Revisiting the Pancreaticoduodenectomy for Trauma: a Single Institution's Experience

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STRUCTURED ABSTRACT

Background—Major pancreaticoduodenal injury can be devastating even if identified and controlled early. To date, both morbidity and mortality have resisted the improvements achieved with many other life-threatening injuries, with reported mortalities of 31–50%. We sought to elucidate the impact of the initial operation in the management of severe pancreaticoduodenal injury.

Methods—A retrospective review of all patients presenting to a single level-one trauma center who required pancreaticoduodenectomy for trauma from 1996–2010. We collected demographic and in-hospital data and compared subjects based on their initial operation.

Results—Fifteen patients (median age 29 yrs, 93% male, median ISS=35) underwent pancreaticoduodenectomy following blunt (n =5) or penetrating trauma (n=10). Twelve (80%) underwent damage control surgery (DCS) +/− the initial stage of Whipple resection as their first operation. Three (20%) underwent a complete Whipple procedure, including reconstruction, as their first operation. Overall, 87% of patients (13 of 15) were acidotic, hypothermic and coagulopathic during their first operation. Average operative time was longer for the completion pancreaticoduodenectomy vs. DCS (460±98 mins vs. 243±112 mins). There were no overall differences in complication rates, although the two patients that did not suffer a complication had DCS. In-hospital mortality was 13% (n=2).

Conclusions—We present both the largest series of patients to date who underwent a DCS or staged-Whipple procedure for complex pancreaticoduodenal trauma and the largest series due to

blunt trauma. Using a staged approach, we report the lowest mortality rate for such injuries in the literature; less than half of that reported in the most recent series (33%). Given the frequent occurrence and recognized detrimental impact of acidosis, hypothermia and coagulopathy in patients with severe pancreaticoduodenal trauma, and proven benefits of DCS, we propose that these patients should undergo initial damage control surgery and staged reconstruction.

Keywords

pancreaticoduodenectomy; trauma

BACKGROUND

In 1935, Dr. Allen O. Whipple described the currently accepted surgical treatment for pancreatic-head carcinoma in the first series of three patients.(1) In his initial description, Dr. Whipple advocated for a two-staged procedure due to the universal presence of a bleeding diathesis in these patients. He stated that first draining the bile ducts to allow resolution of jaundice would decrease the risk of hemorrhage as well as mortality. In a follow up article, published in 1945, following the discovery and commercial availability of vitamin K; Dr. Whipple described the one-staged pancreaticoduodenectomy that carries his name today.(2) Since that time, a single-staged Whipple procedure has also been adopted to treat massive disruption of the pancreaticoduodenal complex following trauma, despite the known frequent occurrence of a significant coagulopathy in these patients.

Major injury to the mid-epigastrium involving the pancreaticoduodenal complex can be devastating if not identified and controlled early. While rare, pancreaticoduodenectomy secondary to abdominal trauma is an operative challenge and the subsequent hospital course is often long and resource-consuming.(3) Whereas penetrating trauma to the mid-abdomen requires immediate operative exploration; blunt injuries to the pancreaticoduodenal complex are more difficult to identify. Further complicating care is that these patients typically present with significant additional injuries. Operative intervention is frequently complicated by active intra- or retroperitoneal hemorrhage and concomitant hollow viscous injuries may lead to gross contamination of the abdominal cavity. Prior studies have documented that major damage to the pancreaticoduodenal complex carries significant hospital care burdens as complications abound with these injuries.(4, 5) To date, both morbidity and mortality have resisted the improvements achieved with many other life-threatening injuries, with the largest series reporting mortalities of 31–50%.(6–10)

The purpose of this study was to review our experience with trauma-related Whipple procedures at a level one trauma center serving as the primary trauma referral center in a mature trauma system for a four state region. Specifically, we sought elucidate the impact of the initial operation in the management of complex pancreaticoduodenal injuries. In addition, we compared our findings with published outcomes to delineate potential areas for improvement.

METHODS

This retrospective sequential cohort study was approved by our Institutional Review Board. The medical records of all patients with injury to the pancreaticoduodenal complex from 1996 to 2010 were reviewed.

