5 ABDOMINAL AND PELVIC TRAUMA

When uncontrolled or unrecognized, blood loss from abdominal and pelvic injuries can result in preventable death.

CHAPTER 5 OUTLINE

OBJECTIVES

After reading this chapter and comprehending the knowledge components of the ATLS provider course, you will be able to:

1. Identify the anatomic regions of the abdomen that are critical in assessing and managing trauma patients.
2. Recognize a patient who is at risk for abdominal and pelvic injuries based on the mechanism of injury.
3. Identify patients who require surgical consultation and possible surgical and/or catheter-based intervention.
4. Use the appropriate diagnostic procedures to determine if a patient has ongoing hemorrhage and/or other injuries that can cause delayed morbidity and mortality.
5. Describe the acute management of abdominal and pelvic injuries.

The assessment of circulation during the primary survey includes early evaluation for possible intra-abdominal and/or pelvic hemorrhage in patients who have sustained blunt trauma. Penetrating torso wounds between the nipple and perineum must be considered as potential causes of intraperitoneal injury. The mechanism of injury, injury forces, location of injury, and hemodynamic status of the patient determine the priority and best method of abdominal and pelvic assessment.

Unrecognized abdominal and pelvic injuries continue to cause preventable death after truncal trauma. Rupture of a hollow viscus and bleeding from a solid organ or the bony pelvis may not be easily recognized. In addition, patient assessment is often compromised by alcohol intoxication, use of illicit drugs, injury to the brain or spinal cord, and injury to adjacent structures such as the ribs and spine. Significant blood loss can be present in the abdominal cavity without a dramatic change in the external appearance or dimensions of the abdomen and without obvious signs of peritoneal irritation. Any patient who has sustained injury to the torso from a direct blow, deceleration, blast, or penetrating injury must be considered to have an abdominal visceral, vascular, or pelvic injury until proven otherwise.

ANATOMY OF THE ABDOMEN

A review of the anatomy of the abdomen, with emphasis on structures that are critical in assessment and management of trauma patients, is provided in (■ FIGURE 5-1).

The abdomen is partially enclosed by the lower thorax. The *anterior abdomen* is defined as the area between the costal margins superiorly, the inguinal ligaments and symphysis pubis inferiorly, and the anterior axillary lines laterally. Most of the hollow viscera are at risk when there is an injury to the anterior abdomen.

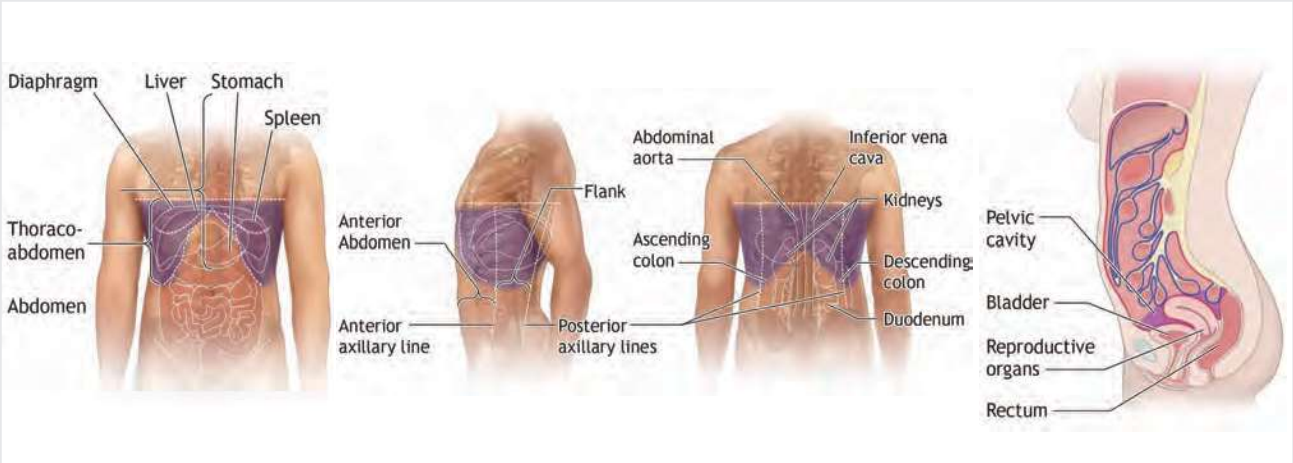
The *thoracoabdomen* is the area inferior to the nipple line anteriorly and the infrascapular line posteriorly, and superior to the costal margins. This area encompasses the diaphragm, liver, spleen, and stomach, and is somewhat protected by the bony thorax. Because the diaphragm rises to the level of the fourth intercostal space during full expiration, fractures of the lower ribs and penetrating wounds below the nipple line can injure the abdominal viscera.

The *flank* is the area between the anterior and posterior axillary lines from the sixth intercostal space to the iliac crest.

The *back* is the area located posterior to the posterior axillary lines from the tip of the scapulae to the iliac crests. This includes the posterior thoracoabdomen. Musculature in the flank, back, and paraspinal region acts as a partial protection from visceral injury.

The flank and back contain the *retroperitoneal space*. This potential space is the area posterior to the peritoneal lining of the abdomen. It contains the abdominal aorta; inferior vena cava; most of the duodenum, pancreas, kidneys, and ureters; the posterior aspects of the ascending colon and descending colon; and the retroperitoneal components of the pelvic cavity. Injuries to the retroperitoneal visceral structures are difficult to recognize because they occur deep within the abdomen and may not initially present with signs or symptoms of peritonitis. In addition, the retroperitoneal space is not sampled by diagnostic peritoneal lavage (DPL) and is poorly visualized with focused assessment with sonography for trauma (FAST).

The *pelvic cavity* is the area surrounded by the pelvic bones, containing the lower part of the retroperitoneal and intraperitoneal spaces. It contains the rectum,



■ FIGURE 5-1 **Anatomy of the Abdomen. A.** Anterior abdomen and thoraco-abdomen. **B.** Flank. **C.** Back. **D.** Pelvic Cavity.

bladder, iliac vessels, and female internal reproductive organs. Significant blood loss can occur from injuries to organs within the pelvis and/or directly from the bony pelvis.

MECHANISM OF INJURY

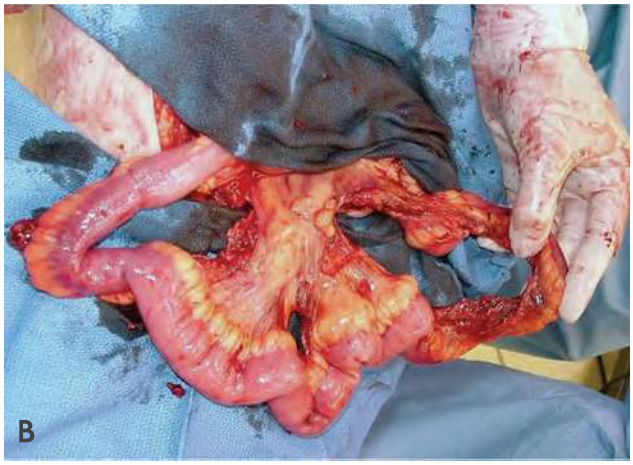
Consideration of the mechanism of injury facilitates the early identification of potential injuries, directs which diagnostic studies may be necessary for evaluation, and identifies the potential need for patient transfer. Common injuries from blunt and penetrating trauma are described in this section.

BLUNT

A *direct blow*, such as contact with the lower rim of a steering wheel, bicycle or motorcycle handlebars, or an intruded door in a motor vehicle crash, can cause compression and crushing injuries to abdominopelvic viscera and pelvic bones. Such forces deform solid and hollow organs and can cause rupture with secondary hemorrhage and contamination by visceral contents, leading to associated peritonitis.

