Penetrating Abdominal Trauma: Evaluation & Treatment

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About this edition

The original version of this article on the evaluation of penetrating abdominal trauma was originally published on Trauma.org in 2004 with a large number of references and images. In an attempt to decrease the size of the article and update basic information, it has been heavily edited (for instance, all those references and images have been removed, a section on management of specific injuries has been added, and some anglicisms have been altered). This article has been redesigned for informal or semi-formal teaching and has been updated without regard for citation or the pesky notion of rigorous evidence. Those desiring more formality (and content) are encouraged to read the original article or, even better, pretty much all of *Top Knife* by Hirshberg & Mattox. The original may be found at http://www.trauma.org/index.php/main/article/414/. This is version 20170821-2. The latest version can always be found at http://jonessurgery.com/penetrating-abdominal-trauma.

Penetrating abdominal injury

The abdomen extends from the nipples to the groin crease anteriorly, and the tips of the scapulae to the gluteal skin crease inferiorly. Any penetrating injury to this area, or that may have traversed this volume, should be considered as a potential abdominal injury, and evaluated as such.

The incidence of penetrating injury will vary from hospital to hospital and region to region. Some institutions will have a very low incidence of penetrating trauma, and yet it is vital that penetrating injury is treated differently from blunt trauma. The mechanisms and physical characteristics of injury are different, as are the relevance and accuracy of investigations and the methods and timing of repair.

Presentation

Patients with significant penetrating abdominal injury tend to fall into 3 major categories:

Presentation	Likely injury	Management priority
Pulseless	Major vascular injury	Emergency laparotomy or resuscitative thoracotomy with aortic cross-clamp
Hemodynamically unstable	Vascular and/or solid organ injury AND/OR Hemorrhage from other sites	Identify & control hemorrhage; damage control
Hemodynamically normal	Hollow viscus injury, pancreas, or renal	Identify presence of gastrointestinal, diaphragmatic, or retroperitoneal injury

The appropriate investigations and management pathway vary with each of these clinical presentations.

Pulseless

Patients who arrive without palpable pulses but with witnessed recent or current signs of life (e.g., pulseless electrical activity) need immediate laparotomy in the operating room for hemorrhage control. However, the ability to transfer such a patient from the ambulance bay directly to the operating room and start the laparotomy within 5 minutes of arrival is vital if this is to have any chance of success, and this is not possible in most centers.

A second option is to perform a thoracotomy in the emergency department and cross-clamp the aorta. This is a poor second choice option as it does not completely arrest hemorrhage, delays laparotomy, and opens a second body cavity which will contribute to further

heat and blood loss. This maneuver has a very low functional survivor yield, and yet remains the only hope for salvage in this group of patients where immediate access to an operating room is not available.

Hemodynamically unstable

There should be no delay in trying to resuscitate the patient prior to surgery.

Patients with penetrating trauma who are hemodynamically unstable require immediate operation. 'Haemodynamically unstable' includes non-responders and transient-responders to initial small-volume fluid bolus administration or transfusion. Patients should be taken immediately to the operating room, without further unnecessary investigations or interventions.

The only decision to be made in these patients is where is the bleeding and this which cavity to expose first. Where there is a stab or gunshot wound obviously involving the abdomen, the decision is simple, and the patient has a laparotomy. If there is a question about the abdomen being the source of the bleeding, FAST scan is used to determine the presence of free intra-peritoneal fluid. In the absence of ultrasound, diagnostic peritoneal aspiration is reasonable; aspiration of frank blood or succus confirms intraabdominal injury, and time for a formal lavage is unnecessary.

The decision to perform a laparotomy may be complicated if:

- There are multiple stab wounds/gunshot wounds to multiple cavities.
- The wounds are at, or cross, junctional zones (e.g., the costal margin, groin, or buttocks).
- There is evidence or the possibility of cardiac tamponade

The diagnosis of massive hemothorax may be made clinically, with a FAST scan, chest tube or Chest X-ray, depending on the degree of shock present and the rapidity with which such tests can be performed. Cardiac tamponade may be diagnosed with FAST or in the operating room with a pericardial window.

