Chapter

Management of Duodenal Injuries

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Abstract

The duodenum is mostly a retroperitoneal structure, composed by 4 segments (D1-D4) and surrounded by other vital organs like pancreas or great vessels. Injuries to this organ are rare and difficult to diagnose, with an incidence of 1–5% in cases of abdominal trauma. The most common causes of duodenal injuries are gunshot wounds and stabbing. Duodenal injuries are often associated with other organ injuries, thus delaying diagnosis in some cases and increasing the risk of complications. When diagnosed at optimum timing, it can be treated with relatively low mortality rates. Great number of repair techniques exist and the treatment of choice depends on the surgeon's experience and hemodynamic stability of the patient, with the goal of preserving life and preventing a major complication such as leak or fistula. Outcomes are good, and the prognosis is tightly ligated to associated injuries, thus high index of suspicion and applying ATLS and surgery trauma principles are essential.

Keywords: hollow viscus, blunt trauma, anastomosis, pyloric exclusion, acute care surgery

1. Introduction

Duodenal injuries are rare and difficult to diagnose [1], with a reported incidence of 1–5% in cases of abdominal trauma [2, 3]. In a review by García-Santos et al., where 23 case series of duodenal injury were included, the ratio of penetrating and blunt abdominal trauma was found to be 3.9: 1. Among the penetrating injuries, 81% were caused by gunshot wounds and 19% by stabbing [2]. Among blunt abdominal trauma cases, the most frequent mechanism was motor vehicle accidents in 85% [2] due to crushing of the duodenum between the steering wheel and the spine [4].

In general, it is estimated that 4.3% of patients with a history of duodenal trauma present intra-abdominal lesions at the duodenal level; in various case series they range from 3–7%, reporting a male–female ratio of 5:1 with an age disposition of 16 to 30 years in 70% of the cases.

Mortality associated with this type of injury ranges from 18 to 30% [1, 2]. Early deaths are caused by massive hemorrhage from major vascular injuries or associated

traumatic brain injuries, while late deaths are associated with sepsis, duodenal fistulae, and multi-organ failure. It is imperative to recognize these lesions in a timely manner, since the most important risk factor associated with mortality is the delay between diagnosis and treatment [2], since a delay in diagnosis in the first 24 hours can increase mortality up to 4 times. Other risk factors that increase the mortality rate include the presence of associated pancreatic injury and common bile duct injury.

Because the duodenum is surrounded by vital structures and organs, it presents associated intra-abdominal injuries in 68–100% [1, 2, 4]. The kinematics of trauma play an important role in the severity and injured organs; the abdominal structures with the highest rate of injury are: liver (17%), pancreas (12%), small intestine (11%), colon (13%), stomach (9%), bile duct (6%), kidney and urinary tract (6.5%), spleen (4.1%) and vascular injuries such as aorta, vena cava and porta up to 15%, the latter being the ones with the highest mortality due to the high possibility of massive hemorrhage [2].

With reference to the duodenum, an analysis of 1042 patients found that the most frequent site of injury was the second segment (36%), followed by the third portion (18%), and the fourth portion (15%). The least frequently injured portion of the duodenum was the first (13%), and in 18% of the cases, injuries to multiple portions were found [2].

2. Duodenal injuries

2.1 Surgical anatomy

The duodenum is the first portion of the small intestine, it has an approximate length of 30 cm. It is divided into four segments; the first segment has an approximate length of five centimeters, it crosses over the muscular ring of the pylorus towards the vesicular neck. The common bile duct, portal vein, inferior vena cava and the gastroduodenal artery are found behind it; anteriorly, it is related to the hepatic square lobe; superiorly, with the gastroepiploic foramen and inferiorly, with the pancreatic head. This segment is irrigated by the supraduodenal artery and the posterosuperior pancreaticoduodenal branch of the gastroduodenal artery, which is a branch of the common hepatic artery.

