a Doppler probe may detect blood flow to an extremity. The Doppler signal must have triphasic quality to ensure no proximal lesion. Loss of se
PITFALL

Failure to perform a thorough secondary survey can result in missing potential life- and limb-threatening injuries.

...sation in a stocking or glove distribution is an early sign of vascular impairment.

...In patients with no hemodynamic abnormalities, pulse discrepancies, coolness, pallor, paresthesia, and even motor function abnormalities suggest an arterial injury. Open wounds and fractures in proximity to arteries can be a clue to an arterial injury. A Doppler ankle/brachial index of less than 0.9 is indicative of an abnormal arterial flow secondary to injury or peripheral vascular disease. The ankle/brachial index is determined by taking the systolic blood pressure value as measured by Doppler at the ankle of the injured leg and dividing it by the Doppler-determined systolic blood pressure of the uninjured arm. Auscultation can reveal a bruit with an associated palpable thrill. Expanding hematoma or pulsatile hemorrhage from an open wound also are indicative of arterial injury.

X-Ray Examination

The clinical examination of patients with musculoskeletal injuries often suggests the need for x-ray examination. Any area over a bone that is tender and deformed likely represents a fracture. In patients who have no hemodynamic abnormalities, an x-ray film should be obtained. Joint effusions, abnormal joint tenderness, or joint deformity represent a joint injury or dislocation that also must be x-rayed. The only reason for electing not to obtain an x-ray film prior to treatment of a dislocation or a fracture is the presence of vascular compromise or impending skin breakdown. This is seen commonly with fracture-dislocations of the ankle. If there is going to be a delay in obtaining x-rays, immediate reduction or realignment of the extremity should be performed to reestablish the arterial blood supply and reduce the pressure on the skin. Alignment can be maintained by appropriate immobilization techniques.

MAJOR PELVIC DISRUPTION WITH HEMORRHAGE

Injury

Patients with hypotenion who have pelvic fractures have a high mortality, and sound decision making is crucial. Pelvic fractures associated with hemorrhage commonly exhibit disruption of the posterior osseous-ligamentous (sacral, sacrospinous, sacrotuberous, and the fibromuscular pelvic floor) complex from a sacral fracture and/or dislocation, or from a sacral fracture (Figure 8-1). The force vector opens the pelvic ring, tears the pelvic venous plexus, and occasionally disrupts the internal iliac arterial system (antero-posterior compression injury). This mechanism of pelvic ring injury may be caused by motorcycle crashes and pedestrian-vehicle collisions, direct crushing injury to the pelvis, and falls from heights greater than 12 feet (3.6 meters). Mortality in patients with all types of pelvic fractures is approximately one in six (5%—30%). In patients with closed pelvic fractures and hypotension, mortality rises to approximately one in four (10%—42%). Hemorrhage is the major reversible contributing factor to mortality.

In motor vehicle collisions, a common mechanism of pelvic fracture is force applied to the lateral aspect of the pelvis that tends to rotate the involved hemipelvis internally, closing down the pelvic volume and relieving any tension on the pelvic vascular system (lateral compression injury). This rotational motion drives the pubis into the lower genitourinary system, creating injury to the bladder and/or urethra. Hemorrhage from this injury, or its sequelae, rarely results in death, as it does in the completely unstable pelvic injury. *See Skill Station XII: Musculoskeletal Trauma: Assessment and Management; Skill XII-F: Identification and Management of Pelvic Fractures.*

$\textbf{Figure 8-1}$ Radiograph showing pelvic fracture associated with hemorrhage. Notice the disruption of the posterior osseous-ligamentous complex.

Potentially Life-Threatening Extremity Injuries

$\textbf{? What are my priorities, and what are my management principles?}$

Extremity injuries that are considered potentially life-threatening include major pelvic disruption with hemorrhage, major arterial hemorrhage, and crush syndrome.
Assessment

Major pelvic hemorrhage occurs rapidly, and the diagnosis must be made quickly so that appropriate resuscitative treatment can be initiated. Unexplained hypotension may be the only initial indication of major pelvic disruption with instability in the posterior ligamentous complex. The most important physical signs are progressive flank, scrotal, or perianal swelling and bruising. This is associated with failure to respond to initial fluid resuscitation. Open fracture wounds about the pelvis (especially if the open area is in the perineum, rectum, or buttocks), a high-riding prostate gland, blood at the urethral meatus, and demonstrable mechanical instability are signs of unstable pelvic ring injury.

