chapter 55

Trauma

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objectives

Based on the content in this chapter, the reader should be able to:

- Describe phases of initial assessment and related care of the trauma patient.
- Discuss the assessment of patients with thoracic, abdominal, musculoskeletal, and maxillofacial trauma.
- Contrast the response of solid and hollow abdominal organs to trauma.
- Explain the management and nursing care of patients with thoracic, abdominal, musculoskeletal, and maxillofacial trauma.
- Describe immediate, early, and late complications of trauma and the impact of these complications on mortality.

Trauma is defined by the *American Heritage Dictionary* as "a wound, especially one produced by sudden physical injury."[1] *Injury* is defined by the National Committee for Injury Prevention and Control as "unintentional or intentional damage to the body resulting from acute exposure to thermal, mechanical, electrical, or chemical energy or from the absence of such essentials as heat or oxygen."[2] This chapter specifically discusses mechanical injury.

Unintentional injury includes motor vehicle crashes (MVCs), poisonings, falls, drownings, fires, and burns. In 2000, unintentional injuries accounted for 97,300 deaths and 20,500,000 disabling injuries. The total cost of fatal and nonfatal unintentional injuries to employers and insurers was 512.4 billion dollars in the year 2000. To put this in perspective, the total cost is equivalent to 51 cents of every dollar paid in federal personal income taxes or 54 cents of every dollar spent on food in the United States.[2]

Of these numbers, MVCs accounted for 43,000 deaths and 2,300,000 disabling injuries. The total cost of MVCs to consumers was 201.5 billion dollars. This figure is equivalent to

- What it would cost to purchase 610 gallons of gas for each registered motor vehicle in the United States, or
- Approximately 1,100 dollars per licensed driver, or
- Greater than 25 times the combined profits reported by Ford and General Motors.[2]

Unintentional injuries are the leading causes of death in people between the ages of 1 and 34 years. In the 35- to 44-year age bracket, unintentional injury is second only to cancer as a leading cause of death. Unintentional injuries are the fifth leading cause of death among people of all ages. In 2000, unintentional injuries accounted for 15,127 deaths (11,078 male and 4,049 female victims).[2]

Intentional injuries (e.g., suicide attempts, assaults, and homicides) include injuries from poisoning, hanging, drowning, firearms, cutting, and jumping. In 1998, these injuries accounted for 30,575 deaths. Of these, 17,424 were caused by firearms.[2]

MECHANISM OF INJURY

Knowing the mechanism of injury is important. The mechanism of injury can help explain the type of injury, predict the eventual outcome, and identify common injury combinations.[3] In addition, an injury may exist in a trauma patient without the classic signs. The mechanism of injury may indicate the need for additional diagnostic workup and reassessment.

The mechanism of injury is related to the type of injuring force and the subsequent tissue response. Injury occurs when the force deforms tissues beyond their failure limits. Wounds vary depending on the injuring agent. The effect of injury also depends on personal and environmental factors, such as the person's age and sex, the presence or absence of underlying disease process, and the geographic region.

Force may or may not be penetrating. The injury delivered from force depends on the energy delivered and the area of contact. In penetrating injury, the concentration of force is to a small area. In blunt or nonpenetrating injury, the energy is distributed over a large area. The predominant feature affecting the impact is speed, or acceleration:

$$\text{Force} = \text{mass} \times \text{acceleration}$$

Blunt Injury

Mechanisms of blunt injury include MVCs, falls, assaults, and contact sports. Multiple injuries are common with blunt trauma, and these injuries are often more life-threatening than penetrating injuries because the extent of the injury is less obvious and the diagnosis can be more difficult.

Blunt injury is caused by a combination of forces. These forces include acceleration, deceleration, shearing, crushing, and compressive resistance:

- *Acceleration* is an increase in the velocity (or speed) of a moving object.
- *Deceleration*, on the other hand, is a decrease in the velocity of a moving object.
- *Shearing* occurs across a plane when structures slip relative to each other.
- *Crushing* occurs when continuous pressure is applied to a body part.
- *Compressive resistance* is the ability of an object or structure to resist squeezing forces or inward pressure.

In blunt trauma it is the direct impact that causes the greatest injury. Injury occurs when there is direct contact between the body surface and the injuring agent. Indirect forces are transmitted internally with dissipation of energy to the internal structure. The extent of injury from an indirect force depends on transference of energy from an object to the body. Injury occurs as a result of energy released and the tendency for the tissues to be displaced on impact.[3] Acceleration–deceleration injuries are the most common causes of blunt trauma.

In an MVC, the vehicle size and design change injury patterns. Small cars are involved in more crashes per mile and cause more deaths than larger vehicles. Before the crash, the occupant and the car are traveling at the same speed. During the crash, both the occupant and the car decelerate to zero, but not necessarily at the same rate. There are actually three collisions involved in one crash. The first is the car into another object; the second is the occupant's body with the interior of the car; and the third is the internal tissues impacting against the rigid body surface structure. For example, rapid deceleration in an MVC can cause direct injury to tissue. Subsequently, injury occurs as internal organs impinge on bony internal structures and cause major vessels to undergo stretching and bowing.

Wearing shoulder and lap restraints reduces the incidence and severity of injury by reducing the force with which a person strikes a surface, thereby preventing the occupant from striking multiple surfaces and being ejected from the vehicle[3] (Fig. 55-1). The occupant's position in the vehicle also makes a difference in the blunt injury received. When a vehicle strikes a pedestrian it is important to visualize the size of the vehicle and the size of the pedestrian. The area of impact can vary depending on these factors (Fig. 55-2).

Penetrating Injury

Penetrating trauma refers to an injury produced by foreign objects penetrating the tissue. The severity of the injury is related to the structures damaged. The mechanism of injury is caused by the energy created and dissipated by the penetrating object into the surrounding areas.[3] The amount of tissue damaged by a bullet is determined by the amount of energy that transfers into the tissue along with the amount of time it takes for the transfer to occur. The surface area over which the transfer is distributed also contributes to tissue damage.[4]

Velocity determines the extent of cavitation and tissue damage (Fig. 55-3). Low-velocity missiles localize the injury to a small radius from the center of the tract and have little disruptive effect. They cause little cavitation and blast effect, essentially only pushing the tissue aside.

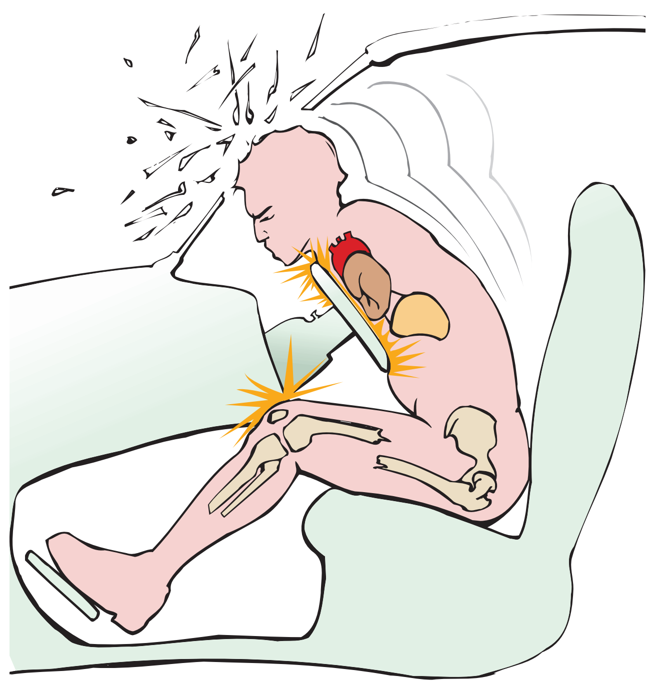

figure 55-1 In a motor vehicle accident, if the driver is not wearing a seat belt, damage may occur in various sections of the body. Common injuries occur to the skull, scalp, face, sternum, ribs, heart, liver, or spleen. Bones of the pelvis and lower extremities also may be damaged.

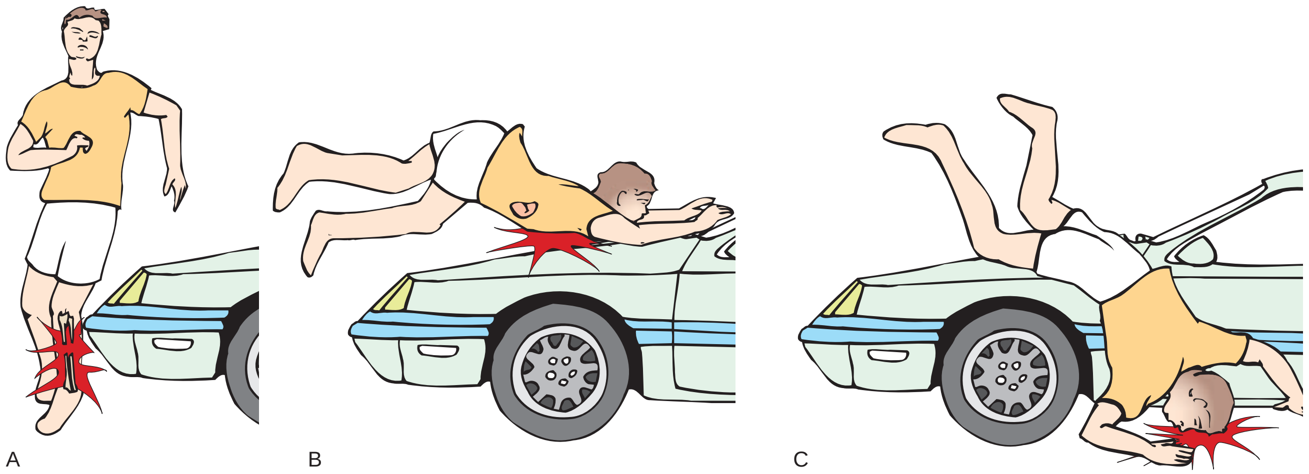

figure 55-2 Pedestrians may be hurt critically when hit by a moving vehicle. (**A**) A common injury is the fracture of the tibia and fibula at the time of impact. (**B**) Impact when the pedestrian strikes the hood of the car may cause fractured ribs and a ruptured spleen. (**C**) Injuries to the head and additional fractures of the extremities may occur as the pedestrian rolls off the braking car or is thrown by the impact.

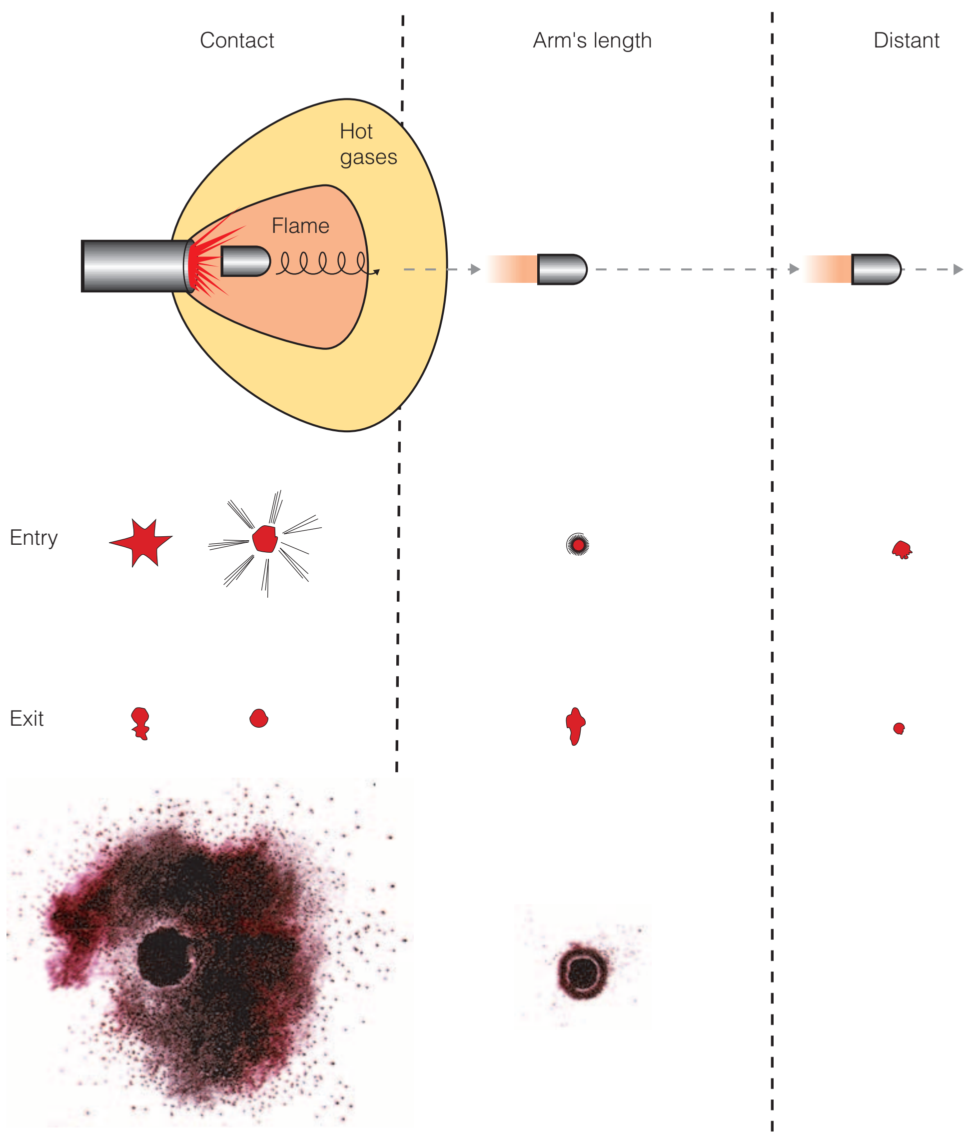

figure 55-3 Diagrammatic views of the effects of gunshot wounds on the body surface. Kinetic energy is dependent on the distance from which the weapon is fired and the tissue involved. Entry and exit wounds are shown when in direct contact, at arm's reach, and at a distance. The bottom illustrations show entry wounds of .22 rifle at 5-cm range (*left*) and at 20-cm range (*right*). The drilled-in entry wound and faint power markings are indicated.

