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Lessons learned from isolated blunt major pancreatic injury: Surgical experience in one trauma centre

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ABSTRACT

Introduction: The aim of this study was to present our surgical experience of isolated blunt major pancreatic injury (IBMPI), and to compare its characteristic outcomes with that of multi-organ injury.
Materials and methods: From 1994–2015, 31 patients with IBMPI and 54 patients with multi-organ injury, who underwent surgery, were retrospectively studied.
Results: Of the 31 patients with IBMPI, 22 were male and 9 were female. The median age was 30 years (interquartile range, 20–38). Twenty-one patients were classified as the American Association for the Surgery of Trauma–Organ Injury Scale Grade III, and 10 patients as Grade IV. Patients with IBMPI had significantly lower shock-at-triage rates, lower injury severity scores, longer injury-to-surgery time, and shorter length of hospital stay than those with multi-organ injury. There were no statistically significant differences in sex, age, trauma mechanism, laboratory data, surgical procedures, and complications between the two groups. Eight patients with IBMPI underwent endoscopic retrograde pancreatography, and 5 patients with complete major pancreatic duct (MPD) disruption underwent pancreatectomy eventually. The remaining 3 patients had partial MPD injury and two of them received a pancreatic duct stent for the treatment of existing postoperative pancreatic fistula. Spleen-sacrificing distal pancreatectomy (SSDP) was performed in 13 patient with IBMPI, followed by spleen-preserving distal pancreatectomy ($n = 12$), peripancreatic drainage ($n = 4$), and central pancreatectomy with Roux-en-Y reconstruction ($n = 2$). The overall complication rates, related to the SSDP, SPDP, peripancreatic drainage, and central pancreatectomy, were 10/13 (77%), 4/12 (33%), 3/4 (75%), and 2/2 (100%), respectively. Three patients died resulting in a 10% mortality rate, and the other 16 patients developed intra-abdominal complications resulting in a 52% morbidity rate. In the subgroup analysis of the 25 patients who underwent distal pancreatectomy, SPDP was associated with a shorter injury-to-surgery time than SSDP.
Conclusions: Patients with IBMPI have longer injury-to-surgery times, compared to those with multi-organ injury. Of the distal pancreatectomy patients, the time interval from injury to surgery was a significant associated factor in preserving or sacrificing the spleen.

Introduction

Blunt pancreatic injury is relatively uncommon and its unique retroperitoneal location, obscure clinical presentation, and high frequency of multi-organ involvement showed a mean morbidity rate of 60% and a mean mortality rate of 5% [1–4]. From literature reviews, most blunt pancreatic injuries were often a combination of isolated and multi-organ injuries, and real data on isolated blunt pancreatic injury is scant. Isolated blunt pancreatic injury has only been reported sporadically, and the true outcomes of a large series of patients are seldom reported, especially for surgeries of major degree injury (Organ Injury Scale (OIS) ≥ III). The nonoperative management of minor pancreatic injury (OIS≦ II) is well accepted, thus we focused on the surgical management of major degree injury. We collected data on the surgical experiences of 91 patients with blunt major pancreatic injury in a 22-year period and extracted 31 patients with isolated injury to constitute this study. We analysed the outcomes of these 31 patients and compared them with outcomes of multi-organ injury and we tried to determine the true nature of isolated blunt major pancreatic injury (IBMPI).

