

Trauma Reports

EVIDENCE-BASED MEDICINE FOR THE ED

Volume 13, Number 4

July/Aug 2012

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Statement of Financial Disclosure

To reveal any potential bias in this publication, and in accordance with Accreditation Council for Continuing Medical Education guidelines, we disclose that Dr. Dietrich (editor in chief), Drs. Kman, Knepel, and Hays (authors), Dr. Menaker (peer reviewer), and Ms. Behrens (nurse reviewer) report no relationships with companies related to this field of study. Ms. Mark (executive editor), and Ms. Hamlin (managing editor) report no relationships with companies related to the field of study covered by this CME activity.

The Approach to Penetrating Abdominal Trauma

Penetrating abdominal trauma (PAT) has the potential to be a devastating injury and ranks in the top 15 causes of death for all ages. This article will define the problem of PAT and review the initial management, including the ability to identify, resuscitate, and initiate treatment in patients with unstable PAT prior to their transfer to the operating room (OR).

Additionally, this article will discuss the ongoing evaluation, diagnostic testing, and ultimate disposition of those patients with PAT who do not go emergently to the OR. In the past, nearly all patients with PAT were sent to the OR. In recent years, this has been changing and remains an area that trauma specialists continue to refine. This article will discuss selective non-operative management (SNOM), a treatment choice for select stable patients with penetrating abdominal wounds.

— Ann M. Dietrich, MD, Editor

Definition

Penetrating abdominal trauma results when an object (usually a bullet, knife, shrapnel, etc.) has breached the abdominal cavity.^{1,2}

Epidemiology

Unintentional injury, suicide, and homicide rank in the top 15 causes of death for all ages, and traumatic injury is the leading cause of death for ages one to 44.³ According to the National Vital Statistics Report for 2009, the accidental discharge of firearms accounted for 588 deaths, suicide by firearm for 18,689 deaths, and homicides by firearm for 11,406 deaths. There were 31,228 additional non-fatal injuries by firearms.³ Stab wounds occur approximately three times more frequently than gunshot wounds; however, gunshot wounds are responsible for up to 90% of the mortalities associated with penetrating abdominal injuries.^{4,6}

Males suffer more PAT than females.⁷ In the United States, non-Hispanic black males 15 to 34 years of age have the greatest death rate from PAT, including abdominal gunshot wounds.⁷ Non-Hispanic whites older than 70 years have the highest mortality from penetrating trauma, usually as a result of suicide attempt.⁴

As with other types of trauma, penetrating abdominal injuries have a tremendous negative impact on families, society, hospital resources, and the economy. Morbidity associated with PAT can also be devastating and includes loss of productivity, ongoing medical costs, long-term disability, and psychological sequelae.⁸ The economic burden of firearm injuries is greater than \$123 billion annually, with the average direct cost of medical care totaling about \$17,000 per gunshot injury.⁹

Etiology

PAT may be accidental or intentional. Intentional penetrating trauma may be self-inflicted or due to assault. PAT is most commonly seen in urban violence,

Executive Summary

- The intra-abdominal organs vary in the length of their individual mesentery or ligaments; therefore, the location of the external wound that is visible on physical examination may not correlate with the location of the patient's internal injuries.
- Gunshot wounds most commonly injure the small bowel (50%), colon (40%), liver (30%), and vasculature (25%).
- Permissive hypotension is a term used to describe restricted resuscitation of the trauma patient, with the goal of improving systemic pressure and end-organ perfusion while avoiding the risks inherent to normotension in PAT.
- Massive transfusion is defined as replacing the patient's total blood volume in 24 hours or one-half of the blood volume in one hour.

domestic violence, and war.

The most common causes of PAT are gunshot and stab wounds. Interestingly, a wide variety of case reports exist regarding penetrating abdominal wounds from unusual sources such as swordfish,¹⁰ elephant tusks,¹¹ chainsaws,¹³ and shrapnel from firecracker accidents.¹³ This article will focus on the most common causes of PAT.

Pathophysiology

The abdomen can be divided into the abdominal cavity, retroperitoneum, and pelvis. The abdomen begins at the diaphragm and extends to the pelvis. The abdomen contains the stomach, small intestine, the liver and gallbladder, and parts of the large intestine and pancreas. The retroperitoneum is the space between the parietal peritoneum and the posterior abdominal wall. It contains the kidney, ureter, aorta, inferior vena cava, duodenum, ascending and descending colon, and part of the pancreas. The pelvis contains the bladder, urethra, rectum, ovaries, and prostate. (*See Table 1.*)

It is important to note that because the intra-abdominal organs vary in the length of their individual mesentery or ligaments, the location of the external wound that is visible on physical examination may not correlate with the location of the patient's internal injuries.¹ For example, the small bowel and transverse colon are the most mobile abdominal organs and may descend down into the lower quadrants of the abdominal cavity or even into the pelvis

when standing or sitting. Therefore, a person who is shot or stabbed while in the standing position may have an external entrance wound located in the lower abdomen while the actual intra-abdominal injury is located in the upper quadrants when evaluated in the supine position.

Stab wounds are relatively straightforward. Stabbing causes injury by lacerating and cutting. Approximately 30% of abdominal stab wounds cause intraperitoneal injury.⁶ The most commonly injured organs are the liver (40%), small bowel (30%), diaphragm (20%), and colon (15%).⁶ (*See Table 2.*)

In contrast, gunshot wounds are relatively complex. In gunshot wounds, a basic knowledge of wound ballistics is important because certain historical factors (such as velocity of the missile and its distance from the patient) can help to elucidate the extent and severity of the injury.¹⁴ High-velocity gunshot wounds contribute to injury via the transfer of kinetic energy and often cause much more internal damage than the external entry wound may indicate. Bullets and bones may fragment and ricochet, and these secondary missiles can cause substantial harm. In contrast, heavy clothing (such as down-filled coats or multiple layers of clothing) can provide some protection from small handguns and low-velocity shotgun pellets and can significantly decrease the extent of injury sustained as a result of a gunshot wound.¹⁴ In general, a gunshot wound sustained at a closer range portends greater injuries than

wounds sustained at longer ranges from the weapon.

