Managing pancreatoduodenal trauma

Pancreatoduodenal injuries are an uncommon but important source of morbidity and mortality in the trauma patient. They require a multidisciplinary approach, with a pancreatic surgeon involved at the earliest opportunity. The investigation and management of these injuries are discussed along with the role of operative intervention.

Injuries to the pancreas and duodenum are relatively uncommon, and by virtue of their retroperitoneal location and proximity to other organs they are often difficult to diagnose and manage (Fabian et al, 2002; Rickard et al, 2005). The incidence of pancreatic injury ranges from 0.2–7.0% of patients with abdominal trauma of any aetiology and is associated with an average of 3.5 injuries to other organs (Akhrass et al, 1997; Bulger and Jurkovich, 2000; Vasquez et al, 2001). Given the close proximity of the duodenum to the pancreas, injuries to one organ often involve the other: associated duodenal injuries occur in 46% of pancreatic injuries (Allen et al, 1998; Antonacci et al, 2011). The duodenum is injured in 0.2–5.0% of patients with abdominal trauma, and is associated with an average of 3.9 injuries to other organs (Snyder et al, 1980; Chen and Yang, 2011).

Outcome

Pancreatoduodenal injuries carry high morbidity and mortality rates (Asensio et al, 1999). Complications develop in 40% of pancreatic injuries and in 16–18% of duodenal injuries (Antonacci et al, 2011). Death occurs in 13–46% of all patients with pancreatic or duodenal trauma, but these deaths often result from associated injuries (Vasquez et al, 2001; Tan et al, 2009). Deaths directly attributable to pancreatoduodenal trauma are rare and related to severity of injury; they occur in 3% of pancreatic injuries and 2% of duodenal injuries (Recinos et al, 2009).

Initial presentation

Any patient with abdominal trauma could potentially harbour a pancreatoduodenal injury. Patients should be managed in accordance with key Advanced Trauma Life Support principles in a multidisciplinary modality. In particular, trauma to the epigastrium can crush the pancreas against the vertebral columns and fracture the organ (Campbell and Kennedy, 1980; Cirillo and Koniaris, 2002). Isolated pancreatoduodenal injury may produce minimal signs at first, so a high index of suspicion is required (Asensio et al, 1999). A stable patient will benefit from further investigation (notably computed tomography) to reveal the extent of any pancreato-duodenal injury and help in management planning. An unstable, deteriorating patient is best treated with prompt resuscitation and laparotomy (Tan et al, 2009).

Investigations

Amylase

The role of serum amylase measurement in the management of pancreatoduodenal injury is controversial. The sensitivity may be as high as 75% in pancreatic trauma (Takishima et al, 1997), yet other workers have found hyperamylasaemia neither specific nor sensitive (Buechter et al, 1990). A persistently elevated serum amylase level is usually diagnostic of undetected pancreatic injury, and elevated levels in peritoneal lavage fluid are also indicative of pancreatic trauma (Campbell and Kennedy, 1980; Degiannis et al, 2008; Tan et al, 2009).

Computed tomography

Computed tomography is the imaging modality most frequently used to detect pancreatoduodenal injuries (Becker et al, 1998). Its sensitivity increases with time as a result of oedema and leakage of pancreatic enzymes and subsequent autodigestion (Tan et al, 2009). Computed tomography is more sensitive in detecting pancreatic injuries (up to 91% sensitivity) than duodenal injuries (60% sensitivity in blunt trauma) (Allen et al, 1998; Wong et al, 2008). It can detect pancreatic lacerations, predict subsequent ductal disruption and display haematoma and peripancreatic fluid (Tan et al, 2009). Computed tomography can also demonstrate focal oedema at the site of injury, infiltration of the retroperitoneal fat, and fluid separating the splenic vein from the pancreatic parenchyma (Cirillo and Koniaris, 2002). For duodenal injury, computed tomography may show free or retroperitoneal gas, which can be confirmed by leakage of oral contrast (Chen and Yang, 2011).

