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Editorial

Operative strategies in pancreatic trauma – keep it safe and simple

Injuries to the pancreas are infrequently encountered in surgical practice but may result in substantial morbidity and mortality if pancreatic, visceral vascular and adjacent organ injuries occur in combination.[1-4] Recent data indicate a rising incidence of pancreatic trauma owing to high-speed car accidents and an escalation in civil violence involving increasingly dangerous weapons.[1-4] In South African and North American cities, penetrating abdominal injuries from gunshot wounds are the most common cause of pancreatic trauma, while in Western Europe, England and Australia, traffic accidents predominate.[4-7] The mechanism of injury dictates intervention. After penetrating injuries, the diagnosis is usually established at laparotomy, while in those who have sustained blunt polytrauma, pancreatic injuries are generally detected by radiological investigations, allowing some patients to be managed without recourse to surgery. This geographical variation in aetiology and the difference in investigative approach results in considerable disparity in the reported severity and spectrum of pancreatic injuries.[1,4,5]

The unique anatomic features of the pancreas influence the site and type of injury while the proximity of major vascular structures and surrounding viscera compounds the complexity of injury management. Severe blunt and penetrating abdominal trauma invariably damages adjacent organs, including liver, spleen, duodenum and colon. Isolated pancreatic injuries, though rare, pose specific problems in diagnosis and management owing to the lack of overt clinical signs. Ultimately, the outcome of a pancreatic injury is influenced by the cause and complexity of the specific injury, the amount of blood lost, duration of shock, speed and adequacy of resuscitation, number of associated injuries, and the quality and magnitude of surgical intervention.[8-10] The unforgiving nature of complex pancreatic injuries results in substantial mortality rates, and most patients who die from a pancreatic injury do so within the first 48 hours of injury owing to uncontrolled bleeding from associated vascular or major adjacent organ injuries.[1-4] Late mortality is generally the result of persistent intra-abdominal infection or multiple organ failure. Neglect of a main pancreatic duct injury invariably leads to major complications that include pseudocysts, fistulae, sepsis and secondary haemorrhage.[4,5,10-13]

Comparisons between various forms of treatment are often difficult to analyse, as pancreatic injuries are infrequent and there are wide variations in reported morbidity and mortality rates.[1,4] These discrepancies are influenced by cohort bias owing to small sample sizes and underpowered studies from some centres that lack structured injury protocols and standardised management planning, compared with high-volume trauma centres that have established protocols and prospective documentation of perioperative outcomes. Most studies include all patients with pancreatic injuries without distinguishing between blunt and penetrating pancreatic injuries, which invariably skews outcome and interpretation. Other reports do not consistently divide complications into those involving the pancreas and those resulting from associated injuries. These inconsistencies have led to widely disparate and incongruent results. A wide variety of pancreatic injury severity grades exist, and their prime use is for comparative epidemiological studies of outcome. There is still no concise and universally accepted classification system that predicts the outcome of pancreatic injuries and allows the formulation of a rational management plan for the individual. Optimal intervention is further hampered by the persisting description of a raft of different surgical techniques, some of which have survived transcription from outdated sources and are now wholly inappropriate and should be expunged from the surgical lexicon. It is not surprising, therefore, that the neophyte surgeon, battling in the trenches to understand the concepts and apply logical treatment principles to pancreatic injuries through the fog of perpetuated myth and misinformation, should be bewildered by the plethora of recommended options, some of which are obsolete and others unsubstantiated.

Major injuries to the pancreas remain among the most complex challenges that a trauma surgeon or a general surgeon with a trauma practice are likely to encounter. Successful treatment of complex injuries to the pancreas depends largely on initial correct assessment and appropriate treatment. The gravity of major pancreatic injuries and the resultant potentially serious complications necessitate a clear surgical strategy with a comprehensive and multidisciplinary approach to the management of complications.[4] The principles of optimal management of pancreatic trauma include the need for early diagnosis and accurate definition of the site and extent of injury.[3,4,14] Serious sequelae result if the injury is underestimated or inappropriately treated.[3,4] The treatment of combined injuries to the pancreas and duodenum is complex, especially where devitalised tissue and associated damage to contiguous vital structures including the bile duct, portal vein, vena cava, aorta or colon are present.[10,15]