One special consideration is shotgun wounds. The typical ammunition used with shotguns consists of a collection of individual pellets. When fired at close range, the pellets impact at a significantly higher velocity than when fired at ranges greater than three to seven yards. Of note, shotgun wounds sustained from firings at longer ranges also display increased scatter of the pellets and carry an increased risk of multiple injuries.

Gunshot wounds most commonly injure the small bowel (50%), colon (40%), liver (30%), and vasculature (25%).⁶ (*See Table 2.*)

Prehospital Management

Most scene deaths occur due to exsanguination. In the setting of penetrating abdominal wounds, bleeding can be very difficult to control in the field. The first priority should be to minimize field time and transport the patient as expeditiously as possible to a center for definitive care. Depending on the location of the patient, the decision of whether to use ground or air transport must be determined by those on scene.

Of note, occult cervical spine injury is unlikely. Unless there is a deficit or concerning mechanism (e.g., the patient fell out of a window after being shot), a cervical collar is rarely necessary and may hinder treatment.

In the past, aggressive resuscitation with intravenous crystalloid to attempt to maintain a normal blood

pressure was the standard of care. Current recommendations endorse permissive hypotension, using radial pulse and mentation to dictate fluid resuscitation. Permissive hypotension is a term used to describe restricted resuscitation of the trauma patient, with the goal of improving systemic pressure and end-organ perfusion while avoiding the risks inherent to normotension in PAT. The theory behind permissive hypotension is that increasing intravascular pressure impedes the body's natural clotting process, leading to increased blood loss and worse outcomes. Permissive hypotension has been shown to be beneficial in patients with PAT.^{15,16}

Initial Emergency Department Management

Penetrating trauma to the abdomen is associated with a high morbidity and mortality. Appropriate triage, adherence to standard protocols, prompt evaluation, and appropriate management may lower morbidity and complications.¹⁷

History

The clinician needs to gain some key information about the nature of the penetrating injury. Important information includes time of injury, type of weapon, distance from weapon, number of wounds, initial vital signs, current vital signs, location of pain, and amount of blood at the scene.

Patients who present after sustaining stab wounds should be questioned about the type of instrument used, its length and width, and their position during the stabbing.¹⁸

Patients who present after sustaining gunshot wounds should be questioned about the type of gun used, the number of shots heard, their position during the shooting, and the type of clothing they were wearing.^{4,14}

Evaluation

Any patient who presents for evaluation of PAT should undergo initial assessment according to advanced

Table 1. Anatomy Review

Abdominal Contents	Retroperitoneal Contents	Pelvic Contents
Stomach	Kidney	Bladder
Small intestine	Aorta	Urethra
Liver	Ureter	Ovaries
Gall bladder	Inferior vena cava	Prostate
Large intestine (partial)	Large intestine (partial)	Rectum
Pancreas (partial)	Pancreas (partial)	
	Duodenum	

trauma life support (ATLS) protocol, which dictates evaluation in the standard ABC sequence.

Primary Survey. *Airway.* Intubate all patients who are significantly hypoxic, agitated, or obtunded.⁶

Breathing. If the patient is not intubated, place the patient on oxygen as appropriate. Listen for bilateral breath sounds. Perform chest decompression with a 14-gauge needle in the second intercostal space in the mid-clavicular line or place a chest tube as indicated.

Circulation. Check for pulses. Place the patient on a monitor. Insert two large-bore IVs and draw labs. If unable to place an IV, consider an intraosseous line.

Most sources recommend initial fluid resuscitation with 2 liters of normal saline or lactated Ringers, then infusion with uncross-matched blood for further resuscitation. For patients in the process of exsanguinating, consider initiating a massive transfusion protocol (MTP). Massive transfusion is defined as replacing the patient's total blood volume in 24 hours or one-half of the blood volume in one hour.¹⁹ The goal is to rapidly replace adequate blood volume and maintain blood composition within safe limits with regard to hemostasis, oxygen-carrying capacity, oncotic pressure, and biochemistry. Massive transfusion protocols have been shown to decrease mortality.²⁰ Complications of aggressive transfusions of packed red blood cells (PRBCs) include thrombocytopenia, coagulation factor depletion,

hypocalcemia, hyperkalemia, acid-base disturbances, hypothermia, and acute respiratory distress syndrome (ARDS). When transfusing large volumes, monitor platelet count, coagulation studies, and fibrinogen. For patient's requiring massive transfusion, consider infusion of fresh frozen plasma (FFP), platelets, cryoprecipitate, and whole blood to avoid the coagulopathy that commonly complicates the infusion of large blood volumes. Currently, the optimal combination of these products remains a subject of debate. A PRBC to FFP ratio of 1:1^{21,22} or 1:2^{22,23} has been recommended, as has a PRBC to FFP to platelet ratio of 1:1:1.^{24,25} Future treatment may be individualized and may also include systemic anti-fibrinolytics, local hemostatic agents, and coagulation factor concentrates, such as fibrinogen, prothrombin complex, or recombinant factors VII and X.²⁶ Prospective, randomized trials are needed to answer the question regarding the optimal MTP.