Because computed tomography can differentiate minor from major injuries, it has a huge bearing on the patient's subsequent management. However, computed tomography can either miss the trauma or underestimate its severity, so a low threshold for repeat scanning must be adopted, especially in the presence of persistent symptoms (Thomas et al, 2009). Computed tomography also has a role in detecting post-traumatic complications:

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pancreatitis, pseudocyst, abscess, fistula, peripancreatic infiltration and vascular involvement (Becker et al, 1998). Moreover, computed tomography-guided interventions can be performed to minimize the need for further operative procedures (Tan et al, 2009). Thus, specialist gastrointestinal radiologists play a vital role in the initial detection of pancreatoduodenal injuries and their subsequent non-operative management.

Pancreatic ductography

Preoperative pancreatography can be obtained by the endoscopic retrograde route or as part of magnetic resonance imaging. It offers the most accurate means of identifying ductal injuries and stenotic segments in the main pancreatic duct (Cirillo and Koniaris, 2002). In addition, ductograms can be obtained during laparotomy, either by on-table endoscopic retrograde cholangiopancreatography or by direct cannulation if there is an obvious disruption. Successful endoscopic stenting of a disrupted duct in the head or neck of pancreas may avoid the need for operative intervention (Lin et al, 2007). Endoscopic retrograde cholangiopancreatography is also useful in managing post-injury or postoperative complications such as pseudocyst, fistula and chronic pancreatitis (Degiannis et al, 2008).

Other investigations

Peritoneal lavage is generally considered to be of little value in detecting pancreatoduodenal injuries, and it has fallen from favour with the widespread availability of computed tomography (Asensio et al, 1999). Pancreatoduodenal injury may be suggested by the presence of bile or intestinal contents in peritoneal washings, but these findings are non-specific. Plain radiographs can detect air in the retroperitoneal space, loss of psoas shadowing or pneumoperitoneum (Campbell and Kennedy, 1980). Ultrasound scanning may show free fluid and blood within the abdomen, but often overlying bowel gas impairs the images. The role of endoscopic ultrasound in a trauma patient has not been fully elucidated (Cirillo and Koniaris, 2002).

Diagnosis at laparotomy

Patients with abdominal trauma who are haemodynamically unstable require immediate laparotomy to identify and manage life-threatening injuries. Evidence of pancreatoduodenal injury should be sought once major haemorrhage is contained and gastrointestinal contamination limited (Fabian et al, 2002). Exploration should be careful, accurate and quick (Chen and Yang, 2011). Injuries to surrounding organs highlight the risk of pancreatoduodenal injury (Vasquez et al, 2001), and up to 95% of pancreatic injuries can be diagnosed during laparotomy (Degiannis et al, 2008).

Key findings in pancreatoduodenal trauma include retroperitoneal oedema and haematoma plus contusion and laceration of the pancreas and duodenum. Pancreatic injury is suggested by blood in the lesser sac and retroperitoneal haematoma above the level of the iliac vessels (Tan et al, 2009). Splenic rupture can mask concomitant injury to the pancreatic tail, and thus careful palpation at the time of splenectomy is essential (Campbell and Kennedy, 1980). Signs suggestive of duodenal injury include:

1. Free gas or bile-stained fluid of undetermined origin
2. The presence of bile or intestinal juice in a retroperitoneal haematoma
3. Oedema, haematoma, ecchymosis or crepitus in the periduodenal retroperitoneum or the root of mesentery and mesocolon (Chen and Yang, 2011).

Complete examination of the pancreas and duodenum requires three specific manoeuvres (Campbell and Kennedy, 1980; Asensio et al, 1999; Britt, 2000; Fabian et al, 2002):

1. An extended Kocher mobilization of the duodenum and head of pancreas, particularly their posterior aspect
2. A generous opening through the gastrocolic omentum to examine the neck and body of pancreas
3. Division of the ligament of Treitz to inspect the third and fourth parts of the duodenum.

