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Trauma Whipple: Do or Don't After Severe Pancreaticoduodenal Injuries? An Analysis of the National Trauma Data Bank (NTDB)

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Abstract

Background Pancreaticoduodenectomy for trauma (PDT) is a rare procedure, reserved for severe pancreaticoduodenal injuries. Using the National Trauma Data Bank (NTDB), our aim was to compare outcomes of PDT patients to similarly injured patients who did not undergo a PDT.

Methods Patients with pancreatic or duodenal injuries treated with PDT (ICD-9-CM 52.7) were identified in the NTDB 2008–2010 Research Data Sets. We excluded those who underwent delayed PDT (>4 days). The PDT group ($n = 39$) was compared to patients with severe combined pancreaticoduodenal injuries (grade 4 or 5) who did not undergo PDT (non-PDT group, $n = 38$). Patients who died in the emergency department or did not undergo a laparotomy were excluded. Our primary outcome was death. Secondary outcomes were intensive care unit length of stay (LOS), hospital LOS, and total ventilator days. A multivariate model was used to determine predictors of in-hospital mortality within each group and in the overall cohort.

Results The non-PDT group had a significantly lower systolic blood pressure and Glasgow Coma Scale values at baseline and more severe duodenal, pancreatic, and liver injuries. There were no significant differences in outcomes between the two groups. The Injury Severity Score was the only independent predictor of mortality among PDT patients [odds ratio (OR) 1.12, 95 % confidence interval (CI) 1.01–1.24] and in the entire cohort (OR 1.06, 95 % CI 1.01–1.12). The operative technique did not influence any of the outcomes.

Conclusions Compared to non-PDT, PDT did not result in improved outcomes despite a lower physiologic burden among PDT patients. More conservative procedures for high-grade injuries of the pancreaticoduodenal complex may be appropriate.

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Introduction

Pancreaticoduodenectomy as a single-stage procedure was first reported by Whipple et al. [1] in 1935 for elective resection of periampullary carcinoma. While the operative mortality rate of this radical procedure has been improved to <5 %, it is still associated with a 40 % complication rate and a poor (<10 %) 5-year survival when performed for adenocarcinoma of the pancreatic head [2, 3].

Three decades elapsed before this procedure was first reported in trauma patients [4, 5]. The frequency of duodenal and pancreatic injuries is low compared to other abdominal organ injuries. Isolated duodenal injuries are rare, and we found no adequate documentation of the exact incidence. Asensio et al. [6] reviewed duodenal injuries and estimated their incidence at 4.3 % of all abdominal injuries (range 3.7–5.0 %). Pancreatic trauma has been reported as present in only 3.0 % [7].

Combined pancreaticoduodenal injuries are equally uncommon. Overall, 80 % are caused by a penetrating mechanism, morbidity is high, and mortality ranges from

Table 1 AAST OISs for the pancreas and duodenum

Injured structure and AAST grade[a]	Characteristics of injury	AIS-90 score	AIS-2005 score
Pancreas			
I	Small hematoma without duct injury; superficial laceration without duct injury	2	2
II	Large hematoma without duct injury or tissue loss; major laceration without duct injury or tissue loss	2, 3	2
III	Distal transection or parenchymal laceration with duct injury	3	3
IV	Proximal[b] transection or parenchymal laceration involving ampulla	4	4
V	Massive disruption of pancreatic head	5	5
Duodenum			
I	Single-segment hematoma; partial-thickness laceration without perforation	2, 3	2
II	Multiple-segment hematoma; small (<50 % of circumference) laceration	2, 4	2
III	50–75 % Disruption (laceration) of segment D2 or 50–100 % disruption of segment D1, D3, or D4	4	3
IV	Large (75–100 %) laceration of segment D2; rupture of ampulla or distal CBD	5	4
V	Massive duodenopancreatic injury; devascularization of duodenum	5	5

AAST American Association for the Surgery of Trauma, *AIS-90* Abbreviated Injury Score, 1990 version, *AIS-2005* Abbreviated Injury Score, 2005 version, *CBD* common bile duct

[a] Advance one grade for multiple injuries, up to grade III

[b] Proximal pancreas is to the patient's right of the superior mesenteric vein

18 to 30 % [8–10]. Pancreaticoduodenectomy for trauma (PDT) therefore is rarely performed and is usually reserved for the most severe pancreaticoduodenal injuries (grade 4 or 5, according to the organ injury scale (OIS) of the American Association for the Surgery of Trauma) (Table 1) [11]. The largest study on PDT to date consists of only 18 patients from a single center [12].

