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Pancreaticoduodenectomy in trauma patients with grade IV–V duodenal or pancreatic injuries: a post hoc analysis of an EAST multicenter trial

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ABSTRACT

Introduction The utility of pancreaticoduodenectomy (PD) for high-grade traumatic injuries remains unclear and data surrounding its use are limited. We hypothesized that PD does not result in improved outcomes when compared with non-PD surgical management of grade IV–V pancreaticoduodenal injuries.

Methods This is a retrospective, multicenter analysis from 35 level 1 trauma centers from January 2010 to December 2020. Included patients were ≥15 years of age with the American Association for the Surgery of Trauma grade IV–V duodenal and/or pancreatic injuries. The study compared operative repair strategy: PD versus non-PD.

Results The sample (n=95) was young (26 years), male (82%), with predominantly penetrating injuries (76%). There was no difference in demographics, hemodynamics, or blood product requirement on presentation between PD (n=32) vs non-PD (n=63). Anatomically, PD patients had more grade V duodenal, grade V pancreatic, ampullary, and pancreatic ductal injuries compared with non-PD patients (all $p<0.05$). 43% of all grade V duodenal injuries and 40% of all grade V pancreatic injuries were still managed with non-PD. One-third of non-PD duodenal injuries were

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Pancreaticoduodenal trauma is rare, and the literature favors less complex repair strategies, with primary repair alone with extraluminal drain placement preferred when feasible.

WHAT THIS STUDY ADDS

⇒ It was unclear whether pancreaticoduodenectomy (PD) in the setting of high-grade injuries (grade IV–V) improves outcomes compared with non-PD surgical interventions.

⇒ This study demonstrated PD patients did not have improved outcomes compared with non-PD patients without ampullary injuries.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ As PD patients endured more anastomotic leaks, the role for PD should be limited to cases of massive destruction of the pancreatic head and ampullary complex, given the likely procedure-related morbidity and adverse outcomes when compared with non-PD management.

managed with primary repair alone. PD patients had more gastrointestinal (GI)-related complications, longer intensive care unit length of stay (LOS), and longer hospital LOS compared with non-PD (all p<0.05). There was no difference in mortality or readmission. Multivariable logistic regression analysis determined PD to be associated with a 3.8-fold greater odds of GI complication (p=0.010) compared with non-PD. In a subanalysis of patients without ampullary injuries (n=60), PD patients had more anastomotic leaks compared with the non-PD group (3 (30%) vs 2 (4%), p=0.028).

Conclusion While PD patients did not have worse hemodynamics or blood product requirements on admission, they sustained more complex anatomic injuries and had more GI complications and longer LOS than non-PD patients. We suggest that the role of PD should be limited to cases of massive destruction of the pancreatic head and ampullary complex, given the likely procedure-related morbidity and adverse outcomes when compared with non-PD management.

Level of evidence IV, Multicenter retrospective comparative study.

INTRODUCTION

Pancreaticoduodenal trauma is rare and is associated with high morbidity and mortality secondary to frequent concomitant injuries of surrounding structures. The surgical management of high-grade pancreaticoduodenal injuries remains controversial. Since Dr Allen Whipple's 1945 publication detailing a single-staged pancreaticoduodenectomy (PD), this complex procedure has become the standard treatment for pancreatic head cancers, although it is far less commonly used for severe trauma.[1] When PD is performed in the setting of trauma, mortality estimates range from 13% to 50% and morbidity up to 87%.[1,2]

Pancreatic trauma is exceptionally rare, constituting a mere 1.1%–3.0%[3,4] of penetrating traumas, while duodenal injuries account for only 4.3% of abdominal traumas.[4] High-grade pancreaticoduodenal trauma requiring operative intervention is even more uncommon. Consequently, the scarcity of data presents a formidable challenge when assessing the efficacy of PD. Current literature and guidelines do not provide a standardized surgical approach regarding PD versus alternative surgical approaches to improve outcomes.[1,5,6]

Recent comprehensive analyses, drawing from large data banks, suggest PD may not improve outcomes of patients with severe traumatic pancreaticoduodenal injuries.[2,7] Additionally, our prior research suggested that primary repair alone (PRA) was associated with a lower risk of duodenal leak compared with complex repairs with adjunctive measures (CRAM) across a range of injury severities, while simultaneously resulting in shorter hospital stays and fewer major complications.[8]

With a trend in literature and clinical practice favoring less complex repairs, we aimed to compare PD versus non-PD surgical interventions in high-grade injuries. We hypothesized that PD does not result in improved outcomes when compared with non-PD surgical management of the American Association for the Surgery of Trauma (AAST) grade IV–V pancreaticoduodenal injuries.