A close inspection should be made for pancreatic ductal injuries during exploratory laparotomy as they are associated with an increased risk of complications (Kao et al, 2003). Transection of the main duct should be readily identifiable in the neck or tail of the pancreas, but injuries to the duct within the head of the gland or minor ductal injuries can be difficult to assess by exploration alone (Bulger and Jurkovich, 2000). Other techniques of potential value in detecting ductal injury are intraoperative pancreatography via cannulation of the pancreatic duct (during amputation of the pancreatic tail or after opening the duodenum), endoscopic retrograde cholangiopancreatography, cholangiography (via cannulation of the common bile duct, cystic duct or even gall bladder) and intraoperative ultrasound scanning (Vasquez et al, 2001; Fabian et al, 2002; Degiannis et al, 2008; Tan et al, 2009). Non-specialist surgeons who detect incidental pancreatic injuries may want to consider discussion with a regional specialist unit for advice.

Pancreatoduodenal organ injury scales

The pancreas organ injury scale is based on the extent of haematoma, laceration and the presence and localization of any lesion of the pancreatic duct (*Table 1*). The duodenal organ injury scale is based on the presence of haematoma, laceration and vascularity of the duodenum (*Table 2*)(Moore et al, 1990).

Operative management: general principles

The management of pancreatoduodenal trauma at laparotomy should be tailored to the overall condition of the patient and any associated injuries. Treatment should focus on three key areas: haemorrhage control, selective debridement of devitalized tissues and drainage (Fabian et al, 2002). The majority of pancreatoduodenal injuries require no further operative intervention (Ivatury et al 1985;

Degiannis et al, 2008; Tan et al, 2009; Chen and Yang, 2011). All patients should receive antibiotic cover and nasogastric intubation. Feeding jejunostomy should be considered in serious injuries (Rickard et al, 2005). Tube gastrostomy drainage is invaluable in duodenal disruption.

Abdominal trauma patients can be haemodynamically compromised and quickly descend into the triad of acidosis, hypothermia and coagulopathy (Rickard et al, 2005). Moreover, pancreatoduodenal injuries are often diagnosed intraoperatively, and lengthy complex procedures in these patients risk a poor outcome. Additionally the release of pancreatic enzymes and bile may jeopardize anastomotic healing, especially in the presence of poor tissue perfusion and coagulopathy (Rickard et al, 2005). Patient outcomes are heavily influenced by the patient's age, his/her physiological state, increasing organ injury scale score, intraoperative cardiac arrest and length of operation (Antonacci et al, 2011). Thus operative strategy has moved towards simple drainage and direct repair of lesions, and the more frequent use of damage control surgery rather than major resections (Rickard et al, 2005; Antonacci et al, 2011).

Damage control surgery implies prevention of metabolic failure by application of limited or staged procedures to control haemorrhage, limit sepsis and prevent further injury. Its application to pancreatic and duodenal injuries would probably lead to improved survival (Rickard et al, 2005; Antonacci et al, 2011). For pancreatoduodenal injuries this also means that initial management of injuries can be undertaken by a general surgeon, before onward referral or discussion with a specialist unit once the patient has stabilized.

Management of pancreatic injuries

Minor injuries (grades I–II)

Grade I–II pancreatic injuries (*Table 1*) should be primarily treated with drainage – drains placed both anterior and posterior to the gland at the site of injury – plus haemostasis and debridement of obviously necrotic or devitalized tissue (Campbell and Kennedy, 1980; Fabian et al, 2002; Thomas et al, 2009). Adequate drainage reduces the risk of pancreatic abscess, sepsis and fistula (Bulger and Jurkovich, 2000). The duration of abdominal drainage is controversial: some centres recommend routine drainage for 7–10 days until eating is established, while others allow earlier removal of drains when drainage is minimal or ceases (Vasquez et al, 2001). The management of capsular lacerations is also controversial; repair may predispose to pancreatic pseudocyst (Tan et al, 2009).

