ASTR

ORIGINAL ARTICLE
pISSN 2288-6575 • eISSN 2288-6796
https://doi.org/10.4174/astr.2018.95.1.29
Annals of Surgical Treatment and Research

Pancreatic fistula and mortality after surgical management of pancreatic trauma: analysis of 81 consecutive patients during 11 years at a Korean trauma center

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Purpose: Pancreatic trauma is infrequent because of its central, deep anatomical position. This contributes to a lack of surgeon experience and many debates exist about its standard care. This study aimed to investigate the postoperative pancreatic fistula (POPF) and mortality of pancreatic trauma after operation.
Methods: We reviewed records in the trauma registry of our institution submitted from January 2006 to December 2016. The grade of pancreatic injury, surgical management, morbidity, mortality, and other clinical variables included in the analyses.
Results: Data from a total of 26,072 trauma patients admitted to the Emergency Department were analyzed. Pancreatic trauma was observed in 114 of these patients (0.44%). Laparotomy was performed in 81 patients (2 pancreaticoduodenectomies, 2 pancreaticogastrostomies, peripancreatic drainage in 41 patients, distal pancreatectomies in 34 patients, and 9 patients who underwent surgery for damage control). The incidence of POPF was 38.3%. The overall mortality was 8.8% (7 of 81). In multivariate analysis, pancreas injury grade IV (≥4) (adjusted odds ratio [AOR], 4.071; P = 0.029) and preoperative peritonitis signs (AOR, 2.903; P = 0.039) were independent risk factors for POPF. All patients who died had also another major abdominal injury (≥grade 3). Multiorgan failure was a major cause of death (6 of 7, 85.7%). The mortality rate of isolated pancreas injury was 0%.
Conclusion: The pancreas injury grade and preoperative peritonitis were significant risk factors of POPF. The mortality rate of isolated pancreatic trauma was very low.
[Ann Surg Treat Res 2018;95(1):29-36]

Key Words: Pancreas, Trauma, Pancreatic fistulas, Mortality

INTRODUCTION

Of all abdominal injuries, pancreatic trauma is very rare, occurring in only 0.21%–3.1% of cases; however, it is associated with major morbidity and mortality [1-3]. This low incidence is attributable to its anatomical position deep position within the retroperitoneal space. Although its morbidity is profound, the extremely low incidence of pancreatic trauma contributes to the lack of surgeon experience and high levels of evidence. Controversy remains regarding the optimal choices that lead to favorable outcomes in high-grade pancreatic trauma in the era of damage control operations and the development of nonoperative management strategies [4]. One of the major complications of pancreatic trauma is postoperative pancreatic

Received October 14, 2017, **Revised** November 10, 2017, **Accepted** November 21, 2017

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fistula (POPF), which can be lethal. However, the incidence and predictors of POPF remain unknown. In 2016, the International Study Group of Pancreatic Surgery (ISGPS) redefined [5]. In the present study, POPF was defined using this new ISGPS definition.

The aim of present study was to investigate the morbidity, including POPF, and mortality of pancreatic trauma after operation. Furthermore, the factors that predict the development of pancreatic fistula were also analyzed.

METHODS

After receiving study approval from the Institutional Review Board of Chonnam National University Hospital, data were retrospectively reviewed from consecutive patients from January 2006 to April 2016 who underwent exploratory laparotomy after pancreatic trauma at a tertiary referral trauma center. Patients who died before the surgery, who did not undergo abdominal surgery, and who were transferred to another hospital were excluded from the study.

Patient demographic and clinical data including age, sex, systolic blood pressure, pulse rate, body temperature, Glasgow Coma Scale on admission, Injury Severity Score (ISS), Abbreviated Injury Scale scores, operative data, and postoperative outcomes were collected and analyzed. All intra-abdominal injuries were identified by operative findings abstracted from operative reports and radiologic examinations such as CT. All pancreatic injuries were graded according to the Organ Injury Scaling Committee of the American Association for the Surgery of Trauma (AAST) [6]. An inotropic agent was used for uncontrolled hypotensive patients who did not respond to initial fluid resuscitation and transfusion in the Emergency Department (ED).

