Clinics in Oncology

Review Article
Published: 13 Feb, 2017

# Current Diagnosis and Management of Pancreaticoduodenal Injury: A Concise Review

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## Abstract

Owing to the proximity of the pancreas and duodenum, the pathogenesis, diagnosis, and management of pancreaticoduodenal injury, while being distinct are all still interrelated. While management of pancreatic injury is related to injury classification, which may vary greatly from non-surgical intervention, operative therapy, or pancreaticoduodenectomy (PD), identification of pancreatic duct injury is the top priority. Although Magnetic Resonance Cholangiopancreatography (MRCP) and Endoscopic Retrograde Cholangiopancreatography (ERCP) are used as diagnostic modalities for pancreatic duct evaluation, sphincterotomy or stenting by ERCP for duct injury are still controversial. Non-surgical management is recommended for patients that do not have duct injuries. Once duct injury has occurred, appropriate debridement, resection, and reconstruction should be considered. Damage Control Surgery (DCS) is an option for critically ill patients concurrently with appropriate initial treatment and delayed reconstructive procedures. Decision-making of duodenal injury also depends on injury classification, and the consensus is primary repair with adequate drainage in case of perforation. Combined pancreaticoduodenal injury is associated with high morbidity and mortality. The effective prevention for pancreaticoduodenal injury-related complications are significant including delicate operation, precise hemostasis, thorough irrigation, and appropriate surgical options.

**Keywords: Pancreaticoduodenal injury; Diagnosis; Operative management; Magnetic resonance cholangiopancreatography; Endoscopic retrograde cholangiopancreatography**

## Introduction

In two large retrospective studies of pancreaticoduodenal injury, pancreatic injury was seen in 58-69% cases; duodenal injury, in 24-26%; and combined injury, in 11–16% [1,2]. Early diagnosis and classification of pancreaticoduodenal injury is crucial for decision-making. Early treatment of pancreaticoduodenal injury requires either non-surgical or surgical approaches, aiming to improve patient outcomes and preserve the bodies' and organs' potential for recovery on the basis of the identified risks. Later treatment emphasizes multidisciplinary cooperation to seek and choose feasible approaches that could solve the existing problems in view of the patients' condition and secondary manifestations [3,4]. In this study, we present a concise review of the management of traumatic pancreaticoduodenal injury, including diagnostic approaches, options for surgical determination, Damage Control Surgery (DCS) in pancreaticoduodenal injury, and treatment of complications.

## Diagnosis

The retroperitoneal location of the pancreas and duodenum provides protection from blunt and penetrating injuries; hence, the overall incidence of injury is low. However, this characteristic can easily conceal the symptoms and signs of injury, resulting in delayed diagnosis and incorrect classification, thereby leading to higher rates of morbidity and mortality [2,5]. For any upper abdominal trauma, pancreaticoduodenal injury should be considered. Laboratory data such as serum amylase levels have low sensitivity and specificity in the acute phase. An increase in amylase levels after blunt pancreaticoduodenal injury is time-dependent, and a persistently increasing amylase level is a more reliable indicator of pancreaticoduodenal injury, but it does not indicate the severity of the injury. Diagnostic Peritoneal Lavage (DPL) can be useful in diagnosis, and amylase detected in DPL fluid is a much more sensitive and specific indicator of pancreaticoduodenal injury than serum or urine amylase estimations. Computed Tomography (CT) is the priority choice of examination for hemodynamically stable patients, as it provides a safe and comprehensive means of diagnosing traumatic pancreaticoduodenal injury [6,7].

