Trauma of the Gastrointestinal Tract

Series Editor:
Timothy A. Pritts, MD, PhD
Associate Professor, Division of Trauma and Critical Care, Department of Surgery, University of Cincinnati, Cincinnati, OH

Contributors:
Michael Petro, MD
Assistant Professor of Surgery, Division of Trauma and Critical Care, Department of Surgery, University of Cincinnati, Cincinnati, OH

Gerald Fortuna, MD
Clinical Instructor of Surgery, Division of Trauma and Critical Care, Department of Surgery, University of Cincinnati, Cincinnati, OH

Bryce RH Robinson, MD
Assistant Professor, Division of Trauma and Critical Care, Department of Surgery, University of Cincinnati, Cincinnati, OH

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NOTE FROM THE PUBLISHER:
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INTRODUCTION

The gastrointestinal (GI) tract runs from the mouth to the anus, passing through the head, neck, thorax, and abdomen. The GI tract is vulnerable to trauma in each of these areas. In blunt trauma, the small or large bowel may be injured in up to 5% to 10% of patients, with injury occurring secondary to direct compression, deceleration, or a rapid increase in intra-abdominal pressure. In penetrating trauma, all regions of the GI tract are vulnerable to missiles or blades. A thorough understanding of the evaluation and management of trauma to the GI tract is essential to surgeons who care for traumatically injured patients.

ESOPHAGEAL TRAUMA

CASE PRESENTATION 1

A 21-year-old man presents to the emergency department (ED) trauma resuscitation area 10 minutes after sustaining a gunshot wound to the neck. Upon arrival the patient is awake and alert with moderate anxiety. There is an obvious 5-mm wound at the midline just above the thyroid cartilage, with air exiting the wound on expiration. He is vocalizing with mild hoarseness and no dyspnea. Peripheral pulses are intact and symmetric. His heart rate is 104 bpm.

• What are the next steps in the assessment of this patient?

The first step is to assess the ABCs of trauma as described in the Advanced Trauma Life Support Course. The next step in management is to fully assess the patient for additional wounds or injuries and determine the location of projectiles. After removing all clothing, the patient must be promptly log rolled to look for additional wounds, and a chest radiograph should be obtained. Radiographs of the cervical spine may aid in assessing the location of the projectile. Given the risk for loss of airway, the patient can never be left unattended and should not be taken to the radiology department without a secured airway.

CASE 1 CONTINUED

The physician notes that the patient is hemodynamically stable with a patent airway on arrival. Secondary survey demonstrates focal sensory and motor deficits of the right upper extremity. Cervical spine immobilization is continued with a hard collar. Plain films of the cervical spine and chest show a retained projectile and a likely cervical spine injury (Figure 1). There is no evidence of pneumothorax. Airway remains intact with no change in the subtle hoarseness of the patient’s voice.

• Should this patient be intubated at this time?

Although the patient has a patent airway at present, he has an obvious injury to the airway as evidenced by air exiting the wound. Blind intubation may inadvertently create a false passage in the submucosal space and thus worsen an injury or totally occlude the airway. Preferred options to secure this patient’s airway include fiberoptic image-guided intubation or placement of a surgical airway (tracheostomy) below the level of the injury.

CASE 1 CONTINUED

The patient undergoes an uneventful tracheostomy under local anesthetic and mild sedation in order to maintain his airway. Direct bronchoscopy performed at the time of his tracheostomy reveals an injury at the level of the vocal cords anteriorly. The patient remains hemodynamically stable without active bleeding from the wound or evidence of neck hematoma.

• Once the airway is secured, is formal neck exploration mandatory?

For the evaluation and care of trauma patients, the neck is often divided into 3 anatomical zones (Figure 2). By physical examination and imaging, the patient appears to have an injury in zone 2 of the neck. Traditional teaching in the care of trauma patients is that penetrating injuries to zones 1 and 3 are managed with a strategy of selective operative exploration and that hemodynamically stable patients undergo evaluation with endoscopy, esophagography, angiography, and bronchoscopy. In contrast, patients with injuries to zone 2 typically have undergone mandatory neck exploration.
to evaluate for organ injury, an approach based in large part on data from a 1956 paper by Fogelman.\(^2\) This approach minimized missed injuries but resulted in a high rate of negative or nontherapeutic explorations.\(^3,4\) Since the 1980s, there has been a steady increase in the acceptance of selective surgical exploration for injuries in all zones of the neck.

