Review article

Trauma to the Pancreas: What We Need to Know

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ABSTRACT

Blunt pancreatic trauma is an uncommon injury but has high morbidity and mortality. In modern era of trauma care, pancreatic trauma remains a persistent challenge to radiologists and surgeons alike. Early detection of pancreatic trauma is essential to prevent subsequent complications. However, early pancreatic injury is often subtle on CT and can be missed unless specifically looked for. Signs of pancreatic injury on CT include laceration, transection, bulky pancreas, heterogeneous enhancement, peripancreatic fluid and signs of pancreatitis. Pancreatic ductal injury is a vital decision-making parameter as ductal injury is an indication for laparotomy. While lacerations involving more than half of pancreatic parenchyma are suggestive of ductal injury on CT, ductal injuries can be directly assessed on MRI or endoscopic retrograde cholangiopancreatography. Pancreatic trauma also shows temporal evolution with increase in extent of injury with time. They are associated with considerably high morbidity and mortality in cases of delayed diagnosis, incorrect classification of the injury, or delays in treatment.

INTRODUCTION

The pancreas is a relatively uncommon organ to be injured in trauma (7–9%), occurring in less than 2% of blunt trauma cases. This injury is associated with considerably high morbidity and mortality in cases of delayed diagnosis, incorrect classification of the injury, or delays in treatment (1, 2). Mortality for pancreatic injuries ranges from 9% to 34%; however, only 5% of the pancreatic injuries are directly related to the fatal outcome. Physical examination is usually not reliable in the setting of acute pancreatic trauma (3). Early and accurate diagnosis can decrease morbidity and mortality, and various imaging modalities play a key role in recognition of pancreatic injuries (4, 5). Knowledge about the mechanisms of pancreatic injury, the presence of coexisting injuries, the time to diagnosis, the presence or absence of major ductal injury, and the roles of various imaging modalities are essential for prompt, early and accurate diagnosis. Early detection of disruption of the main pancreatic duct (MPD) is of paramount importance because such disruption is the main cause of delayed complications like pseudopancreatic cysts (6). The most common site of traumatic

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pancreatic injury is at the junction of the body and tail. Significant pancreatic injury may occur in the absence of abnormality on various imaging modalities (7). Conservative management is mainly advocated for pancreatic trauma without ductal injuries. CT is routinely used as the first-line imaging modality in acute abdominal trauma cases and is helpful in recognizing injuries to the pancreas and other organs and their associated complications (8). US is useful in cases of pancreatic ascites and pseudocyst formation, which are more likely to occur in cases with traumatic pancreatitis (3, 9). Magnetic resonance cholangiopancreatography (MRCP) allows direct imaging of the pancreatic duct and its disruption (10). Recently, with emphasis on early detection of ductal injury and an increasing trend towards non-operative management of low-grade pancreatic injuries, MRI, endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic stenting have also been incorporated into pancreatic trauma management protocols (2, 4–8).

ANATOMIC CONSIDERATIONS

The pancreas is a long J-shaped, soft, lobulated retroperitoneal organ. It is situated transversely across the posterior abdominal wall, at the back of the epigastric and left hypochondriac regions at level of lumbar spine (L1–2) (11). The MPD of Wirsung traverses the entire length of the gland. The superior pancreaticoduodenal artery from the gastroduodenal artery and the inferior pancreaticoduodenal artery from the superior mesenteric artery run in the concave contour of the second part of the duodenum to supply the head of the pancreas. The pancreatic branches of the splenic artery supply the neck, body, and tail of the pancreas. The body and neck of the pancreas drain into the splenic vein, whereas the head drains into the superior mesenteric and portal veins. The proximity of many larger vessels such as the inferior vena cava, portal vein, and abdominal aorta makes injuries to the pancreas difficult to manage because of the risk of exsanguinating hemorrhage, which is a frequent cause of death in patients with a pancreatic injury. The splenic artery and splenic vein run superior and posterior to the body and tail of the pancreas and are relatively easier to expose and control compared to the inferior vena cava and portal vein. The vascular anatomy causes problems in repairing the injuries to the head of the pancreas whereas injuries to the body and tail are easier to manage (11, 12) (Figure 1).

