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Duodenal Injuries

Erik J. Teicher[1] · Paula A. Ferrada[1]

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Abstract

Purpose of Review Duodenal injuries are rare but challenging injuries to manage for the acute care surgeon. These injuries often occur concomitantly with other organs and major vascular structures. Once diagnosed, these injuries have been managed in a variety of ways and historical beliefs are slowly being replaced by evidence when confronting some of these difficult injuries. This review reintroduces the important topic of duodenal trauma and attempts to discuss the mechanisms, diagnosis, outcomes, and most importantly, management of duodenal trauma.

Recent Findings Management will be outlined along with organ injury scoring. We will examine past surgical options such as complex reconstructions and adjuncts that have been called into question with evidence that shows primary repair should be attempted whenever possible.

Summary Operative management of duodenal trauma has progressed and simplified. The evidence demonstrates improved outcomes with primary duodenal repair when possible.

Keywords Duodenum · Duodenal trauma · Duodenal injury · Penetrating trauma · Blunt trauma · Hollow-viscous injury

Introduction

The duodenum is the first, and shortest, section of the small intestine about 25–38 cm in length beginning at the duodenal bulb and ends at the suspensory ligament (of Treitz) and can divided into four portions. The first, or superior, portion is a continuation of the pylorus and is about 2 cm long, slightly dilated, and terminates at the superior duodenal flexure. It is the only intraperitoneal part of the duodenum. The second, or descending, portion begins at the superior duodenal flexure and courses inferiorly ending at the inferior duodenal flexure. The main pancreatic duct (of Wirsung) and common bile duct (CBD) enter the descending duodenum through the major duodenal papilla (of Vater) and the accessory pancreatic duct (of Santorini) enters the descending duodenum through the more proximal minor duodenal ampulla. The third, or horizontal, portion begins at the inferior duodenal flexure and courses transversely to the left. The fourth, or ascending, portion courses upwards and joins with the jejunum at the duodenojejunal flexure at the suspensory ligament (Fig. 1). Important relationships of the duodenum include the head and neck of the pancreas within the curvature of the duodenum, the gallbladder, liver, and colon anterior to the duodenum, as well as the inferior vena cava, aorta, and portal vein passing posteriorly to the duodenum.

The duodenum has a dual blood supply, and the transition is located near the major duodenal papilla of the second portion of the duodenum. Proximal to the second portion of the duodenum, the blood supply is from the anterior and posterior branches of the superior pancreaticoduodenal artery, a branch of the gastroduodenal artery. Distal to the second portion of the duodenum, the blood supply is from the anterior and posterior branches of the inferior pancreaticoduodenal artery, a branch of the superior mesenteric artery. The venous drainage of the duodenum follows the arterial supply, through the splenic or superior mesenteric vein, and ultimately to the portal vein.

Mechanisms of Duodenal Injury

Trauma to the duodenum is rare, representing 3–5% of all trauma laparotomies performed [1]. In a review inclusive of 24 series, 1760 cases of duodenal injuries were