Indications for immediate operative exploration in patients sustaining penetrating trauma to the neck include hemodynamic instability and hard signs of vascular injury (arterial bleeding, expanding hematoma, bruit, airway compromise). The evaluation of patients who are hemodynamically stable and lack hard signs of vascular injury varies based on the presentation. Some authors advocate primary reliance on clinical exam,\(^3,5,6\) with angiography, esophagostomy, or esophagram being utilized as needed based on physical exam or suspicion of injury. Other studies have advocated routine angiography and esophagography for all patients.\(^7\) There are several potential limitations to esophagography. The patient must be able to swallow and participate in the exam, and it may be challenging to evaluate oropharyngeal and hypopharyngeal injuries using this imaging study.\(^5,9\)

While this selective approach avoids unnecessary operation on many patients, it requires allocating significant resources to these patients and has been shown to increase overall morbidity. In addition to the direct risks of angiography and endoscopy, obtaining these studies can cause significant delays in operation.\(^10\) These delays have been linked to a doubling of esophageal-related complications.\(^10,11\) Based on these findings and the emergence of newer, faster computed tomography (CT) scanners, many centers now advocate the use of multislice helical CT angiography (MCTA) in the evaluation of penetrating neck trauma.\(^12-14\)

MCTA of the neck for penetrating trauma often allows visualization of the trajectory of the projectile and evaluation of potential arterial injuries. If the images are of sufficient quality, they allow evaluation of soft tissue structures as well. By defining the trajectory of penetration, unnecessary endoscopy or esophagography may be avoided. In addition, the sensitivity of MCTA has been shown to be as high as traditional angiography for identifying surgically significant injuries in these patients.\(^15\) This allows a selective management approach that is minimally invasive and can be done in a timely manner.

**CASE 1 CONTINUED**

The patient is taken to the CT scanner where MCTA is performed. Imaging reveals the presence of significant air in the soft tissues of the neck as well as a projectile path through the posterior neck and

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**Figure 1.** Lateral cervical spine radiograph in patient 1 demonstrates likely cervical spine fracture as well as a retained projectile.

**Figure 2.** Zones of the neck as characterized for the care of the trauma patient. Zone 1 is from the clavicles to the cricoid cartilage. Zone 2 is from the cricoid to the angle of the mandible. Zone 3 is from the mandible to the base of the skull. (Adapted with permission from Borkon MJ, Cotton BA. Neck trauma. In: Brooks AJ, Clasper J, Midwinter M, et al., editors. Ryan’s ballistic trauma. 3rd ed. New York: Springer; 2011:397.)
in near proximity to the esophagus. Based on these findings, the patient is taken to the operating room for rigid and flexible esophagoscopy. An 8-mm contusion without clear mucosal penetration is found at the level of the cricopharyngeus muscle.

- **What are the possible next steps in management?**

The endoscopic findings suggest that an esophageal injury is present. The next best steps are somewhat controversial. In this patient, the lack of a mucosal defect and the level of the contusion could allow nonoperative management of this injury. Extensive algorithms have been developed to allow nonoperative management in selected circumstances. Critical issues that must be considered include the kinetic energy associated with the wound (stab versus low-velocity versus high-velocity gunshot wounds), level of the injury (hypopharynx versus cervical esophagus), and the timing until initial antibiotics. Most authors agree that any patient being observed for an esophageal penetrating injury must have, at most, a contained leak on contrast study. Some centers will limit this option to only those patients with no demonstrable leak on the swallow study. Injuries of the true cervical esophagus, below the constrictors, are less likely to heal with conservative management and thus are best managed operatively. Regardless of location, the most conservative option with penetrating neck trauma is to pursue operative exploration and repair. Penetrating thoracic and abdominal esophageal injuries are best managed with operation.

- **What are the operative approaches to the esophagus for trauma?**

In the neck, the cervical esophagus can be exposed via a collar incision if vascular injury is excluded, or an oblique incision along the anterior border of the sternocleidomastoid can be used if bilateral exposure is not needed. The left side is preferred unless the injury is a limited rightsided laceration. These incisions can be extended or combined as needed. Exposure of the esophagus will usually require division of the omohyoid. The carotid sheath is gently retracted laterally. Exposure is improved with division of the middle thyroid vein and inferior thyroid artery. Care must be taken to protect the recurrent laryngeal nerve.

