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Traumatic Pancreatitis – Endoscopic and Surgical Management

Hirotaka Okamoto[1,2] and Hideki Fujii[2]
[1]*Department of Surgery, Tsuru Municipal Hospital,*
[2]*Department of Gastrointestinal,*
Breast & Endocrine Surgery, Faculty of Medicine, University of Yamanashi
Japan

1. Introduction

Acute pancreatitis is inflammation of the pancreas that occurs suddenly and usually resolves in a few days with treatment. Acute pancreatitis can be a life-threatening illness with severe complications. The most common cause of acute pancreatitis is the presence of small gallstones that cause inflammation of the pancreas as they pass through the common bile duct. Chronic heavy alcohol use is also a common cause. Acute pancreatitis can occur within hours or as long as 2 days after consuming alcohol. Other causes of acute pancreatitis include abdominal trauma, medications, infections, tumors, and genetic abnormalities of the pancreas.

Pancreatic trauma is uncommon, accounting for only 0.2-6% of all injuries resulting from abdominal trauma, and is associated with a high mortality rate of 13.8-31% (Leppäniemi et al., 1988). The high mortality rate is due to the frequent occurrence of associated abdominal injuries. In addition, blunt abdominal trauma is considered to be the cause of one fifth of all cases of traumatic pancreatitis and it may result in contusion, parenchymal fracture, or ductal disruption (Portis et al., 1994). These injuries to the pancreas are typically caused by compression of the organ against the vertebral column, mostly in traffic related-accidents. Blunt trauma to the epigastrium is caused by steering wheels, handlebars, seatbelts, or directly. Other mechanisms of injury include sporting accidents, such as direct hits from a ball or a blunt blow.

Therapeutic decisions for pancreatic trauma are based on the injury site and status of the pancreatic ductal system. When pancreatic ductal disruption exists or when duodenal injury cannot be ruled out, surgical exploration is usually required; however, surgery carries considerable morbidity and mortality risks. In this chapter, we discuss the management of pancreatic trauma and acute pancreatitis, including therapeutic endoscopy and surgical exploration.

2. Amatomy and physiology

The pancreas grows rapidly during a child's first five years of life with a slower growth rate up to the age of 18 years of age (Spiegel et al., 1997). It is a large complex gland that lies

outside the walls of the alimentary tract parallel to the stomach at the level of the first and second lumbar vertebrae. It is surrounded anteriorly by the upper abdominal intraperitoneal organs and posteriorly by the thick paraspinal muscles. The lobules of the pancreas drain into the main pancreatic duct of Wirsungs which traverses the length of the gland and joins the common bile duct, emptying into the duodenum through the ampulla of Vater. The minor duct of Santorini usually branches off from the main pancreatic duct and also empties into the duodenum. The gland is not encapsulated; therefore, tears in pancreatic tissues permit pancreatic digestive enzymes to invade the peripancreatic tissue and leak into the peritoneal cavity.

3. Pathogenesis

The mechanism of blunt pancreatic trauma usually involves anterior compressive forces applied to the pancreas, which lies over the vertebral column. The pancreas is relatively fixed so that during blunt impact, the pancreas is not displaced and absorbs the full amount of force applied (**Rawls, 2001**).

4. Classification

Classically, according to Lucas's classification of pancreatic injury, injuries without MPD disruption are designated Class I, while Class II or III injuries involve MPD disruption (Lucas, 1977). The Organ Injury Scaling Committee of the American Association for the Surgery of Trauma has proposed a pancreatic organ injury scale that is widely used and is based on the extent of parenchymal damage as well as the presence or absence of pancreatic duct injury (Moore et al., 1990). Minor contusions or superficial lacerations of the pancreas without duct involvement are classified as grade I injury. Grade II injuries are major contusions or lacerations without duct disruption. Distal transection of the pancreas or major parenchymal injuries with duct injuries is described as grade III. Grade IV injuries are proximal transections or any proximal parenchymal injuries involving the ampulla. Grade V injuries describe massive destructions of the pancreas head (**Table 1**).

