

# Damage Control Pancreatoduodenectomy for Severe Pancreaticoduodenal Trauma: A Multicentric Case Series in Colombia

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## ABSTRACT

**Introduction:** Emergency pancreatoduodenectomy is a procedure that is indicated for the management of severe pancreaticoduodenal trauma after damage control surgery.

**Objectives:** To present our experience of pancreaticoduodenal trauma management with emergency pancreatoduodenectomy and damage control surgery.

**Materials and methods:** Retrospectively recorded data of patients with severe pancreaticoduodenal trauma who underwent a pancreatoduodenectomy and damage control for trauma at a high-volume trauma center.

**Results:** In a period of 6 years, four patients (three men and one woman, median age 17.5 years, range: 16–21 years) with severe pancreaticoduodenal trauma underwent a pancreatoduodenectomy and damage control procedure (gunshot  $n = 4$ ), and in a second surgical procedure underwent gastrointestinal tract reconstruction. In total, 75% incidence of surgical site infection (SSI) was reported, 25% health-care-associated pneumonia, and 50% postoperative pancreatic fistula (POPF). Intensive care unit (ICU) of 12.25 and hospital stay of 29.5 days mean and no mortality.

**Conclusion:** An emergency pancreatoduodenectomy can be a lifesaving procedure in patients with non-reconstructable duodenopancreatic injuries. Damage control surgery in pancreaticoduodenal trauma is an alternative for management although with high risk of morbidity.

**Keywords:** Abdominal trauma, Advanced trauma life support care, Duodenum, Multiple trauma, Pancreas, Trauma severity indices.

## RESUMEN

**Introducción:** La pancreatoduodenectomía de emergencia es un procedimiento que está indicado para el tratamiento del trauma duodenal pancreático severo después de la cirugía de control de daños.

**Objetivos:** Presentar nuestra experiencia en el manejo del trauma duodenal pancreático con pancreatoduodenectomía de emergencia y cirugía de control de daños.

**Materiales y métodos:** Datos registrados retrospectivamente de pacientes con traumatismo duodenal pancreático grave que se sometieron a una pancreatoduodenectomía y control de daños por traumatismo en un Centro de Trauma de alto volumen.

**Resultados:** En un período de 6 años, cuatro pacientes (3 hombres y 1 mujer, mediana de edad de 17,5 años, rango 16-21) con trauma duodenal pancreático grave se sometieron a un procedimiento de pancreatoduodenectomía y control de daños (disparo  $n = 4$ ). En un segundo procedimiento quirúrgico, los pacientes fueron sometidos a reconstrucción del tracto gastrointestinal. Se informaron 75% de incidencia de infección del sitio quirúrgico, 25% de neumonía asociada a la atención médica y 50% de fístula pancreática postoperatoria. Con una estadía promedio en la unidad de cuidados intensivos de 12.25 días, y una estadía hospitalaria promedio de 29.5 días y sin mortalidad.

**Conclusiones:** Una pancreatoduodenectomía de emergencia puede ser un procedimiento que salva vidas en pacientes con lesiones duodenopancreáticas no reconstruibles. La cirugía de control de daños en el traumatismo duodenal pancreático es una alternativa para el tratamiento, aunque con un alto riesgo de morbilidad.

**Palabras clave:** Atención de Apoyo Vital Avanzado en Trauma, Duodeno, Índices de Gravedad del Trauma, Páncreas, Trauma abdominal, Trauma múltiple.

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## INTRODUCTION

Severe trauma to the head of the pancreas and duodenum in a hemodynamically unstable patient with associated injuries is a complex situation to manage and is associated with a poor prognosis. In this entity, morbidity and mortality have resisted the improvements achieved with many other life-threatening injuries, with the largest series reporting mortalities 38–75%.<sup>1–9</sup>

Usually, these pancreaticoduodenal trauma grades IV and V require an emergency pancreatoduodenectomy, an unusual

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procedure with great technical difficulty.<sup>10–12</sup> There are many technical challenges for resecting and reconstructing complex pancreatic injuries frequently requiring special surgical skills and expertise.