✉ Erik J. Teicher
erik.teicher@inova.org

1 Inova Health System, Trauma and Acute Care Surgery, 3300 Gallows Road, Falls Church, VA 22042, USA

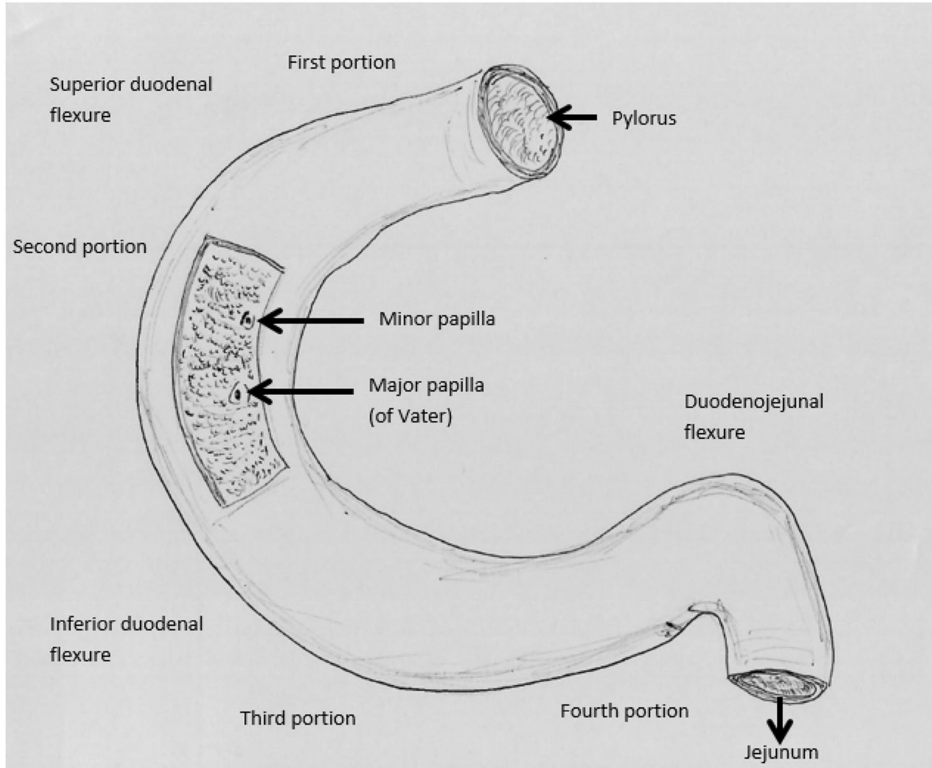


Fig. 1 The duodenum

identified between 1968 and 2014 and penetrating mechanisms accounted for 80% and blunt mechanisms 20% of these. Among the penetrating injuries, 81% were from gunshot wounds and 19% from stabbings. Motor vehicle collisions were the most common cause of blunt duodenal injuries with 85%. The second portion of the duodenum is the most frequently injured (36%), followed by the third (18%), fourth (15%), and the first (13%). Injuries at multiple portions were found in 18%. The relationship of the duodenum to other important structures renders isolated duodenal injuries uncommon. The incidence of associated organ injuries ranges from 30 to 87% with the liver as the most common associated injury (17%), followed by colon (13%), pancreas (12%), small intestine (11%), stomach (9%), gallbladder and biliary system (6%), and spleen (1%). Major venous (9%) and arterial (6%) injuries are also associated with duodenal trauma [2].

Low energy penetrating mechanisms, such as stab wounds, produce injury that is dependent on the depth of penetration and direct laceration of the duodenum. High energy penetrating mechanisms, such as gunshot wounds, create more extensive injuries due to the cavitary effect of the missile as it traverses the duodenum. Blunt mechanisms, such as motor vehicle collisions or falls from heights with direct force to the abdomen, cause duodenal injuries as the duodenum continues to move relative to the sites of attachment to the retroperitoneum or by compression of the duodenum between a closed pylorus and duodenojejunal junction between the anterior abdominal wall and spinal column.

Diagnosis of Duodenal Injury

All trauma patients should be fully evaluated using the guidelines in the Advanced Trauma Life Support course established by the American College of Surgeons Committee on Trauma. Patients with blunt or penetrating abdominal trauma who are hemodynamically abnormal or have peritonitis require operative exploration. Those that are hemodynamically normal and without peritonitis, however, should undergo further radiological imaging of the abdomen. It has been well established that patients with low energy penetrating abdominal trauma, hemodynamically normal, and without peritonitis, even with peritoneal violation, may undergo further radiological imaging and observation with serial abdominal examinations. Those with high energy penetrating abdominal trauma, regardless of patient hemodynamics or peritonitis, have historically undergone laparotomy. This mandate has changed in the past few decades. Further management decisions may be based on additional radiological imaging and observation with serial abdominal examinations of patients that are hemodynamically normal and without peritonitis.

In the hemodynamically abnormal or peritoneal patient, the diagnosis of a duodenal injury should be made during laparotomy. Following control of hemorrhage and intestinal spillage the retroperitoneum should be explored for the diagnosis of duodenal injury. It is not uncommon to diagnose duodenal injury based on the need to undergo laparotomy determined by diagnosis of associated injuries mentioned previously. In the hemodynamically normal and nonperitoneal patient, the diagnosis of duodenal injury is more challenging. Early diagnosis and management are critical as delayed treatment increase morbidity and mortality [3]. There are minimal specific findings on physical examination for isolated duodenal injuries. A review demonstrated that epigastric pain was observed in 100% of patients, vomiting in 100%, shock (tachycardia, hypotension, and oliguria) in 57%, peritonitis in 43%, back pain in 36%, and abdominal distention in 36% [4]. If the patient develops peritonitis or signs of sepsis then operative exploration is warranted.