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**Received Date**: *29 Nov 2016*
**Accepted Date:** *03 Jan 2017*
**Published Date:** *13 Feb 2017*

***Citation:***
*Dai X, Lu C, Gao W. Current Diagnosis and Management of Pancreaticoduodenal Injury: A Concise Review. Clin Oncol. 2017; 2: 1205.*

The American Association for the Surgery of Trauma (AAST) organizes pancreatic and duodenal injury patterns into five grades, which are determined by the presence or absence of ductal disruption and by the anatomic location of injury. Grades I and II injuries are treated with non-surgical management techniques or simple drainage, whereas grade III or higher injuries often require resection with possible reconstruction and/or drainage procedures. For example, pancreatic duct injury (Grade III) and duodenal perforation (Grade II) form a crucial demarcation between non-surgical and surgical management, respectively. Therefore, the identification of duct injury and duodenal perforation are top priority.

### Diagnosis of pancreatic duct injury

Signs of pancreatic injury on CT include intrapancreatic or retroperitoneal hematoma, peripancreatic fluid, parenchymal laceration, prerenal fascial thickening, and pancreatic laceration and fracture. Both sensitivity and specificity of CT for pancreatic injuries are greater than 85% [6]. Injury to the main pancreatic duct occurs in up to 15% of all pancreatic injuries, and the majority is penetrating trauma [8]. CT can detect main pancreatic duct injury with a low accuracy of approximately 43% [9]. In early stages, a depth of pancreatic laceration above 50% correlated with increased risk of duct injury. In later stages, posttraumatic pseudocyst and distant pancreatic duct dilatation are generally associated with a ductal leak until proven otherwise [10,11].

Therefore, if pancreatic injury remains highly suspicious in a hemodynamically stable patient without clear operative indications, the surgeon should further investigate the potential for pancreatic duct injury. This should be done with Magnetic Resonance Cholangiopancreatography (MRCP) or Endoscopic Retrograde Cholangiopancreatography (ERCP). The advantages of MRCP are its noninvasive nature, shorter procedure time, and ready availability; further, it allows observation of the entire duct as one continuous image. However, MRCP cannot provide dynamic information as to whether there is continuing leakage, pathologic fluid accumulation, and ductal disruptions trafficked with pseudocysts [12]. Although MRCP is used more frequently, ERCP is also increasingly being used to help in both early and delayed diagnosis of pancreatic ductal injury. However, the use of ERCP as a direct image-guided therapy is still debatable.

### Diagnosis of duodenal perforation

Sensitivity of CT for duodenal perforation is about 76% [9]. Free air in the abdomen and pneumoretroperitoneum shown in CT are indications for surgical intervention. However, oral contrast medium does not increase the diagnostic accuracy.

## Non-surgical and Surgical Management

### Operative exploration

High-energy trauma, peritonitis, peritoneal effusion, abdominal active bleeding, and hypodermal petechiae including emphysema are surgical indicators. Regardless of whether there is radiographic confirmation, timely operative exploration in such cases is imperative as it also provides a direct and accurate diagnostic method. Subsequently, pancreatic duct injury or duodenal injury may be determined during the laparotomy.

### Duodenal injury

Generally, operative indication for duodenal injuries depends on duodenal perforation (Grade II and above). Duodenal contusion or hematoma and secondary obstruction can be equally well treated by non-surgical management [13].

### Pancreatic injury

Injury to the great vessels, hemodynamic instability, and main duct injury (Grade III or above) are specific operative indicators. Grades I and II can be treated with non-surgical management; only 10% cases will fail and present with complications. Failed non-surgical management increases the incidence of complications by only 3% [1]. Whereas grade III or higher injuries often require surgical resection with possible reconstruction or drainage procedures [14].

The accuracy of CT, which often fails to identify pancreatic duct injury, is moderate at best. Damage to the ductal system, if ignored or untreated, can result in fistula, traumatic pancreatitis, pseudocyst formation, abdominal abscess, and other complications. Therefore, if a CT scan cannot exclude ductal injury, investigation by MRCP or ERCP should be considered. In addition, non-surgical management of pancreatic injury, serial examinations, laboratory evaluation of serum amylase levels, and CT are warranted. CT-guided abdominal puncture and drainage or operative drainage should be performed when abdominal signs get worse or peritoneal effusion is accompanied with infection.