Mechanical instability of the pelvic ring is tested by manual manipulation of the pelvis. This procedure should be performed only once during the physical examination, as repeated testing for pelvic instability can result in further hemorrhage. The first indication of mechanical instability is leg-length discrepancy or rotational deformity (usually external) without a fracture of that extremity. The unstable hemipelvis migrates cephalad because of muscular pull and rotates outward secondary to the effect of gravity on the unstable hemipelvis. Because the unstable pelvis is able to rotate externally, the pelvis can be closed by pushing on the iliac crests at the level of the anterior superior iliac spine. Motion can be felt if the iliac crests are grasped and the unstable hemipelvis is pushed inward and then outward (compression distraction maneuver). With posterior disruption, the involved hemipelvis can be pushed cephalad as well as pulled caudally. This translational motion can be felt by palpating the posterior iliac spine and tubercle while pushing and pulling the unstable hemipelvis. The identification of neurologic abnormalities or open wounds in the flank, perineum, and rectum may be evidence of pelvic ring instability. When appropriate, an AP x-ray of the pelvis confirms the clinical examination. See Skill Station IV: Shock Assessment and Management.

Management

Initial management of a major pelvic disruption associated with hemorrhage requires hemorrhage control and rapid fluid resuscitation. Hemorrhage control is achieved through mechanical stabilization of the pelvic ring and external counterpressure. Patients with these injuries may be initially assessed and treated in hospitals that do not have the resources to definitively manage the degree of associated hemorrhage. Simple techniques can be used to stabilize the pelvis before transferring the patient. Longitudinal traction applied through the skin or the skeleton is a first-line method. Because these injuries externally rotate the hemipelvis, internal rotation of the lower limbs also reduces the pelvic volume. This procedure may be supplemented by applying a support directly to the pelvis.

A sheet, pelvic binder, or other devices may apply sufficient stability for the unstable pelvis. These temporary methods are suitable to gain early pelvic stabilization. Definitive care of patients with hemodynamic abnormalities demands the cooperative efforts of a team that includes a trauma surgeon and an orthopedic surgeon, as well as any other surgeon whose expertise is required because of the patient's injuries. See Chapter 5: Abdominal and Pelvic Trauma.

Open pelvic fractures with obvious bleeding require pressure dressings to control hemorrhage, which is done by packing the open wounds. Early surgical consultation is essential.

MAJOR ARTERIAL HEMORRHAGE

Injury

Penetrating wounds of an extremity may result in major arterial vascular injury. Blunt trauma resulting in an extremity fracture or joint dislocation in close proximity to an artery also may disrupt the artery. These injuries may lead to significant hemorrhage through the open wound or into the soft tissues. The use of a tourniquet to control bleeding may be of benefit in select patients.

Assessment

Assess injured extremities for external bleeding, loss of a previously palpable pulse, and changes in pulse quality, Doppler tone, and ankle/brachial index. A cold, pale, pulseless extremity indicates an interruption in arterial blood supply. A rapidly expanding hematoma suggests a significant vascular injury. See Skill Station XII: Musculoskeletal Trauma: Assessment and Management, Skill XII-G: Identification of Arterial Injury.

Management

If a major arterial injury exists or is suspected, immediate consultation with a surgeon is necessary. Management of major arterial hemorrhage includes application of direct pressure to the open wound and aggressive fluid resuscitation.

The judicious use of a pneumatic tourniquet may be helpful and lifesaving (Figure 8-2). It is not advisable to apply vascular clamps into bleeding open wounds while the patient is in the ED, unless a superficial vessel is clearly identified. If a fracture is associated with an open hemorrhaging wound, it should be realigned and splinted while direct pressure is applied to the open wound. A joint dislocation simply requires immobilization; joint reduction may be extremely difficult, and therefore should be managed by emergency surgical intervention. The use of arteriography and other investigations is indicated only in resuscitated patients who have no hemodynamic abnormalities. Urgent consul-
CRUSH SYNDROME (TRAUMATIC RHABDOMYOLYSIS)

Injury
Crush syndrome refers to the clinical effects of injured muscle that, if left untreated, may lead to acute renal failure. This condition is seen in individuals who have sustained a crush injury of a significant muscle mass, most often a thigh or calf. The muscular insult is a combination of direct muscle injury, muscle ischemia, and cell death with release of myoglobin. Muscular trauma is the most common cause of rhabdomyolysis, which ranges from an asymptomatic illness with elevation of the creatine kinase level to a life-threatening condition associated with acute renal failure and disseminated intravascular coagulation (DIC).

Assessment
The myoglobin produces dark amber urine that tests positive for hemoglobin. The myoglobin assay must be specifically requested to confirm the presence of myoglobin. Rhabdomyolysis may lead to hypovolemia, metabolic acidosis, hyperkalemia, hypocalcemia, and DIC.

Management
The initiation of early and aggressive intravenous fluid therapy during the period of resuscitation, along with the administration of sodium bicarbonate and electrolytes, is critical to protecting the kidneys and preventing renal failure. Myoglobin-induced renal failure may be prevented by intravascular fluid expansion and osmotic diuresis to maintain a high tubular volume and urine flow. Alkalization of the urine with sodium bicarbonate reduces intratubular pre-
cipitation of myoglobin and is indicated in most patients. It is recommended to maintain the patient’s urinary output at 100 mL/hr until the myoglobinuria is cleared.