In most patients with abdominal stab or bullet wounds, the diagnosis of a pancreatic injury is made at laparotomy.[2,4] In those patients who have complex pancreatic injuries and are haemodynamically unstable owing to multiple organ or major vascular injuries, a damage control approach should be employed with control of bleeding and contamination. In stable patients, determining the presence and extent of a pancreatic injury intra-operatively requires recognition of the features indicating a potential pancreatic injury, adequate exposure of the pancreas, definition of the integrity of the pancreatic parenchyma, and determination of the status of the pancreatic duct.[1,3] Minor contusions or lacerations of the pancreatic parenchyma do not require further treatment, but this decision should only be made after careful local exploration to exclude a major duct injury. Gross inspection and palpation of the pancreas alone may be misleading, because retroperitoneal or subcapsular haematomas or peripancreatic oedema may mask major parenchymal and ductal injuries.[4] Clues suggesting the presence of

a pancreatic injury include a lesser sac fluid collection, retroperitoneal bile-staining, and crepitus or haematoma overlying the pancreas at the base of the transverse mesocolon or visible through the gastrohepatic ligament. Fat necrosis of the omentum or retroperitoneum may be present if there has been undue delay before laparotomy. With these findings, complete visualisation of the gland and accurate determination of the integrity of the pancreatic duct is crucial, remembering that failure to recognise a major pancreatic duct injury is the principal cause of postoperative morbidity.

To fully assess the pancreas, the lesser sac is entered through the gastrocolic omentum outside the gastroepiploic arcade[4] and, by retracting the transverse colon inferiorly and the stomach superiorly, exposure of the anterior surface and the superior and inferior borders of the body and tail of the pancreas is obtained. Surrounding haematoma may complicate adequate assessment of the body and tail, and further detailed evaluation may require division of the lateral peritoneal attachments. If necessary, the spleen, tail and body of the pancreas can be reflected forwards and medially by developing a plane between the kidney and the pancreas. This manoeuvre allows full exposure and access for bimanual palpation of the tail and body of the pancreas. Findings that indicate an obvious main duct injury are a transected pancreas and a visible duct injury. In addition, other intra-operative features suggesting a major pancreatic duct injury include a laceration involving more than half of the width of the pancreas or a large central perforation.[15]

Intra-operative evaluation of the head of the pancreas includes assessment of the integrity of the main pancreatic duct, and must establish whether the pancreatic head or duodenum are devitalised, the presence and extent of duodenal injury, whether the ampulla is disrupted, if the bile duct is intact, and whether an adjacent vascular injury has occurred. To provide the access for detailed inspection of the pancreatic head and uncinate process, both an extensive Kocher manoeuvre to mobilise the second part of the duodenum medially toward the superior mesenteric vessels and, if necessary, complete mobilisation at the ligament of Treitz are required.[1,2,4] Dissection and inferior reflection of the hepatic flexure of the colon and the right transverse mesocolon further improve exposure of the second portion of the duodenum and uncinate process.[4] All penetrating wounds should be traced through their entire intra-abdominal course to exclude an unsuspected pancreatic or other visceral injury.[3,4]

Intra-operative radiological techniques pose logistic difficulties in acute abdominal trauma surgery and are entirely inappropriate in a damage-control situation. Several radiological methods of intra-operative evaluation of the biliary and pancreatic ducts have been touted and, if applicable, should only be considered in the stable patient. A cholangiogram is the easiest to perform. A 25-gauge butterfly needle is inserted into the common bile duct and 10 ml full-strength iodinated contrast injected under fluoroscopic control. The image obtained may demonstrate biliary integrity and exclude an injury to the intrapancreatic portion of the bile duct, but seldom provides reliable information regarding the state of the ampulla or the pancreatic duct. In severe disruptive injuries with an associated duodenal injury, the papilla may be conveniently accessible and visible. A firm squeeze of the gallbladder produces bile at the ampulla, confirming its continuity.[4] A fine lacrimal probe passed through the papilla into the pancreatic duct in the neck may provide sufficient information by demonstrating the position of an intact duct to be away from the site or direction of a penetrating pancreatic parenchymal injury. Equally, a 5Fr paediatric feeding tube can be used for operative pancreatography by cannulating the ampulla of Vater. A separate duodenotomy or a distal pancreatic resection to obtain a prograde pancreatogram are never indicated. An endoscopic retrograde cholangiopancreatography (ERCP) can be performed intra-operatively but, even in well-equipped units, implementation is demanding and complicated.

Ultimately, 70% of pancreatic injuries are minor grade 1 injuries and include contusions, haematomas and superficial capsular lacerations without underlying major ductal injury. Control of bleeding and simple external drainage without repair of capsular lacerations is sufficient treatment. A closed silastic suction drain is used as pancreatic secretions are thus more effectively controlled, skin excoriation at the drain exit site is reduced, and bacterial colonisation is diminished. In this context, even if a fistula develops, it can be managed conservatively.