Disability and Exposure. Assess the patient's Glasgow coma scale (GCS) if not done previously. After assessing for disability, patients must be fully undressed for a thorough, head-to-toe examination.⁵ With all gunshot wounds, especially those sustained from a shotgun blast, a patient must be fully inspected, including log-roll to evaluate for exit wounds, additional gunshot wounds, and other injuries. Significantly, multiple wounds are present in approximately 20% of patients who present after

Table 2. Most Commonly Injured Organs

Gunshot Wound	Stab Wound
Small bowel	Liver
Colon	Small bowel
Liver	Diaphragm
Vasculature	Colon

Note: Injuries are listed in decreasing order of frequency.

stabbing.¹⁸ One should be sure to evaluate the axilla, inguinal areas, skin folds, and scalp, as these are potentially less obvious locations where penetrating wounds can go unnoticed, resulting in a potentially lethal outcome.²⁷

Secondary Survey. After the primary survey, perform the secondary survey as per ATLS protocol. Be sure to do a thorough abdominal exam. Diffuse abdominal tenderness and bruising of the flanks are physical exam signs that are suggestive of peritoneal violation and injury in the form of internal bleeding. Perform a rectal exam to evaluate for bright red blood and high-riding prostate, which can indicate bowel injury and genitourinary (GU) tract injury, respectively.¹ Carefully inspect the GU area. Blood at the urethral meatus is another clue that suggests genitourinary tract injury.

Adjuncts. Place a nasogastric (NG) tube and Foley catheter as indicated. Administer tetanus vaccine booster, tetanus immunoglobulin, pain control (usually with IV opioids if blood pressure is stable), and antibiotics as indicated based on the clinical scenario. Choose a broad-spectrum antibiotic with both aerobic and anaerobic coverage. Use a beta-lactam antibiotic or aminoglycoside plus clindamycin plus metronidazole.²⁸

Operative Management

After the primary and secondary surveys are completed, the initial efforts are directed at determining whether the patient requires immediate laparotomy in the operating room. In unstable patients,

patients with peritoneal signs, and patients with evisceration, immediate exploratory laparotomy is mandatory.²⁹ When an unstable penetrating abdominal injury is identified, and it has been determined that the patient will require immediate laparotomy, direct further management and resuscitation efforts at stabilizing the patient's identifiable injuries and the hemodynamic status to get the patient to the OR.

Patients identified as having a true evisceration require special mention. A true evisceration is considered a surgical emergency in most trauma centers and occurs when a major laceration of the anterior abdominal wall traverses from the skin through the layers of the anterior abdominal wall, including the peritoneum, and allows extrusion of abdominal contents into the outside environment.³⁰ An evisceration is different from a hernia because the latter is caused by a weakness in the bowel wall and, thus, the integrity of the peritoneum is maintained. Therefore, a hernia does not result in exposure of the involved organ to the outside environment. Because of its mobility, the greater omentum is the intra-abdominal organ most commonly involved in abdominal evisceration. The small bowel and transverse colon are the second and third most common organs involved, respectively, owing to their longer mesentery and ligaments when compared with the liver, spleen, and ascending colon.¹ Eviscerating injuries are unlikely to involve the pancreas, duodenum, kidneys, aorta, and inferior vena cava because of their fixed posterior position in the retroperitoneum.¹

Abdominal stab wounds are the classic etiology of abdominal evisceration in trauma.

Management of eviscerated organs should proceed in a sterile fashion, with almost all injuries proceeding to the OR. Do not attempt to reduce eviscerated organs back into the abdominal cavity because this can worsen the injury. Cover the extruded organs completely with sterile gauze and then moisten liberally with sterile saline.¹

Other indications for emergent laparotomy include gunshot wounds that traverse the peritoneal cavity or retroperitoneum, bleeding from the stomach, rectum or GU tract, and CT scan showing penetrated bowel or viscera.³¹ (See Table 3.)

Patients undergoing emergent damage control laparotomies have a high mortality rate. An initial systolic blood pressure (SBP) of less than 60 mmHg is a poor prognostic factor.²⁹ Those that survive have a significant complication and readmission rate.³²

Non-operative Management

In hemodynamically stable patients without peritoneal signs or evisceration, further imaging and work-up likely will be indicated to explore the extent and character of any intra-abdominal injuries. The practice of selective non-operative management (SNOM) is increasing. When successful, it helps avoid non-therapeutic laparotomies; however, failure is associated with increased mortality.³³ Careful patient selection, appropriate adjunctive studies and procedures, and strict adherence to protocol are needed for successful SNOM.³³ Of note, this is still a controversial area and there is no definitive standard of care.³⁴ It is most appropriate in facilities with adequate resources, experience, and capability.³³

Diagnostic Studies

Order the following laboratory tests upon patient arrival: complete blood count (CBC), complete chemistry panel, blood alcohol level, coagulation studies, blood gas, lactate, type and cross, urine analysis, urine

pregnancy for female patients, and urine toxicology screen. Note that the CBC provides a baseline hemoglobin and may not accurately reflect a true value if the patient has recently lost a large amount of blood. For patients displaying signs and symptoms of shock, request that the blood bank hold 4-8 units of PRBCs in addition to obtaining a type and cross, and consider initiating a massive transfusion protocol. Blood gas analysis may show elevated anion gap and a base deficit, consistent with impaired oxygen delivery secondary to hypoperfusion.

Obtain plain films of the chest, abdomen, and pelvis. Mark the wounds with radiopaque markers to assist in identifying the wound trajectory. Hemothorax or pneumothorax may indicate an associated thoracic injury. Evaluate the width of heart silhouette for signs concerning for pericardial effusion. Look for air under the diaphragm indicating a perforated viscus. Look for foreign bodies and attempt to account for all bullets if applicable.

A cervical spine film is most likely unnecessary unless there are specific concerns for neck trauma.