It is more important to take the patient to the operating room and commence surgery than to make a definitive diagnosis. If a thoracic injury is suspected during a laparotomy a hemithorax can be explored through the diaphragm or a formal thoracotomy, and a tamponade explored through a pericardial window and sternotomy.

Hemodynamically Normal

Patients with clinical signs of peritonitis or with evisceration of bowel should be taken immediately to the operating room.

Currently there are several possible options for the evaluation of penetrating abdominal trauma in the hemodynamically normal trauma patient without signs of peritonitis. Many of these patients will have some superficial tenderness around the wound site, but no signs of peritoneal inflammation.

The goal of any algorithm for penetrating abdominal trauma should be to identify injuries requiring surgical repair, and avoid unnecessary laparotomy with its associated morbidity.

Adjuncts to the initial evaluation of the trauma patient can provide clues to significant intra-peritoneal injury:

- **Chest X-ray**
  An erect chest radiograph may identify sub-diaphragmatic air. This must be interpreted with some caution in the absence of peritonitis, as air may be entrained into the peritoneal cavity with a stab or gunshot wound. However it certainly signals peritoneal penetration and warrants further investigation.
- **Nasogastric Tube**
  Blood drained from the stomach will identify gastric injury.
- **Urinary catheter**
  Macroscopic hematuria indicates a renal or bladder injury. Microscopic injury suggests but is not pathognomonic of ureteric injury.
- **Rectal examination**
  Rectal blood indicates a rectal or sigmoid penetration. Proctoscopy & sigmoidoscopy should be performed (see below)

Options for evaluation

Further evaluation requires the use of one or more of the following diagnostic modalities:

- Serial Physical Examination (PE)
- Local Wound Exploration (LWE)
- Diagnostic Peritoneal Lavage (DPL)
- Ultrasound (FAST)
- CT Scan
- Laparoscopy
- Laparotomy

These different methods, each discussed below, are by no means equal. The decision on which method, or combination of methods, to choose will depend primarily on hospital factors such as trauma patient load, access to inpatient beds, availability of in-house surgical teams, access to high resolution CT scanners, etc. Whichever decision tree is chosen should be accepted at a hospital-wide level. The practice should not change from surgeon to surgeon and day to day. The algorithm should be routinely audited for missed injuries, effectiveness, and use of resources.

Serial physical examination

Serial physical examination has the best sensitivity and negative predictive value of all modalities for the evaluation of penetrating abdominal trauma.

The patient is admitted for observation for 24 hours. During this time the patient is has frequent (hourly), regular checks of their hemodynamic status. The abdomen is examined routinely for signs of developing peritonitis. Ideally the same surgeon should examine the patient each time. If this is not possible, during a handover period both surgeons should examine the patient at the same time so they agree on the current status of the abdomen and whether there has been any progression in symptoms. The timing of examinations varies in the literature, but should probably start out more frequently and then decrease over time. A suggested sequence of examination might be at 1, 4, 12 and 24 hours after the initial assessment. Some authors recommend examination every four hours.

If the patient develops signs of hemodynamic instability or peritonitis during this period of observation, a laparotomy is performed. If the patient is well the following day they start a normal diet, and are discharged once diet is tolerated and they have completed the observation period.

Patients who do not develop frank peritonitis, but who have persistent local symptoms of pain and tenderness, with perhaps a fever or tachycardia at 24 hours should be evaluated by another modality: CT scan, laparoscopy, or laparotomy.

The disadvantages of serial physical exam are primarily the requirement to admit all patients with a penetrating injury, and the requirement for frequent hemodynamic and physical examinations. This usually requires the patient to be in a high dependency type setting, and requires a body of in-house surgeons to perform the serial evaluations.

Local wound exploration

Local wound exploration (LWE) requires a formal evaluation of a stab wound under at least local anesthesia. This procedure is usually performed in the operating room, but is performed in the emergency department by some institutions. This procedure is not a simple probing of the wound with a cotton swab, and is not the basic retraction of edges in an attempt to visualize the wound base. The wound must be extended enough to allow following the track through tissue layers; this is often extension of the wound and exposure of the fascia for several centimeters.