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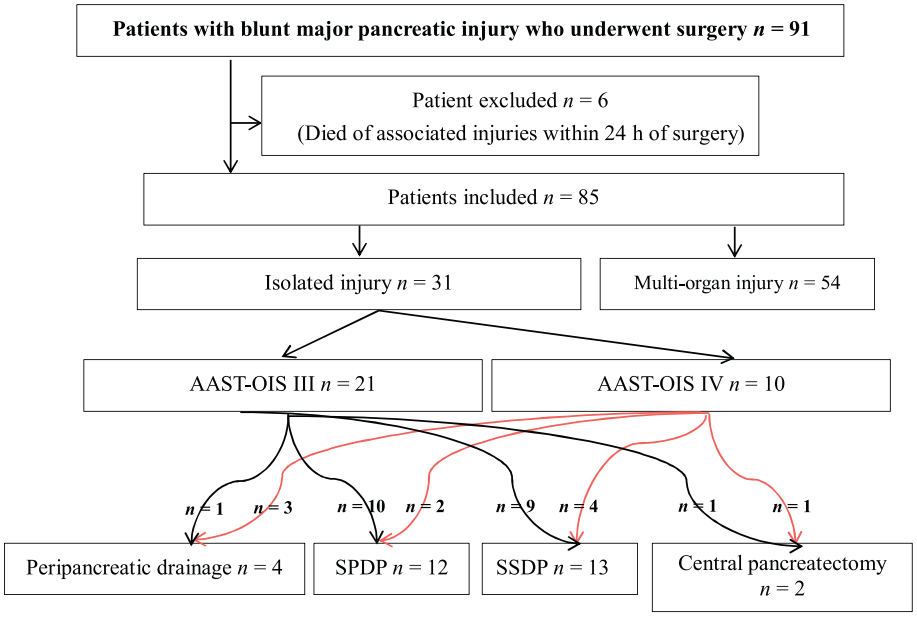
Materials and methods

This study was approved by our institutional review board. From January 1994 to December 2015, 91 surgical patients (injury-to-surgery time, 3 h - 26 days) with blunt major pancreatic injury (OIS ≥ III) were treated in our institution. We excluded 6 patients who died of associated injuries within 24 h of the surgery. Of the remaining 85 patients, 31 patients (36%) developed isolated pancreatic injury (3 patients who had minor extremity soft tissue injuries were also included), and 54 patients (64%) developed multi-organ injury (associated with intra-abdominal injury, $n = 27$; extra-abdominal injury, $n = 11$; combined extra and intra-abdominal injuries, $n = 16$) (Fig. 1). Medical charts were reviewed with respect to age; sex; trauma mechanism; results of imaging studies such as abdominal computed tomography (CT), endoscopic retrograde pancreatography (ERP), and magnetic resonance imaging (MRI); surgical procedures; and outcomes. Pancreatic injuries were graded in accordance with the American Association for the Surgery of Trauma–Organ Injury Scale (AAST–OIS) (Table 1) [5]. Diagnosis and grading of postoperative pancreatic fistula (POPF) were based on the 2016 update of the International Study Group on Pancreatic Surgery [6]. Biochemical leak refers to the drain output of any measurable volume of fluid with an amylase level greater than three times the upper limit of institutional normal serum amylase activity, and it has no clinical impact. Patients with biochemical leak usually remain clinically well. Grade B POPF requires a change in the postoperative management; drains are either left in place for more than three weeks or repositioned through endoscopic or percutaneous procedures. The patient with grade B POPF shows signs of infection without organ failure. Grade C POPF refers to those fistulas that require reoperation, or lead to single or multiple organ failure, and/or mortality attributable to the pancreatic fistula [6]. The integrity of the major pancreatic duct (MPD) was graded in accordance with our pancreatographic classification system (Table 2) [7]. Demographic data and clinical characteristics between the two groups were compared. Categorical data are presented as numbers, and continuous data as median (interquartile range (IQR)) values. For comparisons of categorical data, Fisher's exact test or Pearson's χ^2 test was used, as appropriate. For continuous data, the Mann–Whitney U test was employed. All statistical analyses were performed using SPSS® version 20.0 (IBM, Armonk, New York, USA). $P < 0{\cdot}05$ (two-sided) was considered statistically significant.

Results

Of the 31 patients with IBMPI, 22 patients were male and 9 were female, and the median age was 30 (IQR, 20–38) years. Only 1 patient (3%) presented with shock at the emergency department's triage area. The most frequent cause of injury was motorcycle accident (61%), and the second was motorcar crash (23%). With regard to injury severity, 21 patients were classified as AAST-OIS grade III and 10 patients as grade IV. Compared to the 54 patient counterparts with multi-organ injury, the 31 patients with IBMPI had a significantly lower shock rate (3% vs. 30%, $p = 0.003$), lower injury severity score (median (IQR), 9 (9–16) vs. 17 (12–25), $p < 0.0001$], longer injury-to-surgery time (median (IQR), 36 (15–59) vs. 19 (10–43) h, $p = 0.03$), and shorter length of hospital stay (median (IQR), 17 (10–30) vs. 29 (16–44) days, $p = 0.002$) (Table 3). There were no statistically significant differences in sex, age, trauma mechanism, laboratory data, surgical procedures, and complications between the two groups (Table 3). Of the 31 patients with IBMPI, laboratory data revealed that all patients had raised serum amylase and lipase levels (amylase range 127–3425 U/L; lipase range 336–20293 U/L), and all underwent abdominal CT imaging. Eight patients with inconclusive MPD injury status underwent ERP (preoperation, $n = 4$; postoperation, $n = 4$) (Table 4), 3 patients had class 2 injury with partial MPD injury (Fig. 2), and 5 patients had



AAST-OIS = American Association for the Surgery of Trauma-Organ Injury Scale.