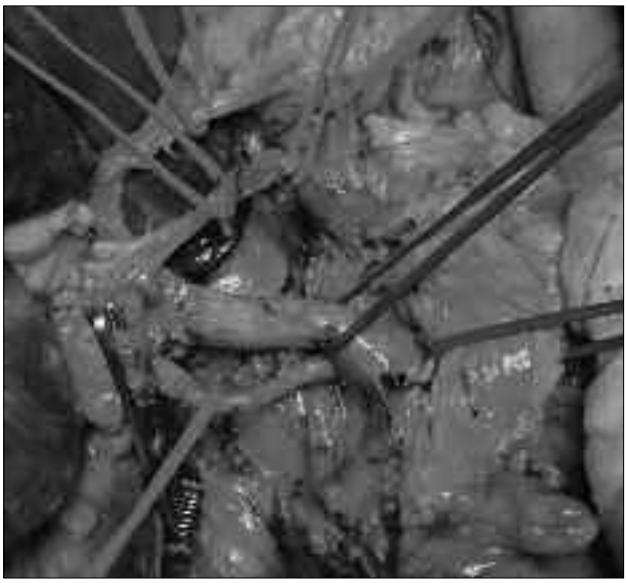

Figure 1. Vasculature of the pancreas

CLASSIFICATION AND GRADING OF PANCREATIC INJURIES

Pancreatic injuries are classified and graded according to the damage to the pancreatic parenchyma and the ductal system. Grading of pancreatic injuries enables an exact description of injuries, can influence management and allows a comparison of outcomes and effective quality control of treatment (13). There are several classification systems of traumatic pancreatic injuries (14, 15) but the pancreatic organ injury scale (OIS) proposed by the American Association for the Surgery of Trauma (AAST) fulfils most of these criteria and at present is the universally accepted classification scheme (16). This OIS involves five grades, which concedes the significance of more complex injuries to the pancreas, particularly to the pancreatic duct and the pancreatic head (Table 1). This classification scheme can also be correlated with other organ injury scales, as well as integrated into more complex scoring systems, such as Injury Severity Score or Trauma Score-Injury Severity Score from

Table 1. Pancreatic organ injury scale according to American Association for the Surgery of Trauma.

Grade	Injury Description
I	Minor contusion or superficial laceration wihtout duct injury
II	Major contusion or laceration without duct injury or tissue loss
III	Distal transection or parenchymal injury with duct injury
IV	Proximal transection or parenchymal injury involving ampulla
V	Massive disruption of pancreas head

which probability of survival of an individual case is determined.

CLINICAL AND LABORATORY DIAGNOSIS

Pancreatic injury should be suspected in all polytrauma patients or patients with history of any high-risk mechanism of injury. Due to the deep retroperitoneal location of pancreas, early diagnosis of pancreatic injury may be missed. Isolated pancreatic trauma may be clinically occult initially and can present later with complications while in polytrauma patients, pancreatic trauma may be masked by signs of more severe other organ injuries (17). Clinically, patients may present with diffuse abdominal or epigastric pain, epigastric ecchymosis, abdominal guarding, tenderness and absent bowel sounds, along with metabolic acidosis and leucocytosis secondary to the inflammatory response induced by leakage of pancreatic enzymes (18, 19). Both serum amylase and lipase are unreliable markers for pancreatic trauma. While serum amylase is usually elevated after pancreatic trauma, it can also be normal in up to 40% of patients (20). Thus initial serum amylase levels are neither sensitive nor specific for diagnosis of pancreatic trauma and can also be elevated in non-pancreatic abdominal and bowel injuries (21, 22). Hence serum amylase determinations may support clinical suspicion in the diagnosis of pancreatic trauma but are not reliable or cost-effective as screening tools. While absolute values of serum amylase do not correspond to the grade and severity of injury, hyperamylasemia in general is an indicator of development of complications, pancreatic fistula and pseudocyst formation (23). Also while initial amylase may be normal, repeat amylase measurements at later intervals, persistent or significant hyperamylasemia (more than three times baseline) are suggestive. Thus, the trend of serum amylase/lipase levels (increase/decrease) rather than any absolute value are helpful indicators of pancreatic involvement and development of subsequent complications (24, 25).

