# Traumatic pancreatic injury after blunt abdominal trauma among children

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## Keywords

Blunt abdominal trauma, traumatic pancreatic injury, practical guideline, management

## Abstract

Traumatic pancreatic injuries or traumatic pancreatitis are rare among children and difficult to diagnose because of the nonspecific symptoms. A review of the literature from the last 20 years on the diagnostic approaches and management of blunt pancreatic injury in children was performed and practical guidelines are proposed.

A high index of suspicion for pancreatic injuries is needed for all pediatric patients with blunt abdominal injuries. Diagnosis is made based on a combination of laboratory findings and radiological imaging (ultrasound, or more preferably in the acute setting, computed tomography of the abdomen). Early surgical treatment may benefit patients with main pancreatic duct injuries, while other types of pancreatic injuries can be treated non-operatively. Although, randomized controlled trials are lacking to justify the most appropriated approach. The most common short-term complication after pancreatic injury is the development of pseudocysts and can be treated conservatively if asymptomatic. The risk of development of diabetes mellitus or exocrine pancreatic insufficiency as long-term complication in children remains unknown. More prospective trials and research initiatives are required.

## Introduction

Pancreatic injuries and associated traumatic pancreatitis are rare among children. The incidence of acute pancreatitis among children is 12,3 per 100 000, of which 10-40% are caused by trauma (1).

Blunt abdominal trauma is the most frequent cause of abdominal injury among children, while among adults, penetrating abdominal traumas are more common (2). According to data of National Trauma Data Bank of America, blunt pancreatic injuries occur among 0,6% of pediatric patients with abdominal injuries and comprises 0,3% of all traumas (2). An observational cohort study based on a trauma register in Norway, identified a total of 14 patients with pancreatic injury over a 15-year period. Nine of these patients were children, representing 1% (9/869) of all injured children in the registry and 11,4% (9/79) of the children with documented abdominal injuries (3).

Pancreatic injury is the fourth most common solid organ injury, following injuries of the spleen, liver, and kidney (4). Blunt pancreatic injury among children has a high morbidity and mortality rate of respectively 26.5% and 5% (2).

Acceleration- deceleration injuries and direct compression force in the epigastrium (for example caused by the force of a seat belt in a motor vehicle accident or bicycle handlebar injuries) are most likely responsible for pancreatic injury. The pancreas is crushed against the lumbar vertebrae resulting in compression and contusion of the pancreatic tissue and sometimes even tearing of the pancreatic duct resulting in a broad range or injuries from traumatic pancreatitis to complete gland transection (5). In addition, the pancreas is closely related to the duodenum, the stomach, the common bile duct, the spleen and the major upper abdominal vessels and therefore, associated intra-abdominal injuries are common (2).

Injury to the pancreas may be difficult to diagnose, especially among children. This is due to the retroperitoneal positioning of the pancreas. Therefore, onset of abdominal symptoms is delayed and the signs and symptoms are often vague and nonspecific. Epigastric pain is the most common complaint of pediatric pancreatic injury, followed by abdominal distension and nausea (6). It is recommended to keep a high index of suspicion for possible pancreatic injury in trauma patients based on the mechanism of injury (7). Among adults, delayed diagnosis is associated with higher complication rate that contributes to morbidity and mortality (8). However, data on this topic in children are scarce.

The aim of this literature review is to investigate the diagnostic approach and management of blunt pancreatic injury in children and to propose a practical guideline.

## Method

A literature search was performed according to the PRISMA guidelines in PubMed/Medline using the Medical Subject Heading (MeSH) terms: (("Abdominal Injuries"[Mesh]) OR "Wounds, Nonpenetrating"[Mesh])) AND "Pancreas"[Mesh] AND "Child"[Mesh]. Only articles published in English between 2001 and January 2022 were selected. Case reports with less than five patients were excluded. An exception was made for a case report describing long-term complications after pancreatic injury. In addition, the reference list of all selected articles was manually searched for relevant articles.