As of its second segment, it becomes retroperitoneal, with an average length of 7.5 cm, referentially from the vesicular neck to the fourth lumbar vertebra; it is divided into two portions (supramesocolic and inframesocolic) since it is crossed by the transverse colon and the mesocolon. Due to its descending disposition, it crosses in front of the right kidney, right ureter, right renal vessels, psoas major and inferior vena cava. Its first half is retroperitoneal and it becomes intraperitoneal distally. The major duodenal papilla is located in the middle portion.

Its third segment has a length of 10 cm, it is located approximately five centimeters from the right side of the third or fourth lumbar vertebra, to the left side of the abdominal aorta, it has a transverse disposition in a leftward direction relating with the ureter, the right gonadal vessels, psoas muscle and the inferior vena cava, as well as with the uncinate process of the pancreas; the inferior pancreaticoduodenal artery is found in a groove located between the duodenum and the pancreas.

The fourth segment is ascending, has a length of 2.5 centimeters, has an oblique disposition in a cranial direction, and ends in the duodenojejunal junction, which is suspended by the ligament of Treitz, being found approximately 4 centimeters below and medial to the ninth costal cartilage. It is anteriorly related to the left sympathetic

trunk, and its distal end approaches the terminal portion of the inferior mesenteric vein, the left ureter and the left kidney.

The last three segments of the duodenum receive their irrigation from an anterior and a posterior arcade, from which the pancreatic and duodenal branches arise [5].

2.2 Diagnosis

The diagnosis of duodenal injury is usually difficult, especially in cases of blunt trauma, since the symptoms may not be very obvious, however, it may present data of abdominal tenderness or peritonitis in the initial evaluation, highly suggestive of intra-abdominal injuries, but unspecific to a duodenal injury [4, 6].

FAST (Focused Assessment with Sonography in Trauma) is a widely accepted and useful method in cases of blunt abdominal trauma due to its ability to obtain faster results and with practically zero invasion. However, it has a low sensitivity for duodenal injuries, since up to 30% of patients with some type of retroperitoneal injury, including the duodenum, may present a FAST without alterations, determining the need to perform other extension studies such as abdominal computed tomography (CT) [4, 6].

Abdominal X-ray in standing position may suggest duodenal injury if right psoas muscle effacement or retroperitoneal air is found, however, it is unreliable [1, 2]. CT is one of the best methods to diagnose duodenal injuries in hemodynamically stable patients, even without the need to use water-soluble contrast [1]. The sensitivity of abdominal CT to detect biliopancreatic and duodenal (BPD) injuries approaches an 83%, decreasing to 79% for biliopancreatic (BP) injuries and 50% in bilioduodenal (BD) injuries [6, 7].

CT findings of duodenal injury include wall thickening, right pararenal or periduodenal fluid, decreased enhancement in the injured duodenal segment, and accumulation of clots near the injury site, visualized as a collection of heterogeneous fluid ("sign of the sentinel clot") [4]. Findings that are suggestive of duodenal perforation are the presence of air in the retroperitoneum, wall disruption and contrast extravasation [2, 6].

Magnetic resonance imaging (MRI) is more sensitive than CT for the detection of low-grade injuries, however, it is more expensive and lacks utility in the context of trauma, its use is generally reserved for the evaluation of associated pancreatic or biliary ductal injuries [6].

2.3 Classification

Different scales have been developed to classify the severity of duodenal injuries in the context of trauma, such as the World Society for Emergency Surgery (WSES) and the American Association for the Surgery of Trauma (AAST) classifications, the latter classifies duodenal injuries in 5 grades (**Table 1**) [8].

