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Pediatric blunt pancreatic trauma at a single center in Korea: a retrospective review from 2007 to 2022

Joong Kee Youn, MD[1,2], Hee-Beom Yang, MD[3], Dayoung Ko, MD[1], Hyun-Young Kim, MD[1,2]

[1]Department of Pediatric Surgery, Seoul National University Hospital, Seoul, Korea
[2]Department of Pediatric Surgery, Seoul National University College of Medicine, Seoul, Korea
[3]Department of Surgery, Seoul National University Bundang Hospital, Seongnam, Korea

Purpose: Blunt pancreatic trauma in pediatric patients is relatively rare, yet it is associated with high risks of morbidity and mortality This study aimed to review pediatric patients with blunt pancreatic trauma treated at a single center and provide treatment guidelines.

Methods: This study included patients under the age of 18 years who visited our center's pediatric emergency department and were diagnosed with pancreatic injury due to abdominal trauma via radiological examination between January 2007 and December 2022. Patients' medical records were retrospectively reviewed and analyzed.

Results: Among 107 patients with abdominal trauma, 14 had pancreatic injury, with a median age of 8.2 years (interquartile range, 3.1–12.3 years). Eight patients were male and six were female. The most common mechanism of injury was falls from a height and bicycle handlebars (four cases each). Six patients had associated injuries. Two patients had American Association for the Surgery of Trauma grade I or II, eight had grade III, and four had grade IV or V injuries. Eight patients underwent surgical resection, and four were discharged with only an intervention for duct injuries.

Conclusions: Patients with blunt pancreatic trauma at our center have been successfully treated with surgical modalities, and more recently through nonsurgical approaches involving active endoscopic and radiologic interventions.

Keywords: Abdominal injuries; Wounds and injuries; Pancreas; Pancreatectomy

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Correspondence to
Hyun-Young Kim, MD
Department of Pediatric Surgery, Seoul National University College of Medicine, 103 Daehak-ro, Jongno-gu, Seoul 03080, Korea
Tel: +82-2-2072-2478
Email: spkhy02@snu.ac.kr

INTRODUCTION

Background

Pediatric pancreatic blunt trauma is relatively rare, occurring in 0.5% to 9.5% of pediatric blunt trauma cases [1–4]. However, it is associated with high severity, especially in patients with grade III or higher ductal injuries, which have morbidity and mortality rates of 60% and 8%, respectively [4]. The causes of blunt pancreatic trauma in children are known to include falls, bicycle accidents, and motor vehicle accidents. The primary mechanism of injury is direct compression of the pancreas against the vertebrae, due to the thin layer of retroperitoneal fat [5].

The primary approach to treating pediatric blunt pancreatic trauma can vary, depending largely on the severity of the injury,

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and is still a subject of debate. However, the most crucial factor is maintaining the integrity of the main pancreatic duct [6,7]. Depending on the location of the injury, surgical intervention may be required to excise the damaged section. Other techniques, such as endoscopic retrograde cholangiopancreatography (ERCP), have also been reported as effective treatment alternatives.

Nonoperative treatment is the mainstay of treatment for low-grade injuries. However, for injuries of grade III or higher that affect the main pancreatic duct, a variety of treatments have been employed, including nonoperative methods, drainage procedures, and surgical interventions [8–10].

Objectives

This study aimed to retrospectively review pediatric blunt pancreatic trauma patients treated at a single center, including the causes of their injuries, treatment methods, and outcomes, and to provide treatment recommendations for patients with blunt pancreatic trauma.

METHODS

Ethics statement

This study was approved by the Institutional Review Board of Seoul National University Hospital (No. 2302-108-1407). The requirement for informed consent was waived due to the retrospective nature of the study. This study was conducted in accordance with the principles of the Declaration of Helsinki.

Study design

We enrolled patients aged < 18 years who presented to the pediatric emergency room at our hospital and were diagnosed with pancreatic injuries due to abdominal trauma between January 2007 and December 2022. Patients who underwent surgery or intervention for pancreatic injuries at other hospitals were excluded.