Grade III

Transection of the pancreatic duct in the neck or body of the gland (*Figure 1a* and *Figure 2*), whether overt or suspected, may be managed with drainage alone (Rickard et al, 2005), but most centres advocate distal pancreatectomy (Vasquez et al, 2001; Thomas et al, 2009). Resection of the body and tail of pancreas is a safe, reliable and quick procedure which seldom results in pancreatic insufficiency. Pancreatic fistula can be anticipated in 15% of patients with distal pancreatectomy irrespective of the technique of parenchymal or ductal closure, but it will almost always dry up spontaneously (Bulger and Jurkovich, 2000).

Grade IV

Grade IV injuries (*Figure 1b*) are difficult to manage and should be treated by distal resection, when feasible, or by drainage alone. Patients may benefit from endoscopic retrograde cholangiopancreatography and possible stenting of the pancreatic duct (Thomas et al, 2009). Most grade IV injuries can be managed by distal or subtotal pancreatectomy because the ampulla is not involved (Bulger and Jurkovich, 2000; Tan et al, 2009). In very special circumstances – resection of more than 80% of the pancreas is likely to cause diabetes – preservation of the distal pancreas and internal drainage by Roux-en-Y jejunal anastomosis should be considered. Alternatively, either pancreatojejunostomy or pancreatoduodenectomy may be indicated in these unusual cases.

Grade V

Grade V injuries involve major destruction and devascularization of the pancreatic head (*Figure 1c*) with ampullary and ductal involvement (Bulger and Jurkovich,

Table 1. Pancreas organ injury scale

Grade	Type	Description
I	Haematoma	Minor contusion without duct injury
	Laceration	Superficial laceration without duct injury
II	Haematoma	Major contusion without duct injury or tissue loss
	Laceration	Major tissue laceration without duct injury
III	Laceration	Distal transection of parenchyma
IV	Laceration	Proximal transection of parenchyma
V	Laceration	Massive disruption of pancreatic head

From Moore et al (1990)

Table 2. Duodenal organ injury scale

Grade	Type	Description
I	Haematoma	Involving single portion of duodenum
	Laceration	Partial thickness, no perforation
II	Haematoma	Involving more than one portion
	Laceration	Disruption of <50% of circumference
III	Laceration	Disruption of 50–75% of D2 Disruption of 50–100% of D1, DD3, D4
IV	Laceration	Disruption of >75% D2 Involving ampulla or common bile duct
V	Laceration	Massive disruption of duodenopancreatic complex
	Vascular	Devascularization of duodenum

From Moore et al (1990)

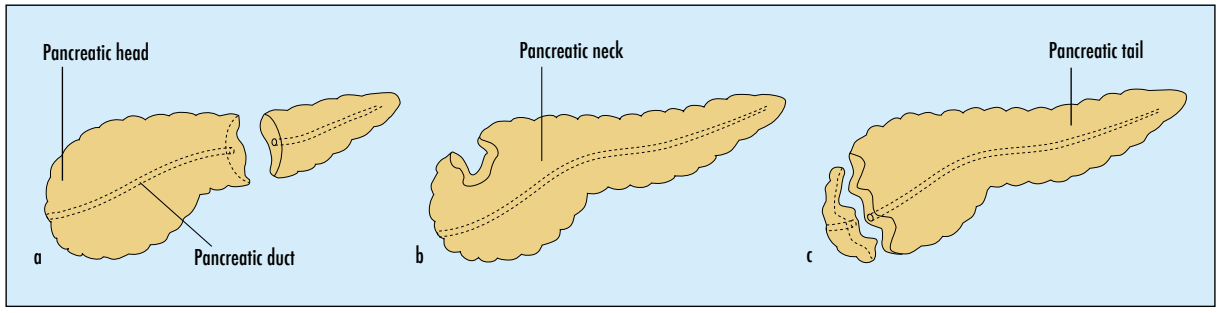


Figure 1. Pancreatic injuries. a. Grade III pancreatic injury (distal transection of parenchyma). b. Grade IV (proximal transection of parenchyma). c. Grade V (massive disruption of pancreatic head).

