Surgical Management of Abdominal Trauma

Hollow Viscus Injury

Jamie J. Coleman, MD[a], Ben L. Zarzaur, MD, MPH[b,*]

KEYWORDS

• Blunt abdominal trauma • Penetrating abdominal trauma • Hollow viscus injury

KEY POINTS

- Hollow viscus injury due to blunt trauma is infrequent, yet difficult to diagnose.
- Computed tomography scans are a commonly used diagnostic tool in hemodynamically stable patients with blunt and penetrating trauma, but they do have limitations.
- Appropriate operative management of hollow viscus injury is imperative in improving patient outcomes and preventing complications, such as the development of enterocutaneous fistulae.

INTRODUCTION

Injuries to the stomach, duodenum, small intestine, and colon are common in penetrating trauma and relatively rare in blunt trauma. Violation of the peritoneum occurs in between 20% and 80% of patients with penetrating trauma, depending on the type of weapon used.[1,2] Conversely, hollow viscus injuries are found in approximately 1% or less of blunt trauma admissions.[3,4] The most common site of injury in both blunt and penetrating trauma is the small intestine.[3,5]

Although hollow viscus injuries do not often contribute to hemodynamic instability, they are associated with significant morbidity and mortality. Injuries to the colon, and subsequent contamination, have been cited as the most significant risk factor toward the development of a surgical site infection.[6,7] However, morbidity rates directly related to gastric and small bowel injuries are also high, and have been reported up to 27%.[8] Furthermore, the presence of multiple hollow viscus injuries and concomitant gastric and colon injuries, for example, has been shown to have a synergistic, additive effect on the rate of postoperative surgical site infections.[9]

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[a] Department of Surgery, Indiana University School of Medicine, 1604 North Capitol Avenue, Office B242, Indianapolis, IN 46202, USA; [b] Department of Surgery, Indiana University School of Medicine, Indianapolis, IN, USA

* Corresponding author. 720 Eskenazi Avenue, H-2 Room 431, Indianapolis, IN 46202.

E-mail address: bzarzaur@iupui.edu

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The diagnosis of hollow viscus injuries, particularly in blunt trauma, can be difficult, and a delay in diagnosis can significantly increase the morbidity, mortality, and difficulty in management.[10,11] Operative management varies by the organ that is injured, as well as its severity. The American Association for the Surgery of Trauma (AAST) Organ Injury Scale is most commonly used to diagnose severity, and injuries are assigned a grade of I to V.[12]

DIAGNOSIS

As previously mentioned, the diagnosis of injury to the gastrointestinal tract can be difficult, particularly in blunt trauma. Symptoms vary depending on what organ was injured because a perforated stomach tends to produce significant signs of peritonitis, due to the low pH of its contents, in comparison with full-thickness injuries to the small bowel, which may take a longer time to produce significant signs and symptoms. The retroperitoneal position of portions of the colon can also hinder the development of classic peritonitis. To add to the difficulties, clinical examination of injured patients, many of whom have multisystem trauma, can be unreliable at best.

Historically, before the advent and widespread use of computed tomography (CT) scans in trauma patients, diagnostic peritoneal lavage (DPL) was a commonly used diagnostic tool in the evaluation of patients with both blunt and penetrating trauma. DPL is a very sensitive tool for possible intra-abdominal injury. Patients often underwent exploratory laparotomy for solid organ injury, even if they were hemodynamically stable. Due to the frequency of patients undergoing exploratory laparotomy during this time period, hollow viscus injuries were often diagnosed intraoperatively, and delays in the diagnosis of these injuries were uncommon.[13] As CT scans became the diagnostic imaging of choice, more and more patients began undergoing nonoperative management with periods of observation for solid organ injuries. Currently, studies have shown that more than two-thirds of patients with trauma to the spleen or liver are managed nonoperatively, including some patients with grades IV and V injuries.[13–17] This has led to a significantly larger proportion of patients who never undergo a laparotomy. Thus, the ability to diagnosis hollow viscus injury relies primarily on physical examination and CT scan findings.

