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Pancreatic injuries after blunt abdominal trauma: An analysis of 110 patients treated at a level 1 trauma centre

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Summary

Background and objective. Injuries to the pancreas are uncommon, but may result in considerable morbidity and mortality. This study evaluated the management of blunt pancreatic injuries using a previously defined protocol to determine which factors predicted morbidity and mortality.

Methods. The study design was a retrospective chart review of all adult patients with blunt pancreatic injuries treated at a level 1 trauma centre between March 1981 and June 2009.

Results. One hundred and ten patients (92 men, 18 women; mean age 30 years, range 13 - 68 years) were treated during the study period. Forty-six patients had American Association for the Surgery of Trauma (AAST) grade 1 or 2 pancreatic injuries and 64 had AAST grade 3, 4 or 5 pancreatic injuries. Injuries involved the head (*N*=21), neck (*N*=15), body (*N*=48) and tail (*N*=26) of the pancreas. The mean number of organs injured was 2.7 per patient (range 1 - 4). One hundred and one patients underwent a total of 123 operations, including drainage of the pancreatic injury (*N*=73), distal pancreatectomy (*N*=39) and Whipple resection (*N*=5). The overall complication rate was 74.5% and the mortality rate 16.4%. Only 2 of the 18 deaths were attributable to the pancreatic injury. Shock on presentation was highly predictive of death; 17 of 39 patients with shock died, compared with 1 of 71 patients who were not shocked ($p<0.0001$). Fourteen of 46 patients with grade 1 and 2 pancreatic injuries died compared with 4 of 64 patients with grades 3, 4 and 5 injuries ($p<0.001$). Mortality increased exponentially as the number of associated injuries increased. Two of 57 patients with injury to the pancreas only or one associated injury died, compared with 16 of 53 with two or more associated injuries ($p<0.0013$).

Conclusions. This study demonstrated a significant correlation between the AAST grade of injury and pancreas-specific morbidity and between shock on admission, the number of associated injuries and death, in patients with blunt pancreatic injuries. Although morbidity and mortality rates after blunt pancreatic trauma are high, death was usually the result of major associated injuries and not related to the pancreatic injury.

Injuries to the pancreas are uncommon, but may result in considerable morbidity and mortality due to associated organ injury.[1-4] Prognosis is influenced by the complexity of the pancreatic injury, the amount of blood lost, the duration of shock, the speed of resuscitation and the quality and nature of surgical intervention.[5-7] Major injuries to contiguous organs, including liver, bile ducts, duodenum, vena cava and superior mesenteric and portal veins, in severe blunt injuries to the pancreatic head exponentially increase the complexity of operative intervention. Early death is usually the result of substantial blood loss from associated vascular injuries or severe adjacent organ injuries.[5,8,9] Late mortality is generally a consequence of infection or multiple organ failure. Neglect of a main pancreatic duct injury leads to major complications including pseudocysts, fistulas, sepsis and secondary haemorrhage.[1-3,5,6,9]

Few large series specifically addressing the treatment of blunt pancreatic trauma have been published.[10-15] The aim of this study was to evaluate the management of blunt pancreatic trauma treated at a major trauma centre using a previously defined protocol to determine which factors predicted morbidity and mortality in patients with blunt pancreatic injuries.

Patients and methods

The study was a retrospective review of the medical records of all adult patients who had sustained a blunt pancreatic injury between March 1981 and June 2009 and had been treated at the level 1 trauma centre or the Hepatopancreatobiliary and Surgical Gastroenterology units at Groote Schuur Hospital, Cape Town, or had received their initial treatment elsewhere and been referred with a complex pancreatic injury or a complication related to the injury. The data recorded for each patient used a specifically designed binary and narrative form comprising 60 items with 54 data fields. Data included demographic information, mechanism of injury, trauma indices scores, presence of shock on admission, anatomical location and grade of the pancreatic injury, associated intra- and extra-abdominal injuries, injury-to-operation interval, surgical procedure used, duration of hospital stay, presence and type of pancreas-related and other complications, and mortality.

