

Surgical experience and clinical outcome of traumatic pancreatic injury

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Backgrounds/Aims: Traumatic pancreatic injury is rare and various surgical procedures can be applied according to the severity of injury. We reviewed our experience of pancreatic injury and investigated the clinical outcome. **Methods:** Fifty-six patients were treated conservatively or with surgery for pancreatic injury at the Department of Surgery, Korea University Medical Center of Korea University College of Medicine from January 2001 to February 2012. **Results:** Forty-one men and 15 women were included (mean age, 32 years; range, 5-66 years). Twelve patients were hypotensive at admission. According to the American Association for the Surgery of Trauma grade, 15 patients were grade I, 16 were grade II, 10 were grade III, 13 were grade IV, and one patient was grade V. A total of 41 patients underwent exploratory surgery. Complications developed in 35 patients, and 19 patients demonstrated intra-abdominal abscesses associated with pancreatic leakage. Four mortalities occurred. More adult patients (n=42) required intensive care than that of pediatric patients (n=14) ($p=0.03$). However, more pediatric patients had hyperamylasemia at admission ($p=0.023$). A significantly higher proportion of patients in the hypotensive group had blunt abdominal injuries, associated extra-abdominal injuries, combined intra-abdominal injuries, longer ICU stays, and a higher mortality rate. **Conclusions:** Associated intra-abdominal and extra-abdominal injuries are frequent in patients with traumatic pancreatic injury. Despite the complication rate, most patients recovered. Mortalities were associated with combined injuries being placed into bleeding, hypovolemic shock, and multiorgan failure. (*Korean J Hepatobiliary Pancreat Surg 2012;16:160-166*)

Key Words: Pancreatic injury; Pancreatic fistula; Distal pancreatectomy

INTRODUCTION

Pancreatic injury is rare consisting of 5% of patients with blunt abdominal trauma and 5% of those with penetrating injury.^{1,2} Blunt abdominal trauma to the pancreas is associated with direct linear or focal pressure caused by seat belt or bicycle handle injuries and blunt assault. The diagnosis is typically made with an imaging study, particularly abdominal computed tomography (CT). However the sensitivity of CT for the initial trauma evaluation is insufficient; therefore, missed diagnoses can occur in the clinical setting of blunt abdominal trauma.³

Surgical management of traumatic pancreatic injury is challenging, and a very experienced surgeon is required, particularly in young traumatized patients and patients with associated complex injuries. Morbidity from a pancreatic injury is high, and the mortality rate is significant.^{1,2,4,5}

The aim of this study is to evaluate our pancreatic trauma surgical experience and management since 2000.

Special reference to pediatric pancreatic injuries was also described based on the clinical differences between pediatric and adult patients. The clinical outcomes of the traumatized patients with hypotension at initial admission were also compared with patients without hypotension.

METHODS

Fifty-six patients were treated conservatively or underwent surgery for pancreatic injuries at the Department of Surgery, Korea University Medical Center of Korea University College of Medicine, Seoul, Korea from January 2001 to February 2012.

The following demographics and clinical information were reviewed retrospectively from medical records: age, gender, initial visit to our department or referral from another center, mechanism of injury (blunt vs. penetrating), initial vital signs, diagnostic approach, concomitant intra-abdominal or extra-abdominal injuries, preoperative

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laboratory results, American Association for the Surgery of Trauma (AAST) grade,⁶ time interval from initial diagnosis to date of operation, operative procedure, operative time, transfusion requirement, necessity for intensive care, and the postoperative course, including development of complications, length of hospital stay, and final outcome.

The definition for postoperative pancreatic fistula following a pancreatic injury is different from that of non-traumatic pancreatic surgery. The definition of pancreatic fistula is a change in the color of the drainage fluid, suggesting a pancreatic fistula or an abrupt increase in the level of amylase drainage during the postoperative course and the reason for maintaining the drainage catheter for a longer duration. This definition included patients with serous drainage color fluid or low amylase level in the drainage fluid. However, the clinical findings of pancreatic fistula or abdominal abscess including abdominal pain, and fever, leukocytosis, and the presence of a pancreatic fistula or abscess was confirmed on abdominal CT.

