Original article

BJS Open Open Access

Spleen-preserving *versus* spleen-sacrificing distal pancreatectomy in adults with blunt major pancreatic injury

B.-C. Lin[1], R.-J. Chen[3] and T.-L. Hwang[2]

[1]Division of Trauma and Emergency Surgery, Department of Surgery, and [2]Department of General Surgery, Chang Gung Memorial Hospital, Chang Gung University, Tao-Yuan City, and [3]Department of Surgery, Taipei Medical University Hospital, Taipei, Taiwan

Correspondence to: Dr B.-C. Lin, Division of Trauma and Emergency Surgery, Department of Surgery, Chang Gung Memorial Hospital, Chang Gung University, 5, Fu-Hsing Street, Kwei-Shan, Tao-Yuan City, 333, Taiwan (e-mail: linbc@cgmh.org.tw)

Background: **The aim of this study was to analyse outcomes of spleen-preserving (SPDP) and spleen-sacrificing (SSDP) distal pancreatectomy in adults with severe blunt pancreatic injuries.**

Methods: **This was an observational study of adult patients who underwent distal pancreatectomy for grade III or IV blunt pancreatic injury between 1991 and 2015. Outcomes of SPDP and SSDP were compared.**

Results: **Fifty-one patients were included, of whom 23 underwent SPDP and 28 SSDP. The median Injury Severity Score (ISS) was 13·0 (i.q.r. 9·0–18·0). No significant differences were observed between the groups regarding sex, trauma mechanism, shock at triage, laboratory data, location, ISS, associated injury, length of stay, mortality or morbidity. Age (27·0 *versus* 36·5 years; $P = 0·012$) and time interval from injury to distal pancreatectomy (15·0 *versus* 44·0 h; $P = 0·022$) differed significantly between SPDP and SSDP groups respectively. The mortality rate was 4 per cent (1 of 23) *versus* 11 per cent (3 of 28) respectively ($P = 0·617$). Nine patients (39 per cent) developed abdominal morbidity after SPDP, compared with 17 (61 per cent) after SSPD ($P = 0·125$). In the SPDP group, eight patients had grade B postoperative pancreatic fistula (POPF), two of whom required further intervention. In the SSDP group, six of ten patients with grade B POPF required CT-guided drainage, and a further five patients required reoperation for other causes. There were more reinterventions after SSDP: 11 of 28 (39 per cent) *versus* 3 of 23 (13 per cent) in the SPDP group ($P = 0·037$).**

Conclusion: **SPDP was performed more often in younger patients and at a shorter interval after severe blunt pancreatic injury. SPDP was associated with fewer reinterventions.**

Funding information
No funding

Paper accepted 30 May 2018
Published online 10 July 2018 in Wiley Online Library (www.bjsopen.com). **DOI:** 10.1002/bjs5.89

Introduction

Adult patients with grade III or IV blunt injury to the pancreas require distal pancreatectomy[1–5]. The spleen is frequently sacrificed during this procedure because of its anatomical relation to the pancreas and decreased operating time. Spleen preservation, however, might be preferable because of the spleen's important role in host defence, including the elimination of rare but potentially fatal infections with encapsulated bacteria. Spleen-preserving distal pancreatectomy (SPDP) has been well described in the management of benign and malignant pancreatic disorders[6,7], but only a few reports exist regarding its use in injured patients[2,8–10]. The aim of this study was to compare baseline factors and outcomes of adult patients who underwent distal pancreatectomy for grade III or IV blunt pancreatic injury with or without spleen preservation.

Methods

This study was approved by the institutional review board of Chang Gung Memorial Hospital, Chang Gung University, Taiwan, a 3704-bed medical centre, including trauma care. Patients who were admitted with grade III and IV blunt pancreatic injury and who underwent distal pancreatectomy between 1991 and 2015 were eligible. During the