In the thoracic esophagus, the level of injury dictates the operative approach. The upper two-thirds are best approached by a right posterolateral thoracotomy. The lower third is best approached by a left-sided sixth or seventh rib posterolateral thoracotomy. In either case the exposure can be modified to an anterior thora-cotony if the patient requires concurrent exposure to the abdominal cavity. On the right side, the azygos vein is divided and the lung retracted anteriorly. If the injury is very low in the chest, it may be best approached by laparotomy.

Regardless of location, the full extent of the injury must be exposed and addressed while avoiding excessive mobilization of healthy tissue. In order to allow full evaluation of the extent of mucosal injury, the muscular layer should be opened proximally and distally to the injury prior to repairing the mucosa. Repair can be accomplished with a running absorbable monofilament suture in the mucosa and interrupted sutures in the muscularis. Care should be taken to avoid narrowing the esophageal lumen, and placement of an esophageal bougie at the time of repair may be helpful in this regard. In the cervical region, a flap of the strap muscles or sternocleidomastoid can be used to cover the repair. This is mandatory if there is a concomitant tracheal injury. In the chest, a flap can be created from the pleura or intercostal muscles in order to buttress the repair. In the distal esophagus, the gastric fundus can be used to buttress the repair or to patch a defect. Wide drainage of injuries is important, especially in the thoracic esophagus. It should be noted that in the narrow portion of the cervical esophagus, wide drainage without repair is an acceptable alternative to repair if that repair will cause narrowing of the lumen. In the rare case of tissue devastation or delayed diagnosis, the patient may require diversion with T-tube or fistula formation.

**CASE 1 CONCLUSION**

Because of the esophageal injury noted on endoscopy, the patient undergoes cervical exploration via a left sternocleidomastoid incision. At operation, a 2-cm laceration to the cervical esophagus is found. After local debridement of damaged tissue, this is repaired in 2 layers. Due to the presence of an airway injury, a local muscle flap is used to buttress the repair. A drain is placed. The patient recovers and is discharged to a rehabilitation facility on postoperative day 5.

**INJURY TO THE SMALL INTESTINE**

**CASE PRESENTATION 2**

A 21-year-old man is brought to the ED by ambulance after sustaining a single stab wound to the abdomen. He was reportedly hypotensive in the ambulance with a systolic blood pressure of 82 mm Hg. Emer-
Emergency medical service (EMS) personnel began resuscitation with 2 L of crystalloid fluid through 2 large-bore peripheral intravenous (IV) lines with normalization of his blood pressure to the low 100s mm Hg systolic. He arrives in the resuscitation bay complaining of abdominal pain. He appears clammy and is cool to the touch. Initial vitals include a heart rate of 148 bpm and a systolic blood pressure of 92 mm Hg. His abdomen is mildly distended and slightly tender. Trauma labs are drawn and sent for point-of-care testing.

- What clinical information can be determined from his initial response to resuscitation efforts?

This patient’s tachycardia and initial hypotension are indicators that this injury may be more severe than appearances on physical exam alone would suggest. The patient has all the signs of significant hemorrhagic shock. The initial response to IV fluids, as has been taught in ATLS courses throughout the country, places this patient in a category described as a transient responder. The transient response to IV fluids, as noted by the EMS crew, suggests that this patient is suffering from ongoing hemorrhage. Together, the clinical findings and vital signs suggest that this patient is critically ill.

- Should aggressive IV fluid resuscitation be started?

A landmark study by Mattox in 1994 gave insight into the role of IV fluids in the pre-hospital care of patients with penetrating wounds to the torso. This study demonstrated that the timing of fluid resuscitation had a significant impact on patient outcomes, as patients randomized to aggressive early fluid resuscitation while en route to the hospital had a statistically significant increase in postoperative complications, longer hospital stays, and increased mortality. The finding that permissive hypotension may be beneficial to patients suffering from penetrating torso trauma has led to the practice of delaying initiation of aggressive IV fluid resuscitation until surgical control of bleeding is obtained in these patients, as long as the patient is mentating and has a palpable radial pulse.

The strategy of permissive hypotension in trauma patients with penetrating torso injuries was further supported by a recent study which showed that patients randomized to a hypotensive resuscitation strategy received less crystalloid and fewer blood transfusions and developed less coagulopathy. In addition, they had a lower mortality rate in the early postoperative period.