SPDP = spleen-preserving distal pancreatectomy.

SSDP = spleen-sacrificing distal pancreatectomy.

Fig. 1. Flow diagram of patients with blunt major pancreatic injury (Organ Injury Scale ≥ III) who underwent surgery in Chang Gung Memorial Hospital between 1994 and 2015.

Table 1
AAST grading of pancreatic trauma.

Grade	Type of injury	Description of injury
I	Hematoma	Minor contusion without duct injury
	Laceration	Superficial laceration without duct injury
II	Hematoma	Major contusion without duct injury or tissue loss
	Laceration	Major laceration without duct injury or tissue loss
III	Laceration	Distal transection or parenchymal injury with duct injury
IV	Laceration	Proximal[a] transection or parenchymal injury involving ampulla
V	Laceration	Massive disruption of pancreatic head

AAST = American Association for the Surgery of Trauma.
[a] Proximal pancreas is to the patients' right of the superior mesenteric vein.

class 3 injury with complete MPD disruption (Fig. 3) (Table 2). MRI was performed on four patients; however, the status of the MPD could only be evaluated properly in 2 patients. Distal pancreatectomy was the most common surgical procedure (spleen-sacrificing, $n = 13$; spleen-preserving, $n = 12$), followed by peripancreatic drainage alone ($n = 4$), and central pancreatectomy with Roux-en-Y reconstruction ($n = 2$) (Table 3). The overall complication rates, related to the surgical procedures of spleen-sacrificing distal pancreatectomy (SSDP), spleen-preserving distal pancreatectomy (SPDP), peripancreatic drainage, and central pancreatectomy, were 10/13 (77%), 4/12 (33%), 3/4 (75%), and 2/2 (100%), respectively. Three patients had pancreas-related deaths secondary to sepsis with multiple organ failure (MOF) ($n = 2$), and pancreatitis with splenic artery erosion and haemorrhage ($n = 1$). Sixteen patients developed intra-abdominal complications, and according to prevalence order, they include, 10 patients with grade B POPF ($n = 10$), grade C POPF ($n = 2$), intra-abdominal abscess ($n = 2$), postoperative haemorrhage ($n = 1$), and surgical wound infection ($n = 1$), with a 61% overall in-hospital complication rate. In the subgroup analysis of the 25 patients who underwent distal pancreatectomy, the SPDP group was associated with a shorter injury-to-surgery time than SSDP ($p = 0.04$) (Table 5).

Table 2
Lin classification of major pancreatic duct injury, endoscopic retrograde pancreatography findings, and treatment modalitis.

Classification	ERP findings				Treatment modalities
	MPD status	Location	Presentation of contrast medium	MPD continuity	
Class 1	Normal			Intact	Nonsurgical
Class 2a	Partial	Tail	Contrast extravasation	Intact	Nonsurgical
Class 2b	injury	Body			Nonsurgical (stent for adjunctive therapy)
Class 2c		Head			Nonsurgical (stent for adjunctive therapy)
Class 3a	Complete injury	Tail	Contrast extravasation or obstruction of the MPD	Disrupted	Laparotomy: distal pancreatectomy
Class 3b		Body			Laparotomy: distal pancreatectomy
Class 3c		Head			Laparotomy: drainage, distal pancreatectomy, Roux-en-Y reconstruction, Whipple procedure

MPD = major pancreatic duct.
ERP = endoscopic retrograde pancreatography.

Table 3
Comparison of the demographic data of 31 patients with isolated blunt major pancreatic injury (IBMPI) and 54 counterparts with multi-organ injury.