Grade	Injury Description
I	Minor contusion or superficial laceration wihtout duct injury
II	Major contusion or laceration without duct injury or tissue loss
III	Distal transection or parenchymal injury with duct injury
IV	Proximal transection or parenchymal injury involving ampulla
V	Massive disruption of pancreas head

Table 1. Pancreatic injury severity scale (Moore et al., 1990)

5. Diagnosis

5.1 Laboratory data

It is generally reported that laboratory findings are relatively insensitive and non-specific in diagnosing pancreatic injury (Arkovitz et al., 1997; Bradley et al., 1998; Jobst et al., 1999). Serum amylase evaluation can suggest pancreatic injury; however, amylase levels have failed to predict or correlate with the degree of injury or disclose potential ductal disruption, especially when obtained in the early post-trauma period (Simon et al., 1994).

Serum lipase is often based clinically in the setting of acute pancreatitis, but after blunt trauma, elevated serum lipase levels may be nonspecific and a poor indication of injury (Buechter et al., 1990). Because of their low sensitivity and specificity for pancreatic trauma, serum amylase and lipase have limited diagnostic value, but elevated levels may provide a clue to a severe injury requiring further investigation.

5.2 Ultrasound

An ultrasound examination will usually be performed to enable the diagnosis of free abdominal fluid or gross damage to the liver or spleen. The pancreas is not easily identified and examined to its full extent; therefore, pancreatic injuries, parenchymal or ductal, will frequently be missed. However, routine abdominal ultrasound examination in the emergency room will establish the diagnosis of an intra-abdominal injury and therefore establish the need for an urgent explorative laparotomy. To disclose main pancreatic duct injury in blunt and penetration pancreatic trauma, intraoperative ultrasonography has proven to be helpful (Hikida et al., 2004).

5.3 Computed tomography

When initially evaluating for injury, CT scanning is a simple, noninvasive means of evaluating the pancreas. New-generation helical CT scanners quickly enable an overview of abdominal injuries in severely traumatic patients. CT was reported to have 90% sensitivity in detecting pancreatic disruption (Teh et al., 2007). Furthermore, CT allows additional assessment of the severity and extent of pancreatic tissue damage and concomitant injuries (Bigattini et al. 1999).

5.4 Magnetic resonance cholangiopancreatography

Magnetic resonance cholangiopancreatography (MRCP) is another non-invasive diagnostic tool that allows the evaluation of pancreatic injuries with high sensitivity and specificity. Particularly in stable patients with suspected pancreatic injury, MRCP enables the non-invasive detection or exclusion of pancreatic duct trauma and pancreatic specific complications. It may therefore provide information that can be used to guide management decisions in the further course of pancreatic trauma patients; however, its purely diagnostic nature and its inability to provide real-time visualization of ductal findings and extravasation are two of its disadvantages (Fulcher et al., 2000). Recently, secretin-stimulated MRCP was also reported to be a safe, non-invasive test that can provide additional useful information about duct integrity and facilitate management (Gillams AR et al., 2006).

5.5 Endoscopic retrograde cholangiopancreatography

Endoscopic retrograde cholangiopancreatography (ERCP) was documented to be a useful diagnostic tool, displaying sensitivity and specificity of 100% for pancreatic duct injury (Gougeon et al., 1976; Doctor et al., 1995). ERCP was also reported to be the definitive test for pancreatic duct injury, particularly, to demonstrate clearly the site of duct disruption and the grade of duct injury, whether the branch or main duct and partial or complete disruption of the main pancreatic duct MPD (Kim et al., 2001).

Recently, ERCP has been shown not only to provide sufficient information for conclusive diagnosis but also to be an effective and safe non-operative treatment tool (Bendahan et al., 1995; Huckfeldt et al., 1996; Kim et al., 2001; Cay et al., 2005; Houben et al., 2007). In certain cases of leakages of the pancreatic duct, transpapillary stent insertion might seal the injury and stabilize it in a way that eventually leads to resolution of the leakage

6. Therapy

Isolated pancreatic trauma is rare and usually results from direct trauma to the epigastrium, for example from the handle bars in bicycle accidents or in sports, typically in children or adolescents. Most patients with pancreatic lesions will present with multiple injuries, some of them hemodynamically unstable, and concomitant abdominal injuries; therefore, unstable patients may require initial damage control and correct assessment of the extent of pancreatic injury. On the other hand, in stable patients, ERCP plays an important role in the diagnosis, but also in the treatment of pancreatic duct injuries. Reports on the transpapillary stenting of duct lesions are very encouraging and justify the extensive use of ERCP (Canty et al., 2001).