Shearing injuries are a form of crush injury that can result when a restraint device is worn inappropriately (■ FIGURE 5-2A). Patients injured in motor vehicle crashes and who fall from significant heights may sustain *deceleration injuries*, in which there is a differential movement of fixed and mobile parts of the body. Examples include lacerations of the liver and spleen, both movable organs that are fixed at the sites of their supporting ligaments. Bucket handle injuries to the small bowel are also examples of deceleration injuries (■ FIGURE 5-2B).

In patients who sustain blunt trauma, the organs most frequently injured are the spleen (40% to 55%), liver (35% to 45%), and small bowel (5% to 10%). Additionally, there is a 15% incidence of retroperitoneal hematoma in patients who undergo laparotomy for blunt trauma. Although restraint devices reduce the incidence of many more major injuries, they are associated with specific patterns of injury, as shown in ■ TABLE 5-1. Air-bag deployment does not preclude abdominal injury.



■ **FIGURE 5-2 Lap Belt and Bucket Handle Injuries. A.** Injuries may be more likely when a restraint device is not in the optimal position. **B.** Small bowel "bucket handle" injury.

PENETRATING

Stab wounds and low-energy gunshot wounds cause tissue damage by lacerating and tearing. High-energy gunshot wounds transfer more kinetic energy, causing increased damage surrounding the track of the missile due to temporary cavitation.

Stab wounds traverse adjacent abdominal structures and most commonly involve the liver (40%), small bowel (30%), diaphragm (20%), and colon (15%) (■ FIGURE 5-3).

Gunshot wounds can cause additional intra-abdominal injuries based on the trajectory, cavitation effect, and possible bullet fragmentation. Gunshot wounds most commonly injure the small bowel (50%), colon (40%), liver (30%), and abdominal vascular structures (25%). The type of weapon, the muzzle velocity, and type of ammunition are important determinants of degree of tissue injury. In the case of shotguns, the distance between the shotgun and the patient determines the severity of injuries incurred.

BLAST

Blast injury from explosive devices occurs through several mechanisms, including penetrating fragment

TABLE 5-1 INJURIES ASSOCIATED WITH RESTRAINT DEVICES

RESTRAINT DEVICE	INJURY
Lap Seat Belt • Compression • Hyperflexion	• Tear or avulsion of bowel mesentery (bucket handle) • Rupture of small bowel or colon • Thrombosis of iliac artery or abdominal aorta • Chance fracture of lumbar vertebrae • Pancreatic or duodenal injury
Shoulder Harness • Sliding under the seat belt ("submarining") • Compression	• Rupture of upper abdominal viscera • Intimal tear or thrombosis in innominate, carotid, subclavian, or vertebral arteries • Fracture or dislocation of cervical spine • Rib fractures • Pulmonary contusion
Air Bag • Contact • Contact/deceleration • Flexion (unrestrained) • Hyperextension (unrestrained)	• Face and eye abrasions • Cardiac Injuries • Spine fractures

■ **FIGURE 5-3** Stab wounds most commonly injure the liver, small bowel, diaphragm, and colon.

wounds and blunt injuries from the patient being thrown or struck by projectiles. The treating doctor must consider the possibility of combined penetrating and blunt mechanisms in these patients. Patients close to the source of the explosion can incur additional injuries to the tympanic membranes, lungs, and bowel related to blast overpressure. These injuries may have delayed presentation. The potential for overpressure injury following an explosion should not distract the clinician from a systematic approach to identifying and treating blunt and penetrating injuries.

PITFALL	PREVENTION
Missed abdominal injury	• Understand the role that mechanism of injury plays in abdominal injury. Do not underestimate the extent of energy delivered to the abdomen in blunt trauma. • Recognize that small, low-energy wounds (e.g., stab and fragment wounds) can cause visceral and/or vascular injuries. • Perform frequent abdominal reevaluation, as a single examination does not completely eliminate the presence of injury. • High-energy projectiles can produce injuries tangential to the path of the missile. • Missile trajectories can be altered by tumbling or creation of a secondary path after striking bone or fragmenting. This can result in remote injuries (compared with cutaneous wounds).

ASSESSMENT AND MANAGEMENT

In hypotensive patients, the goal is to rapidly identify an abdominal or pelvic injury and determine whether it is the cause of hypotension. The patient history, physical exam, and supplemental diagnostic tools

can establish the presence of abdominal and pelvic injuries that require urgent hemorrhage control. Hemodynamically normal patients without signs of peritonitis may undergo a more detailed evaluation to determine the presence of injuries that can cause delayed morbidity and mortality. This evaluation must include repeated physical examinations to identify any signs of bleeding or peritonitis that may develop over time.

HISTORY

When assessing a patient injured in a motor vehicle crash, pertinent historical information includes the vehicle speed, type of collision (e.g., frontal impact, lateral impact, sideswipe, rear impact, or rollover), any intrusion into the passenger compartment, types of restraints, deployment of air bags, patient position in the vehicle, and status of other occupants. For patients injured by falling, the height of the fall is important historical information due to the increased potential for deceleration injury at greater heights. The patient, other vehicle occupants, witnesses, law enforcement, and emergency medical personnel may be able to provide historical information. Prehospital care providers should supply data regarding vital signs, obvious injuries, and patient response to prehospital treatment.

When assessing a patient who has sustained penetrating trauma, pertinent historical information includes the time of injury, type of weapon (e.g., knife, handgun, rifle, or shotgun), distance from the assailant (particularly important with shotgun wounds, as the likelihood of major visceral injuries decreases beyond the 10-foot or 3-meter range), number of stab wounds or gunshots sustained, and the amount of external bleeding noted at the scene. Important additional information to obtain from the patient includes the magnitude and location of abdominal pain.

Explosions can produce visceral overpressure injuries. The risk increases when the patient is in close proximity to the blast and when a blast occurs within a closed space.

PHYSICAL EXAMINATION

The abdominal examination is conducted in a systematic sequence: inspection, auscultation, percussion, and palpation. This is followed by examination of the pelvis and buttocks, as well as; urethral, perineal, and, if indicated, rectal and vaginal exams. The findings, whether positive or negative, should be completely documented in the patient's medical record.

Inspection, Auscultation, Percussion, and Palpation

In most circumstances, the patient must be fully undressed to allow for a thorough inspection. During the inspection, examine the anterior and posterior abdomen, as well as the lower chest and perineum, for abrasions and contusions from restraint devices, lacerations, penetrating wounds, impaled foreign bodies, evisceration of omentum or bowel, and the pregnant state.

Inspect the flank, scrotum, urethral meatus, and perianal area for blood, swelling, and bruising. Laceration of the perineum, vagina, rectum, or buttocks may be associated with an open pelvic fracture in blunt trauma patients. Skin folds in obese patients can mask penetrating injuries and increase the difficulty of assessing the abdomen and pelvis. For a complete back examination, cautiously logroll the patient. (See *Logroll video on MyATLS mobile app.*)

At the conclusion of the rapid physical exam, cover the patient with warmed blankets to help prevent hypothermia.

Although auscultation is necessary, the presence or absence of bowel sounds does not necessarily correlate with injury, and the ability to hear bowels sounds may be compromised in a noisy emergency department.

Percussion causes slight movement of the peritoneum and may elicit signs of peritoneal irritation. When rebound tenderness is present, do not seek additional evidence of irritation, as it may cause the patient further unnecessary pain.

Voluntary guarding by the patient may make the abdominal examination unreliable. In contrast, involuntary muscle guarding is a reliable sign of peritoneal irritation. Palpation may elicit and distinguish superficial (i.e., abdominal wall) and deep tenderness. Determine whether a pregnant uterus is present and, if so, estimate the fetal age.