METHODS

This was a post hoc analysis of an observational retrospective multicenter study completed across 35 level 1 trauma centers in the USA, Canada, and Greece between January 2010 and December 2020. Patients 15 years of age and older with traumatic AAST grade IV–V duodenal injuries and/or grade IV–V pancreatic injuries requiring surgical intervention were included. Patients who died within 24 hours of presentation were excluded from analysis. Patients were identified through trauma registry data or International Classification Diagnosis (ICD)-9 and ICD-10 codes. Standardized data were collected by participating sites and entered into the Research Electronic Data Capture secure web-based program. The Strengthening the Reporting of Observational Studies in Epidemiology guideline was used to safeguard proper reporting.

PD was defined as resection of the duodenum and the head of the pancreas followed by enteric, biliary, and pancreatic exocrine reconstruction including gastrojejunostomy, hepaticojejunostomy, and pancreaticojejunostomy. Patients were included regardless of whether PD was performed as a single-stage or multi-stage procedure. Non-PD patients underwent PRA (which included extraluminal wide drainage), wide extraluminal drainage alone without repair, or CRAM (other than PD). CRAM was previously defined as any repair that included adjunctive measures such as pyloric exclusion with gastrojejunostomy, duodenectomy with enteric anastomosis, duodenal diverticulization, or any combination of those complex repairs.[8] Ampullary injury was defined based on direct visualization in the

Table 1 Demographics, presenting vital signs, and injury severity of patients with traumatic grade IV–V pancreaticoduodenal injuries managed with PD versus non-PD

	All patients (n=95)	PD (n=32)	Non-PD (n=63)	P value
Age (median (25%–75% IQR))	26 (22–34)	25.5 (22.5–33)	26(21–35)	0.972
Male	78 (82.1%)	28 (87.5%)	50 (79.4%)	0.405
BMI (kg/m^2)	24.4 (22.1–29.7)	25.4 (22.4–30.8)	23.8 (22.1–29.6)	0.606
Mechanism of injury				
Blunt	23 (24.2%)	7 (21.9%)	16 (25.4%)	0.803
Penetrating	72 (75.8%)	25 (78.1%)	47 (74.6%)	0.803
Gun shot wound	68 (71.6%)	24 (75%)	44 (69.8%)	1.000
Stab wound	4 (4.2%)	1 (1.6%)	3 (4.8%)	1.000
Systolic blood pressure (mm Hg)	120 (102–140)	116.5 (102–140.5)	120 (102–139)	0.884
Glasgow Coma Scale	15 (13–15)	15 (13–15)	15 (14–15)	0.627
Injury Severity Score	26 (17–34)	26 (20.5–31.5)	26 (16.5–35)	0.755
AIS abdomen	4 (4–5)	4 (4–5)	4 (4–5)	0.906
Massive transfusion protocol	45 (47.4%)	18 (56.3%)	27 (42.9%)	0.278

AIS, Abbreviated Injury Scale; BMI, body mass index; PD, pancreaticoduodenectomy.

Table 2 Injury pattern and management among patients with traumatic grade IV–V pancreaticoduodenal injuries managed with PD versus non-PD

