Pancreatic and Duodenal Trauma in Children

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Abstract

Keywords

- ▶ pancreatic injuries
- ▶ duodenal injuries
- ▶ blunt trauma
- ▶ pediatric

Trauma is the leading cause of death in children of all ages. The most common site of injury in pediatric patients is the head followed by the extremities and the abdomen. Though less than 10% of admissions to the hospital are secondary to intra-abdominal injuries, mortality related to these injuries is not insignificant. Pancreatic and duodenal trauma occurs in 3 to 12% of the patients with abdominal injuries and can be associated with significant morbidity. The management of pancreatic and duodenal trauma in children is based mostly on adult data, but there is an increasing volume of research on the subject.

Injuries to the Pancreas

Mechanism of Injury

Penetrating injuries occur in 10% of pediatric trauma patients with injuries isolated to the pancreas in low velocity situations such as stab wounds and impalements. Injuries to the pancreas secondary to gunshot wounds often involve multiple systems, and the pancreas should be evaluated during operative exploration for penetrating injuries. The majority of pancreatic injuries in children occur after blunt trauma with handlebar injuries being the most common cause.¹ Child abuse, pedestrian struck, motor vehicle collision, and fall are other causes of pancreatic trauma with equivalent rates (10–20%). In a review comparing pancreatic injuries in children to adults, kids have a higher rate of injury secondary to bicycle accidents, are more likely to have isolated injuries, and have lower grade injuries than adults.²

Diagnosis

The diagnosis of pancreatic injuries can be very difficult and usually starts with a high index of suspicion based on mechanism. A complete history and physical examination can be helpful, but physical examination findings are rare from most pancreatic injuries secondary to the retroperitoneal location of the pancreas and the higher frequency of

isolated injuries in children. Laboratory values are often obtained though their significance in diagnosing and grading injury is questionable. Amylase and lipase are often used as a screening tool in patients with blunt abdominal trauma, though the sensitivity was only 84% in one study with a low positive predictive value related to the low prevalence of disease.³ Another multicenter review revealed no correlation with grade of injury, length of stay, or mortality,⁴ though one study did show a correlation of peak amylase level and major pancreatic injuries.⁵

A variety of imaging modalities are available for evaluating the pancreas for injury. Computed tomography (CT) is often utilized for the workup of patients with abdominal trauma though historical studies reported low sensitivity and specificity for diagnosing pancreatic injury.⁶ More recent studies examining multidetector CT have shown improved sensitivity and specificity for detecting pancreatic injury, though a multicenter study sponsored by the American Association for Trauma reported low sensitivity and high specificity for identifying pancreatic ductal injuries.^{7,8} Additional imaging with magnetic resonance and endoscopic retrograde cholangiopancreatography are often used when ductal anatomy is difficult to ascertain. Studies evaluating the use of magnetic resonance imaging report favorable results, though the

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number of patients imaged was low and sensitivity and specificity when reported is equivalent to multidetector CT results.^{6,9,10} Endoscopic retrograde cholangiopancreatography has also been utilized for diagnosis when pancreatic ductal anatomy is unclear and for stent placement to decompress the duct. Small series have been published in children with favorable results.^{11,12}

Grading of Injuries

Pancreatic injuries are grouped based on the American Association for Trauma Grading Scale (►Table 1, ►Fig. 1).¹³ In a recent review, most pediatric patients sustain low-grade injuries (70%) with a minority having pancreatic ductal disruption.⁴ Diagnosis can be challenging secondary to the retroperitoneal location of the pancreas and is based on suspicion for injury secondary to mechanism in conjunction with physical examination, laboratory values, and imaging findings. The differentiation of grade II (major contusions or laceration without ductal injury) and grade III (ductal transection) can often be challenging, particularly in small children.⁶

Management

Once the diagnosis of injury has been made, it is imperative to grade the injury to determine the appropriate treatment. Children with low-grade injuries are treated nonoperatively with bowel rest, pain management, and repeated abdominal examinations. Although pancreatic enzymes may not aid the diagnosis of injury, repeat amylase and/or lipase are generally monitored to assess the patient's response to injury. If the patient's clinical examination worsens, repeat imaging with CT may be necessary as pseudocyst formation can occur.