Specific data collected included patient characteristics (age, gender, date, mechanism of injury), initial vital signs, diagnostic studies, additional injuries, intraoperative blood and fluid replacement, operative procedures and duration, and results of laboratory studies. Transfusion requirements, ICU and hospital length of stay, in-hospital complications, overall

mortality, length of follow-up and total inpatient charges were also recorded. We categorized the patients into two groups by their first operative procedure; either 1) damage control surgery (DCS) with or without an initial stage-Whipple resection defined as control of hemorrhage, gross enteric spillage from visceral injury, and leakage from pancreatic and biliary disruptions, duodenum and/or pancreas resection if required, or 2) Whipple procedure defined as pancreaticoduodenectomy and complete reconstruction.

Data were analyzed using Stata 12 statistical software (StataCorp LP, College Station, TX). Categorical data are presented as counts and percentages. Continuous data are presented as mean ± standard deviation. Ordinal data are presented as median and range.

RESULTS

During the study period, 56,271 patients were admitted with blunt or penetrating trauma and 276 patients (0.49%) were admitted with trauma to the pancreaticoduodenal complex. Of this group, 15 patients underwent pancreaticoduodenectomy yielding an incidence rate of 5.4% of all pancreaticoduodenal complex injuries. The overall cohort was young (median age 29 years, range 17–53) and predominately male (93%, n=14). The subjects were severely injured with a median injury severity score (ISS) of 35 (range 25–66). Six patients (40%) were transferred from other hospitals: three were transferred from in-state institutions while one each was transferred from the other three referral states. Penetrating trauma was the predominant mechanism of injury occurring in 10 patients (67%). Motor vehicle crashes accounted for the remaining 5 patients (33%), two of who were unrestrained.

Two patients (13%) arrived hemodynamically unstable with a systolic blood pressure of less than or equal to 90 and 10 patients (67%) were tachycardic (heart rate greater than 100 bpm) on arrival. Eight patients arrived coagulopathic with an international normalized ratio (INR) of greater than or equal to 1.5. The total number of trauma code activations was 12 (80%).

Thirteen patients had plain film imaging in our ED; 7 had trauma series imaging (lateral cervical spine, chest, and pelvic x-rays), 5 (all penetrating trauma) patients had chest and abdomen x-rays, and one patient, who had undergone an operation at an outside facility for a GSW, had a chest x-ray to confirm endotracheal tube placement. Of the two patients that were not imaged in the ED, one suffered epigastric stab wounds and went directly to the OR and the other required a resuscitative thoracotomy for loss of vital signs in the resuscitation bay. Two patients had computed tomography (CT) scan of their abdomen and pelvis in our ED while another patient arrived with a CT from an outside institution; all patients who underwent these studies were hemodynamically normal and stable. The two at our facility had MVCs, whereas the patient that was imaged at the outside institution had a GSW. Two received a diagnostic peritoneal lavage (DPL), both of which were grossly positive and one patient underwent a focused assessment using sonography for trauma (FAST) exam which was non-diagnostic. Indications for operation included hemorrhagic shock, hemoperitoneum, pneumoperitoneum, and penetrating trauma to the abdomen.

Vascular injuries occurred in 10 patients (67%). The majority of these were venous, occurring in 9 patients (60%). The most commonly injured venous structure was the inferior vena cava (5 patients; 33%). The gastroduodenal artery was the predominant arterial structure that was injured (2; 13%). The most commonly associated organ injuries were liver (11; 73%), stomach (7; 47%), and colon (5; 33%). Overall, there were a total of 53 associated injuries yielding an average of 3.5 associated injuries per patient.

Twelve (80%) patients underwent damage control surgery (DCS) with or without the resection for a staged-Whipple as their first operation, including five of the transferred patients who had their first operation at the outside institution. In all of these cases, a

temporary abdominal closure was utilized and the patient was brought back to the operating room (OR) after resuscitation and stabilization of their hemodynamics. Three patients (20%) underwent a pancreaticoduodenectomy with reconstruction at their first operation; one patient was a restrained driver in a motor vehicle crash, one suffered three stab wounds to the epigastrium, and one had a single gunshot wound to the epigastrium. All three of the patients who had a complete Whipple were from the first 4 years of the study period and since 1999 our institution has only performed damage control or staged-Whipple operations for these injuries. Of note, during the study period, no patient died in the OR while undergoing an attempt at a primary pancreaticoduodenectomy. There were no statistically significant differences between the presenting characteristics of the two groups.