## Results

### *Diagnosis*

Pancreatic injury among children is diagnosed based on a combination of laboratory findings and radiological imaging, in combination with a high index of suspicion after blunt abdominal trauma. In case of pancreatitis at least two of the following criteria should be presented according to the INSPPIRE (INternational Study Group of Pediatric Pancreatitis: In Search for a CuRE) criteria: 1) abdominal pain (epigastric or right upper quadrant with or without radiation to the back), 2) serum amylase and/or lipase values 3 or more times

upper limits of normal (ULN), 3) imaging findings consistent with inflammation of pancreas (9).

### Biochemical diagnosis

Elevated serum levels of pancreatic enzymes (and especially amylase) are not specific for pancreatic injury, because high levels have also appeared in case of craniofacial injuries or other intra-abdominal conditions (8). A recent prospective cohort study among 164 adult patients with blunt abdominal trauma showed a specificity of 100% and sensitivity of 85% of combined serum amylase and lipase levels (> 2 times ULN) for predicting pancreatic injury (10). No separate data are available for children and therefore, the predictive value in pediatric patients remains unclear.

To avoid false negative results, these pancreatic enzymes should be determined at least six hours after the injury. Since serum lipase and amylase will increase gradually over time with a significant dose-time response association. Measuring the levels before that timepoint will have no diagnostic value in both adults as children (10,11). A retrospective multicenter study showed no correlation between initial or peak amylase/lipase level and grade of pancreatic injury in 131 children. However, a maximal amylase level greater than 1100 U/L (> 10 times ULN) was predictive for development of a pancreatic pseudocyst among pediatric patients in this study (12).

### Radiological imaging

Imaging plays an important role shortly after the trauma in determining the localization and severity of the pancreatic injury and the treatment options. The most commonly used grading system for pancreatic injury was developed by the American Association for the Surgery of Trauma (AAST) and is illustrated in table 1 and figure 1 (13). The scale contains 5 grades determined by ductal integrity and anatomic location of the injury and is used for both adults and children. Sutherland et al. suggested to add grade 0 stage that contains children with clinical and biochemical signs of acute pancreatitis after blunt abdominal trauma without large radiological abnormalities (14).

Ultrasound (US), known as extended Focused Assessment with Sonography in Trauma care setting (eFAST), is a screening tool for detecting acute life-threatening conditions. It can detect the existence of free fluid and large damage to abdominal organs. The most important limitation of the US is the difficulty in identifying pancreatic injury because of the retroperitoneal location of the pancreas (15). In case of high suspicion (depending on the trauma mechanism and the force of impact) a computed tomography (CT) of the abdomen with intravenous contrast should be performed with a low threshold.

CT of the abdomen is a rapid, easily available test and the primary imaging modality of choice for evaluating pediatric patients with high impact blunt abdominal trauma. Assessing the integrity of pancreatic duct is important for deciding the treatment options of the pancreatic injury (surgical or conservative). The sensitivity of CT for the accurate determination of the grade of pancreatic injury shows a large heterogeneity, ranging from 60-80% among reported studies in adults (16,17,18). No data are available for children. A negative CT within the first 24 hours after the accident does not rule out a pancreatic

Figure 1.