This surgery is indicated in pancreatic and duodenal injuries with a degree greater than III on the scale of the American Association for the Surgery of Trauma (AAST).<sup>1,8</sup> Further complicating the care is that these patients typically present with significant additional injuries. Operative intervention is frequently complicated by active intraperitoneal or retroperitoneal hemorrhage, and concomitant hollow viscus injuries may lead to gross contamination of the abdominal cavity.<sup>13</sup>

The outcomes of pancreaticoduodenal trauma is determined by the grade of injury, extent, and magnitude of the associated hollow and solid organs injuries, presence and type of vascular injuries, degree of intra-abdominal contamination, development of coagulopathy, presence of hypothermia, amount of blood loss and shock duration, time of resuscitation, pancreatic postoperative fistula, type of surgical intervention, that could be in one or two stages.<sup>14</sup>

Early mortality is due to major adjacent organ injuries or uncontrolled vascular bleeding from large splanchnic veins and vena cava. Late mortality is generally a consequence of infection or multiple organ failure.<sup>10</sup>

Several issues regarding the role of a pancreatoduodenectomy for major pancreatic injuries are unresolved. Therefore, we want to present our experience in the approach of emergency pancreatoduodenectomy in two hospitals in Bogotá, Colombia, with a review of the literature.

## MATERIALS AND METHODS

### Study Population

This study design was a multicenter retrospective cohort analysis of four patients who underwent emergency pancreatoduodenectomy, and damage control for trauma between January 2012 and January 2018 in Bogotá, Colombia. The study protocol was approved by the ethics committee.

The protocol was implemented in accordance with ethical guidelines of the “World Medical Association Declaration of Helsinki—Ethical Principles for Medical Research Involving Human Subjects” adopted by the 18th WMA General Assembly, Helsinki, Finland, June 1964, and revised in Tokyo 2004.

### Data Collection

During the 6 years study period in these two high-volume trauma institutions, 234 patients were treated for pancreatic and duodenal injuries, of which 4 underwent a damage control surgery and pancreatoduodenectomy (PD) for complex non-reconstructable injuries, the Department of General Surgery, Universidad El Bosque and the Simón Bolívar Hospital and Cardiovascular del Niño de Cundinamarca Hospital, Bogotá, Colombia. All the patients were treated by trauma and general surgeons. Data relating to each patient were entered retrospectively, standardized, and analyzed using Microsoft Excel 2017.

Data collected included age, sex, cause of the emergency pancreatoduodenectomy, degree of duodenal trauma according to the AAST scale, injury severity score (ISS), association with vascular trauma, trauma to other organs, number of surgical times to complete the emergency pancreatoduodenectomy, type of pancreatoduodenectomy performed, realization of Roux-en-Y, type of pancreaticojejunostomy, surgical time, bleeding, number of units of blood products transfused, complications, pancreatic fistula,

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time of stay in the ICU, length of hospital stay, re-intervention, and mortality.

All patients who had a PD had grade V pancreatic injuries according to the Organ Injury Scaling of the AAST,<sup>15</sup> postoperative complications were classified according to the Clavien–Dindo grading system.<sup>16</sup>

### Definitions

Shock was defined as a systolic blood pressure less than 90 mm Hg measured pre- or intraoperatively. Pancreatic fistula was graded according to the International Study Group of Pancreatic Fistula classification scheme.<sup>17</sup> Postoperative pancreatic fistula is defined as drain output of any measurable volume of fluid on or after postoperative day 3 with an amylase content greater than three times the serum amylase activity.<sup>17</sup> Infectious complications were defined as a clinical or culture positive for nosocomial infections in accordance with the Society of Critical Care Medicine guidelines.<sup>18</sup> Postoperative complications recorded as Clavien–Dindo grade III or greater were regarded as severe.<sup>16</sup> Mortality was defined as any cause of death occurring in hospital after a pancreatic and duodenal injury. An initial pH measuring less than 7.3 was defined as acidosis; a temperature less than 35.5°C was defined as hypothermia; coagulopathy was defined as an international normalized ratio (INR) greater than 1.5. The Denver Multiple Organ Failure Scoring System was used to define organ dysfunction and multiple organ failure.<sup>19</sup>

### Operative Management of Pancreaticoduodenal Injury

Initial resuscitation was according to Advanced Trauma Life Support (2018) guidelines. All patients in this study underwent emergency laparotomy because of continuous shock with evidence of major intra-abdominal bleeding or an acute abdomen and signs of peritonitis due to gunshot injury.