Instead, the WSES divides injury into four classes, considering the AAST classification and the hemodynamic status [9]:

I. Mild (AAST I)

II. Moderate (AAST II)

III. Severe (AAST III-V)

IV. Hemodynamic instability (AAST I-V of duodenal-biliary-pancreatic injury)

Grade	Type of injury	Description of injury
I	Hematoma Laceration	Involving single portion of duodenum Partial thickness, no perforation
II	Hematoma Laceration	Involving more than one portion Disruption <50% of circumference
III	Laceration	Disruption 50–75% circumference of D2 Disruption 50–100% circumference of D_1
IV	Laceration	Disruption >75% circumference of D_2 Involving ampulla or distal common bile duct
V	Laceration	Massive disruption of duodenopancreatic complex Devascularization of duodenum

Table 1.
AAST duodenal injury scale: D1, D2, D3, and D4 indicates the first, second, third and fourth segments of the duodenum, respectively (adapted from [8]).

This premise arises from the need to standardize local and regional anatomical disruptions, which allow determining the characteristics of the injury conditioned by the kinematics of the trauma; allowing the development of systematic approach strategies that have a positive impact on patient morbidity and mortality [9].

2.4 Management

The initial management is in accordance with the Advance Trauma Life Support (ATLS), hence, patients with hemodynamic instability, peritonitis or evisceration, must be transferred promptly to the operating room (OR). Hemodynamically stable patients with CT findings of low-grade injuries can be treated non-operatively.

2.4.1 Non-operative management (NOM)

Hemodynamically stable patients with CT findings of duodenal hematoma (AAST grade I-I) and no other associated injuries requiring surgical intervention are good candidates to conservative management [3]. The cornerstone of non-operative management in duodenal trauma are nil per os (NPO) with nasogastric tube (NGT) decompression, close monitoring with serial abdominal exams, serum amylase, lipase and follow-up CT scan in 12-24 h if clinical suspicion or deterioration [3].

In patients with hematoma and signs of obstruction, NOM is appropriate up to 14 days and should be taken to the OR to drain the hematoma if clinical deterioration, worsening findings on interval CT or to relieve the mechanical obstruction [3, 9, 10].

2.4.2 Operative management

During surgery, the decision to proceed with definitive repair versus damage-control and delayed repair is an important one, taking into account the high rate of complex or combined injuries, frequently resulting in hemorrhagic shock. During damage-control laparotomy, the aim is to achieve contamination control, often with primary suture repair, drainages and sometimes externally drain the bile duct.

Once adequate [11] resuscitation and hemodynamic stability is established in the intensive care unit, assessment of a definitive repair is considered at a second-look surgery [10].

Assessment of duodenal injuries is often made possible during surgery. Up to 55–85% of duodenal injuries can be managed by primary closure [1–3, 10]. Primary suture repair should be the initial approach in most situations, with more complex repairs reserved for extensive injuries. High-grade injuries are those which involve >75% of duodenal wall, D1 or D2 injuries, delayed repair and associated biliary or pancreatic injuries [2]. Injuries at D1 or proximal D2 can benefit from performing an antrectomy and Billroth II reconstruction [3].

Almost all grade I-II hematomas diagnosed pre-operatively resolve with adequate non-operative management. If hematomas are discovered during surgery and > 50% of lumen is compromised, it should be externally drained without entering the duodenal lumen. A gastrojejunostomy should be considered in case the hematoma compromises >75% of the lumen due to the risk of delayed obstruction [10]. Simple grade I and early grade II lacerations are managed by simple, tension-free repair with imbricating sutures in a transverse orientation and ensuring viable edges [3, 10]. Drains should not be routinely placed for Grade I-II injuries [9].

Up to 30% of duodenal injuries will require complex repair techniques [12]. Delayed or contaminated grade II injuries may be managed as grade III injuries. This often requires to perform a roux-en Y duodeno-jejunostomy in cases of extensive defects (grade III) [10] or grade II injuries where a tension-free repair is not possible or in some cases with moderate contamination [1].