High-velocity missiles can cause more serious injury because of the amount of energy and cavitation produced. The damage depends on three factors: the density and compressibility of the tissue injured, the missile's velocity, and the fragmentation of the primary missile. High-velocity bullets compress and accelerate tissue away from the bullet, causing a cavity to form around the bullet and its entire tract.

Shotguns are short-range, low-velocity weapons that use multiple lead pellets encased in a larger shell for ammunition. Each pellet is a missile (Fig. 55-4).

It is important to obtain a brief description of the mechanism of gunshot injuries, including the weapon, the ammunition, and ballistics. This essential information is used to guide the assessment of patients who sustain injuries from these weapons. All trauma patients must be undressed and inspected for entrance and exit wounds during the assessment process.

Stab Wounds and Impalements

A stab wound or impalement is a low-velocity injury. The main injury determinants are length, width, and trajectory of the penetrating object and the presence of vital organs in the area of the wound. Although the injuries tend to be localized, deep organs and multiple body cavities can be penetrated.

INITIAL ASSESSMENT AND MANAGEMENT

When a trauma patient is brought to the emergency department or the trauma resuscitation unit, it is imperative to obtain a thorough history of the preceding events. This initial evaluation aids in assessment and treatment, and can decrease morbidity and mortality. During this initial assessment, it is important to obtain as much detail as possible about the circumstances surrounding the injury, including the mechanism of injury. To facilitate initial assessment, intervention, and triage of the trauma victim, the American College of Surgeons (ACS) Committee on Trauma has developed guidelines. These guidelines provide an organized, standardized approach to the initial assessment of trauma patients, increasing the speed of the primary assessment and minimizing the risk that injuries will be overlooked.

Prehospital Management

The trauma patient has a greater chance of a positive outcome if definitive care is initiated within 1 hour of injury. Care begins in the prehospital arena and is continued throughout the hospital stay. There are currently two theories about prehospital management of patients, the "stay and play" theory and the "scoop and run" theory.[5] Proponents of the "stay and play" theory believe that "time in the field can be well spent stabilizing the patient's physiologic status,"[5] whereas proponents of the "scoop and run" theory believe that "only life-threatening issues should be addressed in the field."[6] Several studies demonstrated that the time taken to establish intravenous access was longer than the transport time to definitive care.[5] This prolongation of transport was associated with an increase in patient mortality. Therefore, it was suggested that each emergency medical system (EMS) evaluate its approach to prehospital management, taking into account the transport time to definitive care. For example, in an urban area, the "scoop and run" theory may be appropriate because transport time to a definitive care setting is very short. In a rural area, however, the extra minutes that it may take to stabi-

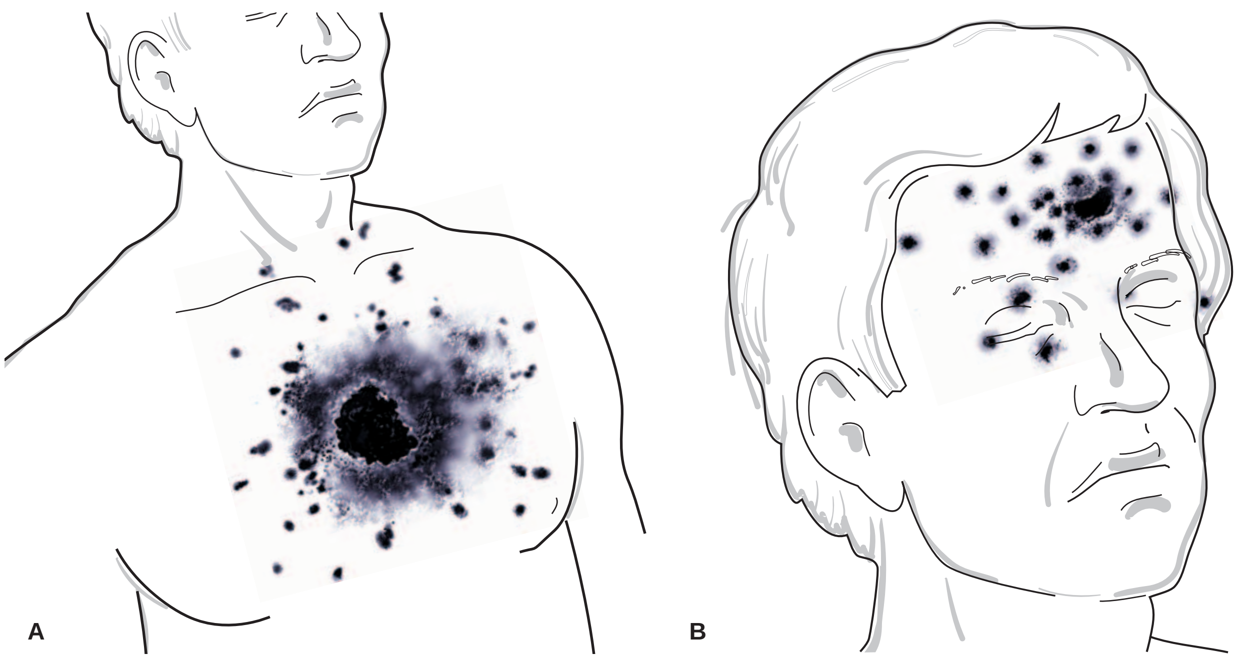

figure 55-4 Damage is caused by shotguns at two different distances. (**A**) At close range, opening is extensive and is surrounded by blood splatters and powder burns. (**B**) At medium range (8–10 feet), the larger entry wound is surrounded by individual pellet wounds.

lize the patient may have a positive impact on the overall outcome because of the long transport time.

The advanced trauma life support (ATLS) guidelines state that the emphasis for assessment and management in the prehospital phase should be placed on maintaining the airway, ensuring adequate ventilation, controlling external bleeding and preventing shock, maintaining spine immobilization, and transporting the patient immediately to the closest appropriate facility.[7]

The prehospital priority of maintaining adequate airway, breathing, and circulation (ABCs) may be difficult to attain owing to the mechanism of injury. It is imperative that cervical spine immobilization be maintained at all times during airway management and transport to definitive care. After assessing and managing the ABCs, the trauma patient's neurological status is assessed, including level of consciousness and pupil size and reaction. Once this primary assessment is complete, a secondary assessment is done to determine any other injuries.

The prehospital providers must consider the facility that will receive the patient (Table 55-1). Transporting the patient to a level I facility allows definitive care to be initiated earlier in the process, thereby reducing patient mortality. Transport of the patient to a lesser facility for "stabilization," followed by transport to the definitive care setting later on, is associated with higher patient mortality rates.

In-Hospital Management

In-hospital patient management entails a rapid primary evaluation and resuscitation of vital functions, a more detailed secondary survey, and initiation of definitive care. Table 55-2 shows the process, commonly referred to as the "ABCDEs" of trauma care. According to the ACS, adhering to this sequence allows for the efficient identification of life-threatening conditions.[7]

PRIMARY SURVEY

During the primary survey, each priority of care is dealt with in order. The patient's assessment does not continue to the next phase until each preceding priority is effectively managed. For example, if a patient does not have a patent airway, breathing and ventilation cannot be established. Therefore, it is during this initial phase that life-threatening injuries are identified and managed. So, if the patient does not have a patent airway, endotracheal intubation, chest tube insertion, and central line access may be initiated and intravenous fluid and blood products may be administered to maintain life-sustaining vital signs before moving on to the next phase of the evaluation.

Assessing the patient for evidence of hypovolemia is essential. Blood loss can result from an external injury, associated with obvious bleeding, or from an internal injury, where bleeding may not be obvious. Any of these injuries can lead to inadequate tissue perfusion, which equals traumatic shock. It is necessary to first stop the bleeding with compression or surgery and then replace the lost intravascular volume. Some signs of hypovolemia include pallor, poor skin integrity, diaphoresis, tachycardia, and hypotension. Usually, trauma patients arrive at the trauma center with a large-bore intravenous line already in place, with intravenous fluid running in rapidly.

During the resuscitation period, an electrocardiogram (ECG) is done. The patient is placed on a monitor with pulse oximetry and end-tidal carbon dioxide monitoring. A Foley catheter and a nasogastric or orogastric tube are placed, and bloodwork is sent to the laboratory for evaluation. Bloodwork analysis includes evaluation of electrolytes, hemoglobin and hematocrit, blood type and crossmatch, and arterial blood gases (ABGs), if the patient is expected to have a high level of injury.

The patient is also assessed for hypothermia. The trauma patient is often subjected to environmental factors, which, along with his or her altered physiological state and possible wet clothing, predispose the patient to hypothermia. Measures taken by health care professionals, such as the infusion of room-temperature intravenous fluids or exposure of the patient's body to inspect for injuries, can exacerbate hypothermia. Warm fluids and blankets are used whenever possible to increase body temperature or maintain normothermia.

table 55-1 **Trauma Center Designation**

	Level I	Level II	Level III	Level IV
Admission requirements	1200 patients per year; 20% with an Injury Severity Score (ISS) ≥15 or 35 patients per surgeon with an ISS ≥15	Varies depending on geographical area, population, resources available, and system maturity	No requirement	No requirement
Surgeon availability	24-hour in-house attending surgeon	Rapidly available	Promptly available	24-Hour emergency coverage
Research center	Required	Not required	Not required	Not required
Education, prevention, and outreach	Required	Required	Required	Required

Source: Scalea TM, Boswell SA: Initial management of traumatic shock. In McQuillan KA, Von Rueden KT, Hartsock RL, et al. (eds): Trauma Nursing (3rd Ed). Philadelphia, WB Saunders, 2002.

table 55-2 Initial Assessment and Management of the Patient With Trauma

Parameter	Assessment	Interventions
Airway	Air exchange Airway patency	Jaw thrust, chin lift Removal of foreign bodies Suctioning Oropharyngeal or nasopharyngeal airway Endotracheal intubation (orally or nasally) Cricothyrotomy
Breathing	Respirations (rate, depth, effort) Color Breath sounds Chest wall movement and integrity Position of trachea	Supplemental oxygen Ventilation with bag–valve device Treatment of life-threatening conditions (e.g., tension pneumothorax)
Circulation	Pulse, blood pressure Capillary refill Obvious external bleeding Electrocardiogram	Hemorrhage control: direct pressure, elevate extremity, pneumatic antishock garment Intravenous therapy: crystalloids, blood transfusion Treatment of life-threatening conditions (e.g., cardiac tamponade) Cardiopulmonary resuscitation
Disability	Level of consciousness Pupils	—
Exposure	Inspection of body for injuries	—

SECONDARY SURVEY

Once the primary survey is completed, a more detailed secondary survey is initiated. This survey begins at the head and works down to the patient's feet. Non–life-threatening injuries are revealed during this survey. During this time, a plan is developed and the appropriate diagnostic tests (e.g., x-rays, ultrasound studies, computed tomography [CT] scans, angiographic studies) are ordered for the patient. This is also the time when a more detailed patient history can be obtained, as well as important information regarding the mechanism of injury. The nurse asks the field providers for information regarding the incident because the patient may not be able to speak or may not remember the event. Family and friends might be helpful in providing additional information about the patient.

Questions the nurse asks before or during the trauma patient's arrival to the hospital include the following:

- Was the person involved in an MVC? Was the person wearing a restraining device? If the person was hit by a vehicle, was the person on foot or on a bike? What kind of vehicle was involved? Where was the person at the time of impact? What was the speed, point of impact, type of impact? Was there a fatality at the scene?
- Are we concerned with blunt or penetrating trauma?
- Did the patient fall? How far? Was the fall off a ladder, or down a flight of stairs?

Based on the information obtained from field providers or family members of the patient, other injuries may be suspected and further investigation may be warranted. This is especially true in intubated, comatose, or paralyzed patients who are unable to verbalize their complaints. The nurse continuously reassesses the trauma patient because injuries often go undetected.

FLUID RESUSCITATION

Most trauma patients have a fluid volume deficit that must be corrected. The goals of fluid resuscitation are to maintain physiological support of circulation and oxygen transport while avoiding physiological and hemostatic deficiencies.[8] It is essential to have adequate intravascular volume and oxygen-carrying capacity to transport needed nutrients to the tissues. To guide fluid resuscitation, the nurse uses the patient's physical assessment and hemodynamic parameters.