	All patients (n=95)	PD (n=32)	Non-PD (n=63)	P value
Duodenal injury				
Injury AAST grade I	4 (4.2%)	1 (3.1%)	3 (4.8%)	1.000
II	9 (9.5%)	3 (9.4%)	6 (9.5%)	1.000
III	16 (16.8%)	4 (12.5%)	12 (19.0%)	0.565
IV	38 (40%)	8 (25%)	30 (47.6%)	0.046
V	28 (29.5%)	16 (50%)	12 (19.0%)	0.004
Grade IV or V	66 (69.5%)	24 (75%)	42 (66.7%)	0.484
Pancreatic injury	73 (76.8%)	29 (90.6%)	44 (69.8%)	0.038
Injury AAST grade I	3 (3.2%)	1 (3.1%)	2 (3.2%)	1.000
II	6 (6.3%)	1 (3.1%)	5 (7.9%)	0.660
III	2 (2.1%)	1 (3.1%)	1 (1.6%)	1.000
IV	27 (28.4%)	5 (15.6%)	22 (34.9%)	0.057
V	35 (36.8%)	21 (65.6%)	14 (22.2%)	<0.001
Grade IV or V	62 (65.3%)	26 (81.2%)	36 (57.1%)	0.023
Concomitant pancreas+duodenal injuries	73 (76.8%)	29 (90.6%)	44 (69.8%)	0.038
Grade V injuries of both duodenum and pancreas	22 (23.2%)	13 (40.6%)	9 (14.3%)	0.009
Duodenal injury involved the ampulla	35 (36.8%)	22 (68.8%)	13 (20.6%)	<0.001
Pancreatic ductal injury	48 (50.5%)	22 (68.8%)	26 (41.3%)	0.017
Pancreatic head injury	65 (68.4%)	29 (90.6%)	36 (57.1%)	<0.001
Both duodenal ampulla and pancreatic ductal injuries	23 (24.2%)	16 (50%)	7 (11.1%)	<0.001
Duodenal operative management				
Primary repair alone (with extraluminal drainage)	22 (23.2%)		22 (34.9%)	
Wide extraluminal drainage alone	4 (4.2%)		4 (6.3%)	
Complex repairs with adjunctive measures	69 (72.6%)	32 (100%)	37 (58.7%)	
PD	32 (33.7%)	32 (100%)		
Pyloric exclusion with gastrojejunostomy	18 (18.9%)		18 (28.6%)	
Duodenectomy (with enteric anastomosis)	12 (12.6%)		12 (19.4%)	
Duodenal diverticulization	1 (1.1%)		1 (1.6%)	
Combination of complex repairs/other	6 (6.3%)		6 (9.5%)	
Duodenal injury managed in index operation	76 (80%)	29 (90.6%)	47 (74.6%)	0.102
Damage control laparotomy	74 (77.9%)	24 (75%)	50 (79.4%)	0.613
Total number of abdominal operations	2 (1–6)	2 (2–7)	2 (1–5)	0.321
Primary abdominal closure	60 (63.2%)	21 (65.6%)	39 (61.9%)	0.823

AAST, American Association for the Surgery of Trauma; PD, pancreaticoduodenectomy.

operating room, intraoperative cholangiogram, magnetic resonance cholangiopancreatography, or endoscopic retrograde cholangiopancreatography findings. Leak from the duodenal injury site was defined as any dehiscence or drainage following surgery evidenced by CT scan, upper gastrointestinal (GI) fluoroscopy, MRI, endoscopy, operating room exploration, or clinically based on bilious extraluminal drain output. Outcomes included leak, complications, GI complications, hospital and intensive care unit (ICU) length of stay, ventilator days, and mortality. GI-specific complications were defined as intra-abdominal abscess, GI bleed, ulcer, ileus, abdominal compartment syndrome, enterocutaneous fistula, or anastomotic leak.

Data were analyzed using SAS software V.9.4 (SAS Institute, Cary, North Carolina, USA). Patients with high-grade injuries with PD versus non-PD surgical intervention were compared. As we hypothesized, PD does not result in improved outcomes when compared with non-PD management. Patients without ampullary injuries may be more amendable to non-PD management; therefore, we performed subgroup analyses of patients with and without ampullary injuries, comparing PD versus non-PD. Continuous variables were compared using Student's t-test and the Mann-Whitney U test for parametric and non-parametric data, respectively. Categorical variables were compared by using the χ^2 test or Fisher's exact test. Univariate and multivariable logistic regression were used to determine factors associated with the primary study end point: GI complications. Variables included in the multivariable logistic regression were selected based on selection theory and those identified as significant by univariate analysis ($p<0.01$). The variables included were surgical management (PD vs non-PD), duodenal injury (grade V vs less than grade V), pancreatic injury (grade IV or V vs less), and age.

As this was a retrospective post hoc analysis, a predetermined sample size was used to compare PD versus non-PD patients with traumatic grade IV–V pancreaticoduodenal injuries, focusing on GI complications as the outcome. Given this sample size, the effect was achieved with an actual power of 0.577 at the 0.03 alpha level.

