Curr Surg Rep (2020) 8:6
https://doi.org/10.1007/s40137-020-00251-9

Traumatic Duodenal Injury: Current Management Update

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Published online: 4 April 2020
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Abstract
Purpose of Review Although duodenal injuries are a rare entity of all trauma, they carry high risk of morbidity and mortality. The management of duodenal injuries should encompass a multidisciplinary approach. Optimal operative management of duodenal injuries has evolved in the last few decades.
Recent Findings Isolated duodenal injuries are rare due to its proximity to major vascular and organ structures. Immediate mortality from duodenal injuries is due to hemorrhage from major vascular injuries. Non-operative management of isolated low-grade classification of duodenal injuries is accepted with close clinical and laboratory monitoring of patients. When operative management is necessary, recent evidence suggests simple repair over complex reconstructions that carry less morbidity and improved outcomes. When dealing with injuries to the duodenopancreas complex, reconstruction of the pancreaticobiliary system should involve expertise of hepatobiliary surgeons.
Summary Management of duodenal injuries and its complications should engage a multidisciplinary approach. Damage control techniques should be utilized in patients in extremis with associated major vascular injuries. Low-grade duodenal injuries may be monitored closely with clinical examinations and laboratory values. When duodenal repair is needed, conservative repair techniques over complex reconstructions should be utilized.

Keywords Duodenal injury · Traumatic duodenal injury · Operative management duodenal injury · Duodenal fistula · Non-operative management duodenal injury

This article is part of the Topical Collection on *Trauma Surgery*.

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Introduction

Duodenal injuries are a rare entity existing in 1–4.7% of abdominal trauma in adult patients [••1]. However, duodenal injuries carry a high risk of morbidity and mortality. The incidence of pediatric duodenal trauma is < 1% [••1]. Isolated duodenal injuries are rare. In a retrospective review from the Pan-American trauma society, the authors found concurrent intra-abdominal injuries in 68% of patients with duodenal injuries [•2]. Reports have stated up to 100% of duodenal injuries have associated injuries [••3, 4]. Anatomically, the duodenum sits in a retroperitoneal location except for the anterior segment of the first portion of the duodenum and the most distal fourth portion of the duodenum. The proximity of the duodenum to vital structures makes isolated injuries rare. The duodenum is closely associated with the gastroduodenal artery, common bile duct, pancreas, the superior and inferior mesenteric vessels, right and transverse colon, aorta, and the inferior vena cava.

Injury Epidemiology

The most common cause of duodenal injuries in adult patients is penetrating trauma with incidences ranging from 53 to 90% of cases [••1, 5]. The most commonly associated injuries were liver, pancreas, and colon. Blunt abdominal trauma is the most common cause of duodenal injury in pediatric patients, which occurs in 70–78% of cases. Deceleration with blunt abdominal trauma to the epigastrium results in a crushing mechanism of the duodenum to the spinal column. Duodenal trauma has a reported mortality of 15 to 47% with increasing mortality associated with higher number of injuries and major vascular injuries. It also carries a morbidity of 39% to 56% [6].

Classification

The most commonly used classification system for duodenal injury is the American Association for the Surgery of Trauma organ injury scale (AAST-OIS). The injury scale is categorized by the presence of hematoma or laceration. However, the grading system does not correlate with outcomes or mortality (Fig. 1).

Diagnosis

In blunt abdominal trauma, findings such as epigastric abdominal tenderness, ecchymosis in the upper abdomen, lower rib fractures, and upper lumbar spine fractures may suggest an underlying duodenal injury. Penetrating injuries to the abdomen and thoracoabdominal region raise concerns for intra-abdominal injuries. The diagnostic modalities of duodenal injury are contingent upon patient's hemodynamic stability. For all trauma patients, Advanced Trauma Life Support (ATLS) guidelines must be used to evaluate the patients. A Focused Assessment with Sonography in Trauma (FAST) exam should be performed as an adjunct to the primary survey.