In order to stratify the severity of the pancreatic injuries for analysis, all pancreatic injuries were graded according to the pancreatic organ injury scale proposed by the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (AAST), as shown in Table I.[15] Shock was defined as a systolic blood pressure less than 90 mmHg measured on admission to hospital. Pancreas-specific complications (PSCs) and pancreas-specific mortality (PSM) were defined as complications and deaths solely attributable to the pancreatic injury. Postoperative morbidity was divided into three categories: patients with pancreatic-specific complications, those with non-pancreatic abdominal complications, and those with systemic complications. Pseudocysts were diagnosed on computed tomography (CT) scan and pancreatic fistulas were defined as drainage of amylase-rich fluid (amylase >3 times normal) that persisted postoperatively for more than 7 days.

Initial resuscitation was according to Advanced Trauma Life Support protocol guidelines. Urgent surgery was performed in patients who had an acute abdomen with signs of peritonitis or evidence of major intra-abdominal bleeding, or those in whom there was clinical suspicion of a major pancreatic injury. In patients who were initially managed conservatively, surgery was performed promptly if there was evidence of clinical deterioration or increasing abdominal tenderness.

In stable patients who did not require emergency surgery, specific investigations included abdominal ultrasonography (US) and CT. Endoscopic retrograde cholangiopancreatography (ERCP), and magnetic resonance imaging (MRI) and cholangiopancreatography (MRCP) were performed selectively in stable patients who had possible pancreatic duct injuries or presented late with evidence of a complication related to a pancreatic injury such as a pseudocyst or a fistula.

Operative management of pancreatic injury

The operative management of the pancreatic injury was based on the haemodynamic stability of the patient, the magnitude and extent of associated injuries, and the location and severity of the pancreatic injury. Management of specific pancreatic injuries was according to an established protocol that has been published previously.[4] In brief, the principles applied were urgent control of bleeding using packing and sutures, closure of visceral perforations to prevent contamination of the peritoneal cavity, and rapid volume replacement to correct acidosis, coagulopathy and hypothermia. Minor lacerations of the body and tail of the pancreas remote from the pancreatic duct without visible duct damage were managed by external drainage. Major lacerations of the body or tail of the pancreas with evidence of a probable duct injury were treated with distal pancreatectomy. Injuries to the head of the pancreas without devitalisation of pancreatic tissue were managed by external drainage. Pancreatoduodenectomy was restricted to stable patients with disruption of the ampulla of Vater or major devitalising injuries of the pancreatic head and duodenum.[4,9] Unstable patients who had destruction of the head of the pancreas underwent an initial damage control procedure before the definitive Whipple resection. All pancreatic injuries were drained using closed Silastic suction drains. Selected patients had intra-operative cholangiography either through the cystic duct or direct via a butterfly needle in the common bile duct. Intra-operative retrograde pancreatography was used when the second part of the duodenum was injured and the papilla exposed.

Data analysis

The data were analysed using Stata, a statistical software programme (Stata Corp 2003, Release 8, College Station, TX: StataCorp LP). Continuous variables were compared using Student's *t*-test, and univariate analysis of categorical variables was performed by using Fisher's exact test or a chi-square test with Yates' correction, as indicated; $p<0.05$ was considered statistically significant.

Results

Patient characteristics and mechanism of injury:

One hundred and ten patients (92 men (83.6%), 18 women (16.4%), mean age 30 years, range 13 - 68 years) were treated for blunt pancreatic injuries during the study period. Motor vehicle accidents (MVAs) were the commonest mechanism of injury (65 patients, 42 of whom were pedestrians). Of the motor vehicle-related injuries, 14 were sustained by unrestrained drivers due to impact with the steering wheel and 6 by unrestrained passengers. Blunt assault (a blow or kick to the epigastrium) caused the pancreatic injury in 34 patients, 3 men had fallen from heights, 2 patients sustained polytrauma on being struck by a train, and 2 youths had been injured by bicycle handle bars. Sports injuries occurred in 4 patients: 2 schoolboy goalkeepers each sustained a fracture of the neck of pancreas when kicked during a soccer game, a university student had a pancreatic duct injury after a rugby tackle, and a schoolboy had a pancreatic injury after a go-cart accident.