Penetration of the anterior fascia is considered a positive LWE, as penetration of the peritoneum is difficult to identify. A positive LWE leads to either laparotomy or diagnostic laparoscopy.

When LWE is used alone to determine laparotomy, there will be a high non-therapeutic laparotomy rate. Even if peritoneal (rather than anterior fascial) penetration were used as a cut-off, many of these patients will have no intra-peritoneal injury, or an injury that does not require surgical intervention—most commonly omental laceration, mesenteric laceration, or liver tears that have stopped bleeding.

Diagnostic peritoneal lavage

Diagnostic peritoneal lavage (DPL), though seldom practiced in the era of bedside ultrasound, may remain a useful adjunct with FAST is unavailable. This involves passing a small catheter into the peritoneal cavity, usually at the umbilicus or just inferior to it. If blood can be aspirated through this catheter, this is referred to as a positive 'tap' or aspiration (DPA). If no blood can be aspirated a liter of warm crystalloid solution is run into the peritoneal cavity and then allowed to drain out. This lavage fluid is traditionally then sent to the laboratory for analysis of red cell count, white cell count, and any bowel contents (feces, succus, or food matter).

It is important to realize that the role of DPL in the hemodynamically stable patient is different from that in the unstable patient. In the unstable patient the problem is one of major hemorrhage. DPL is used as an alternative to the FAST scan to identify intraperitoneal hemorrhage only when the cavity of penetrating injury is unknown. In the unstable patient one is searching for a lot of blood, so a positive DPL in this setting requires either a positive aspiration.

A hemodynamically unstable patient with a clearly abdominal stab wound needs no further investigations and will proceed to laparotomy, as discussed above. So the role of DPL in the hemodynamically normal patient with penetrating abdominal injury is to identify hollow viscus injury (stomach, small bowel, or colon) or diaphragmatic injury, either of which is more easily and safely performed with alternative tools.

FAST

The role of FAST in penetrating trauma has not been as fully evaluated as in blunt injury. FAST is sensitive for pericardial fluid and can be used, like DPL, to evaluate whether the abdomen is the source of massive bleeding in the hemodynamically unstable patient. Ultrasound as yet cannot detect the small amounts of fluid which may be associated with a hollow viscus injury, so for the hemodynamically stable patient:

- A positive FAST indicates peritoneal penetration and mandates at least diagnostic laparoscopy, but is poor at discriminating for injuries requiring intervention
- A negative FAST does not exclude significant abdominal injury

CT

CT scanning is finding an increasing role in the evaluation of penetrating abdominal injury. A modern scanner with triple-contrast protocol (intravenous, oral and rectal) is sensitive for most major abdominal injuries, and identifies secondary signs of injury for those not visualizable. With ability to recognize those secondary signs, the oral and rectal contrast are probably also unnecessary. Of all the diagnostic modalities listed, CT gives the best assessment of retroperitoneal structures.

The CT, however, is most useful for defining the tract of extraperitoneal penetrating wounds and allowing disposition of patients without further evaluation. If an obvious tract is present and does not violate the abdominal fascia, the wound can be cleaned and closed and the patient discharged. However, lack of a visualized tract does not imply this; further evaluations (typically wound exploration or diagnostic laparoscopy) are needed. Positive CT signs mandating at least laparoscopy include:

- Free intraperitoneal air
- Free intraperitoneal fluid
- Wound track extending through fascia or through retroperitoneum to colon
- Bowel wall thickening
- Intraperitoneal fat stranding
- Intraluminal contrast leak
- Intravenous contrast extravasation
- Diaphragmatic defect (for which the CT still has low sensitivity)

The use of CT for penetrating intraabdominal injury is again unnecessary and even contraindicated for the hemodynamically unstable patient, or for the hemodynamically stable patient with a positive FAST or obviously penetrated peritoneum (such as with eviscerated bowel). These patients should go directly to the OR.

