

The Management of Pancreatic Trauma

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Abstract

Pancreatic trauma is an uncommon occurrence and so a consensus about optimal management is not readily available. Isolated pancreatic injury occurs only occasionally, as in the majority of cases there is concurrent visceral or vascular injury. Morbidity and mortality are related to delay in diagnosis, concurrent organ injury or the presence and extent of pancreatic duct injury.

Introduction

Pancreatic injuries are one of the most complicated traumatic gastrointestinal injuries to deal with [1]. They are relatively uncommon and overall account for only 1–4% of severe abdominal injuries; penetrating abdominal wounds result in pancreatic injury in up to 3% of cases [2–3]. The incidence is increasing [4–5]. The pancreas was found to be the cause of admission in 0.4% of all trauma admissions in one large series [6].

The first reported case of pancreatic trauma was described by Travers in 1829 [7], when a woman was struck down by the wheel of a stage coach. A definitive diagnosis was established at post mortem, where she was found to have a hepatic laceration and a complete transverse tear through the pancreas. The first successful operative intervention for pancreatic trauma was reported by Garré in 1905 [8] in a patient with a completely transected pancreas – the opposing ends of the gland were sutured together with fine silk and a gauze pack was placed. Recovery was complicated by the development of a pancreaticocutaneous fistula which closed spontaneously after six weeks.

This review examines the current evidence for the diagnosis and management of pancreatic trauma. The pancreas is however so intimately related to the duodenum and many other visceral structures, that much of the available evidence also includes injury to the duodenum and so, in parts, the evidence for management of the entire pancreaticoduodenal complex are also included.

Mechanism of Injury and Pathophysiology

The incidence of these injuries is slowly increasing as vehicular accidents, industrial accidents and acts of violence increase [2], and aetiologically can be divided into blunt and penetrating mechanisms.

Blunt trauma

Blunt pancreaticoduodenal injuries usually occur due to unrestrained drivers striking their abdomen/thorax against the steering wheel [9] or children involved in bicycle accidents where they impact the epigastrium on the handlebars during road traffic accidents. Bicycle accidents are the commonest cause of pancreatic injuries in children, accounting for 42–75% of cases [10]. The

degree of force required to injure the pancreas is considerable, and there will usually be associated visceral injuries. In blunt abdominal trauma, the mechanism of injury is compression of the pancreas, especially the neck, against the vertebral bodies, leading to parenchymal injury with or without damage to the main pancreatic duct which increases morbidity and mortality in patients with pancreaticoduodenal injuries [11].

Parenchymal damage and duct injury may lead to premature activation of pancreatic enzymes and acute pancreatitis. Once activated, trypsin initiates an enzymatic cascade leading to pancreatic autodigestion and systemic release of activated enzymes. The systemic manifestation of this will include vasodilation, increased capillary permeability and third space fluid losses [12].

Penetrating trauma

Penetrating abdominal injuries following gunshot or knife assault are increasing in frequency and pancreatic injury should be considered in all patients with a penetrating injury to the abdomen or chest below the nipple line. Isolated injuries are rarely seen, and in the majority of cases, trauma to the pancreas is complex and involves injuries to an abdominal viscus (38%), most commonly the duodenum, liver (19%) or an associated major vascular injury (14%) – rarely is one vessel involved in isolation. The overall mortality, which may be as high as 27% in penetrating pancreatic injury [13] does not appear to be related to the mechanism or degree of penetrating pancreatic injury, but is related to the associated injuries [6].

Presentation

The clinical manifestations of pancreatic injury vary widely. All patients undergoing laparotomy for penetrating abdominal trauma should have a thorough assessment of the viability of the duodenum and pancreas. Patients with visible blunt trauma to the epigastrium, and a history that is suggestive of possible pancreatic injury, should be appropriately investigated. The retroperitoneal location of pancreas combined with reduced secretion and inactivity of pancreatic enzymes following injury may account for the paucity of early physical signs.

The early diagnosis of pancreatic injuries requires a high degree of suspicion. The initial complaints from the patient are often vague, and nonspecific; most commonly mid-epigastric or back-pain, occurring 6–24 hours after the injury. Physical signs include mid-epigastric tenderness in the early stages and frank peritonitis in late presentation cases [14]. Delayed presentation may be

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the result of associated retroperitoneal duodenal perforation or duodenal haematoma with subacute bowel obstruction. Alternatively retroperitoneal leakage of pancreatic enzymes may cause digestion of tissues in the flanks, generating flank bruising (Grey-Turner's sign) or may track down the falciform ligament to digest the periumbilical tissues (Cullen's sign).