Duodenum injury scale

Grade*	Type of injury	Description of injury	ICD-9	AIS-90
I	Hematoma	Involving single portion of duodenum	863.21	2
	Laceration	Partial thickness, no perforation	863.21	3
II	Hematoma	Involving more than one portion	863.21	2
	Laceration	Disruption <50% of circumference	863.31	4
III	Laceration	Disruption 50%-75% of circumference of D2	863.31	4
		Disruption 50%-100% of circumference of D1,D3,D4	863.31	4
IV	Laceration	Disruption >75% of circumference of D2	863.31	5
		Involving ampulla or distal common bile duct		5
V	Laceration	Massive disruption of duodenopancreatic complex	863.31	5
	Vascular	Devascularization of duodenum	863.31	5

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

Fig. 1 AAST-OIS for duodenal injury

A stable patient with penetrating trauma to the thoracoabdominal region with suspicion for intra-abdominal injuries should undergo operative exploration. A positive FAST exam demonstrating intraperitoneal fluid in a penetrating trauma patient further warrants operative exploration. A negative FAST exam in the setting of penetrating injuries does not rule out intra-abdominal solid organ or hollow viscus injury.

A positive FAST exam in blunt abdominal trauma patients with hemodynamic stability may be further examined with a Computed Tomography (CT) scan of the abdomen and pelvis with intravenous contrast. Administration of oral contrast to improve sensitivity in detecting duodenal injuries has not been proven to be beneficial. An abdominal CT scan has high sensitivity (86%) and specificity (88%) for diagnosing duodenal injuries [••1, 7–9]. However, missed duodenal injuries have been described. CT scan findings of periduodenal fluid and hematoma do not call for immediate exploration. Nevertheless, such findings must be followed closely with serial abdominal exams, serial serum amylase and lipase levels, and a follow-up CT scan of abdomen and pelvis within 12–24 h of presentation.

Hemodynamically stable patients with a negative initial CT, yet with high suspicion for duodenal injuries, should be observed and receive serial clinical examinations. A repeat CT scan within 12–24 h of initial injury should be considered in this patient population. CT findings of free fluid especially in penetrating injuries raise concern for hollow viscus injuries. CT scan findings of extraluminal gas or oral contrast, localized edema, and mesenteric stranding are diagnostic of duodenal injury [10].

Examination of serum amylase and lipase may be prognostic of duodenal injuries. Measurements of serial amylase and lipase in the hemodynamically stable patient with a high suspicion of duodenal injuries should be performed every 6 h. A normal amylase does not exclude duodenal injury. Amylase may also be elevated in hepatic injuries, bowel injuries, alcohol abuse, and pancreatic injuries [11].

Treatment

Management of duodenal injuries are contingent upon hemodynamic stability.

Non-operative Management (NOM)

The opportunities to perform non-operative treatment of duodenal injury are scarce. Patients with peritonitis and evisceration are not candidates for NOM. The hemodynamically stable patient with CT scan findings of periduodenal hematoma with AAST-OIS grade I–II with no other associated intra-abdominal injuries may be monitored closely with serial abdominal exams, serum amylase and lipase levels, and a follow-up CT scan in 12–24 h if clinical suspicion warrants or if the patient has clinical deterioration. These patients must be kept nil per os (NPO) with nasogastric tube (NGT) decompression [12].

The patient with AAST-OIS grade I–II periduodenal hematoma who develops signs of obstruction may be monitored for up to 14 days. If there is no resolution in this time period, operative management should be considered to evacuate the periduodenal hematoma in order to relieve the mechanical obstruction. The patient should be kept NPO with NGT. Total parenteral nutrition (TPN) should be considered if enteral nutrition is not initiated during this time period.

Operative Management (OM)

In the hemodynamically unstable patient with traumatic injuries, or the patient with a positive FAST exam, an emergent operative exploration should be performed. Patients with evisceration or signs of peritonitis on exam should have urgent operative exploration. In the hemodynamically stable patient who received a CT scan, findings of extravasation of oral contrast if utilized, and free air should prompt emergent operative exploration.

During operative exploration, full duodenal mobilization utilizing the Kocher maneuver is essential for the examination of both anterior and retroperitoneal surfaces of the duodenum. The fourth portion of the duodenum is exposed by dividing the Ligament of Treitz. This is carefully performed to avoid injury to the superior mesenteric vein.

Damage control surgery (DCS) is indicated in patients with concomitant vascular injuries with hemorrhagic shock, acidosis, and hypothermia. This includes containing any intestinal contamination and control of hemorrhage with temporary abdominal wall closure. Once hemodynamic stability is established and shock physiology has normalized duodenal injury repair and reconstruction is considered in subsequent operations. DCS seems to improve survival and reduce complications in treating severe duodenal injuries [••3, 13, 14].