The treatment of high-grade injuries (III–V) is quite controversial with numerous studies reporting conflicting results. Nonoperative therapy for all pediatric pancreatic injuries was initially reported in 1997 with a review of 154 patients over a 7-year period.¹⁴ Most patients with low-grade injuries were successfully managed with nonoperative therapy while 50% of high-grade injuries underwent operative intervention. Based on their review, they concluded that nonoperative management was appropriate in the absence of clinical deterioration or major ductal disruption (grade III, IV, and V injuries). A more recent article looked at patients

with pancreatic ductal transection only treated nonoperatively and reported a 50% rate of pseudocyst formation with a median length of stay of 24 days.¹⁵ Conflicting evidence was presented in a similar series of patients with pancreatic duct transections treated operatively with a shorter length of stay of 11 days.¹⁶ One of the larger series reported in 2006 attempted to identify factors associated with the 50% failure rate for nonoperative management, but there was no difference in age, sex, injury severity score, mechanism of injury, or length of stay between the two groups.¹⁷

Based on these retrospective data, most surgeons advocate for selective management of pancreatic injuries in children. Patients with low-grade injuries are treated conservatively and patients with known ductal disruption are treated with operative exploration and intervention.⁵ A series with selective management reported a shorter length of stay and fewer complications with earlier intervention.¹⁸ A more recent review of the American Pediatric Surgical Association Trauma Committee reported the results from 167 patients with grades II and III injuries.¹⁹ Distal pancreatectomy ($n = 57$) was associated with quicker time to goal feeds, but no difference in hospital length of stay. Patients managed nonoperatively ($n = 95$) had a higher pseudocyst formation and more endoscopic or interventional radiologic procedures. Patients who had drain placement alone had the longest hospital stay and similar clinical course to the nonoperatively managed patients. The generalizability of the conclusions are difficult because grade 2 and grade 3 injuries were studied together, though the pancreatic duct is intact in grade 2 injuries and disrupted for grade 3 injuries. The rare nature of pancreatic injuries in children discourages randomized studies; therefore, there is no level 1 evidence to direct therapy.

Injuries to the Duodenum

Evidence to support the management of duodenal injury in children is derived largely from the adult literature; however, retrospective series from the pediatric literature have become increasingly available.^{20,21} Injury patterns for duodenal trauma can be divided into blunt and penetrating mechanisms. Penetrating duodenal injury may occur in up to 21% of the cases.²⁰ Penetrating injury typically requires operative

Table 1 Grading scale

Grade	Type of injury	Description of injury
I	Hematoma	Minor contusion without duct injury
	Laceration	Superficial laceration without duct injury
II	Hematoma	Major contusion without duct injury or tissue loss
	Laceration	Major laceration without duct injury or tissue loss
III	Laceration	Distal transection or parenchymal injury with duct injury
IV	Laceration	Proximal transection or parenchymal injury involving ampulla
V	Laceration	Massive disruption of the pancreatic head

Fig. 1 Representative images of pancreatic injuries.

intervention with management principles of duodenal repair being similar in both groups. In contrast to adults, blunt duodenal injury is more common than penetrating injury in children. Blunt duodenal injury is a diagnostic and therapeutic challenge because on physical examination, signs may be subtle and associated injuries are common. The duodenum is a unique hollow viscus in that it is retroperitoneal and closely associated with the vertebral column. Early diagnosis of duodenal injuries may be delayed by subtle findings on physical examination due to the retroperitoneal nature of the organ. Additionally, the position of the duodenum immediately adjacent to the vertebral column makes frank perforation or disruption possible, which is described in the lap belt complex.²²

Epidemiology

Evidence from administrative database analyses combining adult and pediatric patients suggests that blunt injury to the duodenum occurs in approximately 0.2% of blunt trauma, with full thickness rupture occurring in 14% of those.²³ In a retrospective study of only pediatric patients at a large pediatric trauma center, injuries to the duodenum were identified in 0.3%²⁴ in a population of nearly 9,000 patients. Another report from 16 pediatric trauma hospitals found that the operative blunt duodenal injuries were identified and treated at a rate of 0.67 patients per hospital per year.²¹ In a single-center report from a tertiary pediatric hospital in Toronto, 27 children sustained blunt duodenal trauma over a 10-year period. Of these, approximately half of the patients had perforations ($n = 9$) and the other half had duodenal hematomas ($n = 10$).²⁵ Compared with the patients with duodenal hematoma, the patients with duodenal perforation were older (9 vs. 5 years of age) and had higher injury severity score (25 vs. 10). Associated injuries were encountered in 19

patients, including 10 pancreas, 5 spleens, and 4 livers, among others.

