

Original Research Article

Surgical management of traumatic pancreatic injuries and their consequences

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ABSTRACT

Background: Management of pancreatic trauma remains challenging due to difficulty in diagnosis and complexity of surgical interventions. In Egypt, reports on pancreatic trauma are scarce.

Methods: Medical records of adult patients with pancreatic trauma who were admitted at Sohag University Hospital (2012-2019) were retrospectively studied. Patients were categorized into group A of non-operative management (NOM), group B which required upfront exploratory laparotomy due to hemodynamic instability and group C in which surgical management was implemented after thorough preoperative assessment. Pancreatic injuries were ranked by the pancreas injury scale (PIS).

Results: Thirty-two patients (25 males and 7 females) were enrolled, and median age of 36 (range: 23-68) years. Twenty-eight patients (87.5%) had blunt trauma whereas penetrating injury occurred in 4 (12.5%). There were 9 patients in group A, 7 in group B and 16 in group C. High grades of pancreatic injury ≥ 3 occurred in 4 patients from group B and 5 from group C. Distal pancreatectomy was performed in 7 patients while central resection and pancreatecogastrostomy in one. Grade IV injury occurred only in one patient who received damage-control laparotomy. Post-operative complications were significantly increased in group B compared with C, in correlation with worse hemodynamic status and increased severity of PIS. Post-operative mortality occurred in 2 patients (6%), both from group B. Late consequences included pancreatic pseudocyst (4 cases) and walled off pancreatic necrosis (2 cases).

Conclusions: High grades of pancreatic injury and hemodynamic instability correlate with worse outcome after surgery for pancreatic trauma.

Keywords: Pancreatic trauma, Pancreatectomy, Pancreatic fistula, Pseudocyst, Pancreatic abscess, Pancreatic necrosis

INTRODUCTION

Traumatic injuries of the pancreas are rare, encountered only in 1% of all traumas in adults.¹ Blunt abdominal trauma induces almost two thirds of pancreatic injuries, most commonly due to motor vehicle accidents, followed by penetrating injuries inflicted by stab wounds and gunshots.^{2,3} The retroperitoneal location of the pancreas could be protective against trauma, meanwhile it hinders early diagnosis of parenchymal and ductal damage and results in significant delays of diagnosis and definitive management.⁴ Traumatic pancreatic injuries are associated in more than 50% of cases with other injuries of abdominal

organs such as the spleen, liver and kidney.⁵ Pancreatic trauma might trigger several consequences including pancreatic leaks, abscesses, pseudocysts, pancreatitis and pancreatic necrosis.⁶⁻¹⁰ The risk of complications and mortality should be considered with extensive parenchymal and ductal injuries as well as when the diagnosis is delayed.^{11,12}

Evaluation of the extent of pancreatic injury by various imaging techniques in the setting of abdominal trauma might be demanding.¹³ For instance, conventional ultrasonography (USG) usually does not provide sufficient diagnostic data due to the retroperitoneal location of the

pancreas and the overlying intraluminal gases. Optimally, it can be used for follow-up assessment through comparison among repeated scans.^{1,14} Contrast-enhanced computed tomography (CECT) is the primary diagnostic imaging modality for suspected pancreatic injury. However, it fails to detect almost one third of injuries, especially during the early phase of trauma due to tissue edema which results in close opposition of pancreatic segments and obscures parenchymal disruption planes.^{15,16} In contrast, magnetic resonance imaging (MRI) can accurately localize most of the ductal injuries and parenchymal lacerations.¹⁷

Given the infrequent incidence of pancreatic trauma, long-term debate on the ideal management strategy remains ongoing.¹⁸ A standardized evaluation of severity of traumatic pancreatic injuries is commonly applied to conclude the pancreas injury scale (PIS) using the American Association for the Surgery of Trauma (AAST) grading system.^{19,20}

There is a consensus that the extent of morbidity and potential for mortality are directly related to the degree of injury.^{19,20}

In absence of other abdominal injuries, the choice of operative versus non-operative management is essentially dependent on hemodynamic stability and grade of pancreatic injury.⁵ During surgical management, location of injury decisively determines the optimal surgical intervention that can be applied on individual basis.^{3,10}

Studies from Egyptian trauma centers have not adequately highlighted the subject of pancreatic trauma. Therefore, we will address for the first time traumatic pancreatic

injuries with regard to types, grades, management strategies and clinical outcome at the emergency and trauma unit, Department of Surgery, Sohag University Hospital.