Operative Techniques

AAST-OIS I–II

Duodenal lacerations are primarily repaired in a transverse orientation. A tension-free repair must be utilized. Transverse orientation repair ensures patency of the duodenum and prevents luminal narrowing. Necrotic or non-viable edges of duodenal injury are debrided to healthy tissue. A two-layer closure should be considered, though a one-layer repair is acceptable. NGT decompression is required for proximal decompression. If a small 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 $> 50\%$ of diameter of the lumen, the hematoma must be carefully drained. It is preferred to not enter the duodenal lumen while draining the hematoma. If an underlying duodenal laceration is encountered, it should be repaired using the principles mentioned above.

AAST-OIS III–V

Injuries Not Involving Duodenopancreas Complex

There are many operative techniques that were described for the management of higher AAST-OIS grade injuries without involving the duodenopancreatic complex. Recent studies have demonstrated that utilizing simple repair techniques has better outcomes compared to complex reconstructive methods [•2, ••3, 13].

If a duodenal laceration is too extensive for primary repair, a primary end-to-end duodenoduodenostomy may be considered. This technique may not be feasible for injuries to the 2nd or 3rd portion of the duodenum due to the adjacent attachments to the pancreas and the intimate location of the ampulla of Vater.

The duodenal diverticulization procedure as described by Berne et al. has not been supported due to the additional length and complexity of the operation [15]. The procedure calls for duodenal repair, vagotomy, antrectomy, gastrojejunostomy, tube duodenostomy, and T tube biliary drainage (Fig. 2).

Another technique for repair and protection of the suture is the "triple tube ostomy" [16]. The technique calls for proximal NGT decompression, a retrograde jejunostomy for duodenal drainage and an anterograde jejunostomy for distal feeding. This technique has also failed to improve outcomes [17] (Fig. 3).

Vaughn et al. developed the pyloric exclusion technique in 1977 [18]. The pyloric muscle is either stapled or sutured closed with an absorbable suture. A gastrojejunostomy is then performed for passage of gastric contents. The stapled or sutured pylorus will open

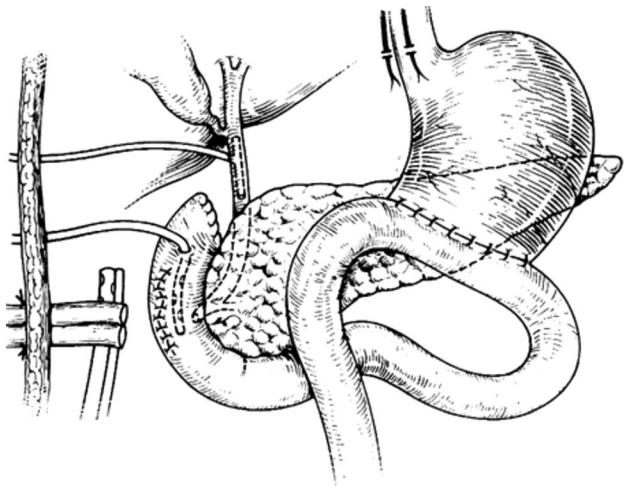

Fig. 2 Duodenal diverticulization procedure

spontaneously in several weeks (Fig. 4). Although still used today, this procedure has been demonstrated to cause increased operative times and gastric suture line ulcers. Higher overall complication rates were also demonstrated (71% vs. 33%) [••3, 4, 5, 13]. If the patient presents with significant injury to the medial wall of the second portion of the duodenum, pyloric exclusion should be considered.

For more extensive injury or injuries near the ampulla, a Roux-en-Y duodenojejunostomy should be considered to avoid injury with mobilization to the distal common bile duct. The duodenal laceration may be repaired primarily and a Roux-en-Y duodenojejunostomy may be created in the proximal duodenum. If the duodenal injury is involving the first or proximal second portion, an antrectomy with a gastrojejunostomy reconstruction (Billroth II) may be considered [12].