2000). Definitive management of these exceptional injuries requires pancreatoduodenectomy, which can be regarded as debridement of devitalized tissue (Rickard et al, 2005). Because such extensive injuries are usually associated with other life-threatening trauma, a major pancreatic resection is generally best avoided in favour of a lesser undertaking. A damage control approach with extensive peripancreatic drainage and primary repair of the duodenum is indicated in critically ill patients, with a second procedure performed after a period of resuscitation on intensive care (Vasquez et al, 2001). Rapid control of the situation can be obtained by transection of the duodenum distal to the pylorus, transection of the common bile duct with intubation to the exterior, pancreatic transection and distal duodenal transection (Gupta et al, 2008).

A second-stage operation can then reassess and deal with pancreatic damage in patients who survive (Tan et al, 2009). A traditional reconstruction – pancreatojejunostomy, choledochojejunostomy and retrocolic gastrojejunostomy – or a pylorus-sparing procedure can restore continuity of the digestive system. A biliary stent (across the biliary anastomosis) is recommended in addition to a feeding jejunostomy (Bulger and Jurkovich, 2000).

Duodenal trauma: operative management

Minor injuries (grade I–II)

Conservative management of minor duodenal injuries has a failure rate of approximately 10% (Velmahos et al, 2009). Intramural haematomas should be left alone if there are no signs of perforation or likely luminal obstruction, as haematoma evacuation increases the likelihood of perforation (Chen and Yang, 2011). Lacerations of less than 50% of the duodenal circumference should be debrided and closed primarily (Rickard et al, 2005). Full-thickness injuries can be primarily closed in a two-layer fashion; an omental buttress can be used to augment a tenuous repair (Britt, 2000).

Grade III

By definition, grade III duodenal injuries involve laceration of more than 50% of the circumference. The extent of this laceration needs to be considered when undertaking repair: primary closure of the defect should be attempted, but it may narrow the lumen or result in undue tension on the suture line (resulting in wound breakdown). Extensive duodenal mobilization can decrease such tension. Alternatively, a Roux-en-Y jejunal loop anastomosis (*Figure 3*) may be useful to close the defect, with oversewing of the distal duodenum (Britt, 2000). As a further alternative, segmental resection can be undertaken with primary end-to-end duodenoduodenostomy if there is only a small amount of duodenum involved (Chen and Yang, 2011). The diversion of gastric juice is subject to debate; some surgeons will choose pyloric exclusion (cross stapling the pylorus), while others suggest that nasogastric or gastrostomy tube drainage is sufficient to protect the anastomosis. Given the drive towards simplistic, quick operations in a patient with multiple trauma, simple nasogastric intubation alone may be the best option (Rickard et al, 2005).

Major duodenal injuries pose a difficult problem even if they do not involve the ampulla of Vater. Duodenal diverticulization (*Figure 4*) entails closure of the duodenal injury, gastric antrectomy with end-to-side gastrojejunectomy, tube duodenostomy and generous drainage (Snyder et al, 1980; Chen and Yang, 2011). This major procedure may be unsuitable in unstable patients, so many centres have discarded it (Rickard et al, 2005). Damage control surgery is quicker and safer in such circumstances. It comprises adequate debridement, primary closure, extensive drainage and feeding jejunostomy.

Figure 2. Computed tomography showing partial transection of pancreatic neck, with a cyst anteriorly (note drain in situ laterally).

Major injuries (grades IV–V)

Major duodenal injuries are associated with a high risk of severe complications and death (Britt, 2000; Rickard et al, 2005). Fortunately they are rare: only 3% of duodenal injuries involve the papilla (Snyder et al, 1980), and only 10% of duodenal injuries necessitate a pancreatoduodenectomy (Bulger and Jurkovich, 2000). Proximal pancreatoduodenectomy should be considered if the patient has either massive peripancreatic haemorrhage or injury to the proximal pancreatic duct or ampulla that precludes the possibility of reconstruction (Chen and Yang, 2011).