METHODS

Medical records of adult patients, who underwent surgical management of pancreatic injuries and their consequences following abdominal trauma at the emergency and trauma unit, Department of Surgery, Sohag University Hospital, between June 2012 and May 2019 were retrospectively reviewed. Demographic and clinical data including age, gender, imaging studies, surgical treatment, post-operative complications including mortality were extracted and analyzed. Severity of pancreatic injury was assessed by the PIS as described in the AAST grading system (Table 1). The study was conducted in accordance with the guidelines of medical research ethics committee at the Faculty of Medicine, Sohag University.

Patient groups, assessment of pancreatic injury and surgical interventions

Patients were categorized according to their management strategies into three groups. Group A received NOM, group B comprised patients who were directly transferred to emergency surgery theater without comprehensive imaging studies due to hemodynamic instability that could not be reversed with adequate resuscitation and group C which included hemodynamically stable patients. Group I and III patients were meticulously assessed by abdominal ultrasonography, chest radiographs and routine laboratory investigations. Suspected pancreatic injury was then evaluated using CECT.

Table 1: Grades of pancreatic injury ranked by pancreas injury scale (PIS) of the American Association for Surgery of Trauma (AAST).

Grade	Form of injury	Details of injury
I	Hematoma	Minor, with no ductal damage
	Laceration	Superficial, with no ductal damage
II	Hematoma	Major, with no ductal damage or tissue loss
	Laceration	Major, with no ductal damage or tissue loss
III	Laceration	Distal parenchymal division or damage with duct injury
IV	Laceration	Distal parenchymal division or damage involving ampulla of Vater
V	Laceration	Massive pancreatic head disruption

The aims of surgery were to eliminate life-threatening factors through damage control surgery along with definitive therapeutic procedures whenever feasible. The pancreas was inspected during exploration of the lesser sac after division of the gastrocolic omentum. Surgical management of minor pancreatic trauma (grades I and II) classically entailed control of minor bleeding and suture repair of parenchymal lacerations. Serious parenchymal damage, ductal injuries and their subsequent complications (parenchymal necrosis and abscesses,

pseudocysts and fistulas) required pancreatic resection, major debridement and drainage and possibly pancreatico-digestive anastomosis tailored individually according to the extent of trauma and location of injury.

Assessment of surgical complications

Post-operative complications following surgical management (groups B and C) were evaluated using Clavien-Dindo classification.²¹ In this system, 7 grades of

postoperative complications are ranked according to the therapy used to treat each complication. Grade I refers to events that require pharmacologic treatment (by pain killers, antiemetics, antipyretics, and electrolytes) without further interventions (except bedside wound opening). Grade II designates the use of additional drugs, blood transfusion and parenteral nutrition. Grade IIIa and b indicate interventions requiring local and general anesthesia, respectively. Grade IVa and b denote the need of treatment in intermediate care or intensive care unit due to single or multiple organ dysfunction, respectively. Grade V indicates postoperative death.²¹ A number of points from 1 to 7 was assigned for each complication in ascending order (grade I: 1, grade II: 2, grade IIIa: 3, grade IIIb: 4, grade IVa: 5, grade IVb: 6 and grade V: 7 points).²² Statistical analysis was conducted using GraphPad Prism 6.0 software.

RESULTS

Demographic data and types of trauma

Thirty-two patients with pancreatic trauma were identified, among them 25 were males (78%) and 7 were females (22%) with median age of 36 (range 23-68) years. Pancreatic injuries were induced by blunt trauma in 28 patients (87.5%) and penetrating trauma in 4 (12.5%) patients. The study population was distributed among group A (9), group B (7) and group C (16) patients. Details on the mechanism of trauma are shown in Figure 1.