Ultrasound may be useful in the hemodynamically stable patient. Perform a focused assessment with sonogram in trauma (FAST) exam. The FAST exam consists of four views to evaluate for the presence of free fluid. Views obtained on the FAST examination include a subxiphoid view to evaluate the pericardium, a view of Morison's pouch in the right upper quadrant (between the liver and kidney), a parasplenic view to identify free fluid in the left upper quadrant, and a suprapubic view looking for free fluid the pouch of Douglas in the pelvis. Note that free fluid in the left upper quadrant preferentially accumulates above the spleen (between the spleen and diaphragm) and not between the spleen and kidney, although large amounts of fluid may be visible there. (See *Figure 1.*)

A positive FAST exam indicates intraperitoneal blood or spillage from a luminal injury and is 94-98%

Table 3. Indications for Operative Management

- Unstable/shock
- Peritoneal signs
- Evisceration
- Gunshot wound that penetrates peritoneum/retroperitoneum
- Bleeding from stomach, rectum, genitourinary tract
- CT positive for penetrated bowel or viscera
- Patient not able to participate in serial exams

Figure 1. Positive FAST Image of LUQ

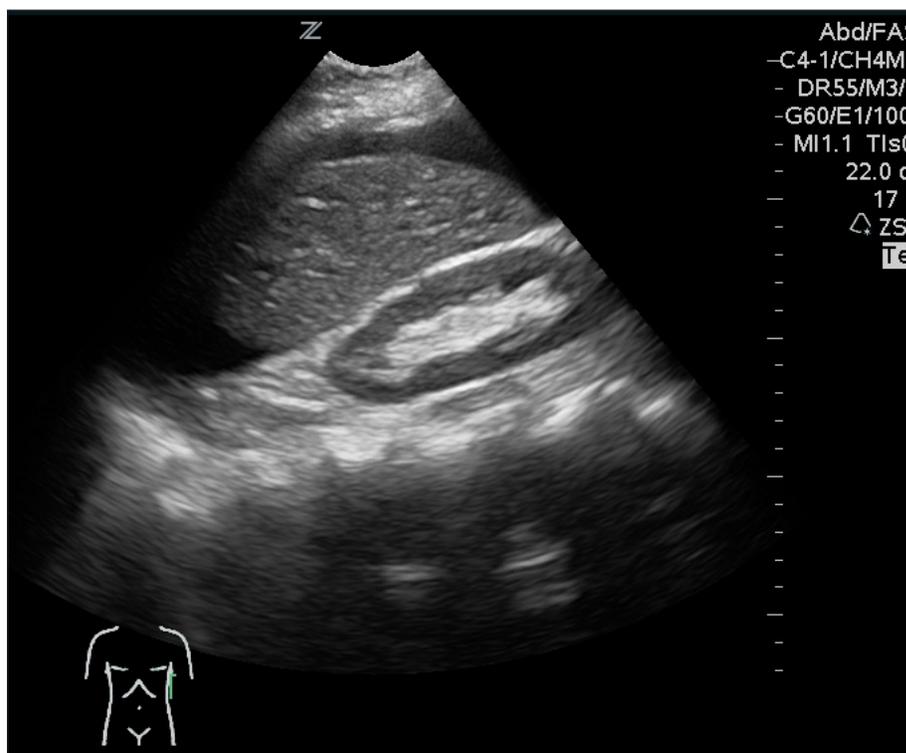


Image courtesy of David Bahner MD, RDMS

specific and 46-67% sensitive.^{35,36} (See *Figure 2.*) A positive FAST in the setting of penetrating abdominal trauma often indicates an emergent need for surgery. However, in a stable patient with a positive FAST, the trauma team may opt for further diagnostic testing before making the decision to go to the OR. Some injuries that may result in a positive FAST scan, such as an isolated laceration to the liver, may ultimately be managed non-operatively. A negative

or indeterminate FAST indicates a need for further evaluation.

Patients who are hemodynamically stable with a negative or indeterminate FAST scan should be sent for CT after the trauma evaluation if there remains concern for peritoneal penetration. CT can be used to evaluate for peritoneal penetration and to identify solid organ injury that may be able to be managed non-operatively.^{37,38} Triple-contrasted CT is highly sensitive and specific for

Figure 2. Positive FAST Image of RUQ

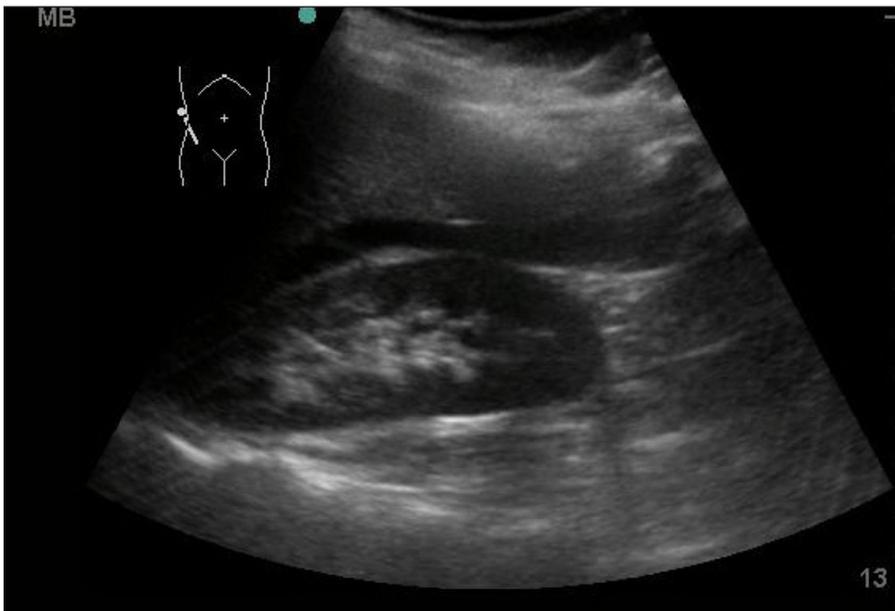


Image courtesy of David Bahner MD, RDMS

Table 4. Positive CT Findings in Penetrating Abdominal Trauma

- Intra-peritoneal foreign body
- Free air
- Free fluid
- Contrast “blush”
- Bullet tract with hematoma or free air