The sensitivity and specificity of CT scan in the diagnosis of hollow viscus injury have varied widely in the literature, especially in determining which injuries require operative intervention. The sensitivity has been reported in ranges between 55% and 95%, with specificity between 48% and 92%.[5,18,19] In particular, false-negative rates in CT scans of patients with small bowel injury have been reported as high as 15%.[20] There are numerous pitfalls in the interpretation of CT scans for hollow viscus injury because there are numerous signs suggestive of but not specific to bowel injury. These signs include irregular contrast enhancement of the bowel, bowel wall thickening, mesenteric abnormality, and fluid inside the abdomen without an associated solid organ injury.[19,21]

The finding of free intraperitoneal fluid without findings of a solid organ injury remains a particular challenge to the surgeon. When a decision is made to operate on a patient solely for this radiographic finding, the rates of therapeutic laparotomy have varied widely, from 27% to 54%.[13,22,23] Due to this wide variation, few centers recommend immediate exploration for free intra-abdominal fluid without additional signs or symptoms of bowel perforation. Traditionally, the finding of pneumoperitoneum on CT scan has prompted immediate operative exploration. With the increasing sensitivity of CT scanners, an increased incidence of clinically insignificant pneumoperitoneum has been described in blunt trauma patients. In the series reported by

Marek and colleagues,[24] 78% of subjects with blunt abdominal trauma and pneumoperitoneum detected by CT scan were without an identified gastrointestinal perforation. In addition, no combination of radiologic findings has been shown to consistently predict bowel perforation.[25] These factors have combined to make bowel and mesenteric injuries the most commonly missed abdominal injury.[5] Some centers have advocated the use of repeat CT scans in the evaluation of patients for blunt bowel injury, particularly in patients with significant head trauma.[25]

Early reports of delays less than 12 to 24 hours in the diagnosis of small bowel injuries showed limited, if any, increase in morbidity and mortality.[26–28] However, more recent literature has shown increased mortality directly related to a missed hollow viscus injury in delays of less than 8 hours.[10,11] The morbidity of a negative laparotomy, which has been reported between 8% and 40%, should be taken into account, and this information used in the counseling of patients in regard to operative intervention.[29–32]

CT also plays a role in the evaluation of patients with penetrating trauma to the torso who are hemodynamically stable. CT scans were originally found in the late 1980s to be highly sensitive and specific in patients with stab wounds to the back and flank, allowing for nonoperative management in most patients.[33,34] Since then, several investigators have examined the use of triple contrast CT (oral, intravenous, and rectal contrast) in hemodynamically stable patients with both stab and gunshot wounds to the abdomen, back, and flank. Himmelman and colleagues[35] showed a 100% sensitivity of CT scans for retroperitoneal injury in subjects with penetrating trauma to the back and flank. In subjects with gunshot wounds to the abdomen, not just the back and flank, Munera and colleagues[36] found CT scans with triple contrast to be 96% accurate in detecting injury. Reflecting these findings, the latest practice management guideline from the Eastern Association for the Surgery of Trauma states "abdominopelvic CT should be strongly considered as a diagnostic tool" in hemodynamically stable patients with penetrating abdominal trauma.[37]

Despite its limitations, CT remains the diagnostic method of choice for both blunt and penetrating mechanisms of injury; however, great care should be taken in the evaluation of patients with concern for hollow viscus injury. Oral and rectal contrasts have been shown to improve accuracy in hemodynamically stable patients with penetrating trauma and can be used unless the administration of contrast would delay a diagnosis. Diligent physical examination, laboratory studies, and repeat imaging are all used as adjuncts in determining a patient's need for operation.