TABLE I. AAST CLASSIFICATION OF PANCREATIC TRAUMA

Grade	Injury	Description of the pancreatic injury
I	**Haematoma**	**Mild contusion without duct injury**
	Laceration	**Superficial laceration without duct injury**
II	**Haematoma**	**Major contusion without duct injury**
	Laceration	**Major laceration without duct injury or tissue loss**
III	**Laceration**	**Distal transection or parenchymal injury with duct injury**
IV	**Laceration**	**Proximal transection or parenchymal injury involving ampulla**
V	**Laceration**	**Massive disruption of the pancreatic head**

Thirty-nine patients (35.5%) were hypotensive on admission to hospital despite volume resuscitation by paramedical staff while in transit. The median delay from the time of the injury to hospital admission for acute injuries was 1.5 hours (range 0.5 - 18 hours); the longer delays occurred in patients who were distant referrals.

Diagnosis, investigations and initial management

One hundred and one (91.8%) of the 110 patients underwent laparotomy. Fifty-five (54.4%) had an emergency operation for an acute abdomen, or intra-abdominal bleeding or shock not responding to fluid resuscitation. Forty-six patients were haemodynamically stable after resuscitation and were investigated by ultrasound (*N*=13), contrast-enhanced CT scan (*N*=43), ERCP (*N*=26), digital Statscan (*N*=5) and MRCP (*N*=3). Nine patients were referred from other hospitals with pancreatic pseudocysts which occurred after laparotomy for blunt injury to the pancreas and had an ERCP and endoscopic management of the pseudocyst in our unit.

Anatomical site and severity of injury

Thirty-six patients had proximal pancreatic injuries, 21 to the head or uncinate process of the pancreas and 15 to the neck of the pancreas. Forty-eight patients had an injury to the body of the pancreas, and 26 injuries involved the tail. Most injuries were mild to moderate in severity as indicated by the severity scores. Forty-six patients had AAST grade 1 or 2 pancreatic injuries and 64 had grade 3, 4 or 5 pancreatic injuries.

Operative management

The 101 patients underwent a total of 124 operations (Table II). Twenty-three patients required a second (*N*=21) or third laparotomy (*N*=2) (Table II). Liver injuries (*N*=31) were treated with packing and with or without temporary intra-operative vascular inflow control. Splenectomy (*N*=31) was the procedure of choice for splenic injuries. Drainage of the pancreatic injury (*N*=73) and distal pancreatectomy (*N*=39) with or without splenectomy were the commonest operative procedures performed.

Fifteen patients had combined pancreaticoduodenal injuries. Six of these patients had AAST grade 5 injuries with maximal disruption of the pancreatic head and duodenum. Three had an initial damage control laparotomy, 1 of whom had the damage control operation at a peripheral hospital and was transferred to our centre for definitive surgery. One of these 3 patients, a pedestrian struck by a bus, had a damage control procedure and in addition to the grade 5 pancreatic injury had an avulsed superior mesenteric vein and a major right lobe liver injury involving the right and middle hepatic veins, and died of multiple organ dysfunction syndrome (MODS) before the Whipple resection. The remaining 5 patients (4.9%) underwent a pylorus-preserving pancreaticoduodenectomy; 3 of the 5 had a pancreatojejunal anastomosis, but in 2 patients gross oedema of the jejunum precluded a safe pancreatic anastomosis and both had a pancreatogastrostomy. All 5 patients developed postoperative complications, which included a bile leak, pancreatic fistula, jejunal fistula, renal failure, subphrenic abscess and wound sepsis. The subphrenic abscess was drained percutaneously while the remaining complications resolved on conservative treatment.