peritoneal violation, 97% sensitive and 98% specific in some studies.^{39,40} Signs of peritoneal penetration include a wound tract outlined with blood or air; intraperitoneal free air, foreign body, or fluids; or intraperitoneal organ injury. (See Table 4.) Once the missile trajectory is determined by CT scan, patients are put into three groups. The first group, consisting of patients with no evidence of peritoneal violation, can be managed medically. The second group, consisting of patients with evidence of peritoneal violation, can only be managed non-surgically if they have no obvious organ injury and can tolerate serial clinical exams. A third group of patients who have

evidence of direct solid-organ or hollow viscous injury will most likely be managed surgically.⁴¹

Historically, patients received triple contrast to enhance CT exams: intravenous, PO, and rectal. This may be changing, as it has been shown that single IV contrasted studies may be just as effective without the delays and aspiration risks.³⁷ Triple contrast may still have an advantage for flank and back wounds. CT scan is rapidly improving in all forms secondary to decreased radiation and improved resolution.

Other imaging studies to consider include a skeletal survey to look for bullets that may have moved intravascularly, a CT of the head for

concomitant traumatic brain injury, a retrograde urethrogram or cystogram if the patient has hematuria, or an IV pyelogram.

Procedures

Intubation, NG tube placement, Foley catheter, IV access, and chest tubes should be performed as per ATLS protocol.⁶

At times, it is difficult to determine if a wound is “merely a flesh wound” or if it actually penetrates the peritoneum. Imaging is one way to further evaluate this, as discussed above, but there are some other options.

Local wound exploration remains a subject of debate. It is indicated for select cases involving single wounds when it is unclear if the peritoneum has been violated. To perform the procedure, prep and drape the area in a sterile fashion, inject local anesthesia, widen the wound, and retract. Use Kelly forceps to spread the rectus abdominis muscle, if needed. If penetration of the peritoneum is discovered or if fat or omentum is observed, the patient should go to the OR. The benefits of wound exploration include avoiding unnecessary procedures or imaging. The risks include infection, pain, and missed violation of the peritoneum. While some authors recommend local wound exploration of stab wounds, Tsikitis et al do not recommend this approach.⁴² They believe that the pain, bleeding, and risk of wound infection are not outweighed by the chance of confirming a superficial wound. Furthermore, local wound exploration is often difficult and misleading in uncooperative, obese, or very muscular patients.⁴²

In the past, the diagnostic peritoneal lavage (DPL) was standard of care for stable patients with penetrating wounds to the abdomen to identify hollow viscous and diaphragmatic injuries. The DPL has several drawbacks, including invasiveness, time consumption, false-positive rate, and lack of evaluation of the retroperitoneum. Largely, DPL has fallen out of favor and has been displaced by CT, FAST, and

sometimes exploratory laparoscopy; however, it occasionally still may be performed.

The DPL may be performed in an open or closed fashion. The bladder and stomach are first decompressed. An incision is made, and a catheter is placed in the direction of the pelvis. A syringe is used to aspirate fluid. Gross blood is an indication to immediately go to the OR. If no blood or bowel contents are aspirated, 1 L of warm saline is infused. After 5 minutes, the fluid is drained and a sample is sent to the laboratory for cell count with differential, Gram stain, bilirubin, amylase, and assessment for vegetable or fecal matter.⁴³ According to ATLS guidelines, findings of RBC greater than 100,000/mm³ or WBCs 100-500/mm³ indicate a positive DPL and a need to go to the OR.³⁶ Of note, however, if the mechanism is concerning for diaphragmatic injury, RBC greater than 5,000/mm³ may be considered positive and an indication for surgical intervention.⁴⁴ Lowering the threshold for a positive DPL decreases specificity but increases sensitivity.

The use of diagnostic laparoscopy may also be considered for stable penetrating trauma. Patient selection is paramount for the use of this modality. In patients with unreliable abdominal exams, such as those with head injuries or intoxication, this may be a helpful adjunct.⁴⁵ Laparoscopy also has the advantage of visualizing the peritoneum, diaphragm, mesentery, and omentum. Furthermore, direct visualization can aid with judging the stability of hemostasis.⁴⁵ Lastly, a laparoscope offers an excellent tool to remove foreign objects such as shrapnel, clothing, or bullets. In their study, Ahmed et al conclude that nontherapeutic exploratory laparotomy can be avoided in 75% of patients at a cost reduction of 50% over controls.⁴⁵ A diagnostic laparoscopy may enable the avoidance of unnecessary laparotomy.

Finally, consider thoracotomy for patients with penetrating thoracoabdominal trauma who become

pulseless or are exsanguinating. Thoracotomy can be used to relieve tamponade, control cardiac bleeding, obtain proximal aortic control, and to perform open cardiac massage. It should be used very selectively in penetrating abdominal trauma, and survival is rare.

Further Management

Over time, the management of PAT has evolved. Lessons learned on the battlefields of World Wars I and II dictated that patients with penetrating abdominal wounds were taken directly to surgery. Through the 1950s, mandatory laparotomy was the standard of care. In the 1960s, the first DPL was performed, and practitioners began treating selected patients with non-operative management. Now, with further advancements in diagnostic procedures, imaging, and resuscitation protocols, care of PAT continues to evolve. Today, SNOM may be becoming the standard of care. Emergency providers can learn more about the nature of the injury and manage select patients without surgery.