Limb-Threatening Injuries

Extremity injuries that are considered potentially limb-threatening include open fractures and joint injuries; vascular injuries, including traumatic amputation; compartment syndrome; and neurologic injury secondary to fracture-dislocation.

OPEN FRACTURES AND JOINT INJURIES

Injury
Open fractures represent a communication between the external environment and the bone (Figure 8-3). Muscle and skin must be injured for this to occur. The degree of soft tissue injury is proportional to the energy applied. This damage, along with bacterial contamination, makes open fractures prone to problems with infection, healing, and function.

Assessment
Diagnosis of an open fracture is based on the history of the incident and physical examination of the extremity that demonstrates an open wound with or without significant muscle damage, contamination, and associated fracture. Management decisions should be based on a complete history of the incident and assessment of the injury.

Figure 8-3 Example of an open fracture.
Documentation regarding the open wound begins during the prehospital phase, with the initial description of the injury and any treatment rendered at the scene. If the documentation is adequate, no further inspection of the open wound is warranted. If the documentation or the history is inadequate, the dressing should be removed under as sterile conditions as possible to visually examine the wound. A sterile dressing is then reapplied. At no time should the wound be probed. If a fracture and an open wound exist in the same limb segment, the fracture is considered open until proved otherwise.

If an open wound exists over or near a joint, it should be assumed that this injury connects with or enters the joint, and surgical consultation should be obtained. The insertion of dye, saline, or any other material into the joint to determine whether the joint cavity communicates with the wound is not recommended. The only safe way to determine communication between an open wound and a joint is to surgically explore and debride the wound.

Management

The presence of an open fracture or a joint injury should be promptly determined. Apply appropriate immobilization after an accurate description of the wound is made and associated soft tissue, circulatory, and neurologic involvement is determined. Prompt surgical consultation is necessary. The patient should be adequately resuscitated, with hemodynamic stability achieved if possible. Wounds then may be operatively debrided, fractures stabilized, and distal pulses confirmed. Tetanus prophylaxis should be administered

Vascular Injuries, Including Traumatic Amputation

Injury

A vascular injury should be strongly suspected in the presence of vascular insufficiency associated with a history of blunt, crushing, twisting, or penetrating injury to an extremity.

Assessment

The limb may initially appear viable because extremities often have some collateral circulation that provides enough retrograde flow. Partial vascular injury results in coolness and prolonged capillary refill in the distal part of an extremity, as well as diminished peripheral pulses and an abnormal ankle/brachial index. Alternatively, the distal extremity may have a complete disruption of flow and be cold, pale, and pulseless.

Management

An acutely avascular extremity must be recognized promptly and treated emergently. Although controversial, the use of a tourniquet may occasionally be lifesaving and/or limb-saving in the presence of ongoing hemorrhage uncontrollable by direct pressure. A properly applied tourniquet, while endangering the limb, may save a life. A tourniquet must occlude arterial inflow, as occluding only the venous system can increase hemorrhage. The risks of tourniquet use increase with time. If a tourniquet must remain in place for a prolonged period to save a life, the physician must be cognizant of the fact the choice of life over limb has been made.

Muscle does not tolerate a lack of arterial blood flow for longer than 6 hours before necrosis begins. Nerves also are very sensitive to an anoxic environment. Therefore, early operative revascularization is required to restore arterial flow to the impaired distal extremity. If there is an associated fracture deformity, it can be corrected quickly by gently realigning and splinting the injured extremity.

If an arterial injury is associated with a dislocation of a joint, a doctor who is skilled in joint reduction may attempt one gentle reduction maneuver. Otherwise, splinting of the dislocated joint and emergency surgical consultation are necessary. Arteriography must not delay reestablishing arterial blood flow, and is indicated only after consultation with a surgeon. CT angiography may be helpful in institutions in which arteriography is not available.

The potential for vascular compromise also exists whenever an injured extremity is splinted or placed in a cast. Vascular compromise can be identified by the loss of or change in the distal pulse, but excessive pain after cast application also must be investigated. The splint, cast, and any other circumferential dressings must be released promptly and the vascular supply reassessed.

Amputation is a traumatic event for the patient both physically and emotionally. Traumatic amputation, a severe form of open fracture that results in loss of an extremity, may benefit from tourniquet use and requires consultation with and intervention by a surgeon. Certain open fractures with prolonged ischemia, neurologic injury, and muscle damage may require amputation. Amputation of an injured extremity may be lifesaving in patients with hemodynamic abnormalities who are difficult to resuscitate.

Although the potential for replantation should be considered, it must be put into perspective with the patient's other injuries. A patient with multiple injuries who requires intensive resuscitation and emergency surgery is not a candidate for replantation. Replantation usually is performed with an injury of an isolated extremity. A patient with clean, sharp amputations of fingers or of a distal extremity, below the knee or elbow, should be transported to an appropriate surgical team skilled in the decision making for and management of replantation procedures.