Patients with a clinical suspicion of major pancreatic duct injury underwent emergent or delayed laparotomy. Emergent laparotomy was also performed in patients with signs of peritonitis, intra-abdominal bleeding, and other hollow viscous organ injuries. Patients with penetrating wounds including peritoneal injury were explored. Delayed operation was defined as operation after 24 hours from admission in patients who were initially managed conservatively and underwent laparotomy for clinical deterioration such as peritonitis. In patients with a suspicion of pancreatic main duct injury who did not require emergent laparotomy, endoscopic retrograde cholangiopancreatography (ERCP) and endoscopic retrograde pancreatic drainage (ERPD) were initially performed selectively. In order to manage the intractably high output of POPF, ERCP, and ERPD were also performed selectively. All patients who underwent pancreatic surgery, including resection or drainage alone, received 0.1-mg octreotide subcutaneously for one week.

The primary outcomes were pancreatic fistula and mortality after surgery for pancreatic trauma. All complications after surgery were classified according to the recommendations by Dindo et al. [7]. Damage control surgery was defined as abbreviated laparotomy and fascia left open with temporary abdominal closure in hemodynamically unstable patients [8]. Prolonged weaning was defined as at least three weaning attempts or the need for more than seven days of weaning after the first spontaneous breathing trial [9]. Ileus was defined as the development of clinical symptoms including nausea, vomiting, and abdominal distension after surgery [10]. Acute kidney injury is defined based on any of the following: increase in serum creatinine (SCr) levels by ≥0.3 mg/dL with 48 hours; increase in SCr levels to ≥1.5 times the baseline value that is known or presumed to have occurred within the prior 7 days; or urine volume of 0.5 mL/kg/hr for 6 hours [11]. Preoperative peritonitis symptoms were defined as clinical symptoms including whole abdominal tenderness, rebound tenderness, and rigidity.

POPF was defined according to updated 2016 ISGPS definition and grading [5]. In 2005, ISGPS defined a clinically relevant POPF as a draining output of any measurable volume of fluid with an amylase level > 3 times the upper limit of normal serum amylase activity [12]. The new definition [5], redefined the former "grade A postoperative pancreatic fistula" as a "biochemical leak" with no clinical impact but with high-rich amylase levels containing a drain and which is no longer considered a true pancreatic fistula. POPF grades B and C are considered true pancreatic fistulas. Grade B fistula requires a change in management; drains are either left in place > 3 weeks or repositioned through endoscopic or percutaneous drainage or interventional radiology for bleeding or signs of infection without organ failure. Grade C fistula requires reoperation or leads to single or multiorgan failure and/or mortality attributable to the pancreatic fistula. In the present study, a pancreatic fistula was defined as POPF grades B or C.

Continuous data are presented as medians with range or mean with standard deviation. Continuous data are compared using independent t-test. Categorical data are presented as proportions. Proportions were compared using chi-square or Fisher exact tests as appropriate. Logistic regression was used to identify significant risk factors associated with pancreatic fistula and mortality. To adjust for confounding factors, variables with a univariate P-value < 0.20 were included in the multivariate analysis. P-values < 0.05 were considered statistically significant. All statistical analyses were performed using the IBM SPSS Statistics ver. 23.0 (IBM Co., Armonk, NY, USA).

RESULTS

From January 2006 to December 2016, 26,072 trauma

Table 1. Patient characteristics (n = 81)

Characteristic	Value
Age (yr)	45.08 (6–75)
Male sex	67 (82.7)
Injury	
Injury type	
Blunt	77 (95.1)
Penetrating (stab)	4 (4.9)
Pancreas injury grade, AAST grade	
I	5 (6.2)
II	25 (30.9)
III	35 (43.2)
IV	12 (14.8)
V	4 (4.9)
Pancreas injury site	
Head	30 (37.0)
Neck	26 (32.1)
Body	17 (21.0)
Tail	8 (9.9)
Pancreas injury only in the abdomen	22 (27.2)
ISS	16 (4–43)
ISS ≥ 16	50 (61.7)
ISS ≥ 25	22 (27.2)
Head AIS	0 (0–4)
Chest AIS	0 (0–4)
Abdomen AIS	4 (2–5)
Operative finding	
Gastrointestinal perforation	17 (21.0)
Staple closure for pancreatic resection	8 (9.9)
Enteric anastomosis	4 (4.9)
Transection of pancreas	29 (35.8)
Transection of pancreas neck	19 (23.5)
Operation	
Operation time (min)	160 (45–470)
Delayed laparotomy	7 (8.6)
Damage control surgery	9 (11.1)
Reoperation	12 (14.8)
Inotropic agent (ED)	16 (19.8)
Serum amylase (unit/L)	157 (23–1,284)
Transfusion	
Transfusion during operation	
PRBC (unit)	3 (0–30)
FFP (unit)	2 (0–12)
PC (unit)	0 (0–20)
Transfusion within 24 hours postoperatively	
PRBC (unit)	0 (0–34)
FFP (unit)	0 (0–24)
PC (unit)	0 (0–25)
ERCP	9 (11.1)
ERPD	8 (9.9)
Physiologic parameter	
Systolic blood pressure (ED) (mmHg)	100 (30–190)
Respiratory rate (ED)	20 (16–32)
Body temperature (ED) (Celsius)	36.2 (36.0–38.0)
Pulse rate (ED)	90 (54–140)
ICU stay (day)	5 (0–67)
Hospital stay (day)	37 (1–134)
Mortality	7 (8.6)

