

Approach to Penetrating Abdominal Trauma

Richard Davis and Caleb Van Essen

Background:

Penetrating abdominal trauma can challenge even the seasoned clinician. Hemodynamically unstable patients cause stress to both the surgeon and the system, as they have ongoing bleeding and need immediate surgery. On the other hand, sometimes when patients present with penetrating abdominal injuries, it can be difficult to decide whether surgery is needed at all.

The initial evaluation of these patients begins, as with all trauma patients, with a rapid primary and secondary survey, according to the principles of the Advanced Trauma Life Support (ATLS) course. Secondary survey is supplemented with carefully chosen adjuncts such as ultrasound and plain x-rays, bearing in mind that a poorly chosen study in our setting can cause a delay, potentially making the outcome worse.

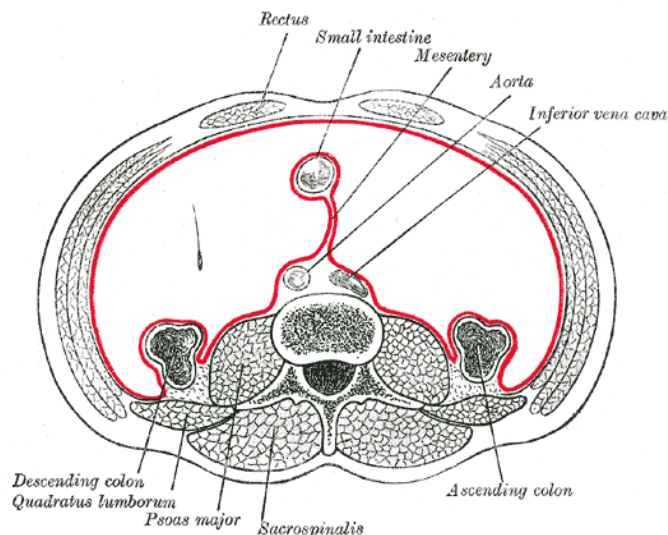
“Penetrating” trauma refers to stab wounds, shrapnel injuries, and gunshot wounds. The latter have much more tissue injury due to the velocity and cavitation effect of the bullet. Remember also that patients who present with apparent blunt trauma, as after a motor vehicle accident, can have penetrating trauma from vehicle fragments or stationary objects that they struck. Such wounds can be missed if all trauma patients are not thoroughly disrobed and examined.

Most of the modern literature on decision-making in penetrating trauma is written in resource-rich environments. In this chapter we hope to address the limitations that we face, including:

- Unavailability of advanced imaging technology
- Difficulty in quickly mobilizing resources such as blood, anesthetists, and other operating room staff
- More frequent delayed presentation
- Lack of sufficient personnel and excessive fatigue or burnout in those who are present

Anatomy:

The abdominal cavity is lined with peritoneum, a thin lining that reacts in a unique way to irritation. When peritoneum is in contact with pus, succus, or blood, its irritation causes a reflex contraction of the adjacent muscles.



Schematic cross-section of the lower abdomen: the peritoneum is represented by a Red line. When the peritoneum is irritated, the adjacent muscles contract in a reflexive manner, which can be detected by careful physical examination. Notice also that the ascending and descending colon are only partly intraperitoneal: injury to them from posteriorly, as a stab wound to the back, would not cause peritoneal irritation and thus would be harder to detect on physical examination. .

In the anterior abdomen, reflex contraction of muscles is detectable as classic “Peritoneal Signs” The most obvious of these is rigidity of the muscles with severe tenderness, so called “Diffuse Peritonitis.” More subtle signs include a reflex tensing of the muscles when depressed steadily (“Involuntary Guarding”) or pain after sudden release of an examining finger that has slowly pressed into the abdomen (“Rebound Tenderness.”) These signs are sometimes present in one location but not another- when this finding is present, it is called “Localized Peritonitis.”