Patients without reasons for immediate laparotomy should undergo further imaging. Computed tomography (CT) has become the most important tool in assessing the hemodynamically normal patient following abdominal trauma. In the majority of institutions the use of CT involves transport of the patient away from the resuscitation area to the radiology department and therefore such patients should be hemodynamically normal. The standard method for evaluating abdominal and pelvic trauma has been a portal venous scan acquired at about 70 s following intravenous (IV) contrast administration which allows for assessment of bowel perfusion and evaluation of solid organ parenchyma [5]. CT has an overall sensitivity and specificity for general bowel injury of 64–95% and 94–100%, respectively [6]. Specific findings on CT pertaining to duodenal injuries include bowel wall thickening, discontinuity of the bowel wall with possible intravenous or oral contrast extravasation, and adjacent fluid or air within the retroperitoneum (Fig. 2) [7]. A series describing blunt duodenal injuries demonstrated on CT scans performed less than 4 h following presentation that 73% of patients had intraperitoneal fluid, 40% had a duodenal hematoma, 33% had pneumoperitoneum, 13% had contrast extravasation, and 13% had retroperitoneal air. Interestingly, 27% of patients with a blunt duodenal injury had a completely normal CT scan [8].

Fig. 2 CT scan with arrow demonstrating duodenal wall thickening and retroperitoneal air

In those cases where the CT findings are equivocal and suspicion remains high, a duodenography with oral water soluble contrast can be obtained. This should be performed under fluoroscopy with the patient in a right lateral decubitus position. The patient should be then made supine and turned to a left lateral decubitus position if there is no contrast extravasation is visualized initially. If no extravasation of water soluble contrast is observed then this should be followed by administration of oral barium contrast which allows detection smaller duodenal perforations. Unfortunately, the sensitivity was found to be low at 54% and specificity was 98% in a study of duodenography that ultimately confirmed retroperitoneal air was the most important CT finding associated with duodenal perforation [9].

Serum amylase levels have been examined for usefulness in diagnosing duodenal injury. While initial hyperamylasemia was found to be associated with a greater injury severity score (ISS) and death rate, lower Glasgow Coma Score (GCS), increased risk of facial fractures, traumatic brain injury, pancreatic, hollow viscus injuries, and hypotension. However, the positive predictive value for elevated amylase levels from hollow viscus injuries was only 3% as 83% of patients with hollow viscus injuries had normal amylase levels [10]. Additionally, serial measurements of serum amylase have been shown to be inadequate to predict abdominal injuries in non-pancreatic blunt abdominal trauma patients [11].

The severity of duodenal trauma is a spectrum from a minor hematoma, partial thickness, perforations of various circumferences, involvement of the ampulla, to massive disruption of the duodenopancreatic complex. The Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (AAST) developed a Duodenum Injury Scale in 1990 (Table 1) [12]. Grades I and II are regarded as minor injuries and grades III, IV, and V represent severe injuries as seen on imaging or during laparotomy.

Management of Duodenal Injury

Immediate hemorrhage control, containment of gastrointestinal contamination, followed by abdominal exploration is standard for abdominal trauma management. The entire duodenum should be carefully examined especially when

Table 1 AAST organ injury scale for duodenum

Grade		Injury description
I	Hematoma	Involving single portion of duodenum
	Laceration	Partial thickness without perforation
II	Hematoma	Involving more than one portion of duodenum
	Laceration	Disruption by < 50% of circumference
III	Laceration	Disruption by 50–75% of circumference of D2
		Disruption by 50–100% of circumference of D1, D3, or D4
IV	Laceration	Disruption by > 75% of circumference of D2
		Involving ampulla or distal common bile duct
V	Laceration	Massive disruption of the duodenopancreatic complex
	Vascular	Duodenal devascularization

retroperitoneal edema, hematoma, bile staining, or gas are encountered during exploration [13•]. The mobilization of the entire duodenum is mandatory in these situations. A Kocher maneuver is performed by dividing the lateral peritoneal attachments of the duodenum allowing mobilization of the second and proximal third portions medially. Entering the lesser sac by dividing the gastrocolic ligament allows exposure of the first and medial second portions. Improved visualization of the distal third and proximal fourth portions can be accomplished by performing a Cattell–Braasch maneuver. This necessitates mobilization of the ascending colon and hepatic flexure medially and dividing the retroperitoneal attachments from the right lower quadrant to the ligament of Treitz. The ligament of Treitz may also be divided for better examination of the distal fourth portion.