### Conservative management of pancreatic injury (Grade III)

In children, non-surgical management of pancreatic injuries had a few reported [15]. While operative management of pancreatic injury (grades III-IV) remains controversial, conservative management shows a trend toward a longer duration of hospital stay and a higher rate of pseudocyst formation [16].

### ERCP management of pancreatic injury (Grade III or IV)

ERCP as a therapeutic tool for pancreatic injury (Grade III or IV) can be used for sphincterotomy, stent placement, and may help to avoid unnecessary emergency operation. Stent therapy can improve the clinical condition and resolve fistula and pseudocyst, but ductal stricture is a major complication in the long-term.

Complications caused by stent or Endoscopic Nasopancreatic Drainage (ENPD) although rare, have been reported, including occlusion, migration, pancreatitis, duodenal erosion, and infection. Stent exchanges may be required because of pancreatic ductal stricture, which is almost inevitable. The diameter of the major pancreatic duct is the most important factor in deciding ductal stricture [17].

Remarkably, despite the widespread notion that non-surgical treatment of pancreaticoduodenal injuries that require surgical intervention leads to disastrous outcomes, objective evidence is hard to find. In a number of retrospective studies, missed diagnosis did not affect mortality rates and length of hospital stay [1]. The feasibility of non-surgical management or observation for pancreaticoduodenal injury can be acceptable in the absence of hemodynamic instability, peritonitis, and uncertainty of diagnosis and classification. Although missed diagnosis can lead to fistula, pseudocyst, and other complications, subsequently, delayed operation or non-surgical management can be adopted.

## Operative Decision-Making for Pancreatic Injury

Patients with peritonitis, active hemorrhage, intestinal spillage, grade III or higher injuries, and hemodynamic instability with a positive focused abdominal CT for trauma or pancreatic duct

disruption require operative intervention [18,19]. The motives for operation include hemostasis; wide drainage; debridement of necrotic tissue; preservation of pancreatic function; and reasonable surgery on the basis of grade of injury, additional injuries, and patients' condition. Treatment strategy for the trauma is based on the grading and traumatic status.

### Delayed repair and DCS

The current concepts of DCS are based on the severity of trauma and tolerance in patients, which has been applied to the staged procedures to control hemorrhage, limit sepsis, and protect from further injury. A simple and effective laparotomy is priority for optimizing the physiological state and reducing disturbance of homeostasis to the best extent in severely traumatized patients. After the initial resuscitation is stable, the definitive repairs are completed in a second surgery [20]. The principles of DCS are as follows:

Phase I: The use of rapid and temporary measures to control bleeding and contamination and quick and temporary closure of the abdominal cavity;

Phase II: Physiological resuscitation to correct hypothermia, metabolic acidosis, and coagulopathy further;

Phase III: Planned reoperation for definitive repair of the damaged organs [21].

For patients with severe trauma, damage control techniques should subsequently be used (i.e., 48-96 h later), followed by definitive operation [22]. The concepts of DCS should be applied to treat pancreatic trauma from a perspective viewpoint that surgeons should identify the main and secondary contradictions. Hypothermia, hypoxia, and coagulopathy comprise a lethal triad. Before this triad materializes, life-saving treatment should be initiated, because if the patient dies, all efforts are in vain regardless of the perfection of the chosen procedure. Thus, the ultimate objective should be to save the patient's life and improve survival rate.

### Key points of operation

Patients who require laparotomy should undergo a systematic, prompt, and rational exploration so that all areas of the abdomen are assessed and injuries are not missed. Because of the adjacent location of the pancreas and duodenum, injuries to the abdomen are frequently associated with pancreaticoduodenal injuries. As standard technique, management of solid organ injuries including liver and spleen injuries is top priority, followed by hollow visceral injury with contaminated fields, from the gastroesophageal junction to the rectum. This process includes entering the lesser sac to evaluate the posterior duodenum and pancreas.