Pelvic Assessment

Major pelvic hemorrhage can occur rapidly, and clinicians must make the diagnosis quickly so they can initiate appropriate resuscitative treatment. Unexplained hypotension may be the only initial indication of major pelvic disruption. Mechanical instability of the pelvic ring should be assumed in patients who have pelvic fractures with hypotension and no other source of blood loss. Placement of a pelvic binder is a priority and may be lifesaving in this circumstance.

Physical exam findings suggestive of pelvic fracture include evidence of ruptured urethra

(scrotal hematoma or blood at the urethral meatus), discrepancy in limb length, and rotational deformity of a leg without obvious fracture. In these patients, avoid manually manipulating the pelvis, as doing so may dislodge an existing blood clot and cause further hemorrhage.

Gentle palpation of the bony pelvis for tenderness may provide useful information about the presence of pelvic fracture. Distraction of the pelvis is not recommended during the early assessment of injuries because it may worsen or cause recurrent pelvic bleeding.

The mechanically unstable hemipelvis migrates cephalad because of muscular forces and rotates outward secondary to the effect of gravity on the unstable hemipelvis. External rotation of the unstable pelvis results in an increased pelvic volume that can accommodate a larger volume of blood. The pelvis can be stabilized with a binder or sheet to limit this expansion. The binder should be centered over the greater trochanters rather than over the iliac crests. The presence of lower-extremity neurologic abnormalities or open wounds in the flank, perineum, vagina, or rectum may be evidence of pelvic-ring instability. An anteroposterior (AP) x-ray of the pelvis is a useful adjunct to identify a pelvic fracture, given the limitations of clinical examination. (See Appendix G: Circulation Skills.)

PITFALL	PREVENTION
Repeated manipulation of a fractured pelvis can aggravate hemorrhage.	• Gentle palpation of the bony pelvis may provide useful information about the presence of pelvic fractures; avoid multiple examinations and distraction of the pelvis. • Apply a pelvic binder correctly and early to limit hemorrhage.
Skin folds in obese patients can mask penetrating injuries and increase the difficulty of abdominal and pelvic assessment.	• Examine skin folds for wounds, foreign bodies, and injuries.
The abdominal examination of pediatric patients may be difficult to interpret.	• Use diagnostic studies (e.g., FAST, CT or other imaging) as needed to assess equivocal findings.

Urethral, Perineal, Rectal, Vaginal, and Gluteal Examination

The presence of blood at the urethral meatus strongly suggests a urethral injury. Ecchymosis or hematoma of the scrotum and perineum is also suggestive of urethral injury, although these signs may be absent immediately after injury. In patients who have sustained blunt trauma, the goals of the rectal examination are to assess sphincter tone and rectal mucosal integrity and to identify any palpable fractures of the pelvis. Palpation of the prostate gland is not a reliable sign of urethral injury. In patients with penetrating wounds, the rectal examination is used to assess sphincter tone and look for gross blood, which may indicate a bowel perforation. Do not place a urinary catheter in a patient with a perineal hematoma or blood at the urethral meatus before a definitive assessment for urethral injury.

Bony fragments from pelvic fracture or penetrating wounds can lacerate the vagina. Perform a vaginal exam when injury is suspected, such as in the presence of complex perineal laceration, pelvic fracture, or trans-pelvic gunshot wound. In unresponsive menstruating women, examine the vagina for the presence of tampons; left in place, they can cause delayed sepsis.

The gluteal region extends from the iliac crests to the gluteal folds. Penetrating injuries to this area are associated with up to a 50% incidence of significant intra-abdominal injuries, including rectal injuries below the peritoneal reflection. These wounds mandate an evaluation for such injuries.

ADJUNCTS TO PHYSICAL EXAMINATION

After diagnosing and treating problems with a patient's airway, breathing, and circulation, clinicians frequently insert gastric tubes and urinary catheters as adjuncts to the primary survey.

Gastric Tubes and Urinary Catheters

The therapeutic goals of a gastric tube placed early in the primary survey include relief of acute gastric dilation and stomach decompression before performing DPL (if needed). Gastric tubes may reduce the incidence of aspiration in these cases. However, they can trigger vomiting in a patient with an active gag reflex. The presence of blood in the gastric contents suggests an injury to the esophagus or upper gastrointestinal tract if nasopharyngeal and/or oropharyngeal sources are excluded. If a patient has severe facial fractures or possible basilar skull fracture, insert the gastric tube through the mouth to prevent passage

of the nasal tube through the cribriform plate into the brain.

A urinary catheter placed during resuscitation will relieve retention, identify bleeding, allow for monitoring of urinary output as an index of tissue perfusion, and decompress the bladder before DPL (if performed). A full bladder enhances the pelvic images of the FAST. Therefore, if FAST is being considered, delay placing a urinary catheter until after the test is completed. Gross hematuria is an indication of trauma to the genitourinary tract, including the kidney, ureters, and bladder. The absence of hematuria does not exclude an injury to the genitourinary tract. A retrograde urethrogram is mandatory when the patient is unable to void, requires a pelvic binder, or has blood at the meatus, scrotal hematoma, or perineal ecchymosis. To reduce the risk of increasing the complexity of a urethral injury, confirm an intact urethra before inserting a urinary catheter. A disrupted urethra detected during the primary or secondary survey may require insertion of a suprapubic tube by an experienced doctor.

PITFALL	PREVENTION
In a patient with midface fractures, a nasogastric tube can pass into the sinuses and cranial cavity.	• Avoid a nasogastric tube in patients with midface injury; instead use an orogastric tube.
Pediatric patients have high rates of acute gastric distention following trauma.	• A gastric tube may be beneficial in pediatrics patients to reduce the risks of aspiration and vagal stimulation.
Passage of a gastric tube may be impossible in patients with hiatal hernias (more common in older adults).	• To avoid iatrogenic injury, do not continue to attempt nasogastric tube placement if several attempts are unsuccessful. Eventual placement may require radiologic or other assistance.

Other Studies

With preparation and an organized team approach, the physical examination can be performed very quickly. In patients with hemodynamic abnormalities, rapid exclusion of intra-abdominal hemorrhage is necessary and can be accomplished with either FAST or DPL. The only contraindication to these studies is an existing indication for laparotomy.

Patients with the following findings require further abdominal evaluation to identify or exclude intra-abdominal injury:

- Altered sensorium
- Altered sensation
- Injury to adjacent structures, such as lower ribs, pelvis, and lumbar spine
- Equivocal physical examination
- Prolonged loss of contact with patient anticipated, such as general anesthesia for extraabdominal injuries or lengthy radiographic studies
- Seat-belt sign with suspicion of bowel injury

When intra-abdominal injury is suspected, a number of studies can provide useful information. However, when indications for patient transfer already exist, do not perform time-consuming tests, including abdominal CT. ■ **TABLE 5-2** summarizes the indications, advantages, and disadvantages of using DPL, FAST, and CT in evaluating blunt abdominal trauma.

X-rays for Abdominal Trauma

An AP chest x-ray is recommended for assessing patients with multisystem blunt trauma. Hemodynamically abnormal patients with penetrating abdominal wounds do not require screening x-rays in the emergency department (ED). If the patient is hemodynamically normal and has penetrating trauma above the umbilicus or a suspected thoracoabdominal injury, an upright chest x-ray is useful to exclude an associated hemothorax or pneumothorax, or to determine the presence of intraperitoneal air. With radiopaque markers or clips applied to all entrance and exit wounds, a supine abdominal x-ray may be obtained in hemodynamically normal penetrating trauma patients to demonstrate the path of the missile and determine the presence of retroperitoneal air. Obtaining two views (i.e., AP and lateral) may allow for spatial orientation of foreign bodies. An AP pelvic x-ray may help to establish the source of blood loss in hemodynamically abnormal patients and in patients with pelvic pain or tenderness. An alert, awake patient without pelvic pain or tenderness does not require a pelvic radiograph.