Classification of pancreatic injuries

Hirshberg classified the anatomical structures that are related to the pancreaticoduodenal complex into deep, middle and superficial layers (Figure 1) [15]. Superficial layer injuries can be further subdivided into a classification proposed by Frey and Wardell [16,17], which includes duodenal injuries and describes the extent of damage to the of pancreas, duodenum and main pancreatic duct (Table 1).

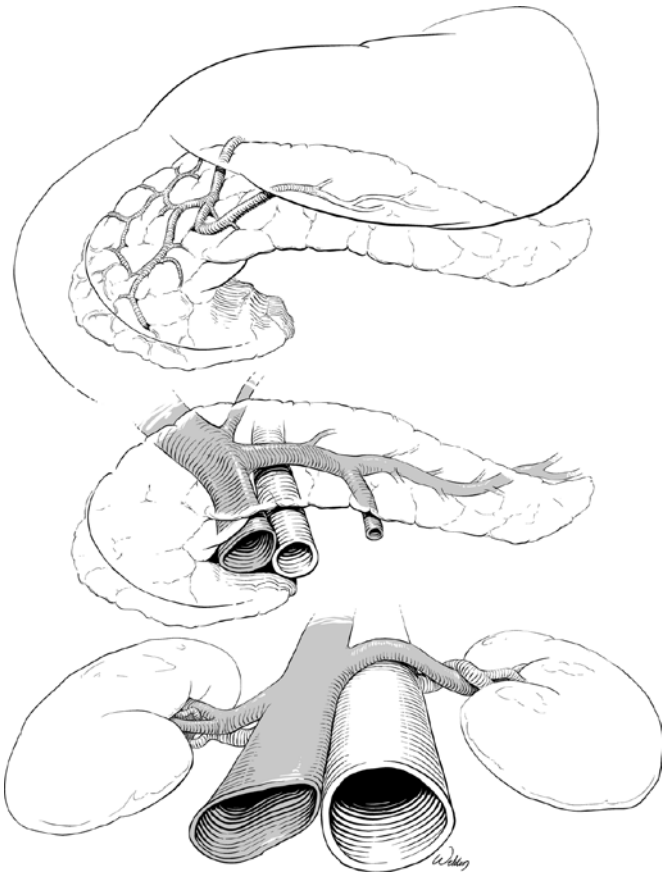


Figure 1. The three layers around the pancreaticoduodenal complex, described as the 'the wounded surgical soul'. The superficial layer (Top image) contains the pancreaticoduodenal complex itself; the middle layer (Middle image) contains the pancreaticoduodenal arcade, superior mesenteric artery and vein, and the portal vein and the deep layer (bottom image) contains the inferior vena cava and the right renal pedicle.

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Diagnosis

Patients with penetrating abdominal trauma will usually undergo early laparotomy at which pancreatic injuries will be evident, if looked for. Difficulties arise in those with blunt abdominal trauma, in whom the early and accurate diagnosis of a pancreatic injury is fundamental to successful management.

Pancreatic Injury	
Class I	Capsular damage, minor gland damage (P ₁)
Class II	Body or tail pancreatic duct transection, partial or complete (P ₂)
Class III	Major duct injury involving the head of the pancreas or the intrapancreatic common bile duct (P ₃)
Duodenal Injury	
Class I	Contusion, haematoma or partial thickness injury (D ₁)
Class II	Full thickness duodenal injury (D ₂)
Class III	Full thickness duodenal injury with >75% circumference injury or full thickness duodenal injury with injury to the extrahepatic common bile duct (D ₃)
Combined Pancreaticoduodenal Injuries	
Type I	P ₁ D ₁ , P ₂ D ₁ or P ₁ D ₂
Type II	D ₂ P ₂
Type III	D ₃ P ₁₋₂ or P ₃ D ₁₋₂
Type IV	D ₃ P ₃

Table 1: Pancreaticoduodenal injury classification proposed by Frey and Wardell [16,17]