Operative management of the pancreatic injury was according to a specific operative strategy based on the hemodynamic stability of the patient, the magnitude and extent of associated injuries, and the location and severity of the pancreatic injury.

In brief, the principles applied were urgent control of intra-abdominal bleeding; closure of visceral perforations to prevent

contamination of the peritoneal cavity; and rapid volume replacement to correct acidosis, coagulopathy, and hypothermia.

Patients who remained unstable or those in extremis with major associated organ and visceral vascular injuries had an initial damage control operation which comprised a truncated laparotomy followed by continued resuscitation and correction of hemodynamic, metabolic, and physiological defects in the ICU and definitive surgery in 48–72 hours for gastrointestinal reconstruction. All the patients remain intubated with mechanical ventilation in the ICU during this period.

Emergency pancreatoduodenectomy was done in all patients in the first stage plus abdominal cavity packing and open abdomen with Bogota Bag. Head and neck of pancreas were resected in all patients.

Pylorus-preserving pancreatoduodenectomy (Traverso–Longmire) was performed, except in those in whom the injury had irretrievably damaged the pylorus, in which case a classic Whipple resection was done. The pancreatic stump was anastomosed to the jejunum using a telescoped technique with simple interrupted sutures with 4-0 polydioxanone (PDS, Ethicon, Inc., Cincinnati, OH), only if the pancreatic duct was adequately identified, a lateral terminal pancreaticojejunostomy—Blumgart type—was performed (Fig. 1).

When the remnant pancreatic tissue was minimum, it was managed with a duct occlusion technique with interrupted U-shaped sutures of silk. The bile duct was anastomosed to the jejunum in the standard fashion for bile duct reconstruction with a lateral terminal hepaticojunctionostomy anastomosis, using a Hepp–Couinaud approach without tension—performing simple interrupted sutures with 4-0 PDS (Ethicon, Inc.). A 5-mm incision was made in the anterior border of the common hepatic bile duct to augment its anastomotic diameter prior debridement of devitalized tissue. The reconstruction of the gastrointestinal tract was performed with a Roux-en-Y. In high-risk biliary anastomoses, the duodenojejunostomy was created as the first anastomosis using the Imanaga technique to allow postoperative Endoscopic retrograde cholangiopancreatography (ERCP). All pancreatic anastomoses were stented internally with 8-cm-long 5-Fr silastic pediatric feeding tubes cut to size.

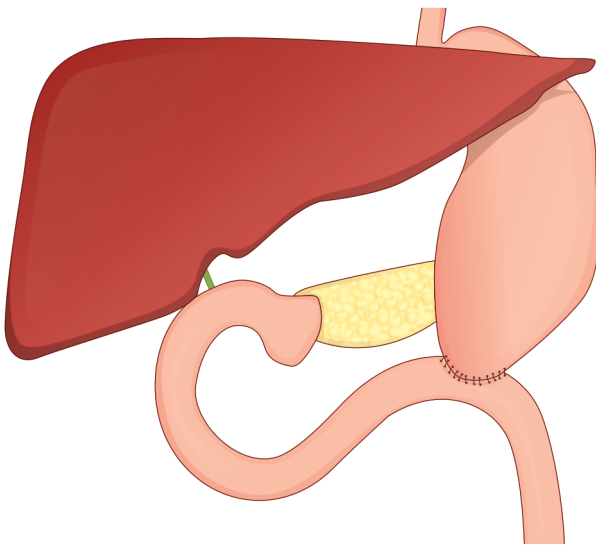


Fig. 1: Three-dimensional representation of pancreaticojejunostomy—Blumgart type by Jean Andre Pulido

All biliary and pancreatic anastomoses were drained using closed silastic suction drains. Drainage volumes and amylase levels were measured daily postoperatively. Drains were left *in situ* while drain amylase levels were elevated or volume measured over 30 mL/day. All patients had intraoperative placement of double- or triple-lumen internal jugular central lines for venous access and total parenteral nutrition. Nasojejunal low-residue enteral feeding was initiated as soon as the patient was hemodynamically stable, inotropes had been discontinued, and intestinal continuity reestablished. No dietary restrictions were imposed if a pancreatic fistula occurred, and oral food intake was continued while the fistula drained. Suspicion of infected intra-abdominal collections postoperatively was investigated by contrast-enhanced computed tomography scan and treated by ultrasound-guided 7-Fr percutaneous catheter drainage.

