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Review Article

Management of the complex duodenal injury

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ABSTRACT

Introduction: Complex duodenal trauma is a rare injury with an incidence of 1–4.7% of all abdominal trauma. Historically, varied approaches have been used in the management of these complex injuries and the prevention of complications. This is a review of the current management methodology of complex duodenal injury.
Methods: A review of the medical literature to include the past and current management of duodenal trauma was performed. Google scholar (1970–2022) and PubMed (1970–2022) were searched using the keywords: complex duodenal trauma, surgical management, and duodenal complications.
Discussion: Complex duodenal trauma can be classified using the AAST grading scale as those encompassing grades III-V. Multiple studies and review articles characterize the difficulty in managing complex duodenal injuries. The tenets of operative management of duodenal trauma include the decision for damage control, resection of non-viable tissue, restoring gastrointestinal continuity, diversion of gastrointestinal contents, bile and pancreatic enzymes, allowing the repair to heal, and providing feeding access. The variety of both historic and current approaches attempt to address these tenets. The incidence of complications are as high as 65% with the most common complications including abscess formation, suture line dehiscence and fistula formation. The overall mortality ranges from 5 to 30%.
Conclusions: Many different approaches and strategies have been proposed to repair complex duodenal injuries, all of which address important tenets of its management. The risk of complications remains high, therefore, it is vital to have a thoughtful and multidisciplinary approach when treating these injuries.

1. Introduction

Duodenal trauma is a rare occurrence existing in 1–4.7% of all abdominal trauma.[1] Its posterior and partially retroperitoneal location shields it from most traumatic mechanisms. Colloquially referred to as the 'surgical soul', its proximity to complex regional anatomy makes duodenal trauma particularly at risk for biliary, pancreatic and major vascular injury with 68–86.5% of patients sustaining an associated injury.[2,3] Pediatric duodenal trauma is also rare, with an occurrence of less than 1% of all pediatric trauma. Duodenal injuries predominantly occur secondary to penetrating mechanisms accounting for 53.6–90% of cases.[1,4,5] Pediatric duodenal injuries most frequently occur due to blunt trauma.[4] Blunt duodenal injury results from direct epigastric impact from steering wheels or handlebars. The anterior abdominal impact crushes the duodenum against the spinal vertebrae. These injuries carry a significant morbidity up to 65% and mortality of 5.3%–30%.[6–8]

The management of complex, high-grade duodenal injury is difficult and presents a challenge for the surgeon. Because of its rarity and complexity, surgeons may not be proficient in its most up to date management. Its' association with concomitant injuries to the biliary tree, pancreas and major vascular structures requires a multidisciplinary approach. The initial phase of management follows those principles of damage control surgery, focusing on the control of hemorrhage and enteric leakage, while the later stages are managed on the tenets of reconstruction to reinstate gastrointestinal continuity, diversion, drainage and feeding access. Throughout the years, surgeons have developed varied approaches to the management of complex duodenal injuries to prevent repair breakdown and fistulization. We aim to evaluate the historical, and evidence-supported approaches to the management of complex duodenal injury.

2. Methods

A thorough review of the medical literature to include the past and current management of duodenal trauma was performed. The main search engines utilized were Google scholar (1970–2022) and PubMed

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Table 1
AAST duodenum injury grade with associated AIS scale.[31]

Grade[a]	Type of Injury	Description of Injury	AIS-90
I	Hematoma	Involving single portion of duodenum	2
	Laceration	Partial thickness, no perforation	3
II	Hematoma	Involving more than one portion	2
	Laceration	Disruption <50% of circumference	4
III	Laceration	Disruption 50–75% of the circumference of D2	4
		Disruption 50–100% of D1, D3 or D4	4
IV	Laceration	Disruption >75% of circumference of D2	5
		Involving ampullar or distal common bile duct	5
V	Laceration	Massive disruption of duodenopancreatic complex	5
	Vascular	Devascularization of duodenum	5

D1-first portion of duodenum; D2-second portion of duodenum; D3-third portion of duodenum; D4-fourth portion of duodenum.
[a] Advance one grade for multiple injuries up to grade III.

(1970–2022) using the keywords complex duodenal trauma, surgical management, and duodenal complications. Over 30 journal articles met criteria with pertinent information to review the comprehensive management of complex duodenal trauma.