**No pancreatic duct injury (Grade I and Grade II):** Pancreatic contusion and superficial pancreatic lacerations without ductal disruptions (Grades I and II) are treated with operative management techniques, if non-surgical management proves ineffective [23,24]. Pancreatic injuries not involving the pancreatic duct, including hematomas, parenchymal contusions, and lacerations of the capsule or superficial parenchyma, can only be managed with external debridement and simple repair. A fine lacrimal probe passed through the papilla into the pancreatic duct for operative pancreatography may provide sufficient information, but sometimes it is difficult to find the papilla with this procedure and thereby, the risk for duodenal fistulas increase. In rare cases, some centers recommend intraoperative secretin, ultrasound (US), or ERCP, but these methods are difficult to popularize. In damage control situations, the ductal injury may be overlooked during a simple drainage of more complex injuries that can cause postoperative pancreatic fistula and pseudocyst formation, but endoscopic and interventional therapy and delayed operation can be conducted subsequently in the hemodynamically stable patient. The patients with pancreatic trauma (Grade III) with high suspicion of injury to the pancreatic duct generally require distal pancreatectomy and debridement [25].

**Pancreatic injury (Grade III):** The management of pancreatic injuries with ductal involvement depends on the location of the injury. Injuries to the left of the superior mesenteric vessels are managed with a distal pancreatectomy with or without splenic preservation. For life-threatening injuries, a closed suction drain should be placed in the remaining proximal duct, then given delayed pancreaticoenterostomy.

**Pancreatic injury (Grade IV):** Middle pancreatectomy and debridement are recommended for injuries to the right of the superior mesenteric vessels (grade IV).

**Pancreatic injury (Grade V):** Extensive damage to the pancreatic head involving the duodenum and ampulla, combined pancreaticoduodenal injuries, and uncontrollable bleeding of pancreatic head may require a PD [26]. When the patient is hemodynamically abnormal and unsuited for surgery, damage control techniques should be used. Primary management of pancreatic injury includes control of both hemorrhage and contamination, abdominal packing, external drainage, and temporary abdominal closure with plans for delayed PD. If the patient is hemodynamically unstable, PD should be performed as a two-step procedure. After the initial damage control surgery, reconstructions are completed during a second surgery when the patient is stable. Even during a secondary operation, reconstructions may not include pancreaticojejunostomy. Damage to the pancreatic head and duodenum should be repaired rapidly during operation. During the procedure, the common bile duct is ligatured and biliary drainage is established by bile duct intubation and stoma. Pancreatic secretion can be drained by pancreatic duct intubation, and then mattress suture of distal pancreatic stump is accomplished. The pancreatic bed is placed with a three-sump drainage tube, and then rapidly temporarily closed. The patients are immediately readmitted to the intensive care unit to ensure invasive monitoring, cardiopulmonary support, aggressive rewarming, and replacement of blood and clotting factors to correct any coagulopathy and/or acid-base imbalance [21,27]. Furthermore, management of patients include octreotide to control posttraumatic pancreatic fistula, enteral and parenteral nutrition support, and prevention and control of infection. The definitive operation should be completed after 72 h of successful resuscitation. The definitive operation includes removal of packing materials; exploration of the omitted trauma; management of the remaining issues of DCS, such as pancreaticojejunostomy, cholangioenterostomy, gastroenterostomy; and final closure of the abdominal cavity.

## Operative Decision-Making for Duodenal Injury

Management of duodenal injuries depends on the severity and location of the injury. The consensus is a simple operation with essential debridement, primary repair, adequate drainage, and lack of complicated reconstruction. Treatment of the majority of duodenal injury consists of primary repair, gastric decompression, initiation of

total parenteral nutrition, and placement of drains [28]. If the existing injury is in the first and second part of the duodenum that cannot undergo primary repair, the Roux-en-Y jejunal limb to repair (serosal or mucosal) a large defect is necessary. If the duodenal injury involves the third or fourth part of the duodenum distal from the ampulla, a local excision and duodenojejunostomy can be performed. Pancreas-preserving duodenectomy is reserved for those patients with higher duodenal injury (Grade IV) on the second part of the duodenum or severe destruction of duodenum [29]. Surgical options when dealing with the distal common bile duct injury include primary repair or a delayed Roux-en-Y choledochojejunostomy. PD is indicated when there is extensive trauma to the pancreatic head, a severe combined pancreaticoduodenal injury, or destruction of the ampulla of Vater; the reconstruction often depends on the severity of specific illness [30].