TABLE 5-2 COMPARISON OF DPL, FAST, AND CT IN ABDOMINAL TRAUMA

	DPL	FAST	CT SCAN
Advantages	• Early operative determination • Performed rapidly • Can detect bowel injury • No need for transport from resuscitation area	• Early operative determination • Noninvasive • Performed rapidly • Repeatable • No need for transport from resuscitation area	• Anatomic diagnosis • Noninvasive • Repeatable • Visualizes retroperitoneal structures • Visualizes bony and soft-tissue structures • Visualizes extraluminal air
Disadvantages	• Invasive • Risk of procedure-related injury • Requires gastric and urinary decompression for prevention of complications • Not repeatable • Interferes with interpretation of subsequent CT or FAST • Low specificity • Can miss diaphragm injuries	• Operator-dependent • Bowel gas and subcutaneous air distort images • Can miss diaphragm, bowel, and pancreatic injuries • Does not completely assess retroperitoneal structures • Does not visualize extraluminal air • Body habitus can limit image clarity	• Higher cost and longer time • Radiation and IV contrast exposure • Can miss diaphragm injuries • Can miss some bowel and pancreatic injuries • Requires transport from resuscitation area
Indications	• Abnormal hemodynamics in blunt abdominal trauma • Penetrating abdominal trauma without other indications for immediate laparotomy	• Abnormal hemodynamics in blunt abdominal trauma • Penetrating abdominal trauma without other indications for immediate laparotomy	• Normal hemodynamics in blunt or penetrating abdominal trauma • Penetrating back/flank trauma without other indications for immediate laparotomy

Focused Assessment with Sonography for Trauma

When performed by properly trained individuals, FAST is an accepted, rapid, and reliable study for identifying intraperitoneal fluid (■ FIGURE 5-4). It has the advantage of being repeatable and can also detect pericardial tamponade, one of the nonhypovolemic causes of hypotension.

FAST includes examination of four regions: the pericardial sac, hepatorenal fossa, splenorenal fossa, and pelvis or pouch of Douglas (■ FIGURE 5-5A). After doing an initial scan, clinicians may perform a single or multiple repeat scans to detect progressive hemoperitoneum (■ FIGURE 5-5B). FAST can be performed at the bedside in the resuscitation room at the same time other diagnostic or therapeutic procedures are performed. See *Appendix G: Circulation Skills*, and *FAST video on MyATLS mobile app.*

PITFALL	PREVENTION
False-negative FAST examination	• Recognize that obesity can degrade images obtained with FAST. • Maintain a high index of suspicion. • Use alternative diagnostic testing and/or repeat evaluation(s). • Recognize that FAST is insensitive for the diagnosis of hollow visceral injury.

Diagnostic Peritoneal Lavage

DPL is another rapidly performed study to identify hemorrhage (■ FIGURE 5-6). Because it can significantly alter subsequent examinations of the patient, the surgical team caring for the patient should perform the DPL. Note that DPL requires gastric and urinary decompression for prevention of complications. The technique is most useful in patients who are hemodynamically abnormal with blunt abdominal trauma or in penetrating trauma patients with multiple cavitary or apparent tangential trajectories. Finally,

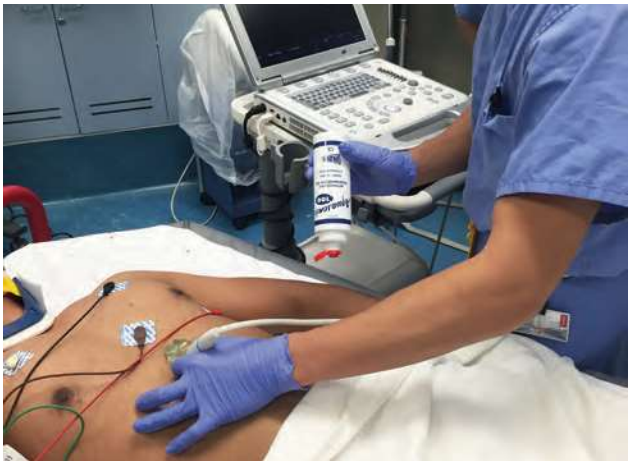


FIGURE 5-4 Focused Assessment with Sonography for Trauma (FAST). In FAST, ultrasound technology is used to detect the presence of hemoperitoneum.

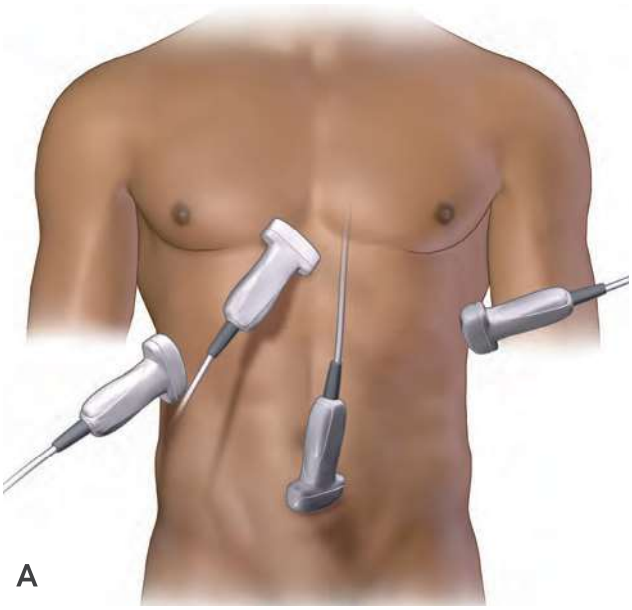


FIGURE 5-5 A. Probe locations. **B.** FAST image of the right upper quadrant showing the liver, kidney, and free fluid.

FIGURE 5-6 Diagnostic Peritoneal Lavage (DPL). DPL is a rapidly performed, invasive procedure that is sensitive for the detection of intraperitoneal hemorrhage.

hemodynamically normal patients who require abdominal evaluation in settings where FAST and CT are not available may benefit from the use of DPL. In settings where CT and/or FAST are available, DPL is rarely used because it is invasive and requires surgical expertise.

Relative contraindications to DPL include previous abdominal operations, morbid obesity, advanced cirrhosis, and preexisting coagulopathy. An open, semi-open, or closed (Seldinger) infraumbilical technique is acceptable in the hands of trained clinicians. In patients with pelvic fractures, an open supraumbilical approach is preferred to avoid entering an anterior pre-peritoneal pelvic hematoma. In patients with advanced pregnancy, use an open supraumbilical approach to avoid damaging the enlarged uterus. Aspiration of gastrointestinal contents, vegetable fibers, or bile through the lavage catheter mandates laparotomy. Aspiration of 10 cc or more of blood in hemodynamically abnormal patients requires laparotomy. (See *Appendix G: Circulation Skills*.)

Computed Tomography

CT is a diagnostic procedure that requires transporting the patient to the scanner (i.e., removing the patient from the resuscitation area), administering IV contrast, and radiation exposure. CT is a time-consuming (although less so with modern CT scanners) procedure that should be used only in hemodynamically normal patients in whom there is no apparent indication for an emergency laparotomy. Do not perform CT scanning if it delays transfer of a patient to a higher level of care.