The remaining 9 patients with combined pancreatoduodenal injuries had grades 2 and 3 duodenal injuries and grades 3 and 4 pancreatic injuries. The duodenal injuries were treated with debridement, single-layer primary repair, intraluminal tube drainage and a feeding jejunostomy and the pancreatic injuries with closed suction drainage.

TABLE II. PANCREATIC OPERATIONS PERFORMED

	1st operation	2nd operation	3rd operation	Total
Drainage of the pancreas	**70**	**3**	**-**	**73**
Distal pancreatectomy and splenectomy	**22**	**8**	**1**	**31**
Distal resection with spleen preservation	**6**	**1**	**1**	**8**
Whipple resection	**3**	**2**	**-**	**5**
Cystgastrostomy	**-**	**4**	**-**	**4**
Pancreaticojejunostomy	**-**	**2**	**-**	**2**
Cystjejunostomy	**-**	**1**	**-**	**1**
Total	**101**	**21**	**2**	**124**

TABLE III. DEATHS ACCORDING TO AAST GRADE AND SITE OF PANCREATIC INJURY

AAST	*N*	Head	Neck	Body	Tail	Deaths
1	**31**	**7 (3)***	**4 (1)**	**13 (3)**	**7 (3)**	**10**
2	**15**	**2**	**0**	**5 (1)**	**8 (3)**	**4**
3	**45**	**3**	**4**	**27 (2)**	**11 (1)**	**3**
4	**13**	**3**	**7**	**3**	**0**	**0**
5	**6**	**6 (1)**	**0**	**0**	**0**	**1**

*Deaths in parentheses.

Associated injuries

In 36 patients (32.7%) the injury was confined to the pancreas. The remaining 74 patients (67.3%) had a total of 199 associated injuries. Intra-abdominal injuries accounted for most (113/199, 56.8%) of the associated injuries. The liver (*N*=31), spleen (*N*=27), duodenum (*N*=15), kidney (*N*=11), colon (*N*=8) and small bowel (*N*=7) were the most frequently injured intra-abdominal organs. Vascular injuries occurred in 7 patients (inferior vena cava 3, portal vein 2, superior mesenteric vein 1, splenic vein 1). The associated extra-abdominal injuries were mainly of the chest (28 patients), head (25) and limbs (22). The mean number of organs injured was 2.7 per patient (range 1 - 4).

Morbidity

A total of 158 complications occurred in 82 patients (74.5%); 28 patients had no complications after the pancreatic injury. Pancreatic-related complications were the most common, followed by intra-abdominal sepsis, and respiratory failure and pneumonia. Twenty-six patients had only pancreatic complications, 17 had both pancreatic and other complications, and 39 had extrapancreatic complications. The mean number of complications in each patient was 2.2 (range 1 - 5). The average hospital stay in this group was 25.7 days (range 5 - 94 days).

Pancreatic complications

Fistula. Sixteen patients developed a pancreatic fistula as a complication of the pancreatic injury (Table III). Seven of the 39 patients who had a distal pancreatectomy developed a fistula and 9 of 73 patients developed a fistula after drainage of the pancreatic injury. All were managed conservatively initially. Nine of the fistulas, including those in the 7 patients who had a distal pancreatectomy, resolved spontaneously after a mean of 34 days (range 21 - 58 days). Seven patients with a persistent fistula (>3 months) had an ERCP, of whom 1 had placement of a 7 Fr pancreatic duct stent and 1 a pancreatic duct sphincterotomy, with resolution of the fistula in both. The remaining 5 patients with persistent fistulas had pancreatic duct strictures in the neck of the pancreas and underwent distal pancreatectomy (*N*=3) or Roux-en-Y pancreaticojejunostomy (*N*=2) to the fistula at the pancreatic neck.