We used internal stents to prevent POPF, which are introduced into the main pancreatic duct, over which the pancreatoenteric anastomosis is fashioned. Conceptually, this is designed to divert pancreatic juice further downstream, away from the pancreatic anastomosis, and also to avoid inadvertent sutured closure of the pancreatic duct.

## RESULTS

During the period from January 2012 to January 2018, 234 patients [210 (90%) men, 24 (10%) women, median age 22 years (range: 13–43 years)] had confirmed pancreatic injuries. Sixty-five injuries (28%) were caused by blunt trauma, 33 (14%) were caused by motor vehicle accidents, 21 (9%) were assaults, 11 (5%) were others, 126 (54%) were gunshot wounds, and 43 (18%) were stab wounds.

Of these, four (1.7%) patients had AAST grade V injuries involving the head of the pancreas and duodenum underwent damage control surgery in the first surgical time and then pancreatoduodenectomy with gastrointestinal reconstruction after physiological resuscitation in the ICU in a second time.

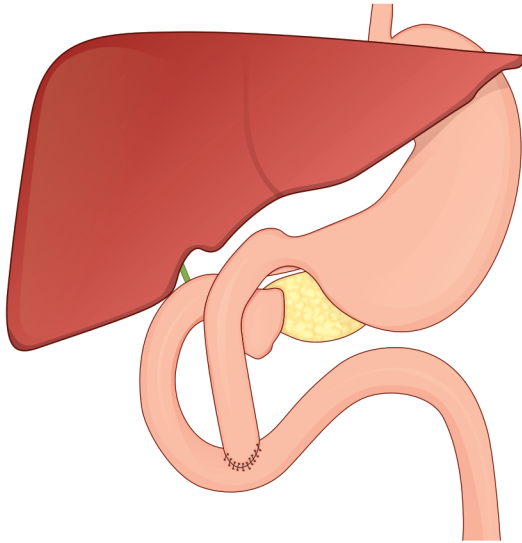
All patients had penetrating injuries due to low-velocity gunshot wounds. All patients were in cardiovascular shock on admission to hospital in spite of volume resuscitation by paramedical staff while in transit. On admission to the Trauma Unit, patients' median recorded systolic blood pressure was 88 mm Hg (range: 60–116 mm Hg) and median pulse rate was 100/minute (range: 99–102/minute).

From the four patients with grades IV and V pancreatoduodenal trauma, 25% were women and 75% men, median age 17.5 years (range: 16–21 years). The lesion in all the cases was secondary to penetrating abdominal trauma by firearm projectile, resulting in 100% of the lesions with duodenal trauma grade V on the scale of AAST, with an average ISS of 39.5 points, with associated vascular trauma in all the cases.

In total, 75% presented lesion of the portal–spleen–mesenteric system in any of its ramifications, and a 25% had a lesion of the inferior vena cava. Regarding associated organ trauma, 75% presented hepatic trauma grades III to IV and 25% grade IV splenic trauma on the AAST scale. In total, 75% of the emergency pancreatoduodenectomy performed were made without preservation of the pylorus Kausch–Whipple technique, and only 25% were performed with preservation of the pylorus, Traverso–Longmire technique, due to the traumatic compromise of the pyloric tissue. The second stage of the surgery, 48–72 hours later, was performed always by the same general surgeon, because in our institution, there was lack of hepato-bilio pancreatic surgeons

and no availability to transport the patient to other center. The reconstruction of the gastrointestinal tract in the second surgical time was performed in 50% with a Roux-en-Y and in 50% with a single intestinal loop, Imanaga technique.

The pancreaticojejunostomy was carried out in 25% with Blumgart technique (Fig. 1), in 50% telescoped technique, and in 25% duct occlusion technique (Fig. 2). It was managed with



**Fig. 2:** Three-dimensional representation of pancreaticojejunostomy—telescoped by Jean Andre Pulido

duct occlusion due to the minimal pancreatic remnant residual. With an average of surgical time in both stages of 430 minutes. Surgical average time in both stages of 430 minutes. Presurgical bleeding was of 1,300 cc and intraoperative bleeding of 1,825 cc approximately. All patients required blood products transfusion with an average of 5.5 units of red blood cell (RBC) and an average of 8.75 units of fresh frozen plasma (FFP). All the patients presented postoperative complications, 50% developed SSIs, 25% health-care-associated pneumonia, and 50% developed a POPF, of which one was type I, resolving only with medical management (antibiotic, total parenteral nutrition (TPN), and octreotide) and one type II, which required percutaneous drainage associated with medical management. Both POPFs resolve with total parenteral nutrition plus somatostatin analogs during the hospital stay of the patients. None of the patients required surgical re-intervention or endoscopic management.