Grade III injuries involving D1, D3 or D4 may likely undergo primary repair alone [11]. Extensive duodenal lacerations in D2-D3 segments may be repaired by an end-to-end duodenoduodenostomy [3]. Grade III-IV injuries not involving the ampulla or bile duct, benefit from the same approach as Grade III injuries [4, 9]. Small bowel anastomosis has an overall 9% complication rate. In trauma patients undergoing damage-control surgery, a delayed anastomosis shows comparable complication rates to those undergoing single-stage anastomosis [13].

Grade IV-V injuries are devastating, the patient often presents in hemorrhagic shock and usually requires a complex reconstruction technique [4]. These patients present with injuries involving the duodenopancreatic complex and often benefit from a damage-control surgery and a second-look surgery for a definitive repair or reconstruction. Surgical approaches range from surgical techniques used in grade III injuries such as duodeno-jejunostomy, or even performing a Whipple procedure if extensive duodenal devascularization or pancreatic head destruction is present [2, 10].

Pancreaticoduodenectomy (Whipple procedure), is indicated for injuries in the pancreatic head, duodenum, distal common bile duct, massive hemorrhage of difficult control and combined grade V pancreatic and duodenal injuries [1]. Reimplantation of the common bile duct into the duodenum carries a high risk of stricture formation [3]. In patients with destructive pancreatic injuries, anastomotic leaks are to be expected, thus external drainage of the anastomosis is vital for leakage control and enabling the formation of a controlled fistula [3].

2.4.2.1 Duodenal diversion

Procedures that divert enteric contents away from the duodenum may be considered in cases of high-grade injuries. All duodenal diversion techniques have similar complication and mortality rates. Their goal is to divert gastric contents and, in some

situations, bilio/pancreatic contents from the duodenum to minimize the possibility of suture dehiscence, leakage and contamination.

2.4.2.2 Pyloric exclusion

Developed in 1977 by Vaughn et al., it consists of primary repair of the duodenum and diverting the gastric contents to the jejunum. After the duodenal repair, the pylorus is closed from the inside through a gastrotomy by means of suture or staples. The final step is to perform a gastrojejunostomy at the site of the gastrotomy [10]. The pylorus reopens spontaneously at 3 weeks, but the main long-term complication is an anastomotic ulcer in up to 33% of patients [10, 14]. Overall complication rates are higher in these patients (71%) [3].

2.4.2.3 Duodenostomy tube

This method of diversion consists in creating a lateral or end-tube duodenostomy near the injury site in cases where the degree of inflammation hinders any other approach.

2.4.2.4 Duodenal Diverticulization

This historic technique described by Berne et al. [15] was employed in cases of complex duodenal injuries and its principle is to divert all gastric and biliary secretions from the duodenum. It consists of primary repair of the duodenal injury, antrectomy, vagotomy, closure of duodenal stump over a decompressive end duodenostomy, placement of a T-tube in the common bile duct and periduodenal drains [10].

2.5 Nutrition

Early enteral feeding improves complications and mortality in critically ill trauma patients [16]. A greater benefit associated with early enteral nutrition is reported once the patient's hemodynamic stability has been established [10]. Feeding jejunostomy is an excellent way of accomplishing early enteral feeding after major trauma [10], especially in patients with severe pancreaticoduodenal injuries requiring resection and reconstruction [9]. Up to 75% of critically ill patients with severe duodenal injuries do not tolerate early enteral feeding even with concurrent decompression and feeding jejunostomy [16], this being the reason why 37–75% of patients may still require total parenteral nutrition [9].

2.6 Complications

Mortality ranges from 15 to 47% [3], many of them attributed to the associated injuries, especially major vascular injuries causing hemorrhagic shock [3]. In-hospital mortality and postoperative sepsis is similar in patients with primary-repair compared with gastrojejunostomy (6.6% vs. 4.5% and 10.4 vs. 6.7% respectively), but hospital length of stay is shorter in the primary repair group (11 days vs. 18 days) [17].