Pseudocysts. Fifteen patients, including 9 patients referred from other hospitals, developed a pseudocyst as a complication of the pancreatic injury at a mean of 7 (range 3 - 11) weeks after the initial injury (Table III). The pseudocysts were located in the head (3), body (7) and tail (5) of the pancreas and ranged in size from 5 to 12 cm in diameter (median 7 cm). ERCP was attempted in 11 patients and successful cannulation of the pancreatic duct was achieved in 8. Pseudocyst communication with the main

TABLE IV. MORBIDITY AND MORTALITY ACCORDING TO ANATOMICAL SITE OF PANCREATIC INJURY

Site	*N*	Total morbidity	Other morbidity	Only pancreas-specific morbidity	Mortality
Head	**21**	**21**	**13**	**8**	**4**
Neck	**15**	**15**	**10**	**5**	**1**
Body	**48**	**39**	**19**	**20**	**6**
Tail	**26**	**19**	**15**	**4**	**7**

TABLE V. RELATIONSHIP OF AAST GRADE TO PANCREATIC MORBIDITY

AAST	*N*	No. of patients with complications	Pancreas-specific morbidity
1	**31**	**18**	**3**
2	**15**	**9**	**2**
3	**45**	**36**	**26**
4	**13**	**13**	**11**
5	**6**	**6**	**1**
	110	**82**	**43**

TABLE VI. NUMBER OF ASSOCIATED ORGAN INJURIES – MORTALITY AND SURVIVAL

Injury	Total No.	Alive	%	Died	%
Pancreas-only injury	**36**	**36**	**100**	**0**	**0**
Pancreas + 1 associated organ	**21**	**19**	**90.5**	**2**	**9.5**
Pancreas + 2 associated organs	**19**	**14**	**73.7**	**5**	**26.3**
Pancreas + 3 associated organs	**11**	**9**	**81.8**	**2**	**18.2**
Pancreas + 4 or more associated organs	**23**	**14**	**60.9**	**9**	**39.1**
Total	**110**	**92**	**83.6**	**18**	**16.4**

pancreatic duct was present in 2, a cut-off of the main pancreatic duct in 5, and no connection demonstrated with the pseudocyst in 1. Five patients had an endoscopically visible bulge into the posterior wall of the stomach and were drained into the stomach using a needle knife to create an endoscopic cystgastrostomy (*N*=2) or to place a 10 Fr 6.5 cm transmural pigtail stent (*N*=3) into the cyst cavity. The stents were retrieved 8 weeks later after ultrasound or CT scan had confirmed that the cyst had resolved. Ten patients who were unsuitable for endoscopic cyst drainage (no visible endoscopic bulge, intervening wall too thick) underwent an operation and had a cystgastrostomy (*N*=4), cystjejunostomy (*N*=1) or distal pancreatectomy and splenectomy (*N*=5).

Fluid collections. Five patients had CT confirmation of a persistent postoperative acute pancreatic fluid collection in the lesser sac with endoscopic pancreatographic evidence of an intact main pancreatic duct. All 5 resolved after percutaneous ultrasound guided 7 Fr catheter drainage.

Ascites. Three patients had pancreatic ascites due to a major leak from the main pancreatic duct in the neck which did not resolve on conservative therapy, and all 3 required a distal pancreatectomy and splenectomy.

Necrotising pancreatitis. One patient had an urgent damage control laparotomy at a peripheral hospital after a car accident. A lacerated inferior vena cava was repaired and a pancreatic injury drained. He was transferred on a ventilator, and during the repeat laparotomy distal pancreatectomy was done for a fracture at the neck of the pancreas. He developed severe necrotising pancreatitis and despite several further laparotomies for sepsis died of multi-organ failure 17 days later.

Pancreatic pseudocyst-colocutaneous fistula. One patient developed a pseudocyst secondary to an injury to the neck of the pancreas, complicated by a pancreatic pseudocyst-colocutaneous fistula. He required a distal pancreatectomy, splenectomy and left hemicolectomy, and a temporary stoma which was closed 3 months later.

Abdominal complications

Forty patients (50.9%) developed non-pancreatic abdominal complications after the pancreatic injury. The major complications were intra-abdominal sepsis (*N*=13), bleeding (*N*=7), wound infection (*N*=6) wound dehiscence (*N*=5) and biliary and enterocutaneous fistulas (*N*=5).