IMAGING IN PANCREATIC TRAUMA

The objectives of imaging are: 1) to detect pancreatic trauma as early as possible to mitigate the consequences of delayed diagnosis; 2) to identify ductal injury; i.e. to identify grade 3 and above injuries as ductal involvement has higher morbidity and mortality; 3) to evaluate evolution of pancreatic trauma; and 4) to diagnose complications and facilitate image-guided interventions. With these objectives in mind, CT is the workhorse of imaging in pancreatic trauma. MRI with MRCP and ERCP are useful in definitive diagnosis of ductal injury both early and late cases while a newer modality like contrast-enhanced US (CEUS) has also been evaluated in pancreatic trauma.

Ultrasound

A US examination will usually be performed to enable the diagnosis of free abdominal fluid or gross damage to the liver or spleen. The pancreas is not easily identified and examined to its full extent; therefore, pancreatic injuries, parenchymal or ductal, will frequently be missed. However, routine abdominal US examination in the emergency room will establish the diagnosis of an intra-abdominal injury and therefore establish the need for an urgent exploratory laparotomy. To disclose MPD injury in blunt and penetration pancreatic trauma, intraoperative US has proven to be helpful.

Computed tomography

When initially evaluating for injury, CT scanning is a simple, non-invasive means of evaluating the pancreas. New-generation helical CT scanners quickly enable an overview of abdominal injuries in severely traumatic patients. CT was reported to have 90% sensitivity in detecting pancreatic disruption by The et al. (30). Furthermore, CT allows additional assessment of the severity and extent of pancreatic tissue damage and concomitant injuries. Another factor affecting diagnostic performance in pancreatic trauma is the evolution of pancreatic injury. Findings can be subtle in early cases leading to a low CT sensitivity. In the study by Arkovitz et al. (26), CT had 85% sensitivity within the initial 24 hours after pancreatic injury while overall sensitivity was 90%. The pancreas can appear normal in 20–40% of patients with acute blunt pancreatic injuries, especially when imaging is done within the first 12 hour after injury. This is due to the obscuration of the fracture plane, hemorrhage, and close apposition of the pancreatic fragments. On repeat scanning at 12–24 hours, an abnormality which was initially ambiguous or subtle becomes more evident. Findings become more radiologically apparent over time with the development of post-traumatic pancreatitis, edema, leakage of pancreatic enzymes, and subsequent autodigestion of the surrounding parenchyma (27, 28). The delay in CT findings of pancreatic injury is especially pronounced in pediatric or thin patients who often lack the contrast provided by surrounding adipose tissue to appreciate pancreatic injuries (29, 30). CT can either miss or underestimate depth of laceration too in very early stage because accumulation of fluid within the gap and separation of fragments is a time-dependent phenomenon (31). Thus, the inability to detect early pancreatic trauma even with advanced multidetector CT technology is not a reflection of failure of technology but due to the natural history and evolution of trauma (32).

Magnetic resonance cholangiopancreatography

MRCP is another non-invasive diagnostic tool that allows the evaluation of pancreatic injuries with high sensitivity and specificity. Particularly in stable patients with suspected pancreatic injury, MRCP enables the non-invasive detection or exclusion of pancreatic duct trauma and pancreatic specific complications. It may, therefore, provide information that can be used to guide management decisions in the further course of pancreatic trauma patients; however, its purely diagnostic nature and its inability to provide real-time visualization of ductal findings and extravasation are two of its disadvantages. Recently, secretin-stimulated MRCP was also reported to be a safe, non-invasive test that can provide additional useful information about duct integrity and facilitate management (47).

Endoscopic retrograde cholangiopancreatography

ERCP was documented to be a useful diagnostic tool, displaying sensitivity and specificity of 100% for pancreatic duct injury. ERCP was also reported to be the definitive test for pancreatic duct injury, particularly, to demonstrate the site of duct disruption and the grade of duct injury, whether the branch or main duct and partial or complete disruption of the MPD (53). Recently, ERCP has been shown not only to provide sufficient information for conclusive diagnosis but also to be an effective and safe non-operative treatment tool. In certain cases of leakages of the pancreatic duct, transpapillary stent insertion might seal the

injury and stabilize it in a way that eventually leads to resolution of the leakage.

MANAGEMENT OF PANCREATIC INJURIES

Management of pancreatic trauma depends on 1) grade/severity of injury; 2) location of injury; 3) other associated abdominal injuries, and 4) time elapsed after injury (2, 9, 14). If CT shows ductal involvement (more than 50% depth of laceration), the operative management is preferred. If CT is equivocal, MRI (or ERCP) should be done to look for ductal involvement followed by laparotomy in presence of ductal involvement.

