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Operative vs nonoperative management of blunt pancreatic trauma in children

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Abstract

Purpose: The aim of this study was to evaluate the outcome of nonoperative vs operative management of blunt pancreatic trauma in children.

Methods: Retrospective review of pancreatic injuries from 1995 to 2006 at an urban level I regional pediatric trauma center.

Results: Forty-three children with pancreatic injury were included in the analysis. Injuries included grade I (n = 18), grade II (n = 6), grade III (n = 17), and grade IV (n = 2). For grade II to IV injuries, patients managed operatively (n = 14) and nonoperatively (n = 11) had similar lengths of stay and rates of readmission, despite increased pancreatic complications (PCs) in the nonoperative cohort (21% vs 73%; $P = .02$). There was a trend toward increased non-PCs in patients managed with resection ($P = .07$). Twelve patients underwent successful diagnostic endoscopic retrograde cholangiopancreatography in which duct injury was identified. In this group, nonoperative management was pursued in 6 patients but was associated with increased rates of PC (86% nonoperative vs 29% operative; $P = .02$).

Conclusions: Operative management of children with grades II to IV pancreatic injury results in significantly decreased rates of PCs but fails to decrease length of stay in the hospital, possibly as a result of non-PCs. Endoscopic retrograde cholangiopancreatography may serve as a useful diagnostic modality for guiding operative vs nonoperative management decisions.

Although the incidence of pancreatic injury in children sustaining blunt abdominal trauma is low [1,2], management of pancreatic injuries remains a challenge. In the past 10 years, there has been ongoing debate about the optimal approach to treating pancreatic injuries, with some authors advocating early operative intervention [3,4] and others suggesting that a nonoperative approach is advantageous and safe [5,6]. We therefore reviewed our single-institution experience with the management of pancreatic trauma in children for the last decade to assess the outcomes of operative and nonoperative management.

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1. Methods

With approval by the Colorado Multiple Institution Review Board (COMIRB protocol no. 08-0778), we reviewed the medical records of all children diagnosed with pancreatic injury from April 1995 to September 2006 at our urban level I regional pediatric trauma center. Patients were identified using the hospital trauma registry.

Pancreatic injuries were graded using all available data including radiographic imaging and operative reports according to the American Association for the Surgery of Trauma guidelines as follows: grade I = minor contusion without duct injury or superficial laceration; grade II = major contusion or laceration without duct injury or tissue loss; grade III = distal transection or parenchymal injury with duct injury; grade IV = proximal transection or parenchymal injury involving the ampulla; and grade V = massive disruption of the pancreatic head [7].

Outcomes data were obtained from the hospital medical record and The Children's Hospital Trauma Registry database. Data analysis was performed using analysis of variance for normally distributed continuous variables and the Kruskal-Wallis test for variables with nonnormal distribution. The χ^2 test or the Fisher's Exact test (for comparisons with expected cells values < 5) were used for categorical variables. Data are presented as mean ± SD (range) or, for nonnormally distributed variables, such as median and interquartile range (IQ). *P* values of .05 or less were considered significant.

2. Results

Forty-four children with pancreatic injury were identified. There were 29 boys (66%) and 15 girls with an average age of 7.3 ± 4.2 (1-17) years. The most common mechanisms of injury were motor vehicle collision (n = 12; 27%), bicycle accidents (n = 11; 25%), and nonaccidental trauma (n = 6; 14%). Other injuries included animal-related injuries (n = 3 horse, 1 bull); autopedestrian collisions (n = 3); sports injuries (n = 3); falls (n = 2); and scooter, golf-cart, and all-terrain vehicle accidents (n = 1 each).

The median injury severity score (ISS) was 10 (IQ, 10-17; range, 4-59). Thirty children (68%) had at least one associated injury, including intraabdominal (n = 23), orthopedic (n = 6), diaphragmatic (n = 4), renal (n = 4), intracranial (n = 4), and thoracic (n = 3). One child, with grade III pancreatic injury, died on hospital day one because of other injuries and was excluded from subsequent outcome analysis.

For the remaining 43 children, pancreatic injuries were graded as I (n = 18), II (n = 6), III (n = 17), and IV (n = 2). There were no significant differences in age, sex, or ISS between grades (Table 1). Median time from injury to operation was 1 day (IQ, 1-3 days; range, 0-11 days). Median hospital length of stay (LOS) was 9 days (IQ, 6-22 days; range, 1-66 days). Twenty-one patients (49%) required intensive care unit (ICU) admission, and for these, median ICU stay was 3 days (IQ, 2-4 days; range, 0-25 days). Median LOS increased with pancreatic injury grade (*P* = .0008), but there were no differences in ICU stay between groups (*P* = .84). These findings are summarized in Table 1.