In this study, we examined this uncommon operation at a national level using the National Trauma Data Bank (NTDB). Our aim was to evaluate the outcomes of PDT patients and compare them to outcomes of similarly injured patients who did not undergo PDT.

Methods

The NTDB is a database that contains information on trauma patients that has been submitted on a voluntary basis by trauma centers in the United States. Designed and maintained by the American College of Surgeons, Committee on Trauma, it has been running since 1997. Currently, the data set includes more than 5 million cases from more than 900 trauma centers of all levels of designation. We used NTDB version 7.2 and focused on the Research Data Sets for 2008, 2009, and 2010. (A new, more complete data set was introduced in 2008.)

Patients undergoing PDT were identified using the International Classification of Diseases, 9th Revision (ICD-9) procedure code 52.7 (radical pancreaticoduodenectomy). A total of 47 patients were found. Because the focus of this study was on outcomes of patients who underwent PDT acutely (either at the initial operation or within 4 days from admission), we excluded three patients who underwent delayed PDT (beyond 4 days). Five additional patients were excluded because their ICD-9 diagnosis codes did not include pancreatic or duodenal injuries. The final PDT sample comprised 39 patients (PDT group) (Fig. 1). This group was compared with patients who had severe combined pancreaticoduodenal injuries—grade 4 or 5 in both organs according to the OIS of the American Association for the Surgery of Trauma (AAST) (Table 1) [11]—but did

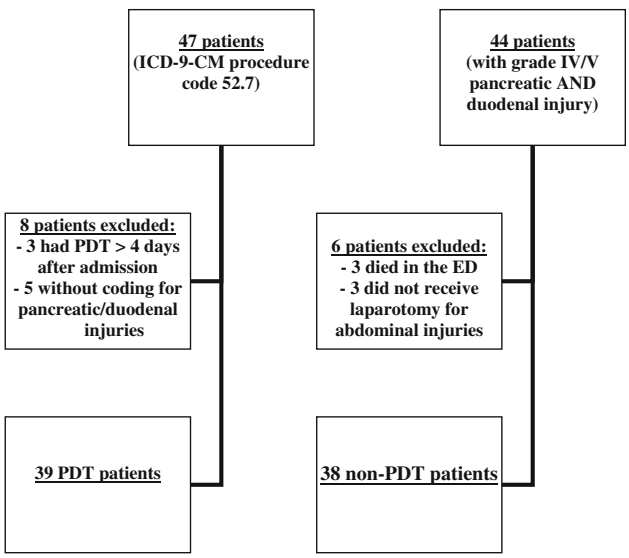

Fig. 1 PDT group versus non-PDT group

Table 2 Comparision between patients managed with PDT vs. non-PDT for severe injuries to the pancreaticoduodenal complex

Parameter	PDT group ($n = 39$)	Non-PDT group ($n = 38$)	p
Age (years)	34 ± 18	30 ± 14	0.26
Male sex	29 (74 %)	30 (79 %)	0.79
ISS (AIS based)	27 ± 13	30 ± 10	0.21
ISS >25	16 (41 %)	22 (58 %)	0.17
Penetrating trauma	30 (77 %)	26 (68 %)	0.45
Systolic blood pressure (mmHg)	118 ± 36	101 ± 47	0.22
<90 mmHg	6 (15 %)	8 (21 %)	0.028
<110 mmHg	11 (28 %)	20 (53 %)	0.01
Heart rate (beats/min)	96 ± 31	97 ± 42	0.90
>100 beats/min	16 (41 %)	19 (50 %)	0.19
GCS	14 ± 3	10 ± 6	0.002
AIS head/neck	0.2 ± 0.7	0.2 ± 0.7	0.85
AIS abdomen	3.8 ± 0.8	4.7 ± 0.5	<0.0001
Severe injury			
Duodenal and/or pancreatic (IV–V)	31 (79 %)	38 (100 %)	0.005
Duodenal (IV–V)	11 (28 %)	38 (100 %)	<0.0001
Pancreatic (IV–V)	28 (72 %)	38 (100 %)	0.001
Splenic (IV–V)	0	4 (11 %)	0.12
Liver (IV–V)	7 (18 %)	16 (42 %)	0.006
Gallbladder (IV–V)	4 (10 %)	0	0.23

Results are given as the number and percent of patients or as otherwise noted

ISS Injury Severity Score, *SBP* systolic blood pressure, *HR* heart rate, *GCS* Glasgow Coma Scale, *AIS* Abbreviated Injury Scale

not undergo PDT (non-PDT group) (Fig. 1). Patients who died in the emergency department (ED) or did not have a laparotomy for their abdominal injuries were excluded from the non-PDT group.