No patient required surgical re-intervention. ICU stay of 12.25 days, hospital stay of 29.5 days mean. There were no mortalities. In Table 1, we present the demographic variables of the patients.

## DISCUSSION

Traumatic destruction of the pancreaticoduodenal complex is a rare but life-threatening condition, occurs in less than 1–2% of the patients with blunt abdominal trauma<sup>20</sup> vs 10–30% penetrating abdominal trauma; spleen and liver are the most frequently injured organs reported on the literature in abdominal trauma.<sup>8,21</sup>

Despite aggressive surgical intervention, even at high-volume trauma centers, patients still experience a high rate of complications, long ICU stays, and high overall mortality.<sup>13</sup> Outcomes are

**Table 1:** Demographic data population under study

Patient	No. 1	No. 2	No. 3	No. 4
Sex	Male	Male	Female	Male
Age (years)	16	16	21	18
Type of wound	Gunshot wounds	Gunshot wounds	Gunshot wounds	Gunshot wounds
ISS	36	48	31	43
Severity	V	V	V	V
Vascular trauma	Confluent spleen-portal	Portal vein and cava inferior vein	Splenic vein	Portal vein
Other structures involved	Hepatic trauma grade II	Hepatic trauma grade IV	Splenic trauma grade IV	Hepatic trauma grade III
Type of surgery	PD without pylorus preservation	PD without pylorus preservation	PD with pylorus preservation	PD without pylorus preservation
Roux-en-Y	No	Yes	Yes	No
Pancreaticojejunostomy—telescoped	Yes	No	No	Yes
Pancreaticojejunostomy—Blumgart	No	No	Yes	No
Pancreas abandoned	No	Yes	No	No
Surgical time (minute)	390	450	420	460
Presurgical bleeding (cc)	1,500	1,500	1,000	1,200
Intraoperative bleeding (cc)	2,000	1,800	2,000	1,500
Units transfused	6 RBC, 12 FFP	4 RBC, 6 FFP	5 RBC, 10 FFP	7 RBC, 7 FFP
Postoperative complications	Pancreatic fistula	Pneumonia associated with health care	SSI grade III	SSI grade II
Pancreatic fistula	Type I	No	Type II	No
Days in the ICU	7	14	23	5
Hospital stay	20	30	50	18
Mortality	No	No	No	No

determined primarily by the cause and the grade of the injuries, and number and severity of associated injuries and secondarily by complication related to the surgical and medical procedures; this also implies the need of emergency pancreatoduodenectomy in trauma, as seen in our case series.<sup>22–26</sup>

This procedure was performed according to the indications described by McKone which are (I) extensive devitalization of the head of the pancreas and of the duodenum that cannot be repaired, (II) classification AAST grade V of pancreaticoduodenal trauma, and (III) damage to the ampulla of Vater with interruption of the main pancreatic duct.<sup>10</sup>

Van der Wilden et al., present simplified criteria for deferring surgery in order to decrease the high rates of mortality in this complex type of patients using, damage control principles (arrest hemorrhage, temporary control contamination, restore physiological balance), consist in identify massive non-reconstructable injuries involving pancreas, duodenum, common bile duct, or destruction of the ampulla of Vater are evident.<sup>27</sup>

Mortality of this type of lesions ranges between 9% and 34% and increases significantly when pancreatic compromise is related to injury of adjacent organs.<sup>24,28</sup>

There is a close correlation between mortality, associated injuries, and the number of intra-abdominal organs injured when compared with survivors,<sup>20</sup> the most affected liver, colon, jejunum, duodenum, and ileum. As evidenced in our case series, liver injury is frequent and occurred in 75% and as well as spleen injury in 25% of cases without any mortality. In accordance with other series, most early deaths were due to associated non-controlled vascular injuries.<sup>20</sup> We believe that two-stage management with initial damage control and resection surgery (pancreatoduodenectomy) with subsequent physiological resuscitation in the ICU and a second surgical event to complete the gastrointestinal tract reconstruction is the ideal strategy for the management of this type of patients. Late deaths are related to sepsis, shock, or multiorgan failure,<sup>20</sup> so close postoperative observation in ICU is mandatory.

