

Staged Pancreaticoduodenectomy for Penetrating Pancreatic and Duodenal Injuries

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Background	Major penetrating trauma involving the pancreas and duodenum is classically considered to have high morbidity and mortality rates. The proximity of the pancreas to many other structures, particularly major vasculature, accounts for some of the hemodynamic instability and severity of illness in these patients. If these injuries could be managed with a fast, well-tolerated, technically simple, and universally taught operation, they would carry much lower risk. However, the technical complexity of the operations, the patients being critically ill and unable to tolerate them, and possibility of not having an in-house hepatobiliary surgeon indicate the need for consideration of damage-control strategy (DCS). It allows for time, resuscitation, stabilization, and expertise for ultimate pancreaticoduodenectomy and reconstruction. Our aim is to provide specific parameters as guidance for when to operate with a damage-control approach in patients with major penetrating trauma to the pancreas and or duodenum.
Summary	The American Association for the Surgery of Trauma (AAST) clearly defines categories of both pancreatic and duodenal injury. Low-grade AAST injuries can often be managed conservatively or with some combination of resection, primary repair, biliary diversion, and drain placement. Massive disruption of the pancreatic head (characterized as grade five pancreatic injury) is the indication for a trauma pancreaticoduodenectomy. The complexity is not limited to the operation itself but includes associated systemic concerns such as acidosis, coagulopathy, hypothermia, blood loss, gross contamination of the field, and the presence of other injuries. This does not take into account injuries identified and characterized for the first time in the operating room (OR) during exploratory laparotomy. Hence, the subjectivity that underlies the AAST's seemingly clear system of diagnosis and treatment is where complex decision-making is required but also must be shared in the literature to develop the best patient outcomes. Staged intervention in the form of an index DCS with later repair and reconstruction is well-established in the literature, but few criteria exist to guide these decisions. Our case series demonstrates two victims of catastrophic penetrating abdominal trauma with high-grade pancreaticoduodenal injuries that benefited from the staged approach of initial DCS and delayed reconstruction.
Conclusion	With the various strategies for managing complex pancreaticoduodenal injuries, our paper highlights some objective guidelines for staged pancreaticoduodenectomy. Additional research will benefit these rare but critically ill patients.
Key Words	hepatobiliary trauma; pancreatic trauma; staged Whipple procedure; pancreaticoduodenectomy

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Case Description

Traumatic pancreatic injuries, though rare (0.2% blunt, 1% to 12% penetrating trauma),^{1,2} carry significant morbidity and mortality. The reported mortality rate for pancreatic trauma varies widely in the literature (15.7% to 54.4%), largely due to the influence of hemodynamic instability and associated vascular injuries.³⁻⁵ Trauma pancreaticoduodenectomy (TPD) is rarely indicated, but these patients are often critically ill and benefit from damage control surgery (DCS) to reduce mortality rates.³ This report details the role of DCS and staged repair in a complex pancreatic injury, focusing on objective parameters to guide similar treatment decisions at other institutions.

Case Presentation 1

A nineteen-year-old man was brought to the emergency department (ED) with a gunshot wound (GSW) to the abdomen. He was tachycardic, hypotensive, and had a low Glasgow Coma Scale score. He was intubated and taken to the OR for exploratory laparotomy. When he was moved to the OR table, he lost pulses, and a resuscitative left thoracotomy was performed with aortic cross clamp and return of spontaneous circulation. Exploratory laparotomy revealed injuries to the retro-hepatic inferior vena cava (IVC), portal vein, second portion of the duodenum of 80% circumference, laceration through the head of the pancreas, an expanding zone 1 hematoma, and multiple jejunal enterotomies. The IVC and portal vein injuries were oversewn with 5-0 Prolene and jejunal injuries were excluded by stapling off the affected portion of bowel. Hemostasis was achieved, but the patient was persistently hypotensive refractory to blood product and vasopressors. This, in addition to desaturation, was an indication for placement of a right chest tube with return of blood, but insufficient to necessitate right sided thoracotomy. Based on the finding of coagulopathy, hypothermia, moderate acidosis, and persistent hemodynamic instability despite resuscitation, the operative team chose to leave him in discontinuity with temporary closure. The abdomen was temporarily closed, followed by permanent left chest closure with chest tube insertion; the patient was then transferred back to the ICU for continued monitoring. Despite adequate resuscitation, the patient remained tachycardic, hypotensive, and febrile.

On hospital day 3, the patient returned to the OR for exploration and reconstruction with pancreaticojejunostomy, hepaticojejunostomy, and gastrojejunostomy. Two days later, we performed abdominal exploration, wash out, placement of multiple drains near his anastomoses, closure of the fascia, and placement of a wound vac in the subcutaneous tissue. He developed a pancreatic fistula that resolved with nonoperative management. The patient recovered well without any further complications; his drains were removed, and his diet was advanced appropriately.