Overall complications reach 65% and include intra-abdominal abscess and sepsis, duodenal leakage (0–33%), bowel obstruction, and complications related

to other injuries [3, 11]. Patients with severe intestinal injuries are at higher risk of intestinal leaks, perforation, volvuli and bowel necrosis [16]. Hypotension in both the preoperative and intraoperative period is the primary risk factor for complications [14].

Other risk factors include blunt abdominal trauma, high-speed projectiles, high-grade duodenal injuries, associated biliary tree injuries or severe pancreatic injuries and more than 24-hour delay in treatment [4, 18]. And some physiological measures associated with complications include lactate and pH level [19].

Intra-abdominal abscess presents with clinical deterioration between 7 to 10 days post-injury. Antibiotics and percutaneous drainage remain the standard of care [3].

Duodenal leak and fistula rates vary according to AAST injury grade and the affected duodenal segment. The more severe the injury, the higher risk of duodenal leak. AAST Grade I injuries have a risk of about 0% of leakage, AAST-II 1.6% and AAST III 66.7%. [19]. According to the affected segment, the risk of duodenal leak is 32% in D1, 12.5% in D2, 38.5% in D3 and 16% in D4 [19]. Factors that may enhance the risk of suture failure include distal intestinal obstruction and pancreatic injury with enzyme leaks.

The mainstay of treatment is adequate drainage, output control, maintaining euvolemia, replacing electrolytes losses and adequate nutrition [3]. Also, decompression of the bile and pancreatic secretions produced daily reduces the risk of duodenal leakage [11].

3. Conclusion

Duodenal injuries are often associated with other organ injuries, thus delaying diagnosis in some cases and increasing the risk of complication. When diagnosed in time, it can be treated with relatively low mortality rates.

There are several surgical techniques described to treat high-grade duodenal injuries, some of which are more complex than others, however, it is evident that primary closure has been superior in terms of results, inferring that it is less complex and with shorter surgical time. Outcomes are good, and the prognosis is tightly ligated to associated injuries, thus high index of suspicion and applying ATLS and surgery trauma principles are essential.

Based on the premise set forth by the Pan American Trauma Society, primary closure is postulated as the treatment of choice in duodenal trauma regardless of its grade; taking as a reference the adequate optimization of surgical times that allow the prompt resolution of the acute event, reducing the patient's exposure to metabolic response to trauma induced during the intervention; systematically resolving the patient's determinant of morbidity and mortality. This precept is mostly applicable in cases that present with hemodynamic instability. In addition, it is suggested that alternative procedures such as pyloric exclusion and/or additional decompression should be reserved for special cases [14].

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References

[1] Rickard MJFX, Brohi K, Bautz PC. Pancreatic and duodenal injuries: Keep it simple. ANZ Journal of Surgery. 2005;**75**:581-586. DOI: 10.1111/j.1445-2197.2005.03351.x

[2] García Santos E, Soto Sánchez A, Verde JM, Marini CP, Asensio JA, Petrone P. Lesiones duodenales secundarias a traumatismo: Revisión de la literatura. Cirugía Española. 2015;**93**:68-74. DOI: 10.1016/j.ciresp.2014.08.004

[3] Ratnasekera A, Ferrada P. Traumatic duodenal injury: Current management update. Current Surgery Reports. 2020;**8**:6. DOI: 10.1007/s40137-020-00251-9

[4] Magaña, Sánchez IJ, Manuel García Núñez L. Alternativas de manejo del trauma duodenal. Cirujano General. 2013;**34-37**

[5] Skandalakis JE, Colborn GL, Foster RS, Weidman TA, Skandalakis LJ, Skandalakis PN. Surgical Anatomy and Technique: A Pocket Manual. New York: Springer; 2002

[6] Melamud K, LeBedis CA, Soto JA. Imaging of pancreatic and duodenal trauma. Radiologic Clinics of North America. 2015;**53**:757-771. DOI: 10.1016/j.rcl.2015.02.009