6.1 Case of endoscopic treatment

A 17-year-old man was brought to the emergency department of our hospital with severe upper abdominal pain following a blow received in a rugby game. Emergency computed tomography (CT) revealed severe pancreatic neck injury. Forty-eight hours later, follow-up enhanced CT revealed that the pancreas was clearly lacerated and that the amount of peri-

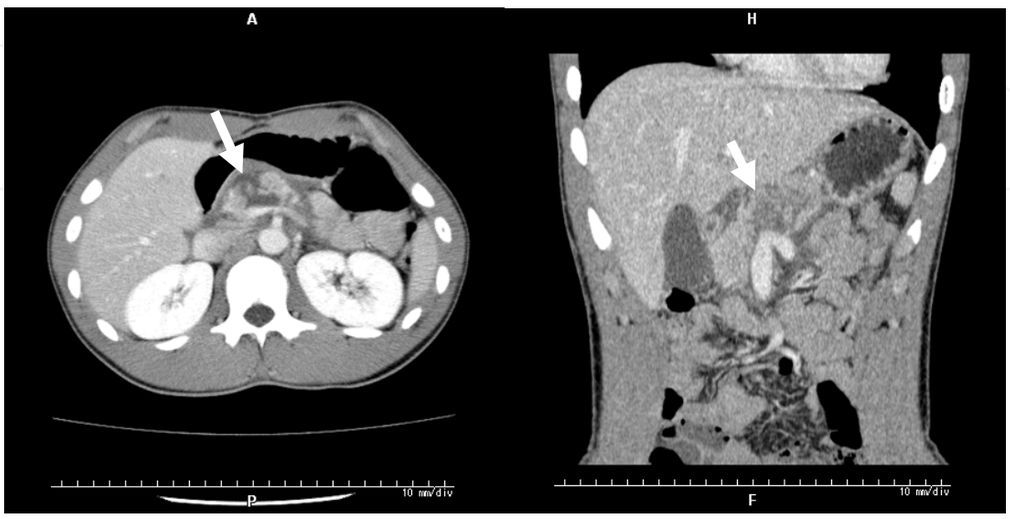

Fig. 1. Enhanced CT revealed an obvious laceration of the pancreas neck. (white arrow)

pancreatic fluid was increasing (**Fig. 1**); furthermore, serum amylase and elastase levels were elevated. ERP (endoscopic retrograde pancreatography) revealed that contrast medium in the main pancreatic duct (MPD) had leaked into the parenchyma, indicating MPD injury (**Fig. 2**). To prevent the traumatic pancreatitis from worsening, a stent was inserted endoscopically at a site distal to the injured portion of the MPD (**Fig. 3**). Thereafter, the patient's complaint was markedly reduced, and his serum amylase levels returned to normal. In addition, the apparent pancreatic edema and peripheral fluid were decreased on CT (Okamoto et al., 2010).

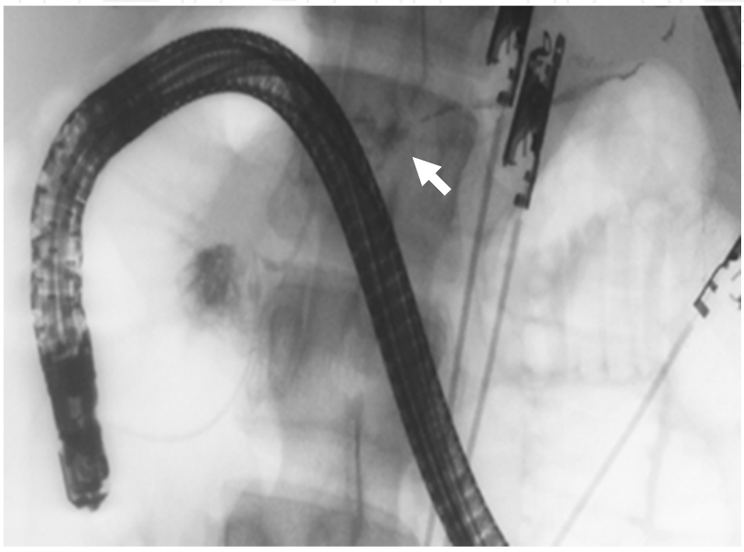

Fig. 2. Endoscopic pancreatography (ERP) revealed leakage of contrast medium.(white arrow)