Laparoscopy

A full trauma laparoscopy for the evaluation of penetrating injury still requires general anesthesia and complete examination of intra-peritoneal contents, including visualization of the whole small bowel and intra-peritoneal colon. In most studies laparoscopy has a significant false negative rate, primarily from missed bowel injuries. Laparoscopy is also limited in the evaluation of retroperitoneal injury. While an expert laparoscopist can capably run the bowel, the other limitations require any finding of peritoneal violation—certainly any finding of significant hemoperitoneum—to nearly mandate laparotomy. The best exception to this laparoscopy undertaken in the setting of a thoracoabdominal wound requiring evaluation for diaphragmatic injury. A laceration of the right diaphragm and no other blood in the abdomen can typically be repaired laparoscopically without the need to open. While a left diaphragm laceration is more likely to be associated with intraperitoneal injury, most authors suggest handling these similarly. In either case, of course, care must be taken to avoid higher insufflation pressure which would result in a hemodynamically significant pneumothorax.

Laparotomy

Exploratory laparotomy for all penetrating abdominal wounds still has a role in resource-limited environments, or occasionally in cases of multi-cavitary injuries. For most situations however the non-therapeutic laparotomy rate will be unacceptable high. With the incidence of complications with a negative laparotomy at of 12%-41%, it is difficult to support such a strategy where adjunctive methods such as CT or FAST are available and serial physical examination has such a low missed injury rate.

Special Situations

Wounds to thoracoabdominal junction zone

Thoracoabdominal injuries need to be evaluated for diaphragmatic injury. Where there is evidence of thoracic and abdominal injury there must, by definition, be an injury to the diaphragm. For example, if there is a right pneumothorax and a liver laceration, the diaphragm must also be torn.

If the evidence for this is less clear, but diaphragm injury is still suspected, the options are ultrasound, MRI, CT or laparoscopy/thoracoscopy. All radiological studies may miss small diaphragmatic tears, and so laparoscopy/thoracoscopy remains the investigation of choice. Laparoscopy is preferred for left sided injuries, thoracoscopy or laparoscopy for right sided injuries. Diaphragmatic lacerations may also be repaired through a laparoscopic or laparoscope-assisted approach.

Flank or back wound

Flank or back wounds may be associated with injuries to retroperitoneal organs such as the colon, kidney and lumbar vessels; or more rarely the pancreas, aorta and inferior vena cava. Of these, the colon is the injury most often missed. Where colon injury is a possibility, the duration of serial physical examination is extended to 72 ours, watching for fever or a rise in the white cell count. An alternative is to perform a triple-contrast CT scan. When the wound track extends up to the colon, or there is evidence of abnormal bowel wall thickening, laparotomy is indicated.

Wound to buttock or perineum

The most dangerous missed injury here is the occult rectal injury. Any penetrating injury to the gluteal region carries the risk of rectal injury. Digital rectal examination is inadequate and full proctoscopy and sigmoidoscopy should be performed, looking for the presence of blood and/or a mucosal tear.

Recommended approaches

Which diagnostic tree a hospital chooses for the evaluation of penetrating injury will be dependent on numerous factors, including trauma patient load, surgical team availability and coverage, the availability of CT scanners and trauma radiologists, and access to the operating room and critical care beds.

Many different systems are used around the world. The following recommendations form a reasonable simple algorithm for modern trauma centers, but are by no means the only possibilities. Each diagnostic tool is associated with the caveats listed above.

1. ABCs
2. If the patient is hemodynamically unstable and has multiple potentially injured body cavities, perform FAST to distinguish between them.
3. If the patient is hemodynamically unstable with an abdominal injury (either identified by FAST showing intraabdominal fluid or obvious abdominal wound location), or is hemodynamically stable and has peritonitis, evisceration of omentum or bowel, leakage of succus or stool, or uncontrolled bleeding, proceed to OR for laparotomy.
4. If the patient is hemodynamically stable and has none of the above, perform FAST; if intraabdominal fluid is identified, proceed to OR for laparotomy.
5. If stable and none of the above, obtain high-resolution CT with IV contrast. Any of the findings listed above in the “CT” section should result in laparotomy.
6. If there are none of the above, and CT demonstrates only an obvious tract outside the abdominal fascia (not the absence of a tract that penetrates, but a clear one that does not), the patient may be discharged after appropriate local wound care.
7. If there are none of the above, consider serial abdominal exams for 24 hours, diagnostic laparoscopy, or local wound exploration. Choice of these is dependent upon surgeon preference and available resources.