If a Grade I duodenal hematoma is diagnosed by CT scan without other indication for laparotomy then an initial nonoperative approach should be attempted with nasogastric decompression and parenteral nutrition. Duodenal hematomas are caused by a vascular rupture within the submucosal or subserosal part of the duodenal wall and are more commonly seen in those with coagulation disorders, on anticoagulants, or with a history of alcoholism [14]. This hematoma may progress to a complete duodenal obstruction but this nonoperative approach is appropriate for up to 14 days [15]. If the obstruction remains unresolved following this period then operative intervention with drainage of the hematoma and primary repair should be performed. Laparoscopic drainage of duodenal hematomas have been described [16]. If a Grade I hematoma is identified during laparotomy then management is based on the percentage of luminal obstruction. The hematoma should be drained and primarily repaired when the lumen is narrowed by 50% or greater. There should be consideration of including a duodenal bypass with a gastrojejunostomy when the lumen is narrowed by 75% or greater [17••]. Grade I duodenal partial thickness lacerations diagnosed during laparotomy should be repaired primarily. Grade II duodenal hematomas are should he dealt with similarly to the single duodenal hematoma. Grade II duodenal lacerations should be repaired using suture techniques in one or two layers that are oriented transversely to minimize luminal narrowing and tension (Fig. 3a). Longitudinal lacerations can be closed transversely if the length of the laceration is less than 50% of the duodenal circumference [18]. When more extensive duodenal reconstruction is necessary, it is reasonable to perform an abbreviated laparotomy, followed by planned repeat laparotomy for delayed repair and reconstruction, after appropriate resuscitation in the intensive care unit. These staged procedures have shown a lower mortality [19]. More extensive lacerations such as Grade III and IV may require mobilization of the duodenum with duodenoduodenostomy (Fig. 3b). If a primary duodenal anastomosis is not possible and the laceration is less than 50% of duodenal circumference then a duodenojejunostomy may be performed (Fig. 3c). For larger lacerations 50 to 100% of duodenal circumference the duodenum must be closed and a roux-en y duodenojejunostomy should be performed (Fig. 3d). If the laceration is to the first portion then an antrectomy and gastrojejunostomy (Billroth II) may be performed.

When major injuries to the second portion and adjacent pancreatic head are encountered, cholangiopancreatography should be performed to assess for injuries involving the ampulla, distal CBD, or proximal main pancreatic duct. The ampulla is located and cannulated with a small catheter and injected with about 3 mL of contrast during portable radiography [20]. For Grade IV lacerations that involve the ampulla or distal CBD the duodenum can be reconstructed with duodenoduodenostomy or roux-en y duodenojejunostomy with reimplantation of the distal CBD into the duodenum or the roux-en y jejunum [21]. Grade IV and V injuries that cannot be reconstructed require a pancreaticoduodenectomy (Whipple procedure) [22]. An algorithm for management of duodenal trauma has been published from the AAST (Fig. 4) [23••].

Throughout the years, acute care surgeons have developed adjuncts to the duodenal repair that would decompress and divert gastrointestinal fluids from the duodenum