Characteristics		IBMPI	Multi-organ injury	*P* value
No. of patients		31	54	
Gender	Male, *n* (%)	22 (71)	40 (74)	0.76
	Female, *n* (%)	9 (29)	14 (26)	
Age (years) Median (IQR)		30 (20-38)	28 (21-41)	0.78
Mechanism	Motorcycle, *n* (%)	19 (61)	25 (46)	0.32
	Motorcar, *n* (%)	7 (23)	23 (43)	
	Compression, *n* (%)	2 (6)	2 (4)	
	Others (fall, bicycle etc.), *n* (%)	3 (10)	4 (7)	
Initial serum amylase(U/L) Median (IQR)		432 (251-1235)	350 (207-701)	0.11
Initial serum lipase (U/L) Median (IQR)		839 (250-4261)	1462 (717-2953)	0.57
Initial serum hemoglobin (g/dL) Median (IQR)		13 (12-14)	13 (11-14)	0.12
Shock at triage	Yes, *n* (%)	1 (3)	16 (30)	**0.003**
AAST-OIS	III, *n* (%)	21 (68)	43 (80)	0.16
	IV, *n* (%)	10 (32)	9 (17)	
	V, *n* (%)	0	2 (4)	
Injury Severity Score Median (IQR)		9 (9-16)	17 (12-25)	<**0.0001**
Injury- to- surgery time (h) Median (IQR)		36 (15-59)	19 (10-43)	**0.03**
Length of hospital stay (days) Median (IQR)		17 (10-30)	29 (16-44)	**0.002**
Surgical procedures	SSDP, *n* (%)	13 (42)	25 (46)	0.89
	SPDP, *n* (%)	12 (39)	18 (33)	
	Peripancreatic drainage, *n* (%)	4 (13)	5 (9)	
	Central pancreatectomy, *n* (%)	2 (6)	4 (7.4)	
	Whipple procedure, *n* (%)	0	2 (4)	
Morbidity, *n* (%)		16 (52)	31 (57)	0.60
Mortality, *n* (%)		3 (10)	5 (9)	>0.99
Overall complication, *n* (%)		19 (61)	36 (67)	0.61

Table 4
Demographic characteristics, endoscopic retrograde pancreatography finding, and outcomes of the 8 patients with isolated blunt major pancreatic injury.

No.	Age (years)	Sex	AAST-OIS	ERP timing[a]	MPD injury	Pancreatic duct stent	Outcomes	Stay[b] (days)
1	36	M	III	Post-operative[c] ERP (8 days)	Partial[d]	Yes[e]	MPD stricture/alive	23
2	61	F	III	Pre-operative ERP (28 h)	Complete[f]	Yes	Pancreatic duct stent first, and convert to SSDP/death	5
3	20	F	III	Pre-operative ERP (8 h)	Complete	No	SPDP/alive	7
4	58	F	III	Pre-operative ERP (12 h)	Complete	No	SPDP/alive	10
5	33	F	IV	Post-operative[c] ERP (4 days)	Partial	No	Alive	26
6	35	M	IV	Post-operative[g] ERP (19 days)	Partial	Yes[e]	MPD stricture/alive	45
7	17	M	IV	Post-operative[c] ERP (8 days)	Complete	No	SPDP[h]/alive	40
8	20	M	III	Pre-operative ERP (48 h)	Complete	No	SPDP/alive	8

AAST-OIS = American Association for the Surgery of Trauma-Organ Injury Scale.
ERP = endoscopic retrograde pancreatography.
MPD = major pancreatic duct.
SSDP = spleen-sacrificing distal pancreatectomy.
SPDP = spleen-preserving distal pancreatectomy.
[a] time interval from injury to ERP.
[b] length of hospital stay.
[c] patient underwent peripancreatic drainage first.
[d] intact MPD continuity.
[e] for the management of the postoperative pancreatic fistula.
[f] disrupted MPD continuity.
[g] patient underwent SPDP first.
[h] patient underwent SPDP 4 months later.