Systemic complications

The system ic morbidity in this series was significant and included disseminated intravascular coagulopathy (*N*=12), respiratory failure requiring prolonged ventilation (*N*=12), renal failure necessitating dialysis (*N*=10), pneumonia (*N*=10) and septic shock (*N*=10).

Complications

The overall incidence of complications related to the injury and subsequent operation/s was high. All 36 patients with injuries to the head and neck of the pancreas developed complications, 13 of which were pancreas specific. Of the 74 patients with injuries involving the body and tail of the pancreas, 58 were complicated, of which 24 were related to the pancreas (Table IV). The presence of shock on admission did not predict the development of subsequent complications, as 10 of 39 shocked patients developed a complication compared with 15 of 71 patients without shock (p=0.638). There was no correlation between the AAST grade of injury and pancreas-related morbidity (Table V). Fifty-eight patients were admitted to the intensive care unit (mean stay 8.5 days, range 1 - 38 days). Mean hospital stay was 22.7 days (median 15, range 1 - 95 days).

Mortality

Eighteen patients (16.4%) died as a result of the injuries sustained (11 MVA pedestrians, 4 MVA drivers, 1 MVA passenger, 1 assault and 1 other), a median of 1.5 days after the injury (range 1 - 23 days, mean 5.8 days). Ten patients had head injuries, 8 chest injuries and 8 limb injuries, and 2 patients had cervical and thoracic spinal injuries as well as pancreatic injuries. Seventeen of the 18 patients were shocked on admission, and 10 required an emergency laparotomy, which was done within 2 hours of admission (range 1 - 4 hours). Sixteen of the 18 patients who died had associated abdominal injuries (mean 2, range 1 - 4). Thirteen patients had liver, 6 splenic, 3 kidney, 3 inferior vena caval, 2 duodenal, 2 colonic and 1 small-bowel injuries. During the initial surgery, 2 patients had a distal pancreatectomy and splenectomy and 16 were drained. Four of the 18 patients had re-look surgery (range 1 - 6). At re-look laparotomy 1 patient had a spleen-preserving distal pancreatectomy.

Seven patients died as a result of their head injuries, 6 of multi-organ failure and disseminated intravascular coagulation, 2 as a consequence of their liver injuries, and 1 as a result of an associated cardiac injury. In 2 patients the pancreatic injury was the cause of death. Both had initial urgent damage control laparotomies after car or bus accidents. One patient underwent repair of a lacerated inferior vena cava, needed several further laparotomies for severe necrotising pancreatitis, and died of sepsis and multi-organ failure. The other died of multi-organ failure after the damage control procedure and surgery for a grade 5 pancreatic injury, an avulsed superior mesenteric vein and a major right lobe liver injury involving the right and middle hepatic veins.

Shock on presentation was highly predictive of death. Seventeen of the 39 patients who had a systolic blood pressure <90 mmHg on admission to hospital subsequently died compared with 1 of the 71 patients who were not shocked (p<0.0001). Ten of the 31 patients with grade 1 pancreatic injuries died, 4 of 15 with grade 2, 3 of 45 with grade 3, none with grade 4 and 1 with grade 5 (Table III). Surprisingly, 14 of 46 patients with grade 1 and 2 pancreatic injuries died compared with 4 of 64 patients with grade 3, 4 and 5 injuries (p<0.001). Five of the 36 patients with injuries involving the head and neck of the pancreas died compared with 13 of the 74 patients with injuries involving the body and tail of the pancreas. This difference was not significant (p=0.68) (Table IV).

None of the 36 patients with an isolated pancreatic injury died (Table VI). Mortality increased exponentially as the number of associated injuries increased. Two of 57 patients with injuries of the pancreas only or one associated injury died, compared with 16 of 53 with two or more associated injuries (p<0.0013). Nearly 40% of patients with 4 or more associated injuries died (Table VI). In these situations the cause of death was invariably the combined sequelae of severe head, spinal and multiple limb injuries.