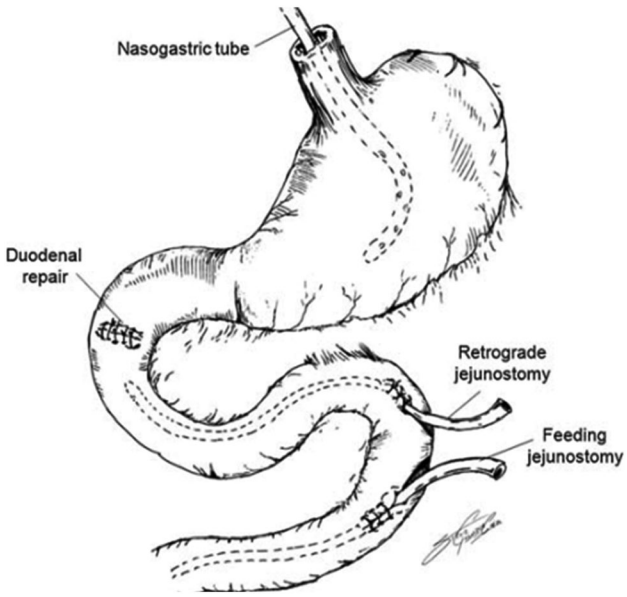

Fig. 3 Triple tube duodenostomy

A jejunal serosal patch has been described and historically utilized. A study by Ivatury et al in 1985 did not report successful outcomes for patients who was managed with a jejunal serosal patch [19]. The technique involves using a loop of jejunum to buttress a tenuous primary duodenal repair. A vascular pedicled omentum can also be used in this case. A jejunal serosal patch may also be used if the duodenal defect primary repair will cause significant narrowing of the lumen.

Injuries Involving Duodenopancreas Complex

Injuries to the second portion of the duodenum involving the ampulla or distal common bile duct are rare, however, needs complex reconstruction. Reimplantation of distal common bile duct into healthy duodenum is an option; however, this technique carries a high risk of stricture formation. The choledochoduodenostomy should be performed over a stent or a small pediatric feeding tube. External drainage of the anastomosis is vital for any future anastomotic leaks and establishes the ability to create a controlled fistula. A Roux-en-Y reconstruction for biliary drainage should be considered.

When the duodenum and pancreatic head are severely devitalized, a pancreaticoduodenectomy (Whipple procedure) may be required. Classic Whipple procedures and pyloric-preserving reconstructions are used. Physiologic derangements should be controlled and signs of shock should resolve prior to reconstruction. DCS should be utilized in this patient population. Morbidity and mortality are high. Early mortality is related to hemorrhage and injuries to surrounding associated organs. Late mortality is due to infectious causes such as intra-abdominal abscess and duodenal or pancreatic fistulas. Expertise of hepatobiliary surgeons should be employed in staged reconstruction [20, 21]. Complexities such as creation of pancreaticojejunostomies in young patients with soft pancreatic texture is technically challenging and may require hepatobiliary expertise. Small pancreatic duct size also presents with challenging duct to mucosa anastomosis creation. In these cases, suturing the capsule of the pancreas to bowel as a "dunking the pancreas" maneuver may decrease incidence of leaks. Use of distal feeding tubes in these patients to allow for early and adequate enteral nutrition must be considered. Pancreatic leak rates have been described as a result of soft pancreatic texture and small duct size. In patients with injuries that are destructive to the pancreas, anastomotic leaks are to be expected. Liberal use of external closed suction drainage is paramount. Vast majority of pancreatic leaks may be managed with control of sepsis and adequate drainage to allow for a controlled fistula.