Average operative time for the initial operation for the DCS group was 243±112 minutes compared to 460±98 minutes for the complete Whipple group. The average volume of intraoperative crystalloid administered for DCS was less compared to that for the Whipple (9662±4653ml vs. 24500±14807ml); which is potentially due, in part, to the greater amount of time spent in the operating room by this group. All patients were hypotensive during their initial operation. The majority of patients (13 of 15, 87%) were acidotic, coagulopathic and hypothermic during their first operation; one patient who underwent DCS was not and one patient who underwent a complete Whipple was not. Operative details are summarized in Table 1.

Of the 12 patients who did not have a complete Whipple as their initial operation, the pancreaticoduodenectomy was performed in two stages in 8 patients (67%) and three stages in 4 patients (33%). All patients undergoing DCS or a multi-stage pancreaticoduodenectomy received initial external drainage. The average overall hospital length of stay (LOS) was 21.4±24 days and average intensive care unit (ICU) LOS was 21.4±27 days.

The overall complication rate was 87% with complications occurring in 13 of the 15 patients. Both of the patients who did not have a complication underwent a DCS as their first operative procedure. A total of 56 complications were encountered yielding an average of 3.73 complications per patient. Only the incidence of sepsis (100% in Whipple group, 17% in DCS group; p=0.01) and enterocutaneous/enteroatmospheric fistula (67% in Whipple group, 8% in DCS group, p=0.04) was different between the two groups.

Overall in-hospital mortality was 13% (2 patients); both patients expired while in the ICU. Both of these patients had DCS as their first operation (16.7% mortality for the group). One patient died on hospital day one due to massive hemorrhage and multiple organ failure, this patient had complete destruction of the portal triad secondary to gunshot wound and had undergone a resuscitative thoracotomy in the ED followed by a pancreaticoduodenectomy without reconstruction. The second patient died on hospital day six due to sepsis and multiple organ failure following a motor vehicle crash, this patient had an initial DCS to control hemorrhage followed by a two-staged Whipple. Of the 13 surviving patients, 7 (54%) were discharged to home while 3 each (23%) went to inpatient rehabilitation services and skilled nursing facilities (SNFs). Average length of follow-up with our post-operative clinic was 281±350 days. The majority of patients returned to clinic without nutritional, bowel, or pain complaints. Two patients returned months later troubled by ventral hernias and were subsequently repaired. One patient returned to our institution as an inpatient over a year after discharge and subsequently died. He presented with failure to thrive and sepsis secondary to short bowel syndrome as a result of extensive bowel resection for ischemia during his initial post-injury hospitalization.

This study contains the largest reported cohort of blunt injury patients undergoing a pancreaticoduodenectomy to date (n=5). Median ISS was 43 (range 25–66) and all had an

OIS grade IV or V for the pancreas, duodenum, or both. One patient died on hospital day six (80% survival) and the average number of complications per patient was 2.8. The patients who suffered blunt trauma had a trend of shorter average ICU length of stays (9.6±5 days vs. 27.3±31.7 days) and total hospital length of stays (29.6±18.4days vs. 56.2±59days) compared to those with penetrating trauma.

DISCUSSION

Traumatic destruction of the pancreaticoduodenal complex is a rare but life-threatening condition. Despite aggressive surgical intervention, even at high volume trauma centers, patients still suffer a high rate of complications, long ICU stays, and high overall mortality. (3, 4) Previous studies quote a 31–50% mortality rate with severe pancreaticoduodenal injury.(6–10) Asensio et al. reported 33% mortality in the largest series to date of 18 patients requiring pancreaticoduodenectomy, the majority following penetrating trauma (94%).(9) Our series demonstrates the lowest mortality rate to date of 13% for the initial hospitalization.

The lower mortality rate observed at our institution is unlikely due to the degree of physiologic derangement as our data revealed a higher median ISS compared to Asensio and colleagues' study (35 versus 27). Nevertheless, average revised trauma scores between the two were similar (6.38 versus 6.84). Our study group did yield a lower overall grade of pancreatic injury as compared to the LA county experience (all grade V); however, grading is somewhat subjective and the concomitant pancreatic and duodenal injuries observed in our patients appear to represent a similar degree of overall injury to the pancreaticoduodenal complex.