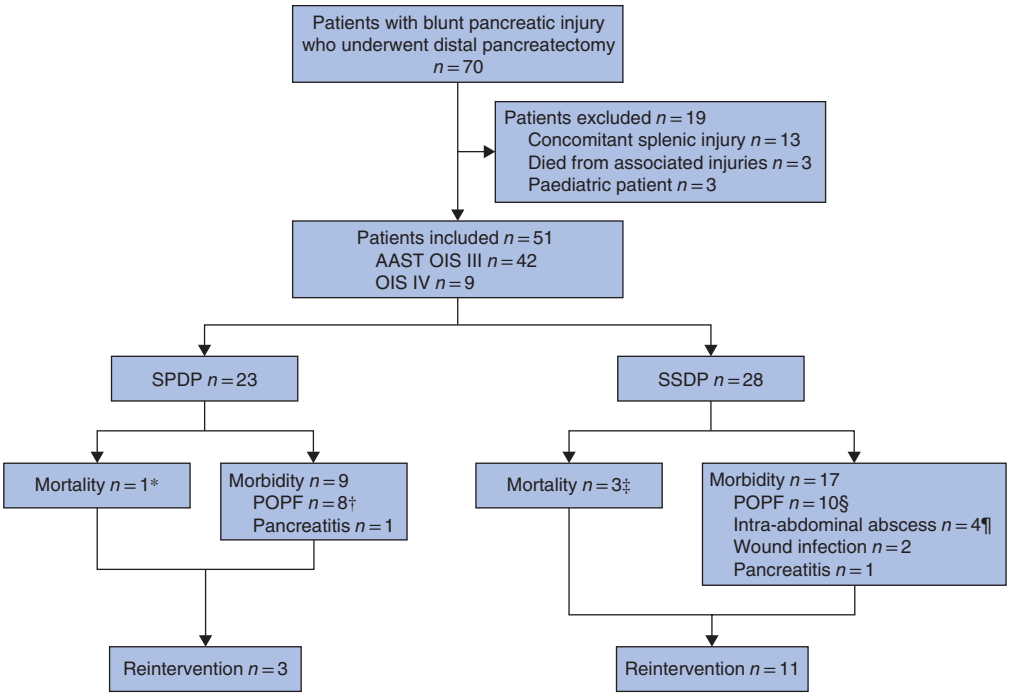


Fig. 1 Flow diagram of patients with blunt pancreatic injury who underwent distal pancreatectomy in Chang Gung Memorial Hospital between 1991 and 2015. *Reoperation in hospital for perforated gastric ulcer; †one patient had CT-guided drainage and another one had pancreatic duct stent therapy; ‡two patients underwent reoperation; §six patients had CT-guided drainage; ¶three patients underwent reoperation. AAST OIS, American Association for the Surgery of Trauma Organ Injury Scale; SPDP, spleen-preserving distal pancreatectomy; SSDP, spleen-sacrificing distal pancreatectomy; POPF, postoperative pancreatic fistula

study period, there were on average 385–400 admissions with blunt abdominal trauma annually. Of these around 5 per cent had pancreatic injuries, with a previously reported[2] incidence of major injury (grade III or above) of 1·3 per cent. Exclusion criteria included death from an associated injury within 24 h of surgery, concomitant splenic injuries that mandated splenectomy, and age less than 18 years.

Abdominal CT is now used routinely as the first-line imaging modality in patients with acute trauma and can be helpful in detecting injury to the pancreas. In the early days of the study, CT was not performed in all patients. During the study interval, more than ten surgeons were responsible for abdominal trauma surgery, and none preferred either preserving or sacrificing the spleen while performing distal pancreatectomy. The decision was based on the clinical condition of the patient.

Splenic preservation during distal pancreatectomy was achieved either by maintaining the splenic vessels[11] or, after ligating these vessels, by preserving the short gastric vessels for perfusion (Warshaw technique)[12], depending on the surgeon's expertise and preference. Identification and ligation of the main pancreatic duct stump, followed by sutured pancreatic stump closure, was the preferred approach, although many techniques were used to close the pancreatic stump, including sutures, staples, mesh application, or a combination of these techniques, again depending on the preference of the surgeon[13–16]. A peripancreatic drain was placed routinely in every patient who had a distal pancreatectomy.