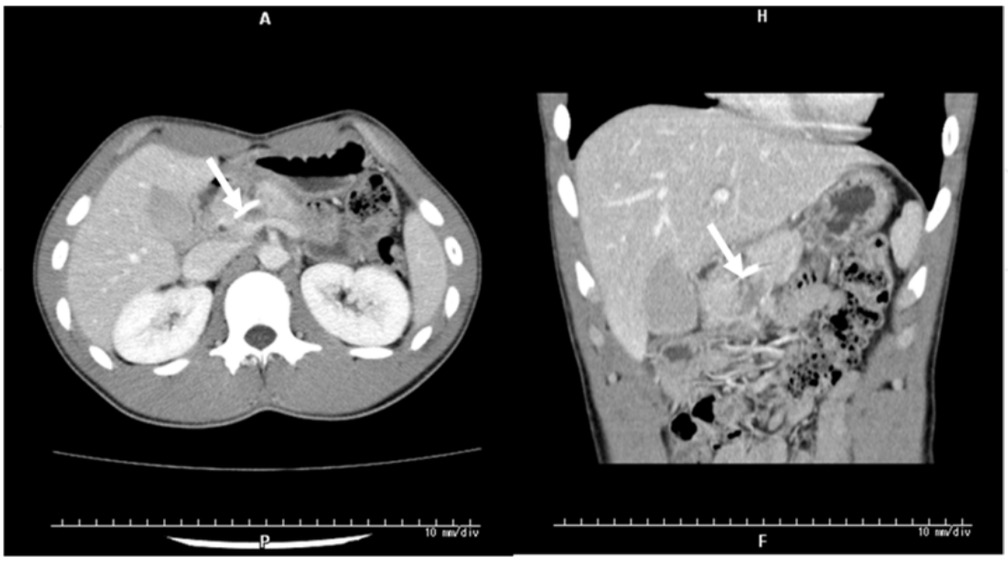

Fig. 3. Enhanced CT revealed the inserted pancreatic stent and disappearance of pancreas peripheral fluid.（white arrow)

6.2 Endoscopic pancreatic duct stent treatment

Endoscopic transpapillary stent insertion by literature review is summarized in **Table 2**.