Diagnosis of pancreatic injury

In group A, all nine patients had blunt abdominal trauma with grade I and II pancreatic injury diagnosed by CECT.

The decision of NOM was based on hemodynamic stability and absence of major injuries in the pancreas and other organs. Group B comprised 7 hemodynamically unstable patients who suffered from life threatening trauma including 4 with penetrating abdominal injuries and 3 with blunt trauma. In this group, diagnosis of pancreatic injury was achieved intra-operatively. Group C included 16 hemodynamically stable patients, among them 15 presented after blunt trauma whereas 1 had penetrating abdominal injuries. In this group, CECT was performed in all patients and was the cornerstone of diagnosis. Surgical interventions were decided upon confirmation of major (PIS ≥3) pancreatic damage, accompanying visceral injury and/or peritonitis. The distribution of patients in groups II and III by PIS is summarized in Figures 2 and 3.

There was no isolated pancreatic injury among patients of this study. Table 2 shows the incidence of injuries in other abdominal organs.

Table 2: Accompanying visceral injuries.

Injured organ	Number	Percentage
Spleen	10	31
Liver	8	25
Lung/pleura	5	16
Stomach	4	12.5
Colon	3	9
Diaphragm	3	9
Small bowel	3	9
Gall bladder	2	6
Small bowel mesentery	2	6
Kidney	2	6
Extrahepatic bile ducts	1	3

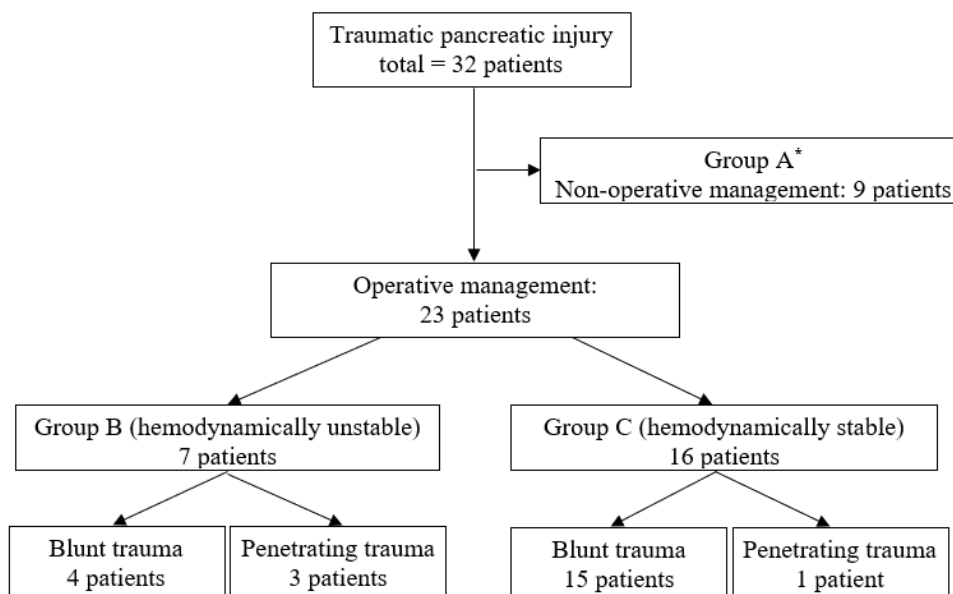


Figure 1: Patient groups according to hemodynamic status at presentation.

*All patients in group A had grade I pancreatic injuries (minor hematomas with no evidence of ductal injury) diagnosed by CECT.