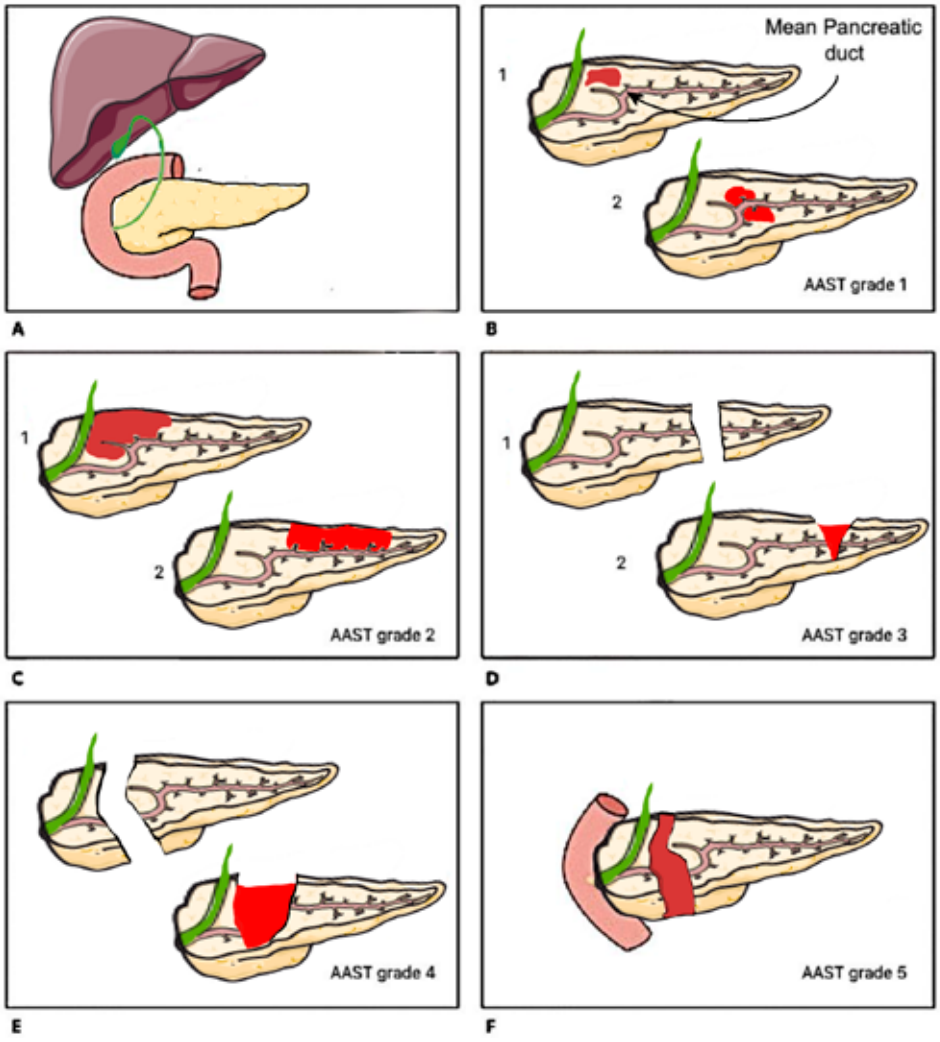


**Table 1:** Organ Injury scoring scale for pancreatic injury according to AAST

| | Day 0 | Reference value |
|---|---|---|
| 1 | Hematoma | Minor contusion without duct injury |
| | Laceration | Superficial laceration without duct injury |
| 2 | Hematoma | Major contusion without duct injury or tissue loss |
| | Laceration | Major laceration without duct injury or tissue loss |
| 3 | Laceration | Distal transection or parenchymal injury with duct injury |
| 4 | Laceration | Proximal transection or parenchymal injury involving ampulla |
| 5 | Laceration | Massive disruption of pancreatic head |

injury since the lack of direct or indirect signs of pancreatic trauma shorty after blunt abdominal trauma. A repeat CT more than 24 hours after the injury can be useful in case of high index of suspicion of pancreatic trauma, however the cumulative dose of radiation in case of repeated CT scans must be considered (19). Therefore, a contrast enhanced ultrasound (CEUS) can be used as a safer alternative. Since this is an ionizing-radiation-free technique that can detect in highly sensitive way intra-abdominal injury in children, but only when performed by trained radiologist (20).

During the acute assessment of blunt pancreatic injuries, the role of magnetic resonance cholangiopancreatography (MRCP) is limited due to its restricted availability and longer scanning time in comparison to CT. However, in case that the status of the pancreatic duct is unclear on CT, MRCP can be useful to assess secondary changes in pancreatic parenchyma and the pancreatic duct (19,21). A retrospective multilevel study in 21 children with pancreatic injury by Rosenfeld et al. showed that MRCP is more useful than CT for identifying the pancreatic duct but is non-superior to confirm the integrity of the duct (19).