Medical charts were reviewed with respect to age, sex, trauma mechanism, Injury Severity Score (ISS), associated injury, time interval from injury to distal pancreatectomy, length of stay, and complications. Major trauma is defined as ISS greater than 15. Pancreatic injuries were graded in accordance with the American Association for the Surgery of Trauma Organ Injury Scale (AAST OIS) for pancreatic injury[1]: grade I, minor contusion/laceration without duct injury; grade II, major contusion/laceration without duct injury or tissue loss; grade III, distal (left of superior mesenteric vein) transection or parenchymal injury with duct injury; grade IV, proximal (right of superior mesenteric vein) transection or parenchymal injury involving ampulla; grade V, massive disruption of the pancreatic head.

Table 1 Comparison of demographic data and clinical characteristics in patients undergoing spleen-preserving and spleen-sacrificing distal pancreatectomy

	SPDP ($n = 23$)	SSDP ($n = 28$)	P†
Age (years)*	27·0 (19·0–38·0)	36·5 (28·0–44·0)	0·012‡
Sex ratio (M : F)	15 : 8	21 : 7	0·446
Shock at triage	2	8	0·091
Mechanism of injury			0·213
Motor car accident	7	16	
Motorcycle accident	14	9	
Compression	1	1	
Other (fall, bicycle, assault, etc.)	1	2	
Initial serum amylase (units/l)*	510·0 (310·0–1034·5)	301·0 (187·0–1116·0)	0·217‡
Initial serum lipase (units/l)*	926·0 (497·0–2015·0)	1069·0 (460·0–3551·0)	0·878‡
Initial serum haemoglobin (g/dl)*	13·2 (12·0–13·8)	12·5 (10·3–14·2)	0·675‡
AAST OIS grade			> 0·999
III	19	23	
IV	4	5	
Injury Severity Score*	13·0 (9·0–18·0)	14·5 (9·0–17·7)	0·790‡
Associated injury	10	15	0·473
Extra-abdominal	6	4	0·316
Intra-abdominal	2	7	0·159
Combined	2	4	0·678
1 injured organ	6	10	0·461
2 injured organs	4	3	0·687
≥ 3 injured organs	0	2	0·495
Time interval to distal pancreatectomy (h)*	15·0 (12·0–24·0)	44·0 (12·2–96·0)	0·022‡
Length of stay (days)*	16·0 (10·0–35·0)	31·5 (17·2–49·2)	0·070‡

*Values are median (i.q.r.). SPDP, spleen-preserving distal pancreatectomy; SSDP, spleen-sacrificing distal pancreatectomy; AAST OIS, American Association for the Surgery of Trauma Organ Injury Scale. †Fisher's exact or χ^2 test, except ‡Mann–Whitney U test.

Table 2 Comparison of outcomes in patients undergoing spleen-preserving and spleen-sacrificing distal pancreatectomy

	SPDP ($n = 23$)	SSDP ($n = 28$)	P#
Mortality	1*	3‡	0·617
Morbidity	9	17	0·125
Postoperative pancreatic fistula	8†	10§	0·945
Intra-abdominal abscess	0	4¶	0·117
Wound infection	0	2	0·495
Pancreatitis	1	1	> 0·999
Total no. of radiological interventions and reoperations	3*†	11‡§¶	0·037