The medical records of these patients were retrospectively analyzed, and the following factors were examined: age, weight, sex, mechanism of injury, accompanying injuries to other organs, Pediatric Traumatic Score (PTS), Injury Severity Score (ISS), Glasgow Coma Scale, vital signs at the time of emergency room admission, initial laboratory data, transfer status from other hospitals, use of imaging or endoscopic interventions, whether surgery was performed or not, type of surgery, length of hospital stay, length of intensive care unit (ICU) stay, early and late complications, and mortality. The data of all patients were collected. For the analysis, patients were divided into those who underwent surgery and those who did not undergo surgery, and the details of their treatment were analyzed. The pancreatic injury grade was defined according to the American Association for the Surgery of Trauma (AAST) scale and ranged from minor (grade I) to devastating (grade V).

Statistical analysis

Statistical analyses were performed using IBM SPSS ver. 20.0 (IBM Corp). Means and standard deviations or medians with interquartile ranges are provided for continuous variables. Categorical variables were calculated as percentages. The patients were compared according to whether or not they underwent surgery. Comparisons between categorical variables were performed using the Kruskal-Wallis test because of the nonparametric nature of the data. A P-value < 0.05 was considered statistically significant.

RESULTS

During the study period, out of 107 patients suffering from abdominal trauma, 14 were hospitalized for treatment of confirmed pancreatic injuries. These injuries, identified via computed tomography, included parenchymal fractures, lacerations, pancreatic edema, hematomas, active bleeding, and fluid accumulation between the splenic vein and the pancreas. The median age of the patients with pancreatic injuries was 8.2 years (interquartile range, 3.1–12.3 years), and they consisted of eight boys and six girls. Of these patients, eight underwent surgical procedures (Table 1).

The most frequent causes of injury were falls from heights and bicycle accidents, each responsible for four cases. These were followed by incidents involving pedestrians and passengers in traffic accidents, each contributing two cases. One case of child abuse was reported, where the injury resulted from a father's kick and the child being crushed by soccer goalposts. The mechanism of injury did not differ between patients who required surgery and those who did not.

In total, six patients presented with associated injuries, of whom three had more than two injuries in addition to their pancreatic damage. Within the abdominal cavity, two instances of liver injury and one instance of splenic injury were observed. There were also three cases of limb fractures, two instances of thoracic injuries, and one instance of head or facial injury.

The median PTS was 11, while the median ISS was 9; these figures were not associated with the decision to perform surgery.

Table 1. Patient demographics

Demographic	Total (n=14)	NOM (n=6)	OM (n=8)	P-value
Age at trauma (yr)	8.2 (3.1–12.3)	7.5 (6.6–8.9)	8.7 (5.4–10.5)	0.699
Body weight at trauma (kg)	27.3 (25.0–32.0)	26.3 (25.0–30.0)	27.8 (22.5–33.5)	0.651
Male sex	8 (57.1)	4 (66.7)	4 (50.0)	0.533
Mechanism of injury				0.323
Fall from height	4 (28.6)	1 (16.7)	3 (37.5)	
Bicycle accident	4 (28.6)	3 (50.0)	1 (12.5)	
Pedestrian in MVA	2 (14.3)	0	2 (25.0)	
MVA (on board)	2 (14.3)	1 (16.7)	1 (12.5)	
Assault (child abuse)	1 (7.1)	0	1 (12.5)	
Run over	1 (7.1)	1 (16.7)	0	
Associated injury	6 (42.9)	3 (50.0)	3 (37.5)	0.640
Liver	2 (14.3)	0	2 (25.0)	
Spleen	1 (7.1)	1 (16.7)	0	
Extremity	3 (21.4)	1 (16.7)	2 (25.0)	
Thorax	2 (14.3)	1 (16.7)	1 (12.5)	
Head and neck	1 (7.1)	1 (16.7)	0	
Pediatric Traumatic Score	11 (11–11)	11 (11–12)	11 (11–11)	0.641
Injury Severity Score	9 (9–16)	9 (4–16)	9 (9–25)	0.662
Glasgow Coma Scale score	14 (14–15)	15 (15–15)	14 (14–15)	0.036
Vital sign at ED				
Systolic blood pressure (mmHg)	111±18	112±9	110±24	0.747
Pulse (beats/min)	109±22	105±13	112±27	0.699
Respiratory rate (breaths/min)	26±6	26±8	26±6	0.602
Body temperature (°C)	37.1±0.9	37.7±0.5	36.8±1.0	0.043
Initial laboratory value				
Serum hemoglobin (g/dL)	11.7 (10.3–12.9)	12.1 (11.8–12.6)	12.4 (9.1–13.5)	0.846
pH	7.40 (7.35–7.45)	7.40 (7.39–7.40)	7.41 (7.32–7.45)	>0.999
Lactate (mmol/L)	1.2 (0.8–1.6)	0.7 (0.6–0.8)	1.5 (1.2–1.7)	0.025
Amylase (U/L)	298 (119–944)	298 (119–1,085)	598 (125–497)	0.606
Lipase (U/L)	327 (31–938)	933 (34–1,716)	179 (15–428)	0.150
Transfer to other hospital	13 (92.9)	6 (100)	7 (87.5)	0.369
Radiological intervention	5 (35.7)	4 (66.7)	1 (12.5)	0.036