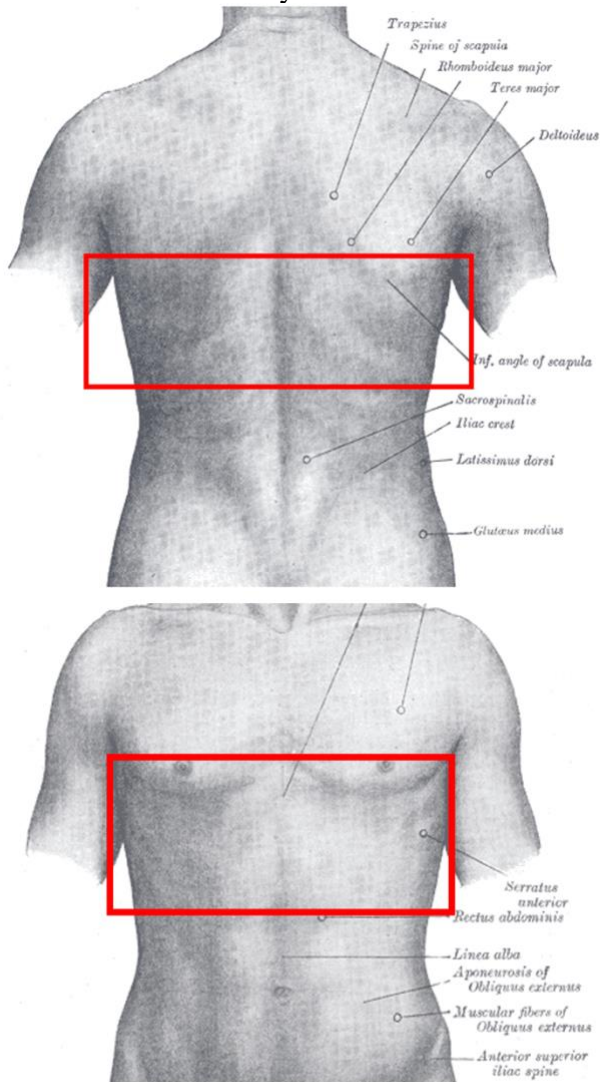
In the posterior abdomen, localized peritonitis is more difficult to detect. It can be noted by pain on passive movement of the muscles that are adjacent to the posterior peritoneum, as through hip flexion (“Psoas Sign”) or hip rotation (“Obturator Sign.”)

The abdominal cavity’s boundaries extend anteriorly from the inguinal ligaments and pubic symphysis to the nipples, and posteriorly from the upper buttocks to the inferior tips of the scapulae. In other words, the abdominal cavity can extend well up into the rib cage. The region of lower chest / upper abdomen is called the “Junctional Zone,” to denote the fact that penetrating objects in this area can cause

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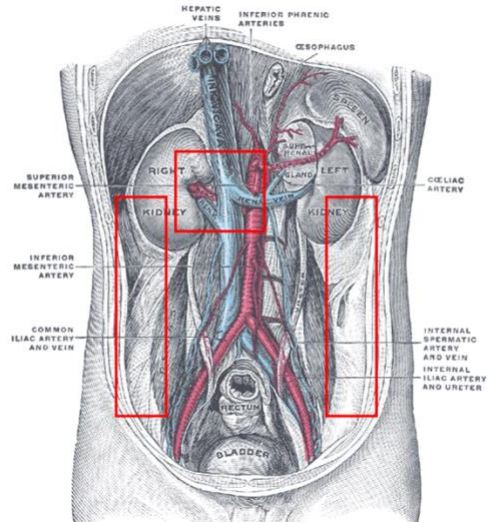
injuries in the chest, abdomen, mediastinum, or all of these areas simultaneously.



The “Junctional Region,” an area where penetrating trauma can potentially injure intrathoracic, mediastinal, or intra-abdominal contents, or both. The superior boundary is the nipples anteriorly, and the tips of the scapulae posteriorly. The inferior boundary is the costal margin. Remember to think about diaphragm injury, which can be difficult to detect.

The retroperitoneum is an enclosed area posterior to the viscera, with the thick muscles of the flank and back shielding it from examination. The ascending and descending colon and the duodenum are partly or completely within the retroperitoneum. Penetrating injuries to these structures can be quite difficult to detect if spillage occurs only in the retroperitoneum. Abdominal examination, abdominal ultrasound, and even early CT scan may not detect these injuries. The aorta, vena cava, renal and iliac vessels are also contained in the

retroperitoneum. Injury to these structures will usually be easier to detect, due to hemodynamic instability, though they can present in a delayed fashion.



Retroperitoneum with vessels, kidneys, ureters, bladder and rectum shown. The ascending colon, duodenum and descending colon are found within the Red boxes. Stab wounds to the flank and back involving these organs can be undetected by physical examination or even during laparotomy.