CT scans provide information relative to specific organ injury and extent, and they can diagnose

retroperitoneal and pelvic organ injuries that are difficult to assess with a physical examination, FAST, and DPL. Relative contraindications for using CT include a delay until the scanner is available, an uncooperative patient who cannot be safely sedated, and allergy to the contrast agent. CT can miss some gastrointestinal, diaphragmatic, and pancreatic injuries. In the absence of hepatic or splenic injuries, the presence of free fluid in the abdominal cavity suggests an injury to the gastrointestinal tract and/or its mesentery, and many trauma surgeons believe this finding to be an indication for early operative intervention.

Diagnostic Laparoscopy or Thoracoscopy

Diagnostic laparoscopy is an accepted method for evaluating a hemodynamically normal, penetrating trauma patient with potential tangential injury and without indication for laparotomy. Laparoscopy is useful to diagnose diaphragmatic injury and peritoneal penetration. The need for general anesthesia limits its usefulness.

Contrast Studies

Contrast studies can aid in the diagnosis of specifically suspected injuries, but they should not delay the care of hemodynamically abnormal patients. These studies include

- Urethrography
- Cystography
- Intravenous pyelogram
- Gastrointestinal contrast studies

Urethrography should be performed before inserting a urinary catheter when a urethral injury is suspected. The urethrogram is performed with an 8 French urinary catheter secured in the meatus by balloon inflation to 1.5 to 2 mL. Approximately 30 to 35 mL of undiluted contrast material is instilled with gentle pressure. In males, a radiograph is taken with an anterior-posterior projection and with slight stretching of the penis toward one of the patient's shoulders. An adequate study shows reflux of contrast into the bladder.

A *cystogram* or *CT cystography* is the most effective method of diagnosing an intraperitoneal or extraperitoneal bladder rupture. A syringe barrel is attached to the indwelling bladder catheter and held 40 cm above the patient. Then 350 mL of water-soluble contrast is allowed to flow into the bladder until either the flow stops, the patient voids spontaneously, or the patient reports discomfort. An additional 50 mL of contrast is instilled to ensure bladder distention. Anterior-posterior pre-drainage, filled, and post-drainage radiographs are essential to definitively exclude bladder injury. CT evaluation of the bladder and pelvis (CT cystogram) is an alternative study that yields additional information about the kidneys and pelvic bones.

Suspected urinary system injuries are best evaluated by contrast-enhanced CT scan. If CT is not available, *intravenous pyelogram (IVP)* provides an alternative. A high-dose, rapid injection of renal contrast ("screening IVP") is performed using 200 mg of iodine/kg body weight. Visualization of the renal calyces on an abdominal radiograph should appear 2 minutes after the injection is completed. Unilateral renal non-visualization occurs with an absent kidney, thrombosis, or avulsion of the renal artery, and massive parenchymal disruption. Non-visualization may warrant further radiologic evaluation.

Isolated injuries to retroperitoneal gastrointestinal structures (e.g., duodenum, ascending or descending colon, rectum, biliary tract, and pancreas) may not

PITFALL	PREVENTION
Delayed recognition of intra-abdominal or pelvic injury, leading to early death from hemorrhage or late death from a visceral injury.	• Recognize mechanisms of injury that can result in intra-abdominal injury. • Recognize the factors that can limit the utility of the physical examination. • Use diagnostic adjuncts such as FAST, DPL, and CT to aid in the diagnosis of injury.
Assessment with physical exam and adjuncts such as ultrasound and x-rays can be compromised in obese patients.	• Maintain a high index of suspicion for abdominal/pelvic injury in obese patients with the potential for abdominal injury, regardless of mechanism. • Recognize the potential limitations of imaging adjuncts.
Seemingly minor abdominal and pelvic injuries can result in severe bleeding in older, frail individuals, as well as individuals receiving anticoagulant therapy.	• Early and aggressive therapy is essential for optimal results. • Make an early determination of the degree of coagulopathy and initiate reversal, when appropriate.

immediately cause peritonitis and may not be detected on DPL or FAST. When injury to one of these structures is suspected, CT with contrast, specific upper and lower gastrointestinal intravenous contrast studies, and pancreaticobiliary imaging studies can be useful. However, the surgeon who ultimately cares for the patient will guide these studies.

EVALUATION OF SPECIFIC PENETRATING INJURIES

The etiology of injury (e.g., stab wound or gunshot), anatomical location (e.g., thoracoabdominal, anterior, posterior, or flank) and available resources influence the evaluation of penetrating abdominal trauma. In anterior abdominal stab wounds, options include serial physical examination, FAST, and DPL. Diagnostic laparoscopy is a reliable study to determine peritoneal and diaphragmatic penetration in thoracoabdominal injuries, in addition to double (PO and IV) and triple (PO, rectal, and IV) contrast CT scans. Double- or triple-contrast CT scans are useful in flank and back injuries. In all cases of penetrating trauma, immediate surgery may be required for diagnosis and treatment.

PITFALL	PREVENTION
Transfer is delayed to perform CT scan of the abdomen.	• When a patient requires transfer to a higher level of care, CT must not delay transfer. • CT should be performed if it will alter care at the referring facility or facilitate stabilization of the patient for transfer.

Most abdominal gunshot wounds are managed by exploratory laparotomy. The incidence of significant intraperitoneal injury approaches 98% when peritoneal penetration is present. Stab wounds to the abdomen may be managed more selectively, but approximately 30% cause intraperitoneal injury. Thus, indications for laparotomy in patients with penetrating abdominal wounds include

- Hemodynamic abnormality
- Gunshot wound with a transperitoneal trajectory
- Signs of peritoneal irritation
- Signs of peritoneal penetration (e.g., evisceration)

PITFALL	PREVENTION
Delayed diagnosis of intra-abdominal injury in a patient with a tangential gunshot wound to the abdomen	• Tangential GSWs may not be truly tangential (e.g., penetrate the peritoneal cavity). • High-velocity penetrating wounds can produce injury without peritoneal penetration but by blast effect; this is most common with explosive or military wounds.

Thoracoabdominal Wounds

Evaluation options for patients without indications for immediate laparotomy, but with possible injuries to the diaphragm and upper abdominal structures include thoracoscopy, laparoscopy, DPL, and CT.

Anterior Abdominal Wounds: Nonoperative Management

Approximately 55% to 60% of all patients with stab wounds that penetrate the anterior peritoneum have hypotension, peritonitis, or evisceration of the omentum or small bowel. These patients require emergency laparotomy. However, nonoperative management can be considered in hemodynamically normal patients without peritoneal signs or evisceration. Less invasive diagnostic options for these patients (who may have pain at the site of the stab wound) include serial physical examinations over a 24-hour period (with or without serial FAST exams), DPL, CT scan, or diagnostic laparoscopy.

Although a positive FAST may be helpful in this situation, a negative FAST does not exclude the possibility of a visceral injury without a large volume of intra-abdominal fluid. Serial physical examinations are labor intensive but have an overall accuracy rate of 94%. CT scan and DPL may allow for earlier diagnosis of injury in relatively asymptomatic patients. Diagnostic laparoscopy can confirm or exclude peritoneal penetration, but it is less useful in identifying specific injuries. The surgeon determines when DPL and laparoscopy are to be used.

Flank and Back Injuries: Nonoperative Management

The thickness of the flank and back muscles protects underlying viscera against injury from many stab wounds and some gunshot wounds. For those who

do not demonstrate indications for immediate laparotomy, less invasive diagnostic options include serial physical examinations (with or without serial FAST exams), double- or triple-contrast CT scans, and DPL. In patients with wounds posterior to the anterior axillary line, serial examination for the development of peritonitis is very accurate in detecting retroperitoneal and intraperitoneal injuries.

Double or triple contrast-enhanced CT is a time-consuming study that may more fully evaluate the retroperitoneal colon on the side of the wound. The accuracy is comparable to that of serial physical examinations. However, the CT should allow for earlier diagnosis of injury when it is performed properly.