Overall, 24 children underwent an abdominal operation, including nonpancreas-related procedures. Children with grade I injury were significantly less likely to undergo any operation, compared to children with grades II to IV injury (33% vs 69%; *P* = .03). A total of 14 patients underwent pancreatic resection. Three patients had a negative laparotomy for suspected pancreatic ductal injury, but all had drains placed in the pancreatic bed during operation. Seven children underwent laparotomy for other intraabdominal injuries. Twenty-nine children were managed without pancreatic resection (67%) in all groups, including 18 grade I (100%) and 11 grades II to IV (44%) injuries (*P* = .0002; Table 1). Overall, there was a trend (*P* = .15) toward shorter median LOS for nonresected patients (median LOS, 8 days; IQ, 5-22 days) compared to patients who underwent resection (median LOS, 13 days; IQ, 8-24 days). For the total study population, there was no association of nonoperative management and pancreatic complications (PCs), including pseudocyst, leak, or fistula formation (*P* = .71).

2.1. Grades II to IV injury

Because no children with grade I injuries underwent resection, outcomes for operative vs nonoperative management were analyzed in the subset of patients with grades II to IV injuries (n = 25). In these children, the median time to final follow-up after injury was 58 days (IQ, 25-256 days),

Table 1 Patient data by pancreatic injury grade

	Grade I (n = 18)	Grade II (n = 6)	Grade III (n = 17)	Grade IV (n = 2)	*P*
Age (y)	7 ± 5	4.5 ± 2	8.9 ± 4	7.5 ± 3.5	.18
Male	67%	67%	61%	100%	.71
ISS	14 (6-22)	16 (10-22)	10 (10-10)	26 (10-42)	.34
LOS (d)	5.5 (3-9)	8.5 (6-9)	17 (11-22)	26 (10-42)	.0008
ICU (d)	0.5 (0-3)	1 (0-2)	0 (0-2)	10.5 (0-21)	.84
Nonop	0%	50%	41%	50%	.0002

Nonop indicates nonoperative management. Data are presented as mean ± SD (age) or median and IQ (ISS, LOS, ICU).

with no difference between patients managed nonoperatively or by resection (P = .11). Eleven children (44%) were managed without resection, and 14 (56%) underwent distal pancreatectomy (13) or Whipple procedure (1). In the nonresection group, there was one negative laparotomy with drains placed in the pancreatic bed, and 2 children had pancreatic drains placed during operation for other injuries. There was no significant association between resection and grade of injury (P = .29) or ISS (P = .78).

No differences were found in LOS (operative median, 13; IQ, 8-24 vs nonoperative median, 17; IQ, 9-25 days; P = .82) or rates of readmission (11% vs 40%; P = .5) between patients managed operatively vs nonoperatively. There was a trend toward an increased rate of non-PCs (requirement of total parenteral nutrition [TPN], postoperative ileus, pleural effusion, infection, and complications related to secondary procedures) in patients treated with resection, although differences did not reach statistical significance (57% vs 20%; P = .07). With TPN excluded from complications, the differences were less significant (10% vs 36%; P = .31). These findings are summarized in Table 2.

2.2. Pancreatic complications

Nonoperative management resulted in an increased incidence of PCs, including pancreatic pseudocyst, leak, or fistula (21% vs 73%; P = .02; Table 2). Pancreatic complications occurred in grades II (n = 1), III (n = 9), and IV (n = 1) injuries, whereas no PC occurred in II (n = 5), III (n = 8), and IV (n = 1) (P = .38). The only patient with grade II injury to subsequently develop a pseudocyst underwent negative laparotomy with drain placement. If this patient is excluded, then the association of grade III and IV with PC becomes statistically significant (0% grade II vs 53% grade III-IV; P = .05).