Crystalloids

Typically, crystalloids are used in the trauma patient. Crystalloids contain water and other electrolytes that are premixed into the fluid. These electrolytes may include sodium, potassium, and chloride. Crystalloids can be further broken down by their tonicity. The tonicity is based on the amount of sodium in the solution. Crystalloids can be classified as isotonic, hypotonic, and hypertonic (Table 55-3).

Hypertonic saline has been shown to enable a more rapid restoration of cardiac function with a smaller volume of fluid. It is supplied either in a 3%, 7.5%, or 23.4% sodium chloride (NaCl) solution. As little as 4 mL/kg, if given rapidly, may have the same hemodynamic effect as several liters of isotonic crystalloid.[9] Hypertonic saline has the effect of shifting water into the plasma. This water comes from the red blood cells, interstitial space, and tissue. The result is a rapid increase in blood volume, which supports and improves hemodynamics.[10] Hypertonic saline increases the mean arterial pressure and cardiac output,

table 55-3 ■ Intravenous Fluid

Isotonic	• Example: 0.9 normal saline • Equivalent to the tonicity of the human body • Causes minimal shifts between intracellular and extracellular fluid
Hypotonic	• Example: 5% dextrose in water (D_5W) • Tonicity is less than that of human body • May cause swelling, pulls into extracellular space
Hypertonic	• Example: 3% saline • Tonicity is more than that of human body • Pulls fluid into the intravascular space

Modified from American Association of Critical-Care Nurses: Clinical Reference for Critical-Care Nursing (4th Ed). Aliso Viejo, CA, American Association of Critical-Care Nurses, 1998.

which then leads to peripheral vasodilation. The peripheral vasodilation allows for an increase in total splanchnic, renal, coronary, and mesenteric blood flow.[11]

The initial management of trauma patients often requires the rapid infusion of 2 L of isotonic crystalloid as rapidly as possible, while trying to obtain a normal heart rate and blood pressure. However, research has shown that the infusion of crystalloids in patients with hypotension can cause more harm by displacing a hemostatic clot, only to cause more bleeding.[8,10–12] The infusion of crystalloid also further dilutes the patient's hemoglobin and can increase intraperitoneal blood loss.

Colloids

Colloids can also be given to resuscitate a trauma patient. Colloids, such as albumin, dextran, and hetastarch, create oncotic pressure, which encourages fluid retention and movement of fluid into the intravascular space. Proponents for colloid use have argued that less volume of fluid is necessary to achieve hemodynamic stability and the fluid is retained in the intravascular space longer. Despite possible advantages, there is no clear evidence that colloids are superior to crystalloids for resuscitation of the trauma patient. Potential complications, such as anaphylaxis and coagulopathy, have been reported with certain colloids. These potential adverse affects, together with higher costs, make colloid use less desirable than crystalloid use for resuscitation of trauma patients.

Blood Products

Blood products are considered an excellent resuscitation fluid.[12] Red blood cells increase oxygen-carrying capacity and allow for volume expansion. Blood also stays in the intravascular space for longer periods of time compared with the other resuscitation fluids.[12] Although there is some concern about bloodborne pathogens and transfusion reactions, it is essential to understand the advantages offered by blood transfusion.

Blood should be transfused when patients are hemodynamically unstable or are showing signs of tissue hypoxia despite crystalloid infusion.[13] Crossmatched blood is preferred but is not always possible if emergent transfusion prohibits type and crossmatching of the patient's blood. O-negative blood is the preferred type of uncrossmatched blood, especially in women of childbearing age. O-positive blood may be used in male and postmenopausal female patients. If the patient requires large amounts of blood, transfusion of fresh frozen plasma and platelets is initiated.[13] It is important to replace coagulation factors and platelets not contained in blood. In the event of massive blood transfusions, the risk of acute respiratory distress syndrome (ARDS) and disseminated intravascular coagulation (DIC) is heightened. An extended period of hypotension increases the possibility of renal failure.

Autotransfusion is another common modality used in the hemorrhaging trauma patient. Obviously, the nature of trauma prevents patients from donating their own blood, as they could in an elective surgery. However, sometimes blood is salvaged from wounds, drains, and body cavities.[8] Most often blood is saved from a chest tube underwater seal device. A cell saver is connected into the system and the blood from the wound collects there. Once full, the cell saver is disconnected from the underwater seal device and this blood is then transfused into the patient using a macroaggregate filter.[8]

Blood Substitutes

Blood substitutes have been developed but have not been approved for use in all countries. These agents do not require crossmatching and do not carry the risk of bloodborne pathogen transmission. Blood substitutes have a long shelf life and are not immunosuppressive. They also have a lower viscosity then blood, which promotes flow and peripheral oxygen delivery.[12]

DEFINITIVE CARE

Increasingly, trauma care consists of nonoperative management of stable patients. Traditionally, solid organ injuries, both blunt and penetrating, were treated with surgery. Today, many trauma surgeons are choosing nonoperative management for their patients whenever possible. Ever more sophisticated techniques for visualization of internal structures, such as CT, ultrasonography, and angiography, have reduced the need for immediate surgical exploration in many cases. In addition to being used for diagnosing a person's injury, many of these techniques can be used to manage the person's condition as well. For example, angiographic interventions may be used to embolize a hemorrhaging internal vessel, obviating the need for invasive surgical intervention. Nonoperative diagnosis and management reduces the need for blood transfusion, minimizes the number of missed injuries, and places the patient at lower risk for delayed bleeding.[14] Patients who are treated nonoperatively require frequent assessment and are admitted to the intensive care unit to facilitate this.

To observe the patient effectively, the nurse must be aware of potential injuries and associated signs and symptoms. Examples of nursing diagnoses and collaborative problems are given in Box 55-1. Attention is also given to the management of pre-existing medical conditions and the identification of injuries missed during treatment of life-threatening problems. Once again, knowledge regarding the mechanism of injury is necessary. Finally, the patient is monitored for the development of complications. The

box 55-1 ***Examples of Nursing Diagnoses and Collaborative Problems for the Person With Trauma***

- Deficient Fluid Volume related to hemorrhage, "third spacing"
- Impaired Gas Exchange related to pulmonary trauma, respiratory complications (e.g., acute respiratory distress syndrome [ARDS], pain)
- Impaired Tissue Integrity related to trauma, surgery, invasive procedures, immobility
- Anxiety related to critical illness, fear of death or disfigurement, role changes within social setting, or permanent disability
- Risk for Ineffective Tissue Perfusion: Multiple Organs related to decreased cardiac output, decreased oxygenation, decreased gas exchange
- Risk for Infection related to trauma, invasive procedures
- Pain related to trauma
- Impaired bowel elimination related to intraabdominal trauma, ileus, or both
- Increased Risk for Ineffective Family and Individual Coping related to trauma

critical care nurse must be aware of potential complications and related risk factors associated with various injuries. Certain situations, such as prolonged extrication, prolonged hypothermia, respiratory or cardiac arrest, massive fluid resuscitation, or massive blood transfusions, suggest an increased likelihood of severe injuries and a greater chance of complications and death after trauma. A Collaborative Care Guide for the patient with multisystem trauma is given in Box 55-2.

ASSESSMENT AND MANAGEMENT OF SPECIFIC INJURIES

Although this section discusses traumatic injuries related to specific areas of the body, the nurse must keep in mind that head-to-toe assessment is required for each trauma patient. Physical assessment of each organ system is indicated, as described in previous chapters throughout this text.

Thoracic Trauma

Thoracic injuries are responsible for 25% of all trauma-related deaths and are second only to central nervous system (CNS) injuries as the leading cause of all trauma deaths.[15–17] MVCs are responsible for approximately 70% of thoracic injuries.[15] One seventh of all deaths by injury now involve violence. A significant number of these deaths are from penetrating gunshot or stab wounds to the chest.[18]

TRACHEOBRONCHIAL TRAUMA

Injuries to the trachea or bronchi can be caused by blunt or penetrating trauma and frequently are accompanied by esophageal and vascular damage. Ruptured bronchi often are present in association with upper rib fractures and pneumothorax. Severe tracheobronchial injury has a high mortality rate; however, with continued improvements in prehospital care and transport, more of these patients are surviving.

Airway injuries often are subtle. Presenting signs include dyspnea (occasionally the only sign), hemoptysis, cough, and subcutaneous emphysema. A chest x-ray can alert the physician to a possible injury; however, diagnosis usually is made with bronchoscopy or during surgery. Tracheobronchial injury is considered whenever a persistent air leak accompanies a pneumothorax.

Small lung lacerations or pleural tears can be managed conservatively with mechanical ventilation delivered through an endotracheal tube or tracheostomy. Larger injuries may require surgical repair. Simultaneous independent lung ventilation, where each lung is ventilated separately (each with a dedicated ventilator), may also be used.

Nursing care involves the assessment of oxygenation and gas exchange, along with appropriate pulmonary care. During the first few days, the physician may perform a bronchoscopy to visualize the repair site and provide more effective secretion removal. Pneumonia is a potential short-term complication, whereas tracheal stenosis may occur later.

BONY THORAX FRACTURES

Rib fractures, sternal fractures, and flail chest are thoracic fractures commonly seen in trauma patients. The greatest concerns for nurses caring for patients with such injuries are pain, ineffective ventilation, and secretion control. Ribs 1 and 2 are usually protected by the clavicle, scapula, humerus, and surrounding muscles. If these ribs are fractured, it often signifies high-impact trauma and other injuries, such as to the aorta, the thorax, and the spine, are very likely and should be investigated. Ribs 3 through 9 are most commonly fractured in blunt trauma. These fractures are often associated with underlying lung injuries. Fractures of the lower ribs can also be associated with injury to the liver or other abdominal structures. Sternal fractures are associated with blunt trauma.

Flail chest is an injury that involves multiple rib fractures. These fractures can be anterior, posterior, or lateral, and usually a sternal fracture is present as well. The stability of the thorax is disrupted and the rib cage no longer moves in unison. The injured area does not respond to the action of the respiratory muscles; rather, it moves in accordance with the changes in intrapleural pressure. The flail segment movement is paradoxical, hence the term *paradoxical breathing*. The flail segment causes a decrease in the normal negative pressure of the chest, thereby decreasing ventilation and causing some degree of hypoxia.

Initial management of patients with bony thorax fractures includes airway management, pain management, and oxygen therapy to maintain adequate saturation. The nurse must consider the underlying structures and the possible injury to them. Treatment of flail chest includes turning the patient with the injured side down to improve oxygenation. This is often difficult to perform because of the need to maintain cervical spine immobilization. Other treatment modalities include internal splinting, accomplished by placing the intubated patient on positive-

box 55-2 collaborative care guide *for the Patient With Multisystem Trauma*

OUTCOMES	INTERVENTIONS
Oxygenation/Ventilation	
The patient will maintain a patent airway.	■ Auscultate breath sounds. ■ Perform frequent assessments. ■ Intubate if needed. ■ Provide supplemental oxygen PRN.
The patient will maintain an Sa_{O_2} ≥95% and have adequate ABGs.	■ Provide pulmonary toilet (chest physiotherapy and incentive spirometry). ■ Intubate. ■ Monitor ABGs.
The patient will be able to take deep breaths and will be free of anxiety.	■ Use mechanical ventilation if necessary to support adequate ventilation. ■ Provide adequate pain medication to promote deep breathing (patient-controlled analgesia [PCA], epidural, around-the-clock medications) ■ Medicate before pain increases. ■ Use antianxiety drugs as necessary.
Circulation/Perfusion	
The patient will maintain an adequate blood pressure, heart rate, and respiratory rate.	■ Monitor respiratory rate and depth. ■ Use ECG monitor. ■ Administer intravenous (IV) fluids and packed red blood cells to ensure adequate intravascular volume and oxygen-carrying capacity. ■ Administer medications, such as vasoactive and inotropic agents, after intravascular volume is restored. ■ Install pulmonary artery catheter/A-line. ■ Assess skin color and capillary refill time.
The patient will not experience deep venous thrombosis.	■ Use prophylactic anticoagulants unless contraindicated. ■ Apply TED stockings. ■ Use pneumatic compression devices.
Fluids/Electrolytes	
The patient will maintain an adequate intake and output.	■ Monitor blood pressure, heart rate, central venous pressure, pulmonary capillary wedge pressure, IV fluid ■ Use Foley catheter to monitor urine output. ■ Consider insensible fluid loss in output. ■ Monitor laboratory values.
The patient will maintain electrolyte balance.	■ Replace electrolytes PRN. ■ Monitor ECG.
Mobility/Safety	
The patient's range of motion will be maintained.	■ Consult Physical/Occupational Therapy. ■ Use splints PRN. ■ Do range-of-motion exercises every 8 hours. ■ Out of bed as tolerated.
Skin Integrity	
The patient will not experience skin breakdown.	■ Monitor skin every 4 hours. ■ Turn patient every 2 hours and PRN. ■ Use pressure-relieving devices. ■ Remove splints to monitor skin. ■ Provide prescribed wound care. ■ Monitor wound for evidence of infection.