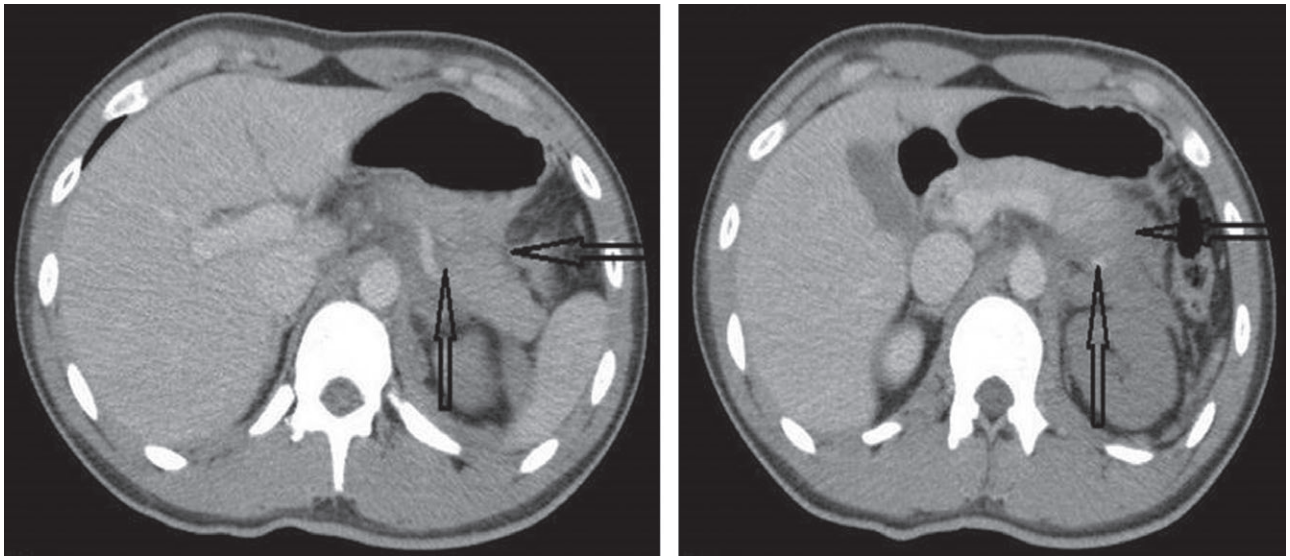
*Reoperation for in-hospital perforated gastric ulcer; †one patient underwent CT-guided drainage and another had pancreatic duct stent therapy; ‡two patients underwent reoperation; §six patients had CT-guided drainage; ¶three patients underwent reoperation. SPDP, spleen-preserving distal pancreatectomy; SSDP, spleen-sacrificing distal pancreatectomy. #Fisher's exact or χ^2 test.

Diagnosis and grading of postoperative pancreatic fistula (POPF) were based on the 2016 update of the International Study Group on Pancreatic Surgery[17]. Biochemical leak refers to drain output of any measurable volume of fluid with an amylase level more than three times the upper limit of institutional normal serum amylase activity, and has no clinical impact. Patients with biochemical leak usually remain clinically well, and the leak is not associated with delayed hospital discharge. Grade B POPF requires a change in postoperative management; drains are either left in place for more than 3 weeks or repositioned via an endoscopic or percutaneous procedure. If POPF-related haemorrhage or pseudoaneurysm occurs, transfusions and/or angiography usually are necessary. Grade B POPF is associated with signs of infection, but not organ failure. Grade C POPF refers to fistulas that require reoperation or lead to single or multiple organ failure and/or death attributable to the fistula[17].

Outcomes focused on length of stay, in-hospital morbidity, mortality and reintervention after distal pancreatectomy with or without spleen preservation.

