The Therapeutic Challenges in Treating Duodenal Injury

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ABSTRACT

Duodenal injuries pose many challenges in diagnosis and treatment. Unless suspected, pursued vigorously and treated by a well-designed plan, can cause significant morbidity and mortality.

Keywords: Duodenal injury, Duodenal trauma, Pancreatoduodenal injury.

How to cite this article: Lucas CE. The Therapeutic Challenges in Treating Duodenal Injury. J Trauma Critical Care Emerg Surg 2013;2(3):126-133.

Source of support: Nil

Conflict of interest: None

INTRODUCTION

The duodenum is strategically located between the pylorus and the ligament of treitz with intimate attachments to the pancreas, thereby creating technical challenges in the treatment of both blunt and penetrating injury. These challenges call for treatment guidelines which are far different from those seen with small bowel and colon injury. Optimal treatment, in turn, varies with the mechanism, location, and extent of duodenal injury. This treatise presents treatment options for duodenal injuries related to mechanism, size, injury severity, and associated injuries to the pancreas and adjacent vessels. The duodenum can be anatomically divided into the proximal segment including bulb (D1), the lateral segment including the ampulla of vater (D2), the inferior segment in proximity to the uncinate process of the pancreas (D3), and the ascending portion terminating at the ligament of treitz (D4).

METHODS OF RESEARCH

Duodenal Injury Severity Score (ISS)

The type of treatment correlates closely with injury severity, which is best reflected by the Abbreviated Injury Scale (AIS) published by the American Association for the Surgery of Trauma (AAST) (Table 1). Class I injuries include partial thickness lacerations or small intramural hematomas typically located in one duodenal segment, usually D2 or D3; class II injuries include full-thickness perforations which involve less than half of the duodenal circumference or large intramural hematomas involving at least two duodenum segments; class III injuries include full thickness ruptures involving 50-100% of the duodenal circumference at D1, D3, or D4 or 50-75% of the circumference at D2; class IV injuries include duodenal transection of more than 75% of the circumference at D2 or associated intrapancreatic bile duct injury; class V injuries include duodenal transection at D2, duodenal devascularization, or a major (AIS 3-5) duodenal injury in association with a pancreatic head injury.

Table 1: Duodenal injury severity

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
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<tbody>
<tr>
<td>I</td>
<td>Segmental hematoma, partial tear</td>
</tr>
<tr>
<td>II</td>
<td>Large hematoma (two or more segments)</td>
</tr>
<tr>
<td>II</td>
<td>Perforation (&lt;50 circumference)</td>
</tr>
<tr>
<td>III</td>
<td>Perforation (50-100% D1, D3, D4 or 50-75% D2)</td>
</tr>
<tr>
<td>IV</td>
<td>Perforation &gt;75% at ampulla or bile duct</td>
</tr>
<tr>
<td>V</td>
<td>Devascularization Pancreatoduodenal crunch</td>
</tr>
</tbody>
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TREATMENT DECISIONS

Class I Injuries

Patients presenting with blunt injury causing a limited (one segment) duodenal hematoma often are relatively asymptomatic if there are no associated injuries. Restoration of liquid diet may not be tolerated, leading to definitive diagnostic imaging. Plain films of the abdomen seldom reveal the hematoma, whereas the CAT scan will demonstrate the intramural mass with narrowing of the lumen at the site of the hematoma (Fig. 1). Endoscopic examination will...
confirm luminal narrowing at the site of the hematoma. Most patients can be treated nonoperatively, as the hematoma will lyse and gradually reabsorb. This is particularly true in children with an intramural duodenal hematoma. When the obstructive symptoms persist beyond a few days, operative intervention is indicated in adults, whereas conservative nonoperative therapy may extend for two weeks. Partial thickness duodenal tears from stab wounds or gunshot wounds are diagnosed at the time of laparotomy performed for other reasons. Treatment consists of local hemostasis and seromuscular approximation of the partial thickness tear.

Class II Injuries

Patients presenting with recent blunt abdominal injury associated with minor duodenal rupture, or class II injury, usually have upper abdominal pain with tenderness if not masked by alcohol or drug ingestion. Imaging studies typically show scoliosis concave to the right, obfuscation of the right psoas shadow and retroperitoneal air, which is located lateral to the duodenum and may be misinterpreted as air in the hepatic flexure (Fig. 2). Abdominal CT scan will confirm the scoliosis and the retroperitoneal air superimposed upon the right kidney. An upper gastrografin or barium study will show extravasation typically in D2 or D3 (Fig. 3).