(continued)

box 55-2 collaborative care guide
for the Patient with Multisystem Trauma (Continued)

OUTCOMES	INTERVENTIONS
Nutrition	
The patient will maintain an adequate calorie intake to meet metabolic needs.	■ Arrange dietary/nutrition consult. ■ Use total parenteral nutrition (TPN)/lipids if enteral nutrition contraindicated. ■ Tube feeds: encourage enteral nutrition when possible. ■ Check prealbumin and electrolytes. ■ Monitor for weight loss.
Comfort/Pain Control	
The patient will maintain a pain score of less than 5.	■ Administer adequate pain medication. ■ Use PCA/epidural PRN. ■ Arrange pain consult if needed. ■ Use sedation as needed. ■ Monitor vital signs.
Psychosocial	
The patient will maintain as much control as possible.	■ Inform patient of procedures. ■ Establish a schedule with the patient if possible. ■ Provide an alternate means of communication if necessary, such as lip reading, writing, and a communication board.
The patient and family will cope effectively with the traumatic event.	■ Provide repeated information. ■ Encourage use of appropriate coping. ■ Encourage use of support systems. ■ Arrange social work consult.
Teaching/Discharge Planning	
Patient will be involved in discharge planning.	■ Discuss discharge with patient. ■ Allow patient to make decisions if possible. ■ Provide patient with list of injuries.
Patient will understand injuries and complications of injuries.	■ Provide discharge instructions accordingly with injury.

pressure ventilation. Sometimes surgical repair is done, especially if a thoracotomy is necessary for other reasons. Surgical repair may help decrease the need for prolonged mechanical ventilation.

PLEURAL SPACE INJURIES

For the purpose of this chapter, the term *pleural space injuries* is used in reference to pneumothorax (intrapleural air collection), hemothorax (intrapleural blood collection), and hemopneumothorax (interpleural air and blood collections). Pleural space injuries are caused by disruption of an intrathoracic structure that allows air or blood to build up in the pleural layers, thereby leading to a decrease in negative intrathoracic pressure. Sometimes air and blood continue to build up in the pleural cavity, causing increased tension, which leads to a tension pneumothorax or a tension hemothorax. Either blunt or penetrating trauma may result in a pleural space injury.

The mechanism of injury may lead the nurse to suspect a pleural space injury. For example, an unrestrained driver whose chest hits the steering wheel has a great potential for this injury. When assessing the patient, respiratory distress may be evident along with altered ventilation, which leads to impaired gas exchange. Impaired gas exchange may be evidenced by restlessness, anxiety, tachypnea, decreased oxygenation, poor color, and diaphoresis. The nurse continuously reassesses the patient because even if the original injury is small, it can expand, causing a life-threatening emergency.

Chest radiography is usually used to diagnose pleural space injuries. Sometimes if the pneumothorax is less than 20% of the chest cavity, it may not be seen initially on chest film. A chest CT scan often shows the smaller pleural space injuries.

Treatment of pleural space injuries includes appropriate management of the patient's airway, ventilation, and oxygenation. A large-bore chest tube, such as a 40-French tube, is often inserted to re-expand the lung and drain the air or blood. This tube is inserted in the fourth or fifth intercostal space at the mid-axillary line. For trauma patients with a simple pneumothorax, a chest tube may be placed in the second intercostal space at the mid-clavicular line. Once the tube is inserted, it is attached to an underwater seal system and then attached to suction. The effects of treatment are assessed by chest x-ray, physical examination, and noting of improved oxygenation. Often there is an air leak in the underwater seal system of the chest tube drainage device that ceases within a few days.

The nurse monitors the amount of blood that drains into the chest tube drainage device. Drainage of more than 200 mL/hour for 2 consecutive hours may indicate a missed injury or the need for further exploration, and should be reported.[7]

A massive hemothorax is defined as 1.5 to 4 L of intrathoracic blood loss and truly constitutes a life-threatening injury. A massive hemothorax is often caused by severe thoracic injuries, and the source of bleeding is a large systemic blood vessel or mediastinal structure. Patients with massive hemothorax often arrive at the emergency department or trauma resuscitation unit in cardiopulmonary arrest. These patients require immediate thoracotomy to control bleeding. The patients who are not in cardiopulmonary arrest present with signs of hypovolemic shock (see Chapter 50), dyspnea, tachypnea, and cyanosis. Initial management of these patients includes treatment of the shock state. Two large-bore intravenous lines should be established and resuscitation fluid administered. The amount of fluid administered depends on the patient's response.[19]

A left massive hemothorax is more common than a right one, and is often associated with aortic rupture.[7] The chest cavity is large enough to hold most of the patient's circulating blood volume. Because of this, the bleeding stops only when the pressure in the pleural cavity is equal to or greater than the pressure in the damaged vessel. Placement of a chest tube in a patient with massive hemothorax could lead to exsanguination by eliminating the tamponade caused by a closed chest injury. If a chest tube is inadvertently placed, it should be clamped until exploratory thoracotomy can be performed.

Tension pneumothorax is a life-threatening condition that requires immediate recognition. It may be the result of a primary injury to the thorax or a delayed complication related to tracheobronchial injury or mechanical ventilation. Tension pneumothorax is caused by air entering the pleural space and becoming trapped without an exit. A one-way valve closed system is formed. This causes a compression of one or more of the intrathoracic structures (trachea, heart, lungs, and great vessels) and prohibits them from functioning adequately. The outcome is ventilation failure, compromised venous return, and insufficient cardiac output.

Tension pneumothorax is often difficult to diagnose in the trauma patient because of other injuries the patient may have, as well as the presence of a shock state. It may not be diagnosed until the patient has decompensated. The nurse may notice that it is difficult to ventilate the patient, despite an open airway. There is often a drop in the patient's oxygenation. Other signs of tension pneumothorax include chest asymmetry, tracheal shift, neck vein distension (unless the patient is hypovolemic), decreased breath sounds on the affected side, and evidence of decreased cardiac output (e.g., decreased blood pressure and poor tissue perfusion).

Treatment of tension pneumothorax requires immediate decompression of the trapped air. This is done initially by placing a 14- or 16-gauge needle into the pleural space, usually between the second to fourth anterior intercostal space. An immediate rush of air should escape and the patient's ventilation should improve. Supplemental oxygen is provided to the patient before decompression. After emergent decompression, the needles are changed to chest tubes. This is done to allow the lungs to expand as well as to prevent a reoccurrence. Last, additional assessment is necessary to determine the cause of tension pneumothorax. The nurse must continue to assess and reassess the patient.

PULMONARY CONTUSION

A pulmonary contusion is a bruising of the lung parenchyma, often caused by blunt trauma. This disorder may not be diagnosed on the initial chest x-ray; however, the presence of a scapular fracture, rib fractures, or a flail chest should lead to the suspicion of a possible underlying pulmonary contusion.

Pulmonary contusion occurs when rapid deceleration ruptures capillary cell walls, causing hemorrhage and extravasation of plasma and protein into alveolar and interstitial spaces. This results in atelectasis and consolidation, leading to intrapulmonary shunting and hypoxemia. Presenting signs and symptoms include dyspnea, rales, hemoptysis, and tachypnea. Severe contusions also result in increasing peak airway pressures, hypoxemia, and respiratory acidosis. Pulmonary contusion may mimic acute respiratory distress syndrome (ARDS); both are poorly responsive to high fractions of inspired oxygen (FIO_2). ARDS is discussed in detail in Chapter 27.

Treatment of pulmonary contusion is supportive. Patients with a mild contusion require close observation with frequent ABG measurements or pulse oximetry monitoring. Additional nursing interventions include frequent respiratory assessment, pulmonary care, and pain control. Chest physiotherapy and continuous epidural analgesia also may be beneficial. An oximetric pulmonary artery catheter and arterial line usually are placed to facilitate monitoring of ABGs, hemodynamics, and respiratory parameters (oxygen delivery, oxygen consumption, intrapulmonary shunt).

Severe pulmonary contusion may require ventilatory support with positive end-expiratory pressure (PEEP). Although alveolar ventilation improves as PEEP is added, blood flow to alveoli may diminish, leading to an increased intrapulmonary shunt. To optimize tissue perfusion and oxygenation, each change in PEEP requires assessment of the status of the shunt, oxygen delivery, and other indicators of tissue perfusion (cardiac output, blood pressure, and urine output). Adequate pain control is necessary and may require epidural or intrapleural infusions of analgesics or an intracostal nerve block. In severe cases of respiratory compromise, increased sedation or paralysis may be indicated to decrease energy expenditure and oxygen requirements. A rotation bed also may be considered to promote pulmonary toilet and respiratory gas exchange. Positioning the patient with the injured side up is beneficial in the case of a severe unilateral contusion. In rare instances, when the patient is not responding to traditional mechanical ventilation, prone positioning and high-frequency jet ventilation may be used.[20,21] Another mode of ventilation commonly used is airway pressure-release ventilation (APRV).

Fluid management also is important. Intake and output, daily weights, central venous pressure, and pulmonary artery and capillary wedge pressures are monitored to guide fluid administration. Medications may need to be more concentrated to compensate for excess fluid intake, and diuretics may be required periodically. Severe fluid restriction is not indicated. Instead, fluid balance should be maintained at a normal level (euvolemia) to support optimal cardiac output and oxygen delivery. The contused lung should show radiographic signs of improvement within 72 hours. The presence of persistent infiltrates may indicate complications, such as pneumonia or superimposed ARDS. Long-term sequelae include prolonged reduced functional residual capacity, dyspnea, and fibrosis.

BLUNT CARDIAC INJURIES

Blunt cardiac injuries include cardiac wall rupture, valvular disruption, coronary artery dissection, and cardiac contusions. Cardiac contusions, the most common form of blunt cardiac injuries, are usually caused by blunt trauma as the heart hits the sternum during rapid deceleration. A contusion can also develop if the heart is compressed between the sternum and the spine.

Symptoms of cardiac contusion vary from none (common) to severe congestive heart failure and cardiogenic shock. Complaints of chest pain must be evaluated carefully after trauma. Nonspecific ECG changes are frequently seen, and can include any type of dysrhythmia. Atrial dysrhythmias and conduction disturbances may be seen with injuries to the right side of the heart; ventricular disturbances are more likely after a left-sided cardiac injury.

A cardiac contusion is suspected when there is a history of severe anterior blunt trauma and the patient has chest wall bruising and fractures of the ribs or sternum. Twelve-lead ECG is done to detect any electrical abnormalities. Most patients with cardiac contusions have ECG abnormalities on admission. These patients are placed on continuous cardiac monitoring and blood is drawn for cardiac isoenzyme and troponin studies. In particular, an elevation in troponin I or the myocardial band of the creatine kinase (CK-MB) is clinically significant with this injury.[22,23]

Controversy exists over the standard of care for patients with cardiac contusion.[22] Because there is no standard in diagnosing this injury, there is also no standard in treatment. Continuous monitoring must be done to evaluate for symptomatic arrhythmias, especially ventricular irritability and conduction defects. Echocardiography or multigated angiography (MUGA) may be helpful in determining any muscle defect or damage. In general, patients are treated to relieve their symptoms.

PENETRATING CARDIAC INJURY

In most cases, a penetrating injury to the heart results in prehospital death. In the remainder of patients, hemorrhage and shock are common presenting signs. The right ventricle is injured most often because of its anterior location. Occasionally, small stab wounds to the ventricles seal themselves owing to the thick ventricular musculature. Treatment of hemodynamically stable patients remains controversial. In some instances, monitoring the patient with serial CT scanning or with pericardial and pleural ultrasound is acceptable.[24] In other cases, surgery to create a thoracoscopic pericardial window may be necessary to aid in the diagnosis of ongoing hemorrhage and to drain pericardial fluid collections.[25] In the presence of ongoing hemorrhage and shock, lost blood volume is replaced, and the patient is immediately transported to the operating room for a median sternotomy and exploration. In severe cases, a thoracotomy in the emergency department may be required as a life-saving measure.

After surgical repair, a pulmonary artery catheter and arterial line are placed to facilitate careful hemodynamic monitoring. Vasopressors or inotropic agents may be necessary to maintain adequate blood pressure and cardiac output. Fluid and electrolyte balance, along with cardiac rhythm, must be monitored closely. Heart sounds are assessed to detect murmurs, indicating valvular or septal defects, and for signs of congestive heart failure. Chest and mediastinal tube drainage are recorded frequently. Fresh frozen plasma and platelets are administered, as indicated, to correct coagulopathies. Complications include continued hemorrhage and postcardiotomy syndrome.

CARDIAC TAMPONADE

Cardiac tamponade, known as both a symptom and injury, can result from both penetrating and blunt trauma. It is a life-threatening injury that needs to be immediately assessed and treated. It is caused by blood filling the pericardium and compressing the heart, causing decreased cardiac filling, which leads to reduced cardiac output and eventually shock. Bleeding into the pericardial sac (hemopericardium) or a small pericardial rupture may or may not cause cardiac tamponade, depending on the amount of pressure in the pericardium.[17]

The pericardial sac normally holds about 25 mL of fluid, which serves to cushion and protect the heart. Only a small amount of pericardial blood (50 to 100 mL) is necessary to increase intrapericardial pressure. Continued bleeding increases the pressure rapidly and the patient presents with signs and symptoms of cardiac tamponade.