An isolated small bowel or colon injury that causes spillage into the peritoneum may not be detectable immediately; there may be a small amount of spillage that cannot be detected by either careful physical examination, ultrasound, or CT scan. Such injuries will usually cause peritonitis and early sepsis within 24-48 hours. This fact is the basis for Non-Operative Management, which we describe further below. Briefly, this is careful serial abdominal examination, done frequently enough to detect intra-abdominal spillage before it has irreversible consequences. If this strategy is done properly it is a very powerful screening tool, allowing the surgeon to operate on those who need it and avoid operation on those who don't. If this strategy is undertaken poorly, patients will get the operation they need too late, or not at all, and will be in danger of death.

Principles:

Decision-making begins with the initial primary and secondary survey, paying special attention to the number of “holes” (even/odd) identified. Perform immediate operation on patients with penetrating abdominal trauma who present with:

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- Hemodynamic instability
- Peritonitis
- Evisceration
- Blood in the rectum
- Bloody vomitus or NG aspirate
- Bilious or feculent discharge from the wound.



Evisceration after a stab wound to the upper abdomen. This patient is best treated by a midline laparotomy and exploration for other injuries in the area. Source: Desalegn M et al, East and Central African Journal of Surgery <https://doi.org/10.4314/ecaajs.v25i3.8>

Patients who have ongoing bleeding present with hemodynamic instability that does not respond to resuscitation, or they will respond transiently and then become hypotensive and tachycardic again. They should undergo laparotomy as soon as possible. The only reason to delay operation is if such a delay would help you know where to operate. This situation arises in injuries to the “Junctional Region,” the area that extends from near the costal margin up to the mid-chest. In this situation, you may have a thoracoabdominal injury and be operating in the abdomen while bleeding continues uncontrolled in the chest. A chest tube can often assist in this decision making. We discuss this situation further below.

Patients who are hemodynamically stable may or may not have an intra-abdominal injury that you have not detected yet. You do not want to miss an injury, but you also do not want to do a full laparotomy if such an injury is not present.

In this situation, your toolkit includes Local Wound Exploration, Diagnostic Peritoneal Lavage, or Non-Operative Management. We discuss the principles behind all these techniques below, followed by principles of imaging. In the final section, Decision Making, we bring all these elements together into a cohesive strategy.

In considering all these techniques, keep in mind that you are attempting to balance one bad outcome, a negative laparotomy, against a much worse outcome, a missed injury. Do not gamble with the patient’s life; if there is any change in the patient’s condition, do not hesitate to explore the abdomen. Find more on the thinking required here in the Chapter, “Detection of Post Operative Intra-Abdominal Complications.”

Local Wound Exploration

This operation ranges from widening and exploring of a small stab wound under local anesthetic, to a full unroofing and debridement of a tangential gunshot wound tract in the operating room. In all cases, the main goal is to detect penetration, through the peritoneum, into the abdominal cavity.

It is impossible to see the peritoneum on local wound exploration. So, we use the most superficial layer of fascia as a surrogate, as this breach can be detected at local wound exploration. (We accept a small false positive rate, for those rare cases where the tip of the missile went through the outer layer of the muscle fascia but no further.)

It is obvious, therefore, that the operation must be conducted so that you can see the fascia clearly and do not miss a penetration. Follow these principles:

- Do the operation with excellent lighting, at least one assistant to retract, and all the equipment you need. In some resource-limited settings, these conditions may only exist in the operating room.
- Conversely, if you are able to perform this operation safely and well in the Casualty under local anesthesia, the patient can be discharged immediately after a negative exploration.
- If you take the patient to the operating room, or if you put them to sleep for the exploration, have them sign consent for both wound exploration and laparotomy. Explain how you would deal with a bowel injury if you found one, including ostomy creation if that seems even remotely possible.
- Open the wound enough to see as far down as you need to. For example, in an obese patient who was stabbed with a 2cm wide blade, you may



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need to open the wound 10cm to definitely rule out penetration into the fascia.

- Once you have finished, wash the wound well and close it loosely.
- For gunshot wounds, consider local wound exploration only if it seems highly likely that the bullet passed through nothing more than skin and fat. In other words, there must be an even number of holes (entry/exit), the trajectory pattern must be superficial, and there must be no hard signs of intraperitoneal violation as noted above. These patients will need debridement of clothing or shrapnel inside the wound at the same time, so do these explorations in the operating room with the appropriate anesthesia. Unroof the entire tract between the entrance and exit wound, debride any dead tissue, make sure there was no entry into abdominal wall muscle, irrigate and close the incision you made loosely, leaving the bullet holes themselves open.