According to principles of damage control surgery, the duodenal injury is simply trimmed and oversewn at each end, with definitive repair postponed to a planned reoperation (Rickard et al, 2005). Major reconstruction is clearly contraindicated in unstable patients. It is better to just close gross duodenal wall defects to prevent soiling, place large-bore drains and control haemorrhage. The patient is then transferred to intensive care for appropriate resuscitation before returning to theatre for definitive surgery.

Figure 3. Roux loop anastomosis covering duodenal injury.

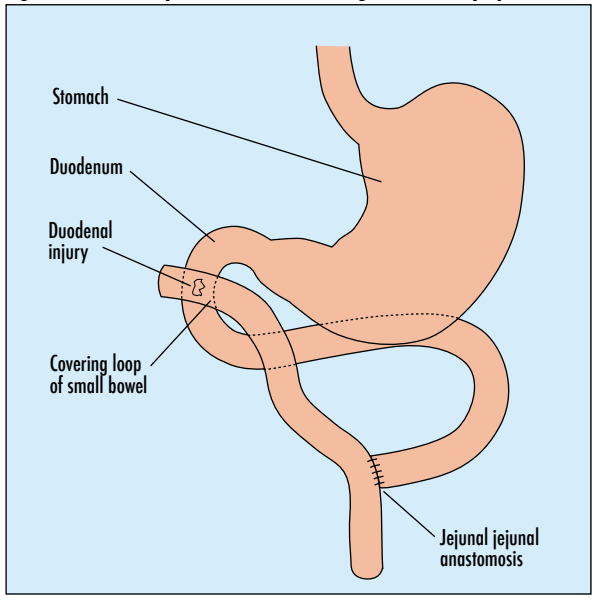
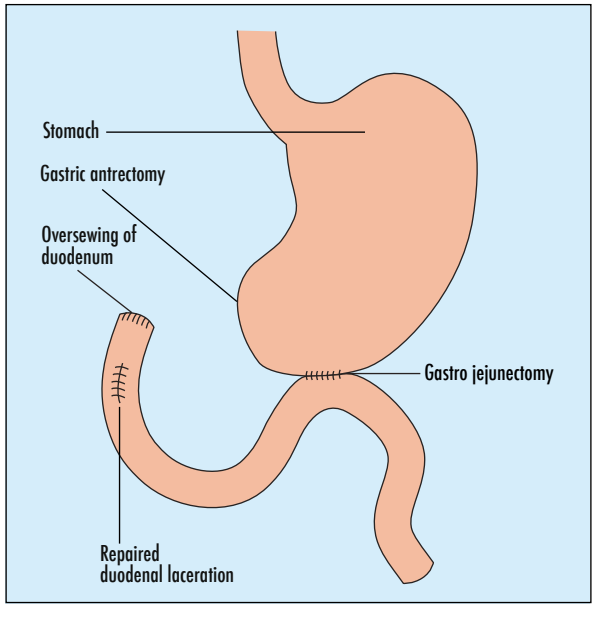


Figure 4. Duodenal diverticulization.



Postoperative complications

Not surprisingly, the frequency of complications relates to the severity of the organ injury. Postoperative complications are common: pancreatic trauma is associated with rates of up to 50% and duodenal trauma with rates of 20% (Allen et al, 1998; Recinos et al, 2009). Most complications are self-limiting and can be treated conservatively (Bulger and Jurkovich, 2000). A high index of suspicion is required to detect complications and judicious use of further radiological and endoscopic investigations is required.