Classic symptoms include decreased blood pressure, muffled heart sounds, and increased central venous pressure manifested by distended neck veins (Beck's triad). Because these signs may be obscured in the hypovolemic trauma victim, patients with a history of precordial trauma must be treated with a high index of suspicion. A pericardiocentesis may be diagnostic and therapeutic; however, thoracotomy often is necessary to identify and repair the source of bleeding. Postoperative nursing care is similar to that for a penetrating cardiac injury.

AORTIC INJURIES

Thoracic aortic disruption from blunt trauma is the leading cause of death in people who fall, people who are struck by motor vehicles, and people who are passengers in vehicles involved in MVCs.[16] A recent study stated that 22% of patients who sustained a ruptured aorta died before reaching the hospital, another 37% died during initial resuscitation or in the operating room, and another 14% died after surgery. Of those who survived, 19% had paraplegia or paresis.[26] These statistics alone indicate the severe nature of these injuries.

There are three common locations of vessel rupture. Because the thoracic aorta is very mobile, the tears occur at points of fixation. The most common is at the aortic isthmus, just distal to the left subclavian artery, where the vessel is attached to the chest wall by the ligamentum arteriosum. The two other sites of rupture are in the ascending aorta, where the aorta leaves the pericardial sac, and at the entry to the diaphragm. The inner layers of the vessel tear on impact from deceleration. The outer layers remain intact and balloon out into a pseudoaneurysm. A partial circumferential hematoma may also be tamponaded by surrounding tissues. Both of these mechanisms may prolong survival, but only for a limited time.

An understanding of the injury history can raise the suspicion of aortic injury. Penetrating mediastinal injuries or thoracic injuries caused by blunt trauma should raise suspicion. Other injuries that may raise suspicion include first or second rib fractures, high sternal fractures, clavicular fractures at the sternal margin, and massive left-sided hemothorax.

Loss of effective blood transport because of major vessel rupture is the main physiological problem associated with aortic rupture. The goal of assessment is to identify evidence of poor perfusion beyond the aortic lesion. Many patients are asymptomatic on presentation. Findings associated with aortic injuries are given in Box 55-3.

A supine chest x-ray is obtained to aid in diagnosis of an aortic injury. After spinal injury has been ruled out, an upright chest x-ray may be obtained as well. If a widened mediastinum is detected on chest x-ray, additional evaluation is necessary for definitive management. Although an aortic tear is sometimes seen on CT scan, aortography is the study used for definitive diagnosis.[26]

A positive aortogram indicates the need for surgical repair. The torn aorta may require end-to-end anastomosis or, more commonly, the placement of a synthetic graft. Cardiopulmonary bypass may be necessary for repair of the ascending aorta or the aortic arch. However, repair of the descending thoracic aorta is usually accomplished during aortic cross-clamping. Because this maneuver occludes distal blood flow, it is imperative that the cross-clamp time be as short as possible (preferably less than 30 minutes). To prevent leakage from the repair site, vasodilators may be administered after surgery to reduce afterload. After replacement of intravascular volume, a vasopressor may be added to support adequate blood pressure. Nursing care focuses on hemodynamic monitoring with a pulmonary artery catheter and titrating medications to maintain optimal blood pressure. Autotransfusion may also be necessary.

Complications are related to the level of the tear and the extent of altered perfusion. Hypoperfusion and resulting damage to organs below the level of the laceration can result from the injury itself or from prolonged cross-clamping during repair. Serious complications resulting from prolonged cross-clamp time include renal failure, bowel ischemia, lower extremity weakness, or permanent paralysis of the lower extremities. Other sequelae, such as ARDS or DIC, can be a consequence of hemorrhagic shock and multiple blood transfusions.

box 55-3 ***Signs and Symptoms of Aortic Injuries***

- Pulse deficit in any area, particularly lower extremities or left arm
- Hypotension unexplained by other injuries
- Upper extremity hypertension relative to lower extremities
- Interscapular pain or sternal pain
- Precordial or interscapular systolic murmur caused by turbulence across the disrupted area
- Hoarseness caused by hematoma pressure around the aortic arch
- Respiratory distress or dyspnea
- Lower extremity neuromuscular or sensory deficit

Adapted from Sherwood SF, Hartsock RL: Thoracic injuries. In McQuillan KA, Von Rueden KT, Hartsock RL, et al (eds): Trauma Nursing (3rd Ed), pp 543–590. Philadelphia, WB Saunders, 2002.

Abdominal Trauma

Abdominal injuries rank third in the causes of trauma deaths.[27] They account for 13% to 15% of trauma deaths, primarily as a result of hemorrhage. Deaths that occur more than 48 hours after abdominal injury are due to sepsis and its complications.[28] In intra-abdominal trauma, rarely does single-organ injury or single-system injury occur.

Abdominal trauma can be caused by both blunt and penetrating injuries. MVCs are the most common cause of blunt abdominal trauma. Diagnosing blunt abdominal trauma can be difficult, especially if there are multisystem injuries. If the patient has abdominal tenderness or guarding, hemodynamic instability, lumbar spine injury, pelvic fracture, retroperitoneal or intraperitoneal air, or unilateral loss of the psoas shadow on x-ray, visceral damage should be suspected.

The abdominal cavity contains solid and hollow organs. Blunt trauma is likely to cause serious damage to solid organs, and penetrating trauma most often injures the hollow organs. The compression and deceleration of blunt trauma lead to fractures of solid organ capsules and parenchyma, whereas the hollow organ can collapse and absorb the force. The bowel, however, which occupies most of the abdominal cavity, is prone to injury by penetrating trauma. In general, solid organs respond to trauma with bleeding. Hollow organs rupture and release their contents into the peritoneal cavity, causing inflammation and infection.

Stab wounds, impalements, and gunshot wounds can cause penetrating trauma. If the mechanism of penetrating trauma is from a stab wound, knowledge of the size, shape and length of the instrument used is helpful in determining the extent of intra-abdominal damage. Impalement is considered a “dirty” wound. “Dirty” wounds can result in high mortality secondary to the infection that is caused by bacterial contamination and subsequent multisystem organ failure. Gunshot wounds (missile injuries) are difficult to evaluate. The amount of major vessel disruption and multiple organ involvement are predictors of mortality. The velocity and amount of energy dispersed by the bullet often determines the extent of injury. A bullet can rebound off organs or bones, changing its trajectory and causing massive internal damage to organs and vessels. The blast effect from bullets can also cause significant intra-abdominal injury.

Abdominal trauma requires continual assessment. Unrecognized abdominal trauma is a frequent cause of preventable death.[7,29] The nurse must be organized and methodical in the approach to patient assessment. The nurse needs to understand the mechanism of injury as well as the patient's complaints to perform an adequate assessment and identify potentially life-threatening abdominal injuries.

Usually, a primary survey is completed and the patient is resuscitated before the abdomen is assessed. During the secondary survey, the abdomen is assessed and reassessed and laboratory and diagnostic tests are performed. An orogastric or nasogastric tube and a Foley catheter are placed during the secondary survey phase.

Diagnostic testing may include focused abdominal sonography for trauma, (FAST), diagnostic peritoneal lavage (DPL), a chest x-ray (to determine gross abnormalities as well as any organ displacement), and an abdominal CT scan. Many trauma centers are performing FAST on all trauma patients. This is a relatively quick examination that provides valuable information.[30] It is performed by placing an ultrasound probe over various areas on the abdomen to determine if free fluid is located in those areas. The areas evaluated are the Morison's pouch in the right upper quadrant, the pericardial sac, the splenorenal region in the left upper quadrant, and the pelvis (Douglas' pouch). If the results of FAST are positive and the patient is hemodynamically unstable, an exploratory laparotomy is performed.

A DPL is a quick diagnostic procedure that is used during the resuscitation phase of care in hemodynamically unstable trauma patients to diagnose intra-abdominal bleeding (Box 55-4). Other indications for use may include:

1. Unexplained hypotension, decreased hematocrit, or shock
2. Equivocal results of abdominal examination
3. Altered mental status caused by brain injury or alcohol or drug intoxication
4. Spinal cord injury
5. Distracting injuries, such as major orthopedic fractures or chest trauma[28]

If the results of DPL are positive and the patient is hemodynamically unstable, an exploratory laparotomy is performed.

There are several contraindications to performing a DPL. These include morbid obesity, third-trimester pregnancy, advanced cirrhosis, a history of coagulopathy, and a history of multiple abdominal surgeries.[28] There is an increased risk of omental laceration and visceral or vascular perforation if DPL is performed in patients with these findings.

When performing DPL, it is important to first ensure that the patient has a Foley catheter and an orogastric or nasogastric tube in place to decompress the stomach and the bladder. Decompression of the stomach and bladder guards against accidental perforation when the lavage catheter is placed. Once the Foley catheter and an orogastric or nasogastric tube are placed, the lavage catheter is inserted into the peritoneal space. If less than 10 mL of frank blood is returned, a liter bag of warm crystalloid (lactated Ringer's solution or 0.9% normal saline) is infused into the peritoneum. After the infusion is complete, the intravenous bag is placed in a dependent position to allow the fluid to exit the abdomen by gravity. A sample of the fluid is then sent to the laboratory for evaluation.

box 55-4
Diagnostic Peritoneal Lavage (DPL)

Indications

- Blunt abdominal injury with:
  - Altered mental status
  - Unexplained hypotension, decreased hematocrit, shock
  - Equivocal results of abdominal examination
  - Spinal cord injury
  - Distracting injuries (e.g., orthopedic fractures, chest trauma)
- Penetrating abdominal trauma (if exploration is not indicated)

Possible Contraindications

- History of multiple abdominal operations
- Third trimester pregnancy
- Advanced cirrhosis of the liver
- Morbid obesity
- Known history of coagulopathy

Technique

1. Insert lavage catheter into peritoneal cavity through 1- to 2-cm incision.
2. Attempt to aspirate peritoneal fluid.
3. Infuse normal saline or Ringer's lactate by gravity.
4. Turn patient from side to side (unless contraindicated).
5. Allow fluid to run back into bag by gravity.
6. Send specimens to laboratory.

Positive Results

- 10–20 mL gross blood on initial aspirate
- Greater than 100,000 red blood cells/mm^3
- Greater than 500 white blood cells/mm^3
- Elevated amylase level
- Presence of bile, bacteria, or fecal matter

CT scans are now being used more often in hemodynamically stable patients. Often, the CT scan is done with both intravenous and oral contrast to visualize the organs and note any disruption. The CT scan allows visualization of the peritoneal, retroperitoneal, and pelvic areas and permits estimation of the amount of fluid in these areas. CT scans are also used to grade solid organ injuries. Limitations to the use of CT include the amount of time required to perform the study, the need to transport the patient out of the resuscitation area, and the requirement that the patient must be hemodynamically stable and have limited movement during the study.

TRAUMA TO THE STOMACH AND SMALL BOWEL

Significant gastric injury is rare. Small bowel injuries are much more common. Although frequently damaged by penetrating trauma, the small bowel can also burst when subjected to blunt trauma. The multiple convolutions occasionally form a closed loop, which, when subjected to increased pressure caused by impact with a steering wheel or seatbelt, can rupture. The bowel's mobility around fixed points (such as the ligament of Treitz) predisposes it to shearing injuries with deceleration.

Blunt small bowel or gastric injury can present with blood in the nasogastric aspirate or hematemesis. Physical signs often are absent, and CT findings may be subtle and nonspecific. Close observation is required; often diagnosis is not made until peritonitis develops. Penetrating injuries usually cause positive results on DPL. Although a mild bowel contusion can be managed conservatively (gastric decompression and withholding oral intake), surgery usually is necessary to repair penetrating wounds or bowel rupture.

Postoperative decompression with a gastric tube is maintained until bowel function returns. In most cases, a feeding jejunostomy tube is placed distal to the repair site, and tube feedings can be initiated early in the postoperative course. As the concentration and rate of feedings are advanced slowly, frequent assessment for signs of intolerance (distension, vomiting) is essential.

Because the stomach and small bowel contain an insignificant amount of bacteria, the risk of sepsis is small after rupture of these organs. On the other hand, the acidic gastric juice is irritating to the peritoneum and may cause peritonitis. Potential complications related to stomach and small bowel trauma are listed in Box 55-5. Some of these conditions may necessitate additional surgical procedures.

TRAUMA TO THE DUODENUM AND PANCREAS

The pancreas and duodenum are discussed together because these retroperitoneal organs are closely related anatomically and physiologically. A great deal of force is necessary to injure these organs because they are well protected deep in the abdomen. Injuries to adjacent organs almost always are present. The retroperitoneal location makes these injuries difficult to diagnose with DPL. An abdominal CT scan is very useful in this instance. Signs and symptoms may include an acute abdomen, increased serum amylase levels, epigastric pain radiating to the back, nausea, and vomiting.

Small lacerations or contusions may require only the placement of drains, whereas larger wounds need surgical repair. Most pancreatic injuries require postoperative closed suction drainage to prevent fistula formation. Distal pancreatectomy and Roux-en-Y anastomosis are two procedures commonly performed for injuries to the body and tail of the pancreas. Occasionally, the spleen also must be removed owing to the multiple vascular attachments it has to the pancreas. Damage to the head of the pancreas is associated with duodenal injury and severe hemorrhage because of the close proximity of vascular structures. Surgical procedures used in these cases include pancreaticoduodenectomy, Roux-en-Y anastomosis, and, on rare occasions, total pancreatectomy.