RESULTS

There were 95 patients included in the study: 32 underwent PD and 63 underwent non-PD surgical interventions. The median age of all patients with grade IV–V pancreaticoduodenal injuries was 25.5 years, the majority were male (82.1%), with a body mass index (BMI) of 24.4 kg/m^2, and most endured penetrating

Table 3 Outcomes among patients with traumatic grade IV–V pancreaticoduodenal injuries managed with PD versus non-PD

	All patients (n=95)	PD (n=32)	Non-PD (n=63)	P value
Duodenal leak	22 (23.2%)	7 (21.9%)	15 (23.8%)	1.000
IR drain placement for duodenal leak	12 (12.6%)	5 (15.6%)	7 (11.1%)	0.530
Antibiotic use for leak	18 (18.9%)	3 (9.4%)	15 (23.8%)	0.105
Days of antibiotics	13 (10–30)	22 (8–30)	12 (10–31)	0.946
Parenteral nutrition	52 (54.7%)	21 (65.6%)	31 (49.2%)	0.190
Days of parenteral nutrition	20 (10–40.5)	22 (11.5–39.5)	18 (6–41.5)	0.537
Days until fistula/duodenal leak resolution	24 (12–43)	24 (5–28)	26 (12–53.6)	0.405
Anastomotic leak	9 (9.5%)	5 (15.6%)	4 (6.3%)	0.159
Any complication	60 (63.2%)	24 (75%)	36 (57.1%)	0.116
GI-related complication (abscess, GI bleed, ulcer, ileus, abdominal compartment syndrome, EC fistula, anastomotic leak)	50 (52.6%)	22 (68.8%)	28 (44.4%)	0.031
ICU length of stay (days)	10 (4–24)	16.5 (7–28.5)	6 (2–23)	0.012
Hospital length of stay (days)	27 (13–42)	33.5 (23.5–45)	24.5 (9–38)	0.017
Ventilator days	4 (2–14)	7.5 (3–14.5)	3 (1–14)	0.079
Mortality	19 (20%)	4 (12.5%)	15 (23.8%)	0.279
30-day readmission	27 (28.4%)	10 (31.3%)	17 (27.0%)	0.810

EC, enterocutaneous; GI, gastrointestinal; ICU, intensive care unit; IR, interventional radiology; PD, pancreaticoduodenectomy.

injuries (75.8%). On presentation, patients had a median systolic blood pressure of 120 mm Hg (IQR 120–140 mm Hg), Glasgow Coma Score of 15 (IQR 13–15), Injury Severity Score of 26 (IQR 17–34), and 47.4% required massive transfusion protocol activation. There was no difference in demographics, BMI, mechanism of injury, presenting vital signs, injury severity, or massive transfusion requirements when comparing PD with non-PD patients (table 1, all p>0.05).

Among non-PD patients, 34.9% underwent primary repair with wide extraluminal drainage, 6.3% underwent wide drainage alone without repair, and 58.7% underwent CRAM (table 2). The surgical management of non-PD CRAM patients included pyloric exclusion with gastrojejunostomy (28.6%), duodenectomy with enteric anastomosis (19.4%), duodenal diverticulization (1.6%), or another combination of complex repairs (9.5%). Anatomically, PD patients had more concomitant pancreaticoduodenal injuries (90.6% vs 69.8%, p=0.038), grade V duodenal injuries (50% vs 19%, p=0.004), and grade V pancreatic injuries (65.6% vs 22.2%, p<0.001). Likewise, PD patients had more ampullary injuries, pancreatic ductal injuries, and pancreatic head injuries (all p<0.05).

While PD patients had more complex injury patterns, 43% of grade V duodenal injuries and 40% of grade V pancreatic injuries were still managed with non-PD. Among the non-PD patients with PRA (n=22), eight (38.1%) had grade IV or V duodenal injuries, 16 (76.2%) had grade IV or V pancreatic injuries, three (14.3%) had ampullary injuries, and 10 (47.6%) had pancreatic ductal injuries. There was no difference in surgical management regarding the use of damage control laparotomy, duodenal injury management during index operation, the number of operations, or primary abdominal closure among PD versus non-PD patients (table 2, all p>0.05).

Table 4 Multivariable analysis of variables associated with GI complications

	OR	95% CI	P value
PD (compared with non-PD)	3.83	1.38 to 10.66	0.010
Age	1.04	1.00 to 1.08	0.043
Grade V duodenal injury (vs less)	1.62	0.52 to 4.99	0.403
Pancreatic injury	0.48	0.10 to 2.29	0.361

GI, gastrointestinal; PD, pancreaticoduodenectomy.