Values are presented as median (range) or number (%).
AAST, American Association for the Surgery of Trauma; ISS, injury severity score; AIS, abbreviated Injury Scale; ED, Emergency Department; PRBC, packed red blood cells; FFP, fresh frozen plasma; PC, platelet concentrates; ERCP, endoscopic retrograde cholangiopancreatography; ERPD, endoscopic retrograde pancreatic drainage; ICU, intensive care unit.

patients were admitted to the ED of our hospital. Of these, 114 patients (0.44%) were identified as having pancreatic trauma. The 81 patients who underwent laparotomies were eligible for analysis. A total of 75 patients underwent an emergent operation. Six patients underwent a delayed operation after conservative management. Patients who recovered successfully with conservative management without surgery (n = 25), who transferred from another hospital after operation (n = 1), and who died in the ED before surgery (n = 3) were excluded.

The patient clinical characteristics are shown in Table 1. Inotropic agents such as norepinephrine or dopamine were administered to 16 patients (19.8%) for severe hypotension unresponsive to fluid resuscitation in the ED. One patient underwent ERCP preoperatively and the other 8 patients underwent ERCP postoperatively.

Operative method

The type of operations for pancreatic trauma and other abdominal operations are summarized in Table 2. Two patients (50%) with grade V injury underwent pancreaticoduodenectomy. Two other patients (50%) with grade 5 injury underwent hemostasis and pad packing with temporary abdominal closure for damage control surgery but died after the first surgery. Two patients (16.7%) with grade 4 injury underwent pancreaticogastrostomy to avoid not only pancreaticoduodenectomy but also pancreatic dysfunction. Nine patients (75.0%) with grade 4 injury underwent peripancreatic drainage without pancreatic resection or enteric anastomosis. Only 1 patient (8.33%) with grade 4 injury underwent extended distal pancreatectomy but eventually developed postoperative diabetes mellitus.

Fourteen patients (38.9%) underwent pancreatic resection, whereas 17 (37.8%) did not. The incidences of pancreatic fistula were similar in the resection and nonresection groups (38.9% *vs.* 37.8%, P = 0.919). Mortality rates were also similar in both groups (8.3% *vs.* 8.9%, P = 0.930). There was no significant difference in intensive care unit stay (resection *vs.* nonresection, 6.9 [11.6] days *vs.* 7.4 [7.3] days, mean [standard

Table 2. Operations for pancreatic trauma and other abdominal operations

Operation	No.	Pancreas injury (AAST grade)				
		I	II	III	IV	V
Pancreas operation						
Pancreaticodoudenectomy	2					2
Hemostasis and pad packing	2					2
Pancreaticogastrostomy	2				2	
Peripancreatic drainge only	40	5	24	2	9	
Distal pancreatectomy	33		1	31	1	
Spleen preserving distal pancreatectomy	2			2		
Total	81	5	25	35	12	4
Other operations (n = 81)						
Gastrointestinal surgery						
Small bowel resection or small bowel primary repair	5					
Mesentery repair	7					
Right hemicolectomy or colon primary repair	6					
Hartmann's operation or Ileostomy	4					
Stomach primary repair or gastrectomy	6					
Duodenal primary repair	1					
Duodenal segmental resection	1					
Hepatobiliary surgery						
Liver suture hemostasis	14					
Liver pad packing	2					
Cholecystectomy	3					
Others						
Splenectomy	9					
Bleeder ligation	11					
Superior mesenteric vein ligation	1					
Nephrectomy	2					
Damage control surgery	9					

AAST, American Association for the Surgery of Trauma.