Data are expressed as the mean±standard deviation or median with 25th and 75th percentiles for continuous variables. The statistical analysis was performed using SPSS version 13.0 for Windows (SPSS Inc., Chicago, IL, USA). Comparisons between the two groups were carried out using Pearson's chi-square test. We performed independent sample *t*-tests for normally distributed continuous variables and the Mann-Whitney *U*-test for non-normally distributed continuous variables. A *p*-value <0.05 was considered statistically significant.

RESULTS

Clinical characteristics

Forty-one men and 15 women (mean age, 32±18 years; range, 5-66 years) were included. Fourteen were pediatric patients with less than 15 years of age. Forty-nine patients had blunt injuries and seven patients had penetrating injuries. Twelve patients were hypotensive (systolic blood pressure <100 mmHg) at the initial visit to the hospital. Forty-seven (84%) patients underwent CT scans at initial admission, and a pancreatic injury was detected in 35 (75%). Nine patients did not undergo a CT scan, and 12 in whom the pancreatic injury diagnosis was missed at the initial CT scan were diagnosed with pancreatic injury after an exploratory laparotomy. However, these 12 patients did not have severe pancreatic injury grades that affected their outcomes negatively. According to the AAST grade for pancreatic injury, 15 patients had grade I injuries, 16 had grade II, 10 had grade III, 13 had grade IV, and one had grade V. One patient visited the outpatient clinic due to a pancreatic pseudocyst that developed after abdominal trauma; however, an abdominal CT scan had not been taken initially; therefore, his AAST grade was unknown. That patient was treated successfully with percutaneous drainage.

Table 1 shows the management of pancreatic injury according to AAST grade in this study. Forty-one patients underwent surgery for pancreatic injuries, and 15 recovered with nonoperative management. Nonoperative management was undertaken for grade I and II patients.

Table 1. Management of pancreatic injury according to American Association for the Surgery of Trauma (AAST) grade

| Management | AAST grade | | | | | | |
|---|------------|----|----|-----|----|---|----|
| | Unknown | I | II | III | IV | V | No |
| Nonoperation | 1 | 8 | 6 | 0 | 0 | 0 | 15 |
| Drainage, debridement | 0 | 4 | 6 | 0 | 1 | 0 | 11 |
| Primary repair | 0 | 2 | 1 | 0 | 0 | 0 | 3 |
| Distal pancreatectomy (Spleen preserving) | 0 | 0 | 0 | 0 | 4 | 0 | 4 |
| Distal pancreatectomy with splenectomy | 0 | 0 | 3 | 10 | 3 | 0 | 16 |
| Near total pancreatectomy | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Debridement and R en Y PJ | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| Debridement and PG | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| PPPD | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Exploration, gauze packing | 0 | 1 | 0 | 0 | 2 | 0 | 3 |
| Total | 1 | 15 | 16 | 10 | 13 | 1 | 56 |

PJ, pancreaticojejunostomy; PG, Pancreaticogastrostomy; PPPD, pylorus-preserving pancreaticoduodenectomy

Drainage and debridement only were performed in 10 patients with grade I and II injuries and one patient with a grade IV injury. One 7 year old boy with a grade IV injury whose pancreatic capsule was intact during exploration but who had a main pancreatic duct injury detected on a CT scan received drainage only without pancreatic resection to preserve the pancreas parenchyma considering his age. Pancreatectomy was performed in 22 patients and debridement with pancreatico-enteric anastomosis in two patients. Distal pancreatectomy was performed in grade III and IV patients. Twenty-two (39%) patients underwent a combined operation for intra-abdominal organ injuries, including the stomach (n=8), duodenum (n=7), liver (n=7), colon (n=3), small bowel (n=3), mesentery (n=3), spleen (n=6), vessel (n=4), diaphragm (n=1), and kidney (n=3). Nineteen (34%) patients had combined extra-abdominal injuries.

The mean operation time was 214±106 minutes (range, 80-480 minutes), and an intraoperative transfusion was required in 32 patients. The median length of hospital stay was 20 days (25th-75th percentiles, 11-42 days) and the median postoperative hospital stay was 22 days (25th-75th percentiles, 13-43 days).