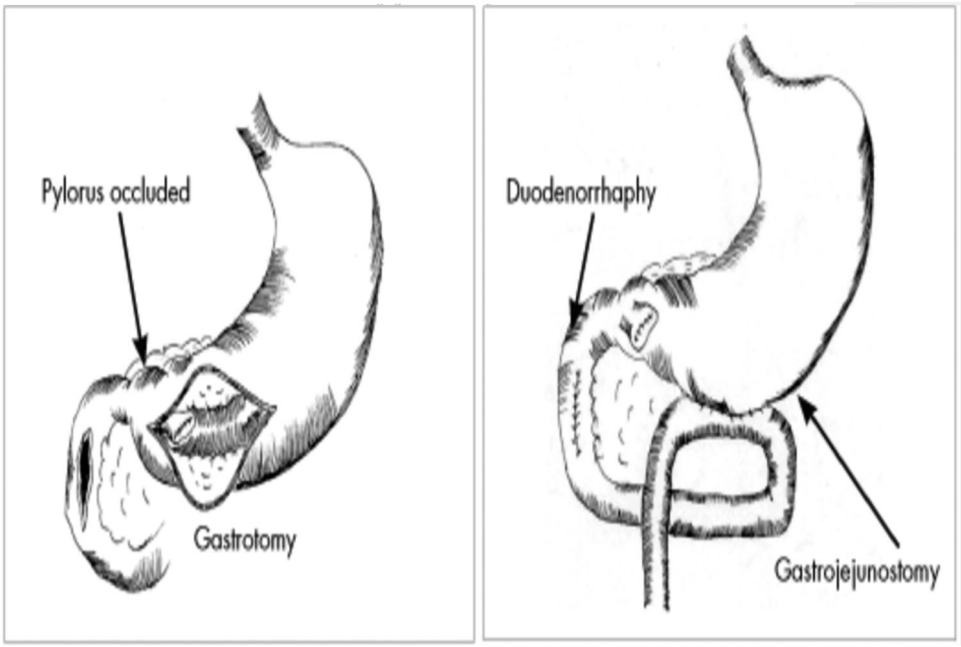

Fig. 4 Pyloric exclusion with gastrojejunostomy

Duodenal drain placement is debated and evidence does not exist for or against its use. Closed suction drains should be applied in any tenuous anastomosis or repair. Drains may be utilized in the setting of a suspected associated pancreatic injury which may lead to a pancreatic leak. If a fistula were to form from suture or anastomotic dehiscence, a closed suction drain would be useful to maintain a controlled fistula.

Complications

Many studies of duodenal trauma are reported from single institution data. The overall mortality is reported as 15–47%. Hospital length of stay (LOS) and ICU LOS for penetrating duodenal injuries were reported ranging from 16 to 24 days and 6 to 11 days, respectively [••3, 5, 6, 22]. 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 [22]. Early deaths after duodenal injuries are attributed to hemorrhagic shock from major vascular injuries.

Intra-abdominal Abscess

Abscess formation should be considered in patients with duodenal injury who develops signs of clinical deterioration seven to ten days in the post injury or post-operative period. CT scan of the abdomen and pelvis should be utilized for diagnosis of intra-abdominal abscess. Percutaneous drainage and intravenous antibiotics remain the mainstay of treatment.

Duodenal Fistula

Duodenal fistulas result from suture line dehiscence or from distal duodenal or intestinal obstruction. Associated pancreatic injuries with pancreatic enzyme leaks may weaken duodenal and anastomotic suture lines leading to leak. Adequate drainage for a controlled fistula is the mainstay of treatment. Studies have shown duodenal fistula rates from 6.6 to as high as 33% in duodenal injuries [23]. Distal feeding jejunostomy tube is vital for distal enteral feeding in this patient population. If distal feeding access is not established, TPN may be utilized till the duodenal fistula has resolved. The duodenum, along with the pancreas, produces up to 2000 ml of intestinal contents daily. The composition of duodenal secretions is rich in sodium and chloride. Pancreatic secretions are rich in sodium, chloride, and bicarbonate. High-output duodenal fistulas may lead to massive fluid losses, electrolyte abnormalities, and normal anion gap metabolic acidosis. Maintaining euvolemia, replacing electrolytes, and establishing adequate nutrition are vital for these patients.

Bowel Obstruction

Post-operative bowel obstructions are expected after major laparotomy. Bowel obstructions from adhesive disease or

expanding duodenal hematomas may occur. These patients may be observed for resolution of obstruction with NGT decompression, NPO status, and serial abdominal exams. Laparotomy is warranted if failure of non-operative management has reached.

Conclusions

Although traumatic duodenal injuries are rare, knowledge of management of injuries and complications is vital to the practicing surgeon. In the operative management of duodenal injuries, simple repair is preferred compared to complex reconstructions.

Compliance with Ethical Guidelines

Conflict of interest Asanthi Ratnasekera and Paula Ferrada declare no conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:
- • Of importance
- •• Of major importance