Table 3. Postoperative complications

Variable	No. (%)
Postoperative complication grade (Clavien-Dindo classification)	
0	14 (17.3)
I	2 (2.5)
II	23 (28.4)
IIIa	21 (25.9)
IIIb	6 (7.4)
IVa	8 (9.9)
IVb	0 (0)
V	7 (8.6)
Pancreatitis	14 (17.3)
Pancreatic fistula	
None	33 (40.7)
Biochemical leak	17 (21.0)
Grade B	25 (30.9)
Grade C	6 (7.4)
Wound infection	15 (18.5)
Intra-abdominal abscess	18 (22.2)
Pneumonia	5 (6.2)
Postoperative ileus (≤30 days)	18 (22.2)
Postoperative ileus (>30 days)	4 (4.9)
Intra-abdominal bleeding	4 (4.9)
Gastrointestinal bleeding	3 (3.7)
Incisional hernia	1 (1.2)
Anastomostic leakage	3 (3.7)
Acute kidney injury	9 (11.1)
Acute respiratory failure or prolonged ventilator weaning	6 (7.4)
Sepsis	3 (3.7)

Values are presented as number (%).

deviation, SD], P = 0.826). However, the mean hospital stay of the resection group was shorter than that of the nonresection group (34.3 [18.2] days *vs.* 48.5 [40.0] days, mean [SD], P = 0.022).

Postoperative complications

The postoperative complications are summarized in Table 3. According to Clavien-Dindo classification, only 14 patients (17.3%) did not have any other complications. The incidence of pancreatic fistula (grades B and C) was 38.3%. Pancreatic fistula was a major complication after pancreatic operation. According to pancreas injury grade, no patients with grade 1 injury had pancreatic fistula (0 of 5, 0%). Seven patients with grade 2 pancreas injury (7 of 25, 28.0%), 14 patients with grade 3 pancreas injury (14 of 35, 40.0%), 9 patients with grade 4 pancreas injury (9 of 12, 75.0%), and 1 patient with grade 5 pancreas injury (1 of 4, 25.0%) had pancreatic fistula. The pancreatic fistula rate was significantly associated with pancreas injury grade (P = 0.021). Four patients with pseudoaneurysm experienced intraabdominal bleeding. Among these 4 patients, 3 underwent interventional radiology such as stent insertion, while two underwent reoperation. One patient underwent both angioembolization and reoperation. The pseudoaneurysm related bleeding occurred on days 15, 16, 20, and 25. One patient underwent embolization of the pseudoaneurysm without bleeding 8 days postoperatively. None of the patients had pseudoaneurysm related bleeding without POPF. One patient who underwent distal pancreatectomy underwent reoperation due to postoperative bleeding at the splenic artery ligation site (not pseudoaneurysm) on the day after the first operation.

Pancreatic fistula and its risk factors

Two of patients with grade 3 pancreatic injury (5.7%) underwent peripancreatic drainage without resection. One underwent ERPD postoperatively owing to high output fistula but experienced pancreatic fistula for 78 days. The other patient