In the present study, the lower mortality can likely be attributed to a higher rate of damage control surgery and a staged approach rather than first-operation completion Whipple procedure. Compared to the LA County study, our institution employed a higher rate of damage control surgery or staged-pancreaticoduodenectomy (80%) as the first operation rather than a predominance of a one-staged pancreaticoduodenectomy with reconstruction (28%).(9)

The initial operative staging in a more rural or less equipped hospital in our dispersed referral region also accounts for the higher percentage of staged-Whipple procedures (all of the five transfers operated on outside our institution had a damage control procedure at the outside hospital). When compared to other series in the literature, our institution is unique in that patients may undergo their initial, stabilizing operation at an outside hospital and then be subsequently transferred for definitive care. Our referral pattern potentially selects for survival, however, given the limited capabilities of the other hospitals in our trauma region it is unlikely that any patient during this time period died during a failed attempt at primary pancreaticoduodenectomy with reconstruction. Of note, using the staged approach, survival was 100% even though definite management was delayed.

Regarding our high number of blunt injury patients, at the current time the authors are unaware any single center study with more patients requiring pancreaticoduodenectomy from blunt injury. In a similar population from Scotland, the authors found that patients with blunt injury to the pancreas had a higher ISS compared to those with penetrating trauma and that mortality was higher in those patients suffering blunt injury to the pancreas.(11) In the current study, patients injured by a blunt mechanism yielded a higher median ISS (45) than those injured by a penetrating mechanism (43) although the ranges were similar. In contrast to the study from Scotland, our patients with blunt trauma did better than those who suffered penetrating trauma. Most notably, the blunt trauma patients had shorter mean ICU LOS and

total hospital LOS; which clinically relevant as ICU LOS for the blunt trauma patients was nearly a third of that for the penetrating trauma patients and total LOS was approximately half. Given the small numbers in each group and the fact that more blunt-injured patients underwent DCS or staged-Whipple (n= 4, 80%), further conclusions regarding any differences between the two groups cannot be made.

The present study does have limitations. First, the sample is very heterogeneous with a penetrating and blunt injury patients and patients who underwent their initial operation at an outside institution. In addition, while we present one of the largest series of patients requiring Whipple procedure for traumatic injuries; as expected, the rarity of such patients resulted in relatively small numbers making statistical comparisons difficult given the high potential for type I and type II errors. For this reason, we have chosen to present the raw data rather than the details and results of statistical analyses. Also, there were multiple attending surgeons involved in the initial care of these patients, only three surgeons operated on more than one patient and each of them operated on only two patients total. Lastly, this study spans a 15 year time period during which operative and critical care management has changed significantly; including our use of damage control surgery with or without staged-Whipple resection for devastating pancreaticoduodenal injuries since 1999. However, these latter facts also make extrapolation regarding outcomes more feasible.

In summary, severe pancreaticoduodenal trauma remains a rare occurrence that yields a difficult scenario for clinicians in the initial evaluation, operative management and postoperative course. The benefits of damage control surgery are appreciable in the literature,(12–15) similarly, a multi-stage pancreaticoduodenectomy for trauma has been shown to yield more favorable operative conditions for reconstruction.(16–18) Despite this, current literature indicates that single-stage pancreaticoduodenectomy remains the predominate management for patients with devastating pancreaticoduodenal injury.(9) While statistical comparisons of outcomes by first operative procedure are difficult due to our limited population, it should be noted that 2 of the 3 patients (67%) who underwent a completion Whipple at first operation were acidotic, hypothermic and coagulopathic, which supports using a staged approach. We advocate staging the operation, first applying damage control principles to prevent major hemorrhage and loss of life and returning to the operating room after the patient is adequately resuscitated and coagulopathy is corrected. In addition to the resolution of the bloody "triad of death,"(19, 20) we believe this produces a firmer pancreas, reduced bowel edema, and a dilated bile duct which can facilitate easier reconstruction. By applying the principles of damage control surgery with delayed reconstruction, we report the lowest mortality in this challenging group of patients in the literature to date.

Acknowledgments

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Table 1

Operative data by first operative procedure

	Entire Cohort (n=15)	DCS or Staged-Whipple (n=12)	Whipple (n=3)
Number of operations per patient	7±8.5	7±9	7±5.5
Operative time (minutes)	293±142	243±112	460±98
Estimated blood loss (ml)	6554±7876	6932±8408	5167±6788
Crystalloid administered (mL)	12842±9503	9662±4653	24500±14807
Packed red blood cells (units)	10±9	10±9	8±8.5
Fresh frozen plasma (units)	6±9	6±9	8±12
Cryoprecipitate (units)	3±6	3±6	4±5.5
Platelets (6 pack)	3±8	1±1	11±18

Data presented as count (%) or mean ± standard deviation. DCS=damage control surgery.