Morbidity and mortality

Complications developed in 35 patients after pancreatic injury (63%). Table 2 shows the occurrence of complications according to the AAST grade. Twenty-five (45%) patients developed a pancreatic fistula/abscess or pseudo-

cyst, which was treated with a drainage catheter inserted during the operation or percutaneous drainage treated by an interventional radiologist. No mortality was associated with septic shock as a result of a pancreatic fistula or abscess. Four patients died after trauma with a mortality rate of 7%. However, none of the mortality cases was associated with the pancreatic injury itself but were closely related with the cascade of bleeding resulting in hypovolemic shock, disseminated intravascular coagulation, and multiorgan failure.

Comparison of the clinical characteristics between the pediatric and adult patients

Table 3 shows the clinical comparison between the pediatric and adult patients. The mechanism of injury in the pediatric group was blunt trauma, and half of the patients developed pancreatic injuries from the belly being compressed against the wheel while riding a bicycle. We detected pancreatic injuries at the initial diagnostic stage more often in pediatric patients than that in adult patients. Of the 14 patients, 13 were diagnosed with a pancreatic injury at the initial diagnostic stage by CT. No difference in organ injury scale was observed between the two groups. A significantly higher proportion of pediatric patients demonstrated hyperamylasemia in the initial laboratory results than that in the adult group ($p=0.023$). Associated extra-abdominal injuries were relatively lower in pediatric patients ($p=0.073$) than those in adults, and combined operations for intra-abdominal organ repair

Table 2. Occurrence of complication following conservative or surgical treatment of pancreatic injury

| Complication | AAST grade | | | | | | |
|--|------------|----|----|-----|----|---|----|
| | Unknown | I | II | III | IV | V | No |
| No | 0 | 12 | 5 | 1 | 3 | 0 | 21 |
| Yes | 1 | 3 | 11 | 9 | 10 | 1 | 34 |
| Pancreatic fistula, intraabdominal abscess | 0 | 2 | 5 | 6 | 6 | 0 | 19 |
| Pseudocyst | 1 | 0 | 3 | 1 | 1 | 0 | 6 |
| Bile duct stricture due to pancreatitis | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| Hematoma | 0 | 2 | 1 | 0 | 0 | 0 | 3 |
| Pleural effusion | 0 | 0 | 2 | 2 | 0 | 0 | 4 |
| Ulcer bleeding | 0 | 0 | 1 | 1 | 0 | 0 | 2 |
| Delayed gastric emptying | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Acute renal failure | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Hypovolemic shock, DIC, MOF | 0 | 0 | 1 | 0 | 3 | 0 | 4 |
| Surgical site infection | 1 | 0 | 0 | 1 | 2 | 0 | 3 |

AAST grade, American Association for the Surgery of Trauma grade; DIC, disseminated intravascular coagulation; MOF, multi-organ failure

Table 3. Comparison of clinical characteristics between pediatric and adult patients

| | | Pediatrics | Adults | <i>p</i> -value |
|--|-------------|------------------|------------|--------------------|
| Age (yrs) | | 8.6±2.6 | 39.9±13.6 | |
| Sex | F | 7 | 8 | 0.024 |
| | M | 7 | 34 | |
| ER visit | No | 1 | 2 | 0.732 |
| | Yes | 13 | 40 | |
| Referred case | No | 7 | 20 | 0.877 |
| | Yes | 7 | 22 | |
| Injury mechanism | Blunt | 14 | 35 | 0.102 |
| | Penetrating | 0 | 7 | |
| CT | No | 0 | 9 | 0.059 |
| | Yes | 14 | 33 | |
| Detection of pancreatic injury at initial diagnostic stage | No | 1 | 11 | 0.060 |
| | Yes | 13 | 22 | |
| AAST grade | I | 5 | 10 | 0.459 |
| | II | 3 | 13 | |
| | III | 1 | 9 | |
| | IV | 5 | 8 | |
| | V | 0 | 1 | |
| Associated extraabdominal injury | No | 12 | 25 | 0.073 |
| | Yes | 2 | 17 | |
| Hypotension at admission | No | 12 | 32 | 0.452 |
| | Yes | 2 | 10 | |
| Hyperamylasemia at admission | No | 1 | 16 | 0.023 |
| | Yes | 13 | 24 | |
| Operation | No | 6 | 9 | 0.117 |
| | Yes | 8 | 33 | |
| Operation time | | 207±68 | 216±115 | 0.830* |
| Combined intraabdominal organ surgery | No | 7 | 12 | 0.009 |
| | Yes | 1 | 21 | |
| Transfusion | No | 3 | 6 | 0.236 |
| | Yes | 5 | 27 | |
| Intensive care unit stay | No | 10 | 16 | 0.030 |
| | Yes | 4 | 26 | |
| Hospital stay | | 15.5 (6.5-23.75) | 22 (13-44) | 0.113 [†] |
| Postoperative hospital stay | | 21.5 (28.5-36.5) | 22 (11-45) | 0.917 [†] |
| Morbidity | No | 8 | 13 | 0.080 |
| | Yes | 6 | 29 | |
| Mortality | No | 14 | 38 | 0.231 |
| | Yes | 0 | 4 | |