	Age	Gender	Trauma	Initial S-Amy (IU/l	CT findings	Time to ERCP	ERCP findings	Disrupted portion	Outcome	References
1	22	M	Stabbed injury	n.d.	(Emergent operation)	3d	Duct disruption	Proximal	Recoverd	Bendahan J., et al., 1995
2	27	F	Car accident	127	Irregular order of the pancreas tail	3-4hr	Extravasation of the contrast from MPD	Neck (isthmus)	Recovered	Huckfeldt R, et al. 1996
3	9	F	Bike fall	436	Partial disruption of pancreatic parenchyma	1d	Extravasation of the contrast from MPD	Body	Recovered	Cantly T.G., et al., 2001
4	8	M	Traffic accident	126	Disruption of the distal pancreas	1d	Extravasation of the contrast from MPD	Tail	Recovered, mild MPD stricture	Cantly T.G., et al., 2001
5	46	M	n.d.	234	Head swelling	1d	Extravasation from tail of MPD	Head	Recovered	Kim HS, et al., 20001
6	35	M	n.d.	390	Pancreas fracture	4d	Intracapsular leakage from MPD	n.d.	Recovered, pseudocyst	Kim HS, et al., 20001
7	40	F	n.d.	742	Body swelling	1d	Intracapsular leakage from MPD	Body	Recovered, pseudocyst	Kim HS, et al., 20001
8	60	M	Car accident	536	Pancreas disruption and pseudocyst	5d	Extravasation of the contrast from MPD	Proximal	Recovered	Hashimoto A, et al., 2003
9	37	F	Steering wheel	2467	Hematoma over pancreatic head	22d	Stricture at the head with contrast extravasation	Head	Recovered, stent migration	Lin B.C., et al.,2006
10	35	M	Steering wheel	435	n.d.	19d	Stricture at the head with contrast extravasation	Head	Recovered, MPD stricture	Lin B.C., et al.,2006
11	36	M	Steering wheel	417	Pancreatic neck laceration	8d	Contrast extravasation at the body and tail	Body	Recovered, MPD stricture	Lin B.C., et al.,2006
12	61	F	Steering wheel	2270	Pancreatic body laceration	1d	Contrast extravasation at the body with retroperiton	Body	Sepsis, Death	Lin B.C., et al.,2006
13	18	M	Steering wheel	366	Pancreatic body laceration	8h	Contrast extravasation at the body	Body	Recovered, MPD stricture	Lin B.C., et al.,2006
14	28	M	Steering wheel	231	Pancreatic head laceration	16h	Contrast extravasation at the head	Head	Recovered, mild MPD stricture	Lin B.C., et al.,2006
15	8	M	Handlebar	n.d.	n.d.	28d	Incomplete disruption	Body	Recovered	Houben C.H., et al., 2007
16	11	M	Hit lamppost	n.d.	n.d.	4d	Transection of MPD	Neck	Recovered	Houben C.H., et al., 2007
17	10	F	Handlebar	n.d.	n.d.	2d	Incomplete disruption	Body	Recovered	Houben C.H., et al., 2007
18	11	M	Handlebar	n.d.	n.d.	2d	Transection of MPD	Neck	Recovered	Houben C.H., et al., 2007
19	11	F	Fall from seesaw	n.d.	n.d.	2d	Transection of MPD	Body	Recovered	Houben C.H., et al., 2007
20	7	M	Handlebar	n.d.	n.d.	9d	Transection of MPD	Neck	Recovered	Houben C.H., et al., 2007
21	10	M	Handlebar	n.d.	n.d.	7d	Transection of MPD	Neck	Recovered	Houben C.H., et al., 2007
22	12	M	Trivial fall	n.d.	n.d.	3d	Transection of MPD	Neck	Recovered	Houben C.H., et al., 2007
23	9	M	Trivial fall	n.d.	n.d.	4d	Transection of MPD	Neck	Recevered	Houben C.H., et al., 2007
24	28	M	Gun shot	406	Pancreatic injuruy involving the head, neck	1m	Leakage of the contrast	Head	Recovered	Rastogi M, et al., 2009
25	31	F	Bicycle accident	406	Pancreatic edema	0d	Disrupted unicinate branch	Unicinate process	Recovered	Rogers S.J., et al., 2009
26	49	M	Car accident	L 7121	Pancreatic edema	0d	Disrupted MPD	Body	Recovered	Rogers S.J., et al., 2009
27	41	F	Car accident	L 480	Pancreatc edema	15d	Disrupted unicinate branch	Unicinate process	Recovered	Rogers S.J., et al., 2009
28	41	F	Car accident	235	Distal pancreatic tear	10d	Disrupted unicinate branch	Unicinate process	Recovered	Rogers S.J., et al., 2009
29	18	F	Skiing fall	L 844	Peripancreatic edema, possible laceration	2d	Transection of MPD	Tail	Recovered	Rogers S.J., et al., 2009
30	54	M	Gun shot	L 583	IVC laceration, retroperitoneal fluid	1d	Extravasation MPD	Head	Recovered	Rogers S.J., et al., 2009
31	17	M	Sport	437	Pancreas disruption and pseudocyst	2d	Leakage from MPD	Neck	Recovered	Okamoto H., et al., 2010

n.d.: not determined, h: hour, d: day, m: month, L: lipase

Table 2. Summary of reported pancreatic duct stent treatment cases

This summary indicates that endoscopic transpapillary stent insertion is an effective technique for managing certain pancreatic traumatic injuries. A significant improvement in outcome was found for patients with stent therapy. Pancreatic stents are known to be associated with minor damage to the duct including ductal irregularity, stenosis, and side branch ectasia (Kozarek et al., 1991). These changes can occur even if the stent is patent, and they can persist or resolve after stent removal (Huckfeldt et al., 1996). A long-term study of a small group showed that 4 of 6 cases were complicated by ductal stricture, although stent therapy could avoid surgery in the acute trauma stage (Lin et al., 2006). Endo- and exocrine function were not examined. Further accumulated experiences are needed to clarify the significance of stent therapy.