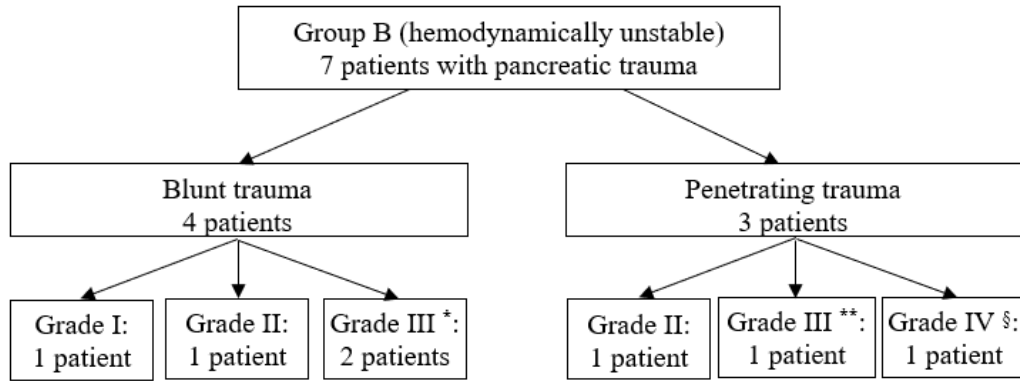


Figure 2: Grades of pancreatic injury and surgical management in group B.

*Both patients had severe injuries of the pancreatic body, managed by distal pancreatectomy. One case (with concomitant severe liver lacerations) died postoperatively due to irreversible shock; **Patient had gunshot injury at the pancreatic neck, managed by suture closure of pancreatic duct on the right side of superior mesenteric artery and anastomosis between the pancreatic body and stomach by EDPSPG (enveloped double purse-string pancreaticogastrostomy) technique; §Patient had gunshot injury which involved the duodenum, ampulla of Vater and pancreatic head, managed (according to damage-control protocol due to multiple other injuries in the chest and extremities) by control of bleeding vessels, suturing of pancreatic head lacerations, external drainage of the duodenum via controlled duodenal fistula). This patient died postoperatively due to uncontrolled leakage, electrolyte imbalance and sepsis.

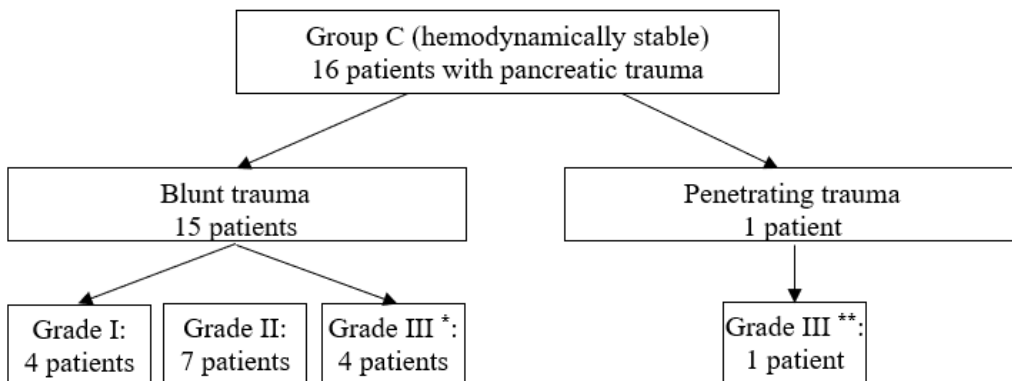


Figure 3: Grades of pancreatic injury and surgical management in group C.

*All 4 patients had pancreatic body injuries, managed by distal pancreatectomy, **This patient had gunshot injury in the pancreatic body, managed by distal pancreatectomy.