ER, emergency room; AAST grade, American Association for the Surgery of Trauma grade. *Calculated with independent samples *t*-test, [†]Calculated with Mann-Whitney U test

were significantly more frequent in adult patients ($p=0.009$) than those in the pediatric group. A significantly higher proportion of adult patients required intensive care unit (ICU) stay ($p=0.03$). The morbidity rate was relatively higher in adult patients ($p=0.080$) than that in pediatric patients. No mortalities were observed in the pediatric group.

Comparison of the clinical characteristics between normotensive and hypotensive patients at initial admission

As shown in Table 4, the hypotensive group had a significantly higher proportion of penetrating injuries ($p=0.001$), associated extra-abdominal injuries ($p=0.044$), combined intra-abdominal organ surgery ($p=0.004$), and the necessity for ICU stay ($p=0.020$). Significantly fewer CT scans were taken for diagnosing hypotensive patients than for normotensive patients ($p<0.001$), and detecting a pancreatic injury at the initial diagnostic stage was less frequent

Table 4. Clinical characteristics between normotensive and hypotensive patients at initial admission

| | | Normotensive | Hypotensive | <i>p</i> -value |
|--|-------------|----------------|-------------|--------------------|
| Age (yrs) | | 31±18 | 37±18 | 0.327 |
| Sex | F | 11 | 4 | 0.563 |
| | M | 33 | 8 | |
| ER visit | No | 3 | 0 | 0.352 |
| | Yes | 41 | 12 | |
| Referred case | No | 18 | 9 | 0.036 |
| | Yes | 26 | 3 | |
| Mechanism | Blunt | 42 | 7 | 0.001 |
| | Penetrating | 2 | 5 | |
| CT | No | 3 | 6 | <0.001 |
| | Yes | 41 | 6 | |
| Detection of pancreatic injury at initial diagnostic stage | No | 12 | 9 | 0.002 |
| | Yes | 32 | 3 | |
| AAST grade | I | 10 | 5 | 0.106 |
| | II | 13 | 3 | |
| | III | 10 | 0 | |
| | IV | 10 | 3 | |
| | V | 0 | 1 | |
| Associated extraabdominal injuries | No | 32 | 5 | 0.044 |
| | Yes | 12 | 7 | |
| Hyperamylasemia at admission | No | 10 | 7 | 0.010 |
| | Yes | 33 | 4 | |
| Operation | No | 14 | 1 | 0.103 |
| | Yes | 30 | 11 | |
| Operative time (min) | | 197±91 | 259±135 | 0.186* |
| Combined intraabdominal organ surgery | No | 18 | 1 | 0.004 |
| | Yes | 12 | 10 | |
| Transfusion | No | 9 | 0 | 0.40 |
| | Yes | 21 | 11 | |
| Intensive care unit stay | No | 24 | 2 | 0.020 |
| | Yes | 20 | 10 | |
| Hospital stay (days) | | 26 (12-43) | 17 (2-21) | 0.085 [†] |
| Postoperative hospital stay (days) | | 26 (17.5-44.5) | 17 (2-22) | 0.055 [†] |
| Morbidity | No | 15 | 6 | 0.313 |
| | Yes | 29 | 6 | |
| Mortality | No | 43 | 9 | 0.007 |
| | Yes | 1 | 3 | |

ER, emergency room; AAST grade, American Association for the Surgery of Trauma grade. *Calculated with independent samples *t*-test, [†]Calculated with Mann-Whitney U test

than that in the normotensive group ($p=0.002$). Morbidity did not differ between the two groups ($p=0.313$); however, mortality was significantly higher in the hypotensive group ($p=0.007$) compared to that in the normotensive group.