6.2.1 Case of surgical treatment

A 34-year-old man was transferred to our hospital 18 hours after blunt abdominal trauma caused by impact against an automobile steering wheel. Emergent CT showed laceration of the pancreatic head and surrounding hematoma. Emergent laparotomy was carried out. Intraoperative pancreatography revealed injury of the proximal main pancreatic duct.

Because stenosis of the main pancreatic duct was predicted as a complication, cholecystectomy, external drainage of the common bile duct, and external abdominal drainage were carried out. He was discharged with a pancreatic fistula 4 months postoperatively. Three months later, pancreatic juice output through the drainage tube decreased, and patient developed acute pancreatitis. CT revealed dilatation of the main pancreatic duct and atrophy of the pancreas distal to the site of injury (**Fig. 4**). A second operation was planed to perform to preserve pancreatic function after the patient's general condition improved. ERP demonstrated ductal stricture of the main pancreatic duct in the head of the pancreas and upstream dilatation of the pancreatic duct. A diagnosis of chronic obstructive pancreatitis was made, and in order to preserve the function of the distal pancreas, longitudinal pancreatojejunostomy with Roux-en-Y anastomosis was performed 10 months after the initial operation. After the second operation, the patient's pancreatic function and pancreatic atrophy improved (Matsuda et al., 1999).

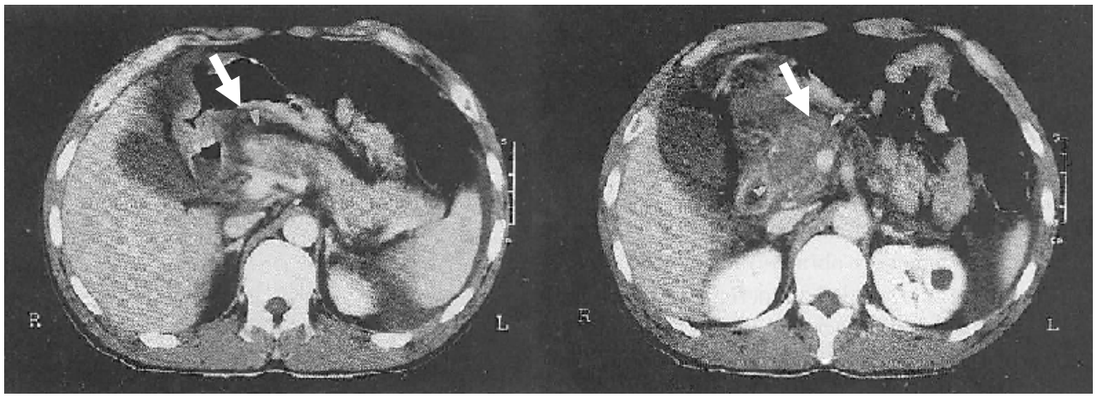

Fig. 4. Enhanced CT revealed a laceration of pancreatic head (left, white arrow) and a hematoma near pancreas head (right, white arrow).

6.2.2 Surgical treatment

Isolated pancreatic injuries are rare and most patients will present with multiple injuries, some of them hemodynamically unstable, and concomitant abdominal injuries; therefore, unstable patients may require initial damage control and correct assessment of the extent of pancreatic injury. This usually allows delayed definitive treatment of complex injuries, especially of the head of the pancreas. With regard to treatment, external drainage alone has been proposed for grade I and II injuries, while surgical intervention, including distal pancreatectomy or pancreaticojejunostomy, is usually performed for grade III, IV, and V injuries.