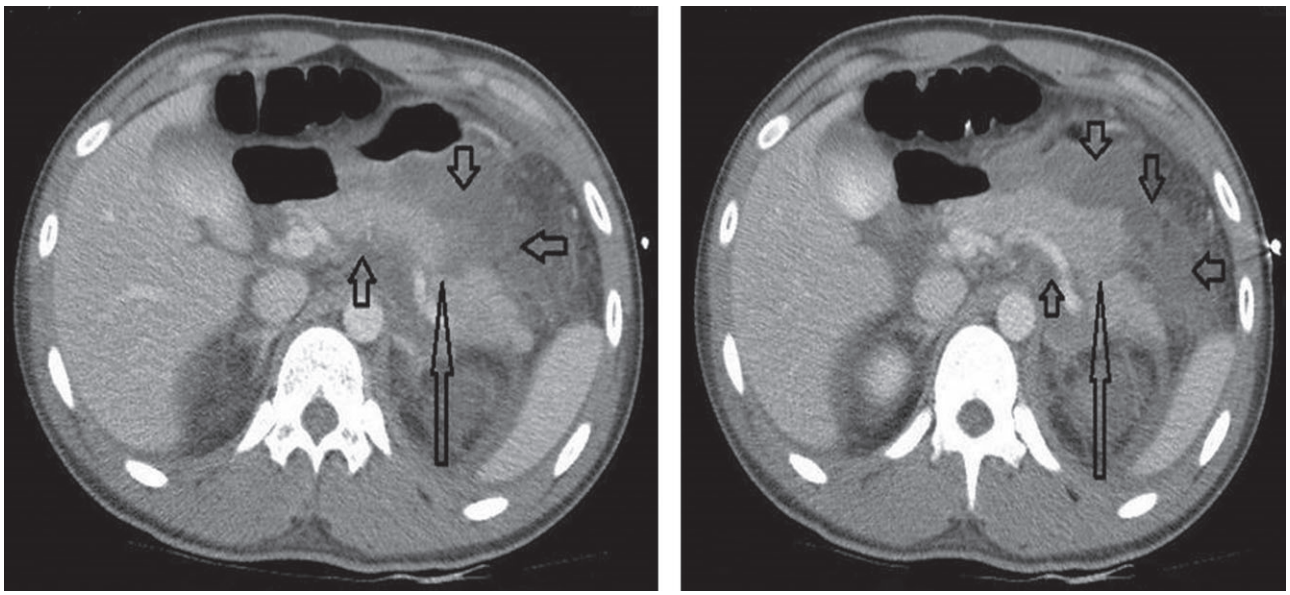
Statistical analysis

Demographic data and clinical characteristics between SPDP and spleen-sacrificing distal pancreatectomy (SSDP) were compared and the determining factors of preservation of the spleen analysed. Categorical data are presented as numbers, and continuous data as median (i.q.r.) 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.



a Acute parenchymal laceration **b** Grade II injury

Fig. 2 Abdominal CT scans of a 20-year-old man showing **a** acute parenchymal laceration (long arrows) at the pancreatic tail, **b** interpreted as a grade II injury initially



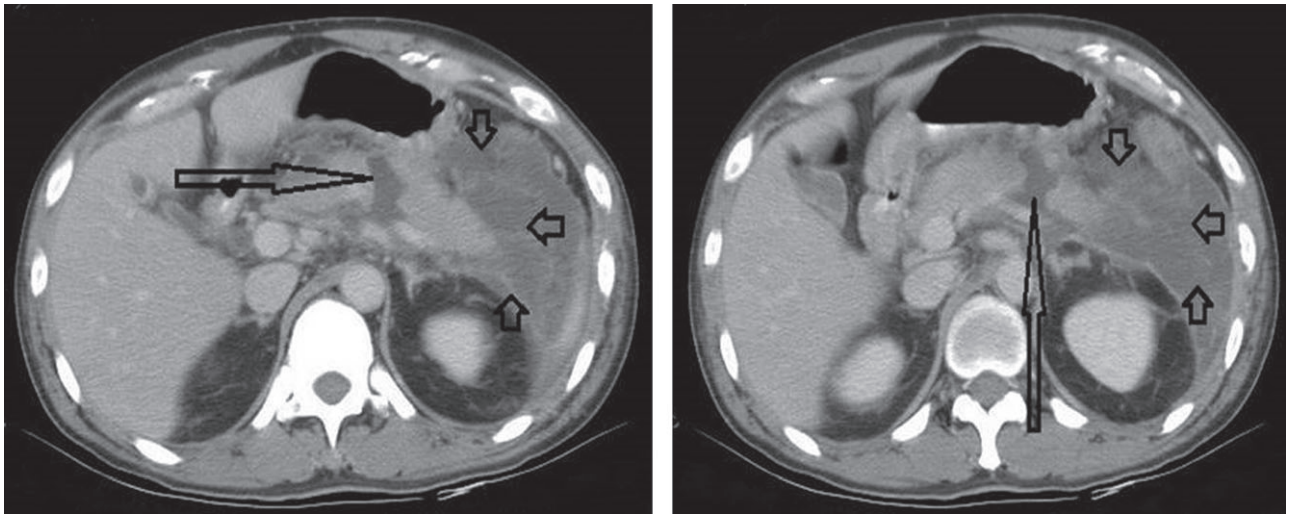
a Parenchymal laceration after 3 days **b** Grade III injury

Fig. 3 Follow-up abdominal CT scans of the patient in *Fig. 2* showing **a** complete parenchymal transection (long arrow) at the pancreatic tail with peripancreatic fluid collections (short arrows) 3 days after injury, **b** interpreted as a grade III injury

Frequencies of factors that resulted in delay of pancreatic surgery are presented. All statistical analyses were performed using SPSS® version 20.0 (IBM, Armonk, New York, USA). $P < 0{\cdot}050$ (two-sided) was considered statistically significant.