An apparently tangential gunshot wound (one wound is under the examiner's gloved index finger.) Especially if a CT scan is not available, the tract between the two wounds should be unroofed, explored to verify no entry into the peritoneum, debrided, and loosely closed. Source: Bobjgalindo, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0> via Wikimedia Commons

Non-Operative Management

As explained above, this strategy depends on the “window” that exists between initial injury and the serious consequences of that injury. This window lasts 24 hours at most. It has been described primarily for isolated solid organ injury, particularly the liver and spleen, in high resource settings. However it is very useful for detecting intestinal injury as well. During this time, patients can deteriorate slowly or very quickly, depending on the size of the hole in

their intestine. Therefore, to make this strategy work you must:

- Watch these patients very closely
- Intervene immediately at the first sign of peritoneal irritation, sepsis or hemorrhagic shock
- Have blood products available, especially if there is a known injury to the liver or spleen.

In a resource-limited hospital you may have difficulty with these requirements. Regarding the first requirement, you are committing that the same team will examine the patient's abdomen very carefully every 4-6 hours for the next 24h. If you are the only surgeon, do not make a habit of placing this extra burden on yourself.

Regarding the second requirement, you must be able to operate on this patient as soon as you detect a change in their condition. If you have limited operating theater space that is usually booked with elective operations, and then the whole team goes home to return at 8AM on the following day, this is not the strategy for you.

The third requirement is also important when monitoring solid organ injury. A delay in operative intervention might ultimately require ongoing blood transfusions. A thorough assessment of one's resources is essential in making this decision.

Recall that this strategy was originally described in high-resource settings. Most of these patients get a high-resolution CT scan with IV and sometimes oral contrast, then they are followed by a dedicated in-house trauma team with an operating room on standby. You may be enthusiastic about this approach after reading their literature, but consider whether their experience applies to you.

Another caution to Non-Operative Management should be applied to patients with multiple injuries or head injuries. Any amount of hypotension may worsen the prognosis here. Often it is not clear where the injury is. Also, serial examination is more difficult with multiple injuries or decreased level of consciousness. We usually have a low threshold to explore the abdomen of such patients if there is any possibility of a missed injury: the consequences would be very grave.

Diagnostic Peritoneal Lavage

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This technique has fallen out of favor in high-resource settings as imaging has become more advanced. Mention of this technique in textbooks and research articles has fallen at a similar rate. However, for a surgeon without a high-quality CT scan or rapid access to an ultrasound machine, this technique can be very useful. We have a separate chapter describing it in more depth (see “Diagnostic Peritoneal Lavage”).

This technique is most suited to patients with back and flank penetrating trauma. Anterior abdominal penetrating injuries can be evaluated with local wound exploration. Consider it in patients who have:

- Penetrating trauma to the back or flank and no access to CT scan.
- Penetrating trauma to the back or flank with an unreliable examination due to head injury, spinal cord injury, intoxication, or other form of impaired consciousness making serial abdominal examination difficult
- Extensive bruising or soft tissue trauma to the abdomen making examination unreliable.
- Penetrating trauma to the back or flank who are in the operating room for another operation.
- Patients who are hemodynamically unstable after any blunt or penetrating multiple trauma, where the source of bleeding is not clear. This indication has mostly been replaced by Focused Abdominal Sonography for Trauma (FAST, See Chapter.) If you do not have ready access to ultrasound, you will be using peritoneal lavage.

Briefly, under general anesthesia a small incision is made just above the umbilicus. If blood returns immediately, proceed directly to laparotomy. If not, a catheter is inserted into the abdomen and directed towards the pelvis. 1L of Normal Saline is run in through IV tubing under gravity, then the IV bag is placed on the floor and the fluid runs back into the bag. If the fluid is so cloudy (but not bloody) that you cannot read a newspaper through the IV bag, proceed immediately with abdominal exploration.

In resource-rich countries, the fluid is assayed for serum amylase, and if the level is 3x the serum amylase, the patient needs exploration. In our setting, this result probably won't return soon enough to help with any decision-making, so the

Lavage is mostly useful for the immediate presence of blood, or a positive “newspaper test.”

Imaging

You must know the limitations of each option in order to interpret the results. On both ultrasound and CT, blood and freshly spilled succus both have the same appearance, that of “fluid.” Patients who have a solid viscus injury such as spleen or liver injury will have fluid in the abdomen on imaging. You may be tempted to think that any intra-abdominal fluid is only blood from these organs. We would recommend laparotomy in anyone with free abdominal fluid on initial presentation, unless you can do Non-Operative Management very well, as described above.