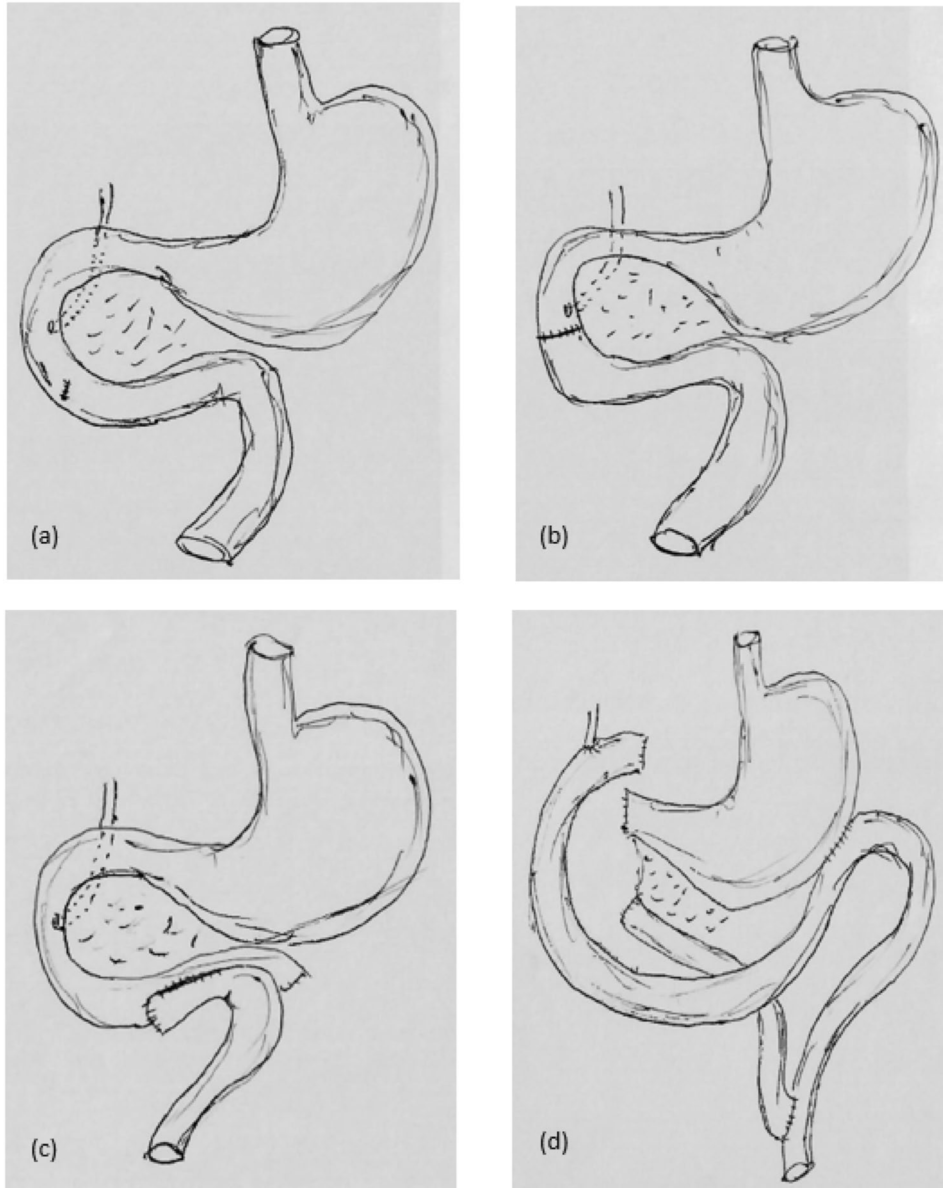


Fig. 3 Duodenal repairs and reconstructions. **a** primary repair, **b** duodenoduodenostomy, **c** duodenojejunostomy, and **d** roux-en y duodenojejunostomy

to help prevent suture dehiscence and fistula formation. Described in 1979, the "triple tube" consists of a gastrostomy, duodenostomy, and jejunostomy (Fig. 5a). The duodenostomy can be introduced either antegrade or retrograde. In this report of 237 patients with duodenal injuries, only one suture dehiscence was observed when tube decompression was used and 8 of the 44 patients without tube decompression developed this complication [24]. However, despite these encouraging results future studies have not demonstrated improved outcomes utilizing tube decompression. There were no significant differences in rates of fistula formation among 101 patients treated with tube decompression and 9% forming fistulas compared with 89 patients treated without the addition of tube decompression and 6% forming fistulas [25]. When comparing repair or reconstruction of duodenal injuries to the addition of tube decompression in patients with gunshot wounds, there were significantly higher duodenal fistulas (75% of all duodenal fistulas in this series), abdominal sepsis, and mortality from sepsis in the patients that received tube decompression [26]. Other studies had similar results demonstrating increase complications when tube decompression is utilized and even more recently the value of tube decompression has showed an increased hospital length of stay without improved clinical outcomes [27]. Duodenal diverticularization was described in 1968 as a method of diversion of gastrointestinal fluids and decompression of the duodenum. This consisted of a duodenal repair or reconstruction, truncal vagotomy, gastric antrectomy with gastrojejunostomy, tube duodenostomy for decompression,