Data that were collected included demographics, Injury Severity Score (ISS), Abbreviated Injury Score (AIS), physiologic status upon arrival at the receiving hospital, associated injuries, and performed procedures. Our primary outcome was death. Secondary outcomes were hospital length of stay (LOS), intensive care unit (ICU) LOS, and ventilator days.

Univariate analysis was performed to compare the two groups. We dichotomized certain continuous variables across clinically meaningful values: ISS at 25; systolic blood pressure at 90 and 110 mmHg; heart rate at 100 beats/min. Continuous variables were summarized using mean values with standard deviations (SDs). They were compared using two-sample t tests or summarized using median values with the range and compared using Wilcoxon rank sum tests. Categoric variables (reported as counts and proportions) were compared using Fisher's exact test.

Table 3 Outcomes

Outcomes	PDT group ($n = 39$)	Non-PDT group ($n = 38$)	p
Hospital LOS (days)	18 (1–180)	12 (1–85)	0.32
ICU LOS (days)	8 (1–106)	10 (1–85)	0.96
Ventilator (days)	7 (1–90)	8 (1–42)	0.73
ED stay (min)	25 (3–3,850)	31 (2–13,055)	0.55
Any complications	20 (51 %)	21 (55 %)	0.82
Death	13 (33 %)	14 (37 %)	0.81

Results are given as the median and range or the number and percent

LOS Length of stay, *ED* emergency department

Logistic regression analysis was performed to identify independent predictors of mortality significant at the 0.05 level for each group and in the overall cohort. Odds ratios (ORs) and 95 % confidence intervals (CIs) were reported for each predictor. A value of $p \leq 0.05$ indicated statistical significance. SAS version 9.3 software (SAS Institute, Cary, NC, USA) was used for the entire analysis. Our institutional review board approved the study.

Results

Among 3 years (2008–2010) of NTDB data, a total of 39 patients were found to have undergone a trauma-related Whipple procedure (PDT group) during the acute phase for severe pancreaticoduodenal injuries. Their mean age was 34 ± 18 years (median 27 years; range 16–80 years), with only 10.3 % being >55 years of age. Among them, 74 % were male, and in 77 % the mechanism of injury was penetrating trauma. The mean ISS (based on the AIS) was 27 ± 13 (median 25; range 4–59). This group was compared to patients who had severe pancreaticoduodenal injuries but did not undergo PDT. As shown in Table 2, no significant differences were found in any of the demographic data.

Comparing physiologic status at baseline (Table 2), the non-PDT group had significantly more patients with a lower systolic blood pressure, both when dichotomized at 90 mmHg (PDT vs. non-PDT, respectively: 15 vs. 21 %, $p = 0.028$) and at 110 mmHg (28 vs. 53 %, $p = 0.01$). No significant difference was found in heart rate, but there was a difference in the Glasgow Coma Scale score (14 ± 3 vs. 10 ± 6, $p = 0.002$). When comparing AIS scores, though, we found no difference in the head and neck AIS ($p = 0.85$).

Patients in the non-PDT group had significantly higher abdominal AIS, a higher percentage of patients with duodenal and pancreatic injuries, and more severe liver injuries. Surprisingly, among the patients who underwent PDT, only 79 % had either a severe (grade 4 or 5) duodenal or