Management of select injuries

As noted above, the instructions here are given without citation or reference, and are intended as basic "survival" information. In many cases, more advanced techniques (or more pedantic adjuncts) are available. As always, obtaining more experienced help in the critically wounded patient is no more a failure than converting an impossible laparoscopic case to open; the patient's wellbeing always comes before the surgeon's pride.

Adjunct antibiotics

Penetrating injuries to the abdomen require the determination of tetanus vaccination and administration if indicated. In addition, empiric wide-spectrum antibiotics identical to those given for elective gastrointestinal surgery are appropriate at the time of operation; a reasonable combination is cefazolin and metronidazole. Even with some spillage, antibiotics for less than 24 hours will usually suffice. In the setting of massive contamination, antibiotics can be continued for four days following the completion of source control. In the case of gastroesophageal injury, addition of an antifungal is recommended.

The unstable patient and the damage control procedure

Patients who remain in shock, acidotic, coagulopathic, and/or hypothermic require a rapid correction of surgical defects followed by safe resuscitation in the intensive care unit. This requires three basic steps:

1. Stop bleeding
2. Stop spillage
3. Get out

Spleens and kidneys can be removed, vessels can be ligated or shunted, the GI tract can be stapled (and even left in discontinuity), livers can be packed (usually), and the abdomen can be (temporarily) closed with a commercial negative pressure wound therapy device, a simple running fascial stitch, or by approximating the skin with a ridiculous number of penetrating towel clips. Get to the ICU, reverse the acidosis, correct the coags, and warm the patient. Go back for more when it's safe.

The bladder

While large defects in the bladder due to rupture or blast injury may require the assistance of our colleagues from urology, simple lacerations may be closed primarily in two layers. Care must be taken to identify the bladder mucosa for inclusion in the inner running absorbable stitch (preferably a monofilament synthetic absorbable suture or chromic gut); permanent suture may become a nidus for stone formation. The usual outer Lembert sutures should include both peritoneum and the bladder's muscular layer, but not penetrate into the mucosa.

Prior to repair, evacuate any clot, and attempt to identify the ureteral orifices on the trigone. If the injury is near these, stenting is recommended, and it may be most appropriate to consult urology. Then place a 3-way indwelling catheter under direct visualization before your closure. This will allow continuous bladder irrigation (either empirically or if there is ongoing bleeding or residual clot). Prior to removal of the Foley, obtain a CT or fluoroscopic cystogram after several days.

The diaphragm

Existence of a diaphragmatic defect mandates an ipsilateral chest tube before closure of the diaphragm. If there is massive contamination of the abdomen, copiously irrigate the chest through the defect (opening it further if necessary) and out the chest tube. After this is done, close the diaphragmatic laceration with a permanent braided suture in the fashion of a running or interrupted horizontal mattress. If the diaphragm is particularly attenuated or only monofilament permanent suture is available, pledgets may be required. In the case of even a very large laceration, primary closure is usually possible; if associated with a blunt or blast-related diaphragmatic rupture, use of a permanent biologic or synthetic implant may be necessary.

The gastrointestinal tract

Most simple small lacerations of the stomach, small intestine, and colon can be easily repaired in two layers. A running full-thickness absorbable suture imbricated by interrupted serosal Lembert sutures provides an adequate seal. On the small intestine, this should be done transversely, perpendicular to the course of the bowel, to avoid a long segment stricture. For a similar reason, a wound that involves more than half the circumference of the small intestine will require a resection rather than repair; in particularly petite patients, the bowel may be small enough that it will tolerate even less of a defect. When in doubt, take it out.

The management of lacerations, punctures, and tears often differs greatly from the management of blast and blunt injuries even when the same organs are involved. A combination of these mechanisms of injury is often the result of gunshot wounds (GSWs), so it is unsurprising that even when repair of an organ is easy after a stabbing, a shooting results in the organ's partial or complete removal. This is most significant in the treatment of the hollow viscus injuries of the abdomen; as a general rule, even if an injury due to a GSW results in a relatively small defect, the involved segment should be resected rather than repaired. If this is not undertaken, invisibly contused tissue surrounding the wound may reveal itself only days later when its ischemia results in necrosis and perforation. For the intestine, a segmental resection (and, if the patient is stable, re-anastomosis) is the best treatment; for the stomach, a wedge resection will usually suffice.