When exploration reveals a class II injury after blunt injury, the location will usually be in D2 or D3. Prior to duodenal mobilization, bile stained fluid will be seen anterior and lateral to the duodenum (Fig. 4A). A full mobilization will demonstrate that the perforation is usually located along the lateral border (Fig. 4B). Treatment consists of a primary two-layer closure with a running absorbable internal layer followed by an interrupted external layer. The anatomy of the duodenum does not lend itself to simple staple closure. No adjunctive procedures are indicated.

When the patient with blunt abdominal injury has a large intramural hematoma involving two or more segments, initial nonoperative therapy will often fail (Fig. 5A). This

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Fig. 2: Within 2 hours after blunt injury, this patient has the typical plain abdominal film findings of duodenal rupture, namely, scoliosis concave to the right, obfuscation of the right psoas shadow, and retroperitoneal air often confused for colonic gas

Fig. 3: Gastrografin swallow done more than 24 hours after injury, shows extravasation from D3 in a patient injured in a motor vehicle crash

Figs 4A and B: Exploration performed 6 hours after injury revealed a bile-stained hematoma anterior and lateral of D2 (A) which, when explored, showed a 2 cm full-thickness laceration of D2 (B)
size of the hematoma takes many days for resolution, so that operative intervention, particularly in adults, should be undertaken if duodenal obstruction persists for one week (Fig. 5B). When exploration is performed, the large intramural hematoma will mimic a duodenal mass extending from D1 to D4. Decompression is best performed by a longitudinal antimesenteric incision through the serosa and superficial portion of the muscular layer. The large clot can then be gently evacuated, being careful not to cause injury to the inner muscular layer or the mucosa (Fig. 6). Once totally evacuated and irrigated, a primary closure can be performed using interrupted nonabsorbable sutures to be placed in a seromuscular location and tied gently to bring about appropriate approximation without injuring the underlying tissues.

Class II penetrating injuries to the duodenum are almost always operated upon early. There will often be a through-and-through perforation. When the through-and-through perforations are in close proximity, the ridge between the two holes can be insized, thereby facilitating a primary two-layer closure in a transverse manner using the same techniques as described above. Again, no adjunctive procedures are needed in patients with penetrating class II perforations when operated upon promptly after the original injury.

Class III Injuries

The patients with class III duodenal injury following blunt trauma will present with the same signs and symptoms as seen with class II injury; early exploratory laparotomy usually ensues. The tear involving 50-100% of the circumference is usually in the D2 or D3 area and centered on the lateral or antimesenteric border (Figs 7A and B). The decision to do a primary two-layer transverse closure alone...
or to supplement this closure with an additional procedure will be based upon the appearance of the laceration margins and timing of operation. When the class III injury has ragged, irregular margins, the primary two-layer closure may be tenuous, creating concerns about postoperative leakage. In this situation, one of the three adjunctive procedures (discussed later) should be added.

The class III duodenal laceration caused by a stab wound seldom has irregular margins, thereby permitting a safe, primary two-layer closure, preferably in a transverse manner. In contrast, the class III injury caused by a gunshot wound is more likely to be associated with irregular bruised margins so that, typically, the primary two-layer closure is somewhat tenuous. Such a patient is a candidate for one of the adjunctive procedures. Likewise, the patient with a penetrating class III duodenal perforation is also more likely to have associated vascular lesions with attendant major blood loss and hemorrhagic shock. When this occurs, the priority of treatment is control of hemorrhage as is discussed later.

Class IV Injuries

Patients presenting with more than 75% transection of D2 often have associated injury to the pancreas and other intra-abdominal organs. Blunt class IV duodenal injury is usually associated with significant mural contusion, placing the primary duodenal closure at risk for leakage. Consequently, the primary closure is often supplemented by one of the adjunctive procedures. Again, the primary closure is best done by hand, since the anatomy of the duodenum does not lend itself well to staple closure of major injuries (AIS 3-5).\(^6,7\)

Class IV stab wounds to the duodenum are very rare and have never been encountered by the author. Class IV gunshot wounds to the duodenum are usually caused by rifle injuries or shotgun blasts and are almost always associated with significant injury to adjacent organs and vessels. The associated margins of injury and duodenal wall will almost always be significantly contused, making primary closure alone a risky procedure; these patients are candidates for one of the adjunctive procedures.