Rarely, retroperitoneal injuries can be missed by serial examinations and contrast CT. Early outpatient follow-up is mandatory after the 24-hour period of in-hospital observation because of the subtle presentation of certain colonic injuries.

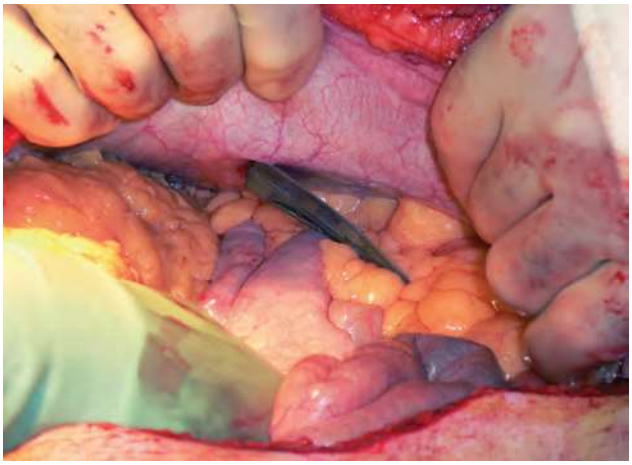
PITFALL	PREVENTION
Concussive and blast injuries can cause intraperitoneal injury without peritoneal penetration.	• Perform evaluation for abdominal/pelvic injury in victims of concussive and blast trauma, even when no exterior wounds are present.
Assessment with physical exam, ultrasound, and x-rays is compromised in the obese patient. Image quality of all radiographs is decreased, and DPL is difficult, if not impossible, in the ED.	• Maintain a high index of suspicion for abdominal/pelvic injury in the obese patient regardless of mechanism. • CT scan may represent the best potential imaging modality. • In some cases, operation may be required for diagnosis.
Delayed exploration of hemodynamically abnormal patient with abdominal stab wound.	• All hemodynamically abnormal patients should undergo laparotomy. • Serial physical examinations are not an option in hemodynamically abnormal patients and those with peritonitis or evisceration. • CT scan, DPL, and FAST are not indicated in hemodynamically abnormal patients or those with peritonitis or evisceration with penetrating abdominal trauma.

DPL also can be used in such patients as an early screening test. A positive DPL is an indication for an urgent laparotomy. However, DPL may not detect retroperitoneal colon injuries.

INDICATIONS FOR LAPAROTOMY

Surgical judgment is required to determine the timing and need for laparotomy (■ FIGURE 5-7). The following indications are commonly used to facilitate the decision-making process in this regard:

- Blunt abdominal trauma with hypotension, with a positive FAST or clinical evidence of intraperitoneal bleeding, or without another source of bleeding
- Hypotension with an abdominal wound that penetrates the anterior fascia
- Gunshot wounds that traverse the peritoneal cavity
- Evisceration
- Bleeding from the stomach, rectum, or genitourinary tract following penetrating trauma
- Peritonitis
- Free air, retroperitoneal air, or rupture of the hemidiaphragm
- Contrast-enhanced CT that demonstrates ruptured gastrointestinal tract, intraperitoneal bladder injury, renal pedicle injury, or severe visceral parenchymal injury after blunt or penetrating trauma



■ FIGURE 5-7 **Laparotomy.** Surgical judgment is required to determine the timing and need for laparotomy.

- Blunt or penetrating abdominal trauma with aspiration of gastrointestinal contents, vegetable fibers, or bile from DPL, or aspiration of 10 cc or more of blood in hemodynamically abnormal patients

EVALUATION OF OTHER SPECIFIC INJURIES

The liver, spleen, and kidney are the organs predominantly involved following blunt trauma, although the relative incidence of hollow visceral perforation, and lumbar spinal injuries increases with improper seat-belt usage (see Table 5-1). Diagnosis of injuries to the diaphragm, duodenum, pancreas, genitourinary system, and small bowel can be difficult. Most penetrating injuries are diagnosed at laparotomy.

Diaphragm Injuries

Blunt tears can occur in any portion of either diaphragm, although the left hemidiaphragm is most often injured. A common injury is 5 to 10 cm in length and involves the posterolateral left hemidiaphragm. Abnormalities on the initial chest x-ray include elevation or "blurring" of the hemidiaphragm, hemothorax, an abnormal gas shadow that obscures the hemidiaphragm, or a gastric tube positioned in the chest. However, the initial chest x-ray can be normal in a small percentage of patients. Suspect this diagnosis for any penetrating wound of the thoracoabdomen, and confirm it with laparotomy, thoracoscopy, or laparoscopy.

Duodenal Injuries

Duodenal rupture is classically encountered in unrestrained drivers involved in frontal-impact motor vehicle collisions and patients who sustain direct blows to the abdomen, such as from bicycle handlebars. A bloody gastric aspirate or retroperitoneal air on an abdominal radiograph or CT should raise suspicion for this injury. An upper gastrointestinal x-ray series, double-contrast CT, or emergent laparotomy is indicated for high-risk patients.

Pancreatic Injuries

Pancreatic injuries often result from a direct epigastric blow that compresses the pancreas against the vertebral column. An early normal serum amylase level does not exclude major pancreatic trauma. Conversely, the amylase level can be elevated from nonpancreatic sources. Double-contrast CT may not identify significant pancreatic trauma in the immediate postinjury period (up to 8 hours). It may be repeated, or other pancreatic imaging performed, if injury is suspected. Surgical exploration of the pancreas may be warranted following equivocal diagnostic studies.

Genitourinary Injuries

Contusions, hematomas, and ecchymoses of the back or flank are markers of potential underlying renal injury and warrant an evaluation (CT or IVP) of the urinary tract. Gross hematuria is an indication for imaging the urinary tract. Gross hematuria and microscopic hematuria in patients with an episode of shock are markers for increased risk of renal abdominal injuries. An abdominal CT scan with IV contrast can document the presence and extent of a blunt renal injury, which frequently can be treated nonoperatively. Thrombosis of the renal artery and disruption of the renal pedicle secondary to deceleration are rare injuries in which hematuria may be absent, although the patient can have severe abdominal pain. With either injury, an IVP, CT, or renal arteriogram can be useful in diagnosis.

An anterior pelvic fracture usually is present in patients with urethral injuries. Urethral disruptions are divided into those above (posterior) and below (anterior) the urogenital diaphragm. A posterior urethral injury is usually associated with multisystem injuries and pelvic fractures, whereas an anterior urethral injury results from a straddle impact and can be an isolated injury.

Hollow Viscus Injuries

Blunt injury to the intestines generally results from sudden deceleration with subsequent tearing near a fixed point of attachment, particularly if the patient's seat belt was positioned incorrectly. A transverse, linear ecchymosis on the abdominal wall (seat-belt sign) or lumbar distraction fracture (i.e., Chance fracture) on x-ray should alert clinicians to the possibility of intestinal injury. Although some patients have early abdominal pain and tenderness, the diagnosis of hollow viscus injuries can be difficult since they are not always associated with hemorrhage.

Solid Organ Injuries

Injuries to the liver, spleen, and kidney that result in shock, hemodynamic abnormality, or evidence of

continuing hemorrhage are indications for urgent laparotomy. Solid organ injury in hemodynamically normal patients can often be managed nonoperatively. Admit these patients to the hospital for careful observation, and evaluation by a surgeon is essential. Concomitant hollow viscus injury occurs in less than 5% of patients initially diagnosed with isolated solid organ injuries.