Table 4. Risk factors for pancreatic fistula

Variable	Univariate analysis			Multivariate analysis		
	COR	95% CI	P-value	AOR	95% CI	P-value
Pancreas injury location						
Head or neck	Reference					
Body or tail	0.519	0.187–1.439	0.207			
Delayed operation	2.321	0.483–11.156	0.293			
Pancreas only injury	0.894	0.324–2.466	0.829			
Stapler use of pancreas resection	0.205	0.024–1.752	0.148			
Pancreas injury ≥ grade 4 (AAST)	3.492	1.119–10.895	0.031	4.071	1.155–14.358	0.029
Pancreas transection	1.922	0.758–4.874	0.169			
Pancreas neck transection	2.169	0.765–6.155	0.146			
Pancreas with associated abdominal injury (OIS ≥ 4)	0.990	0.356–2.754	0.985			
Preoperative peritonitis sign	2.688	1.068–6.762	0.036	2.903	1.054–7.998	0.039
Gastrointestinal perforation	1.585	0.538–4.669	0.404			
Type of pancreas surgery						
Drainage	Reference					
Resection	1.048	0.426–2.581	0.919			
Age (yr)	0.996	0.971–1.023	0.790			
Male sex	1.687	0.480–5.938	0.415			
Time from injury to admission (min)	1.000	0.999–1.000	0.502			
Glasgow Coma Scale	0.868	0.636–1.185	0.374			
pH (ABGA) (ER)	1.302	0.014–118.757	0.909			
Base excess (ER) (mmol/L)	1.006	0.928–1.090	0.891			
Amylase (unit/L)	0.999	0.997–1.001	0.309			
Inotropic drug (used at ER)	0.682	0.212–2.192	0.520			
Body temperature (ER) (Celsius)	0.863	0.257–2.891	0.811			
SBP ≥ 90 mmHg	1.010	0.363–2.810	0.985			
Pulse rate	0.997	0.969–1.026	0.832			
PRBC (OR) (unit)	0.978	0.903–1.058	0.576			
FFP (OR) (unit)	0.963	0.800–1.160	0.694			
PRBC (24 hours postoperative) (unit)	1.081	0.947–1.233	0.249			
FFP (24 hours postoperative) (unit)	1.098	0.968–1.245	0.146	1.132	0.981–1.307	0.088
ISS ≥ 25	1.508	0.558–4.075	0.418			
Operation time (minute)	1.002	0.996–1.007	0.581			

COR, crude odds ratio; CI, confidence interval; AOR, adjusted odds ratio; AAST, American Association for the Surgery of Trauma; OIS, Organ Injury Scale; ABGA, arterial blood gas analysis; ER, Emergency Department; SBP, systolic blood pressure; PRBC, packed red blood cells; FFP, fresh frozen plasma; OR, operating room; ISS, injury severity score.

also underwent ERPD postoperatively and the fistula was closed 18 days postoperatively. However, these patients recovered and were discharged. Of 12 patients with grade 4 pancreatic injury in the present study, 9 (75.0%) underwent surgical drainage without resection. Of these 9 patients, 7 (77.8%) developed pancreatic fistula. Two patients with grade 4 pancreatic injury who underwent pancreaticogastrostomy developed pancreatic fistula (100%) but both recovered and were discharged to home. In terms of patients with grades 3 and 4 pancreatic injuries who underwent surgical drainage only without resection or enteric anastomosis, the incidence of pancreatic fistula was 81.8% (9 of 11), but the mortality was 0%.

Univariate and multivariate logistic regressions were performed to identify the risk factors for pancreatic fistula (Table 4). Pancreatic injury ≥ grade 4 (adjusted odds ratio [AOR], 4.071, P = 0.029) and preoperative peritonitis signs (AOR, 2.903; P = 0.039) were significant risk factors in multivariate analysis.

Intra-abdominal-associated injury and mortality

Mortality according to pancreas and other associated abdominal injuries is shown in Table 5. All patients with only pancreas injury without any other abdominal organ injury survived (100%, P = 0.098). The mortality of patients with ISS under 25 was significantly lower than in those with ISS above 25 (3.4% *vs.* 22.7%, P = 0.014). However, no statistical significance was observed based on the 16-point ISS (3.2% [ISS < 16] *vs.* 12.0% [ISS ≥ 16], P = 0.170). The mortality of patients with grade 5 pancreas injury was high (3 of 4, 75.0%). The

mortalities of patients with grades 4, 3, 2, and 1 pancreas injury were 0.0% (0 of 12), 5.7% (2 of 35), 8.0% (2 of 25), and 0% (0 of 5), respectively. The mortality differed significantly according to pancreas injury grade ($P < 0.001$).

The patients who died were summarized in Table 6. All patients who died also had another major abdominal injury. Multiorgan failure was the major cause of death (6 of 7, 85.7%).