The kidney

Perhaps no injury in trauma causes as much unnecessary consternation as the kidney laceration. There are many worse injuries, but the amount of concern given to the injured kidney is unfortunate. While renal function is important to homeostasis and the daily lives of our patients, the kidney has a contralateral biologic backup system and a technological second backup even if failure is permanent. In the hemodynamically unstable patient, removal of the bleeding kidney is a requirement. Perform a medial visceral rotation, pulling the kidney into the midline as well, and clamp across its hilum. There is no need to separate the artery and vein; tie them off. Do, however, separate the ureter inferior to the artery and vein and ligate it further toward the pelvis to avoid a fistula bleeding into the urinary tract. Although it will not change the management in this situation, identify the contralateral kidney to ensure complete renal failure is not imminent; this may be done by simple palpation in the unstable patient.

For stable patients with kidney injury, renal repair is a possibility, and is probably best left to our urologic colleagues. If unavailable, you may attempt to repair open calyces with running 4-0 absorbable suture and the cortex with interrupteds; pledgets may be required. If the kidney does not appear salvageable, it may be removed. Again, identify the contralateral kidney by palpation (or, as was done traditionally, by on-table pyelogram) and perform a nephrectomy as above.

The liver

While the kidney causes unnecessary concern, concern due to a major liver injury is entirely appropriate. No other abdominal organ laceration leads to the morbidity and mortality that can result from a liver lac. There is a plethora of control and repair mechanisms; only the basics are included here. For more advanced and novel techniques, the book *Top Knife* is again recommended.

Most penetrating liver injuries are quite minor and bleed surprisingly little. For nonbleeding wounds, high-energy electrocautery or the argon beam coagulator (collectively referred to as "fulguration") will more than suffice; if the grossly hemostatic injury is in sensitive areas such as in close proximity to the GI tract, porta hepatis, or outflow of the hepatic veins, a topical hemostatic agent is an appropriate substitute. In either case, you may simply decide to leave it alone altogether.

Bleeding surface wounds up to a depth of about 2cm are similarly controlled quite easily with fulguration. Deeper wounds or those not controllable with such simple measures are best backed temporarily. For stabbings resulting in lacerations with edges that approximate, pushing the liver together to match these edges up and placing lap pads to keep it in this position is one of the simplest temporary bleeding control methods. For gunshot wounds or other injuries that remove more parenchyma, this may not be possible, but direct pressure and tight packing with laparotomy pads is still likely to control bleeding. Liver stitches using large gauge absorbable suture (the classic is 0 chromic) are appropriate in the stable patient not undergoing damage control surgery; the tactic again is to use the suture to approximate the cut edges of the liver rather than to use the sutures to ligate unexposed vessels. Again, one exception is the case of gunshot wounds that avulse a portion of parenchyma and are thus not able to be placed directly in contact; consider mobilizing a strip of omentum to fill in the defect and suture the liver to close this.

Should the patient remain unstable and bleed through tight packing of the liver, the appropriate rescue maneuver is the Pringle: from the patient's right, identify the foramen of Winslow posterior to the porta, and insert a long vascular clamp with one limb through the foramen and one anterior to the porta. Closing the clamp will end blood flow to the liver, though back-bleeding through the hepatic veins is still common. As this is done only when packing has failed, the goal is to identify very large lacerated vessels in the liver parenchyma for direct repair, or, if this is not possible, to use an improvised device such as a balloon to place direct pressure within a long tract. Most importantly, if at all possible, call for help from an experienced colleague.

The pancreas

Control bleeding. Place some drains. Live to fight.

The spleen

Take it out. Bluntly remove small attachments of the spleen to the lateral abdominal wall and retroperitoneum. Come across the short gastric vessels and the splenocolic ligament with clamps and ties or an energy device. Staple across the hilum with a white (vascular) load, or clamp the vessels and tie them. There's no reason to keep the artery and vein separate, despite some prior teaching regarding

arteriovenous fistulae. After removal, roll up a lap pad to affect a shape similar to a burrito or egg roll. Slowly roll it toward you over the splenic bed to identify small bleeding vessels (short gastric arteries, mostly) that are amenable to electrocautery. Leave a drain if you were anywhere near the pancreatic tail.