*Endoscopic retrograde cholangiopancreatography* (ERCP) can accurately diagnose pancreatic duct disruption in children. However, this invasive procedure will only be performed if therapeutic options, such as stent placement, are available (22).

## *Treatment options*

Depending on the severity and grade of the injury of the pancreas or other organs, treatment could be conservative, interventional, or surgical. When the patient is hemodynamically unstable or shows signs of peritonitis, it is necessary to proceed with an urgent surgical exploration by laparotomy or laparoscopy (3).

### Treatment of low-grade pancreatic injuries

For minor pancreatic injuries without pancreatic duct involvement (AAST grade 0-2), non-operative management (conservative and if applicable interventional with ERCP) is recommended, which has widely been accepted as the treatment of choice (23).

In a retrospective study by Rosenfeld et al., ERCP was used in 26 children with pancreatic injury (mostly AAST grade III or IV) in the diagnostic evaluation of pancreatic duct integrity, early management of pancreatic duct leak and the treatment of late complications like duct stricture, pseudocysts, or pancreatic fistulas. No clinical benefit of early ERCP intervention on the length of the hospital stay could be detected, although prospective studies are required to confirm this finding (24).

The non-operative management of blunt pancreatic trauma and associated traumatic pancreatitis consists of supportive care with cardiorespiratory monitoring, preserving effective circulating volume with intravenous fluid and pain medication. In case of signs of acute pancreatitis, early aggressive fluid resuscitation with 1,5-2 times the maintenance rate is recommended (25). Optimal pain management for children with acute pancreatitis should be strived (1). No evidence exists that morphine causes adverse effects on the sphincter of Oddi, and opioids can be administered safely (1).

The use of prophylactic antibiotics for acute pancreatitis or pancreatic injuries is not recommended by the North American Society for Pediatric Gastroenterology, Hepatology and nutrition (NASPGHAN) (26). There are no data on the benefits of somatostatin for the treatment of pancreatic injuries. The early use of parenteral nutrition (PN) has no clinical benefit in the non-operative management of blunt pancreatic trauma and should be avoided unless prolonged oral feeding intolerance (> 7 days) occurs (27). This is supported by a retrospective cohort study of 554 children with blunt pancreatic injury (28). Therefore, NASPGHAN recommends early enteral nutrition in cases of mild pancreatitis and states that a combination of enteral nutrition and PN is superior to PN alone (26).