6.3 Nonoperative management

Conservative management of pancreatic trauma in the absence of a ductal injury (grade I and II) is widely accepted and practiced as the majority are contusions that usually resolve spontaneously after conservative treatment (Rescorla et al., 1995; Keller et al., 1997; Meier et al., 2001; Canty et al., 2001). Nonoperative management of a pancreatic injury consists of bowel arrest, total parental nutrition, and serial imaging with either CT scans or ultrasound to follow injury resolution.

Octreotide, a synthetic somatostatin analogue that inhibits pancreatic secretions has been shown in adults to reduce the incidence of postsurgical pancreatitis after pancreatic surgery. The benefits of octreotide in pancreatic trauma are controversial, and in particular its role in pediatric trauma is still undefined (Amirara et al., 1994; Nwariaku et al., 1995; Mulligan et al., 1995; Cavallini et al., 2001), however, there are few reported cases of octreotide administration being effective for traumatic pancreatic injury (Morali et al.,1991; Shan et al., 2002). Further accumulated evidence is required to prove this effect.

7. Treatment algorithm

We proposed an early treatment algorithm for endoscopic and surgical therapy, based on the presence or absence of a major pancreatic duct lesion.

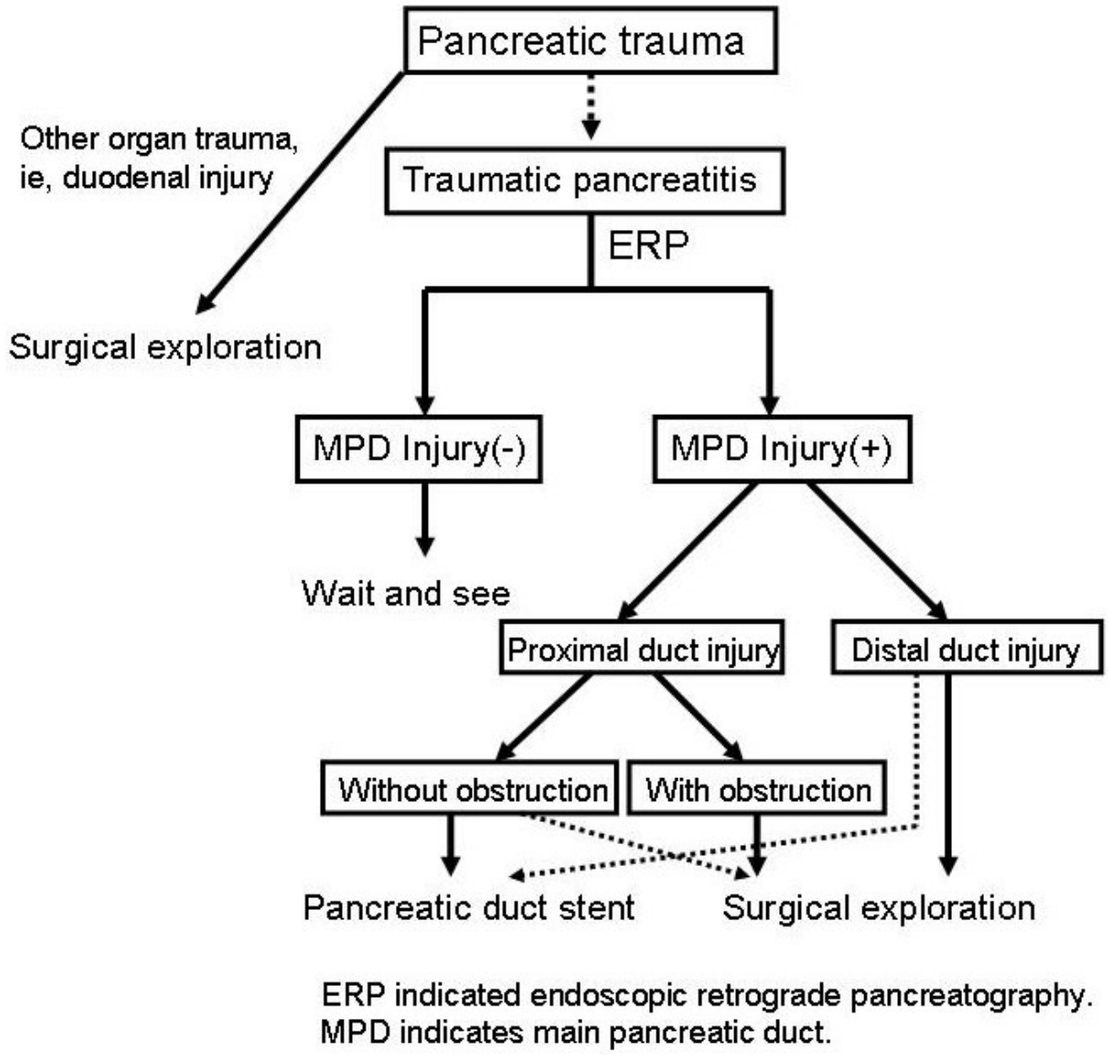

Fig. 4. Proposed early treatment algorithm for endoscopic and/or surgical therapy.

7.1 Proximal duct injury

Incomplete disruption of the MPD or complete disruption of the MPD without duct obstruction is the best candidate for the pancreatic duct stent therapy. Transductal pancreatic stent allows internal drainage of the pancreatic secretion and re-establishment of duct continuity (Bendahan et al., 1995; Huckfeldt et al., 1996; Cantly et al., 2001; Kim et al., 2001; Lin et al., 2006; Houben et al., 2007; Rogers et al., 2009).

Complete disruption of the MPD with duct obstruction increases the difficulty of stent placement beyond the fracture site. Disruption or complex injuries of the pancreatic head involving the ampulla, or devitalizing injuries of the pancreas head and duodenum usually are non-reconstructable injuries. In stable patients, pancreaticoduodenectomy is the best definite treatment for grade IV injuries. In unstable patients, exploration and placing of external drainage may be the best choice for damage control. Definitive treatment of the lesion can be achieved later, after the patient has been stabilized.