The benefits of SNOM in PAT are significant. Two major reasons to avoid surgery, if at all possible, are a significant rate of negative and nontherapeutic laparotomy and the high incidence of complications that accompany this surgery.⁴¹ A negative laparotomy is defined as an unnecessary operation wherein the surgeon fails to find any injury, whereas a nontherapeutic laparotomy is defined as an unnecessary operation wherein the surgeon finds only minor injuries that do not require intervention.⁴⁶ In several series, the rate of clinically significant injuries ranges from as low as 15% in stab wound victims to 33% of patients with gunshot wounds. Therefore, routine laparotomy for PAT is not indicated. Furthermore, it is not without a price: The incidence of complications from nontherapeutic laparotomies for victims of penetrating trauma range from 8.6% to 25.9%.⁴¹

In the current era of economic stewardship, we must always be

concerned with cost and benefit. A hospitalization for PAT with SNOM is typically \$9500 less than one associated with a nontherapeutic laparotomy.⁴¹ Furthermore, the complications associated with unnecessary laparotomy result in increased hospital lengths of stay and hospital charges. One recent study showed a \$9.5 million U.S. savings in hospital charges over an eight-year period.⁴¹

Much like the management of solid-organ injuries in blunt abdominal trauma, there is literature to support SNOM for penetrating solid organ injury. In one recent study, the success rate of SNOM in liver-, kidney-, or spleen-injured patients was 69%.⁴⁷ Stab wounds to the liver are often treated with non-operative management, while the treatment of gunshot wounds to the liver remains more controversial.⁴⁸ An exception is pancreatic injuries. The overall mortality from penetrating pancreatic injuries ranges from 13-27%, with much depending upon whether the major pancreatic duct is involved. Franklin and Casos recommend that all penetrating pancreas injuries be assessed operatively.⁴⁸

Thoracoabdominal wounds can present a special challenge to emergency physicians. This is the region that spans from the nipple line to the costal margins bilaterally and can be filled with thoracic and abdominal organs.⁴⁶ This region presents a challenge because the motion of the diaphragm during respiration can change anatomic relationships. Interestingly, surgery consultants may treat penetrating wounds to the thoracoabdominal region differently depending on the side. Injuries to the right side generally involve the liver and the diaphragm. It is less common for this side to need surgical intervention because of the size and position of the liver.⁴⁶ Penetrating injury to the left thoracoabdominal area has a higher concern for diaphragm and hollow viscous injury. CT scan is sensitive in excluding diaphragmatic injury. However, if the CT is equivocal, further exploration, such

as diagnostic laparoscopy, may be indicated.^{49,50}

Management of Stab Wounds to the Abdomen in the Stable Patient

The non-operative management of stab wounds to the abdomen is well established. A routine laparotomy is not indicated in stable patients with abdominal stab wounds without signs of peritonitis or diffuse abdominal pain.⁵¹ Conservative management of asymptomatic patients with anterior abdominal stab wounds has been shown to decrease length of hospital stay and rate of normal laparotomy.⁵²

Recent studies show the sensitivity of serial abdominal exams to be as high as 97.4%, with a cost savings of \$2800 per patient managed without surgery.⁵³ In patients with a clear sensorium who do not show any evidence of peritonitis, evisceration, hemodynamic instability, or diffuse abdominal pain, practitioners may choose a non-operative approach to management.⁵³

The key to this management modality is serial abdominal exams to be performed by a single dedicated team. The exams should be done by senior residents and attendings.⁴⁷ Serial exams have been found to be 94% specific in abdominal trauma.⁶ The managing team may choose not to give narcotic analgesics, which are sometimes considered to mask the clinical exam. This is, of course, a controversial topic, and treating pain while in the emergency department would be left up to the emergency physician prior to surgical consultation. Each physical examination would be supplemented by evaluation of the vital signs with a specific focus on temperature, blood pressure, and heart rate. Furthermore, serial CBCs to evaluate hemoglobin and white blood cell count are recommended every eight hours.⁵³ A time period of 12 hours is likely sufficient, as studies show that patients who

need surgical intervention will likely present before that time.⁵⁴

Management of Gunshot Wounds to the Abdomen in the Stable Patient

The patient who presents to the emergency department with a gunshot wound to the abdomen offers more of a clinical challenge; however, if the wound is tangential and the patient has no peritoneal signs, SNOM may be appropriate.⁵¹ A recent survey of the practice of SNOM of surgeons in the United States, Canada, Brazil, and South Africa showed that SNOM is not universally practiced and, of those who do use this strategy, no standardized approach exists. Surgeons who had completed trauma or critical care fellowship or those practicing in a higher volume center with more than 50 penetrating abdominal injuries seen per year were more likely to practice SNOM.⁵⁵ While it is true that the rate of intra-abdominal injury is higher with gunshot wounds than with stab wounds, a protocol of mandatory laparotomy is unnecessary. It is expected that mandatory laparotomy will yield a nontherapeutic result in one-third of gunshot wounds to the abdomen and two-thirds of gunshot wounds to the back.⁵³ The contraindications for nonoperative management for gunshot wounds are the same as those for stab wounds to the abdomen. It is most appropriate for a patient with a clear sensorium who may tolerate serial abdominal examinations and is hemodynamically stable with no evidence of peritonitis or diffuse abdominal pain.

The next step in setting up a patient for SNOM is detailed clinical exam. Signs of peritonitis, such as rebound tenderness and involuntary guarding, are evidence of intra-abdominal injury.⁴⁶ Patients with these findings are not appropriate for SNOM. Additionally, attention should be paid to distracting injuries, as these would preclude a patient from non-operative management as well.