CASE 2 CONTINUED

Primary and secondary surveys of the patient are rapidly completed. His airway is patent and breathing is intact. He has no obvious external hemorrhage. Upon removing his clothing, he is found to have a single 1-cm stab wound to the central portion of his abdomen. A focused assessment with sonography for trauma (FAST) exam is completed and reveals the presence of fluid in Morrison’s pouch and the pelvis. An upright chest radiograph shows no evidence of free air under the diaphragm. Lab tests show a hemoglobin of 9.8 g/dL, an INR of 1.6, a pH of 7.23, and a base deficit of ~7. The massive transfusion protocol is activated.

- What are the options for evaluating penetrating trauma to the abdomen?

There are several options to evaluate the abdomen in patients suffering from penetrating trauma, including observation with serial abdominal examinations, FAST, diagnostic peritoneal lavage (DPL), CT imaging, direct exploration of the wound, diagnostic laparoscopy, and exploratory laparotomy. All of these options have a role in the management of penetrating trauma to the abdomen.

The gold standard for penetrating injuries to the abdomen is exploratory laparotomy. However, because of nontherapeutic laparotomy rates as high as 23% to 53% in patients with stab wounds, selective nonoperative management algorithms have been developed. Exploratory laparotomy is mandated in hemodynamically unstable patients and those with peritonitis or evisceration. Patients not meeting these criteria may be considered for nonoperative management, as nontherapeutic laparotomies are associated with complication rates up to 41%.

For these reasons, serial abdominal examinations, FAST, DPL, CT imaging, wound exploration, and laparoscopy have each found credible roles in the management of abdominal stab wounds. The use of serial abdominal examinations involves admission of the patient to the hospital and the performance of interval examinations, ideally by the same surgeon. The patient must be awake, alert, without a head injury, nonintoxicated, and able and willing to cooperate with examinations to be a candidate for this approach. If signs of intra-abdominal injury become evident, the patient is taken for exploration.

Shaftan was the first surgeon to apply selective criteria to patients with traumatic injuries to the abdomen, finding no mortality in patients selected for observation. Operative intervention resulted in a significant number of nontherapeutic laparotomies. This selectively conservative approach to patients with abdominal stab wounds was later supported by several studies per-
formed from 1960 to 1990 which found that a selective nonoperative approach to anterior abdominal wall stab wounds led to laparotomy being avoided in 52.8% to 88.6% of patients.21

FAST and DPL each are diagnostic techniques that allow evaluation of the patient for presence or absence of fluid in the peritoneum. FAST is best utilized to determine the presence or absence of hemoperitoneum in unstable patients, with the presence of hemoperitoneum leading to laparotomy.22 DPL has been utilized to evaluate for evidence of intraperitoneal injury, such as the presence of red blood cells, white blood cells, enteric contents, bile, or fecal matter.24

The use of CT scanning in the evaluation of penetrating stab wounds has been investigated extensively. Initial studies of patients who had been stabbed in the flank or back were able to show that nonoperative management could be successfully employed after a negative CT in 75.6% of the patients.21,23 A subsequent study reported that CT with oral and IV contrast had a sensitivity of 89%, a specificity of 98%, and an accuracy of 97% in the evaluation of stab wounds to the back.25 When IV, oral, and rectal contrast are used simultaneously, a negative CT scan study correlates with 100% sensitivity for retroperitoneal injuries in patients with back and flank stab wounds,21,27 making this approach the standard of care when evaluating this specific injury pattern. The use of helical CT in stab wounds to the anterior abdominal wall has also been investigated. The negative predictive value of helical CT in 1 early study was found to be 100%.21,28 In hemodynamically stable patients without clear signs for the need for emergency laparotomy, CT has become a clear beneficial adjunct in determining the clinical treatment plan.

An additional technique used in evaluating abdominal stab wounds is direct exploration of the wound in the ED or the operating room. If penetration of the anterior fascial sheath of the abdominal wall is found, then many surgeons feel that exploratory laparotomy or diagnostic laparoscopy is indicated. Local wound exploration, if utilized, should be performed only by a surgeon skilled and experienced in evaluating traumatic injuries of the abdomen.