### Treatment of high-grade pancreatic injuries

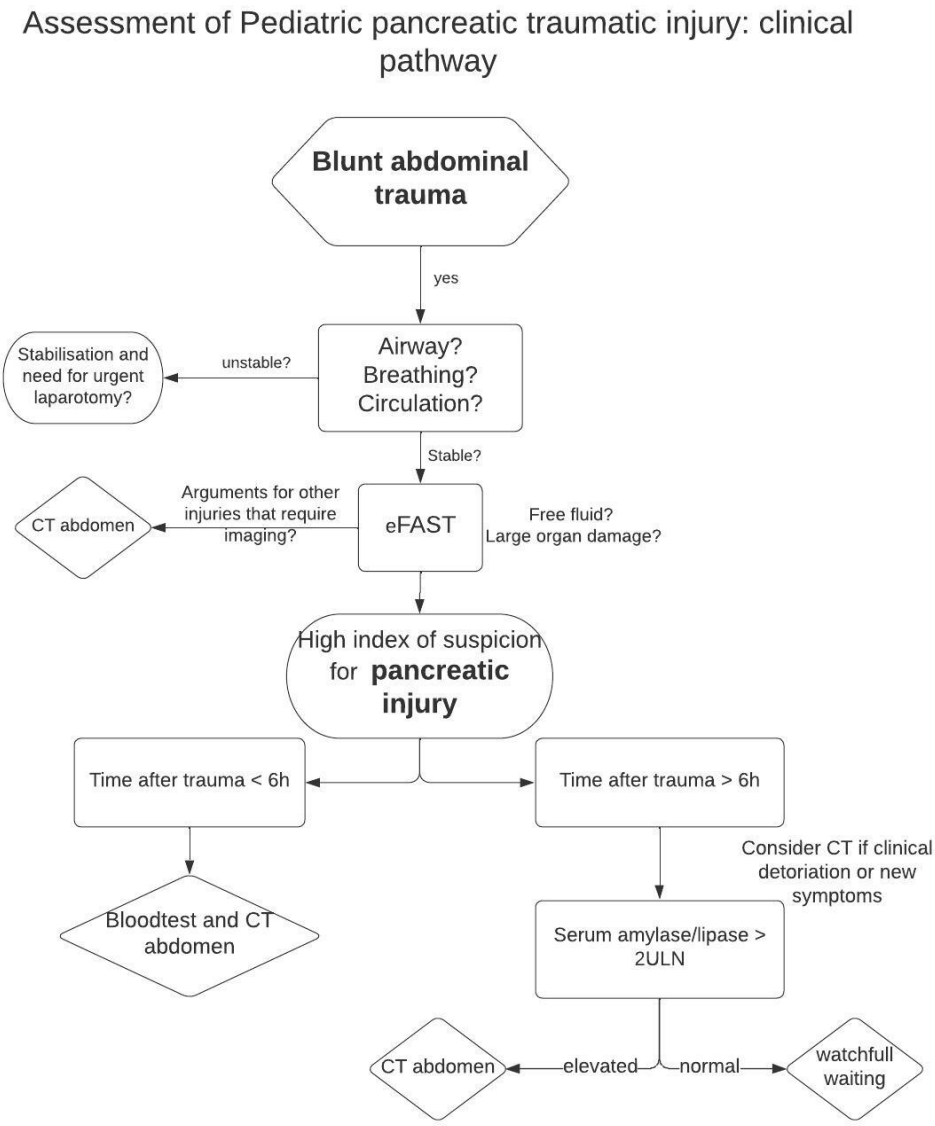
Treatment options of children with major pancreatic injuries of AAST grade 3-5 (meaning pancreatic duct involvement) remain controversial. A Cochrane review in 2014 showed the absence of randomized clinical trials investigating the optimal treatment strategy in this type of injury (29). A recent systematic review and meta-analysis by Kopljar et al., demonstrated that there is no difference in mortality between an initial non-operative management versus initial operative management of pancreatic injuries (30). However, pediatric patients who are initially treated non-operatively developed more frequently pseudocysts than patients treated operatively. Nevertheless, there was no difference in the length of hospital stay between operative or non-operative management for pancreatic injuries or the risk of rehospitalization (30,31). Evidence based selection criteria for patients with pancreatic injury who benefit the most from operative management are urgently needed.

The surgical approach depends on the grade of injury and includes distal pancreatectomy with splenic preservation for grade 3 injuries, spleen-sparing proximal pancreatic resection, and Roux-en-Y drainage of the distal pancreas for grade 4 injuries and lastly, the pylorus-preserving pancreaticoduodenectomy (Whipple operation) for pancreatic head transection (grade 5 injuries) (32).

## *Complications*

Short term complications following pancreatic trauma arise within 30 days after the injury and include inter alia pancreatic pseudocysts and infection. On the long term, formation of ductal stricture and development of exocrine and endocrine pancreas insufficiency can be witnessed (6).

Figure 2.




### Short term complications

A pancreatic pseudocyst can be defined as an organized fluid collection in the pancreas. High initial serum levels of amylase and persistent elevated serum amylase levels 10 days after the trauma are associated with the development of pancreatic pseudocysts (12,33).

The majority of these pseudocysts require drainage because of persistent symptoms or the presence of complications (infection, gastric outlet obstruction, bleeding) (34). Three different strategies for the draining of pancreatic pseudocysts are available: endoscopic drainage, percutaneous drainage, or open surgery. The assessment of pancreatic ductal anatomy is useful for the selection of patients requiring percutaneous drainage. Since there is a higher risk of complications (like pancreatic fistula formation) in adults when performing percutaneous drainage in case of cyst-duct communication (35).