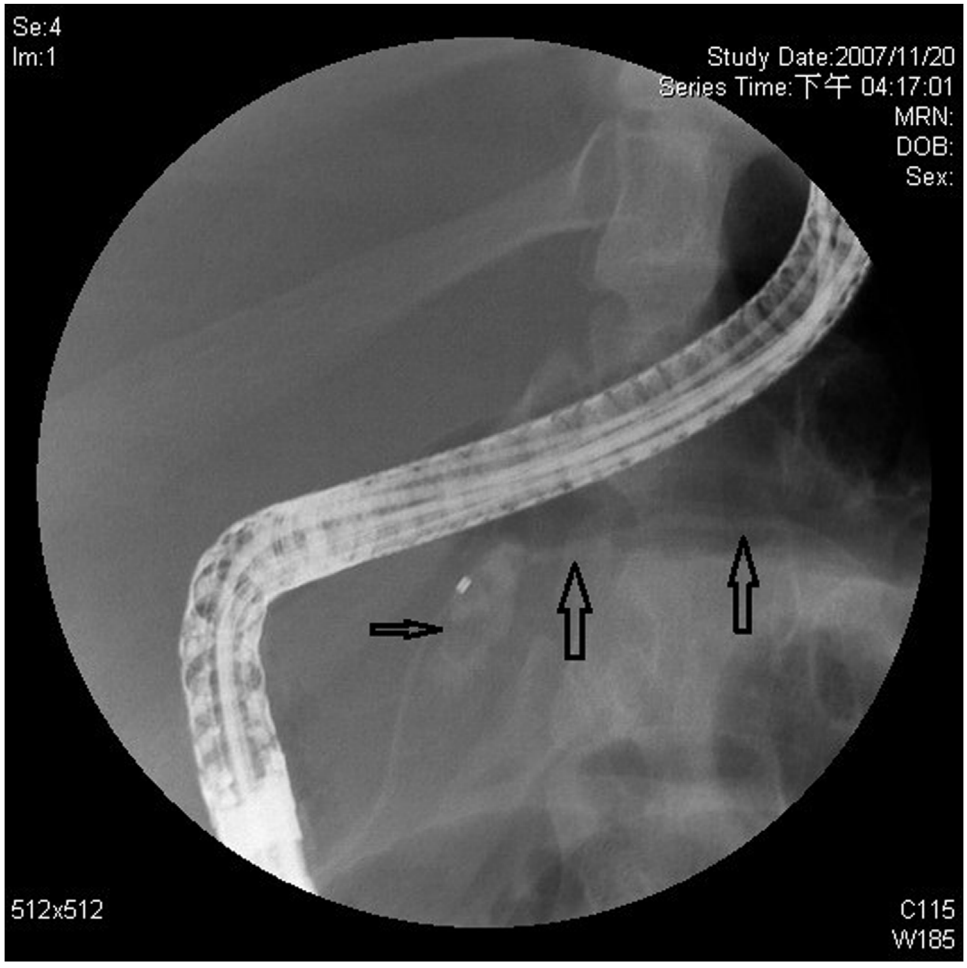


Fig. 2. Endoscopic retrograde pancreatography of an 18-year-old man performed 12 days after trauma, showing partial major pancreatic duct (MPD) injury with contrast extravasation (short arrow) at the pancreatic head; however, the MPD continuity (long arrow) is intact. This is a Lin class 2c MPD injury.

Fig. 3. Endoscopic retrograde pancreatography of a 20-year-old woman performed 8 h after trauma, showing complete MPD injury with contrast extravasation (long arrows) at the pancreatic body. The MPD continuity is disrupted, and only the proximal MPD (short arrows) can be seen. This is a Lin class 3b MPD injury.

Table 5
Comparison of demographic data and clinical characteristics between SPDP and SSDP.

Characteristics	SPDP	SSDP	*P* value
Total number of patients	25		
No. of patients	12	13	
Gender			>0.99
Male, *n* (%)	8 (67)	9 (69)	
Female, *n* (%)	4 (33)	4 (31)	
Age (years) Median (IQR)	23 (19-37)	32 (25-47)	0.17
Shock at triage, *n* (%)	0	0	N/A
Mechanism			0.09
Motorcycle, *n* (%)	8 (67)	6 (46)	
Motorcar, *n* (%)	1 (8)	5 (38)	
Compression	2 (17)	0	
Bicycle, *n* (%)	0	2 (15)	
Assault, *n* (%)	1 (8)	0	
Initial serum amylase (U/L) Median (IQR)	580 (221-1284)	636 (281-1445)	0.67
Initial serum lipase (U/L) Median (IQR)	750 (497-8064)	943 (480-2931)	>0.99
Initial serum hemoglobin (g/dL) Median (IQR)	13 (12-14)	14 (12-4)	0.18
AAST-OIS			0.64
III, *n* (%)	10 (83)	9 (69)	
IV, *n* (%)	2 (17)	4 (31)	
Injury severity score Median (IQR)	9 (9-9)	9 (9-16)	0.57
Time interval to surgery (hours) Median (IQR)	16 (12-64)	48 (31-77)	**0.04**
Length of stay (days) Median (IQR)	10 (8-13)	25 (10-37)	0.16
Morbidity, *n* (%)	3 (25)	9 (69)	0.06
Mortality, *n* (%)	1 (8)	1 (8)	>0.99
Overall complication, *n* (%)	4 (33)	10 (77)	0.07