Emergency pancreatoduodenectomy in trauma is a surgical challenge for the surgeon as the patient is in a state of severe shock with multiple associated injuries, severe tissue edema, and a normal caliber pancreatic and bile duct. Nevertheless, in order to reduce early mortality, bleeding control and management of porto-spleen-mesenteric injuries is vital, as seen in our series all cases had associated vascular injury, of which 75% presented with an injury to the porto-spleen-mesenteric system and 25% inferior vena cava lesions.<sup>6–8,10</sup>

The current concept of damage control surgery has been increasingly accepted, and there is consensus that patients who remain unstable due to persistent or unmanageable bleeding hypothermia, acidosis, or coagulopathy should undergo a damage control procedure with abdominal packing and subsequent re-exploration. This allows hemorrhage control, enteric and pancreatic leakage control, as well as biliary disruption management, as it was carried out in our case series.<sup>20,22,29–31</sup> Although damage control surgery has improved survival rates, mortality remains high reported at 31%.<sup>20</sup>

When ampulla of Vater is identified, it is useful to catheterize it with a 5-Fr tube to perform a retrograde cholangiopancreatography in order to rule out leaks and establish if a pancreatic, duodenal, or pancreaticoduodenal resection is required; this procedure can be done by preserving or resecting the pylorus, before terminating the first surgical time.<sup>32,33</sup>

In the second surgical time, the definitive surgery of digestive tract reconstruction is carried out. In our study, reconstruction was accomplished in 50% of the cases with a Roux-en-Y and in 50% a single intestinal loop. The pancreaticojejunostomy was carried out in 25% of the cases with a Blumgart technique (Fig. 1), in 50% telescoped technique (Fig. 2), and in 25% duct occlusion technique due to the minimal pancreatic remnant residual as described by Asensio et al.<sup>1,3,34</sup> However, other factors that must be taken into account to make these decisions are the patient's hemodynamic status, presence of active bleeding, acid-base status, hypothermia, and presence of coagulopathy; in order to establishing whether or not the patient is a candidate to a primary repair or if it requires an initial damage control, as was done in our series of patients.<sup>10,22,34–39</sup>

When facing minor pancreaticoduodenal injuries, the therapeutic arsenal available to the surgeon includes different procedures and techniques that allow an approximation to this entity, such as primary repair, resection, primary anastomosis, jejunal patch, pyloric exclusion, and duodenal diverticulization; however, facing severe injuries such as those presented in our study, an emergency pancreatoduodenectomy should be carried out.<sup>40–45</sup>

Krige et al. also suggest that the best method of dealing with the divided pancreatic duct and resection margin after distal pancreatectomy for trauma is unresolved, for that reason that group proposes ligation of the pancreatic duct at the transection margin with a transfixing suture and closure of the distal pancreatic resection margin with interrupted absorbable suture to achieve adequate hemostasis and minimize fistula formation.<sup>20</sup>

Postoperative pancreatic fistula remains the main source of major morbidity and mortality after pancreatic resection, affecting between 13% and 41% of patients. Postoperative pancreatic fistula is associated with morbid sequelae including intra-abdominal sepsis and hemorrhage. All patients in this study present common risk factors most consistently shown to predict POPF after PD including soft gland, non-pancreatic cancer non-chronic pancreatitis pathology, small pancreatic duct diameter (<3 mm), and high intraoperative blood loss (>1000 mL).<sup>9,48</sup>

Internal stents do not seem to significantly reduce the rates of POPF, with some studies demonstrating an increase in the rate of this complication especially in high-risk pancreas.<sup>46–49</sup> Stents may also be externalized through the abdominal wall to drain extracorporeally. A Cochrane review evaluating three randomized controlled trials comparing internal vs external stents failed to show superiority of one form of stent over the other in terms of POPF reduction.<sup>9,47,48</sup> External stents have been associated with a significantly longer length of hospital stay than internal stents, likely due to complications of the outpatient management of such a prosthesis.<sup>9,13</sup>

Over the last decade, multiple type of resection and closure techniques have been described and evaluated for the pancreatic remnant during elective surgery in order to minimize complications such as pancreatic fistula;<sup>46</sup> nevertheless, none have reproducible results to reduce fistula rates in a meaningful way or statistical significance.<sup>20</sup>

Cogbill<sup>50</sup> and Fitzgibbons<sup>47</sup> report a significant difference in pancreatic leak rates in trauma patient whose pancreatic stumps were either sutured or stapled after distal pancreatectomy.