Duodenal repair with pyloric exclusion or diversion procedure remains a topic of contention. Duodenal diverticulization has been replaced by pyloric exclusion. However, pyloric exclusion is relatively more time-consuming and has greater complexity, and the associated complications and prognosis are still controversial. Currently, this method has only used for rare high-risk duodenal injuries [31].

Most (70%) pancreaticobiliary and duodenal injuries or perforations often result from periampullary endoscopic interventions, and their respective clinical outcomes and management are varied. Most pancreatic and biliary perforations can be managed nonoperatively; the requirement for operative treatment increases the mortality rate.

## Laparoscopic Operation for Pancreaticoduodenal Injury

Laparoscopic resection of the pancreas with Grade III or higher injuries under hemodynamically stable conditions can be performed safely and can lead to rapid recovery and reduced morbidity [32]. To the best of our knowledge, there are only a few cases of duodenal injury treated with laparoscopy.

## Complications

Among cases treated surgically for pancreatic trauma, 20-40% will present complications. The key is prevention, including appropriate surgical options, delicate operation, definite hemostasis, and adequate drainage. Common complications following pancreaticoduodenal trauma include hemorrhage, pancreatic fistula, pancreatitis, pseudocysts, and abscess that need to be managed by multidisciplinary collaboration [14,25,33].

(1) Abdominal hemorrhage known as delayed hemorrhage can originate from the pancreatic bed or the surrounding vessels as a result of corroded fistulas. Control of pancreatic fistula can prevent postoperative bleeding. The majority of arterial hemorrhage can be diagnosed and treated by Digital Subtraction Angiography (DSA).

(2) The formation of pancreatic fistula is the most common complication after surgical treatment for pancreatic trauma. Adequate external drainage, control of infection and nutritional support are the mainstays of management. Endoscopic management of disrupted pancreatic ducts or strictures improves the outcomes of conservative treatment. Upwards of 90% will be closed within 8 weeks while only about 10% require surgical intervention [34].

(3) Pancreatitis is a complication of unrecognized pancreatic duct injury. Reported incidence of pancreatitis is as high as 17%. The majority of these can spontaneously resolve. Those with recurrent episodes can be treated with ERCP-guided stent placement.

(4) Peripancreatic abscess occurs in around 20% of patients. These cases usually can be treated percutaneously, while some patients need surgical intervention.

(5) Regardless of the causes, almost 60% of pseudocysts will spontaneously resolve in 6-8 weeks. ERCP can be used to determine involvement of the main pancreatic duct. If there is no communication of the duct with the pseudocyst, drainage can be carried out percutaneously with CT or endoscopic US (EUS) guidance. When communication with the main pancreatic duct exists, drainage with a transpancreatic stent with or without intracavity drainage works well with EUS. Endoscopic treatment with successful resolution occurs in around 90% of patients with low recurrence rates [35]. Surgical drainage is selected if the conditions for endoscopy are inappropriate.

## Summary

The early diagnosis and grading of pancreaticoduodenal injury is important to guide individual management. In early stages, management of pancreaticoduodenal injuries should be based on the identified risks; surgeons typically strive to take simple approaches to treat life-threatening complications and restore the body's and organ's potential. In delayed stage, in view of the traumatic situation and secondary complications, multidisciplinary collaborations should be undertaken to ensure a practical approach and improve prognosis. It is necessary for a surgeon to treat and cure patients with the following understanding: "Performing the wonderful operation at the right time and place!".

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