Asymptomatic pseudocysts can be safely followed up with US, irrespective of the size and duration of the collection (36). A retrospective study showed a spontaneous disappearing of these pseudocysts in nine of the eleven asymptomatic children within 1-15 months after the episode of acute pancreatitis, with a median pseudocyst size of 6.4 cm (34).

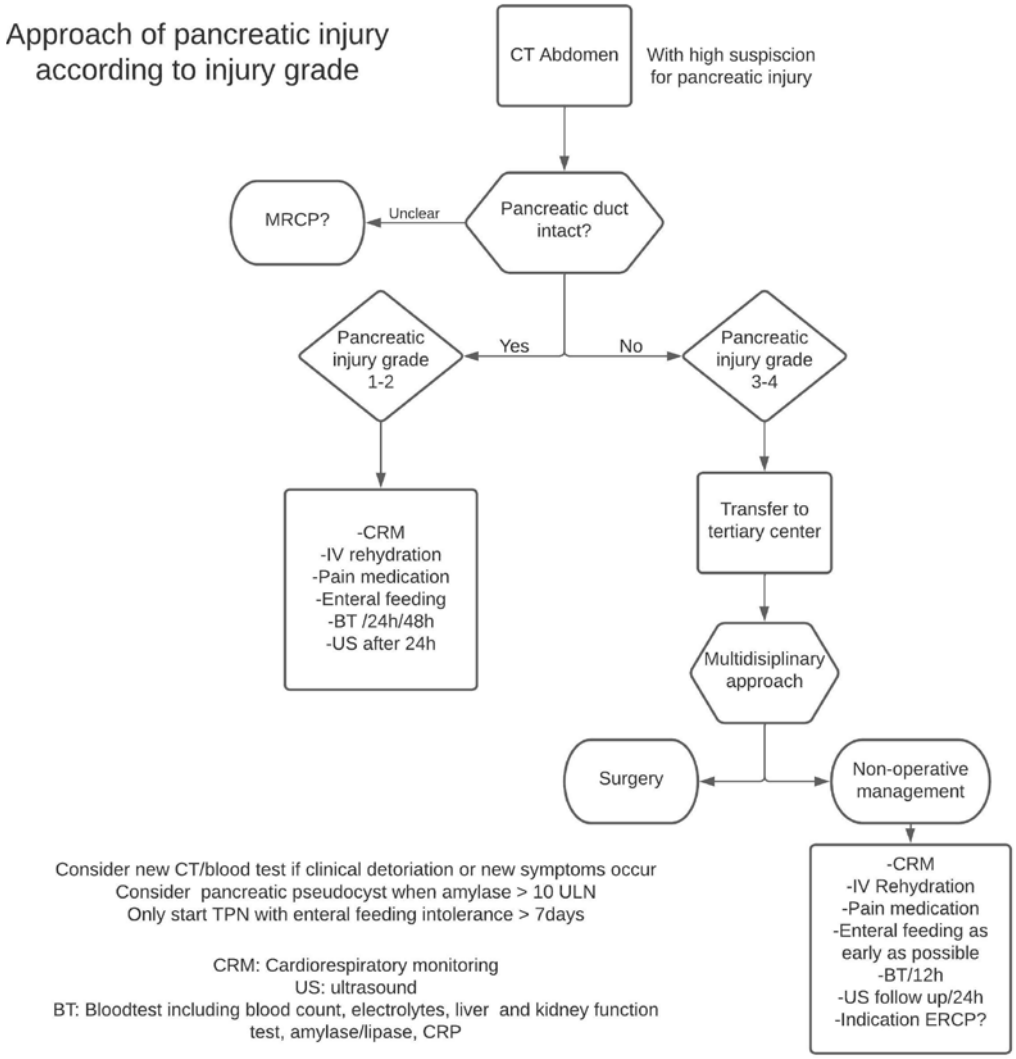
### Long term complications

Ravindranath et al. described long term sequelae of pancreatic trauma in 13 of the 36 studied children on follow up imaging, such as signs of chronic pancreatitis with atrophy of the pancreatic body and tail. Only 46% of the studied patients with radiological changes developed symptoms of chronic pancreatitis such as recurrent epigastric pain (7). The clinical relevance of these radiological changes after traumatic pancreas injury without symptoms remains unclear. Further research and follow up is therefore needed.