Serum Amylase

The role of serum amylase is controversial, with evidence that it is neither sensitive nor specific [11]. Olsen [18] studied the serum amylase in 179 individuals with blunt abdominal trauma; 36 had elevated amylase levels but only 3 had pancreatic injury, suggesting that an elevated serum amylase is not diagnostic of pancreatic trauma. Amylase is a small molecule that is rapidly cleared by the kidneys, so high concentrations may be short lived in pancreatic trauma. Elevated serum amylase levels therefore are not specific in the diagnosis of pancreatic injury, although it is well documented that most patients with a pancreatic injury have an elevated serum amylase level [15]. In addition, this study showed that all patients presenting with a pancreatic injury greater than 3 hours old had a raised serum amylase level. This finding is also echoed by Jones et al [19], who demonstrated a rise in amylase in over 30% of patients less than two hours after injury, and they found a higher chance of detecting a rise in amylase the longer the delay from injury to surgery. There was a higher likelihood of a rise in amylase in blunt injury compared to penetrating injury (71% vs 23%). Perhaps therefore the most useful role for serum amylase in patients with blunt abdominal trauma is as negative predictor of pancreatic injury when levels are normal [20]. Serum lipase, when used in conjunction with serum amylase, has a sensitivity and specificity approaching 95% [12].

Diagnostic Peritoneal Lavage

Diagnostic peritoneal lavage (DPL) has also been proposed as a valuable tool in the assessment of pancreatic injury. Current data indicates that an amylase level of greater than 100 IU per litre of

lavage fluid correlates with the presence of an intra-abdominal injury but again this is not specific for pancreatic trauma [21]. The anatomical location of the pancreas also interferes with DPL; the retro-peritoneal location of the pancreas makes positive findings unlikely [22].

Radiological imaging

Radiological investigations play the most important role in the accurate diagnosis of pancreatic injuries. A plain abdominal film may demonstrate gas bubbles in the retroperitoneum distributed along the right psoas margin or anterior to the first lumbar vertebra [20,21], signifying duodenal injury. Computerised tomography (CT) is the investigation of choice for identifying injury to the pancreatic parenchyma and has an accuracy of up to 97.6% [21, 23-25], with specific findings such as thickening of the anterior renal fascia [23] and fluid between the pancreas and the splenic vein [26] being described as indicative of pancreatic injury. Initial understaging of the extent of pancreatic injury is well described with CT imaging and injury to the main pancreatic duct may sometimes be missed [11]. If a pancreatic duct injury is suspected, especially with injuries to the pancreatic neck, but is not evident on CT, then magnetic or endoscopic retrograde cholangiopancreatography (MRCP or ERCP) can assess ductal integrity [27], as it is this that will have a critical influence of the decision to operate or opt for conservative management in these patients. Patients with an isolated pancreatic injury can be treated non-operatively initially, however, delayed surgery and a missed injury to the main pancreatic duct, is associated with significantly increased morbidity [8].

Management

Patients with an apparent injury to the pancreatic parenchyma on imaging, in whom a major vascular or pancreatic duct injury has been excluded, may initially be treated conservatively, provided there are no signs of peritonitis or haemodynamic instability. These patients must be continually re-evaluated and imaging repeated in those who are not progressing or deteriorating (Figures 2&3). Early consideration of a diagnosis of pancreatic injury coupled with urgent MRCP may demonstrate ductal injury and provide the impetus for early surgery.

Operative management

Patients with penetrating abdominal trauma and those with blunt trauma who have peritonitis or who are haemodynamically unstable should undergo laparotomy. Injuries to other organs including the liver, spleen and duodenum are common in these patients, and these can be identified before laparotomy in stable patients by CT scan. Patients with an associated vascular injury will usually require urgent laparotomy, to prevent catastrophic haemorrhage. Both the deep and middle layers contain major blood vessels and haemorrhage control is the priority before pursuing repair or salvage of the pancreaticoduodenal complex. The presence of shock or major vascular injury will dictate the extent of pancreatic operative intervention [28], however, the mainstay of treatment should initially be nutrition, percutaneous drainage and endoscopic stenting [29].