Results

Between August 1991 and May 2015, 70 patients underwent distal pancreatectomy for grade III–IV blunt pancreatic trauma, of whom 19 were excluded from the present analysis (*Fig. 1*). Of these 19 patients, three died from an



a Complete parenchymal transection 7 days after injury **b** Grade III injury

Fig. 4 Abdominal CT scan of a 40-year-old man showing **a** complete parenchymal transection (long arrow) at the pancreatic body with peripancreatic fluid collections (short arrows) 7 days after injury, **b** interpreted as a grade III injury

associated injury within 24 h of surgery, 13 had concomitant splenic injuries that required splenectomy, and three paediatric patients were also excluded. The remaining 51 adults were included in the study; 23 and 28 underwent SPDP and SSDP respectively.

Baseline characteristics at admission to the emergency department are shown in *Table 1*. The median age of the study population was 33·0 (i.q.r. 23·0–43·0) years. The most common causes of injury were motorcycle and car crashes; the median ISS was 13·0 (i.q.r. 9·0–18·0). Laboratory data revealed that all patients had raised serum amylase and lipase levels (amylase range 127–3425 units/l; lipase range 210–20 293 units/l). Early in the study six patients were operated on directly after either positive diagnostic peritoneal lavage or suspected signs at physical examination. After 2002, all patients underwent abdominal CT or endoscopic retrograde pancreatography (ERP) to diagnose the severity of the pancreatic injury. Patients who underwent SPDP were significantly younger ($P = 0{\cdot}012$) and had a significantly shorter median time interval from injury to distal pancreatectomy ($P = 0{\cdot}022$) (*Table 1*).

Surgical data and in-hospital morbidity and mortality are shown in *Table 2*. Complications occurred in ten of 23 patients after SPDP and in 20 of 28 following SSPD. In the SPDP group, one patient died in hospital from perforated gastric ulcer, even after reoperation. In the SPDP group, eight patients had grade B POPF, six of which were associated with prolonged drainage (tube left in place for more than 3 weeks) that was managed with no discharge delay and drain removal during follow-up[17]; only two patients in this group required further radiological intervention. Conversely, six of ten patients with grade B POPF in the SSDP group required CT-guided drainage, with a further five patients requiring reoperation for intra-abdominal abscess (3), splenic artery stump bleeding (1) and pancreatitis with colonic perforation (1). Three patients died after SSDP.

The timing of surgery in the 28 patients who underwent SSDP was investigated, and the reasons for delay were analysed. A frequency analysis of factors leading to missing the optimal surgical timing at admission suggested there were three contributors: pancreatic injury not detected during surgery (4 patients); failure to detect or undergrading of the pancreatic injury on CT scan (3); and failed pancreatic duct stent therapy (1). The four patients in the first category underwent emergency laparotomy principally for blunt liver injuries, with their grade III pancreatic injury remaining undetected at surgery. Clinical deterioration required reoperation and the spleen was sacrificed when distal pancreatectomy was performed on days 6, 9, 11 and 11 after the liver surgery.

Examples of misclassified pancreatic injuries on CT are shown in *Fig. 2*; *Fig. 3* shows consecutive representative CT scans. A similar clinical course also occurred in a 40-year-old man (*Fig. 4*).

Discussion

Splenic preservation during distal pancreatectomy for grade III–IV blunt pancreatic trauma was associated with younger age at admission and shorter time interval from

injury to surgery. Fewer reinterventions were performed in the SPDP group.

Ho and colleagues[5] performed a review of 37 articles from a total of 319 articles on pancreatic injury. Thirteen articles were selected to study spleen preservation or splenectomy during distal pancreatectomy, from which it was concluded that the data did not conclusively favour either SPDP or SSDP[5]. In the present series, confounding factors such as associated splenic injury and damage control with staged operation were excluded. Some studies[4,5] recommended that spleen preservation should be considered in a haemodynamically stable patient when performing distal pancreatectomy with an isolated pancreatic injury. The present study indicates that, following adequate resuscitation, the spleen could be preserved in patients who present with shock at triage or with multiple associated injuries.