Values are presented as median (interquartile range), number (%), or mean±standard deviation.
NOM, nonoperative management; OM, operative management; MVA, motor vehicle accident; ED, emergency department.

Out of the 14 patients in question, 13 (92.9%) were transferred to other medical facilities.

Two patients were classified as AAST grade II or lower, eight were grade III, three were grade IV, and one was grade V. A sequential evaluation of these patients showed that the initial eight patients with injuries of grade III or higher (from 2007–2011) all received surgical treatment. One patient with severe injuries underwent radiological interventions, including percutaneous catheter drainage (PCD) insertion and arterial embolization, both before and after surgery (Table 2). Two patients with grade I injuries were admitted and monitored for 2 and 9 days, respectively, before subsequent discharge without requiring any additional treatment. Four patients who sustained injuries of grade III or higher after 2014 showed improvement and were discharged following intervention and conservative treatment. The duration of hospital stays for all patients varied from 2 to 49 days, and 12 patients required admission to the ICU for periods ranging from 1 to 16 days. There were no fatalities among the patients.

In patients who had surgery, two individuals with proximal injuries underwent a pylorus-preserving pancreaticoduodenectomy (PPPD), while distal pancreatectomy was performed on those with distal injuries (Table 3). Of the two patients who sustained liver injuries, one only required bleeding control, while the other, who had nearly severed the S2 segment, underwent an S2 segmentectomy. All surgical procedures were carried out via laparotomy. One patient encountered early complications (ileus) 2

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Table 2. Summary of patients (chronological order)

Patient no.	Age (yr)	Sex	Mechanism of injury	Serum		ISS	PTS	Injured area of pancreas	Injury grade[a)]	Intervention	Operation	LOS (day)	ICU stay (day)	Mortality
				Amylase (U/L)	Lipase (U/L)									
1	8	Male	Pedestrian in MVA	12,333	-	25	8	Head	IV	Yes	Yes	25	4	Alive
2	11	Male	Pedestrian in MVA	570	2,660	9	12	Neck	III	No	Yes	9	0	Alive
3	3	Female	Falls from height	157	131	9	11	Neck	III	No	Yes	8	2	Alive
4	3	Male	MVA (on board)	-	-	25	10	Body	III	No	Yes	9	1	Alive
5	9	Female	Falls from height	423	14	16	11	Head	IV	No	Yes	31	4	Alive
6	11	Female	Child abuse	5,898	226	9	12	Tail	III	No	Yes	12	2	Alive
7	7	Male	Bicycle accident	264	428	9	11	Body	III	No	Yes	13	5	Alive
8	8	Female	Falls from height	184	15	9	11	Body	III	No	Yes	16	3	Alive
9	7	Male	Bicycle accident	1,085	1,425	9	11	Body	III	Yes	No	32	3	Alive
10	7	Female	MVA (on board)	56	34	4	11	Body	I	No	No	9	1	Alive
11	6	Male	Bicycle accident	119	27	4	11	Body	I	No	No	2	0	Alive
12	8	Male	Bicycle accident	2,150	3,556	16	12	Head, body	IV	Yes	No	49	16	Alive
13	6	Male	Run over	251	596	10	11	Tail	III	Yes	No	35	3	Alive
14	12	Female	Falls from height	1,514	3,637	25	10	Head	V	Yes	No	33	1	Alive

ISS, Injury Severity Score; PTS, Pediatric Trauma Score; LOS, length of stay; ICU, intensive care unit; MVA, motor vehicle accident.
[a)]According to the American Association for the Surgery of Trauma classification.

weeks postdischarge, necessitating readmission. Additionally, two patients experienced late complications (ileus) and were readmitted for treatment. The patient who had early complications underwent surgical intervention to rectify an intestinal mechanical obstruction.