Access to the Pancreaticoduodenal complex

In terms of practical application Hirshbergs et al's classification is easier to use than that of Frey and Wardell. The potential sources of bleeding include the inferior vena cava, right renal pedicle,

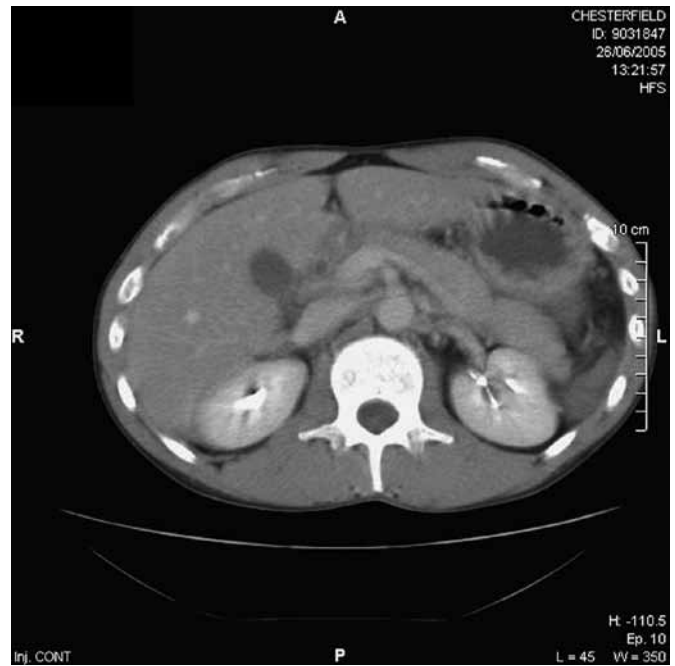


Figure 2. An early CT a few hours after blunt abdominal trauma from assault. The patient was haemodynamically stable with minimal abdominal tenderness and normal serum amylase. The pancreas appears essentially normal.

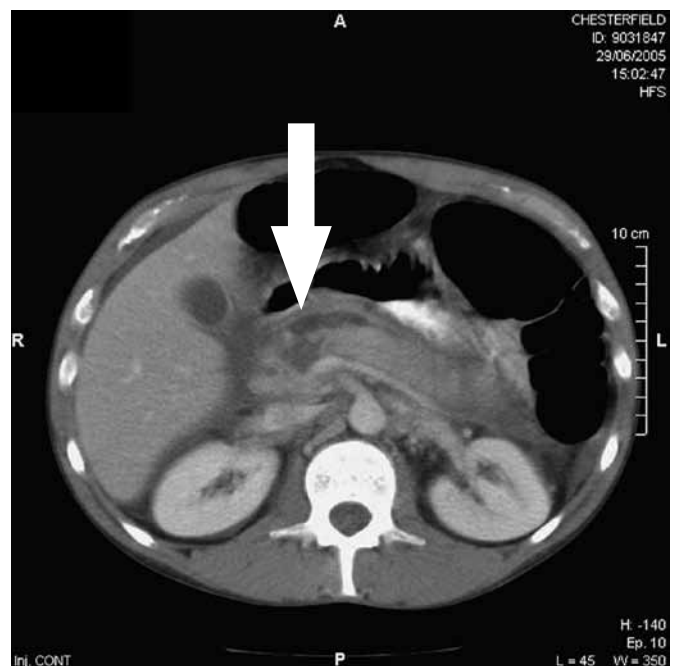


Figure 3. Over the next 72 hours the patient became pyrexial and tachycardic with abdominal distension and marked epigastric tenderness. Repeat CT scan 4 days following the injury shows complete transection of the pancreatic neck (white arrow). The patient underwent laparotomy and insertion of drains

superior mesenteric vessels, pancreaticoduodenal vessels and the supraduodenal portal vein. Rapid control of bleeding from the pancreaticoduodenal complex can be established by Kocherising the duodenum and compressing the complex directly; this allows resuscitation to continue and a more deliberate assessment of the surgical approach required.

Incision along the right peritoneal reflection with medial visceral mobilisation (Cattell – Braasch manoeuvre (Figure 4)) will



Figure 4 – The Cattell – Braasch manoeuvre – allowing exposure of the inferior vena cava, the right kidney and mobilising the pancreatic head.

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expose the retropancreatic vessels, superior mesenteric vessels and allow clamping of the infrarenal aorta [15]. It allows inspection of the vena cava, right kidney, ureter and the iliac vessels. Incision of the left lateral peritoneal reflection from sigmoid colon to spleen with medial visceral mobilisation (Mattox manoeuvre (Figure 5)) provides rapid access to the retroperitoneum. Using blunt dissection along the surface of the posterior abdominal wall, the suprarenal abdominal aorta can be visualised, as well as the posterior surface of the kidney and ureter. Once haemostasis is achieved, attention can then be focussed on assessing the injury to the pancreas and associated visceral injury. It has been documented that 95% of pancreatic injuries can be diagnosed by inspection following adequate exposure [29]. Only about one quarter of pancreatic injuries occur in isolation [2]; in blunt trauma, the liver, spleen and duodenum were the most frequently injured organs, whilst in penetrating trauma, the other organs involved, in order of decreasing frequency, were liver, stomach, colon, kidney, major vessel and duodenum.