Laparoscopy also plays a role in evaluating patients for possible intra-abdominal passage of a bullet or blade. The patient is taken to the operating room and a diagnostic laparoscope inserted. The surgeon evaluates for signs of peritoneal penetration, then performs a laparotomy as necessary. One very useful aspect of laparoscopy is in evaluating the diaphragm in patients who have thoracoabdominal wounds. In a prospective study by Yucel, 36 patients with left thoracoabdominal stab wounds were evaluated with laparoscopy.21 Of these patients, 13 (36.1%) were found to have injuries to the diaphragm and 7 of these 13 patients had associated intra-abdominal injuries. Of the patients with isolated diaphragm injuries, 9 were repaired laparoscopically.

The use of each of these strategies for evaluating the abdomen in penetrating trauma depends on the clinical presentation of the patient at the time of assessment and the clinical judgment of the surgeon evaluating the patient.

**CASE 2 CONTINUED**

Due to the patient’s hemodynamic instability, he is taken emergently to the operating room for an exploratory laparotomy. In the operating room, he is found to have a significant amount of hemoperitoneum with enteric contents staining several loops of bowel. The abdomen is packed in a systematic fashion and the hemoperitoneum evacuated. There are multiple lacerations to the mesentery supplying the small bowel. These are controlled by surgical ligation of the actively bleeding vessels and then the mesenteric defects are oversewn, controlling the hemorrhage.

- **What is the blood supply to the small bowel?**

The arterial supply to the small bowel is predominantly from the superior mesenteric artery and its branches and arcades. The blood supply to the duodenal bulb comes directly from the hepatic artery, with a rich supply of collaterals from the gastroduodenal artery.29 The second and third portions of the duodenum are supplied by a complex arcade of vessels from the anterior and posterior superior pancreaticoduodenal arteries arising from the gastroduodenal artery, as well as the anterior and posterior inferior pancreaticoduodenal arteries from the superior mesenteric artery.30 It is important to note that the second and third portions of the duodenum share a common blood supply with the head of the pancreas, which often makes repairs to injuries suffered in this area more complicated. The fourth portion of the duodenum and the first portion of the jejunum just distal to the ligament of Treitz are supplied by the first jejunal branch of the superior mesenteric artery.30 The superior mesenteric artery supplies the jejunum and ileum through a series of branches that terminate in arcades in the mesentry of the small bowel. The intestinal arteries, or vasa recta, arise from the peripheral arcades near the mesenteric border of the small bowel, directly supplying the small bowel without anastomosing.30 The vasa recta bifurcate as they near the bowel wall. The length of the vasa recta...
can be used to distinguish the jejunum from the ileum, as jejunal vasa recta are long and straight, while in the ileum, the vasa recta are shorter and more tortuous. In general, the venous drainage of the bowel follows the arterial supply, draining into the superior mesenteric vein and then the portal vein.

**CASE 2 CONTINUED**

The intra-abdominal packs are removed and the solid organs are evaluated with no evidence of traumatic injury found. The intestines are then meticulously inspected from the diaphragmatic hiatus to the rectum. The lesser sac is opened and found to be normal. Special attention is paid to the mesenteric border at the vasa recta where the 2 leafs of the mesentery meet the bowel to identify any small perforations caused from the knife wound. Two large lacerations to the antimesenteric portion of the jejunum are found and contamination is controlled with rapid placement of interrupted sutures. On the proximal ileum, an additional injury is found that is very minor. The rest of the intra-abdominal contents appear normal as do all 3 zones of the retroperitoneum.

During the operation, the surgeon discusses the patient’s resuscitation with the anesthesiologist. The surgeon is informed that the patient has received 12 units of packed red blood cells, 11 units of fresh frozen plasma, and a 10 pack of platelets. He is now hemodynamically stable with a pulse in the 90s and a systolic blood pressure of 117 mm Hg.

- **What options are there to finish the operation and repair the patient’s injuries?**

Whenever a patient presents with severe metabolic derangement, the use of damage control laparotomy strategies should be considered. In patients with severe ongoing acidosis and coagulopathy, rapid completion of the initial operation, packing of the abdomen, and performing bowel resection without anastomosis should be considered. At the second operation, bowel continuity can be restored, the abdomen thoroughly examined for missed injuries, and the abdomen then closed. Although useful and potentially lifesaving, this technique should be employed selectively. A recent study has suggested that delayed abdominal closure is associated with increased anastomotic leak rates.