Stomach and Small Intestine

To fully evaluate a gastric injury, the stomach should be mobilized and the posterior wall inspected after opening the gastrocolic ligament in its avascular portion. The importance of full mobilization of the stomach cannot be overemphasized. The entire anterior wall of the stomach should be stretched so that there are no folds in the wall. One can accomplish this by grasping the nasogastric tube and pulling inferiorly on the stomach. Use of malleable or ribbon retractors can aid in visualization of the cardia and the gastroesophageal junction. Similar techniques can be used to visualize the posterior wall of the stomach. After entering the lesser sac, malleable or ribbon retractors can be used in combination with traction on the stomach via the nasogastric tube to fully examine the posterior gastric wall. The other areas to examine closely for a missed injury are the greater and lesser curves. Full visualization of these areas may require dissection of the omentum from the wall greater curvature.

Repair of the injury depends on the severity. Grades I and II lacerations are repaired primarily, in 1 or 2 layers, after wound edges have been debrided back to healthy

tissue, if needed. Grade III injuries, although larger, can be treated in the same manner, or closed with the use of a surgical stapler. Regardless of grade, care should be taken if the injury nears the pylorus so as not to occlude or narrow its lumen. If a wound involves or is directly adjacent to the pylorus, a pyloroplasty should be performed.[1] More extensive injuries with greater tissue loss or devascularization of the stomach, AAST grade IV, may require resection. Reconstruction may then be performed, depending on the amount of resection needed, with a Billroth I (antrectomy with gastroduodenostomy), Billroth II (antrectomy with gastrojejunostomy), or Roux-en-Y gastrojejunostomy or esophagojejunostomy. If a nonanatomic reconstruction is performed, vagotomy should accompany the resection to prevent the formation of a marginal ulcer.

The evaluation of the small bowel for injury should begin with evisceration of the small bowel. The ligament of Treitz is then identified and the small bowel inspected on both sides, in small segments, until its termination at the cecum. Care must be taken in order not to miss small perforations or lacerations. Mural and mesenteric hematomas should be noted and reassessed for expansion. Careful attention should be paid to the very proximal small bowel and the distal ileum because these are 2 locations where injuries can be missed due to the anatomy. To fully visualize the proximal small bowel at the ligament of Treitz, it is often necessary to combine a full Kocher maneuver with a Cattel maneuver. The Cattel maneuver involves mobilization of the avascular plane along the small bowel mesentery. Using these maneuvers, the surgeon can fully visualize the proximal jejunum at the ligament of Treitz. Further, these maneuvers can provide for tension-free repairs when the injury is close to the ligament of Treitz. Another area where injuries to the small bowel can be missed is along the mesenteric border. It is important to investigate all hematomas in the small bowel mesentery to be sure that there are no injuries on the mesenteric side.

Partial-thickness injuries should be closed with interrupted silk sutures in a seromuscular layer. Full-thickness small bowel injuries are treated similarly to the stomach in that grades I and II injuries should be repaired primarily after appropriate debridement, in 1 or 2 layers, running or interrupted. The repair should be performed in a tension-free manner and in a transverse fashion to prevent stenosis or narrowing of the small intestine. Multiple injuries are preferably repaired individually, unless the proximity does not allow for adequate closure. Options for multiple adjacent grades I or II injuries are to either combine them to allow for adequate repair or to treat them as higher grade injuries with resection. Grades III, IV, and V injuries are treated with resection of the injured and/or devascularized segments. Although there has been debate about the best method for performing an intestinal anastomosis, data have shown complication rates between stapled and hand sewn techniques to be similar in the setting of trauma.[1,38,39] Handsewn anastomoses can be performed in either 1 or 2 layers, in an interrupted or running fashion. Care should be taken to avoid the creation of a narrow or stenotic anastomosis. When a stapled anastomosis is performed, the surgeon should be knowledgeable about the stapler itself, which height of staples should be used, and what length of time the stapler should be applied before transection to allow for tissue edema to disperse. The resultant enterotomy after a stapled anastomosis is created can be closed either primarily with suture or a noncutting stapler. When either technique is used, adequate debridement of nonviable tissues must be performed before closure. In addition, attention must be paid to the creation of an anastomosis that is without tension. If the patient's hemodynamic or physiologic status requires damage control principles, then small bowel injuries should be quickly closed or resected to prevent ongoing contamination and anastomosis delayed. Reanastomosis should take place as soon as the patient becomes hemodynamically

stable and physiologically optimized, preferably within 48 hours. Cothren and colleagues[40] have demonstrated a significant trend in the increased rate of leak with increasing fascial closure day. Other risk factors for the development of anastomotic leak and enterocutaneous fistula in the setting of abbreviated laparotomy include resuscitation volumes of more than 5 L within the first 48 hours of hospitalization and an increasing number of explorations.[41]