Operative interventions in groups B and C

Simple ligation of bleeding vessels and suturing of parenchymal lacerations were done in 14 patients with grade I and II injuries (3 from group B and 11 from group C). Distal pancreatectomy was performed in 7 patients (2 from group B and 5 from group C) with grade III injuries which entailed extensive parenchymal tears and ductal transection in the pancreatic body and/or tail. Grade III injury overlying the neck occurred in one case (from group B) who was managed by suture closure of the transected pancreatic duct on the right side of superior mesenteric artery and restoration of pancreatic-digestive continuity between the by pancreatico-gastrostomy using the enveloped double purse-string (EDPS) technique which has been developed and described by the first author at our center (Figure 4 and 5). Only 1 case with grade IV injury

involving the pancreatic head and duodenum with accompanying extensive injuries of the chest and extremities was found. Damage-control surgery rather than pancreatico-duodenectomy was applied. This entailed control of bleeding, debridement and repair of pancreatic tissue, transverse suturing of duodenal defect around duodenal catheter used for external drainage (controlled duodenal fistula) and peritoneal drainage. Nutrition was maintained by nasojejunal feeding tube.

In-hospital post-operative complications and mortality in groups B and C

The median length of hospital stay was 11 (range 5-38 days). Among 23 patients who comprised groups B and C, 15 patients had minor complications (complication grades I and II) while 8 suffered from severe postoperative

complications (III and more) as shown in Table 3. Complication score was significantly higher in group B, $P < 0.05$, likely due to the worse presentation (hemodynamic instability). These complications included intra-abdominal abscesses managed by percutaneous drainage under local anesthesia in 3 patients, septic intraperitoneal collection due to pancreatic fistula in 2 patients who underwent re-laparotomy and wash-out of, and intra-abdominal bleeding in one patient who required re-laparotomy for adequate control. Among patients of this series, there were 2 postoperative deaths (6%) that occurred after surgical interventions in group B. The first followed surgery for grade IV pancreatic injury due to uncontrolled leakage of bilio-pancreatic and duodenal contents and subsequent electrolyte imbalance and sepsis. The second was related to irreversible shock after extensive liver damage and severe pancreatic body lacerations due to blunt trauma (grade III pancreatic injury) that required distal pancreatectomy.

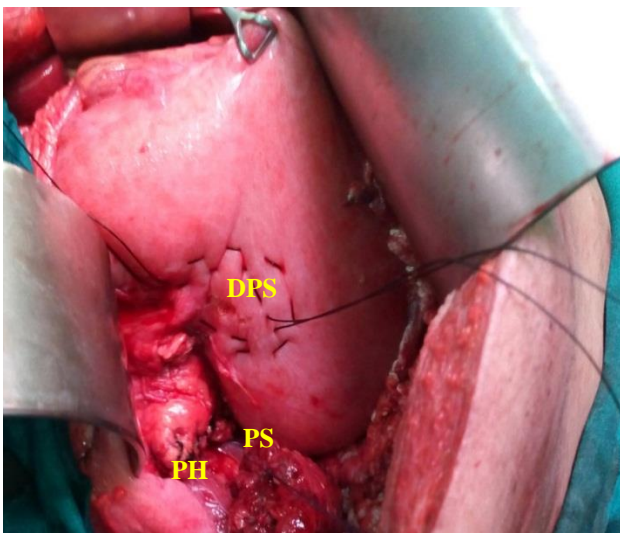


Figure 4: Central pancreatectomy after penetrating trauma of the pancreatic neck with 2 double purse string sutures placed on the outer surface of the posterior gastric wall in preparation for pancreaticogastrostomy using EDPSPG technique.

DPS: Double purse-string sutures on the outer surface of posterior gastric wall, to be tied at 3 and 9 o'clock positions; PH: pancreatic head with its capsule oversewn after parenchymal repair and closure of the proximal end of the pancreatic duct; PS: pancreatic stump with the body and tail remaining after central pancreatectomy (resection of the pancreatic neck).

Operative interventions for late local consequences of pancreatic trauma

During a median follow-up period of 10 (range 3-25) weeks, 6 patients developed local pancreatic complications. Pancreatic body pseudocyst occurred in 4 cases of blunt trauma (after NOM in 1 patient from group A or repair of pancreatic lacerations in 3 patients from group C, possibly due to overlooked ductal injury). Since pancreatic pseudocysts were found in the pancreatic body

in all cases, management by cystogastrostomy was consistently performed (Figure 5). Furthermore, 2 cases of “walled off” pancreatic necrosis in the pancreatic body and tail in one patient (from group A) and in the pancreatic tail in the remaining one (from group C). Both cases were successfully managed by pancreatic necrosectomy (Figure 6) and sewing of the pancreatic stump, including the duct.