3. Discussion

3.1. Classification

The AAST organ injury scale is the most commonly utilized grading system for duodenal injury (Table 1). This tool provides an assessment of the degree of injury that is present and helps to direct the initial management plan. The grading system utilizes the presence of duodenal hematomas and lacerations to describe severity of injury.

Complex duodenal trauma includes those encompassing AAST grades III-V. These grades include lacerations that span 50–100% of the circumference of the duodenum, involving the ampulla or distal common bile duct, with massive disruption of the pancreaticoduodenal complex or devascularization of the duodenum. This anatomic grading system provides a useful tool to assess the severity of the injury and guide management plans but fails to correlate well with mortality outcomes.[12,35,36] However, this finding may be secondary to insufficiently powered studies that fail to establish the correlation of mortality with grading.[27]

The Abbreviated Injury Scale score (AIS) is an anatomically based injury severity scoring system, which classifies injury to a region of the body on a scale of 1–6, with a score of 6 being the most severe and a non-survivable injury. The AIS score is not equivalent to the AAST grade, however is used to assess the Injury Severity Score.[34]

3.2. Operative management of complex duodenal injuries

3.2.1. Tenets of surgical management

The surgical management of complex duodenal trauma requires the general surgeon to utilize damage control surgical techniques as well as careful planning for reconstruction. The presenting physiology of the injured patient is an important factor in predicting mortality.[9–11] In the trauma patient who is hemodynamically unstable, damage control surgery becomes the primary aim. The operative goals are to control hemorrhage and contamination in an expedited manner. In this setting, contamination is controlled by temporary suturing, stapling to exclude injury, and/or resection. Temporary abdominal wall closure and ICU resuscitation to restore hemostatic physiology following damage control surgery is vital. Gastrointestinal continuity is accomplished at a later stage. Lastly, establishing adequate drainage via a closed suction mechanism aids in preventing complications of bile peritonitis and the effects of leaky pancreatic enzymes.

In the hemodynamically stable patient with complex duodenal trauma, the tenets of surgical management include a) resection of non-viable tissue, b) restoring gastrointestinal continuity, c) diversion of gastrointestinal contents, bile and pancreatic enzymes, allowing the repair to heal, and d) providing feeding access. An operative plan to accomplish these goals will depend on the location, severity and its associated injuries. A summarized algorithm proposed by the Western Trauma Association provides guidance for management of complex injuries (Fig. 1).

3.2.2. Duodenal repair

Primary repair of duodenal lacerations should be performed in a transverse orientation, which ensures patency of the duodenum and decreases the risk of luminal narrowing. The repairs must be performed in a tension free technique. Non-viable edges must be debrided to healthy tissue. A two-layer closure should be considered, though a one-layer repair is acceptable. Nasogastric tube (NGT) decompression is required for proximal decompression. If a hematoma is encountered and is not obstructing the lumen of the duodenum, no further intervention is required. However, if the hematoma is obstructing the lumen and is greater than 50% of diameter of the lumen, the hematoma must be opened and drained. It is preferred to not enter the duodenal lumen while draining the hematoma. If an underlying duodenal laceration is encountered, it must be repaired using the principles mentioned above.

Many reports including the WSES-AAST guidelines have advocated for primary repair with NGT decompression and external drain placement even with large high-grade injuries.[1,3,9,13] This technique has been demonstrated to carry improved morbidity and mortality compared with more complex reconstructive procedures.

Several options are available when primary repair would narrow the duodenal lumen. A pedicled mucosal flap from jejunum or the body of the stomach has been described.[14,15] Further, a jejunal serosal patch sutured to the edges of the duodenal injury is another option for the repair of larger defects.[16] However, a study published by Ivatury et al. failed to support its protection against duodenal fistulization.[17]

3.2.3. Duodenal reconstruction

Complex injuries to D1, D3 and D4 can usually be repaired with segmental resection and duodenoduodenostomy. With injuries to these areas, the duodenum needs to be mobilized using the Kocher maneuver and/or the takedown of the ligament of Treitz. Mobilization of these fixed retroperitoneal areas are essential to creating a tension-free anastomosis. In cases where the burden of tissue loss is great, approximated duodenal ends may not be possible. In these instances, injuries to D1 may require antrectomy that includes the first part of the duodenum, reinforcement of the duodenal stump, followed by Billroth II gastrojejunostomy. When significant tissue loss occurs distal to the ampulla of Vater, the approach should be closure of the distal duodenum with Roux-en Y duodenojejunostomy (Fig. 2). External drainage via a closed suction system helps to identify and control complications of the repair.