Discussion

Major injuries to the pancreas remain a significant source of morbidity and mortality even when treated in modern, high-volume trauma referral centres.[16] Despite an increasing body of data on the management of pancreatic injuries, several issues remain unresolved.[17] The absence of a practical and universally applicable classification that accurately predicts the outcome of pancreatic injuries has hampered progress.[18,19] Both the widely used Lucas and AAST classifications have flaws that hinder an accurate comparison of treatment choices in major pancreatic injuries. For example, in the AAST classification no provision is made for associated duodenal injuries, which may be a critical factor determining the need for a pancreatoduodenectomy.[15] In addition, there are wide variations in the reported results of morbidity and mortality after pancreatic injuries. These discrepancies are influenced by cohort bias due 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 peri-operative outcomes. Most studies include patients with both blunt and penetrating trauma, while other reports have not consistently divided complications into those involving the pancreas and those resulting from associated injuries.[17]

Pancreatic injuries seldom occur in isolation. Overall morbidity rates following pancreatic injury range from 30% to 70% and are primarily related to associated vascular, hepatic and bowel injuries.[7-9] Reported mortality rates for pancreatic trauma range from 12% to 46% in different series.[4,20-23] The degree of pre-operative shock, number of associated injuries, and location and complexity of the pancreatic injury are factors that have been reported to influence overall mortality.[24] In this study shock at presentation was highly predictive of death. However, in contrast to the findings of others, in this study there was an inversion of the expected increase in mortality as the grade of pancreatic injury increased. Significantly more patients with grade 1 and 2 pancreatic injuries died compared with those with grade 3, 4 and 5 injuries. A likely explanation is that the natural history of blunt pancreatic injuries differs from penetrating injuries, where morbidity and death are due to associated vascular injuries. In blunt injuries death is invariably due to head injuries and seldom due to pancreatic-related causes. Unexpectedly, in this series there was no significant difference in mortality between injuries involving the head and neck of the pancreas and those involving its body and tail. None of the patients with an isolated pancreatic injury died, but mortality increased exponentially as the number of associated injuries increased. Significantly fewer patients with isolated pancreatic injury or a single associated injury died compared with those with two or more associated injuries. The cause of death was invariably the devastating consequences of high-speed MVAs with the combined sequelae of severe head, spinal and multiple limb injuries.

It has become increasingly clear that the principal cause of pancreas-related morbidity is the presence of a major injury to the main pancreatic duct.[11] The current study, like other studies,[3,7,8,12-14] demonstrated a significant correlation between grade of pancreatic injury, main pancreatic duct injury and morbidity. The most common pancreatic complication after drainage or resection of a major pancreatic ductal injury, both in this series and in the literature, was a pancreatic fistula.[25,26] Previous reports have described fistula rates of 35 - 45% after pancreatic injury.[27] Most fistulas can be managed conservatively and resolve spontaneously, as in this series. For persistent fistulas, a pancreatic duct stent placed endoscopically has been successful.[28,29] When stenting fails, a distal pancreatectomy is recommended for a fistula originating in the body or tail, while a Roux-en-Y pancreatojejunostomy should be used for persistent fistulas involving the main pancreatic duct in the head or neck of the pancreas.[9]

The contention that delayed complications may occur months after pancreatic trauma and are either due to undetected duct disruption at laparotomy or arise after non-operative management following blunt abdominal trauma[30] is supported by the present study, in which 15 patients were treated for a pseudocyst. Management of traumatic pancreatic pseudocysts depends on the patient's symptoms, cyst size and location, the degree of main duct injury and the maturity of the pseudocyst wall. While traumatic pancreatic pseudocysts that result from side-duct injuries with an intact main pancreatic duct generally resolve spontaneously, large persistent or symptomatic pseudocysts that occur as a consequence of proximal main duct injuries require intervention utilising either endoscopic or surgical drainage.[28,29] While previous studies[29,31,32] have indicated that endoscopic drainage of selected traumatic pancreatic pseudocysts is feasible and safe, endoscopic drainage was technically possible in only one third of pseudocysts in this study, and 10 of the 15 patients required operative drainage.