Duodenal leak (21.9% vs 23.8%) and anastomotic leak (15.6% vs 6.3%) were common complications among both PD and non-PD patients (both, p>0.05) with an overall median of 24 days (IQR 12–43) until leak resolution (table 3). The majority of patients (54.7%) received parenteral nutrition for a median of 20 days (IQR 10–40.5). There was no difference in overall complications (24 (75%) vs 36 (57.1%), p=0.116), ventilator days (7.5 (IQR 3–14.5) vs 3 (1–14), p=0.079), mortality (4 (12.5%) vs 15 (23.8%), p=0.279), or 30-day readmission (10 (31.3%) vs 17 (27%), p=0.810) between cohorts.

PD patients were found to have greater GI complications compared with non-PD patients (22 (68.8%) vs 28 (44.4%), p=0.031, table 3). Additionally, PD patients had longer ICU length of stay (16.5 days (7–28.5) vs 6 (2–23), p=0.012) and hospital length of stay (33.5 days (23.5–45) vs 24.5 (9–38), p=0.017) compared with non-PD. After controlling for age, multivariable logistic regression analysis determined PD to be associated with a 3.8-fold greater odds of GI complication when compared with non-PD management (table 4).

Patients without ampullary injuries

The patients with grade IV–V pancreaticoduodenal injuries *without ampullary injuries* (n=60) were then compared by operative management strategy (PD vs non-PD). There was no significant difference in age, gender, mechanism of injury, systolic blood pressure, or Injury Severity Score (table 5). PD was performed more often than non-PD in patients with grade V pancreatic injuries (7 (70%) vs 10 (20%), p=0.003) and pancreatic head injuries (10 (100%) vs 27 (54%), p=0.009). PD was also more commonly performed in patients with concomitant pancreatic and duodenal injuries (10 (100%) vs 34 (68%), p=0.049), however the duodenal injuries were often grade I–III in the PD group. There were 19 (38%) non-PD patients who were managed with PRA and 31 (62%) managed with CRAM. Of those complex repairs, most had duodenal injury repairs or resections along with pyloric exclusion and gastrojejunostomy or duodenectomy with enteric anastomosis. While there was no

Table 5 Injury pattern, surgical management, and outcomes among patients with traumatic grade IV–V pancreaticoduodenal injuries without ampullary injuries managed with PD versus non-PD

	All patients (n=60)	PD (n=10)	Non-PD (n=50)	P value
Age (median (25%–75% IQR))	25.5 (21–32.5)	26 (22–28)	25.5 (21–33)	0.889
Male	50 (83.3%)	9 (90%)	41 (82%)	1.000
Penetrating mechanism of injury	46 (76.6%)	9 (90%)	37 (74%)	0.427
Systolic blood pressure (mm Hg)	121 (104–140)	117.5 (108–145)	122 (101–139.5)	0.781
Injury Severity Score	26 (17–35)	28 (25–34)	26 (16.5–35)	0.723
Massive transfusion protocol	25 (41.6%)	6 (60%)	19 (38%)	0.293
Duodenal injury AAST grade I	4 (6.67%)	1 (10%)	3 (6%)	0.527
II	9 (15%)	3 (30%)	6 (12%)	0.163
III	14 (23.3%)	3 (30%)	11 (22%)	0.685
IV	22 (36.67%)	0	22 (44%)	0.009
V	11 (18.3%)	3 (30%)	8 (16%)	0.371
Pancreatic injury AAST grade I	2 (3.33%)	0	2 (4%)	1.000
II	3 (5%)	0	3 (6%)	1.000
III	2 (3.33%)	1 (10%)	1 (2%)	0.307
IV	20 (33.33%)	2 (20%)	18 (36%)	0.471
V	17 (28.33%)	7 (70%)	10 (20%)	0.003
Concomitant pancreas+duodenal injuries	44 (73.33%)	10 (100%)	34 (68%)	0.049
Pancreatic ductal injury	25 (41.6%)	6 (60%)	19 (38%)	0.293
Pancreatic head injury	37 (61.67%)	10 (100%)	27 (54%)	0.009
Operative management				
Primary repair alone (with extraluminal drainage)	19 (31.67%)	0	19 (38%)	
Complex repairs with adjunctive measures	41 (68.33%)	10 (100%)	31 (62%)	0.022
PD	10 (16.67%)	10 (100%)	0	
Duodenal repair or resection with pyloric exclusion with gastrojejunostomy	17 (28.33%)	0	17 (34%)	
Duodenectomy (with enteric anastomosis)	8 (13.33%)	0	8 (16%)	
Duodenal diverticulization	1 (1.67%)	0	1 (2%)	
Combination of complex repairs/other	5 (8.33%)	0	5 (10%)	
Damage control laparotomy	47 (78.33)	10 (100%)	37 (74%)	0.099
Total number of abdominal operations	2 (1–4.5)	3 (2–12)	2 (1–4)	0.130
Outcomes				
Anastomotic leak	5 (8.3%)	3 (30%)	2 (4%)	0.028
Any complication	33 (55%)	5 (50%)	28 (56%)	0.742
GI-related complication (abscess, GI bleed, ulcer, ileus, abdominal compartment syndrome, EC fistula, anastomotic leak)	26 (43.3%)	4 (40%)	22 (44%)	1.000
ICU length of stay (days)	6 (2.5–23)	15.5 (5–30)	5 (2–23)	0.149
Hospital length of stay (days)	24.5 (11–37.5)	30.5 (16–45)	23.5 (10–33)	0.257
Ventilator days	3 (1–14.5)	8 (3–19)	3 (1–14)	0.219
Mortality	8 (13.3%)	0	8 (16%)	0.330
30-day readmission	18 (30%)	4 (40%)	14 (28%)	0.468