DISCUSSION

Traumatic pancreatic injury is rare,^{1,7} and CT was an important diagnostic tool in patients who were hemodynamically stable. In the current study, most injuries occurred due to blunt abdominal trauma, and a pancreatic

injury was diagnosed in 75% of the patients who received a CT scan. Higher grade injuries were not missed on CT scans. Similarly, the sensitivity of an initial CT scan for blunt pancreatic injury has been reported to be approximately 75%.^{3,8} In the 1990's, pancreatic injuries are often missed on the initial scans and only diagnosed after repeat imaging,^{9,10} however, the detection rate of blunt pancreatic injuries has increased to approximately 80% with the use of newer-generation scanners.³ It seemed reasonable to assume that diagnostic errors and delays would result in poor outcomes; however, missed diagnoses did not affect mortality or the length of hospital stay in patients with

blunt pancreatic injuries reported in another study.³ Similarly, patients in whom the diagnosis was missed on the initial CT scan had relatively lower grades of pancreatic injury when detected during exploratory surgery, and had no adverse outcomes were observed in our study.

Various operative techniques were applied in our study, and distal pancreatectomy for grade III and IV injuries was the mainstay procedure. Disruption of the pancreatic duct is the main determinant when managing pancreatic injuries.¹¹ If there is no evidence of a ductal injury on fine-cut CT, medical treatment is acceptable.⁴ In patients with a proximal neck injury consistent with grade IV, a pancreaticojejunostomy or pancreaticogastrostomy rather than pancreatectomy can be performed to preserve endocrine and exocrine function of the pancreas, particularly in younger patients. The choice of operative procedures depends on the AAST grade, age, and patient condition. Therefore, the surgeon's experience and familiarity with complex pancreatic injuries as well as surgical treatment can be an important factor that affects patient prognosis.¹¹

High morbidity and mortality rates have been reported, although mortality is usually associated with other significant multiple injuries.^{2,12} The presence of a main pancreatic duct injury comprised most of the complications. The most common postoperative or post-traumatic infectious complications and the main cause of morbidity is an intra-abdominal abscess or pancreatic fistula.^{1,2,4,5,12} Clinical outcome has been correlated with injury grade, hemodynamic status, organs involved, operative time, and familiarity with complex pancreatic repair and reconstruction.^{7,11} In the absence of associated injuries, mortality is rare and usually a result of the magnitude of associated injuries,^{8,13} which was consistent with our series.

Pancreatic injuries in children are usually the result of blunt injury to the abdomen, and most patients developed hyperamylasemia in our series. However, no mortalities were observed, and most pancreatic injuries were solitary without associated intra-abdominal and extra-abdominal injuries. As described above, injury to the main pancreatic duct is a key determinant of whether to perform surgery. However, some authors have reported that the response to injury is different between children and adults, and that pseudocysts can be managed effectively with percutaneous drainage in children who undergo complete traumatic pancreatic transection.¹⁴⁻¹⁷ The majority of pancre-

atic injuries in pediatric patients can be managed non-operatively.^{15,16} Of the proximal duct injuries, formation of a pseudocyst and delayed drainage should be considered and a spleen preserving distal pancreatectomy is the best management procedure for cases of distal ductal injuries.¹⁷ However, a recent study reported that children with grade II or III pancreatic injuries managed non-operatively have a higher rate of pseudocysts, lower rate of reoperation, and a comparable length of hospital stay compared with those who underwent surgery.¹⁶

In conclusion, traumatic pancreatic injuries occurred due to blunt abdominal trauma. Associated injuries were common in adult patients, whereas more isolated pancreatic injuries were seen in pediatric patients. Although morbidity related to a pancreatic fistula and intra-abdominal abscess was high, it did not cause mortality resulting from severe septic complications. Mortality occurred in patients with other severe associated injuries, leading to the bleeding cascade, hypovolemic shock, and multi-organ failure.

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