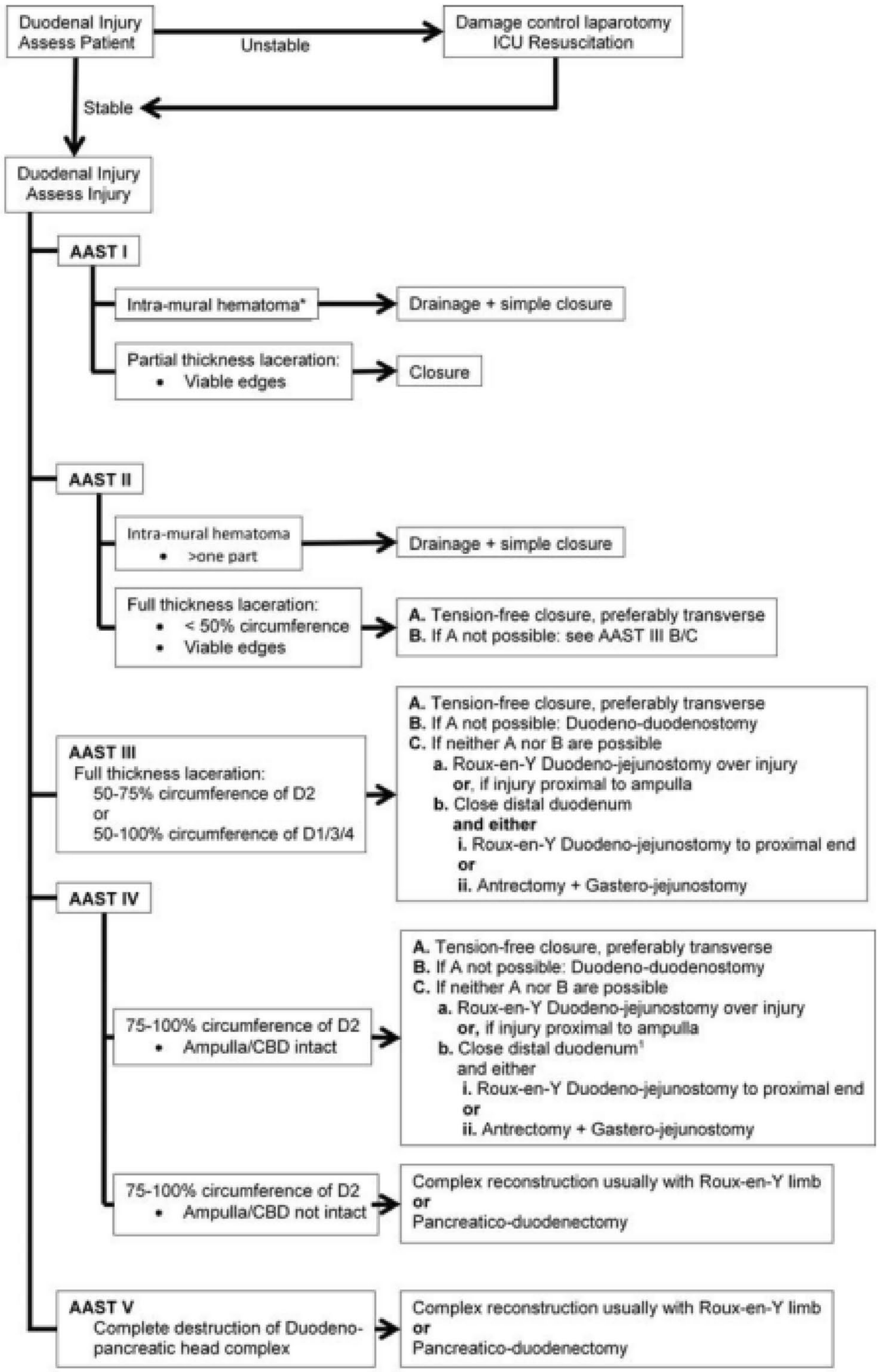
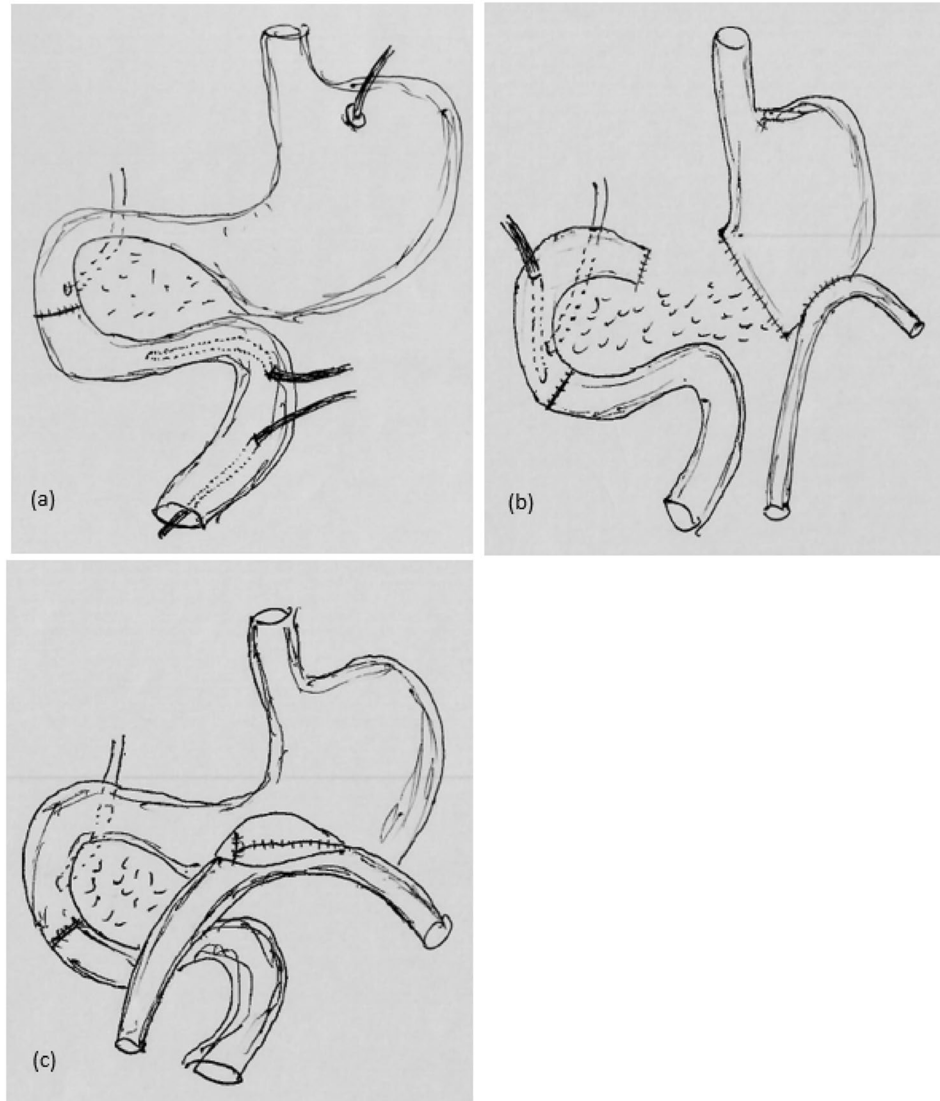