AAST, American Association for the Surgery of Trauma; EC, enterocutaneous; GI, gastrointestinal; ICU, intensive care unit; PD, pancreaticoduodenectomy.

statistically significant difference in GI-related complications, overall complications, ICU length of stay, hospital length of stay, mortality, or readmission, there were more anastomotic leaks in the PD group compared with the non-PD group (3 (30%) vs 2 (4%), p=0.028).

Patients with ampullary injuries

The patients with grade IV–V pancreaticoduodenal injuries *with ampullary injuries* (n=35) were then compared by operative management strategy (PD vs non-PD, table 6). All non-PD patients with ampullary injuries underwent damage control laparotomy compared with 63.6% of PD patients (p=0.015). While not statistically significant, PD patients had more GI-related complications compared with non-PD patients (18 (81.8%) vs 6 (46.2%), p=0.057) but had lower mortality (4 (18.2%) vs 7 (53.9%), p=0.057).

DISCUSSION

Decision making surrounding the surgical management of grade IV–V pancreaticoduodenal injuries with PD versus non-PD is challenging for trauma surgeons as high-quality evidence is sparse given the infrequent injury pattern. In this study, grade IV pancreaticoduodenal injuries were more commonly managed with non-PD, whereas grade V injuries were more often managed with PD. While PD patients had more anatomically complex injuries, there was no difference in Injury Severity Score, blood product requirement, or usage of damage control surgery. The use of PD was associated with more GI complications and greater

Table 6 Injury pattern, surgical management, and outcomes among patients with traumatic grade IV–V pancreaticoduodenal injuries with ampullary injuries managed with PD versus non-PD

	All patients (n=35)	PD (n=22)	Non-PD (n=13)	P value
Operative management				
Primary repair alone (with extraluminal drainage) (n, %)	3 (8.6%)	0	3 (23.1%)	
Complex repairs with adjunctive measures	32 (91.4%)	22 (100%)	10 (76.9%)	0.044
PD	22 (62.9%)	22 (100%)	0	
Duodenal repair or resection with pyloric exclusion with gastrojejunostomy	3 (8.6%)	0	3 (23.1%)	
Duodenectomy (with enteric anastomosis)	2 (5.7%)	0	2 (15.4%)	
Combination of complex repairs/other	5 (14.3%)	0	5 (38.5%)	
Damage control laparotomy	27 (77.1%)	14 (63.6%)	13 (100%)	0.015
Total number of abdominal operations (median (25%–75% IQR))	3 (1–7)	2 (2-6)	5 (1–7.5)	0.555
Outcomes				
Anastomotic leak	4 (11.4%)	2 (9.1%)	2 (15.4%)	0.618
Any complication	27 (77.1%)	19 (86.4%)	8 (61.5%)	0.116
GI-related complication (abscess, GI bleed, ulcer, ileus, abdominal compartment syndrome, EC fistula, anastomotic leak)	24 (68.6%)	18 (81.8%)	6 (46.2%)	0.057
ICU length of stay (days)	13 (7–27)	16.5 (7–27)	8.5 (1.5–28.5)	0.248
Hospital length of stay (days)	31.5 (23–44)	33.5 (25–45)	26 (1.5–43)	0.200
Ventilator days	6 (2–13)	7.5 (3–13)	4.5 (1.5–17)	0.588
Mortality	11 (31.4%)	4 (18.2%)	7 (53.9%)	0.057
30-day readmission	9 (25.7%)	6 (27.3%)	3 (23.1%)	1.000

EC, enterocutaneous; GI, gastrointestinal; ICU, intensive care unit; PD, pancreaticoduodenectomy.

length of stay and did not offer improved outcomes compared with non-PD.