Options to repair small bowel injuries include repair or resection with anastomosis. The severity of small bowel injury is graded by the American Association for the Surgery of Trauma (AAST) small bowel injury scale (Table 1). In general, grade I hematomas may be amenable to observation. Grade I and II lacerations are typically repaired, with care taken not to narrow the intestinal lumen. One clinical study demonstrated equivalence between primary handsewn repair and resection with stapled anastomosis. Repair may be accomplished with either a single-layer or two-layer technique as dictated by the surgeon’s experience and preference.

If the injury involves more than 50% of the bowel circumference (AAST grade III or above; Table 1) or if repair is not practical, resection and anastomosis will likely represent the best surgical option. The technique for anastomosis (stapled versus handsewn) remains an area of some controversy. One study showed no significant differences between these 2 techniques. A retrospective study from multiple level 1 trauma centers suggested that the handsewn technique may be superior to stapled, with increased intra-abdominal complication rates associated with stapled (13%) as compared to handsewn (5%) anastomosis. A more recent meta-analysis indicates that single-layer anastomosis is not in-

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**Table 1. American Association for the Surgery of Trauma Grading Scale for Small Bowel Injury**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Type of Injury</th>
<th>Description of Injury</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>Hematoma</td>
<td>Contusion or hematoma without devascularization</td>
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<td>Laceration &lt; 50% of circumference</td>
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<td>Laceration</td>
<td>Laceration ≥ 50% of circumference without transection</td>
</tr>
<tr>
<td>IV</td>
<td>Laceration</td>
<td>Transection of the small bowel</td>
</tr>
<tr>
<td>V</td>
<td>Laceration</td>
<td>Transection of the small bowel with segmental tissue loss</td>
</tr>
<tr>
<td></td>
<td>Vascular</td>
<td>Devascularized segment</td>
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*Advance 1 grade for multiple injuries up to grade III.

At present, the choice of anastomotic techniques is based on overall patient characteristics as well as time required to complete the repairs.

**CASE 2 CONCLUSION**

Due to the excellent response to resuscitation, the avoidance of coagulopathy during the operation, and the lack of a large amount of enteric contamination within the peritoneal cavity, the surgeon performs a 2-layered primary repair of the small injury at the proximal ileum. The larger injury to the jejunum is resected with a stapling device and a stapled anastomosis performed. The abdomen is closed in a standard fashion with a running absorbable monofilament suture. The patient is transferred to the surgical intensive care unit postoperatively, where he recovers well. He is discharged home in good condition on postoperative day 6.

**TRAUMA TO THE COLON AND RECTUM**

**CASE PRESENTATION 3**

A 23-year-old man presents to the ED with multiple gunshot wounds to the abdomen. In transport, EMS began IV fluids through 2 large-bore lines and found 2 wounds to his anterior abdomen. On arrival, the primary survey performed by the trauma team demonstrates a tachycardic (heart rate 158 bpm) and hypotensive (systolic blood pressure 87 mm Hg) patient who is protecting his airway and answering questions appropriately. Trauma labs are sent and a type and cross rapidly acquired. Upon rolling the patient both directions and examining his perineum, a larger hole is seen in the right posterior flank. A digital rectal exam demonstrates gross blood.

Due to the patient’s class IV hemorrhagic shock, resuscitation is begun immediately with blood and plasma. The chest radiograph is normal. An abdominal radiograph demonstrates a foreign body at the right pelvic brim (Figure 3). There is an additional entrance wound with no corresponding projectile (Figure 3). The secondary survey is negative for additional injuries and the patient is taken emergently to the operating room. Upon opening the abdomen, gross hemoperitoneum is encountered and an obvious destructive injury is seen on the anterior cecum. After packing the 4 quadrants of the abdomen and allowing anesthesia to commence resuscitation, small defects of the transverse colon and sigmoid colon are also appreciated.