Data on the prevalence of endocrine or exocrine insufficiency after pancreatic trauma in children is limited by only three studies. A case cohort study describing the long term outcome of non-operative management of complete pancreatic transection in nine pediatric patients revealed no exocrine or endocrine insufficiency after a median follow up of 47 months (37). Ravindranath et al. followed 13 children with radiological evidence of long term sequelae of pancreatic trauma and found that two pediatric patients developed prediabetes (based on HbA1C) and three exocrine pancreatic insufficiency (7). One additional patient of eight years developed diabetes mellitus and pancreatic atrophy three years after a blunt pancreatic injury (38). Of note, this patient had a genetically susceptibility to develop type 1 diabetes based on the human leucocyte antigen genotype (38).

Therefore, the underlying pathogenesis of this glucose intolerance in children after blunt pancreatic injury remains unclear and could be due to loss of beta cell mass, genetic susceptibility, or environmental

Figure 3.




factors. In adults, impaired glucose tolerance was seen after a loss of 65% of beta cell mass of the pancreas after pancreatic surgery for both tumors or trauma (39). The exact timing of development of these long term complications after pancreatic injury in children is unclear because of the lack of long term data.

## Discussion and conclusion

The accurate and timely diagnosis of pancreatic injury or traumatic pancreatitis after blunt abdominal injury is important to determine the best treatment options. A high index of suspicion for pancreatic injuries is needed for all pediatric patients with blunt abdominal injuries, such as handlebar injuries or motor vehicle accidents. Diagnosis is made based on a combination of laboratory findings and radiological imaging. Serum amylase and lipase should be measured more than 6 hours after the injury to be representative. Normal levels after that timeframe have a high specificity. Ultrasound is a good screening tool in the work up of a trauma patient but, most of the time, not diagnostic for pancreatic injury. CT scan of the abdomen with intravenous contrast is a rapid, easily available test and the primary imaging modality of choice for evaluating pediatric patients with blunt abdominal trauma that can also assess the integrity of the pancreatic duct. Keeping in mind that within 24 hours after the injury, these results could be false negative. When duct integrity is unclear after CT scan, MRCP should be considered.

The optimal strategy for the diagnosis and management of pancreatic trauma among children continues to be a source of controversy due to absence of randomized controlled trials. In addition, a large variation in management strategies exists, making it difficult to compare outcomes and adverse events between operative management or non-operative management.

Based on the available evidence, we can propose recommendations for practical use in a pediatric care setting (figure 2 and 3). Pancreatic injuries grade 1 or 2 can be treated conservatively, while injuries grade 3 to 5 should be referred to a specialized pancreatic surgeon and pediatric gastroenterologist for a multidisciplinary approach.

Non-operative management consist of cardiorespiratory monitoring, rehydration with intravenous fluid and pain medication. The early use of PN has no benefit in the non-operative management of blunt pancreatic trauma and should be avoided unless prolonged oral feeding intolerance (> 7 days) occurs.

Early surgical treatment is recommended for hemodynamic unstable patients. However, evidence-based selection criteria for patients with pancreatic injury that benefit most from operative management are lacking. This choice will often depend on the expertise of the treatment center with pancreatic surgery or endoscopic techniques.

Only symptomatic pseudocyst require treatment and asymptomatic pseudocysts can be safely followed up with ultrasound, irrespective of the size and duration of the collection.

The long-term outcome of pancreatic injuries in children regarding the risk of development of diabetes mellitus or exocrine pancreatic insufficiency remains unknown. More prospective trials and research initiatives are required. Until more data becomes available, we propose a high index of suspicion in the follow up of these patients with check up every two months with ultrasound and blood test until pseudocyst disappears and every two year thereafter with closely follow-up of biometrics of the patients and measurement of HbA1C and fecal elastase every two year or sooner in case of complaints.

## Conflict of interest

The authors have no conflict of interest to declare with regard to the subject discussed in this manuscript.

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