1. •• Coccolini F, Kobayashi L, Kluger Y, Moore EE, Ansaloni L, Biffl W, Leppaniemi A, Augustin G, Reva V, Wani I, Kirkpatrick A, et al. WSES-AAST Expert Panel. Duodeno-pancreatic and extrahepatic biliary tree trauma: WSES-AAST guidelines. World J Emerg Surg. 2019;14:56. *These guidelines are the most recent and up to date for the management of duodenal trauma.*
2. • Ferrada P, Wolfe L, Duchesne J, Fraga GP, Benjamin E, Alvarez A, Campbell A, Wybourn C, Garcia A, Morales C. Management of duodenal trauma: a retrospective review from the Panamerican Trauma Society. J Trauma Acute Care Surg. 2019;86(3):392–6. *Large multicenter retrospective review highlighting predictors of mortality in duodenal trauma and utilization of simple repair as operative management.*
3. •• Ordoñez C, García A, Parra MW, Scavo D, Pino LF, Millán M, Badiel M, Sanjuán J, Rodriguez F, Ferrada R, Puyana JC. Complex penetrating duodenal injuries: less is better. J Trauma Acute Care Surg. 2014;76(5):1177–83. *Utilization of DCS improves outcomes.*
4. Seamon MJ, Pieri PG, Fisher CA, Gaughan J, Santora TA, Pathak AS, Bradley KM, Goldberg AJ. A ten-year retrospective review: does pyloric exclusion improve clinical outcome after penetrating duodenal and combined pancreaticoduodenal injuries?. J Trauma. 2007;62(4):829–33.
5. DuBose JJ, Inaba K, Teixeira PG, Shiflett A, Putty B, Green DJ, Plurad D, Demetriades D. Pyloric exclusion in the treatment of severe duodenal injuries: results from the National Trauma Data Bank. Am Surg. 2008;74(10):925–9.
6. Huerta S, Bui T, Porral D, Lush S, Cinat M. Predictors of morbidity and mortality in patients with traumatic duodenal injuries. Am Surg. 2005;71(9):763–7.
7. Stafford RE, McGonigal MD, Weigelt JA, Johnson TJ. Oral contrast solution and computed tomography for blunt abdominal trauma: a randomized study. Arch Surg. 1999;134:622–6 **(Discussion 626–7)**.
8. Daly KP, Ho CP, Persson DL, Gay SB. Traumatic retroperitoneal injuries: review of multidetector CT findings. Radiographics. 2008;28:1571–90.
9. Stuhlfaut JW, Soto JA, Lucey BC, Ulrich A, Rathlev NK, Burke PA, et al. Blunt abdominal trauma: performance of CT without oral contrast material. Radiology. 2004;233:689–94.
10. Kashuk JL, Burch JM. Duodenum and pancreas. In: Moore EE, Feliciano DY, Mattox K, editors. Trauma. 6th ed. New York: McGraw-Hill; 2004. p. 701–719.
11. Asensio JA, Forno W. Duodenal injuries. In: Demetriades D, Asensio JA, editors. Trauma handbook. Georgetown: Landes Biosciences Co.; 2000. p. 354–360.
12. 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. J Trauma Acute Care Surg. 2015;79(6):1096–101.
13. Mayberry J, Fabricant L, Anton S, Ham B, Schreiber M, Mullins R. Management of full thickness duodenal laceration in the damage control era: evolution to primary repair without diversion or decompression. Am Surg. 2011;77:681–5.
14. Lopez PP, Benjamin R, Cockburn M, Amortegui JD, Schulman CI, Soffer D, et al. Recent trends in the management of combined pancreaticoduodenal injuries. Am Surg. 2005;71:847–52.
15. Berne CJ, Donovan AJ, White EJ, Yellin AE. Duodenal "diverticulization" for duodenal and pancreatic injury. Am J Surg. 1974;127(5):503–7.
16. Stone HH, Fabian TC. Management of duodenal wounds. J Trauma. 1979;19(5):334–9.
17. Ivatury RR, Gaudino J, Ascer E, Nallathambi M, Ramirez-Schon G, Stahl WM. Treatment of penetrating duodenal injuries: primary repair vs. repair with decompressive enterostomy/serosal patch. J Trauma. 1985;25(4):337–41.
18. Vaughan GD, Frazier OH, Graham DY, Mattox KL, Petmecky FF, Jordan GL Jr. The use of pyloric exclusion in the management of severe duodenal injuries. Am J Surg. 1977;134(6):785–90.
19. Ivatury R, Nallathambi M, Gaudino J, Rohman M, Stahl W. Penetrating duodenal injuries. Analysis of 100 consecutive cases. Ann Surg. 1985;202(2):153–8.
20. Krige JE, Nicol A, Navsaria PH. Emergency pancreatoduodenectomy for complex injuries of the pancreas and duodenum. HPB. 2014;16:1043–9.
21. Krige JE, Navsaria PH, Nicol AJ. Damage control laparotomy and delayed pancreatoduodenectomy for complex combined pancreatoduodenal and venous injuries. Eur J Trauma Emerg Surg. 2016;42:225–30.
22. Asensio JA, Petrone P, Roldán G, Pak-art R, Salim A. Pancreatic and duodenal injuries, complex and lethal. Scand J Surg. 2002;91(1):81–6.
23. Schroeppel TJ, Saleem K, Sharpe JP, Magnotti LJ, Weinberg JA, Fischer PE, Croce MA. Fabian TC Penetrating duodenal trauma: a 19-year experience. J Trauma Acute Care Surg. 2016;80(3):461–5.

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