The use of PD has been historically reserved for patients with concomitant grade V injuries to the ampulla, distal common bile duct, and pancreatic duct[9] and may be best served by experienced practitioners in high-volume trauma centers.[10 11] When PD is unavoidably indicated, pursuing a staged approach following damage control surgery principles of initial resection and resuscitation followed by reconstruction in a later operation may be favorable.[12–14]

A standard of care for pancreatic injuries includes management with wide drainage, which minimizes intra-abdominal contamination and possibly mortality.[15 16] Some literature focusing on pancreatic trauma has suggested that management with drainage, when compared with pancreatic resection for high-grade injuries (III–V), results in more pancreatic-related complications. Conclusions from these papers have therefore favored resection.[17–19] Whereas a multicenter trial by Biffl *et al* specifically examined high-grade pancreatic injuries and did not find a difference in pancreatic-related complications when comparing resection versus drainage.[20] Similarly, the Western Trauma Association algorithm for pancreatic injury could not make a firm conclusion regarding resection versus non-resectional management, as the data were not definitive.[21]

Prior literature examining concomitant pancreaticoduodenal trauma has also questioned the role of PD. van der Wilden *et al* used the National Trauma Data Bank and reported on patients who underwent PD versus non-PD for grade IV–V pancreaticoduodenal injuries. Unlike our study, they found that non-PD patients were ‘sicker’, with lower systolic blood pressure, lower Glasgow Coma Scale, and more severe pancreaticoduodenal injuries. Despite this, parallel to our study, PD still did not offer improved outcomes, and the only predictor of mortality was Injury Severity Score.[7] Grigorian *et al* performed a 2:1 propensity-matched analysis using the Trauma Quality Improvement Program database, comparing trauma patients who underwent PD versus those who underwent exploratory laparotomy without PD. Similar to our study, they found that PD patients had more major complications and a longer length of stay.[2] Post-PD complications and prolonged hospital stays have also been shown to nearly double the cost of hospitalization.[22–24]

Our findings, along with this prior literature, suggest there is a role for PD in trauma. In patients with ampullary and concomitant grade V duodenal and pancreatic injuries, we believe PD to be the surgical reconstruction modality of choice. In patients without ampullary injuries with massive pancreatic head disruption, there may still be utility in PD; however, a higher anastomotic leak rate should be expected as compared with non-PD. The use of PD when there are no ampullary injuries may be overused, especially in less severe injury patterns (less than grade V), putting patients at risk for increased complications and length of stay.[2 7]

Our study is not without limitations. As a post hoc analysis of a multicenter study, surgical management was determined by operating surgeon’s discretion, which could have created selection bias. The decision to perform PD versus non-PD was likely based on multiple variables that cannot all be fully appreciated in a retrospective chart review. Differences in practice patterns between centers could also contribute to measured differences in complication development. Specifics regarding surgeon experience, subspecialty training, and the number of pancreaticoduodenectomies previously performed were unknown. Furthermore, while the Injury Severity Score was similar between cohorts, this may not be the best marker of abdominal injury severity when compared with tools like the Penetrating Abdominal Trauma Index, which were not able to be calculated as this was a post hoc analysis. While injuries were defined based on AAST grading criteria for study purposes, interpretations of injury grades could have varied across surgeons and centers intraoperatively, specifically interpretation regarding ‘massive disruption of the pancreatic head’ may have varied.

CONCLUSION

While PD patients did not have worse hemodynamics or blood product requirements on admission, they sustained more complex anatomic injuries and were found to have more GI-related complications and longer length of stay than non-PD patients. Contrary to our hypothesis, PD was not associated with improved outcomes compared with non-PD and in patients without ampullary injuries, PD resulted in more anastomotic leaks. Based on these findings, we suggest that the role for PD should be limited to massive destruction of the pancreatic head and ampullary complex, given the likely procedural-related morbidity and adverse outcomes when compared with non-PD management.

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