A pancreatoduodenectomy may be necessary in 3 - 4% of injuries involving the head of the pancreas and is reserved for stable patients with major injuries of the head of pancreas and duodenum in whom salvage or reconstruction is not feasible.[33,34] The mortality rate for a Whipple resection in severely injured and unstable patients is formidable and ranges from 20% to 40% ,with most series also showing a high postoperative complication rate.[33,34] There is consensus that patients with major pancreatic injuries and haemodynamic instability due to uncontrollable bleeding, hypothermia, acidosis or coagulopathy should have an abbreviated laparotomy with a damage control procedure and subsequent re-exploration, resection and reconstruction when stable.[7,35,36] When faced with a devitalised head of the pancreas and duodenum, an avulsed ampulla or a *de facto* near-complete traumatic resection, a surgeon has little choice but to proceed and complete the resection provided the patient is haemodynamically stable and the necessary surgical expertise is available.[34] When a pancreatoduodenectomy is necessary, technical difficulties may arise in the reconstruction of the pancreatic and biliary anastomoses due to the small size of the ducts and gross oedema of the jejunum.[9] Two patients in this series had a pancreatogastrostomy, which overcame the technical problem. These technical difficulties illustrate the added complexity of a Whipple resection when required for trauma and the need for the assistance of an experienced pancreatic surgeon during the resection.[34]

There has been considerable controversy about the technical details of the operative management of pancreatic injuries.[5,9] Because of the wide spectrum of injuries, no single procedure can be uniformly applied to all pancreatoduodenal injuries.[5,9,37-39] Previous authors have emphasised that accurate operative

assessment of a pancreatic injury can be demanding and that significant injuries may be overlooked at the time of initial laparotomy in a shocked patient when other major life-threatening injuries may take precedence.[30] The key factor determining outcome is whether the main pancreatic duct is injured.[40] Intra-operative assessment using specific clinical criteria has been recommended as the method of choice in determining whether the main pancreatic duct is injured or not.[13,14] However, intra-operative assessment of duct integrity may be difficult and ductal damage may be overlooked with an injury that is concealed within a peripancreatic haematoma. Intra-operative pancreatography has been suggested as the solution to determine ductal integrity by either opening the duodenum, locating the papilla and inserting a paediatric feeding tube into the ampulla, or performing needle cholecystocholangiography or retrograde endoscopy.[41] All these options carry risks, and major complications including duodenal fistulas and bile leakage, and pancreatitis may occur postoperatively. While intra-operative ERCP provides safer access to the pancreatic duct, the access, availability, logistics and technical difficulties make routine use impractical. Under these circumstances, a subsequent pancreatic fistula rate is a reasonable compromise and an event which be managed endoscopically.

This study confirms that the majority of patients with blunt pancreatic trauma have low-grade injuries that can be treated successfully by external drainage. The commonest major injury is a fracture of the proximal body or neck of the pancreas, which requires a distal pancreatectomy.[5,9] Pancreaticoduodenectomy is reserved for severe injuries to the head of pancreas and duodenum, in which salvage or reconstruction is not feasible provided the patient's condition is stable.[34] If the patient's condition is 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 inspection, pancreatic complications can be reduced without the need for complex resections, enteric diversions and pancreatico-enteric anastomoses as a primary procedure during the acute injury in an unstable patient with multiple associated injuries.[5] It should be emphasised that these conclusions specifically apply to civilian blunt pancreatic trauma and reflect the experience of a level 1 urban trauma centre. The modern management of major pancreatic injuries requires multidisciplinary treatment with trauma and pancreatic surgeons, interventional radiologists and intensivists working in tandem for the optimal results in patients who may have complex injuries and considerable postoperative morbidity.[9]

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