Postoperative nursing assessment and care are similar for the various procedures. Patency of drains must be maintained and the patient must be monitored for the development of fistulas, the most common complication. Skin protection is important if a cutaneous fistula does develop because of the high enzyme content of pancreatic fluid. Assessment of fluid and electrolyte balance is also important because a pancreatic fistula results in fluid loss, along with loss of potassium and bicarbonate. Pancreatic stimulation can be decreased by administering parenteral hyperalimentation or jejunal feedings instead of an oral diet. The onset of diabetes mellitus is rare unless a total pancreatectomy is performed.

Primary repair or resection with reanastomosis is sufficient to manage most penetrating duodenal injuries. A duodenostomy tube may be placed for decompression and a jejunostomy tube for feeding. Blunt trauma to the duodenum can cause an intramural hematoma, which may lead to duodenal obstruction. The diagnosis is made with a diatrizoate (Gastrografin) upper gastrointestinal study. A complete obstruction usually requires surgical drainage of the hematoma.

box 55-5 ***Complications Related to Stomach and Small Bowel Trauma***

- Intolerance to tube feedings
- Peritonitis
- Postoperative bleeding
- Hypovolemia caused by "third-spacing"
- Development of a fistula or obstruction

TRAUMA TO THE COLON

Usually, colon injury results from penetrating trauma. The nature of the injury most often dictates surgical exploration (exploratory laparotomy). Primary repair is the treatment of choice for lacerations of the colon.[31] In some situations, such as injury to the left colon or when there is massive blood loss, an exteriorized repair or colostomy is required. A cecostomy tube may be placed for colon decompression. Subcutaneous tissue and skin of the incision site are often left open to decrease the chance of wound infection. The colon has a high bacteria count; spillage of the contents predisposes the patient to intra-abdominal sepsis and abscess formation.

Postoperative nursing care focuses on prevention of infection. Dressing changes are necessary for open incisions, and prophylactic antibiotics may be used. In the case of an exteriorized colon repair, resection and end-to-end anastomosis is performed, and the repair site is exteriorized to facilitate identification of a leak. The exteriorized colon must be kept moist and covered with a nonadherent dressing or bag to protect the integrity of the sutures. Because sepsis is a major complication of colon injuries, a series of radiographic and surgical procedures may be required to locate and drain abscesses.

A Teaching Guide for patients who have undergone a laparotomy can be found in Box 55-6.

TRAUMA TO THE LIVER

After the spleen, the liver is the most commonly injured abdominal organ. Both blunt and penetrating trauma can cause hepatic injuries. Fractures of the right lower ribs increase suspicion for a liver injury. Presenting signs and symptoms may include right upper quadrant pain, rebound

box 55-6
After a Laparotomy

Patient Activity

- No tub baths or showers while the staples/stitches are in place.
- If you are tired, rest.
- Only lift what you can easily lift with one hand.
- You may eat your normal diet.
- Take your temperature once a day at the same time and write it down.
- Maintain a normal schedule with your bowel movements.
- If you become constipated, drink more fruit juices.
- Do not drive until you have your doctor's permission.

Wound Care

- It is important to keep the staple/stitch line clean.
- Monitor your wound closely.
- Cleanse the area once a day. To do this, you will need 4″ × 4″ gauze pads and a solution of half peroxide/half saline.
- Wash your hands.
- Open the gauze pad and leave it on the paper.
- Pour a small amount of the peroxide/saline solution on the center of the pad while it is laying on the paper.
- Pick up the pad, pulling all four corners together without touching the center.
- Wipe over the stitches/staples from top to bottom, covering them well with the solution. It is normal to see bubbles when cleaning with this solution. Wipe the area only once with a single gauze pad.
- Repeat.
- Allow the area to dry.
- Tape a gauze pad over the stitch/staple line to prevent rubbing or irritation caused by a belt or waistband.

Signs of Infection

- Swelling around the site
- Increased redness
- Increased tenderness
- Warmth around the site
- Wound edges separating
- Increased drainage
- Foul-smelling drainage
- Change in color of drainage
- Temperature of 101°F or higher
- Vomiting, diarrhea, or constipation

tenderness, hypoactive or absent bowel sounds, or signs of hypovolemic shock.

Hemodynamically stable patients may be managed nonoperatively. In this case, serial CT scans are done to verify bleeding cessation. In many cases, however, the patient's unstable clinical condition dictates the need for surgery. Hepatic trauma can cause a large blood loss into the peritoneum, but bleeding may stop spontaneously. In some instances, bleeding vessels may be ligated or embolized. Small lacerations are repaired, whereas larger injuries may require segmental resection or debridement. In the case of uncontrollable hemorrhage, the liver is packed. After packing, the abdomen may be closed or simply covered and left open. An additional surgical procedure is required within the next few days to remove the packing and repair the laceration. Large liver injuries also need postoperative drainage of bile and blood with closed suction drains.

After surgery, coagulopathies may be present. Incomplete hemostasis also is a possibility and must be differentiated from coagulopathy-induced bleeding. Severe bleeding resulting from incomplete hemostasis requires clot removal, packing, and additional repair. With a coagulopathy, bleeding arises from numerous sites, whereas with incomplete hemostasis, the bleeding is mainly from the surgical site. Nursing care includes the replacement of blood products while monitoring the hematocrit and coagulation studies. Assessment of the character and amount of tube drainage, along with fluid balance, also is essential. Potential complications of liver injury include hepatic or perihepatic abscess, biliary obstruction or leak, sepsis, ARDS, and DIC.

TRAUMA TO THE SPLEEN

The spleen is the most commonly injured abdominal organ, usually as a result of blunt trauma. Presence of left lower rib fractures increases suspicion for a splenic injury. Presenting signs and symptoms include left upper quadrant pain radiating to the left shoulder (Kehr's sign), hypovolemic shock, and the nonspecific finding of an increased white blood cell count. DPL or abdominal CT is usually necessary for diagnosis.

Adults with minor injuries and most children are treated nonoperatively with observation (serial abdominal examinations, serial hematocrits) and gastric decompression. Because the spleen and stomach are both in the left upper quadrant, decompression of the stomach reduces pressure on the injured spleen. Preferred surgical treatment is splenorrhaphy, although in some cases splenectomy is necessary. Splenic autotransplantation, a fairly new procedure, consists of implanting splenic fragments into pockets of omentum after splenectomy. Splenic autotransplantation may be performed after severe injuries to retain the normal splenic immune functions.[32,33]

Early complications include recurrent bleeding, subphrenic abscess, and pancreatitis resulting from surgical trauma. Late complications consist of thrombocytosis and overwhelming postsplenectomy sepsis (OPSS). Because the spleen plays an important role in the body's response to infection, a splenectomy predisposes the patient to an increased risk for infection. This risk is especially high among children and highest in those younger than 2 years. *Pneumococcus*, an encapsulated microorganism resistant to phagocytosis, is the organism that most often infects patients after splenectomy. OPSS frequently begins with the onset of pneumococcal pneumonia, which progresses to a fulminant sepsis. Postsplenectomy patients can increase their immunity toward pneumococcal infections by receiving a polyvalent pneumococcal vaccine (Pneumovax). Complications of OPSS include adrenal insufficiency and DIC. OPSS has a high incidence and mortality rate, especially within 1 year of surgery. Patient and family teaching should focus on information about signs and symptoms of infection. Splenic autotransplantation may prove beneficial in decreasing the incidence of OPSS.

TRAUMA TO THE KIDNEYS

Injury to the kidney may lead to a "free" hemorrhage, contained hematoma, or the development of an intravascular thrombus. Sudden deceleration injury can cause the kidney to move, avulsing smaller renal vessels or tearing the renal artery intima, which also may lead to vessel thrombosis. Blunt and penetrating trauma can also cause a laceration or contusion of the renal parenchyma or rupture of the collecting system. Lower rib or lumbar vertebral fractures, along with liver and spleen injuries, should raise suspicion of an associated renal injury.[34] Signs and symptoms, when present, consist of hematuria, pain, a flank hematoma, or ecchymosis over the flank.[34] Because the bleeding is retroperitoneal, it can be difficult to detect. A helical CT scan, ultrasound, or an intravenous pyelogram (less commonly used) usually provides the diagnosis.

Renal injuries are classified based on their severity. Many renal injuries can be managed conservatively with observation and bed rest until gross hematuria resolves. However, in some instances (mainly for vascular injury), surgical repair or nephrectomy is necessary.

Postoperative assessment and support of renal function are imperative. Optimal fluid balance must be maintained. Low-dose dopamine may be ordered to promote renal perfusion. Major complications consist of arterial or venous thrombosis and acute renal failure. Other complications include bleeding, perinephric abscess, the development of a urinary fistula, and late onset of hypertension.

TRAUMA TO THE BLADDER

The bladder can be lacerated, ruptured, or contused, most often as the consequence of blunt trauma (usually because of a full bladder at the time of injury).[34] Bladder injuries frequently are associated with pelvic fractures. Gross hematuria is typically noted with bladder rupture. Presence of blood at the urethral meatus, a scrotal hematoma, or a displaced prostate gland requires examination for urethral injuries with a CT scan or conventional cystography before the insertion of a urinary catheter.[34]

A bladder injury can cause intraperitoneal or extraperitoneal urine extravasation. Extraperitoneal extravasation, usually associated with pelvic fractures, can often be managed with urinary catheter drainage. Intraperitoneal extravasation (associated with a high-force injury), however, requires surgery. This injury has a high mortality rate because of associated injuries that occur secondary to the force involved.[34] A suprapubic cystostomy tube may be placed. Complications are infrequent, but infection due to the urinary catheter or sepsis from extravasation of infected urine can occur. Patients may complain of an inability to void or of shoulder pain (caused by urine extravasation into the peritoneal space).

Musculoskeletal Injuries

Although musculoskeletal injuries take a long time to heal and can often result in lifelong disability, they are usually not considered life-threatening injuries unless there is a traumatic amputation or pelvic fracture. Routinely, the musculoskeletal assessment is done in the secondary survey after hemodynamic stabilization. These injuries do require prompt recognition and stabilization to promote optimal recovery and function.

There are approximately 33 million musculoskeletal injuries per year. This includes 20 million fractures, dislocations, and sprains, with approximately 8,000 deaths.[35] Although there are a variety of causes of trauma-related musculoskeletal injuries, the major ones include MVCs; falls; industrial, farming, and home accidents; and assaults. Musculoskeletal injuries are often associated with other injuries to the body.

It is important to understand the circumstances surrounding, and the mechanism involved in, musculoskeletal trauma. Force might be applied to one area but the transferred energy and distribution of force may cause injury somewhere else. For example, in a person who falls off a two-story building and lands on his or her feet, one would expect to find calcaneus or ankle fractures, but the transference of energy may also cause a pelvic or lumbar spine fracture. Obviously, if the patient is conscious, he or she can verbalize his or her pain. However, many times, fractures and sprains go unrecognized because the patient is not able to verbalize and communicate the location of his or her pain.

As in all trauma patients, initial assessment begins with the primary survey. Once this is complete and the patient is hemodynamically stable, the secondary assessment is conducted. When trauma patients are admitted to the resuscitation unit, cervical spine, chest, and pelvis films are obtained first. Sometimes thoracic and lumbar spine films are obtained, depending on the mechanism of injury. The initial pelvic film tells the nurse if the patient has a life-threatening pelvic fracture. If this is the case, immobilization of the pelvis should be maintained to prevent exsanguination. Immobilization of the pelvis is achieved with a C-clamp, external fixator, pelvic binder, or sheets wrapped tightly around the patient to attempt to stop the bleeding.

During the secondary survey, if limb swelling, ecchymosis, or deformity is noted, that extremity should be immobilized. Proper films are ordered to determine the extent of the injury. The nurse tests the extremities for capillary refill (less than 2 seconds is normal), pulses, crepitus, muscle spasm, movement, sensation, and pain.

The most common studies used to diagnose musculoskeletal injuries are plain x-rays, CT, and magnetic resonance imaging (MRI). When obtaining x-rays on a patient it is important to get two views of the affected area. It is also important to assess the joint above and below the injured area. If the affected area is in a place that is difficult to visualize on plain films, a CT scan usually gives a better picture. An MRI also gives more specific detail about the area surrounding the injury and about the injury itself.

There are many types of musculoskeletal injuries, including fractures, fracture–dislocations, amputations, and trauma to the soft tissue (i.e., skin, muscle, tendons, ligaments, and cartilage). Fracture classification is based on type, cause, and anatomical location.[36] Several fracture types are shown in Figure 55-5. If the skin is broken at the fracture site, the injury is considered to be an "open" fracture. If the skin is intact, the injury is said to be a "closed" fracture. An open fracture is further classified as grade I, II, or III, depending on the tissue damage involved.