If there is no associated visceral injury, the pancreas and duodenum should be fully assessed. The gastrocolic ligament between the stomach and transverse colon is divided to allow

good exposure of the body and tail of pancreas. There are sometimes adhesions between the anterior and superior border of the pancreas and the posterior wall of the stomach which must be carefully divided. The head and uncinate process of the pancreas are visualised by performing a Kocher manoeuvre to mobilise the duodenum, which allows examination of the anterior and posterior aspects of the pancreatic head and detailed examination of the duodenum. If this manoeuvre is omitted significant retroperitoneal injuries in this region are easily missed.

Debridement and Drainage

Debridement and drainage is only appropriate in cases with pancreatic parenchymal damage where there is no apparent disruption of the main pancreatic duct. Intraoperative assessment of this can be very difficult as most patients with traumatic injury will have normal sized ducts which can be difficult to see. Therefore, even in the presence of ductal injury, management should be confined to simple drainage [29].

An analysis of 100 consecutive patients [30] with pancreatic and duodenal injuries reported 51 isolated pancreatic injuries, 30 duodenal injuries and 19 combined pancreaticoduodenal injuries. The authors' concluded that debridement of devitalised tissue and drainage can be employed for most cases of pancreatic trauma, and most duodenal injuries can be managed with drainage and primary repair. Studies have demonstrated that debridement and drainage is associated with fistula formation in up to 12% of patients with isolated parenchymal injury and 86% in patients with ductal injury [31]. Our recommendation would be to not attempt to identify a major duct injury at initial laparotomy unless it is apparent during the debridement of devitalised pancreatic

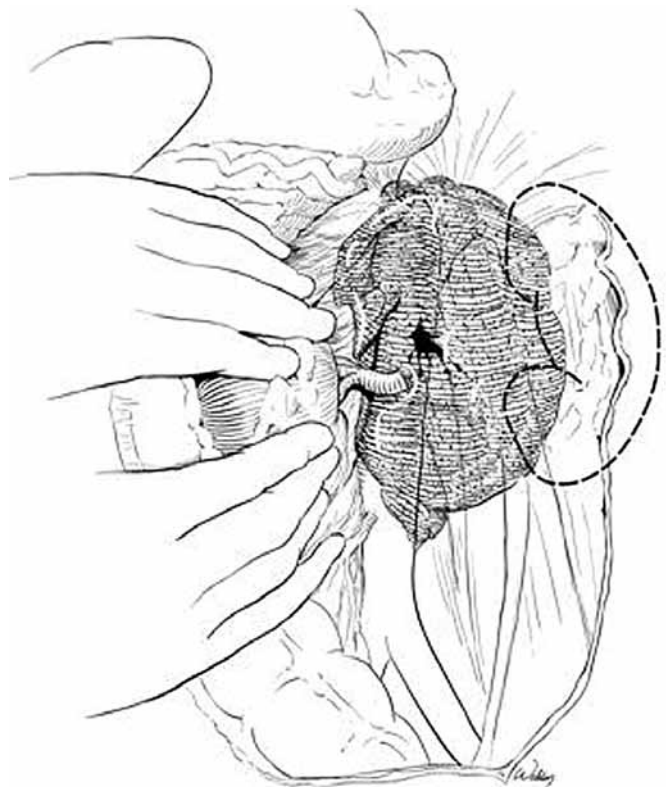


Figure 5 – The Mattox Manoeuvre – allowing exposure of the left kidney, aorta and the mesenteric vessels.

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tissue. Routine drainage is recommended and the management of severe injuries should be tailored according to the overall physiological status [13].

Ductal Injury

In cases where there is an obvious disruption to the main pancreatic duct, the operative approach will depend on the site and extent of the ductal injury. The commonest site of pancreatic injury is the neck and body. Following debridement of non-viable pancreatic tissue ductal injuries here are amenable to two approaches. The most commonly performed procedure is distal pancreatectomy with splenectomy [30] which is safe and effective.