A radiologic or endoscopic intervention was performed in patient 1 and in all patients who did not undergo surgery. Three patients underwent PCD insertion, while endoscopic retrograde pancreatic drainage (ERPD) insertion via ERCP was performed on two patients. Subsequently, embolization was performed (Table 4). Notably, patients 12 and 14 sustained injuries to the head of the pancreas. However, they were discharged without any complications following intervention or supportive management. Since then, no early or late complications have been identified.

DISCUSSION

In our study, pancreatic injury was confirmed in 14 of 107 pediatric patients with abdominal trauma. These patients visited our hospital over a span of 16 years. This finding is not significantly different from other studies or meta-analyses, which reported pancreatic injuries in 13.1% of total patients [10,11]. Among these patients, 42.9% had concurrent injuries to other organs in the abdominal cavity, limbs, chest, and so on. This aligns with other studies that have reported that pediatric pancreatic injuries often coincide with other injuries [10,11]. Generally, the mortality rate for pediatric blunt pancreatic injury is reported to be around 5%. However, in our study, we did not report any deaths [2,11,12]. This could be due to the small patient sample size, but it could also be seen as a testament to the role our hospital plays as a tertiary referral hospital in Korea.

The primary causes of injury were falls and accidents involving bicycle handlebars. This study differed from others because it did not include any incidents related to gunshots, which can be attributed to the restricted ownership of firearms in Korea. The significant number of injuries resulting from bicycle and car accidents, as well as falls, aligns with findings from other reports on injury mechanisms [9,13,14].

In this study, we compared patients who underwent surgical treatment with those who did not. Upon examining the demographic data, no discernible differences were found between the two groups, nor were there any differences in the mechanisms of injury. There were no significant findings in either vital signs or initial laboratory data, which could potentially be attributed to the small patient sample size. However, it is worth noting that all instances of surgery were carried out early in the enrollment pe-

Table 3. Summary of operative findings

Patient no.	Age (yr)	Sex	Procedure name	Time from injury to operation (day)	Operation year	Open /laparoscopy	Operation time (min)	EBL (mL)	Early complication	Late complication
1	8	Male	PPPD, liver bleeding control	83	2007	Open	365	280	None	None
2	11	Male	Spleen-preserving DP	6	2007	Open	230	300	None	Ileus
3	3	Female	Spleen-preserving DP	0	2008	Open	75	300	None	None
4	3	Male	Spleen-preserving DP, liver S2 segmentectomy	0	2008	Open	120	600	None	None
5	9	Female	PPPD	2	2010	Open	320	100	Ileus	Ileus
6	11	Female	DP	2	2010	Open	155	-	None	None
7	7	Male	Spleen-preserving DP	1	2011	Open	265	130	None	None
8	8	Female	DP	0	2011	Open	215	210	None	None

EBL, estimated blood loss; PPPD, pylorus-preserving pancreaticoduodenectomy; DP, distal pancreatectomy.

Table 4. Summary of radiologic and endoscopic interventions

Patient no.	Age (yr)	Sex	Procedure name	Intervention year	Injured area of pancreas	Injury grade[a]	Early complication	Late complication
1	8	Male	PCD insertion, gastroduodenal artery embolization	2007	Head	IV	None	None
9	7	Male	ERPD insertion with ERCP	2014	Body	III	None	None
12	8	Male	PCD insertion	2016	Head, body	IV	None	None
13	6	Male	PCD insertion	2022	Tail	III	None	None
14	12	Female	ERPD insertion with ERCP	2022	Head	V	None	None

PCD, percutaneous catheter drainage; ERPD, endoscopic retrograde pancreatic drainage; ERCP, endoscopic retrograde cholangiopancreatography.
[a]According to the American Association for the Surgery of Trauma classification.

riod, suggesting a possible evolution in treatment methods over time. All eight patients who underwent surgery did so prior to 2012, a time when the hospital was not actively employing radiologic or endoscopic interventions for pediatric trauma patients. Consequently, any differences in demographic and clinical characteristics between the surgical and nonsurgical groups could not be definitively determined.