The patient then must be

thoroughly imaged to identify the path of the bullet and any retained fragments. Once the areas of the body that are at risk for injury have been identified by clinical exam, radiographic imaging is used to determine the path of the projectile. Plain films can be used to quickly support physical examination. A chest X-ray can rapidly exclude life threats. Make sure to ask the patient if he or she has been shot before, as retained projectiles can confound the diagnostic assessment of the injury.⁴⁶

A CT scan with IV contrast and clinical exam should be used judiciously in patients with penetrating solid-organ injuries to monitor for complications. Evidence of free intraperitoneal or retroperitoneal air, free intraperitoneal fluid in the absence of solid organ injury, localized bowel wall thickening, bullet tract close to a hollow viscus with surrounding hematoma, and contrast “blush” in the presence of hemodynamic instability would all lead to laparotomy.⁴⁷ (See Table 4.)

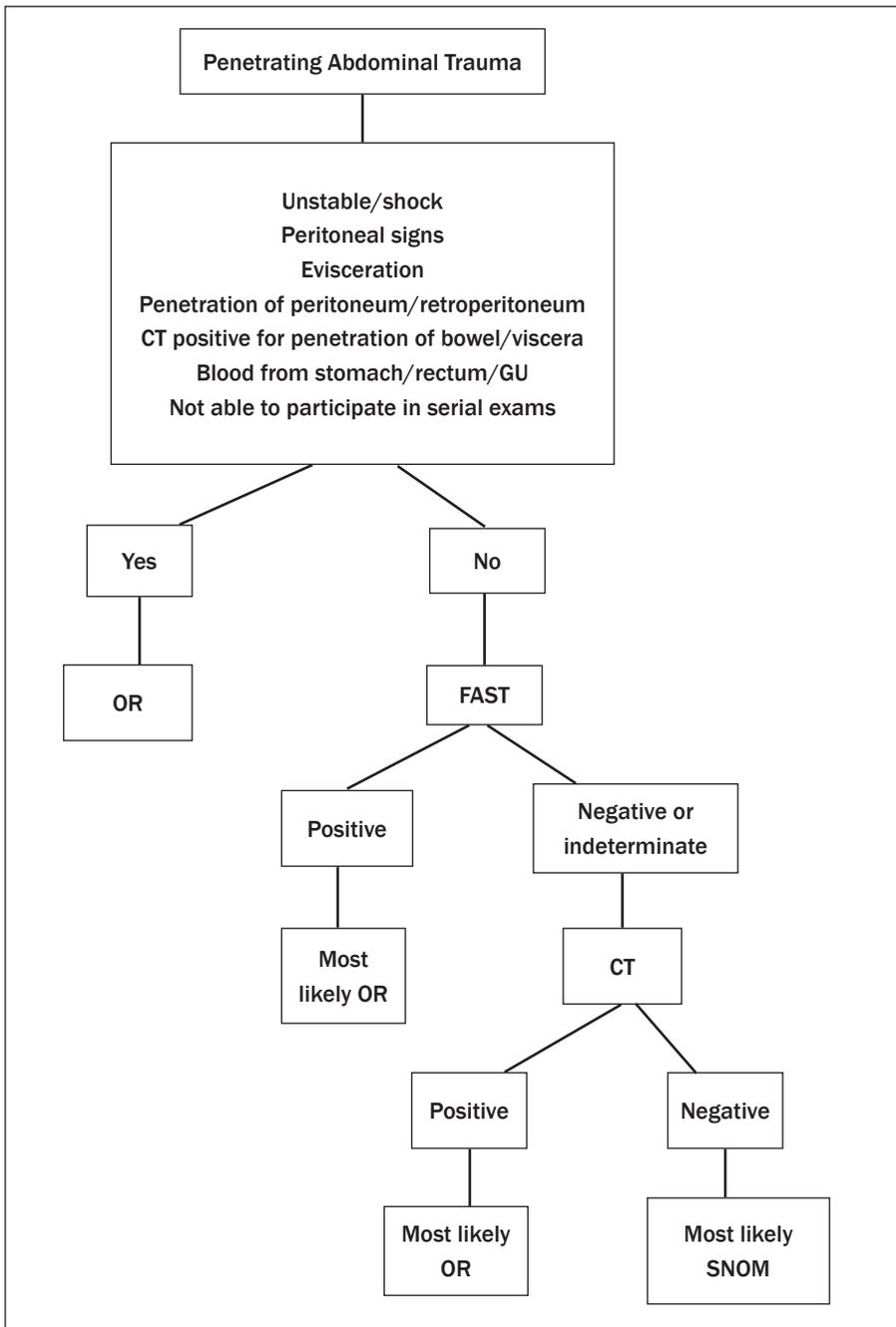
Special Consideration: The Pregnant Patient

Penetrating trauma is responsible for 36% of maternal deaths.⁵⁶ If a pregnant patient sustains a gunshot wound to the abdomen, maternal mortality is approximately 3.9%, but fetal mortality is much higher at 40-70%.⁵⁶ Fetal survival depends on adequate maternal resuscitation and uterine perfusion.

A few important pearls include the following:

- The mother's stability and survival is the top priority.⁵⁷
- During the primary survey, place the patient in the left lateral decubitus position to decrease compression of the IVC.⁵⁶
- During the secondary survey, obtain an obstetric (OB) history, consult OB, and initiate fetal monitoring.
- A fundus palpated midway between the xyphoid and umbilicus is consistent with a gestational age of approximately 28 weeks.
- Bedside ultrasound can be performed with the same ultrasound

Figure 3. General Approach to Managing Penetrating Abdominal Trauma



probe used for the FAST examination and can be useful to determine fetal heart rate.

- Examine the patient for vaginal bleeding, rupture of membranes, and contractions.

- Remember that bowel and abdominal organs are displaced superiorly as the uterus enlarges.⁵³

- Use a supraumbilical approach if attempting a DPL.