Age-related effects on the clinical outcome of injured patients have been reported, especially in the very elderly[18,19]. The median age of the present study population, however, was 33·0 years and does not reflect elderly trauma victims. A significant associated factor in preserving or sacrificing the spleen in the present series was the time interval between injury and distal pancreatectomy, particularly related to missed pancreatic injury in patients with liver trauma. Surgery for the injured liver should be the first priority to control bleeding. Pancreatic injury is easily overlooked if retroperitoneal exploration is neglected. As time passes, the continuously spreading inflammation and autodigestion impair the technical approach, making vascular dissection and ligation difficult when performing distal pancreatectomy. Under these conditions, spleen preservation is technically more difficult.

CT is used routinely as the first-line imaging modality in patients with acute trauma and can be helpful in detecting injury to the pancreas. Its main limitation is the low accuracy in detecting major pancreatic duct (MPD) injury and underestimation of pancreatic injury[20], especially within the first 12 h after the injury. In patients with suspected pancreatic injury, a repeat CT scan is recommended within 24–48 h of admission[21–23]. In patients with suspected MPD injury, magnetic resonance cholangiopancreatography or ERP may be needed to identify MPD injury[24–26].

Delays in surgery that resulted in spleen sacrifice may also have led to the greater need for reintervention in the SSPD group. It is not possible to state with any clarity whether the trend towards better outcomes with splenic preservation reflects the advantages of spleen preservation or simply the need for spleen removal if surgery is delayed. As this was a retrospective study, selection bias was inherently present. The time span within which included patients underwent surgery was more than 20 years. Imaging tools, intensive care and surgical skills have developed over this time interval.

Acknowledgements

The authors thank the team members for their efforts and S.-F. Huang for her statistical assistance.
Disclosure: The authors declare no conflict of interest.

References

1 Moore EE, Cogbill TH, Malangoni MA, Jurkovich GJ, Champion HR, Gennarelli TA *et al.* Organ injury scaling, II: pancreas, duodenum, small bowel, colon, and rectum. *J Trauma* 1990; **30**: 1427–1429.
2 Lin BC, Chen RJ, Fang JF, Hsu YP, Kao YC, Kao JL. Management of blunt major pancreatic injury. *J Trauma* 2004; **56**: 774–778.
3 Jurkovich GJ, Carrico CJ. Pancreatic trauma. *Surg Clin North Am* 1990; **70**: 575–593.
4 Subramanian A, Dente CJ, Feliciano DV. The management of pancreatic trauma in the modern era. *Surg Clin North Am* 2007; **87**: 1515–1532.
5 Ho VP, Patel NJ, Bokhari F, Madbak FG, Hambley JE, Yon JR *et al.* Management of adult pancreatic injuries: a practice management guideline from the Eastern Association for the Surgery of Trauma. *J Trauma Acute Care Surg* 2017; **82**: 185–199.
6 Aldridge MC, Williamson RC. Distal pancreatectomy with and without splenectomy. *Br J Surg* 1991; **78**: 976–979.
7 Fernández-Cruz L, Martínez I, Gilabert R, Cesar-Borges G, Astudillo E, Navarro S. Laparoscopic distal pancreatectomy combined with preservation of the spleen for cystic neoplasms of the pancreas. *J Gastrointest Surg* 2004; **8**: 493–501.
8 Pachter HL, Hofstetter SR, Liang HG, Hoballah J. Traumatic injuries to the pancreas: the role of distal pancreatectomy with splenic preservation. *J Trauma* 1989; **29**: 1352–1355.
9 Yadav TD, Natarajan SK, Kishore VM, Lyngdoh S, Wig JD. Spleen-preserving distal pancreatectomy for pancreatic trauma: a series of six cases. *JOP* 2007; **8**: 422–428.
10 Krige JE, Kotze UK, Nicol AJ, Navsaria PH. Morbidity and mortality after distal pancreatectomy for trauma: a critical appraisal of 107 consecutive patients undergoing resection at a Level 1 Trauma Centre. *Injury* 2014; **45**: 1401–1408.
11 Mallet-Guy P, Vachon A. *Pancreatites Chroniques Gauches*. Masson et Cie: Paris, 1943.
12 Warshaw AL. Conservation of the spleen with distal pancreatectomy. *Arch Surg* 1988; **123**: 550–553.
13 Bilimoria MM, Cormier JN, Mun Y, Lee JE, Evans DB, Pisters PW. Pancreatic leak after left pancreatectomy is reduced following main pancreatic duct ligation. *Br J Surg* 2003; **90**: 190–196.