Case Presentation 2

A thirty-five year-old man similarly presented to the ED after a GSW to the abdomen; the patient was hypotensive, tachycardic, and in distress. He was taken to the OR, where two gastric injuries were primarily repaired, and the discovery of multiple severe duodenal injuries indicated complete pyloric exclusion with stapler and gastrojejunostomy. An injury to the second portion of the duodenum warranted cholangiogram through the dome of the gallbladder for evaluation of the biliary tree. It demonstrated extravasation of dye from the distal common bile duct, diffusely from the pancreas, and into the retroperitoneum with no evidence of contrast reaching the duodenum. It was clear that additional intervention would be needed, but the decision was made to leave the OR as he was hypothermic, had lost at least two liters of blood, and was hemodynamically unstable. Two large drains were placed, and the abdomen was temporarily closed. After significant product transfusion, serial ABGs with improving acidosis, rewarming, and hemodynamic stability without pressor requirement, he returned to the OR. As the cholangiogram warned, the head of the pancreas was shattered with gross spillage of bile into the retroperitoneum and complete disruption of the distal common bile duct. This was a clear indication for pancreaticoduodenectomy and takedown of the previous gastrojejunostomy. The patient remained hemodynamically stable throughout the operation, ventilated easily, did not have significant blood loss, had reassuring ABGs, and had no evidence of intraoperative concerns or complications the operative surgeon considered prohibitive to successful reconstruction. At the end of the case, feeding tube was placed and abdomen closed. The patient recovered well postoperatively.

Discussion

Management of AAST grade V pancreatic injuries, representing less than 0.2% of all traumatic injuries,⁶ pose a significant challenge for the trauma surgeon. DCS has demonstrated improved outcomes in these critically ill patients compared to more aggressive upfront approaches like a trauma Whipple.⁷

The trauma Whipple carries inherent drawbacks, including higher severity of complications, increased blood loss, and the inability to optimize the patient preoperatively. Studies report a morbidity rate of 66% for the trauma Whipple⁴ compared to 40% for the elective Whipple performed on optimized patients with no additional injuries.⁸ Furthermore, trauma patients with associated vascular injuries experience a 3.3-fold increased risk of mortality compared to those without vascular injury.³ While the optimal timing for DCS in pancreatic trauma varies across studies, there is consensus on the potential benefits of a staged approach for patients presenting with severe acidosis, hypothermia, and coagulopathy.

The management of each highlighted patient relied on objective criteria to determine both surgical intervention and subsequent return to the ICU. The need for immediate surgery were demonstrated by the following criteria:

- Initial presentation of an unstable patient
- Uncontrolled major arterial or venous bleeding
- Uncontrolled bile spillage
- Second-look laparotomy for persistent hemodynamic instability
- Suspicion of missed injury
- Persistent postoperative fever
- Change in character of drain or wound vac output
- Need for washout and re-exploration
- Other relevant clinical factors

Factors indicating postoperative return to the ICU for resuscitation included the following indices:

- Persistent coagulopathic bleeding requiring targeted correction based on thromboelastogram (TEG) values despite surgical hemostasis
- Profound acidosis requiring additional medical interventions
- Hypothermia
- Respiratory compromise despite bilateral chest tube placement
- Unsuitability for final reconstructive surgery
- Other critical factors, as assessed by the surgical team

Conclusion

This described series details an exceedingly rare operation and associated with high morbidity and mortality. The critically ill trauma patient may benefit from at least one damage-control operation if not more, as with our first patient. The circle of exploration, isolating a problem, and temporary closure continues until goals transition from damage control to reconstruction. The decision of when the patient is ready for final reconstruction remains very important to the success of the outcome; in our cases, this required three damage control operations in the first patient and only one in the second. Several factors contributed to the second patient being a candidate for reconstruction after fewer procedures including no cardiac arrest or resuscitative thoracotomy, no hemothorax requiring tube thoracotomy, no major vascular injury, and less severe coagulopathy and acidosis. The objective factors in decision-making were hemodynamic instability (systolic blood pressure < 90 mmHg or HR > 100), correction of coagulopathy based on thromboelastography to institution standards, normothermia, and appropriate quality and quantity of drain output per attending surgeon's standards. As such, our paper highlights some objective guidelines for when to pursue a staged approach to pancreaticoduodenectomy and reconstruction in patients with high-grade penetrating pancreaticoduodenal injuries while also demonstrating the importance of subjective input from the surgical team.

Lessons Learned

These case reports highlight the potential for survival in complex pancreaticoduodenal injuries with an early, aggressive damage control strategy followed by delayed, highly conservative reconstruction. Our two patients were unique in their survival despite complex injuries, at least partially attributed to early aggressive damage control strategies with very conservative and delayed reconstruction. In both our patients, reconstruction was not performed for several days after the patients demonstrated they would tolerate the operation. Further research should be performed to establish specific guidelines on how resuscitation differs in patients with pancreaticoduodenal injuries compared to other trauma patients.

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