PITFALL	PREVENTION
Missed diaphragmatic injury in penetrating thoracoabdominal injury	• Exclude the diagnosis of penetrating diaphragm injury with laparotomy, thoracoscopy, or laparoscopy.
Missed intestinal injury	• Additional assessments (e.g., serial physical examinations, repeat CT, repeat ultrasound, DPL, laparoscopy, and laparotomy) are often indicated when bowel injury is a clinical concern.

Pelvic Fractures and Associated Injuries

Patients with hypotension and pelvic fractures have high mortality. Sound decision making is crucial for optimal patient outcome. Pelvic fractures associated with hemorrhage commonly involve disruption of the posterior osseous ligamentous complex (i.e., sacroiliac, sacrospinous, sacrotuberous, and fibromuscular pelvic floor), evidenced by a sacral fracture, a sacroiliac fracture, and/or dislocation of the sacroiliac joint.

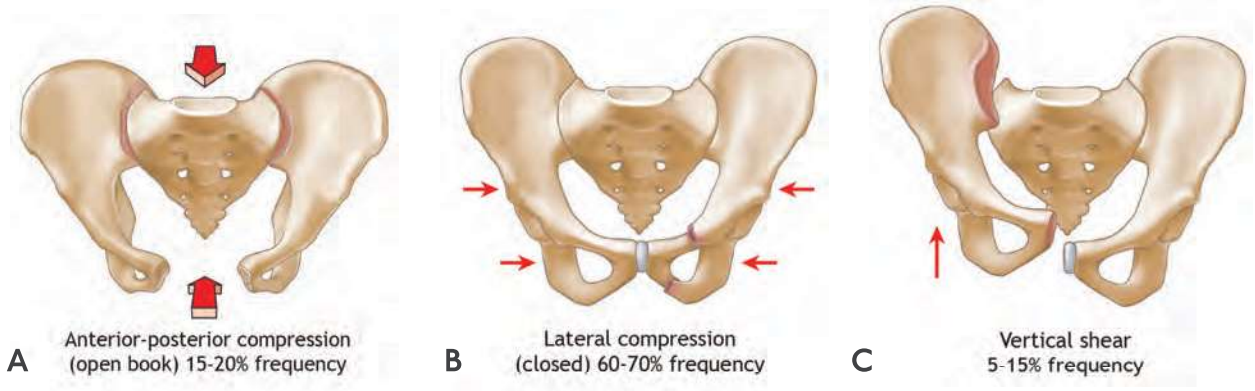
Mechanism of Injury and Classification

Pelvic ring injury can occur following a motor vehicle crash, motorcycle crash, pedestrian–vehicle collision, direct crushing injury, or fall. Pelvic fractures are classified into four types, based on injury force patterns: AP compression, lateral compression, vertical shear, and combined mechanism (■ FIGURE 5-8).

AP compression injury is often associated with a motorcycle or a head-on motor vehicle crash. This mechanism produces external rotation of the hemipelvis with separation of the symphysis pubis and tearing of the posterior ligamentous complex. The disrupted pelvic ring widens, tearing the posterior venous plexus and branches of the internal iliac arterial system. Hemorrhage can be severe and life threatening.

Lateral compression injury, which involves force directed laterally into the pelvis, is the most common mechanism of pelvic fracture in a motor vehicle collision. In contrast to AP compression, the hemipelvis rotates internally during lateral compression, reducing pelvic volume and reducing tension on the pelvic vascular structures. This internal rotation may drive the pubis into the lower genitourinary system, potentially causing injury to the bladder and/or urethra. Hemorrhage and other sequelae from lateral compression injury rarely result in death, but can produce severe and permanent morbidity, and elderly patients can develop significant bleeding from pelvic fractures from this mechanism. When this occurs, these patients require early hemorrhage control techniques such as angioembolization. Frail and elderly patients may bleed significantly following minor trauma from lateral compression fractures.

Vertical displacement of the sacroiliac joint can also disrupt the iliac vasculature and cause severe hemorrhage. In this mechanism, a high-energy shear force occurs along a vertical plane across the anterior and posterior



■ FIGURE 5-8 Pelvic Fractures. **A.** AP Compression fracture. **B.** Lateral compression fracture. **C.** Vertical shear fracture.

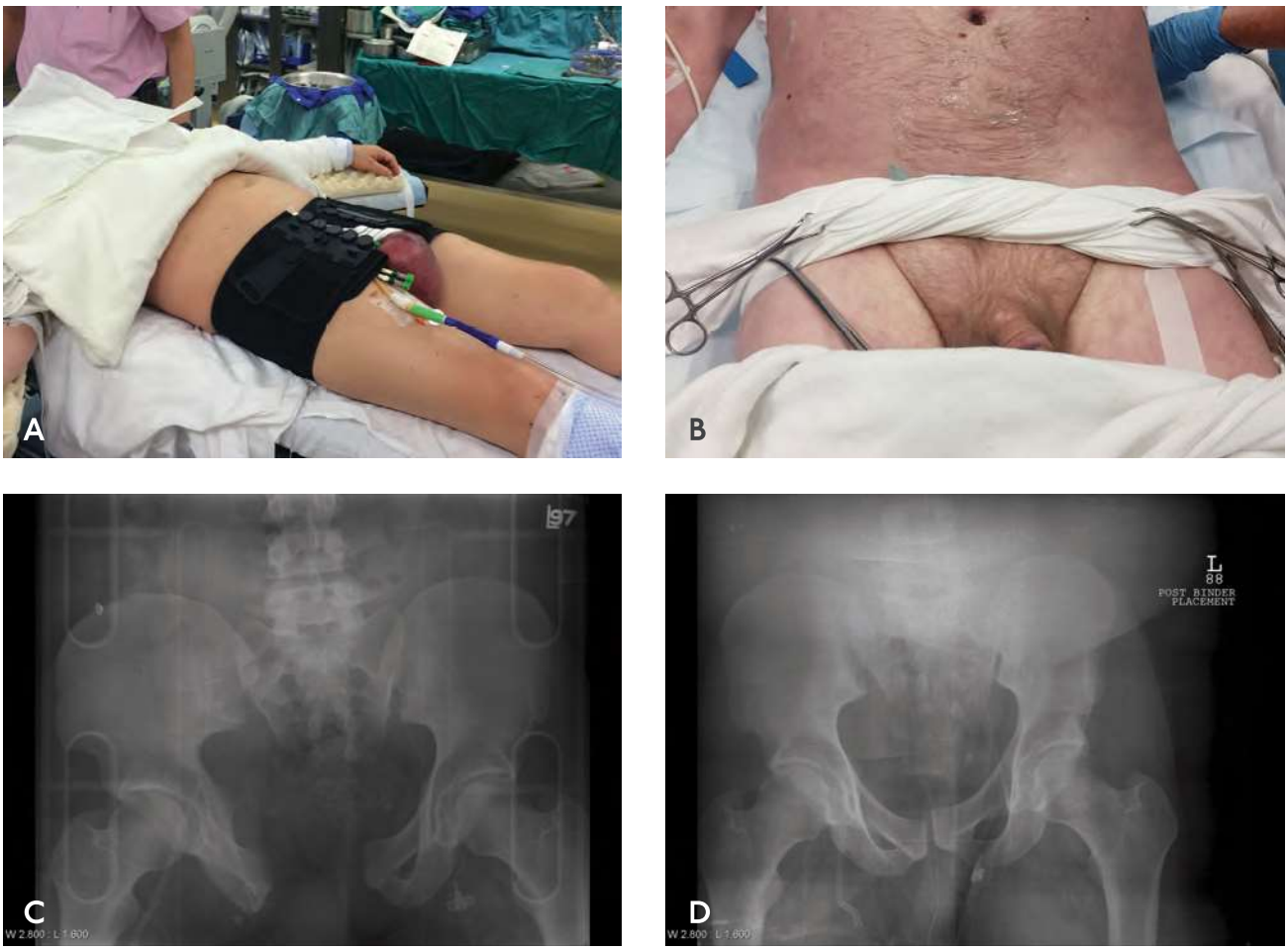
aspects of the ring. This *vertical shearing* disrupts the sacrospinous and sacrotuberous ligaments and leads to major pelvic instability. A fall from a height greater than 12 feet commonly results in a vertical shear injury.