- **How has the treatment of penetrating colon injuries historically evolved?**

The earliest reports for the surgical management of penetrating trauma to the colon are based on military experience during World War I.\(^{36,37}\) Primary repair of these wounds was favored due to the lower mortality rate being described. Postoperative sepsis was common, leading to a mortality rate of 30%.\(^{38}\) Treatment of colon injuries during World War II was based on the perception of an increase in mortality due to primary repair in the hands of many young and inexperienced military surgeons. The U.S. Surgeon General then mandated the routine use of colostomy for all colon injuries by 1943, with the British following in 1944.\(^{39,40}\) Surgical principles of World War II were translated back to the civilian population in that many injuries were treated with colostomy for the next 30 years. Nonetheless, surgeons began to recognize that civilian penetrating injuries are often low velocity with less destructive force than military injuries, allowing for primary repair as a viable surgical option.\(^{41-43}\)

- **Which injuries of the colon are amendable to primary repair?**

Like other penetrating injuries to the abdomen, the principles of control of bleeding and contamination apply. With colonic injuries, one must decide on the
The destructive nature of the wound and the ongoing hemodynamic physiology of the patient. Nondestructive wounds of the colon are often limited to injuries that have a minimal need for debridement. These wounds are often defined as grade I, II, and III wounds on the AAST Colon Injury Scale (Table 2). Multiple authors have demonstrated a lower complication rate and intra-abdominal abscess rate with the use of primary repair versus diverting colostomy in this setting.

Destructive colon wounds require segmental resection secondary to a loss of significant wall integrity or mesenteric injury. These wounds are often Colon Injury Scale IV or V injuries. The decision for segmental resection and primary anastomosis often takes into consideration the ongoing physiology of the patient, the timing of repair, and quantification of intra-abdominal contamination.

Evidence supports the finding that transient hypotension preoperatively or intraoperatively does not affect outcome but that a sustained period of hypotension significantly increases mortality. The duration of time from injury until repair as an independent predictor of postoperative complications is less well defined. Fecal diversion is recommended in nondestructive wounds with operative delays exceeding 12 hours and in destructive wounds with longer than 6 hours of delay with fecal peritonitis and hypotension.

The degree to which fecal contamination from colonic injury impacts outcomes is unclear. It is difficult to objectively quantify the amount of such spillage. Nonetheless, when major contamination is defined as spillage in greater than 1 abdominal quadrant, its impact on increased intra-abdominal infection is seen.

Prospective data for care of patients with destructive colon wounds is difficult to obtain because these wounds occur relatively rarely in civilian practice. The decision to repair as opposed to manage by diversion is multifactorial using criteria as described above. Demetriades and colleagues prospectively investigated this injury subtype to determine factors for mortality and septic morbidities in those undergoing resection and primary repair versus diversion. Univariate analysis demonstrated a difference for abdominal complications but not leak for those who received single-agent antibiotics, had severe fecal contamination, and received more than 4 units of packed blood cells. When multivariate analysis was performed, no difference was found for mortality or septic morbidities between the groups. The study group concluded that destructive colon injuries should be managed by resection and anastomosis rather than diversion, regardless of factors, due to the lack of evidence of benefit for a more conservative approach. Evidence-based guidelines for the management of penetrating colon injuries written prior to the above work take a more conservative approach. Evidence-based guidelines for the management of penetrating colon injuries written prior to the above work take a more conservative approach. Evidence-based guidelines for the management of penetrating colon injuries written prior to the above work take a more conservative approach.

Table 2. American Association for the Surgery of Trauma Grading Scale for Colon Injury

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abscess in those with stapled versus sutured gastrointestinal anastomoses. This work was contradicted by a large meta-analysis of randomized controlled trials that included 1233 patients with elective colorectal anastomoses and found no difference. Further work has demonstrated no superiority in technique for colonic anastomosis in traumatic, penetrating injuries and a decrease in leaks with the use of stapled ileocolic anastomoses in a large meta-analysis of elective interventions. At present, the decision to staple or sew gastrointestinal anastomoses is better left to the surgeon rather than predetermined by existing literature.

CASE 3 CONTINUED

After a period of aggressive resuscitation by anesthesia, an arterial source of hemorrhage is found in the ascending mesocolon. After ligation, the cecum and ascending colon are centrally mobilized, exposing a defect of the cecum that is more than 80% of the diameter. Posterior to the cecum, the tract of bullet can be reapproximated as it exited into the right flank, and a significant amount of fecal contamination is observed within the right lower quadrant. The patient has been hemodynamically stable since the initiation of resuscitation and no other vascular injuries are identified. A right hemicolectomy is performed with a stapled ileocolic anastomosis. Two small defects are seen on the anterior and posterior surface of the transverse colon, distal to the middle colic artery. The missile appears to be in the retroperitoneum and there is no major vascular injury or injury to adjacent structures. The transverse colon injuries are sutured closed in 2 layers. The small intestine is examined in its entirety and no injury is found. The lesser sac and stomach are free of injury. Upon inspection of the sigmoid colon, a single hole is seen on the anterior surface and a soft, nonexpanding hematoma is seen on the right lateral surface of the extraperitoneal rectum. A rigid proctoscopy is performed and no injury is seen; however, a significant amount of fresh blood compromises the exam.