Patients who developed PC (n = 11) had an increased LOS (median, 22 days; IQ, 12-27 days vs median, 9 days; IQ, 8-18; P = .03) compared to patients who did not have PC (n = 14), whereas differences in ICU stay (median, 0 days; IQ, 0-2 days vs median, 1 day; IQ, 0-3; P = .12) and rates of hospital readmission (18% vs 7%; P = .56) did not reach significance. Non-PCs occurred with similar frequency in the 2 groups (45% vs 29%; P = .64). Among patients with PC, 3 required TPN, 1 had postoperative ileus, and 1 had readmission for abdominal pain after an outpatient gastroscopy. In patients without PC, 3 required TPN, 1 had a urinary tract infection, and 2 developed postoperative pleural effusions. Overall, 5 patients with PC and 4 patients without PC developed a non-PC. There was no record of chronic pain in any of the children with grades II to IV pancreatic injury, regardless of pseudocyst or fistula formation. These findings are summarized in Table 3.

Table 2 Operative vs nonoperative management outcomes in grades II to IV pancreatic injuries

	Operative (n = 14)	Nonop (n = 11)	P
LOS (d)	13 (8-24)	17 (9-25)	.82
Readmission	11%	40%	.5
Non-PC	57%	20%	.07
PC	21%	73%	.02

PC indicates pancreatic complication and includes pseudocyst, fistula, and leak. Data for LOS are presented as median and IQ.

Table 3 Outcomes data for patients with grades II to IV pancreatic injuries and PCs

	PC (n = 11)	No PC (n = 14)	P
LOS	22 (12-27)	9 (8-18)	.03
Readmissions	18%	7%	.56
Non-PC	45%	29%	.64
Drainage	45%	0%	.009

Pancreatic complication data for grades II and IV pancreatic injuries. PC includes pseudocyst, fistula, and leak. Drainage, additional drainage procedures. Data for LOS are presented as median and IQ.

Pancreatic complications were managed by drains placed during resection (n = 3), percutaneous catheter drainage (n = 3), cyst-gastrostomy (n = 2), or conservative management (n = 3). Patients managed conservatively were made nil per os (nothing by mouth) and treated with TPN. Two patients received octreotide. Additional postoperative procedures were significantly more likely in patients with PC (45% vs 0%; P = .009; Table 3). However, initial management with pancreatic resection had no effect on the need for additional drainage procedures in patients who subsequently developed PC (50% nonresected vs 33% resected; P = .57). One resected and 4 nonresected patients who developed pseudocysts required an additional drainage procedure. In addition, 2 resected patients had intraoperative drain placement with subsequent fistula formation. One additional resected patient who developed pseudocyst underwent multiple laparotomies for reasons not directly related to PCs. Initial management with resection also failed to decrease LOS (P = .82), readmission (P = .5), and non–pancreas-related complications (P = .31) in patients with PC.

2.3. Diagnostic imaging

All children underwent computed tomographic (CT) scan at presentation, and 15 children (34%) underwent endoscopic retrograde cholangiopancreatography (ERCP). All patients with evidence of pancreatic injury on ERCP also had evidence of injury on CT scan.

Of children with grade I injuries, 3 had CT scans suggestive of possible ductal injury. One patient underwent ERCP that was normal, and no further intervention was pursued. Two children were taken to the operating room (OR) for laparotomy without ERCP, and no significant ductal injury was found.

In patients with grades II to IV injury, 14 (56%) underwent ERCP with adequate results in all but two

(1 pancreatic divisum, 1 failed ampulla intubation). Eleven patients were managed without ERCP. The median time from injury to operation was 1 day (IQ, 1-3 days) for patients who did not undergo ERCP and 1 day (IQ, 0-3 days) for patients who did undergo ERCP. Pancreatic complication occurred more often in the cohort of patients who underwent ERCP (57%) than in those who did not undergo ERCP (27%), but the difference did not reach statistical significance ($P = .22$).

Of the 12 patients with successful ERCP, all were found to have evidence of main or secondary ductal injury on ERCP (n = 11 grade III, 1 grade IV). Six underwent resection, and 6 were subsequently managed nonoperatively (50%), with one successful stent placement at ERCP. Of the 6 children who underwent resection, 5 had evidence of complete main duct transection on ERCP, and 1 had main duct injury without definitive transection. Patients managed nonoperatively had main duct injury without complete transection (4) or secondary duct injury (2). Nonoperative management after ERCP was associated with an increased rate of PC (86% vs 29%; $P = .02$).

There were no negative laparotomies in children who had successful preoperative ERCP. However, both patients with failed ERCP underwent laparotomy. One patient (pancreatic divisum) was taken to the OR where no pancreatic laceration was found and drains were placed. This patient subsequently developed a pancreatic fistula into the drains. The other patient (failed ampulla intubation) underwent distal pancreatectomy with no intraoperative or postoperative complications.