Table 3: Complication grades and scores in the surgically-managed groups (B and C).

Groups	Number of patients (per complication grade)	Complication score per patient
Group B	4 (II)*	2
	1 (IIIa)**	3
	2 (V)‡	7
Group C	8 (I)*	1
	3 (II)*	2
	2 (IIIa)**	3
	3 (IIIb)§	4

*Minor complications (grades I and II) are treated pharmacologically with antiemetics and antipyretics. Treatment includes blood transfusion and/or parenteral nutrition only for grade II complications; **grade IIIa complications require intervention under local anesthesia (percutaneous drainage of intraperitoneal abscess); §grade IIIb were managed under general anesthesia, re-laparotomy and wash-out were carried out due to pancreatic fistula (2 patients) and control of postoperative bleeding (1 patient) and; ‡postoperative death due to uncontrolled bilio-pancreatic and duodenal leaks (1 patient) and irreversible shock (1 patient).

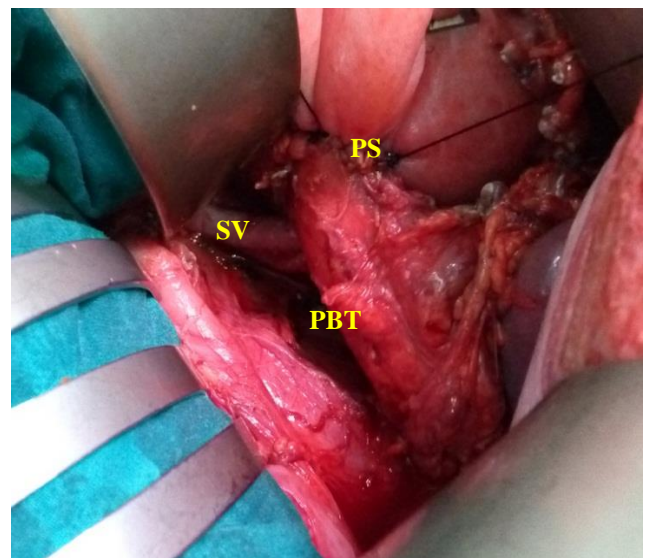


Figure 5: Central pancreatectomy with completed telescoping of the pancreatic stump into the stomach using EDPSPG technique.

PS: pancreatic stump telescoped into the stomach with 2 purse-string sutures tied around with additional, anterior and posterior transfixing sutures to envelop the anastomosis; PBT: pancreatic body and tail remaining after resection of the pancreatic neck; SV: splenic vein.

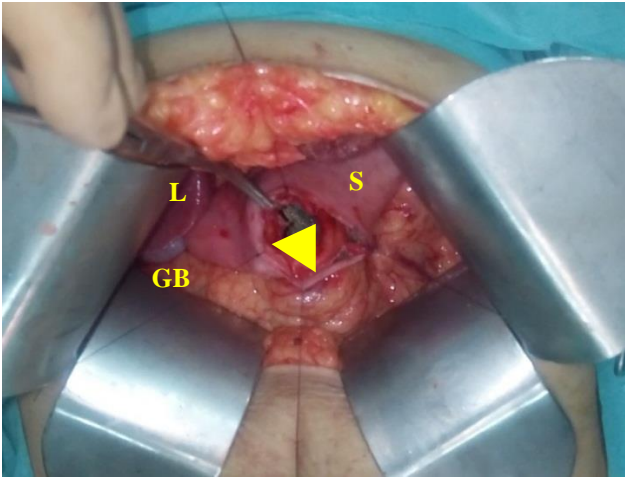


Figure 6: Anterior gastrotomy, opening of the “adherent” posterior gastric and anterior pancreatic pseudocyst walls to allow evacuation of the pseudocyst contents and drainage into the stomach.