DISCUSSION

The present study evaluated both postoperative morbidity and mortality in pancreatic trauma. Morbidity was classified by an internationally accepted grading system. To our knowledge, the current study examined the largest cohort of consecutive pancreatic trauma patients after laparotomy in a single institution in South Korea. Additionally, this is the first study to apply the updated 2016 definition of POPF from the ISGPS [5]. The incidence of POPF in our study (38.3%) was high. Previous studies reported POPF rates ranging from 11% to 26.1% after pancreatic trauma laparotomy [2,13-19]; however, there is a considerable discrepancy in the definition of POPF in these previous studies. Other POPF-related complications such as pancreas-related abscess, organ failure, pseudoaneurysm, and signs of infection were not included in POPF in previous studies. Thus, the high incidence of POPF may be attributed to the more comprehensive nature of the new definition. Unlike POPF, the overall mortality in our study (8.6%) was relatively a favorable outcome compared with other studies [3,20]. However, our study included a relatively low numbers of penetrating injuries and no gunshot wounds, which can cause high-grade multiple injuries with exsanguination. The overall morbidity was high (80.2%, >grade II by Clavien-Dindo). In our study, the risk factors for POPF were symptoms of preoperative peritonitis and pancreatic trauma injury grade.

In the most recent guideline for management from the Eastern Association for the Surgery of Trauma (EAST) [4], the superiority of surgical management (resection or not) remains controversial even in grade 3 or 4 injuries because no randomized studies have assessed this issue and there are only small retrospective or case series. A recently recommended management algorithm based on published observational studies and the expert opinion of Western Trauma Association members [21] promoted surgical drainage alone for grade 4 pancreatic injuries and distal pancreatectomy for grade 3 pancreatic injuries, respectively. However, the nonresection strategy in grade 3 and 4 pancreatic injuries was associated with a high fistula rate (100%) in previous studies [22,23]. In the present study, 2 patients with grade 3 injury and 10 patients with grade 4 injury underwent peripancreatic drainage only without resection owing to the profound difficulty of surgical dissection of severely adhesive and bloody fragile tissue. In an emergency situation for pancreatic trauma patients, proximal resection was dangerous considering that pancreaticoduodenectomy requires long operation time with high surgical skill and experience and

Table 5. Intra-abdominal-associated injury and mortality

Intraabdominal Injury	Alive (n)	Dead (n)	Mortality rate (%)	P-value
Pancreas only	22	0	0	0.098[a]
Pancreas + associated organ (OIS ≥ 1)	52	7	11.9	-
Pancreas + associated organ (OIS ≥ 3)	38	7	15.6	0.013[b]
Pancreas + associated organ (OIS ≥ 4)	15	6	28.6	0.001[c]

OIS, Organ Injury Scale.
[a]Pancreas only vs. pancreas + associated organ (OIS ≥ 1). [b]Pancreas + associated organ (OIS ≥ 3) *vs.* pancreas only or associated organ (OIS ≤ 2) (0% mortality). [c]Pancreas + associated organ (OIS ≥ 4) vs. pancreas only or associated organ (OIS ≤ 3) (1.7% mortality).

Table 6. Mortality after surgical management of pancreatic trauma

Case	Sex/age (yr)	ISS	Pancreas injury (location)	Pancreas injury (grade)	Other major abdominal injury (injury grade)	Operation	Other operation	Hospital stay (day)	Cause of death
1	M/45	38	Head	5	Duodenum (5)	PPPD		68	MOF
2	M/60	16	Head	2	Duodenum (4), colon (3)	Drainage	Duodenojejunostomy, hemicolectomy	8	MOF
3	M/67	13	Neck	2	Duodenum (3)	Drainage	Antrectomy	128	MOF
4	M/47	43	Body	3	Kidney (5), colon (3)	Distal pancreatectomy	Nephrectomy, colostomy	47	MOF
5	M/50	25	Head	5	Liver (4), SMV (4)	Hemostasis with pad packing	Hemostasis, liver pad compression	1	Bleeding
6	M/74	25	Head	5	SMV (4)	Hemostasis with pad packing	SMV ligation	2	MOF
7	F/59	25	Neck	3	Kidney (5)	Distal pancreatectomy	Nephrectomy	2	MOF

ISS, injury severity score; MOF, multiorgan failure; PPPD, pylorus preserving pancreaticoduodenectomy; SMV, superior mesenteric vein.

is always accompanied by a high incidence of morbidity. The pancreatic fistula rate was very high (81.8%) in patients who did not undergo resection in our series and more than half underwent postoperative endoscopic stent insertion for fistula control (63.6%, 7 of 11); however, all patients survived. In the nonresection strategy for grade 3 and 4 pancreatic injury, POPF seems to be unavoidable. However, the nonresection strategy appears to be safe in terms of mortality.