In the 11 patients with grades II to IV injury who did not undergo ERCP (n = 5 grade II, 5 grade III, 1 grade IV), 2 patients (18%) were managed without any operation for pancreatic injury. Seven patients (64%) underwent pancreatic resection, and 2 additional patients (18%) were taken to the OR for suspected pancreatic duct injuries. One patient had splenectomy with drains placed in the pancreatic bed and 1 had negative laparotomy. Rates of PC were 50% in patients managed nonoperatively and 16% in resected patients, but this association was not statistically significant ($P = .28$).

3. Discussion

Pancreatic injury is an unusual complication of blunt abdominal trauma, occurring in approximately 2% to 9% of all injured children [1,2]. Most cases of pancreatic injury are minor, with pancreatic ductal disruption occurring in the minority of cases [2,4]. Despite continued efforts at creating a standard protocol, the optimal management of pediatric patients with pancreatic injury remains poorly defined, at least partly because of the small number of patients available for analysis. Arguments for either operative or nonoperative approaches to pancreatic injury are often made from analysis of a very small number of patients. One author reports managing fewer than one case of pancreatic trauma per year for a 10-year period [8], and this experience is not exceptional [9-11]. The largest single-institution experience report of pancreatic trauma in children included 56 children admitted between 1984 and 1997 [12].

A multi-institutional retrospective review of 173 cases of pancreatic injury was published in 2007 [1], but difficulties related to institutional peculiarities of diagnosis and treatment make meaningful interpretation of data difficult. For example, the authors equate operative management with "nonoperative management failure," which implies that a nonoperative approach was standard at all institutions. However, the data do not seem to support this presupposition, and it is just as likely that the article describes the divergent management approaches of several institutions. This sort of difficulty is inherent to any retrospective review but particularly to a multi-institutional review that attempts to describe predictors of management failures and outcomes.

We report a series of 44 children who sustained blunt pancreatic injury at our institution during an 11-year period. The retrospective nature of the study made robust data comparison difficult for some outcomes. In addition, even at a single institution, the decision to operate for pancreatic trauma appears to be case dependent, with no demonstrable association of either injury grade or ISS with pancreatic resection in patients with grades II to IV injury. This variability highlights the need for more rigorous outcomes research to guide management decisions.

Authors advocating for operative treatment of pancreatic trauma argue that nonoperative treatment results in unnecessary prolongation of hospitalization, inconvenience to patients, and increased incidence of pancreatic pseudocyst, particularly when ductal injury is suspected [3,4,13]. For example, in a study of early resection for patients with main duct transection, Meier et al [3] argue that "early pancreatic resection more expeditiously returns the child to good health and lessens the inconvenience and emotional stress associated with prolonged hospitalization." Indeed, the median LOS (11 days) after early resection for complete main duct transection, as described by Meier et al [3], compares favorably with our operative median LOS (13 days) as well as our nonoperative median LOS (17 days), despite our analysis including patients with grade II injury and with secondary duct injury. However, when only grade III and IV injuries were included in analysis, our data suggest that median LOS is equivalent (18 days) in operatively and nonoperatively managed patients (data not shown).

Other authors have argued for a conservative approach to major pancreatic trauma with selective operative management [2,5,10,14,15]. In 1999, Jobst et al [12] recommended distal pancreatectomy in children with grade II injury, but nonoperative management of grade III, suggesting that pseudocyst formation, should be considered a "favorable outcome in the natural history of traumatic pancreatic injury." In contrast, our data suggest that PCs have a negative impact on LOS as well as need for additional drainage procedures,

although these effects were not reflected in increased length of stay in patients managed nonoperatively.

The multi-institutional retrospective review performed by Mattix et al [1] in 2007 showed a statistically nonsignificant trend toward increased length of stay, pseudocyst formation, drainage procedures, and pancreatitis in patients managed nonoperatively. Likewise, our data support similar LOS, need for additional drainage in patient who develop PCs, and hospital readmission rates in patients with grades II to IV injuries managed with and without resection. However, PCs were much more likely to occur in nonoperatively managed patients in our study. This discrepancy may be partly explained by the additional morbidity conferred by pancreatic resection that, in our study, was similar to morbidity from pancreatic pseudocyst or fistula.

All patients in our population who developed pseudocysts were managed successfully with conservative treatment, percutaneous drainage, or cyst-gastrostomy. Not surprisingly, additional drainage procedures were required more frequently in patients who developed pseudocyst or pancreatic leak. However, as noted above, initial management with resection did not change the need for additional drainage procedures in those patients who subsequently developed PCs, and those resected patients who avoided additional procedures for pseudocyst or fistula were invariably treated with intraoperative drain placement. These results support the arguments of several authors who advocate for nonoperative treatment of pancreatic injury because most pseudocysts resolve with or without drainage [2,5,10,14,15].