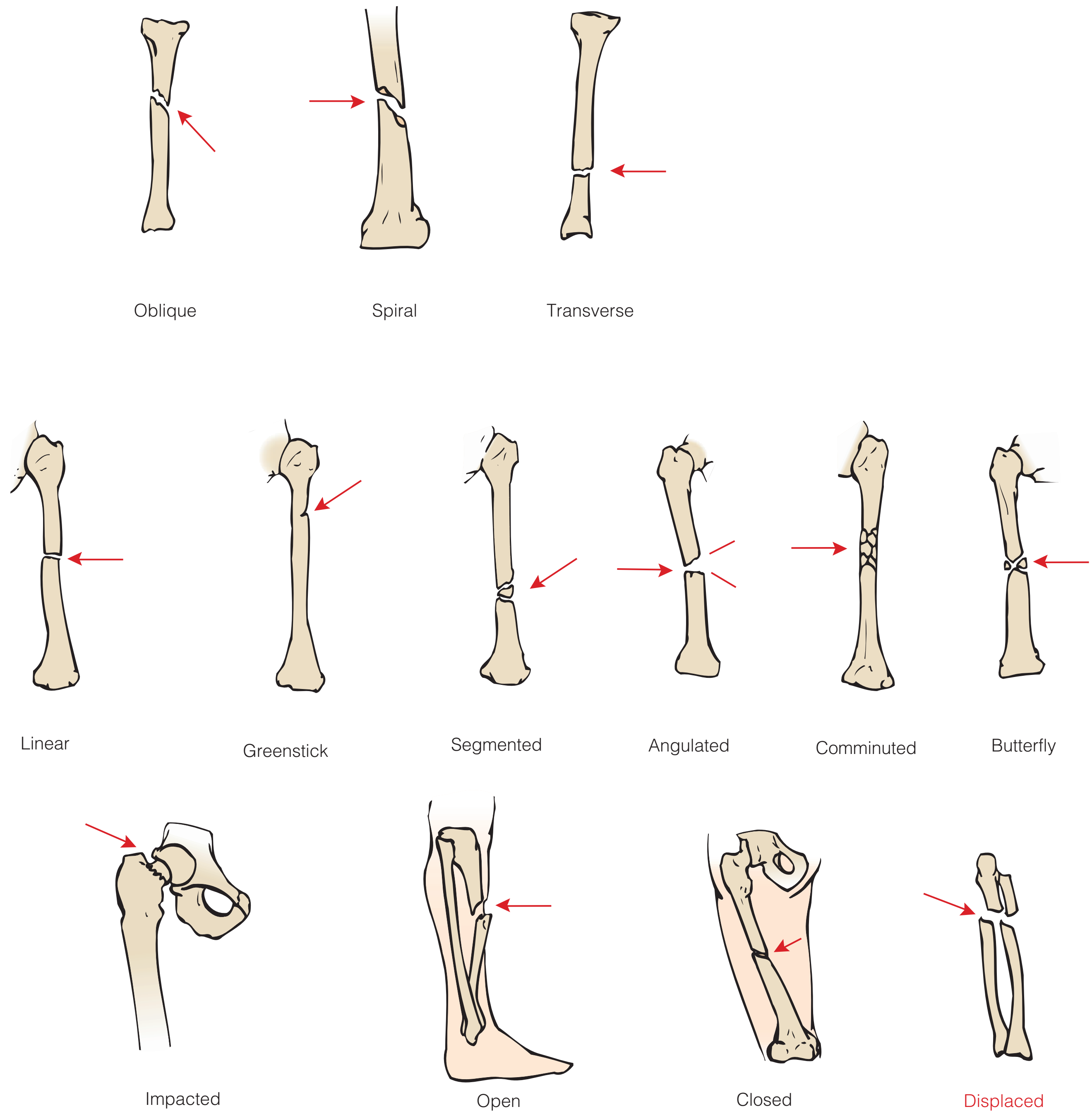

figure 55-5 There are many different types of fractures.

Dislocation occurs when the articulating surfaces of a joint are no longer in contact because of joint disruption. Joint mobility may be restricted. There may also be associated vascular or nerve injury with dislocations. Ligamentous injury usually accompanies dislocations because ligaments stretch or tear at the time of dislocation.

Amputations are classified according to the amount of tissue, nerve, and vascular damage. A cut or guillotine amputation has clean lines and well-defined edges, whereas a crush amputation has more soft tissue damage and the edges are not as well defined. An avulsion amputation occurs when a force stretches and tears away tissues, causing nerves and vessels to be torn in different areas than the bone.

As with any injury, musculoskeletal trauma requires continuous assessment. It is not uncommon for vascular or neurological compromise, or both, to develop in patients with musculoskeletal injury. Any musculoskeletal injury involving bone or soft tissue can cause neurological or vascular compromise because nerves and blood vessels are located in such close proximity to the bones and muscles. The nerves and muscles are very sensitive to impaired circulation and compression.

It is also important to continually assess the patient for hypovolemia. As stated earlier, traumatic amputation and major pelvic ring fractures are known for their extensive blood loss. Other orthopedic injuries can also cause substantial blood loss. Very rarely do patients sustain severe musculoskeletal injuries without other systemic injuries; therefore, other sources of blood loss should also be investigated.

Infection is common in open injuries. Ideally, patients with musculoskeletal trauma are brought to the operating room within 6 hours of injury for a washout of the affected area. Sometimes antibiotic prophylaxis is started; however, this practice is controversial. A tetanus booster is given if indicated to all patients with open injuries.

Other serious complications of musculoskeletal injuries include compartment syndrome, deep venous thrombosis (DVT), pulmonary embolus, and fat embolus syndrome.

COMPARTMENT SYNDROME

Compartment syndrome occurs when the pressure within the fascia-enclosed muscle compartment is increased, causing blood flow to the muscles and nerves in the compartment to become compromised, thereby resulting in tissue ischemia.[37] This ischemia then leads to tissue damage, which compromises nerve and muscle function. A prolonged elevation of compartmental pressure leads to death of the muscles and nerves involved.[38] Intracompartmental pressures that exceed 30 to 40 mm Hg can cause muscle ischemia, and pressures greater than 55 to 65 mm Hg cause irreversible muscle death.[37,38]

Patients with compartment syndrome complain of increased pain in the affected area. The pain is described as being "out of proportion" to the injury.[37,38] The most reliable early sign of compartment syndrome is decreased sensation.[37] The compartment involved is firm and the patient eventually has paresthesia. Pallor and pulselessness are late signs of compartment syndrome. When the compartment syndrome has progressed to the point that the patient is showing late signs, loss of the affected extremity is threatened. The nurse must constantly monitor the affected extremity and compare it with the nonaffected extremity. If any of the signs or symptoms of compartment syndrome are present, the orthopedic or general surgeon should be notified immediately so compartment pressures can be measured. If it is deemed that the compartment pressures are high, a fasciotomy is performed to release the pressure and save the extremity.

DEEP VENOUS THROMBOSIS

DVT is a significant risk for all trauma patients, especially those with musculoskeletal injuries. It is known as a "common, life threatening complication" of major trauma.[39] The danger of DVT is that it may progress to pulmonary embolus. The administration of low-dose heparin or low–molecular-weight heparin and the use of intermittent pneumatic compression devices are recommended to prevent DVT.[39]

The pathophysiology of DVT, and later pulmonary embolus, is related to Virchow's triad:

1. Venous stasis from decreased blood flow, decreased muscular activity, and external pressure on the deep veins
2. Vascular damage or concomitant pathological state
3. Hypercoagulability[35]

The nurse assesses for signs and symptoms of DVT on a regular basis. These include the presence of Homans' sign (calf pain on dorsiflexion of the foot), swelling of the affected area, tachycardia, fever, and distal skin color and temperature changes. If these signs or symptoms are found, they should be reported immediately. Sometimes an acute pulmonary embolus is the first indication of DVT.

PULMONARY EMBOLUS

A pulmonary embolus occurs when a blood clot dislodges from the vein, travels through the heart, and lodges in the pulmonary artery, obstructing blood flow. Sudden onset of dyspnea is the classic sign of a pulmonary embolus, but signs and symptoms vary, depending on the size of the clot and the number of vessels occluded. Signs and symptoms may include a decline in oxygenation, substernal chest pain, hypovolemic relative shock, tachypnea, shortness of breath, anxiety, a feeling of impending doom, a low-grade fever, an altered level of consciousness, and a pale, dusky, or cyanotic skin color.

FAT EMBOLISM SYNDROME

Fat emboli are fat globules in the lung tissue and peripheral circulation after a long bone fracture or major trauma.[40] Fat emboli may or may not cause systemic symptoms. Fat embolism syndrome is a serious (but rare) manifestation of fat emboli that involves progressive respiratory insufficiency, thrombocytopenia, and a decrease in mental status. It usually occurs within 72 hours of injury.[40] Clinical indications of this syndrome include tachypnea, dyspnea, cyanosis, tachycardia, and fever.[35,40] Nurses should be aware of the potential for fat embolism syndrome to develop and monitor the patient for hypoxemia with pulse oximetry. The patient's neurological status is also monitored for signs of a decreasing mental status.

Maxillofacial Trauma

Despite laws that mandate lower speed limits and the use of air bags and seat belts, the incidence of maxillofacial trauma remains high because the face is unprotected during rapid deceleration.[41,42] The degree of maxillofacial injury is directly related to the force at impact when the face makes contact with a stationary object. As the force increases, the amount of energy that is dispersed increases, causing an increase in injury. Penetrating injury is less common than blunt injury in patients with maxillofacial trauma.

As with any trauma patient, initial management priorities remain airway, breathing, and circulation. The trauma team cannot be distracted from these priorities by obvious deformities that may be associated with maxillofacial injuries. Maxillofacial trauma can cause airway obstruction and death if airway and breathing are not adequately and urgently established. When the primary survey is completed, an adequate assessment of the maxillofacial injuries is performed.

When assessing for maxillofacial injuries, soft tissues are assessed as well as bony structures. The face is inspected for symmetry and then palpated systematically to observe for any movement of bony structures. Cranial nerves are assessed. Often, maxillofacial injuries coincide with head injuries, reinforcing the importance of a thorough neurological examination (see Chapter 33). Any midface fractures that communicate through the orbit require a thorough ocular assessment and frequent reassessment.

Most maxillofacial injuries involve the soft tissue. In any soft tissue injury there is potential for contamination. Therefore, each patient's immunization to tetanus is assessed. If needed, a tetanus booster is given. All wounds are assessed for dirt, grease, particles, and other contaminants. Many wounds require an operation for washout to debride the tissue and clean the area. These injuries are usually not life-threatening and are treated in the appropriate order. However, even a small abrasion to a person's face can lead to a lifetime of disfigurement; therefore, all injuries must be attended to appropriately.

As stated earlier, in any type of trauma, but especially in maxillofacial trauma where the patient's airway may be compromised, it is imperative continuously to assess and maintain an adequate airway for the patient. Loss of an artificial airway (e.g., inadvertent removal of the endotracheal tube) can be life-threatening because of soft tissue swelling. It is also essential to assess for and treat hypovolemia secondary to hemorrhage from facial arteries. Epistaxis may also occur with any fracture that communicates with the nose. The nurse also continuously assesses the patient's neurological status and reports any abnormalities. The patient's pain and anxiety must be assessed and treated. Many patients with maxillofacial injuries are robbed of their senses. They may be unable to see, smell, taste, or speak secondary to their injury. This is an anxiety-provoking situation; patients require continuous reassurance and medication as necessary. Many maxillofacial injuries require multiple surgeries before the patient is definitively treated.

box 55-7 ***Delayed Complications of Multiple Trauma***

Hematologic
- Hemorrhage, coagulopathy, disseminated intravascular coagulation (DIC)

Cardiac
- Dysrhythmia, heart failure, ventricular aneurysm

Pulmonary
- Atelectasis, pneumonia, emboli (fat or thrombotic), acute respiratory distress syndrome (ARDS)

Gastrointestinal
- Peritonitis, adynamic ileus, mechanical bowel obstruction, acalculous cholecystitis, anastomotic leak, fistula, bleeding

Hepatic
- Liver abscess, liver failure

Renal
- Hypertension, myoglobinuria, renal failure

Orthopedic
- Compartment syndrome

Skin
- Wound infection, dehiscence, skin breakdown

Systemic
- Sepsis

COMPLICATIONS OF MULTIPLE TRAUMA

Complications associated with multiple trauma are numerous (Box 55-7). Because most trauma patients are in the intensive care unit when these complications develop, the nurse plays an essential role in detecting, preventing, and treating these sequelae.

The unexpected nature of trauma tends to amplify fear and anxiety. Therefore, nursing care must also provide psychosocial support for the seriously injured patient and his or her family. A multidisciplinary approach that recognizes concerns and offers frequent explanations is recommended. Special considerations for pediatric and older trauma patients can be found in Boxes 55-8 and 55-9, respectively.

Death after multiple traumatic injuries, when it occurs, may occur immediately, or it may occur as a result of early or late complications. Immediate deaths occur at the scene and within minutes of the injury. Most common causes of immediate deaths are brainstem or high spinal cord injury, cardiac rupture, transection of the great vessels, and airway obstruction.

Early Complications

Severe head injuries and hemorrhage are the early complications of multiple trauma most often responsible for causing death within hours of the injury, usually in the emergency department or operating room. Often, death at this stage can be prevented with quick assessment, resuscitation, and management of injuries.

Management of head injuries is discussed in Chapter 35. To prevent exsanguination, hemorrhage must be controlled and volume resuscitation begun with the infusion of crystalloids and blood. Patients may require emergent surgical ligation or packing, or embolization by angiography. Massive hemorrhage complicated by hypothermia, metabolic acidosis, and coagulopathy is highly lethal.