[7] Velmahos GC. Blunt Pancreatoduodenal Injury a Multicenter Study of the Research Consortium of New England Centers for Trauma (ReCONECT). In: Archives of Surgery. American Medical Association (AMA). 2009;**144**(5):413. DOI: 10.1001/archsurg.2009.52

[8] Moore EE, Cogbill TH, Malangoni MA, Jurkovich GJ, Champion HR, Gennarelli TA, et al. Organ injury scaling, II: Pancreas, duodenum, small bowel, colon, and rectum. The Journal of Trauma. 1990;**30**:1427-1429

[9] Coccolini F, Kobayashi L, Kluger Y, Moore EE, Ansaloni L, Biffl W, et al. Duodeno-pancreatic and extrahepatic biliary tree trauma: WSES-AAST guidelines. World Journal of Emergency Surgery. 2019;**14**:1-23. DOI: 10.1186/S13017-019-0278-6

[10] Malhotra A, Biffl WL, Moore EE, Schreiber M, Albrecht RA, Cohen M, et al. Western trauma association critical decisions in trauma: Diagnosis and management of duodenal injuries. Journal of Trauma and Acute Care Surgery. 2015;**79**:1096-1101. DOI: 10.1097/TA.0000000000000870

[11] Schroeppel TJ, Saleem K, Sharpe JP, Magnotti LJ, Jordan AW, Fischer PE, et al. Penetrating duodenal trauma: A 19-year experience. Journal of Trauma and Acute Care Surgery. 2016;**80**:461-465. DOI: 10.1097/TA.0000000000000934

[12] Ferrada P, Wolfe L, Duchesne J, Fraga GP, Benjamin E, Alvarez A, et al. Management of duodenal trauma: A retrospective review from the Panamerican trauma society. Journal of Trauma and Acute Care Surgery. 2019;**86**:392-396. DOI: 10.1097/TA.0000000000002157

[13] Bruns BR. Bowel anastomosis in acute care surgery. Current Surgery Reports 2017;5, 29. doi:10.1007/s40137-017-0191-4

[14] Seamon MJ, Pieri PG, Fisher CA, Gaughan J, Santora TA, Pathak AS, et al. A ten-year retrospective review: Does pyloric exclusion improve clinical

outcome after penetrating duodenal and combined pancreaticoduodenal injuries? Journal of Trauma - Injury, Infection and Critical Care. 2007;**62**:829-833. DOI: 10.1097/TA.0b013e318033a790

[15] Berne CJ, Donovan AJ, White EJ, Yellin AE. Duodenal "diverticulization" for duodenal and pancreatic injury. American Journal of Surgery. 1974;**127**:503-507. DOI: 10.1016/0002-9610(74)90305-5

[16] Dickerson RN, Voss JR, Schroeppel TJ, Maish GO, Magnotti LJ, Minard G, et al. Feasibility of jejunal enteral nutrition for patients with severe duodenal injuries. Nutrition. 2016;**32**:309-314. DOI: 10.1016/J.NUT.2015.08.026

[17] Siboni S, Benjamin E, Haltmeier T, Inaba K, Demetriades D. Isolated blunt duodenal trauma: Simple repair, Low Mortality. American Surgery. 2015;**81**:961-964. DOI: 10.1177/000313481508101010

[18] Talbot WA, Shuck JM. Retroperitoneal duodenal injury due to blunt abdominal trauma. The American Journal of Surgery. 1975;**130**:659-666. DOI: 10.1016/0002-9610(75)90416-X

[19] Weale RD, Kong VY, Bekker W, Bruce JL, Oosthuizen G v., Laing GL, et al. Primary repair of duodenal injuries: A retrospective cohort study from a major trauma Centre in South Africa. Scandinavian Journal of Surgery 2019;**108**:280-284. doi:10.1177/1457496918822620