Injuries to the second portion of the duodenum with an injury to the distal common bile duct may be managed with a primary repair of the duodenum with reimplantation of the common bile duct via choledochoduodenostomy or choledochojejunostomy. A Roux-en-Y reconstruction for pancreaticobiliary drainage should be considered. This reconstruction carries a high risk of biliary stenosis, therefore, placement of a biliary stent or pediatric feeding tube should be considered. Pancreaticoduodenectomy or Whipple procedure is the preferred procedure when extensive injury involving the pancreaticoduodenal complex and ampulla of Vater is present. These patients may have other associated major vascular injuries to the IVC, mesenteric vessels such as the superior mesenteric, pancreaticoduodenal, hepatic artery and portal vein. Therefore, damage control surgery should be utilized and a staged reconstruction should be planned once the patient's physiologic status has been restored.[9] Physiologic restoration must be demonstrated with hemostasis, normothermia, normal coagulation profile and resolution of acidosis.[18] Hepatobiliary expertise is recommended for the

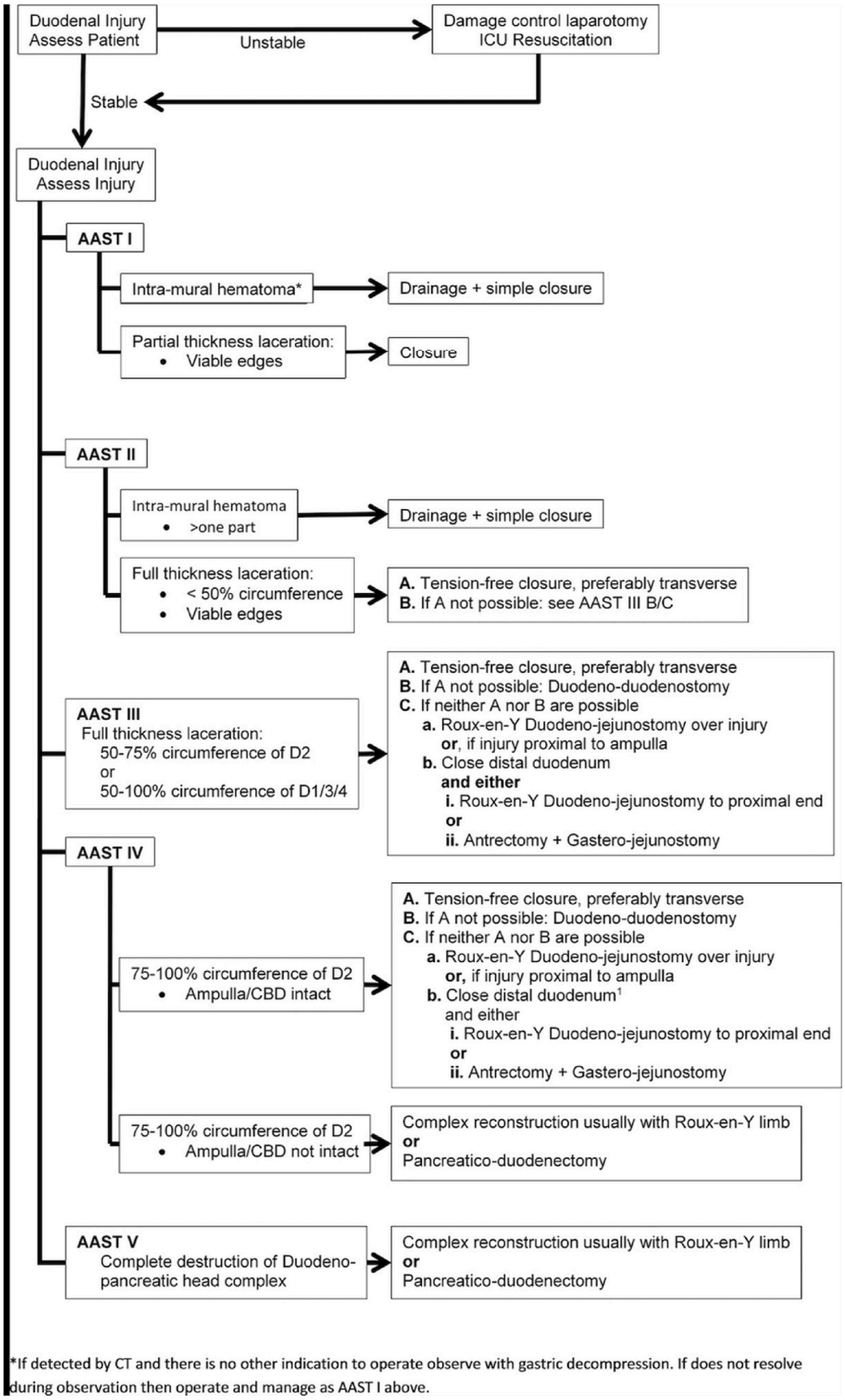


Fig. 1. Proposed algorithm by Western Trauma association for duodenal injuries.[12]