Discussion

According to the report by Siboni et al. [8], the reported incidence of blunt pancreatic injury is 3.1–5.4% of blunt abdominal injuries [1,8], and isolated blunt pancreatic injury is even rarer, occurring in only 0.7% of all abdominal injuries. Krige et al. [9] reported on 34 patients with isolated pancreatic injury (blunt, $n = 28$; penetrating, $n = 6$) who underwent urgent surgery, and 26 of these patients had major injury. Buccimazza et al. [10] also reported on 11 surgical patients with isolated MPD injuries. To our knowledge, our present study includes the largest series of surgical patients with IBMPI from a single institution. In this study, without further interference of the remote damage and/or adjacent intra-abdominal organ involvement, IBMPI could be diagnosed and managed earlier. However, our data revealed that IBMPI had a longer injury-to-surgery time than multi-organ injury (median (IQR), 36 (15–59) vs. 19 (10–43) h, $p = 0.03$) (Table 3). Clinically, an injury with a higher ISS (17% vs. 9%, $p = <0.0001$) and a shock rate higher than that of IBMPI (30% vs. 3%, $p = 0.003$), pushed a multi-organ injury toward surgery earlier than an IBMPI. Additionally, unique retroperitoneal location with obscure clinical presentation and/or low detection rate of the diagnostic tools in IBMPI eventually resulted in delayed surgery. Of these 31 patients, 16 patients had an injury-to-surgery time more than 36.0 h (median of the series), and the causes for the delay in surgery were {1} delayed medical visit ($n = 9$), {2} delayed transfer ($n = 2$), {3} under-graded CT interpretation ($n = 2$), {4} delayed CT image study ($n = 1$), {5} failed pancreatic duct stent therapy ($n = 1$), and {6} pancreatic injury not detected during surgery ($n = 1$). Apparently, delayed medical visit was the most common contributor to delayed surgery and it reflected the unique character of the retroperitoneal organ. The utility of serum amylase and lipase assays has been debated, and the amylase and lipase levels should not be relied upon to either diagnose or exclude pancreatic injury [3]. In this report, the median (IQR) serum amylase levels of patients with grade III and grade IV injury were 402 (248–1084) U/L and 570 (339–1380) U/L, respectively ($P = 0.37$). This finding reflects that raised amylase levels can be a diagnostic clue; however, these were not associated with the severity of pancreatic injury. During the study period, the introduction of multidetector-row CT allowed for high resolution scans and multiplanar reformations that improved diagnosis of blunt pancreatic injury [11–13], however, under-graded CT interpretation still occurred in 2 patients. According to the literature, the CT detecting rate of MPD injury is reported to be 43–75%, especially in the first 12 h after injury [14]. Therefore, in a suspected major pancreatic injury, a repeat CT scan is recommended within 24–48 h after admission [11,12,14]. Of this series, we focused on major degree injury (OIS $\geq$ III), and the key point of the management is the MPD status. In 1978, Belohlavek et al. first reported the use of ERP for the identification of MPD injury in trauma cases [15]. ERP not only allows for the visualisation of the MPD but also determines injury severity and facilitates optimal treatment [8,16–18]. When a large hematoma or deep laceration with an inconclusive major pancreatic duct status was detected on performing abdominal computed tomography, ERP was indicated, and it should be performed earlier after injury in suitable cases [7]. With the improvement of facilities and experience in endoscopic therapy, ERP with pancreatic duct stent placement was performed in this series since 2000. In patients with partial MPD injury, pancreatic duct stent placement could be an adjunctive therapy to decrease complications, even averting surgery, especially in cases of pancreatic head injury [7]. The benefits of pancreatic duct stent placement in resolving pancreatic fistulas, pseudocysts, and potential MPD stricture risks in non-trauma pancreatitis [19,20] or trauma cases [21–24] have been well reported. However, pancreatectomy is warranted in complete MPD injury [7]. Of this series, 8 patients underwent ERP, and 2 of them had grade B POPF after surgery and were diagnosed with partial MPD injury via ERP, and these 2 patients underwent pancreatic duct stent placement 8 days and 19 days after trauma, respectively. The