Grade 2 injuries to the body or tail of the pancreas with major lacerations or transections and associated pancreatic duct injury are best treated by distal pancreatectomy. In the context of firearm wounds injuring the pancreas to the left of the portal vein complex, a splenectomy is usually necessary but, in the young where the risk of overwhelming post-splenectomy infection (OPSI) is substantial and the injury isolated, time can be taken to preserve the spleen by dissecting the splenic vein from the back of the pancreas. Isolated injuries following blunt trauma, with complete transection at the neck, identified pre-operatively, can be safely managed by a pancreatic-enteric anastomosis as a planned procedure, provided the surgeon is experienced.[16,17] This preserves a large volume of pancreatic parenchyma and does not require a tedious dissection of the splenic vein in its entirety and carries no greater risk of a fistula than resection. Optimal management of the divided pancreatic duct and the resection margin after distal pancreatectomy remains controversial, as most series report a 15% pancreatic fistula rate. Some surgeons have advocated the use of a Roux-en-Y pancreatojejunostomy to incorporate and drain the resection margin to reduce this risk.[5] Even in patients without multiple injuries, the added risk of an anastomotic leak is not warranted, and this procedure is *not* recommended. A visible pancreatic duct at the resection margin should be ligated with a transfixing suture. Oversewing or stapling the transected end of the pancreas and using simple methods to buttress or seal the cut margin are sufficient, and have not led to increased fistula formation.

Grade 3 injuries to the head of the pancreas are best managed by simple external drainage. Even if there is a suspected isolated pancreatic duct injury (as may occur with a localised penetrating injury), external drainage of the injured area is often the safest option, provided there is no devitalisation and the ampulla is intact. A controlled fistula so created either resolves spontaneously or may later require elective internal drainage after definition of the exact site of duct leakage. The use of Roux-en-Y loop anastomoses to incorporate an injured area in the head of the pancreas is illogical and is to be condemned because of the difficulty in assuring the integrity of the anastomosis in the acute situation.

Severe combined grade 4 pancreatic head and duodenal injuries are uncommon, and usually result from gunshot wounds or blunt trauma, often with other associated intra-abdominal injuries. If,

on thorough exploration as outlined, the common bile duct and ampulla are shown to be intact, the duodenal laceration is repaired and the pancreatic injury treated according to the site of the injury. As with grade 3 injuries, division or damage to the main pancreatic duct and parenchyma near the junction of head and neck are optimally managed by resection of the neck, body and tail. Penetrating injury in the pancreatic head without devitalisation is best treated by effective drainage. Localised ischaemia at the site of the duodenal injury should be debrided before primary duodenal closure. If there is concern about the integrity of the duodenum, decompression using a carefully placed nasogastric tube in the duodenal loop is useful.

Some authors have advised diversion of gastric and biliary contents away from the duodenal repair with severe injuries to the duodenum in association with a lesser pancreatic head injury. The aim is to convert a potentially uncontrolled lateral duodenal fistula into a controlled end-fistula by diversion of gastric and biliary contents away from the duodenal injury, while making provision for early enteral nutrition via a gastrojejunostomy. Duodenal 'diverticulisation' is the most radical of these procedures with primary closure of the duodenal wound, a vagotomy, an antrectomy with an end-to-side gastrojejunostomy, T-tube common bile duct drainage, and a tube duodenostomy. There is no evidence that this approach is necessary, and it is now of historical interest only. The lesser option, which avoids a vagotomy and antrectomy with less long term physiological disturbance, is the 'pyloric exclusion' procedure. The pylorus is closed with an absorbable suture performed through a gastrotomy, and a side-to-side gastrojejunostomy provides temporary diversion of gastric flow away from the duodenum while the duodenal and pancreatic injuries heal. The pylorus opens when the sutures dissolve 3 or 4 weeks later, or the sutures can be removed endoscopically after an intact duodenum has been confirmed. As with its more radical predecessor, there is little evidence of its efficacy, though some authors recommend it. In our view, the same objectives can be achieved by less complex procedures and, in this situation, primary duodenal closure, external catheter drainage near the site of the repair, a diverting gastrojejunostomy without closure of the pylorus, and a fine-bore silastic nasojejunal feeding tube can be used without escalating the magnitude of the operation, particularly with intravenous proton pump inhibitors and octreotide to reduce the volume of secretions. Temporary endoscopic stenting with a covered duodenal stent allows control of high-output traumatic duodenal fistula during healing.[18]