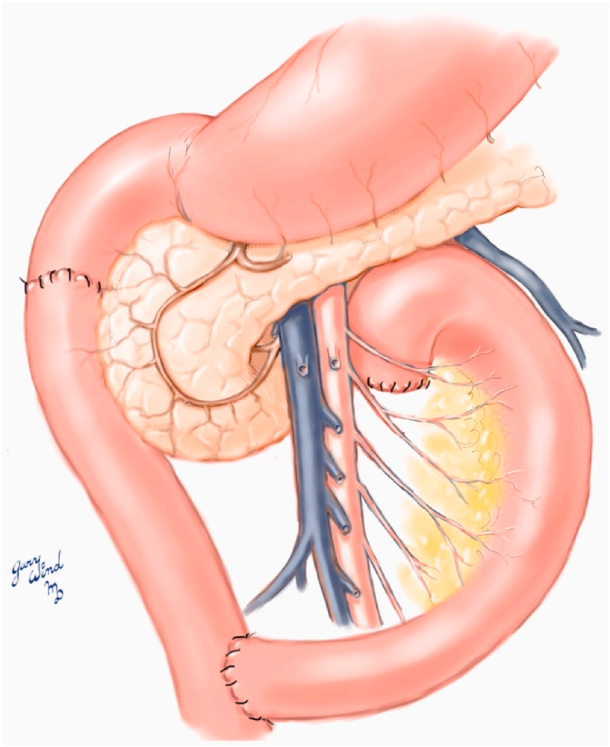


Fig. 2. Duodenal resection with duodenoduodenostomy and Roux-en-Y reconstruction.[32]

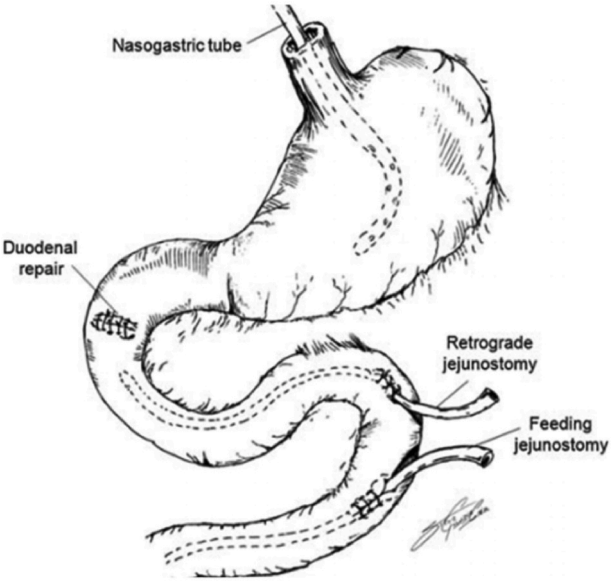


Fig. 3. Triple tube ostomy.

reconstruction. Early mortality is related to hemorrhagic shock and associated injury burden and later morbidity and mortality is related to intra-abdominal sepsis, anastomotic dehiscence, fistulas and multiorgan failure. Outcomes of trauma pancreaticoduodenectomy is not well described and is limited to single center experiences.[9,19–22] An analysis of National Trauma Data Bank did not demonstrate improved outcomes in those with complex duodenal injuries managed with pancreaticoduodenectomy.[23] Although, outcomes of modern pancreaticoduodenectomy are not clear, this remains the mainstay for management of significant pancreatoduodenal injuries. As part of the staged reconstruction, distal feeding access should be considered for