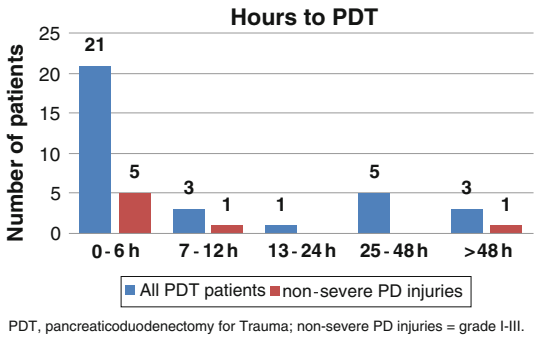

Fig. 2 Hours from admission to pancreaticoduodenectomy

Table 4 Type of abdominal procedures in the non-PDT group

Procedure	No.
Other gastroenterostomy	10
Suture of laceration of duodenum	9
Other partial resection of small intestine	8
Open and other right hemicolectomy	8
Other repair of pancreas	7
Distal pancreatectomy	3
Total pancreatectomy	3
Anastomosis of pancreas	3
Other operations on pancreas	3
Other excision or destruction lesion/tissue of pancreas or pancreatic duct	2
Internal drainage of pancreatic cyst	2
Other partial pancreatectomy	2
Proximal pancreatectomy	1

severe pancreatic injury, whereas in the non-PDT group this figure was 100 % because it was one of the inclusion criteria for this group (Table 2).

There were no significant differences in outcomes. Mortality was 33 versus 37 %, respectively, for the PDT and non-PDT groups ($p = 0.81$). The hospital and ICU LOSs did not differ significantly between the two groups. Similarly, there was no significant difference in the number of minutes spent in the ED or in the number of ventilator days (Table 3). No difference in the incidence of reported complications was found (PDT vs. non-PDT, respectively, 51 vs. 55 %, $p = 0.82$). Looking at the time of death in both the PDT and non-PDT group, our results showed that patients who underwent PDT died at a median of 7 days (range 1–180 days), whereas patients in the non-PDT group died much earlier, at a median of 1 day (range 1–85 days).

For PDT patients with available operating time data ($n = 33$), the majority of procedures (21/33, 64 %) were performed within the first 6 hours after admission. For patients who underwent PDT but did not have severe (grade 4 or 5) injuries of the pancreas or duodenum, the majority (5/7, 71 %) underwent PDT during the index operation (Fig. 2). There was no trend toward institutional bias in preference of one procedure over another (data not shown). Procedures in the non-PDT group are summarized in Table 4.

Survivors and nonsurvivors in both groups were compared. As shown in the univariate analysis, undergoing PDT did not predict mortality ($p = 0.81$). Also, in the non-PDT group there were no predictors significant at the 0.05 level. The systolic blood pressure was significantly higher and the ISS was significantly lower among PDT survivors. However, only the ISS was found to be an independent predictor of mortality in our multivariable model. For every unit increase in ISS, the odds of mortality increased by 1.09-fold (95 % CI 1.01–1.18). For the overall cohort, the ISS remained the only independent predictor of mortality. For every unit increase in ISS, the odds of mortality increased by 1.07-fold (95 % CI 1.01–1.12).

Discussion

In 1964, Thal and Wilson [5] first described the use of PDT in two trauma patients. Numerous subsequent reports have been published, but they have all been limited by small sample sizes, ranging between three and ten patients per study [4, 13–17]. The majority of patients sustained a penetrating injury, they were predominantly male, and mortality ranged from 20 to 100 %. Our results are consistent with the results of these prior studies. In a review of all PDTs described in the literature (245 cases) [18] until 1999, the pooled mortality rate was 31 %. In our study, mortality was found to be 33 %.

Several options are available to treat combined pancreaticoduodenal injuries. A review of the existing published literature [8–10, 19] showed that simple repair and drainage was used in 19–44 % of patients, repair and exclusion in 34–53 %, and distal pancreatectomy in 3–16 %. The trauma Whipple procedure was employed in <8 % of patients. In a review of pancreatic trauma by Glancy [20], the estimated frequency of PDT was 0.07 % among 1,407 patients. We have yet to establish the "hard" indications for performing such a complex procedure.

Subramanian et al. [21], in a review of pancreatic trauma, described the indications for PDT as extensive trauma to the head of the pancreas, severe combined pancreaticoduodenal injury, or destruction of the ampulla of Vater. PDT is also described as a treatment option for isolated grade 5 pancreatic injury [21, 22] or isolated grade 5 duodenal injury [23]. In the study by Asensio et al. [12], all 18 patients had injuries to both the pancreas (grade 5 in 17, grade 4 in 1) and duodenum (all grade 5). The

indications for PDT in three-fourths of the patients were massive uncontrollable retropancreatic hemorrhage from associated vascular injuries and massive nonreconstructable injuries to both the pancreas and duodenum. In our study, 21 % of patients undergoing PDT did not have a grade 4 or 5 injury in either the pancreas or the duodenum, nor did they have significant associated injuries in the abdomen.