Class V Injuries

Class V duodenal injury with associated pancreatic injury presents some of the most challenging problems for the trauma surgeon. When this injury occurs following blunt trauma, the duodenal injury must be treated by the techniques described above if the associated pancreatic injury does not require resection. Following blunt class V duodenal injury, extensive drainage of the pancreatic injury is necessary in addition to providing one of the adjunctive procedures for the duodenal injury. When the associated pancreatic injury includes disruption and extensive damage to the head of the pancreas or duodenal vascular compromise, the patient is a candidate for a pancreatecoduodenectomy (Fig. 8).\(^8,9\)

A class V duodenal/pancreatic injury rarely occurs following a stab wound; this magnitude of injury after a gunshot wound is often lethal because of associated adjacent vascular injury.\(^6,10\) The first priority in these patients is hemostasis as is discussed later.

INTRAOPERATIVE ADJUNCTIVE TECHNIQUES

The unique anatomy of the duodenum with the constant curvature from D1 through D4 and the intimate attachment to the pancreas on the so-called mesenteric border, creates an environment for difficult technical closure and major complications in patients with (AIS 3-5) duodenal rupture.

![Fig. 8: When the head of the pancreas is not totally destroyed and the duodenum is viable, the patient is a candidate for one of the adjunctive procedures. The duodenal exclusion procedure is shown here.](image)

![Fig. 9: The duodenal diverticulization as originally described included vagotomy, antrectomy, primary duodenal closure, end-tube duodenostomy, and wide drainage for the associated pancreatic injury.](image)
This has resulted in a number of intraoperative adjunctive procedures to be performed in addition to the primary duodenal repair in order to facilitate healing of the repair and to accommodate continued gut nutrition when the repair fails. One of these techniques, the triple tube technique, popularized at the Grady Memorial Hospital, includes the placement of a gastrostomy tube, which extends down across the pylorus into the duodenum to reduce the intraluminal pressure. A second retrograde jejunostomy tube is passed from the jejunum across the ligament of Treitz into the distal duodenum to further facilitate a reduction in intraluminal pressure. A third antegrade jejunostomy tube is placed for feeding purposes. Theoretically, the placement of the two tubes within the duodenal lumen will reduce pressure to facilitate primary healing and will help remove duodenal and pancreatic contents if the patient develops leakage and a duodenal cutaneous fistula. If a fistula develops, continued gut nutrition can be provided by the antegrade jejunostomy tube. Theoretically, the low intraluminal pressure and the removal of intraduodenal contents will facilitate a quicker closure of the duodenal fistula, which is usually is laterally sited.

A second adjunctive procedure consists of duodenal exclusion, which is accomplished by performing a distal gastrotomy along the greater curvature of the stomach through which the pylorus is oversewn; the distal gastrotomy is then converted to a side-to-side gastrojejunostomy in order to encourage all gastric juices, and later food, to bypass or exclude the duodenum and go directly into the small intestine (see Fig. 8). Subsequently, the closure of the pylorus spontaneously disrupts, so that by the time the patient has recovered, the food content will transverse the duodenum in a normal fashion.

A third adjunctive procedure consists of the duodenal diverticulization which, when initially described, included vagotomy with a short antrectomy excising about 5 cm of the distal stomach with pylorus followed by an end-to-side gastrojejunostomy (Fig. 9). The original description also included a t-tube choledochostomy. Subsequent to the ready availability of gastric prophylaxis by way of H2 blockers and proton pump inhibitors, the vagotomy is no longer essential; the addition of a tube choledochostomy should be reserved for those patients who have compromise of the pancreaticoduodenal complex and disruption of the intrapancreatic portion of the common bile duct.

A fourth adjunctive procedure consists of primary duodenal repair in a patient whose duodenal laceration meets the criteria for safe, primary repair and a division of a major injury to the head of the pancreas just lateral to where the intrapancreatic portion of the distal common bile duct courses. These patients may have the pancreatic component of their injury treated by complete division of the pancreas just lateral to the intrapancreatic common bile duct with oversewing of the duodenal end of the divided pancreas and Roux-en-Y end-to-side pancreaticojejunostomy to decompress the remaining distal pancreas (Figs 10A and B). The pancreatic area is widely drained.