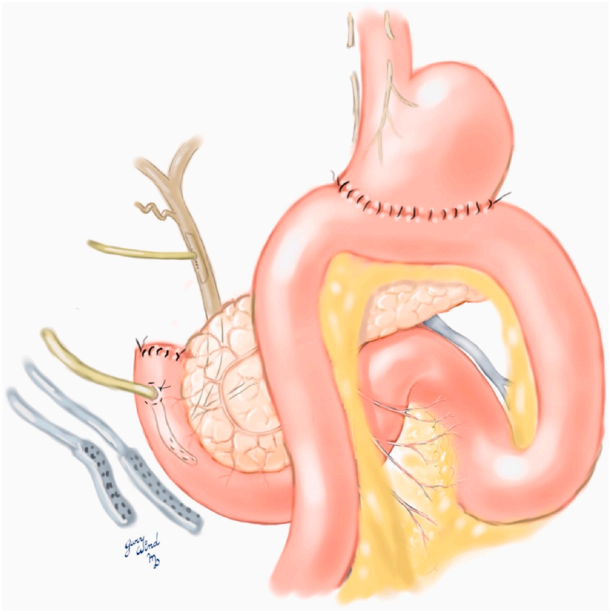


Fig. 4. Duodenal diverticulization.[32]

early enteral nutrition. Due to the high risk of anastomotic leak secondary to tissue destruction, external drainage should be utilized as a strategy to control sepsis and control the development of a fistula.

Performing pancreaticoduodenectomy in trauma patients may present special challenges compared to those performed in elective cases for malignancies where planes are more discernible and devoid of large hematomas with associated hemorrhage. In the reconstruction stage of young trauma patients with pancreaticoduodenal injuries, small pancreatic duct sizes and soft pancreatic tissue yields to difficulty in creation of pancreaticojejunal anastomosis and carries a risk of pancreaticojejunal anastomotic dehiscence. In these cases, suturing the capsule of the pancreas to bowel as a "dunking the pancreas" maneuver may decrease incidence of anastomotic dehiscence.

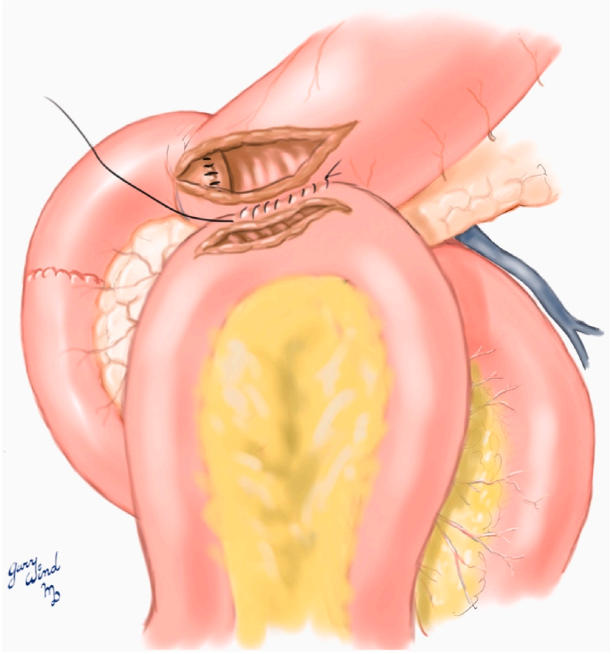


Fig. 5. Pyloric exclusion.[32]

Table 2
Procedures to manage complex duodenal trauma with associated complications and mortality rates.

Procedure	AAST Grade of Injury	Complication Rate	Duodenal related Mortality Rate
Primary Repair	I-IV	5.8%–33%[7,9,13,28,37]	1–24%[7,9,28,37,38]
Segmental Resection with Duodenojejunostomy/Duodenoduodenostomy and Roux-en-Y reconstruction	III-V	11.3–14.2%[17,33]	4.8%–5%[17,33]
Pancreatoduodenectomy	IV-V	42.8–86%[17,23,27,33,39]	19–42.8%[17,21,23,27,33,40]
Triple Tube Ostomy	II-IV	8–33%[7,24,33]	10%[7]
Duodenal Diverticulization	II-IV	20–50%[17,33]	–
Pyloric Exclusion	III-V	5–71%[5,13,26]	7–21%[5,13]

3.2.4. Triple tube ostomy

Significant duodenal injury increases the risk of suture line dehiscence in the post operative period. Diversion is an important principle of surgical management to protect the repair. The triple tube ostomy was a concept first described in 1954 as a method for the closure of the duodenal stump after gastrectomy (Fig. 3). In 1979, Stone and Fabian introduced this technique in trauma for the management of duodenal wounds. It included antegrade decompression, proximal to the site of injury via nasogastric decompression or gastrostomy, retrograde decompression for duodenal and biliary drainage, via a distal jejunostomy, and distal feeding access via an antegrade jejunostomy.[24] However, reports have not supported its use to decrease the incidence of suture line dehiscence.[16]

3.2.5. Duodenal diverticulization

The duodenal diverticulization procedure as described by Berne calls for duodenal repair, vagotomy, antrectomy, gastrojejunostomy, tube duodenostomy and T tube biliary drainage (Fig. 4).[25] However, due to its need for extensive operative time, intestinal anastomosis and vagotomy, it has fallen out of favor for management of duodenal injuries.