Mechanism of Injury

Mechanism of injury should be ascertained early in the care of any pediatric trauma. Because of the retroperitoneal location of the organ, significant force is needed to result in perforation or hematoma. Compression of the duodenum against the vertebral column makes this organ susceptible to injury. Mechanisms that are commonly seen in duodenal injury include nonaccidental trauma,^{20,24,26} motor vehicle collisions,^{20,26} bicycle handlebar injuries,²⁷ falls or crush injuries,²⁰ sports-related accidents,²⁸ or all-terrain vehicle trauma.²⁴ Of these, nonaccidental trauma deserves emphasis. In one large retrospective review from Pittsburgh, duodenal injury was seen in 30 children (0.3%) out of an 8-year experience with nearly 9,000 trauma admissions.²⁴ However, all children less than 4 years of age ($n = 8$) were victims of nonaccidental trauma (2.8% of child abuse admissions). The average age of these children was 2.2 years. Another report of pediatric duodenal trauma found the most common mechanism of injury was nonaccidental trauma or abuse (19%). In these cases, the history may be vague and physical examination equivocal. In this series, two of the children presented with free air and were operated on for suspected perforated appendicitis. A second series of all duodenal injuries in children under 5 years of age over a 20-year period at six level 1 trauma centers found that 62.5% of these injuries were the result of nonaccidental trauma.²⁶ In this series, all patients less than 2 years of age and more than 50% of patients greater than two sustained injuries related to child abuse. Additionally, these injuries were associated with delayed presentation. A high index of suspicion is needed to suspect the syndrome

of child abuse, particularly for children less than 4 years of age.

Diagnosis

Diagnosis of duodenal trauma has historically been difficult because of the retroperitoneal positioning. Differentiating between duodenal hematoma and perforation is important since treatment of the two differs considerably. Upper gastrointestinal series was initially used as a diagnostic modality, but this labor-intensive test may not be appropriate or feasible in the acute posttrauma period. Upright or decubitus abdominal films may be useful in the case of perforation, but may be unremarkable in the setting of duodenal hematoma. CT has emerged as the study of choice in diagnosis of duodenal injury (►Fig. 2). While most CT scans done in the emergent trauma setting are performed without oral contrast, limited oral contrast given in a follow-up scan may be beneficial if perforation has not been ruled out.²⁸ In one series, extravasation of air or enteral contrast was useful in discriminating between duodenal perforation and mural hematoma.²⁵ While air or oral contrast extravasation into the retroperitoneal or periduodenal space was found in every child with perforation, it was not found in any child with isolated duodenal hematoma. CT is also useful in diagnosing duodenal hematoma. In equivocal cases, confirmation can be obtained with an upper gastrointestinal contrast study, which would show duodenal narrowing or obstruction without extravasation.

Fig. 2 Abdominal computed tomography findings in a 7-year-old patient who was involved in a motor vehicle collision as a restrain passenger. Free gas was noted adjacent to the duodenum, along with suspected disruption of the duodenal wall. At laparotomy, three lacerations were found in the second and third portions of the duodenum. These lacerations were repaired primarily and a 10 F nasogastric tube was placed into the proximal jejunum for postoperative feeds. Operative drains were placed adjacent to the repair.

Grading

A duodenal organ injury severity scale was developed in the adult literature by Cogbill et al (►Table 2)¹³ in 1990 to stratify injury and standardize reporting of diagnosis and treatment. Based on their multicenter retrospective data, the majority of less complex injuries can be treated by simple repair. In a recent retrospective cohort study of 32 patients duodenal injury over a 20-year period, most duodenal injuries were grade I or II on the injury severity scale.²⁶ Of the 32 children, 56% were perforations and 44% were duodenal hematomas. In the children who underwent surgery, the vast majority (88.2%) were treated with primary repair of the duodenum, with drain placement in 80% and without drain in 20%. In the case of severe duodenal trauma with devascularization of the duodenum and pancreas, pancreaticoduodenectomy, for example, Whipple procedure, has been reported in the setting of trauma. Generally, this complex operation requiring reconstruction of a biliary-enteric, pancreaticoenteric, and gastroenteric anastomosis is not appropriate in the acute traumatic setting. In the setting that duodenal reconstruction is not possible due to devascularization, damage control laparotomy is the first step, with advanced reconstructions performed at a second-look procedure in a hemodynamically stable patient.