The author’s experience with the triple tube technique is limited but has been associated with failure due to recurrent tube plugging for a number of reasons. Personal experience with the duodenal exclusion procedure is mostly limited to patients who are transferred in because of leakage of paraduodenal and lesser sac collections due to leakage from the gastrojejunostomy causing retroperitoneal and lesser sac sepsis. This complication makes a bad situation worse. The most common adjunctive procedure performed

Figs 10A and B: A patient with a reparable duodenal injury and a partial pancreatic head transection just lateral to the common bile duct (A) may be treated by primary duodenal closure, oversewing of the divided pancreas, and Roux-en-Y pancreaticojejunostomy to decompress the distal pancreas (B). This procedure, which was initially described for the removal of benign tumors located between the superior mesenteric vein and the intrapancreatic bile duct, has only been used once by the author for injury, the patient did well.
by the author has been with the duodenal diverticulization procedure which, as indicated above, no longer includes a vagotomy, whereas a tube choledochostomy is limited to patients with disruption of the intrapancreatic portion of the common bile duct. Patients transferred in because of leakage from the gastrojejunostomy following duodenal exclusion are eventually converted to the duodenal diverticulization procedure.

**UNUSUAL DUODENAL INJURIES**

**Delayed Diagnosis**

Patients presenting with a missed or delayed diagnosis of duodenal injury usually have sustained blunt trauma; penetrating injury to the duodenum is almost always operated upon early. The cause for delay in operative intervention for a full-thickness duodenal rupture reflects the fact that the patient with rupture of the duodenum rarely has pneumoperitoneum, whereas the retroperitoneal air along the margin of the duodenum in the retroperitoneal space can often be misinterpreted as colonic gas. Furthermore, the symptoms of rupture may be subtle particularly in the patient who has had substances onboard, thereby compromising the physical examination. A contrast CT scan will typically show extraluminal contrast, which may be misinterpreted as being intraluminal by the radiologist. The result is that diagnosis of duodenal rupture, not infrequently, occurs late following blunt injury. Delayed operation more than 24 hours after injury is associated with an inflammatory reaction causing difficult dissection while performing the standard Kocher maneuver to get full and proper mobilization of the duodenum. Once identified, the margins of laceration are indurated, edematous, and do not lend themselves well to suture closure. Furthermore, the medial attachments to the duodenum, in contrast to the small intestine, interfere with proximal and distal mobilization in order that the contused, edematous duodenal wall can be approximated without tension. All of these factors lead to a high incidence of leakage and duodenocutaneous fistulæ. These patients are candidates for one of the intraoperative adjunctive procedures.

**ERCP-INDUCED PANCREATICODUODENAL INJURY**

The use of endoscopic retrograde pancreaticoduodenography (ERCP) has led to dramatic improvements in the care of patients with pancreatic and biliary disease. Like all procedures, however, ERCP has complications which lead to the need for surgical intervention. These complications usually are associated with repeat endoscopic attempts at common bile stone extraction, sphincteroplasty for papillary stenosis, or sphincteroplasty for distal biliary stricture. Whether done by electrocoagulation current or by sphincter incision, some patients develop a full-thickness perforation at the origin of the common channel resulting in a combination of bile and pancreatic juice leakage into the retroperitoneum posterior to the duodenal pancreatic junction. The ensuing retroperitoneal sepsis is often not recognized early, so that when the patient is finally evaluated by a surgeon, there is major infection with the classical systemic inflammatory response, a retroduodenal abscess, and dietary intolerance. When operative intervention ensues, the dissection along the retroperitoneal plane is difficult with an inflammatory phlegmon extending up the porta hepatis and posterior to the head of the pancreas and duodenum. The inflamed tissues prevent a direct repair of the medially located perforation, so that one of the adjunctive procedures needs to be performed. The author prefers the duodenal diverticulization procedure with generous paraduodenal external drainage, T-tube choledochostomy to divert the bile away from the perforation, and lateral tube duodenostomy accomplished by placing a 16-French R-tube in the lateral duodenum after the back wall of the T-tube has been excised, thereby making it a lateral tube stent. The tube duodenostomy is never placed through the duodenal stump, which is closed primarily, since the extensive inflammation almost never extends to the duodenal stump.