3.2.6. Pyloric exclusion

The pyloric exclusion technique developed by Vaughan et al., in 1977 requires the pyloric muscle to be either stapled or sutured closed with an absorbable suture.[26] A gastrojejunostomy is then performed for passage of gastric contents. The stapled or sutured pylorus will open spontaneously in several weeks (Fig. 5). Although still used today, this procedure has minimal advantages over NGT decompression and primary duodenal repair. Amongst several reports, Seamon et al. reported a higher overall complication rate (71% vs. 33%).[5,9,13] Similar to duodenal diverticulization. Operative factors such as increased operative time, extra intestinal anastomosis and suture line ulcers have overall mitigated the use of this technique.

3.2.7. Periduodenal drainage

Duodenal drain placement is debated and evidence does not exist for or against its use. Closed suction drains may be utilized in the setting of a suspected associated pancreatic injury which may lead to a pancreatic leak. A closed suction drain would be beneficial to maintain a controlled fistula in the event of a suture line dehiscence.

3.2.8. Complications

Overall mortality from many single center institutions from duodenal injuries are reported at 5.3–30%. Early mortality in duodenal injuries is attributed to hemorrhage from major associated vascular injuries. In a study of penetrating duodenal injury patients in National Trauma Data Bank (NTDB), Phillips et al. found lower initial systolic blood pressure, lower Glasgow Coma Scale (GCS) score, higher pulse, higher Injury severity score (ISS) and higher OIS grades predicted the likelihood of death after penetrating duodenal injuries.[27] Operative repair-related morbidity and mortality is shown in Table 2 and taken predominantly from single center, retrospective reviews.

3.2.9. Suture line dehiscence and fistula

Duodenal fistula commonly results from suture line dehiscence. Duodenal fistula rates range from 6.6 to as high as 33% in duodenal injuries.[28] Ensuring adequate drainage in the event of suture line dehiscence and duodenal fistula formation is vital. Distal enteral feeding access must be obtained to maintain enteral feeding until the fistula has resolved or there has been an adequate time interval for fistula repair. Maintenance of enteral feeding limits complications of parenteral feeding. Duodenal fistulas leading to fluid losses and electrolyte abnormalities must also be managed with a multidisciplinary approach utilizing nutritionists, surgeons and wound care teams. In these patients, management of fistula wounds, maintaining euvolemia and electrolyte replacement is vital for survival.

3.2.10. Abscess

Due to its' partially retroperitoneal location, complex duodenal injuries can lead to intraperitoneal and/or retroperitoneal abscess formation.[29] Abscess formation is most common after delayed diagnosis of complex duodenal injuries. Under these circumstances, drainage of the abscess is recommended. Pyloric exclusion is sometimes added as an adjunctive procedure. Often persistent leakage of digestive enzymes can cause retroperitoneal soft tissue necrosis. Because of the dependent position, transabdominal approach is less effective in achieving source control. Retroperitoneal laparostomy may be the ideal approach for retroperitoneal abscesses as it avoids the peritoneal cavity and allows for sufficient drainage given its dependent location. In a study by Fang et al., retroperitoneal laparostomy was found to be effective in treating extensive intractable retroperitoneal abscess after duodenal injury.[30]

4. Conclusions

Complex duodenal trauma, categorized as AAST grades III-V are a rare occurrence but present a challenge for the general surgeon. Its partially retroperitoneal position and proximity to biliopancreatic and major vascular anatomy may require complex operative repairs. The major tenets of surgical repair include a) assessment for the need for a damage control pathway b) external drainage c) resection of non-viable tissue, d) restoring gastrointestinal continuity, e) diversion of gastrointestinal contents, bile and pancreatic enzymes, allowing the repair to heal, and f) providing feeding access. Recent history has seen different approaches and strategies in repairing these complex injuries, all of which address these tenets. It is vital to have a thoughtful and multidisciplinary approach when treating these injuries and their complications.

Declaration of competing interest

None.

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