Duodenum

The duodenum is largely protected due to its primary location in the retroperitoneum and injuries are rare, accounting for less than 5% of all abdominal injuries.[42–44] In sharp contrast to its rarity, morbidity and mortality rates for injuries to the duodenum are high and range up to 65% and 47%, respectively.[45–48] These high rates are secondary to concomitant injuries, which are common due to the proximity of the duodenum with the pancreas and major vascular structures, and there is a higher incidence of leak in the duodenum compared with the remainder of the small intestine. Due to these factors, repair of duodenal injuries remains a considerable challenge to the surgeon.

Regardless of injury mechanism, surgical options in regard to the repair of duodenal injuries include primary repair, repair with intraluminal drain placement (triple tube therapy), pyloric exclusion, and Roux-en-Y duodenojejunostomy. Pancreaticoduodenectomy has also been used, but its use is typically limited to combined pancreatic and duodenal injuries with significant tissue loss. The choice of operative approach is determined by the stability of the patient and the severity of injury.

Grades I and II hematomas of the duodenum are more common in children but do occur in adults. These injuries are typically identified on CT scan, and typical symptoms include delayed gastric emptying or even gastric outlet obstruction. Treatment is usually nonoperative, with obstruction managed with gastric decompression and intravenous hydration. If, however, the hematoma is encountered at the time of laparotomy, most investigators recommend not opening the hematoma and treating the patient with gastric decompression and distal feeding access either through a nasojejunal tube or tube jejunostomy. Most patients with duodenal hematomas symptomatically resolve within 3 weeks. If a patient remains completely clinically obstructed after 10 to 14 days, re-evaluation should be performed either with CT scan or an upper gastrointestinal fluoroscopy. On re-evaluation, if the patient's hematoma has worsened or is showing no signs of improvement, operative intervention can be considered. Evacuation of the hematoma can be accomplished either with a laparoscopic or open approach after thorough mobilization of the duodenum, then simply closed in a transverse fashion after meticulous hemostasis.[44,49]

Grades I and II lacerations of the duodenum require exploratory laparotomy and should be managed with simple closure in a transverse fashion. The transverse closure is essential to prevent narrowing of the duodenal lumen. When performing a primary repair of the duodenum, necrotic and severely damaged edges should be debrided to ensure wound edges are clean. In addition, thorough mobilization of the duodenum needs to be performed to allow for adequate examination of the back wall and a tension-free repair. This technique is successful for up to 85% of duodenal injuries.[43,44,50] A diligent search for a wound on the pancreatic side of the duodenum should be carried out when there is a high suspicion of this type of injury. Wounds on the pancreatic side of the duodenum can be difficult to identify and repair. Occasionally, it is necessary to expand a laceration on the anterior or lateral border of the duodenum to fully visualize the injury on the medial duodenal border. Using this technique, it is possible to repair the medial wall of the duodenum from the inside.

Care should be taken, though, to identify the ampulla and to be sure it is not included in the repair. Extraluminal drains have been shown by some investigators to be associated with an increased risk of duodenal leak, and routine use is not recommended unless an associated pancreatic leak is suspected.[46,51]

Grade III injuries also should be evaluated for primary repair after mobilization and adequate debridement. If an end-to-end duodenoduodenostomy can be performed without undue tension, then this is a viable surgical option. Due to the duodenum's relatively short mesentery and attachments to the common bile duct and pancreas, this often is not possible. Other surgical repair options for this grade of injury include a Roux-en-Y duodenojejunostomy in which a limb of jejunum is anastomosed to the defect in the duodenum. If significant tissue loss necessitates resection of a portion of duodenum, the distal segment should be closed primarily and reconstruction performed to the proximal segment with an end-to-end Roux-en-Y duodenojejunostomy. Another operative approach if the injury is proximal to the ampulla, as outlined in the Western Trauma Association's algorithm for the management of duodenal injuries, is to perform a Billroth II (antrectomy and gastrojejunostomy).[44,49]