In the present study, the pancreatic injury grade as a risk factor for POPF may be attributed to the difficulty and risks of proximal resection. We found that preoperative peritonitis symptoms were significantly related to POPF. Because of the retroperitoneal position of the pancreas, the initial symptoms may be minimal. Therefore, the presence of peritonitis symptoms suggests the possible widespread leakage of pancreatic juice or other bowel contents. Intra-abdominal contamination and inflammation caused by pancreatic enzymes or bowel contents may inhibit healing of the pancreas tissue. However, there is limited literature on the risk factors for pancreatic complications after pancreatic trauma. In a retrospective review of 193 patients with pancreatic trauma at level 1 trauma center in the United States, Kao et al. [13] reported independent predictors of pancreatic complication including pancreas injury grade and the presence of an associated bowel injury. The authors also reported predictors of mortality including pancreas injury grade, age, ISS, and shock at admission. In a retrospective study of 704 patients who underwent distal pancreatectomy, Nathan et al. [24] reported that pancreatic leak was influenced by patient comorbidities. The authors also reported that surgical management of remnant pancreas such as stapler use, duct ligation, and enteric anastomosis did not affect pancreatic leak. However, the study population contained a limited number of trauma patients (3%). In the present study, stapler closure was not a significant risk factor. In another multicenter randomized controlled trial [25] for distal pancreatectomy including elective surgery of nontraumatic patients, stapler closure did not reduce the rate of pancreatic fistula compared to that of hand-sewn closure.

Pancreaticogastrostomy was performed on 2 patients with grade 4 pancreatic injury in the present study who developed POPF and recovered. There are only small case series addressing pancreatic enterostomy for pancreatic trauma. In a retrospective study of 7 patients including 5 pancreaticogastrostomies and 2 pancreaticojejunostomies, Chinnery et al. [26] reported that there were 2 fistulae and all complications were managed conservatively. However, in a retrospective study of 87 proximal and 123 distal pancreatic injuries, Sharpe et al. [17] reported that all proximal injuries were treated by drainage only without resection and the incidence of pancreas-related morbidity of proximal injuries was 13.5%. In hemodynamically stable patients with complete transection of the proximal pancreas, pancreatic-enterostomy seems to be a viable option but there is limited evidence; it is also a time-consuming procedure compared to peripancreatic drainage only. A drainage-only strategy may be a safer option for most proximal pancreatic trauma. The optimal treatment of proximal pancreatic trauma remains controversial. In terms of surgical management for grade 5 pancreatic injury, the literature is limited and dated; therefore, no recommendation was given in recent guidelines [4]. Although, in the current era of damage control surgery, grade 5 pancreatic injury remains a lethal injury. In the present study, grade 5 pancreatic injuries were extremely rare and fatal despite undergoing damage control surgery.

The results of the current study showed an interesting feature in terms of mortality. In cases of pancreas injury not accompanied by other abdominal organ injuries, the mortality rate was 0%. The present study included high-grade injuries (3 and 4) (72.7%, 16 of 22) without other abdominal organ injuries. In a recent study using data from the United States National Trauma Data Bank database, Siboni et al. [27] reported a very low mortality of isolated blunt pancreatic trauma (2.4%) even with severe injuries. This result is similar to that of our study. Additionally, associated abdominal organ injury was significantly related to mortality. Because the pancreas is located in the central portion of the retroperitoneal space and is protected by other organs such as the bowel, muscles, and spine, isolated pancreatic trauma seems to indicate that the patient received lower traumatic energy. Therefore, pancreatic trauma with other abdominal organ injuries appears to require careful observation.

Our study has several limitations. One of them is the retrospective nature of the study. However, to our knowledge, there are limited prospective data regarding pancreatic trauma because of its rare incidence. Another limitation is the low rate of proximal pancreatic resection, such as pancreaticoduodenectomy, and the small sample size in the present study. This limitation may have contributed to the difficulty in determining the safety of proximal resection, especially in grade 4 and 5 pancreatic injuries. Moreover, the operation was performed by surgeons with varying levels of surgical skill and experience. This may have interfered with the consistency in operation quality, which contributed to the postoperative clinical course.

In conclusion, the pancreas injury grade and pre-operative peritonitis were significant risk factors of POPF. In surgical drainage without resection for main duct injury, the incidence of POPF was very high but mortality was low. The mortality rate of isolated pancreatic trauma was very low.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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