Many patients with pancreatic injuries have multiple associated injuries including vascular and other intra-abdominal organs injury; priority must be given to stabilizing the patient before any definitive management of the pancreatic injury. The initial priorities include control of hemorrhage and spillage of intestinal contents. The decision regarding therapeutic approach of the traumatic pancreatic injury, either with a conservative approach or a surgical approach, depends upon the integrity of the MPD, extent of pancreatic parenchymal damage, anatomical location of the injury, stability of the patient and degree of associated organ damage (33, 34). In patients with an isolated pancreatic contusion or superficial lacerations without ductal disruption, conservative management may be warranted. Treatment of traumatic pancreatitis consists of bowel rest, nasogastric suction, and nutritional support (35). ERCP-guided stent placement to the MPD injury has been indicated in select cases (36). Endoscopic transpapillary drainage has been successfully used to heal duct disruptions in the early phase of pancreatic trauma and in the delayed phase to treat the complications of pancreatic duct injuries. However, in patients with major ductal injury after blunt pancreatic trauma, morbidity and mortality greatly increase unless surgery is undertaken within the first 24 hours. By using the pancreatic OIS grading system of the AAST to help to guide the appropriate surgical management, the morbidity and mortality in blunt pancreatic injury are decreased (37). Grades and are treated with non-operative management techniques or simple drainage, whereas injuries grade or higher often require resection with possible reconstruction and drainage procedures (38). There are some alternative procedures that can be used for the management of high-grade blunt pancreatic injury, such as duodenal diversion, pyloric exclusion, the Whipple procedure or simple drainage, with the choice dependent on the patient's hemodynamic status and the presence or absence of associated duodenal injury (39, 40). Sometimes, the decision to perform a pancreaticoduodenectomy is unavoidable in select cases. If the patient is hemodynamically unstable, pancreaticoduodenectomy should be performed as a two-step procedure. After the initial damage control surgery, anastomoses are completed at a second surgery when the patient is stable (41). The standard of care in penetrating injuries is a surgical approach depending upon the location of the injury and associated abdominal injuries. Damage control surgery in hemodynamically unstable patients with massive injury to the pancreas and associated intra-abdominal organs reduces morbidity and mortality.

Non-operative management

Literature on non-operative management of the injuries (NOMI) mostly pertains to pediatric patients with reported outcomes similar to operative management (42, 43). However, this approach can also be extended to adults (8). Proper patient selection (patients with low-grade injuries, isolated pancreatic injuries, and absence of ductal involvement on MRI or ERCP), continuous patient monitoring, radiological follow-up and availability of radiological or endoscopic interventions for management of local/pancreatic complications are keystones to successful NOMI (44, 45). In case of clinical and radiological progression of injury, subsequent surgical management is preferred over endoscopy as the laparotomy has better outcomes with lesser complications (2, 3).