The most severe injuries, those that meet AAST criteria for grades IV or V, are typically combined pancreatic and duodenal injuries involving lacerations greater than 75% circumference, disruption of the ampulla or the distal common bile duct, and/or devascularization of the duodenum. Even in these severe injuries, emerging evidence has shown primary repair to be safe, with similar rates of sepsis and mortality as gastroenterostomy and pyloric exclusion but with a shorter hospital length of stay.[50–53] When primary repairs are tenuous or concern for dehiscence is high, adjuncts to primary repair include pyloric exclusion and triple-tube drainage. Pyloric exclusion was first described in 1977 by Vaughan and colleagues.[54] This operation entails closure of the pylorus, either by a noncutting stapler or suture, followed by a gastrojejunostomy. This is designed to protect a duodenal suture line or duodenostomy tube by diversion of gastric contents. The closure of the pylorus will spontaneously open over time, usually within 6 to 12 weeks.[49] However, the rate and time to spontaneous opening can vary widely and is largely unknown.[47,51,55] In 1979, Drs Stone and Fabian[55] described a different technique of suture line protection that is now commonly known as triple tube or triple ostomy. This technique involves repair of the duodenal injury in addition to placement of a nasogastric tube, feeding jejunostomy, and retrograde jejunostomy. Increased morbidity related to complications of the jejunostomies has been reported, yet advocates of this approach cite benefits to the diversion of bile and gastric and pancreatic secretions, and lowered intraluminal pressure.[46,48]

In duodenal injuries that are associated with disruptions of the pancreatic head and/or a nonintact ampulla, complex reconstructions are required. However, most of these patients have associated injuries and significant blood loss. Damage control principles should be applied, and the initial operation should focus solely on hemorrhage and contamination control. Reconstruction should occur when a patient is hemodynamically stable and physiologically improved. Options for reconstruction in this delayed setting include reimplantation of the common bile duct into a Roux-en-Y jejunal limb or a Whipple procedure (pancreaticoduodenectomy).[44,49]

Colon

In the first part of the twentieth century, injuries to the colon were often fatal. As surgical techniques improved and the development of antibiotics occurred, there was marked improvement in survival. One of the key principles of management of colon injuries was the creation of an ostomy instead of primarily repairing the injury.

Exteriorization of the injury via an ostomy was standard management until the early 1970s when several investigators reported their experience with primary repair of colon injuries. The controversy continued until 1979 when Drs Stone and Fabian[55] reported the results of their randomized trial of primary repair compared with colostomy for colon injuries. In this study, the investigators performed obligatory colostomy on subjects who were in shock at the time of arrival, who lost more than 1000 mL of blood, and who had more than 2 injured intra-abdominal organs, significant peritoneal soilage, delayed operation, destructive colon injury, or significant abdominal wall loss. There were 139 subjects who did not meet these criteria and who were randomized. The group randomized to primary closure had a lower rate of superficial and deep organ space infections. Morbidity was 10 times greater for the subjects randomized to colostomy compared with those who had a primary closure performed. After publication of this study, the pendulum swung in favor of primary repair. Multiple studies were conducted in the 1990s that supported the increasing use of primary repair with, at worst, equivalent morbidity rates and septic complications.[9,56–58] These findings led to the Eastern Association for the Surgery of Trauma to update their practice management guideline in 1998 to support primary repair for nondestructive colon wounds as standard of care in patients without peritonitis.[59] The practice guidelines further stated that the only patients who will benefit from diversion are those with destructive colon wounds and hemodynamic instability and/or significant comorbidities.[59]