If we assume that PDT is being performed for the appropriate indication of severe injury to the pancreaticoduodenal complex, it is likely that these patients have physiologic derangement or other intra-abdominal injuries requiring attention. Under elective conditions, several authors have recommended enlisting the assistance of an experienced hepatobiliary surgeon when attempting this operation [23–26]. It is not unreasonable to assume that the higher experience-better outcomes relation is also true in unstable trauma patients. Rather than attempt a rare, complex operation on a coagulopathic, hypothermic, academic patient, it may be prudent to employ modern damage control principles (arrest hemorrhage, temporarily control contamination, restore physiologic balance) and defer a time-consuming, complex reconstruction to more favorable conditions [27]. It is surprising, therefore, to discover that the majority of PDTs were performed within 6 h of admission.

This line of thinking is further supported by the difference in time of death. Patients who underwent PDT died much later, and patients with a non-PDT died with a median of only 1 day. As we know, there is a trimodal distribution of death after trauma, with neurologic and exsanguination deaths occurring immediately, hemorrhagic deaths occurring during the first 24 h, and septic/multiorgan failure deaths occurring days to weeks later. Reviewing the median time until death, we concluded that most of the non-PDT patients who died probably died of hemorrhage. The PDT patients who died likely died of progressive organ failure. This is consistent with the above-mentioned finding that non-PDT patients had worse physiologic status upon arrival. We believe that this shows that the surgeon exercised good judgment in deciding not to perform PDT in these patients, as they were probably highly unstable. It is unlikely that performing PDT would have saved the patient's life. A remaining question is whether patients in the PDT group, dying presumably secondary to progressive organ failure, would have done better with a lesser operation (with presumably less physiologic insult), perhaps leading to a higher survival rate. This is a question that should be answered in a new study.

Having shown similar outcomes in patients who were equally injured but managed without PDT, the question arises whether more conservative procedures are appropriate. A study by Velmahos et al. [28] in 2009 demonstrated a failure rate of 10.3 % in 97 patients who were managed nonoperatively for blunt pancreatic injury (BPI), blunt duodenal injury, or both. Among those patients, though, only one had a grade 4 BPI. The rest were all low grade, mostly grades 1 and 2. A study by Duchesne et al. [29] also confirmed that nonoperative management (NOM) of patients with low-grade, blunt pancreatic injuries is successful in most patients, with only few complications and low mortality (5.7 %). However, NOM for high-grade injuries is unlikely to succeed. Nonetheless, more conservative procedures than PDT (e.g., primary repair, drainage, duodenal exclusion, partial pancreatectomy) are worth considering because our study demonstrates that outcomes following these procedures are not significantly different from those after PDT.

We acknowledge that because of its retrospective design, this study has some limitations. Using a large database allowed us to acquire the largest possible sample size for this procedure. However there are limitations with the NTDB that must be mentioned. The NTDB is a convenience sample that is not completely representative of all trauma centers in the United States. Submission of data is voluntary [30], which can result in selection bias. Additionally, there is the possibility of inaccurate diagnostic coding and the limitation of included data variables. Regrettably, the NTDB does not include granular detail (e.g., operative reports, intraoperative hemodynamic parameters, surgeon experience, institutional experience), which may factor into the decision of whether to perform PDT. Also, complications are likely underreported in this database. Despite all these limitations, the NTDB is a powerful tool and is especially useful for studying injuries of very low incidence. We were able to make an accurate comparison between patients managed with PDT versus those were similarly injured, but were managed without PDT.

Conclusions

The trauma-related Whipple procedure, or PDT, is an uncommon procedure. Even when using the largest available trauma database, over the years 2008–2010 we could identify only 39 patients who underwent PDT for severe pancreaticoduodenal injuries during the acute phase. Some 21 % of the PDTs may have been performed for inappropriate indications. In the majority of patients PDT was performed during the index operation. It did not, however, result in an outcome benefit for patients managed with a PDT when compared to similarly injured patients who were managed without PDT. More conservative procedures may be appropriate for treating high-grade injuries of the pancreaticoduodenal complex.

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