POPF resolved after stenting in both patients [7,22]. Four patients underwent pre-operative ERP ranging from 8 h to 48 h of injury, and all were diagnosed with complete MPD disruption; of these, 1 patient underwent pancreatic duct stent placement. However, sepsis developed and the patient died of MOF even after undergoing SSDP [1,7]. After this incident, 3 patients with complete MPD injury underwent SPDP without delay and all recovered well. The 5th patient with complete MPD injury underwent SPDP 4 months after the first surgery with peripancreatic drainage (Table 4). MRI has emerged as an attractive alternative due to its direct imaging of the MPD in patients with acute trauma, and an identification rate of duct injury that could approximate 91% [25]. Four patients of this series underwent MRI ranging from 24h-33 days after the injury and the identification of duct injury rate was only 50%. This result could be attributed to the small sample size in this series, and further evaluation is needed. POPF was the most common problem in this series ($n = 12$). Two patients with grade C POPF required reoperation but survived. The remaining 10 patients had grade B POPF, and 5 of these 10 patients required further re-intervention management (CT-guided drainage, $n = 3$; pancreatic duct stent placement, $n = 2$). The other 5 patients with grade B POPF could be managed in the outpatient department with drain removal at follow-up. Of this series, 3 patients died resulting in a 10% mortality rate, which is higher than the 2.4% mortality rate reported by Siboni et al. [8]; this might be attributed to the major injuries (grade III or IV) in all the patients who all underwent surgery. Conversely, in the report by Siboni et al., only 17.3% of the patients had major injuries, and 55.6% of them were treated surgically. Of the three deaths, one patient failed pancreatic duct stent therapy and another had grade III injury and developed pancreatitis, requiring second surgery for gastric perforation. The third patient's pancreatic head grade IV injury was under-graded on performing CT interpretation; therefore, surgery with peri-pancreatic drainage was delayed until 10 days after injury, and the patient had complications of pancreatitis with uncontrolled splenic artery hemorrhage. Central pancreatectomy is not recommended for the management of blunt major pancreatic injury [3,4]. It takes longer to perform Roux-en-Y reconstruction than distal pancreatectomy. The complication rate of central pancreatectomy with Roux-en-Y reconstruction in this report was 2/2 (100%). Of this series, 25 patients (81%) underwent distal pancreatectomy (SSDP, $n = 13$; SPDP, $n = 12$) and in the subgroup analysis of these 25 patients, the SPDP group was associated with a shorter injury-to-surgery time than SSDP ($p = 0.04$) (Table 5). The time interval from injury to surgery was a significant associated factor in preserving or sacrificing the spleen. As time passes by, the continuously spreading inflammation and autodigestion impair the technical approach making vascular dissection and ligation difficult with resultant spleen sacrifice when performing distal pancreatectomy [26]. Limitations of this report include a rather long study period and the relatively small sample size (25 patients underwent distal pancreatectomy in 22 years). Moreover, this was an observational study, and selection bias was inherently present. Changes such as improvement of imaging resolution, endoscopic techniques, critical care of trauma, and surgical skills occurred during this period.

Conclusions

Patients with IBMPI have longer injury-to-surgery times, compared to those with multi-organ injury, and delayed medical visit was the most common contributor to delayed surgery.

Patients with blunt major pancreatic injury had a high surgical complication rate, regardless of whether the injury was isolated or multi-organ. Of the distal pancreatectomy patients, the time interval from injury to surgery was a significant associated factor in preserving or sacrificing the spleen.

Conflict of interest statement

There are no conflicts of interest, including all affiliations or financial involvement with any organization or entity with a financial interest in, or in financial competition with, the subject matter or materials described, reviewed, evaluated or compared in the manuscript.

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