S: anterior gastric wall; the arrow head points at the interior of pancreatic body pseudocyst; L: liver; GB: gall bladder

DISCUSSION

In this study, we addressed the current trends in diagnosis, management and clinical outcome of surgical interventions for pancreatic trauma and its consequences in adults. The study is the first to emphasize this issue in a large tertiary center in Upper Egypt.

Main cause of injury in this series was blunt trauma due to road traffic accidents. Other western studies report less proportion of blunt trauma possibly due to more strict traffic regulations.¹² Isolated pancreatic injury was not reported in this study. This could be related to inclusion criteria which were limited to adults only. Of note, isolated injuries occur most commonly in children in relation to sport injuries.³

The current literature shows clear tendency toward utilization of NOM of pancreatic trauma.^{5,10,15,23} In the same line, we successfully implemented NOM in 9 patients (28%) with evidence of pancreatic injuries not involving the pancreatic duct. However, 2 patients developed pancreatic-trauma related consequences after initial discharge. Walled-off pancreatic necrosis was diagnosed in one patient and mandated pancreatic necrosectomy.^{9,24} Another patient suffered, several weeks after the initial insult, from pancreatic pseudocyst for which cystogastrostomy was performed.²⁵ The of rate local consequences induced by pancreatic trauma after non-operative management seems lower than other published studies.³ This is likely caused by the limitation we applied on the implementation NOM to minor grades of injury.^{18,26}

Surgery for minor pancreatic injuries with intact pancreatic duct (grades I and II) require simple surgical repair.² We omitted NOM in 14 patients (3 and 11 in groups B and C, respectively) with minor pancreatic

injuries due to hemodynamic instability in group B and other organ injury in group C. All pancreatic injuries were adequately controlled by hemostasis, debridement and suture repair of parenchymal lacerations. Of note, pancreatic pseudocyst developed in 3 patients and required surgical treatment with cystogastrostomy. Failure to identify pancreatic duct injuries may be caused by lack of adequate preoperative imaging in group B or even after imaging with CECT due to marked tissue edema in the early phase of trauma.¹⁶

Higher grades (III and IV) of injury were found in 9 patients. We carried out distal pancreatectomy in 7 patients with grade III injuries involving the pancreatic body and tail. The rationale of this approach is to avoid pancreatico-digestive anastomosis in situations of severe or multiple lacerations of the pancreas as well as when complex pancreatic trauma is associated with other multiple injuries.²

Resection of the central portion of the pancreas appears as better alternative to distal pancreatectomy for injuries affecting only the pancreatic neck.^{27,28} Central pancreatectomy with pancreatico-gastrostomy using enveloped double purse-string technique was carried out only in one case with grade III injury limited to the neck region to preserve the remaining volume of the healthy pancreatic body and tail.²⁹

One patient suffered from grade IV pancreatic injury that seriously affected the duodenum, with concomitant injuries in the chest and extremities. Given the difficulty of this situation, damage-control surgery by hemostasis and drainage was applied as alternative of pancreaticoduodenectomy.³⁰ However, this patient died postoperatively due to sepsis following uncontrolled leaks of the pancreatico-duodenal contents.

Overall, we found that the severity of postoperative complications correlates with the increased extent of injuries during the initial presentation. Among 23 patients who were managed surgically, we reported major postoperative complications in 6 (26%) in addition to 2 postoperative deaths (9%). Our morbidity and mortality rates are in agreement with the available literature, which shows similar or higher morbidity and mortality, particularly with increasing injury grades and hemodynamic instability.^{2,7,11,31}

Among the limitations of this study is the relatively small number of patients. Likewise, lack of interventional management using pancreatic duct stenting could have avoided the need of surgical intervention in a substantial number of patients.

CONCLUSION

In conclusion, we provide, for the first time from Upper Egypt tertiary trauma center, a comprehensive report on pancreatic injury. In particular, we highlighted various

treatment strategies and clinical outcome based on the international guidelines with tailoring of the management plans according to our local resources.

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