The pitfall is, of course, thinking that the intra-abdominal fluid is only blood when it is, in fact, a mixture of blood and succus. This mistake is more likely to occur in non-operative management of solid organ injuries after blunt trauma.

When using abdominal ultrasound to make management decisions, keep in mind that a patient will have a “normal” abdominal ultrasound until there is 600mL of fluid in the abdomen (an extremely skilled operator can detect as little as 400mL.) Also retroperitoneal injuries/blood may not be detected. The useful thing about ultrasound is that it can be easily repeated at the patient's bedside. If a patient's ultrasound was initially negative but they become unstable, repeat it. The amount of blood may have increased and now be visible to you.

Blood, or freshly spilled succus, will look black on ultrasound. Any fluid that looks “cloudy” or has floating elements that can be made to move when pressure is applied to the probe, is probably purulent. Of course, this finding will happen in patients who present late, or in whom you have missed the injury previously.

A high quality IV contrasted CT image will show other signs of viscus injury, such as thickening of bowel wall or stranding of mesentery or other adjacent fat. This depends on timing of injection and quality of the scanner. To assist identifying the penetration trajectory, place small metallic markers (EKG pads are useful) on all stab or gunshot wounds. Although it is helpful having CT imaging in operative planning, do not take a hemodynamically



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unstable patient to the CT scanner! If you aren't clear where the bleeding is, use ultrasound (or DPL if you don't have ultrasound.)

Plain x-rays should not be overlooked in assisting diagnosis of injury. Place metallic markers on all open wounds. Free air on upright or left lateral decubitus indicates need for a laparotomy.

Decision Making:

As with all trauma patients, start with ATLS primary and secondary evaluations. Often early, easy decisions can be made with hemodynamically unstable patients going straight to operation, without any delay for time-consuming imaging. Portable x-rays and ultrasound (to confirm intra-peritoneal fluid and identify cardiac injury) can be considered if they can be performed quickly or performed without delay in the operating room.

Beware the unstable patient with a junctional injury pattern or multiple penetrating wounds. Thoracoabdominal injuries requiring exploration of two cavities have extremely high mortality rates. You do not have time for imaging, but you do not know exactly where to operate! Completely exposing patients, rolling them and identifying the number and trajectory of injuries can assist in the operative approach. An early thoracostomy tube is diagnostic and possibly therapeutic, identifying which side of the diaphragm the injury is on.

See the chapter on trauma laparotomy for details on performing the operation and decision making regarding exploration of hematomas. Briefly, in penetrating trauma, explore hematomas in zone 1, 2 and 3 whether they are expanding or not.

Special considerations need to be made to prepare for any type of injury and the subsequent repair that is needed. Thus preparing and draping patients from neck to knees and elbows, with arms out, will allow exposure for central access, chest cavity exploration and vein harvest for grafting of vascular injury. Make plans for patients' disposition as soon as possible due to constraints mobilizing support staff and equipment for ICU management.

Be thinking about the possible need for damage control and temporary abdominal closure. Damage control is a strategy that focuses on immediate repair of life-threatening injuries, while delaying other measures (such as bowel anastomosis

and abdominal closure) until the patient is more stable. Focus first on controlling hemorrhage and GI spillage. Once this is accomplished, consider whether you should reconstruct and repair at this time, versus applying [temporary abdominal closure](#) and stopping the operation for rewarming and resuscitation. An experienced surgeon will often recognize the situation and choose damage control before the operation has even started.

To summarize, take no chances with the patient. A negative laparotomy is better than a missed bowel or vascular injury. Unclear injury patterns can make management decisions difficult. When you are not sure what intra-abdominal injuries the patient might have, it is worth considering local wound exploration, non-operative management and diagnostic peritoneal lavage.

Remember that injuries in the junctional zone can lead to ongoing bleeding in the chest, mediastinum or abdomen.

Remember that both blood and spilled bowel contents initially look like dark fluid on ultrasound and CT scan. Do not mistake one for the other.

The ideal *local wound exploration* patient includes: single anterior stab wound, known short bladed knife, cooperative patient, insufficient personnel for serial abdominal exam, experienced surgeon and no additional injuries.

The ideal *non-operative management* (watchful waiting) patient includes: stab wound, in-house on-call trauma team (residents,) ability to do an operation at any time, an awake, alert and cooperative patient, initial exam is completely benign, and no advanced imaging available. Consider it also in a very obese patient, in whom local wound exploration would be morbid.

Most patients with abdominal gunshot wounds will need laparotomy, unless it is quite clear that the wound is tangential and didn't enter the peritoneum.

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