**Duodenal Disruption after Duodenotomy and Ampullectomy**

Obstructive jaundice leading to endoscopic assessment is sometimes caused by a benign ampullary tumor. Most of these tumors are villous adenomas which do not require pancreaticoduodenectomy. These tumors can be approached through a lateral duodenotomy with the ampullary area being clearly identified by placement of a probe through the cystic duct stump following cholecystectomy, so that a silk suture may be passed from the duodenal lumen through the cystic duct. This facilitates identifying the exact location of the proximal portion of the ampullary tumor, so that an incision may be made through the full-thickness duodenal wall into the intrapancreatic portion of the common bile duct. This allows for exact placement of interrupted absorbable sutures across all four layers. Repeat exact placement of sutures are continued as the excision is carried out in a circumferential manner, so that the sutures located superiorly will go through the full-thickness duodenal wall and common bile duct, whereas the sutures placed inferiorly will go through the full-thickness duodenal wall and the pancreatic duct. When the frozen section confirms that there is no malignancy, the patient has been cured with an operation that has minimal morbidity and essentially no mortality.
All procedures have complications, however, so that there may be leakage from the reconstruction of the pancreatic duct into the medial duodenum. This may result in dehiscence of the primary closure of the original lateral duodenotomy resulting in extensive retroperitoneal sepsis, a pancreaticoduodenal cutaneous fistula, and dietary intolerance. A successful sequence of correction of this horrible complication is to first achieve full external drain decompression of all duodenal and pancreatic leakage in order to prepare the patient for the diverticulization procedure consisting of antrectomy with anticolic end-to-side gastrojejunostomy and primary closure of the duodenal stump. This will allow for the patient to have continued external drainage from the fistula site while being weaned from total parenteral nutrition and being transferred over to elemental nutrition. The defect in the lateral duodenum will often persist, so that subsequent operative repair of the fistula has to be accomplished after the acute inflammation has subsided. The extent of scar tissue and fibrosis often prevents primary tension-free closure of the fistula, so that a Roux-en-Y jejunal loop has to be created and then passed up in a retrocolic manner to lie next to the mobilized lateral duodenal fistula as a serosal patch. This is accomplished by not opening the lumen of the Roux-en-Y loop but simply placing seromuscular sutures in two layers between the fistula and serosa of the Roux-en-Y loop. This type of serosal patch will contain and correct the external drainage, thereby allowing all of the duodenal and pancreatic juices to flow distally in the normal duodenal channel. Over a period of time the mucosa of the duodenum will spread across the serosal patch, so that on re-examination six months later, the lumen of the duodenum looks normal.

**DAMAGE CONTROL AND DUODENAL INJURY**

Patients who present with penetrating major (AIS 3-5) duodenal injuries often have associated injuries to named peripancreatic and periduodenal vessels. The major challenge to life in these patients is the associated vascular injury and consequent hemorrhagic shock. Many of these patients bleed to death on the operating table despite heroic efforts at vascular control with or without use of damage control packing. Many who survive the initial operation continue to bleed and die shortly thereafter in the recovery room. Those patients who do survive operation and their early postoperative stay in the critical care unit often have no specific treatment for the duodenal perforation, which is simply drained and then covered by packs. These challenges are made worse when a high-injury missile follows either a close-range shotgun or a high-velocity rifle blast. When temporary success is achieved and the patients are taken back to surgery for removal of packs, the wise surgeon does not aggressively dissect the area around the now contained vascular injuries but simply places in drains and gets out. This results in a high incidence of duodenal fistulae. Definitive repair of the duodenum then becomes the primary goal after the patient has entered into the recuperative phase and can tolerate a specific repair rather than treatment by external drainage alone. These drains can be placed by the laparoscopic approach or by an open approach. Long-term correction of the problem should be delayed until the patient has fully recovered and the retroperitoneal problem has been controlled. Comparison of fistula rates between patients undergoing damage control following penetrating duodenal injury to patients with less severe duodenal injuries from penetrating wounds or from blunt injury is like comparing apples and oranges.

**DISCUSSION**

Complex duodenal and pancreatic injuries often create a major surgical challenge. The decision making regarding optimal therapy is based upon extent of injury, timing of injury repair, presence or absence of associated injuries, and the overall condition of the patient being operated upon. This treatise attempts to present a logical approach for dealing with the different types of injuries. The best results of treatment will be achieved when total therapy is directed by the above factors.

**REFERENCES**


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