COMPLICATIONS, MORBIDITY, AND MORTALITY

Despite the relatively low incidence of pancreatic trauma, morbidity and mortality are high. While isolated pancreatic trauma has an incidence of less than 3% (46), the overall morbidity is 30–50% and mortality is 10–30%. There is a proportionately direct increase in adverse outcome with 1) increasing grade of injury; 2) associated organ injuries, and 3) delay in diagnosis with failure to identify ductal injuries (3, 9, 13, 24, 29, 47, 48). Approximately, one-third of the patients that survive the first 48 hours develop complications due to pancreatic injury. Complications include traumatic pancreatitis, pancreatitis-induced vascular complications such as pseudoaneurysms, pseudocysts, pancreatic fistulas, intra-abdominal abscesses, pancreatic strictures and chronic obstructive pancreatitis, wound complications, septicemia and multiple organ failure (14, 49, 50). Post-traumatic pancreatitis occurs due to missed or delayed diagnosis of ductal injury. The incidence of pancreatitis is 17% after pancreatic injury (51). Patients present with abdominal pain and hyperamylasemia. CT demonstrates typical imaging features of pancreatitis with bulky, heterogeneously enhancing pancreas, intrapancreatic and peripancreatic collections and can lead to sepsis and multiple organ failure. Treatment is usually conservative while pancreatectomy, debridement, and drainage may be done for failure of conservative treatment. Patients may also present with recurrent episodes of pancreatitis months after trauma due to persistent duct leak. This may require surgical intervention or endoscopic stenting (52–54). Pancreatic fistula is one of the commonest complications after pancreatic trauma. Its incidence varies from 20% in isolated pancreatic trauma to 35% in combined pancreaticoduodenal injuries (55–57). Fistula output more than 200 mL/day is a low-output fistula while output more than 500 mL/day is a high-output fistula. Conservative management with CT-guided drainage of fistula over weeks is the treatment of choice (58). In case of persistently high-output drainage or internal communication with a hollow viscus or pleural cavity, ERCP may be done to delineate the fistulous anatomy followed by surgery or endoscopic stenting (5). Proximal fistulas are better treated by stenting or Roux-en-Y procedures while distal fistulas are treated by pancreatectomy (3, 14). Pancreatic pseudocysts more commonly occur after missed injuries to distal pancreas or as a sequelae of NOMI (14, 58). These are commonly located anterior to body and tail of pancreas. MRCP or ERCP should be done to look for communication with pancreatic duct. If communication is present, endoscopic stenting along with CT-guided percutaneous drainage is done (59, 60). If there is no communication with pancreatic duct, drainage alone is sufficient. If closely apposing stomach or bowel walls, surgical or endoscopic cystogastrostomy or cystoenterosotmy are other therapeutic options (61). Peripancreatic abscess/infected walled-off collections usually occur secondary to contamination from hollow viscus or skin flora through the external drain. These increase morbidity and mortality due to ensuing sepsis (47, 61, 62–68). On imaging, air foci within peripancreatic collections are suggestive of infection. However, if external drainage is maintained, presence of air foci may be normal. In such cases, MRI can show debris within the collections while positive culture of fluid in the presence of fever, leucocytosis, and acidosis are diagnostic. Vascular complications such as pseudoaneurysms either occur due to complications of surgery or secondary to erosion of vessel wall by pancreatic enzymes (69, 70). Post-pancreatitis and post-traumatic pancreatic pseudoaneurysms commonly involve splenic, gastroduodenal and common hepatic arteries. Pseudoaneurysms are potentially life-threatening events and can rupture if untreated, leading to haemorrhagic death. Imminent rupture or bleeding pseudoaneurysms manifest as upper gastrointestinal bleed (haematemesis/melena) or haemobilia. If patient is hemodynamically stable, CT angiography is the modality of choice to diagnose site and size of pseudoaneurysms followed by angioembolization with coils, glue or thrombin. If hemodynamically unstable, patients can directly be taken for embolization (71–74). In cases of failure of embolization or in cases non-amenable to embolization, surgical management is done. Pancreatic duct strictures and chronic obstructive pancreatitis can occur as sequelae of NOMI wherein fibrosis at injury site can lead to pancreatic

duct strictures. Chronic obstruction and raised intraductal pressure leads to chronic obstructive pancreatitis, presenting months to years after trauma (75). MRI is useful in diagnosis while ERCP and endoscopic stenting are therapeutic. Other options include surgical pancreaticojejunostomy and distal pancreatectomy for distal strictures (76).

SUMMARY

Pancreatic trauma remains a difficult diagnosis with high morbidity and mortality. While multiple detector CT is the mainstay for diagnosing pancreatic injury, early scans may miss pancreatic trauma, especially if not carefully looked for. Thus radiologists should have a very high index of suspicion for pancreatic injury and should carefully evaluate all CT scans for signs of pancreatic involvement.

Early diagnosis of ductal injury is essential to improve outcomes. If ductal involvement is equivocal on CT, MRI should be done to comment on ductal injury versus integrity and guide management. ERCP has a selective role in management of complications of pancreatic trauma. Since pancreatic injury is an evolving process, serial imaging with CT or MRI should be done to look for temporal evolution and follow-up in non-operative management of pancreatic trauma. Radiology also plays a crucial role in follow-up and management of complications in pancreatic trauma. In select situations, including minor injuries, a conservative approach may be successful. With modern imaging modalities and expertise in ERCP, isolated pancreatic duct injury can be successfully managed. A surgical approach is appropriate with major pancreatic injury that necessitates urgent surgical intervention.

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