Fig. 4 AAST algorithm for management of duodenal injuries

and wide drainage of the area (Fig. 5b) [28]. This was reported in 50 patients with an overall mortality of 16% and 7 patients developing duodenal fistulas and 5 developing pancreatic fistulas which all healed spontaneously [29]. In more recent report, there were no patients that underwent a duodenal diverticulization, however, the mortality of 18% was similar and fistula rate was 3.7% and much less than the original descriptive study [30]. The pyloric exclusion was made popular through a report in 1977 as an alternative and simpler method of diversion of

Fig. 5 Adjuncts for duodenal repairs such as the **a** "triple tube" with gastrostomy, retrograde duodenostomy, and antegrade jejunostomy, **b** duodenal diverticulization, and **c** pyloric exclusion



gastrointestinal fluids as compared with the more complicated duodenal diverticulization. This consists of duodenal repair or reconstruction, closure of the pylorus through a gastrotomy, and a gastrojejunostomy at the gastrotomy (Fig. 5c). The pyloric exclusion can also be accomplished with a noncutting linear stapler just distal to the pylorus. During a 12 year period, a pyloric exclusion was added to the duodenal repair in 128 patients out of 313 total patients with duodenal injuries and the duodenal fistula rate was 5.5% compared to 2.2% overall. Among the 42 patients that underwent postoperative gastrointestinal evaluations marginal ulceration was noted in 4 and 94% of these patients had pyloric patency at 3 weeks or more [31]. The routine gastrojejunostomy as part of the pyloric exclusion has been questioned because of risk of marginal ulceration and early spontaneous pyloric opening [32].