- An emergent cesarean section is indicated for maternal shock, term pregnancy, irreparable uterine injury, unstable but viable fetus, maternal death.⁵⁶

Disposition

If you are able to determine that the patient's penetrating injury does not violate the abdominal cavity, the patient can typically be discharged

with local wound care. All patients with true PAT should be admitted. Those who are sent to the OR vary in their length of stay based on the extent of their injuries sustained. Most patients with PAT managed non-operatively can safely be discharged after 24 hours of observation, if there has been a series of reliable abdominal examinations and minimal to no abdominal tenderness.⁵¹

Summary

In summation, most patients with PAT, especially gunshot wounds, still require surgery. On initial survey, patients who are hemodynamically unstable, have diffuse abdominal pain, evisceration, or peritoneal findings must go to the operating room.^{46,47} Patients with an altered sensorium, head injury, inability to cooperate with serial abdominal exams, or patients who will be undergoing an operative procedure somewhere other than the abdomen may be explored as well, depending on the comfort level of the trauma surgeon.⁵³ This leaves a clinical subset that can be managed nonoperatively. In these patients, SNOM can drastically reduce the rates of negative and nontherapeutic laparotomies and result in a cost savings and safety benefit to the patient.

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CNE/CME Questions

1. The most commonly injured organ in abdominal stabbing patients is the:
 - A. spleen
 - B. bowel
 - C. liver
 - D. gallbladder
2. A 22-year-old male presents after a stab wound to the right lower quadrant of the abdomen. He is hypotensive and tachycardic. A FAST scan shows free fluid in the right upper quadrant. What is the next best step in the management of this patient?
 - A. exploring the stab wound
 - B. antibiotics and tetanus prophylaxis
 - C. go to the OR for exploration
 - D. diagnostic peritoneal lavage (DPL)
3. A 36-week pregnant patient presents with a gunshot wound to the abdomen. She is hypotensive and confused. What is the next best step in the management of this patient?
 - A. FAST scan to check for free fluid
 - B. DPL using the suprapubic approach
 - C. observation with fetal monitoring
 - D. emergent cesarean section
4. A 34-year-old male presents with a stab wound to the abdomen. He has a heart rate of 78, BP 123/90, RR 18, temp

98.7, and O₂ saturation of 97%. He complains of minor abdominal pain at the laceration site. What is the next best step in the management of this patient?

- A. serial abdominal exams and CBCs
 - B. probe the wound and send him home if it doesn't seem too deep
 - C. tetanus prophylaxis, cephalixin, and discharge with 12-hour follow-up
 - D. emergent exploratory laparotomy
5. A 19-year-old female presents with a stab wound to the left lower quadrant obtained during a domestic dispute. She is tachycardic and complaining of diffuse abdominal pain. A FAST scan is indeterminate. A DPL is then performed. Which of the following results would necessitate surgical management in the OR?
 - A. RBC 100/mm³
 - B. WBCs 50/mm³
 - C. feculent aspirate
 - D. pain with procedure
 6. A 40-year-old male presents with a gunshot wound to the abdomen. He is complaining of abdominal pain and is becoming hypotensive. His family wants to know what the most likely injured organ is. What will you advise them?
 - A. the spleen
 - B. the small bowel
 - C. the liver
 - D. the gallbladder
 7. A 19-year-old female presents after sustaining a self-inflicted stab wound to the abdomen. EMS brings her to your emergency department. Her mental status is good and vital signs are all within normal limits. What is the best treatment of this patient?
 - A. transfuse 2 units packed red blood cells (PRBC)
 - B. infuse 2 liters lactated Ringers
 - C. infuse 2 liters 0.5 normal saline
 - D. observation with serial abdominal exams
 8. A 39-year-old male presents to your emergency department with a gunshot wound to the abdomen. He is clinically stable with a negative FAST scan, so you send him to CT scan. Which of the following

CT scan findings would allow for observation with serial abdominal exams?

- A. evidence of peritoneal violation with splenic laceration and hematoma
 - B. evidence of peritoneal violation, but no obvious organ injury
 - C. evidence of peritoneal violation with contrast "blush" and free air near bowel
 - D. evidence of peritoneal violation with projectile lodged in liver
9. Which of the following is the most important laboratory test in a hypotensive patient with gunshot wound to the flank?
 - A. chemistry panel
 - B. CBC
 - C. blood type and cross match for transfusion
 - D. urinalysis
 10. A FAST exam is performed on a patient with a gunshot wound to the abdomen. Which of the following is true?
 - A. If the FAST is negative in two windows, it can be considered negative.
 - B. If the FAST shows free fluid in an unstable patient, disposition would be to the OR.
 - C. If the FAST is negative and the patient is stable, DPL is the next appropriate step.
 - D. Positive FAST scans in hypotensive patients must have a confirmatory DPL.

CNE/CME Objectives

Upon completing this program, the participants will be able to:

- discuss conditions that should increase suspicion for traumatic injuries;
- describe the various modalities used to identify different traumatic conditions;
- cite methods of quickly stabilizing and managing patients; and
- identify possible complications that may occur with traumatic injuries.

CNE/CME Instructions

1. Read and study the activity, using the provided references for further research.
2. Log on to www.cmecity.com to take a post-test; tests can be taken after each issue or collectively at the end of the semester. *First-time users will have to register on the site using the 8-digit subscriber number printed on their mailing label, invoice, or renewal notice.*
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Trauma Reports™ (ISSN 1531-1082) is published bimonthly by AHC Media, a division of Thompson Media Group, LLC, 3525 Piedmont Road, N.E., Six Piedmont Center, Suite 400, Atlanta, GA 30305. Telephone: (800) 688-2421 or (404) 262-7436.

Senior Vice President / Group Publisher: Donald R. Johnston

Executive Editor: Shelly Morrow Mark

Managing Editor: Leslie Hamlin

POSTMASTER: Send address changes to Trauma Reports, P.O. Box 105109, Atlanta, GA 30348.

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