For those injuries to the pancreatic neck which would require the entire body and tail of the pancreas to be resected, potentially compromising long-term exocrine and endocrine function, a limited central resection of the affected area can be performed with the preserved distal pancreas being anastomosed to a roux-en-y jejunal loop. The proximal pancreas is either closed with a stapler or the main duct is suture ligated and the pancreatic parenchyma closed with interrupted sutures after haemostasis. Recent evidence has suggested that isolated injuries to the tail and pancreas can be managed without the requirement of resection [32].

Proximal duct injuries are challenging to manage, and should be managed by the safest option. This is usually external drainage and providing that there is no devitalisation of the pancreatic head/duodenum, absence of sepsis and adequate nutrition, there is a high probability that they will heal itself [29]. The problems arise when there is devitalisation and associated injuries, leading to sepsis and subsequent further devitalisation.

A clinical trial compared the sealing and sandwich techniques of fibrin glue usage to prevent pancreatic fistulas after distal pancreatectomy [33]. Sealing involved suture ligation of the pancreatic duct and stump with fibrin glue sprayed over the closed stump whereas the sandwich technique used glue to hold the stump ends closed, supported by sutures. Morbidity (21.8% v 33.9%) and fistula (9.0% v 26.8%) rates were significantly better for the sandwich technique, as a simple and reliable method for preventing pancreatic fistula.

Pancreaticoduodenal Injuries

Patients with a complex injury of the pancreatic head represent a difficult problem and are most likely to have an associated duodenal injury; they have the highest rate of morbidity and mortality for pancreatic trauma and represent a major challenge to the clinicians involved in their management. Jones [19] analysed 300 patients with pancreatic trauma over a 27 year period. Combined pancreaticoduodenal injuries accounted for 19% of cases, with the majority having a duodenal injury combined with a pancreatic head injury. Thirty nine patients underwent laparotomy for a combined duodenal and pancreatic head injury with a 31% mortality rate, compared to a mortality of 12% following debridement and drainage alone. The mortality rate in those patients whose injuries were severe enough to require a pancreaticoduodenectomy (acute Whipple's procedure) was nearly 80%.

It is evident that the majority of problems arise from injuries to the pancreatic head with its subsequent complications such as fistula formation and secondary haemorrhage. The optimal management of these patients is still unclear and depends

largely on the experience of the surgeon undertaking the initial laparotomy and the perioperative condition of the patient.

The best option at first laparotomy will often be to attain haemostasis and place drains around the injured area. Adequate exposure and exploration of the pancreas and duodenum is advocated with conservative operative management where possible [34]. In this situation most patients will recover without major complications. Pancreaticoduodenectomy has been described in this situation but must be reserved for haemodynamically stable patients, and usually as a staged procedure. Even with damage control principles it carries a mortality of 18% [30]. Unstable patients have control of haemorrhage as their main priority and if the extent of the pancreatic injury is such that a pancreatic head resection is needed then this can be performed in a more controlled setting at a later date.

Complications

In many cases of abdominal trauma, morbidity and mortality is often related to the severity of the initial injury, whereas in pancreatic injuries, post surgical complications also have a significant impact on both morbidity and mortality, due to formation of fistulae and breakdown of anastomotic repair, leading to secondary haemorrhage.

Pancreatitis

This is a relatively common occurrence, with an incidence ranging between 7 – 17% in patients who have suffered traumatic pancreatic injury. Over two thirds of patients will have complete resolution within a few weeks and require only supportive treatment; however, one third will require surgical intervention for complications associated with pancreatitis [6, 35].

Fistulae

Fistulas can arise from percutaneous drainage of a communicating pseudocyst, or as a result of open pancreatic debridement when pancreatico-cutaneous fistulas complicate up to 30% of laparotomies for pancreaticoduodenal trauma [30, 36], but in the vast majority of cases they close with conservative management. This is a relatively common occurrence in patients who have suffered pancreatic trauma, with up to 20% affected. The principles of management are the same as for managing all fistulas: control of infection, drainage and total parenteral nutrition.