In the analysis of surgical patients, all patients underwent open surgery. PPPD was performed for injuries to the head of the pancreas, while distal pancreatectomy was used for injuries below the neck. In instances of concurrent splenic vascular damage, the spleen was removed. While the surgical treatment of AAST grades III to VI pancreatic trauma in adults is well understood, there has been less discussion regarding surgical intervention in pediatric patients. However, there have been reports of pancreatic duct recanalization in children who have experienced complete pancreatic transection [13,15]. For class II distal duct injuries, the preferred approach is distal pancreatectomy, with the preservation of the spleen and blood supply. Previous studies conducted early spleen-sparing distal pancreatectomies in eight out of 18 children with distal duct injuries, and they advocate for this treatment as the preferred method [1,13].

Both operative and nonoperative management strategies have been used to treat pediatric patients with pancreatic trauma. Recent studies have highlighted the effectiveness of nonsurgical management in these cases. In 2021, Ishikawa et al. [9] reported that early endoscopic retrograde pancreatography with stent placement or endoscopic nasopancreatic drain (ENPD) insertion proved beneficial in 10 patients with pancreatic duct injuries. This aligns with the findings of a prior study that successfully utilized stent placement via ERCP in three patients [8]. A multicenter study conducted in 2017 analyzed the treatment outcomes of patients with grades III to V injuries, suggesting that nonsurgical management could be effective if initial enzyme levels and associated symptoms were taken into account. This study also established the presence of a standard clinical pathway related to this treatment strategy [16]. Our study's findings align with these results, as we successfully treated four patients with grades III to V injuries using nonsurgical management. These results seem to contradict the assertion made by Mattix et al. [4] that high ISS and injury grades III to V are indicators of nonsurgical management failure. However, this discrepancy could be due to advances

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in pediatric interventions and shifts in treatment paradigms from 2007 to the present.

Simple external drainage is often recommended as the standard surgical procedure for treating contusions or small lacerations when there appears to be no or minor ductal injury during nonoperative management [3,17]. Moreover, even when ERCP is unsuccessful, there are reports of effective nonsurgical treatment through appropriate drainage [18]. In this study, we successfully treated patients with multiple injuries to the pancreas and tail using PCD insertion and tube check procedures. Notably, patient 12, who suffered damage to the head and body from a bicycle handlebar accident, was difficult to treat with stent insertion even with ERCP. However, through two PCD insertions and changes in tube location, we were able to treat the patient conservatively, and they were discharged without any complications. To establish clear treatment guidelines for pediatric pancreatic trauma, we suggest conservative treatment, which includes hospitalization, fluid resuscitation, and close monitoring, for AAST grades I and II. For grade III or higher injuries, surgical intervention may be considered at medical institutions equipped for such procedures. However, if endoscopic and radiological interventions are available, damage control can be achieved through interventions such as ERCP for ERPD and ENPD, and PCD insertion. By closely monitoring symptom improvement, successful nonsurgical management can be accomplished.

Limitations

A limitation of this study is that it presents the results of a retrospective analysis conducted on a relatively small patient group from a single institution. In the future, a comprehensive analysis of treatment outcomes, facilitated by a multicenter registry, will be required. This necessitates the development of a nationwide registry for pediatric patients who have experienced abdominal trauma. It is also crucial to establish a cohort system and gather prospective data. Consequently, it is essential to create a treatment protocol specifically for pediatric patients with traumatic pancreatic injuries.

Conclusions

This case series examines the clinical characteristics and treatment outcomes of pediatric patients with traumatic pancreatic injuries at a single institution. The majority of patients transferred from other hospitals were effectively treated through either surgical or nonsurgical means. For patients with grades I and II pancreatic injuries, conservative treatment typically proves effective and results in positive outcomes. However, for more severe injuries (grade III or higher), determining whether surgical or nonsurgical treatment is more advantageous is challenging based solely on these data. These patients can be treated with minimal complications, whether the chosen treatment method is surgery or endoscopic or radiologic intervention.

ARTICLE INFORMATION

Author contributions

Conceptualization: JKY, HYK; Data curation: HBY; Formal analysis: JKY, DK; Methodology: JKY, HYK; Writing–original draft: JKY, HBY; Writing–review & editing: JKY, HBY, DK, HYK; All authors read and approved the final manuscript.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Data availability

Data of this study are available from the corresponding author upon reasonable request.

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