• If a rectal injury is suspected, how should you proceed?

Isolated rectal injuries, though infrequent, are often caused by penetrating mechanisms, with gunshot wounds constituting the great majority. Like many uncommon wounds, a high index of suspicion needs to be maintained to avoid missing a potentially catastrophic injury. The evaluation of these injuries begins with digital rectal examination, but negative exams may not exclude a rectal injury. A finding of gross blood or a positive guaiac test should prompt the examiner to pursue further testing. If a rectal injury is suspected, rigid proctoscopy should be performed. Proctoscopy for the diagnosis of rectal injuries has demonstrated sensitivity as high as 88% for extraperitoneal wounds. The sensitivity decreases dramatically with more proximal, intraperitoneal injuries.

Screening for rectal injuries preoperatively may be impractical due to the patient’s condition. Intraoperative findings based on trajectory or extraperitoneal fullness or hematoma may suggest the presence of such an injury. Consideration should be given to intra-operative proctoscopy. Many trauma surgeons feel that extensive exploration of the extraperitoneal space in search of an injury is unwarranted in that visualization is difficult in a deep pelvis. In these cases, the presence of an injury should be presumed and the proper steps for treatment taken.

• What are the 4 D’s of treating penetrating rectal injuries?

Much like the treatment of penetrating colon injuries, the fundamentals for the treatment of rectal injuries are based on tenets proposed during the military conflicts of the last 70 years. The 4 D’s of rectal injury are: (1) debridement of nonviable tissue, (2) fecal diversion, (3) presacral drainage, and (4) distal washout. Although the techniques are utilized widely, whether to use them individually or in combination is controversial.

The debridement of devitalized tissue along with primary repair and fecal diversion is often debated in the same manner in which destructive colon injuries are. Primary repair of rectal injuries is less controversial when they are located on the anterior or lateral surfaces of the upper two-thirds of the rectum that resides within the peritoneum. These wounds are analogous to colon wounds and should be treated as such. Wounds located in the extraperitoneal rectum, more specifically the lower one-third or posterior wall, may be repaired if visualization of the wound can occur easily without aggressive dissection. Civilian wounds that cannot be visualized easily are often diverted without other treatment in order to prevent abscess or contamination of pelvic soft tissue that could evolve into necrosis and pelvic sepsis. Fecal diversion is often employed in patients with destructive rectal injuries that would require complex repairs or in patients with ongoing hemodynamic instability.

The use of presacral drainage in association with colostomy is often debated. A transperineal curved incision is made inferior to the anus to allow for blunt dissection in the retrorectal space up to the area of injury. Closed suction or Penrose drains are often employed, with removal
occurring when output is minimal. Such drainage is thought to prevent uncontrolled contamination and infection of the perirectal and retroperitoneal tissues. Such methods were utilized during the Korean War and Vietnam War with a resultant decrease in mortality. Similar beneficial outcomes have been found with civilian, low-velocity injuries. However, Gonzalez et al demonstrated in a randomized, prospective study that mortality and morbidity did not increase when presacral drainage was omitted from fecal diversion.

The use of irrigation into the distal rectum during operative intervention is also based upon improved mortality with its use during the Vietnam War. Surgeons utilized this technique to reduce the stool burden in the distal rectum to decrease pelvic soft tissue exposure to a large inoculum of bacteria. The use of this technique has been translated to a civilian population with debatable benefit. Many still advocate for this technique in patients with high-energy wounds.

CASE 3 CONCLUSION

The assumption that a rectal injury is present is made and the patient undergoes a diverting sigmoid colostomy and presacral drainage is employed with Penrose drains. The drains are removed after 3 days without incident. The patient is begun on a diet on postoperative day 3, and stool is noted in the colostomy bag by day 5, with hospital discharge by day 7. Six months later, a barium enema is performed without any findings of contrast extravasation or stricture of his rectal stump. His colostomy is closed at that time without complication.

REFERENCES