Knaebel et al.<sup>48</sup> in a systematic review and meta-analysis reported a cumulative fistula rate of 32% after elective resection and found no significant relationship between the pancreatic remnant closure technique and the pancreatic leak rate.

In our case series, all patients were taken to emergency pancreatoduodenectomy in two stages. In total, 75% of the emergency pancreatoduodenectomy performed were made without preservation of the pylorus, Kausch–Whipple technique, and only 25% were performed with preservation of the pylorus, Traverso–Longmire technique, due to the traumatic involvement of the first portion of the duodenum and the pylorus.<sup>10</sup> However, if there was any concern regarding a conventional Whipple technique or pancreatoduodenectomy with preservation of the pylorus with the Traverso–Longmire technique, it is important to consider the degree of traumatic tissue involvement to establish if the pylorus can be preserved. It is important to keep in mind that operative times, intraoperative bleeding, the need for transfusion, and mortality do not statistically differ between both approaches. There is a major difference in the incidence of delayed gastric emptying, which is more frequent in pancreatoduodenectomy with pylorus preservation, which results in a longer hospital stay due to the delayed oral intake, although in the long-term, the gastrointestinal physiology is better preserved with the Traverso–Longmire technique.<sup>35,42,44,51</sup>

The reported incidence of overall complications following distal pancreatic resection for trauma ranges from 30 to 60% and is mainly the result of severe trauma with higher AAST grades, associated injuries, diagnostic delay exceeding 24 hours, and inadequate or inappropriate initial treatment.<sup>52</sup>

The most frequent complications of these types of injuries are massive bleeding with the need for blood products transfusion as in our series due to pancreaticoduodenal and associated injuries; all patients required transfusion of blood products with an average of 5.5 units of RBC and 8.75 units of FFP. Next is POPF and intra-abdominal abscesses which occur in up to 90% of patients, as evidenced by the total of the series reported with 50% of SSI grades III and II, 25% health-care-associated pneumonia, and 50% developed POPF, of which one was type I and one type II.<sup>2,3</sup> Pancreatic leaks remain the Achilles' heel of pancreatic resection, as reported by Krige et al.<sup>20,52</sup> The reported incidence of pancreatic fistula after distal pancreatectomy for trauma varies widely ranging from 8 to 69%.<sup>20,50,52,53</sup> In the present series, endoscopic and clinical follow-up management was used in all patients and included intraoperatively placed drains and additional percutaneous drains when necessary. Sharpe et al.,<sup>54</sup> Subramanian et al.,<sup>55</sup> and Ahmed et al.<sup>56</sup> present in their experience with traumatic pancreatic fistula close spontaneously within 8 weeks of conservative management.

No randomized controlled studies have been reported comparing initial damage control surgery with definitive treatment in a single surgical intervention.<sup>36</sup> However, the evidence taken from case series suggests that in patients with pancreaticoduodenal trauma, in extremis, two-stage surgery reduces mortality, as evidenced in our series of cases.<sup>10,27</sup>

## CONCLUSION

Emergency PD is a lifesaving operation in the context of complex pancreaticoduodenal injuries that can be treated by general and trauma surgeons with acceptable results. Damage control approach is the best options for this in extremis patients, two-stage surgery plus physiologic resuscitation in the ICU.

## HIGHLIGHTS

- Pancreaticoduodenal injuries are an uncommon but important source of morbidity and mortality in the trauma patient.

- Surgical management of complex pancreatic and duodenal injuries is uncommon traumatic event that is associated with high injury severity, but survival occurs in most scenarios.
- Damage control with two-stage approach may decrease morbidity and mortality of patients with severe pancreaticoduodenal trauma.

## ETHICAL APPROVAL

Approval from the institutional review board was not required for this study.

## HUMAN AND ANIMAL RIGHTS

This article does not contain any studies with human participants or animals performed by any of the authors.

## INFORMED CONSENT

For this retrospective review, formal consent is not required.

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