Management

Duodenal hematomas can be managed nonoperatively with good success in up to 94% of cases.^{20,29} CT often makes the diagnosis in the trauma setting, but enteral contrast may be administered if a question remains regarding perforation.²⁹ Hematocrit was also found to be significantly lower in duodenal hematoma versus perforation.²⁹ The stomach is decompressed by nasogastric suction and patients are placed on total parenteral nutrition until the obstructing hematoma resolves. In a series from two large pediatric trauma centers, 17 patients with duodenal hematoma were treated nonoperatively.²⁰ The average length of stay was 12 days with an average of 7 days on total parenteral nutrition. One patient underwent operative evacuation of the hematoma. In another series from a single institution, 19 patients with duodenal hematoma, 2 patients underwent surgical drainage of the hematoma because of peritoneal signs.²⁹ In that series, return to diet occurred in 9.3 days on average, with a total length of stay of 16 days. In the case of prolonged duodenal obstruction, laparoscopic drainage of duodenal hematoma has been described.³⁰

Duodenal perforation is routinely treated operatively, although there is considerable variation in procedures depending on the nature of injury. The general principles of surgical management of adult duodenal trauma have been applied with success to the pediatric population. Conceptually, successful repair of duodenal injuries must reestablish intestinal continuity, manage gastric and duodenal drainage, and provide enteral nutritional support.²⁵ Primary closure (duodenorrhaphy) is traditionally performed for lacerations involving less than 25% of the circumference of the bowel. In early literature, failure of duodenorrhaphy resulted in fistula formation, abscess, or peritonitis, with devastating consequences.^{31,32} To address these complications, surgeons began

Table 2 Duodenal injury scale with primary operative procedure

Class	Injury	Technique
I	Small hematoma (single segment), serosal injury	No procedure (67%) Duodenorrhaphy (28%) Drain hematoma (5%)
II	Large hematoma (> 1 segment), < 25% disruption of duodenal wall	No procedure (1%) Duodenorrhaphy (81%) Pyloric exclusion (17%) Drain hematoma (1%)
III	25–75% disruption D2 duodenal wall, 25–100% disruption D1, D3, D4 duodenal wall	Duodenorrhaphy (55%) Pyloric exclusion (34%) Duodenojejunostomy (9%) Pancreatoduodenectomy (2%)
IV	> 75% disruption duodenal wall, involvement of the ampulla or distal common bile duct	Duodenorrhaphy (50%) Pyloric exclusion (50%)
V	Devascularization of duodenum, massive disruption pancreaticoduodenal complex	Pancreatoduodenectomy (100%)

Source: Adapted from Moore et al.¹³

placing drainage catheters to control gastric and biliary-pancreatic secretions. Stone and Fabian described a duodenal decompression by triple tube technique.³² The triple tube technique uses a tube gastrostomy for gastric decompression, a retrograde tube duodenostomy for duodenal decompression, and an antegrade tube jejunostomy for enteral feeding. Failure rate of the duodenal repair fell to less than 1%.

The pyloric exclusion was also described to minimize the chance of duodenal dehiscence and leak. In this technique, a gastrotomy is made and the pylorus is sutured closed with absorbable suture, which eventually dissolved several weeks later, leading the pylorus to reopen. Gastric contents are diverted away from the duodenal repair, classically through a loop of jejunum via a side-to-side gastrojejunostomy. While the pyloric exclusion is temporary, the gastrojejunostomy is permanent. Long-term sequelae of the traditional pyloric exclusion with gastrojejunostomy include marginal ulceration at the gastrojejunostomy anastomosis, which may be present in up to 10%.³³ In adults, several maneuvers were developed to prevent marginal ulceration, including vagotomy. To address these issues in the pediatric population, drainage of the stomach after excluding the pylorus may be done with tube gastrostomy, which can be removed if appropriate after the duodenal closure has healed.³⁴ Postoperative enteral feeds may be started early in this population by construction of a surgical tube jejunostomy placed distal to the injury.

Outcomes of operative treatment of duodenal injury are difficult to generalize since reports are from small case series of patients treated over decades. Mortality of children who undergo surgery is rare.^{20,29} Delay in either diagnosis or operative intervention is associated with increased complication rates and prolonged hospitalization.²⁰ One series of 54 patients from 16 hospitals who underwent operation reported a complication rate of 42%.²¹ Complications included postoperative ileus (19%), wound infection (9%), traumatic

pancreatitis (5%), intra-abdominal abscess (3%), pancreatic fistula (2%), and enterocutaneous fistula (2%).

Both pancreatic and duodenal injuries are rare and difficult to treat in pediatric patients. Evidence to assist in diagnosis and management is sparse and mainly based on retrospective data. Multi-institutional prospective trials are necessary to determine the optimal method for diagnosis and appropriate treatment strategies.

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