Outcomes from Duodenal Trauma

Duodenal injuries are associated with a high morbidity of approximately 27% [33]. Duodenal fistulas are a result of suture dehiscence of the duodenal repair with an overall rate of up to 16.6% of patients [34]. The rate of leakage was found to correlate to the severity of duodenal injury as demonstrated in a recent review that found an overall leak rate of 7.7%, with no leaks in grade I, a 1.6% leak rate in grade II, and a 66.7% leak rate in grade III injuries with significantly lower pH values and higher lactate levels, ICU length of stay, and mortality in those patients that developed leaks [35]. Another review showed an overall leak rate of 8% and increased leak rates were more commonly associated with major vascular injury and pancreatic injury [36]. Lastly, length of time from injury to initial operation with a mean time of 31.4 ± SD 25.3 h was found to be associated with postoperative duodenal leaks as compared to 9.4 ± SD 5.1 h [37]. Additional complications related to the duodenal injury include intraabdominal abscesses (10.9–18.4%), pancreatitis (2.5–14.9%), and obstruction (1.1–1.8%) [38].

Duodenal injuries have an overall mortality of 5–30% [39]. Early mortality is usually related to exsanguinating hemorrhage from associated vascular injury and the resulting physiologic derangements of hemorrhagic shock. Late mortality can be attributed to the duodenal injury and subsequent complications such as sepsis and multiple organ failure. Mortality has been correlated retrospectively with duodenal injury grade and found to be 8.3% for grade I, 18.7% grade II, 27.6% grade III, 30.8% grade IV, and 58.8% grade V duodenal injuries [40]. In addition to AAST grade of duodenal injury, predictors of mortality include hypotension, decreasing GCS, tachycardia, increased injury severity score (ISS), and gunshot wounds [41]. It has been shown that associated pancreatic, superior mesenteric vessel, and colon injuries are also predictive of sepsis and mortality [42].

In a recent review from the National Trauma Data Bank (NTDB) from 2022 to 2014, 2,163 patients were identified with a duodenal injury and 42% were considered grade I and II, 22% grade III, 21% grade IV, and 14% grade V. Primary repair was performed in 78% of patients, followed by pyloric exclusion in 19.2%, duodenojejunostomy 19.1%, and pancreaticoduodenectomy 3.4% [43•]. In a recent review of duodenal from 11 trauma centers between 2007 and 2016, 372 patients required surgical management of a duodenal injury and 24% were considered grade I and II, 62% grade III, 11% grade IV, and 3% grade V duodenal injuries [44••]. Primary repair was the most common method of repair for duodenal injuries and performed in 80% of patients in this series. More extensive techniques such as primary repair with retrograde duodenostomy were performed in 10%, pyloric exclusion with gastrojejunostomy in 4%, pyloric exclusion without gastrojejunostomy in 4%, resection with primary anastomosis in 1%, and pancreaticoduodenectomy in 1%. Leakage from the repair was significantly lower across all AAST injury grades when primary repair was performed over more extensive procedures. Another NTDB review involving 353 patients with operative duodenal injuries demonstrated that primary repair is associated with similar mortality and shorter hospital length of stay when compared to more complicated procedures [45••]. It should be noted that grade V injuries that involve massive destruction of the duodenopancreatic complex always require complex procedures and often result in terrible outcomes.

Conclusion

While rare, duodenal injuries remain a significant challenge for the acute care surgeon. Duodenal injuries are often diagnosed during laparotomy. We reviewed the management options of duodenal injuries including historical procedures and adjuncts to primary repair and reconstruction. Primary repair of the duodenum is the most common method of repair and may be accomplished for most AAST grades of duodenal trauma. More complicated operative strategies should be reserved for grade V injuries that also involve the pancreas.

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Declarations

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- • Of importance
- •• Of major importance

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