Current management of colon injuries is primarily driven by whether or not the injury is deemed destructive at the time of laparotomy. The AAST injury grading scale for the colon can be used to help stratify management of these injuries. Grade I injuries are serosal injuries only. Grade II injuries are single-wall injuries. Grade III injuries involve less than 25% of the colon wall. Together, these make up nondestructive injuries. Most of these can be managed with primary repair. For serosal injuries, seromuscular interrupted suture should be used to close the defect in a transverse fashion. For grades II to III injuries, the edges should be debrided back to good tissue. Repair is usually accomplished in 2 layers if hand sewn. The surgeon can also use a noncutting stapler to close some injuries, but care should be taken not to narrow the lumen of the colon.

There is more controversy regarding the appropriate management of patients with destructive colon injuries. These include AAST grades IV and V injuries in which more than 25% of the colon wall is injured. Also, patients with blunt injury to the colon with more than 50% of the wall involved in a serosal tear or a large mesenteric defect are often included with those who have destructive injuries. For destructive injuries, resection and anastomosis, or resection and colostomy, are the most common management approaches. Some centers use physiologic criteria to stratify patients into those who are primarily anastomosed and those who are managed with a colostomy. The group from Memphis recently reported their experience using a defined management algorithm in patients with colon injuries from penetrating trauma.[60] In their defined algorithm, full-thickness injuries are classified as nondestructive or destructive. Nondestructive colon injuries undergo primary repair. In patients with destructive lesions, those with hemodynamic instability, comorbidities, or have received greater than 6 units of blood undergo diversion. Patients with destructive lesions without these features undergo resection and anastomosis. In their recent study, they compare the morbidity and mortality of patients using this algorithm to patients treated before the initiation of the algorithm. They found, despite an increased incidence of destructive colon injuries, that patients experienced a decreased rate of abscess formation and colon-related mortality.

Another criterion to consider is the location of the anastomosis. The splenic flexure is a known area of the colon that is particularly vulnerable to ischemia. In 2 autopsy studies, the ascending branch of the left colic and the left branch of the middle colic arteries were found to have either a tenuous or incomplete connection in approximately half of sujects.[61,62] Feliciano and colleagues[63] reported on their series of 217 subjects. They found 7 subjects who developed a suture line failure. All 7 had injuries in the watershed area of the colon: the splenic flexure and distal transverse colon. The investigators theorized that the more frequent breakdown of anastomoses on the left side occurred because several of these were in watershed areas of the colon. Based on this information, if the surgeon can perform an anatomic resection and anastomosis then this would be the preferred choice. If not, avoiding an anastomosis in the colon watershed areas is likely a prudent course of action.

With the advent of damage control or abbreviated laparotomy as standard of care in severely injured patients with hemodynamic and physiologic instability, more patients are now being left in intestinal discontinuity. Although small bowel anastomoses are necessary at the time of reoperation, controversy exists as to whether a patient with a colonic injury should undergo an anastomosis or diversion. In a multicenter trial, Tatebe and colleagues[64] hypothesized delayed colonic anastomoses after an abbreviated laparotomy were not associated with an increased rate of complications. Of the 267 subjects enrolled in the study, those who underwent an anastomosis after a damage control laparotomy did not have an increased rate of intra-abdominal abscess formation, surgical site infection, suture line failures, or enterocutaneous fistulae. Eighty percent of subjects with a colonic injury who underwent an abbreviated laparotomy were managed with the use of a stoma. In conclusion, delayed anastomosis of a colon injury is a viable option in most patients. However, clinical judgment should consider the patient's overall health before injury and physiologic status at the time of reoperation to aid in the determination of whether an ostomy remains the best course of action.

SUMMARY

Hollow viscus injuries present a unique challenge to surgeons. These injuries are associated with significant morbidity and mortality and can be difficult to diagnose due to additional injuries and the limitations of current imaging modalities. The operative repair of these injuries is affected by the patient's physiologic and hemodynamic status, and can be technically difficult due to anatomic location. Overall, clinical suspicion should remain high in both hemodynamically unstable and stable patients, and great consideration given to timing and technique of operative repair.

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