Retroperitoneal hematomas & vascular injuries

The retroperitoneal hematoma in bluntly injured patients carries ongoing conundrums; what zone is it? Is it expanding? What's considered expanding—before your eyes, over a given time period, or just larger than expected based on imaging? Is it pulsatile? How do you know there's pulsatile bleeding into the hematoma rather than an underling pulsatile vessel? Does it matter?

The equivalent injuries in the penetrating trauma patient have much more simple guidelines: retroperitoneal hematomas due to a penetrating injury should be explored. The likelihood of a simple "shear" of small vessels or muscular ooze is much less than in a blunt injury. If the patient is hemodynamically unstable and a damage control procedure is being performed, surgeon judgment may again note the lack of expansion or other signs as being more amenable to packing (with possible angiography) rather than exploration, but since the hematoma is not well contained (there is by definition a hole in the peritoneum from the penetrating injury), this must be carefully considered.

Exploring the hematoma may be done directly or, if certain vessel injuries are suspected, after first obtaining proximal and distal control. This is relatively easy if the hematoma is lateral or pelvic and small. The hematoma can then be opened by performing a medial visceral rotation: choose the side of injury (if the hematoma is central, choose the side with the hole) and cut through the white line of Toldt. Bluntly dissect either anterior or posterior to the kidney toward the midline; the hematoma has likely already dissected out some of this space. Identify sources of bleeding and control appropriately (as below).

Even though there is a risk of more blood loss, however, opening the hematoma at the site of penetration is a reasonable alternative to the formal medial visceral rotation. It will not likely be possible to follow a defined tract from the peritoneal laceration to the source of bleeding, but opening the defect into the retroperitoneum more widely while tracking the direction of apparent bleeding is an appropriate path.

Once a bleeding vessel is identified, dissect around it; there is quite possibly an injury through the vessel and into one on the other side. The circumferential dissection will also allow for appropriate proximal and distal control and easier repair or ligation. In the unstable patient, any veins (including the cava) can be ligated; if repair is attempted, running 4-0 or 5-0 permanent monofilament suture is best used, and sewing may require pledgets. The aorta and common and external iliac arteries should be repaired or shunted rather than ligated or bypassed for a damage control surgery. If repairing, use a biologic (autologous vein or exogenous material) or synthetic patch. To insert a Javid shunt into the iliacs, get proximal and distal control, place the shunt with care not to injure the intima, and tie it into place; do not attempt to leave clamps on the shunt to hold it when temporarily closing. For the abdominal aorta, use a cut (nonfenestrated) portion of a chest tube similarly.

For smaller vessels like the renals and splenics, it is often appropriate to simply remove the associated organ. Similarly, the internal iliac arteries or individual vessels feeding the mesentery can be ligated. The major exception to this rule is the superior mesenteric artery; even in the unstable patient, this should be repaired or bypassed.

Most other simple retroperitoneal injuries require little intervention. The remaining organ to be discussed is the retroperitoneal duodenum. In the case of simple laceration, primary repair is appropriate after exposure with a wide Kocher maneuver. For a more destructive injury, pyloric exclusion is probably unnecessary despite prior teaching. Closure with suture or staple is effective. The unstable patient should be left in discontinuity; when stable, the patient should have a gastrojejunostomy. At the time of gastrojejunostomy, surgeon preference dictates Roux-en-Y reconstruction with duodenojejunostomy, placement of a lateral duodenostomy tube, pyloric opening with a Heineke-Mulicz pyloroplasty, or nothing at all—the normal pylorus will allow backflow into the stomach rather than blow out a distal staple line.

More complex injuries

The dreaded retrohepatic IVC laceration, laceration of the retropancreatic mesenteric/portal vein, and the destruction of the head of the pancreas are highly morbid and mortal injuries. The best advice this basic guide can give is to apply pressure (for instance, pushing down on the liver or pancreas) in an attempt to control bleeding, and call for help.

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