Our success with percutaneous drainage contradicts the findings of Rescorla et al [16], who reported 3 failures in 4 consecutive attempts of percutaneous drainage for pancreatic pseudocyst in children in 1990. This discrepancy may be related to increased experience among interventional radiologists today because published reports support a success rate of at least 50% in adult patients [17]. Furthermore, the high success rate in our study suggests that the natural history of traumatic pancreatic pseudocyst in children may be different than in adults. Future advances in percutaneous techniques should aid the nonoperative management of pancreatic trauma by mitigating the impact of PCs.

A secondary purpose of this study was to evaluate the use of diagnostic ERCP for pancreatic trauma in children. Endoscopic retrograde cholangiopancreatography is generally safe in children [18], and some authors have suggested that routine use of ERCP should be considered in patients with equivocal CT evidence of significant pancreatic injury [4,9]. This approach has become standard in our practice to avoid unnecessary pancreatic resection or abdominal exploration. In our more recent experience, diagnostic ERCP is associated with an increase in nonoperative management, despite patients who underwent ERCP generally had more significant pancreatic injury than those who did not. Furthermore, ERCP had no effect on the median time from injury to operation in our study, likely because at our institution patients discovered to have duct injury on ERCP are taken directly to operation while still under anesthesia. On the other hand, nonoperative management in patients without main duct transection on ERCP was associated with increased rates of PC, challenging our bias that secondary duct injuries are less likely to result in pseudocysts. As ERCP has somewhat recently become the standard practice at our institution, we expect that these questions will be addressed more fully with the accumulation of subsequent data. At present, we conclude that, if it is available to the pediatric trauma practitioner, diagnostic ERCP is a useful screening procedure to more definitively identify ductal injury and plan operative or nonoperative treatment accordingly.

The use of diagnostic ERCP introduced two other limitations to our study. Because all pancreatic duct transections discovered on ERCP were treated by resection and all minor duct injuries were treated nonoperatively, we cannot draw meaningful conclusions about nonoperative management in this particular subset of patients. It is also possible that the nonstandardized use of ERCP at our institution introduced a selection bias that skewed outcomes in other subsets of patients by excluding those patients with the most severe injuries from nonoperative management.

Compared to diagnostic ERCP alone, an additional benefit may be derived from therapeutic ERCP, as ductal injuries can potentially be stented endoscopically to facilitate nonoperative management in patients with main duct transection. In 2007, Houben et al published a series of 9 children with main duct injury treated by an endoscopically placed stent. All of these children managed with therapeutic ERCP avoided pancreatic resection, although most (66%) developed pancreatic fluid collections requiring drainage. In our study, only one patient underwent successful endoscopic stenting in our study, and we are therefore unable to comment directly on the potential effect of therapeutic ERCP on nonoperative management of ductal injuries. However, the PC rates described by Houben et al [19] are similar to the rates in our patients managed nonoperatively without duct stenting. This ostensibly suggests that therapeutic ERCP confers no significant additional protection in pancreatic trauma. On the other hand, our nonoperative cohort excluded 6 patients with ERCP-diagnosed pancreatic transection and included several patients with grade II injuries, confounding direct comparison to the study by Houben et al [19] that described patients with more significant injuries.

A number of limitations of our study have been noted throughout this discussion. However, several conclusions about the management of pancreatic trauma in children can be made. Our data suggest that operative management results in significantly decreased rates of PCs but fails to decrease length of stay in the hospital. On the other hand, PCs are associated with increased length of stay and increased need for additional drainage procedures. This discrepancy implies that the morbidity associated with pancreatic resection may offset the gains made by avoidance of PCs. The incidence of PCs in children with grade I and II injuries managed with or

without resection is extremely low, and these patients should invariably be treated nonoperatively. Patients with grades III and IV injuries may benefit from early resection because of the relatively high rates of PCs in this group. However, more data are needed to definitively recommend a single approach to patients with documented duct injury and to clarify the impact of PCs on other outcomes in this population. Furthermore, in our experience, grades II and III injuries are often difficult to distinguish on CT scan, and we advocate the routine use of diagnostic ERCP to guide management decisions, avoid negative laparotomy, and minimize unnecessary pancreatic resections.

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