Patients who persistently drain >500ml/day for greater than one week require ERCP and stent insertion to facilitate drainage [37]. Low output fistulas (<200ml/day) are usually self limiting providing there is adequate drainage [38]. External tube or low suction drains should be used after all laparotomies for pancreatic injury and daily measurement of both the volume and amylase content of the drain fluid will indicate if a pancreatic fistula has developed. Patients who require surgery for non-closing fistulas do best with a fistuloenterostomy, with a high rate of recurrent fistulation in patients who undergo cystoenterostomy [28].

Pseudocyst/Abscess

These usually arise due to unrecognised pancreatic ductal injuries, and can remain asymptomatic for prolonged periods, with an incidence varying between 2-50% [39-40]. The choice of treatment modality depends on the patient's symptoms, location of pseudocyst, evidence of ductal injury and the maturity of the

cyst wall amongst others. The majority of pseudocysts less than 5cm in maximum dimension will heal spontaneously; however, pseudocysts that persist or develop complications may require further intervention. Persistent cysts should undergo ERCP or MRCP to determine the presence of ductal injury. If this is evident, then drainage of the pancreatic duct is facilitated by stent insertion. If there is no evidence of ductal injury then percutaneous or per-gastric drainage should be undertaken. Failure of the patient to respond to these measures may necessitate a surgical cyst-gastrostomy, or a Roux-en-Y bypass.

Pancreatic abscess also tends to present after some delay after injury. It is usually associated with a hollow viscus injury and can occur in up to 25% of injuries [41]. Presentation is often dramatic with the patients showing signs of sepsis, tachycardia and swinging pyrexia. The mainstay of treatment is radiological guided drainage, with patients who fail to resolve requiring surgical intervention.

Adjuvant Treatments

Nutrition

Oral nutrition is well tolerated by most patients within a couple of days of pancreatic debridement and additional nutrition is only rarely needed. Both total parenteral nutrition and enteral nutrition beyond the ligament of Treitz, when required, are equally effective in the reduction of fistula output [42]. A surgically sited feeding jejunostomy fashioned at the time of surgery to deal with non-resolving fistulas is also effective until normal oral nutritional needs can be met [30].

Endocrine Insufficiency

Endocrine insufficiency is unusual after resection for pancreatic trauma. The remaining pancreatic tissue is generally sufficient, as in the majority of cases the injured pancreas is healthy [13]. Jones et al [19] also demonstrated that a significant pancreatic resection can be undertaken, and this does not necessarily mean the development of diabetes. Of the eight patients who underwent greater than 80% resection only three patients developed diabetes, two of which required insulin. This is confirmed by Balasegaram et al [43], who demonstrated that 10-20% of residual functioning pancreatic tissue is sufficient to provide adequate pancreatic function.

Octreotide

The routine use of octreotide to reduce the output from pancreatic fistulas after elective surgery is advocated by many, however there is no proven benefit for the routine use of octreotide in the management of pancreatic fistulas following traumatic injury [44] and its benefits still require assessment using randomised controlled trials.

A study undertaken by Nwariaku et al [45] suggested that there may be an increased rate of fistula formation, longer fistula drainage and increased duration of hospital stay associated with octreotide administration. However, sub-analysis of the data demonstrates that the patients were not randomised, there was a higher rate of duodenal injuries in the octreotide treated group, the dose of octreotide was low (100 mcg three times daily) and there was no consistency as to when the octreotide was started i.e. the range was between two to seven days post injury.

Conversely, a study undertaken by Vasquez et al [13] demonstrated significant decrease in fistula output in patients treated with octreotide. This finding was echoed by a study

undertaken by Amirita et al [46], who demonstrated usage of octreotide was associated with no negative sequelae. Side effects associated with prolonged usage include gallstones, nausea, abdominal pain, flatulence, constipation and diarrhoea

Conclusions

Pancreatic injuries, due to their relative rarity and associated vascular/visceral injuries, present the surgeon with challenging management problems. There are few good studies describing their management and a consensus has yet to be reached on many aspects of care. Early diagnosis is often difficult and immediate CT appearances may reveal little about the severity of the injury. Clinicians require a high degree of suspicion coupled with continual clinical evaluation to avoid the problems associated with the delayed diagnosis of a pancreatic injury.

A major determinant of outcome for these patients is the presence of pancreatic duct injury. Patients with a major ductal injury have a markedly increased rate of morbidity and mortality compared to patients with a pancreatic injury only. The mainstay of surgical treatment involves the simplest repair that can be performed and routine drainage with non-traumatic large calibre drains, due to the high rate of fistulae formation and abdominal sepsis.

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