14 Balzano G, Zerbi A, Cristallo M, Di Carlo V. The unsolved problem of fistula after left pancreatectomy: the benefit of cautious drain management. *J Gastrointest Surg* 2005; **9**: 837–842.
15 Kleeff J, Diener MK, Z'graggen K, Hinz U, Wagner M, Bachmann J *et al.* Distal pancreatectomy: risk factors for surgical failure in 302 consecutive cases. *Ann Surg* 2007; **245**: 573–582.
16 Jensen EH, Portschy PR, Chowaniec J, Teng M. Meta-analysis of bioabsorbable staple line reinforcement and risk of fistula following pancreatic resection. *J Gastrointest Surg* 2013; **17**: 267–272.
17 Bassi C, Marchegiani G, Dervenis C, Sarr M, Abu Hilal M, Adham M *et al.*; International Study Group on Pancreatic Surgery (ISGPS). The 2016 update of the International Study Group (ISGPS) definition and grading of postoperative pancreatic fistula: 11 years after. *Surgery* 2017; **161**: 584–591.
18 Vanzant EL, Hilton RE, Lopez CM, Zhang J, Ungaro RF, Gentile LF *et al.*; Inflammation and Host Response to Injury Investigators. Advanced age is associated with worsened outcomes and a unique genomic response in severely injured patients with hemorrhagic shock. *Crit Care* 2015; **19**: 77.
19 Mees ST, Gwinner M, Marx K, Faendrich F, Schroeder J, Haier J *et al.* Influence of sex and age on morphological organ damage after hemorrhagic shock. *Shock* 2008; **29**: 670–674.
20 Wong YC, Wang LJ, Fang JF, Lin BC, Ng CJ, Chen RJ. Multidetector-row computed tomography (CT) of blunt pancreatic injuries: can contrast-enhanced multiphasic CT detect pancreatic duct injuries? *J Trauma* 2008; **64**: 666–672.
21 Teh SH, Sheppard BC, Mullins RJ, Schreiber MA, Mayberry JC. Diagnosis and management of blunt pancreatic ductal injury in the era of high-resolution computed axial tomography. *Am J Surg* 2007; **193**: 641–643.
22 Venkatesh SK, Wan JM. CT of blunt pancreatic trauma: a pictorial essay. *Eur J Radiol* 2008; **67**: 311–320.
23 Moschetta M, Telegrafo M, Malagnino V, Mappa L, Ianora AA, Dabbicco D *et al.* Pancreatic trauma: the role of computed tomography for guiding therapeutic approach. *World J Radiol* 2015; **7**: 415–420.
24 Lin BC, Wong YC, Chen RJ, Liu NJ, Wu CH, Hwang TL *et al.* Major pancreatic duct continuity is the crucial determinant in the management of blunt pancreatic injury: a pancreatographic classification. *Surg Endosc* 2017; **31**: 4201–4210.
25 Fulcher AS, Turner MA, Yelon JA, McClain LC, Broderick T, Ivatury RR *et al.* Magnetic resonance cholangiopancreatography (MRCP) in the assessment of pancreatic duct trauma and its sequelae: preliminary findings. *J Trauma* 2000; **48**: 1001–1007.
26 Panda A, Kumar A, Gamanagatti S, Bhalla AS, Sharma R, Kumar S *et al.* Evaluation of diagnostic utility of multidetector computed tomography and magnetic resonance imaging in blunt pancreatic trauma: a prospective study. *Acta Radiol* 2015; **56**: 387–396.