Pancreas-related complications

Postoperative problems often reflect missed injury to the pancreatic duct. Thus, there should be a low threshold for performing an endoscopic retrograde cholangiopancreatography or magnetic resonance cholangiopancreatography (Thomas et al, 2009). Routine use of the somatostatin analogue octreotide may decrease the incidence of complications in pancreatic trauma (Amirata et al, 1994), although this is disputed (Nwariaku et al, 1995). The commonest pancreatic complication is an external fistula, with an incidence ranging from 5–38% (Recinos et al, 2009). Fistulas may settle spontaneously, with or without octreotide, but otherwise endoscopic retrograde cholangiopancreatography or reoperation may be needed after 4 weeks (Campbell and Kennedy, 1980). Intra-abdominal abscesses occur in up to one third of patients (Bulger and Jurkovich, 2000; Vasquez et al, 2001); unless they respond to antibiotics, radiological or operative drainage is required. Pancreatic pseudocysts have an incidence of about 5% and may follow an overlooked ductal rupture (Vasquez et al, 2001). If possible, 6 weeks should be allowed for the cyst to mature before drainage, whether percutaneous, endoscopic or operative (Thomas et al, 2009).

Postoperative pancreatitis should be managed conservatively. If these measures fail reoperation and placement of further wide-bore suction drains should be instituted (Campbell and Kennedy, 1980). Secondary haemorrhage is a very serious complication. It is often the result of intense pancreatitis, with a reported incidence of between 2.3 and 8.5% (Recinos et al, 2009). Little can be achieved by further operation, and it is has a high mortality rate.

Duodenum-related complications

Duodenal fistula is the commonest complication, with an incidence of 7% (Velmahos et al, 2009). Unless the fistula settles with conservative management, operative intervention is required. Other complications include intra-abdominal abscess, pancreatitis, duodenal obstruction and bile duct fistula (Allen et al, 1998). Endoscopy plays a useful role in managing duodenal or biliary stenosis, but again operative intervention may be required.

Missed pancreatoduodenal injuries

Pancreas

Missed pancreatic injuries may not be noted until some weeks or even months after the initial trauma. Conditions associated with unrecognized pancreatic injury include chronic pancreatitis, pancreatic fistula, late abscess and pseudocyst (Kao et al, 2003; Rickard et al, 2005). A thorough history of trauma should be sought in patients presenting with any of these conditions. Up to 30% of undetected pancreatic injuries are associated with pseudocyst formation; persistent pseudocysts should be drained to avoid haemorrhage, perforation, infection, or obstruction of the duodenum or bile duct (Lin et al, 2007).

Duodenal

Missed duodenal injuries tend to present sooner than missed pancreatic injuries. They can be picked up either at repeat computed tomography scanning (assessing patient deterioration) or at repeat laparotomy for management of associated injuries (Velmahos et al, 2009). Persistent contamination arising from a missed or delayed duodenal leak probably has a negative impact on patient survival (Allen et al, 1998).

Conclusions

Although uncommon, pancreatoduodenal injuries are often only detected at laparotomy and thus initially managed by general surgeons. The management of these injuries is frequently multimodal and there has been a paradigm shift from complex restorative surgery to simple damage control procedures. This allows for shorter operative intervention followed by resuscitation in the intensive care unit. Patients need to be managed in a team culture with input from surgeons, intensivists, radiologists and endoscopists, supported by specialist nursing staff and other allied health professionals. Involvement by pancreatic surgeons at the earliest opportunity should be encouraged in the management of these complex injuries. BJHM

Conflict of interest: none.

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KEY POINTS

- Pancreatoduodenal injuries are uncommon and often associated with injuries to multiple other intra-abdominal organs; management depends on the severity of injuries and the stability of the patient.
- Computed tomography and pancreatic ductography are the mainstays of investigation, although a substantial proportion of injuries are detected at trauma laparotomy.
- When pancreatoduodenal injuries are detected preoperatively they should be discussed with a specialist centre; those detected at laparotomy should be managed with simple techniques and damage control surgery – definitive intervention should be deferred until the patient is more stable.