Mortality in patients with all types of pelvic fractures is approximately one in six (range 5%–30%). Mortality rises to approximately one in four (range 10%–42%) in patients with closed pelvic fractures and hypotension. In patients with open pelvic fractures, mortality is approximately 50%. Hemorrhage is the major potentially reversible factor contributing to mortality. (See ***Appendix G: Circulation Skills***.)

Management

Initial management of hypovolemic shock associated with a major pelvic disruption requires rapid hemorrhage control and fluid resuscitation. Hemorrhage control is achieved through mechanical stabilization of the pelvic ring and external counter pressure. Patients with these injuries may be initially assessed and treated in facilities that do not have the resources to definitively manage the associated hemorrhage. In such cases, trauma team members can use simple techniques to stabilize the pelvis before patient transfer. Because pelvic injuries associated with major hemorrhage externally rotate the hemipelvis, internal rotation of the lower limbs may assist in hemorrhage control by reducing pelvic volume. By applying a support directly to the patient's pelvis, clinicians can splint the disrupted pelvis and further reduce potential pelvic hemorrhage. A sheet, pelvic binder, or other device can produce sufficient temporary fixation for the unstable pelvis when applied at the level of the greater trochanters of the femur (■ **FIGURE 5-9**). (Also see ***Pelvic Binder video on MyATLS mobile app***.) In cases of vertical shear injuries, longitudinal traction applied through the skin or the skeleton can also assist in providing stability. This should be done with the consultation of an orthopedic specialist.

External pelvic binders are a temporary emergency procedure. Proper application is mandatory, and patients with pelvic binders require careful monitoring. Tight binders or those left in position for prolonged



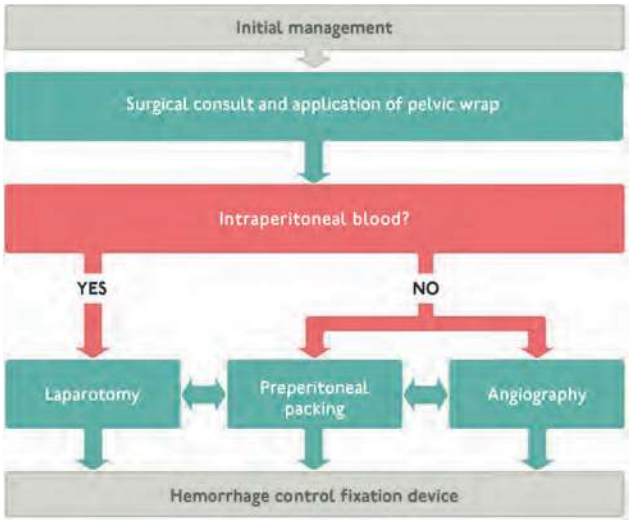
■ **FIGURE 5-9 Pelvic Stabilization. A.** Pelvic binder. **B.** Pelvic stabilization using a sheet. **C.** Before application of pelvic binder. **D.** After application of pelvic binder.

PITFALL	PREVENTION
Delayed treatment of pelvic hemorrhage.	• Achieve hemorrhage control early by applying a pelvic binder, angioembolization, and/or operative measures.
A patient develops a pressure ulcer over the trochanter after a pelvic binders is left in place for 24 hours.	• Carefully monitor patients with pelvic binders for skin ulceration. • Develop plan for early definitive hemorrhage control.
Unexplained hypotension in elderly patient with history of a fall.	• Look carefully for evidence of subcutaneous bleeding. • Recognize that, in frail patients, low-energy mechanism pelvic fractures can cause bleeding requiring treatment and transfusion.

time periods can cause skin breakdown and ulceration over bony prominences.

Optimal care of patients with hemodynamic abnormalities related to pelvic fracture demands a team effort of trauma surgeons, orthopedic surgeons, and interventional radiologists or vascular surgeons. Angiographic embolization is frequently employed to stop arterial hemorrhage related to pelvic fractures. Preperitoneal packing is an alternative method to control pelvic hemorrhage when angioembolization is delayed or unavailable. Hemorrhage control techniques are not exclusive and more than one technique may be required for successful hemorrhage control. An experienced trauma surgeon should construct the therapeutic plan for a patient with pelvic hemorrhage based on available resources.

Although definitive management of patients with hemorrhagic shock and pelvic fractures varies, one treatment algorithm is shown in (■ FIGURE 5-10). Significant resources are required to care for patients with severe pelvic fractures. Early consideration of transfer to a trauma center is essential. In resource-limited environments, the absence of surgical and/or angiographic resources for hemodynamically abnormal patients with pelvic fractures or hemodynamically normal patients with significant solid organ injury mandates early transfer to a trauma center with these facilities.



■ **FIGURE 5-10** Pelvic Fractures and Hemorrhagic Shock Management Algorithm.

TEAMWORK

- The team must be able to determine the priorities of treatment and identify which of perhaps several simultaneous studies and interventions need to be performed. The team leader must recognize the need to apply a pelvic binder and ensure its correct placement while continuing to evaluate the patient's response to resuscitation.
- Ensure that team members work effectively and swiftly to avoid any delay in the transfer of a patient with abdominal injury to definitive care.

CHAPTER SUMMARY

1. The three distinct regions of the abdomen are the peritoneal cavity, retroperitoneal space, and pelvic cavity. The pelvic cavity contains components of both the peritoneal cavity and retroperitoneal space.

2. Early consultation with a surgeon is necessary for a patient with possible intra-abdominal injuries. Once the patient's vital functions have been restored, evaluation and management varies depending on the mechanism of injury.

3. Hemodynamically abnormal patients with multiple blunt injuries should be rapidly assessed

for intra-abdominal bleeding or contamination from the gastrointestinal tract by performing a FAST or DPL.

4. Patients who require transfer to a higher level of care should be recognized early and stabilized without performing nonessential diagnostic tests.

5. Indications for CT scan in hemodynamically normal patients include the inability to reliably evaluate the abdomen with physical examination, as well as the presence of abdominal pain, abdominal tenderness, or both. The decision to operate is based on the specific organ(s) involved and injury severity.

6. All patients with penetrating wounds of the abdomen and associated hypotension, peritonitis, or evisceration require emergent laparotomy. Patients with gunshot wounds that by physical examination or routine radiographic results obviously traverse the peritoneal cavity or visceral/vascular area of the retroperitoneum also usually require laparotomy. Asymptomatic patients with anterior abdominal stab wounds that penetrate the fascia or peritoneum on local wound exploration require further evaluation; there are several acceptable alternatives.

7. Asymptomatic patients with flank or back stab wounds that are not obviously superficial are evaluated by serial physical examinations or contrast-enhanced CT.

8. Management of blunt and penetrating trauma to the abdomen and pelvis includes

   - Delineating the injury mechanism
   - Reestablishing vital functions and optimizing oxygenation and tissue perfusion
   - Prompt recognition of sources of hemorrhage with efforts at hemorrhage control
   - Meticulous initial physical examination, repeated at regular intervals
   - Pelvic stabilization
   - Laparotomy
   - Angiographic embolization and pre-peritoneal packing
   - Selecting special diagnostic maneuvers as needed, performed with a minimal loss of time
   - Maintaining a high index of suspicion related to occult vascular and retroperitoneal injuries

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