Late Complications

Late complications of multiple trauma include hypovolemic shock, infection and septic shock, ARDS, and multiple organ dysfunction syndrome (MODS).

HYPOVOLEMIC SHOCK

Massive hemorrhage or continued bleeding because of incomplete hemostasis or an undiagnosed injury can lead to hypovolemic shock and eventually decreased organ perfusion. The various organs respond differently to the decrease in perfusion caused by hypovolemia. Multiple blood transfusions are often necessary, further increasing the likelihood of ARDS and MODS.

INFECTION AND SEPTIC SHOCK

Another frequent and potentially serious complication of multiple trauma is infection. The risk of infection is increased after close-range shotgun blasts, high-velocity

box 55-8

Considerations for the Pediatric Patient With Trauma

General Principles

- Trauma is the leading cause of death in people between the ages of 1 and 19 years, with motor vehicle crashes being the leading cause.
- Blunt injury is more common then penetrating injury and should raise a high level of suspicion.
- The anatomy of a child is more vulnerable to traumatic injury:
  - *Head:* A child's head is proportionately larger in relation to body mass. Head injury is the most common cause of death in children.
  - *Chest:* A child's chest is more compliant than an adult's. Therefore, bony injuries are less common in children than in adults.
  - *Abdomen:* Liver and spleen injuries are most common in children, followed by bowel and pancreatic injuries. The kidney is less protected in children and often sustains more damage than the bladder and urethra, as seen in adults.
- When treating a child, it is extremely important to consider the entire family in the plan of care.
- When caring for a child, it is important to develop a trusting relationship. Involve the parents, offer a toy, speak to the child on his or her level, and protect the child.
- Children have a decreased reserve, compared with adults.
  - A child has a greater insensible water loss per unit of body weight (due to a larger surface area and an increased metabolic rate). Therefore, the child's fluid requirement is increased. A child's urine output should average 0.5 to 1 mL/kg/h.
  - A child experiences a rapid loss of body temperature secondary to increased surface area.
  - Shock is caused by hypoxia and blood loss. There is a small margin of error in treating shock in a child.
  - Hypovolemia occurs more rapidly in children. A child can compensate up to 25% of blood loss.

Primary Survey

- Airway: Use an uncuffed tube until the child is 7 years of age.
- Breathing: Watch for chest rise and fall.
- Circulation: Central and peripheral pulses are used to determine adequate circulation and capillary refill.
  - *Intraosseous infusion:* A bone marrow needle is inserted into the medial flat surface of the anterior tibia, approximately two fingerbreadths below the tibial tuberosity.
  - *Volume resuscitation:* 20 mL/kg × 1; if no response, give a second bolus. Volume resuscitation is guided by vital signs before and after infusion.

Adapted from Moloney-Harmon PA: Pediatric trauma. In McQuillan KA, Von Rueden KT, Hartsock RL, et al (eds): Trauma Nursing (3rd Ed), pp 747–771. Philadelphia, WB Saunders, 2002.

penetrating injuries, penetrating wounds to the colon, prolonged surgery, multiple blood transfusions, and injury to multiple organs. Other risk factors include advanced age, underlying immunosuppression, and a history of diabetes mellitus.

Infections can range from a minor wound infection to fulminant sepsis syndrome and septic shock. In septic shock, the release of toxins causes dilation of vessels, leading to venous pooling that results in a decreased venous return. Initially, cardiac output increases to compensate for decreased systemic vascular resistance. Eventually, the compensatory mechanisms fail, and cardiac output falls along with blood pressure and organ perfusion (i.e., septic shock).

The source of infection must be found and eradicated to treat sepsis effectively. The nurse must watch for the sometimes subtle indicators of sepsis. Hyperthermia or hypothermia and altered mental status are often present early in the septic process, as well as tachycardia, tachypnea, and an increase in the white blood cell count. These findings should prompt further assessment to detect a possible infectious source.

When sepsis is suspected, cultures are obtained, antibiotics are prescribed, radiological studies are done, and exploratory surgery frequently is performed. Intra-abdominal abscess is a frequent cause of sepsis. Some abscesses can be drained percutaneously, whereas others require surgery. After the surgical drainage of an abdominal abscess, the incision is left open with drains in place to allow healing and prevent recurrence. Other sources of infection are invasive lines, the urinary tract, and the lungs. Pneumonia is a common cause of sepsis in trauma patients. Risk factors for pneumonia include advanced age, aspiration, underlying pulmonary disease, thoracic or abdominal surgery, and prolonged intubation.

Hemodynamics are altered and metabolic demands are increased during sepsis. The typical patient exhibits elevated cardiac output, decreased systemic vascular resistance, and increased oxygen consumption. Hemodynamics must be supported and a balance between oxygen delivery and oxygen consumption maintained. Research suggests that early nutritional support decreases the development of sepsis and MODS. Enteral feeding should be used whenever possible because it is associated with a lower incidence of sepsis than total parenteral nutrition.

ACUTE RESPIRATORY DISTRESS SYNDROME

Sepsis may predispose the patient to ARDS (see Chapter 27). In addition to sepsis, specific injuries (e.g., head trauma, pulmonary contusion, multiple major fractures), massive blood transfusions, aspiration, and pneumonia can also increase the likelihood of ARDS. With a mortality rate of about 50% to 70%, ARDS is characterized by hypoxemia with shunting, decreased lung compliance, tachypnea, dyspnea, and the appearance of diffuse bilateral pulmonary infiltrates. The syndrome requires intensive ventilatory support with PEEP.[43,44] Oxygen delivery is assessed and supported.

box 55-9

Considerations for the Older Patient With Trauma

- By 2030, 20% of the United States population will be older than 65 years of age. This is the fastest-growing segment of our population.
- Trauma is the seventh most frequent cause of death in this population.
- The older person is injured less frequently than the younger person; however, when an older person does sustain injuries, the injuries are more likely to be life-threatening.
- The injuries occurring in this population tend to be less severe but are associated with a greater risk of death.
- Falls are the most prominent cause of trauma in the older person.
- Constant monitoring is essential with the older trauma patient.
- Providers should have a decreased threshold for invasive monitoring with this population, secondary to predisposing conditions and past medical history.
- Management considerations are as follows:
  - Consider cervical osteoarthritis when intubation is necessary.
  - Pain management should be more local if possible (e.g., epidural catheter, nerve block).
  - Fluid management should be done cautiously. This population requires adequate rapid fluid replacement without excess. Consider a pulmonary artery or central venous pressure line for guidance in fluid replacement.
  - This population tends to become hypothermic more quickly than the younger population.
  - Use warm fluid and warming devices as indicated.

Adapted from Atwell SL: Trauma in the elderly. In McQuillan KA, Von Rueden KT, Hartsock RL, et al (eds): Trauma Nursing (3rd Ed), pp 772–787. Philadelphia, WB Saunders, 2002.

MULTIPLE ORGAN DYSFUNCTION SYNDROME

More than 10% of critically injured patients experience MODS.[45] Many factors have been associated with the development of MODS, including hemorrhage, massive blood transfusion, hypovolemic shock, and sepsis. Characterized by the failure of two or more organs, MODS accounts for more than 50% of late deaths in trauma patients.[45] Usually the lungs are the first organs to fail (heralded by the onset of ARDS), followed by the liver, gastrointestinal tract, and kidneys.[46,47]

Liver failure can result from initial damage, vascular compromise, shock, or sepsis. Jaundice is a common indicator of deteriorating liver function, although other causes, such as post-traumatic biliary obstruction, must be ruled out. Liver function tests are diagnostic. Liver failure can lead to a decreased level of consciousness, abnormal clotting study results, and hypoglycemia (see Chapter 41).

Gastrointestinal failure manifests with hemorrhage from stress ulcers requiring blood transfusion. Prophylactic neutralization of gastric acid can minimize the risk of bleeding (see Chapter 41).

Renal failure can be precipitated by a renal injury, ischemia, radiographic contrast material, rhabdomyolysis, hypovolemia (due to hemorrhage, third spacing), or sepsis. Initial signs include increasing blood urea nitrogen (BUN) and serum creatinine levels. Renal failure may be polyuric or oliguric. Dialysis may be necessary (see Chapter 30).

Cardiovascular failure, DIC, metabolic changes (e.g., hyperglycemia, metabolic acidosis), and CNS changes, ranging from confusion to obtundation, also may be evident in MODS (see Chapter 49 for a discussion of DIC).

case study ■ MOTOR VEHICLE TRAUMA

A 35-year-old woman was admitted to the resuscitation unit after being struck by a motor vehicle. She arrived unresponsive, but the paramedics stated that eyewitnesses reported that the woman had landed on the windshield of the car after being thrown into the air by the impact. It was reported that she broke the windshield on impact. Her initial vital signs were as follows: blood pressure 70/50 mm Hg; pulse rate 120 beats/minute; respiratory rate 4 to 6 breaths/minute with assisted ventilation by Ambu bag. Her arterial oxygen saturation (SaO_2) was 85%.

The patient was urgently intubated and multiple x-rays and CT scans were obtained. These studies revealed a subarachnoid hemorrhage, pulmonary contusions, a ruptured bladder, a right acetabular fracture, bilateral upper extremity fractures, a right open humerus fracture, and possibly aortic injury. Despite multiple transfusions and fluid resuscitation, the patient was unable to sustain a systolic blood pressure greater than 90 mm Hg. She was then taken to angiography for further diagnosis and treatment of her injuries. It was determined that she did not have an aortic injury; however, her bladder rupture could not be repaired and the patient was transferred to the operating room for an emergent exploratory laparotomy and repair of her fractures.

After the operation, the patient was transferred to the multitrauma intensive care unit, where she was monitored continuously and maintained on mechanical ventilation. Her abdomen and right upper extremity were left open. Despite continuous monitoring and frequent transfusions, the patient remained hemodynamically unstable. A pulmonary artery catheter and arterial line were inserted for more invasive monitoring. Laboratory values were assessed every 6 hours and indicated a rising lactate level and decreasing hematocrit and hemoglobin.

During an assessment, the nurse noted an increased amount of drainage from the patient's right upper extremity wound. The dressing was removed and an arterial bleed was noted. After the application of direct pressure, the artery was cauterized and the wound redressed. The next set of laboratory values indicated a stable hematocrit and hemoglobin, but the lactate was unchanged and the patient remained unresponsive. It was also noted that the patient had an increased temperature and worsening lung sounds. The results of blood, sputum, urine, and wound cultures suggested that the patient was septic and antibiotics were initiated. A repeat head CT indicated a swollen brain with a new contusion.

After several days without improvement, the patient was removed from life support according to the wishes of her family, who felt that she would not want to be kept alive indefinitely by machines. ■

clinical applicability challenges

Self-Challenge: Critical Thinking

1. *Refer to the case study at the end of this chapter. What other information would have been helpful from the prehospital providers to ensure that this patient received the appropriate care on arrival to the resuscitation unit?*
2. *What complications should the nurse be aware of after a patient sustains the amount of force this patient received and requires this much fluid/blood resuscitation?*
3. *What are the concerns regarding end-of-life decisions, and what services should be provided to the family and the patient?*

Study Questions

1. *A 50-year-old man is admitted to the trauma resuscitation unit. He is intubated on arrival. What is the next step in the primary survey?*
   a. *Obtain a chest x-ray to determine tube placement.*
   b. *Listen to lung sounds to assess for ventilation.*
   c. *Assess the patient's blood pressure and peripheral pulses.*
   d. *Initiate large-bore intravenous catheter placement and replace fluid.*
2. *A patient is admitted to the emergency department after being involved in a motor vehicle crash (MVC). The patient was wearing a seat belt but the air bag did not deploy. What injuries should the nurse be looking for, given the circumstances of the accident?*
   a. *Head injuries*
   b. *Pleural space injuries*
   c. *Abdominal injuries*
   d. *All of the above*
3. *In what phase of care would the health care provider listen for bowel sounds?*
   a. *Primary survey*
   b. *Secondary survey*
   c. *Definitive care*
   d. *Resuscitation*
4. *A patient presents to the intensive care unit after an exploratory laparotomy related to trauma. The patient is hypotensive and tachycardic. This is most likely due to which of the following?*
   a. *Hypovolemia*
   b. *Pain*
   c. *Hypothermia*
   d. *All of the above*
5. *A 40-year-old woman is involved in an equestrian accident. She presents with chest pain, shortness of breath, and difficulty breathing. Her arterial oxygen saturation (Sa_{O_2}) is 85% and her respiratory rate is 40 breaths/minute. A 40-French chest tube is placed and the nurse observes a return of 300 mL blood into the system. What is the nurse's next step?*
   a. *Clamp the chest tube and notify the surgeon immediately.*
   b. *Call for a chest x-ray.*
   c. *Place the patient on oxygen.*
   d. *Explain to the patient what is happening to decrease her anxiety.*
6. *A 16-year-old is admitted to the floor after a football injury. The patient has a femur fracture. An external fixation device was applied in the operating room. This patient is at an increased risk for developing which of the following?*
   a. *Deep venous thrombosis (DVT)*
   b. *Post-traumatic stress disorder*
   c. *Pulmonary embolism*
   d. *None of the above*

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