Reconstruction may not be possible in some combined injuries of the proximal duodenum and head of the pancreas that have extensive tissue devitalisation with complete disruption of the ampulla involving the proximal pancreatic duct and distal common bile duct, or avulsion of the duodenum from the pancreas. Since associated major vascular injuries are frequent, massive blood loss, coagulopathy and hypothermia are often present when the pancreatic repair is undertaken. Damage control surgery is an essential strategy when complex pancreatic trauma is aggravated by coagulopathy, hypothermia and acidosis. The core principles include an abbreviated laparotomy with rapid control of intra-abdominal bleeding, closure of visceral perforations and urgent transfer to a high-dependency unit for invasive monitoring, cardiopulmonary support, aggressive rewarming and rapid volume, blood and clotting factor replacement to correct coagulopathy, acid-base imbalance and hypothermia.

The need for pancreatic head resection is usually obvious at first operation when there is massive destruction with gross devitalisation of the duodenum, or pancreatobiliary, duodenal and ampullary disruption is present.[19] Blunt trauma may result in a near-complete *de facto* pancreaticoduodenectomy. The circumstances are seldom ideal for a major proximal resection, and the procedure may intially have to be staged with definitive reconstruction taking place during a subsequent relook operation. Specific indications that have been proposed for pancreaticoduodenectomy for trauma are: (*i*) extensive devitalisation of the head of the pancreas and duodenum so that reconstruction is not possible, (*ii*) ductal disruption of the pancreatic head in association with injuries to the duodenum and distal common bile duct, (*iii*) injury to the ampulla of Vater, with disruption of the main pancreatic duct from the duodenum, (*iv*) uncontrollable bleeding from vessels in the head of the pancreas, and (*v*) inaccessible exsanguinating retropancreatic portal or superior mesenteric vein injury.[19]

After a pancreaticoduodenectomy for trauma either as a primary or a staged procedure, technical problems in the reconstruction of pancreatic and biliary anastomoses may arise, owing to the small size of the undilated ducts and jejunal oedema.[19] The parenchyma of the pancreatic remnant is also frequently swollen, particularly if there has been a delay between the injury and the operation. The pancreatic duct may also be small or obscured if posteriorly located in the gland. Invagination of the end of the pancreas into a Roux-en-Y jejunal loop has been the most widely used pancreatic-enteric anastomosis. Pancreatogastrostomy has also been used in this situation, with minimal morbidity.[17] Biliary-enteric continuity is commonly restored by means of a side-to-side hepaticojejunostomy, using the high bile duct reconstruction technique with preplaced sutures. In desperate situations with a minute common bile duct, the gall bladder can be used for the anastomosis, after ligating the bile duct below the cystic duct insertion.

Owing to the unplanned nature of the surgery, it is not surprising that pancreatic complications are common. Missed or underestimated injuries may present early with a pancreatic fistula or later with a pseudocyst. In addition, resectional and anastomotic complications are not uncommon. These pancreatic complications need accurate delineation and management by a multidisciplinary team who have the interventional ERCP and radiological skills to allow management without recourse to open surgery. Nutritional support is important as complicated pancreatic injuries often have a prolonged catabolic and septic course. A variety of nutritional strategies may be appropriate. These include a selection of enteral nutritional delivery techniques and nutritional formulas to improve the patient's condition and maintain homeostasis while the fistula closes spontaneously.

In contemporary practice, most pancreatic injuries encountered are minor and can be treated by external drainage.[1] In penetrating trauma, the most common major injury involves the body and tail, which requires a distal pancreatectomy.[14] Pancreatic injuries after blunt trauma usually result in a prevertebral laceration of the neck of the pancreas. These injuries may occur as part of an associated injury complex or may be an isolated injury; the former, as with penetrating trauma, can be managed by distal pancreatic resection, but in the latter a duct enteric anastomosis is a viable option in

selected patients. Pancreaticoduodenectomy is reserved for severe injuries to the head of the pancreas and duodenum in which salvage or reconstruction is not feasible, provided the patient's condition is stable. If unstable, a damage control operation is a prudent option, allowing delay of the definitive procedure until the patient is stable. With careful assessment of the injury by intra-operative evaluation, most pancreatic injuries can be managed by either drainage or distal resection without the need for complex, enteric diversions or pancreatico-enteric anastomoses as a primary procedure during the acute injury in patients with multiple associated injuries. The modern management of major pancreatic injuries requires multidisciplinary treatment with trauma and pancreatic surgeons, interventional radiologists and intensivists working in tandem in patients who have complex injuries and considerable postoperative morbidity.

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