7.2 Distal duct injury

Distal pancreatic injury with duct involvement include major or stab wounds in the body or tail of the pancreas with an obvious duct injury or transection of more than half the width of the pancreas. If the clinical condition of the patient allows it, these grade III injuries are best treated by distal pancreatectomy even in emergency situations. In some cases, such as complete transection of the pancreatic body from the head, a distal pancreaticojejunostomy and closure of the proximal end of the pancreas rupture as in the Letton & Wilson procedure, may even become necessary if an organ-preserving approach is attempted (Letton et al., 1959). It has been documented that 19 patients were treated by distal pancreatectomy with splenectomy, 8 by pancreatectomy with preserving the spleen, and 2 by placing a pancreatic duct stent in a series of 32 grade III patients (Lin et al., 2004). Major distal duct injuries have been managed mainly by surgical exploration.

8. Complications and outcome

The complication rate of any pancreatic injury is not only associated with concomitant injuries, but also with the severity of the pancreatic injury. As is widely accepted, the grade of pancreatic injury is an independent predictor of both pancreas-associated morbidity and mortality. Complications following pancreatic trauma include fistula, pancreatic abscess, pseudocyst formation, and sepsis. The American Association for the Surgery Trauma Organ Injury Score has been shown to predict the development of complications and mortality after pancreatic injury (Kao et al., 2003).

Pancreatic abscesses have been treated interventionally by percutaneous drainage, but are frequently infected by multiple resistant bacteria, leading to sepsis. The treatment of pancreatic pseudocysts is interventional drainage and sealing, endoscopic gastrocystostomy, and operative enteric drainage.

9. Conclusion

Endoscopic transpapillary pancreatic duct stent is effective and safe management for pancreatic duct disruption, especially for proximal duct injury in selected patients. It may

avoid emergent surgery in the acute trauma stage; however, long-term ductal stricture should be carefully investigated during long-term follow-up.

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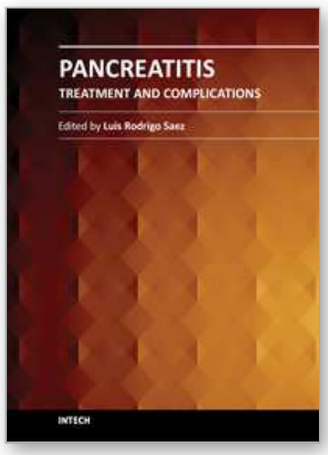

Pancreatitis - Treatment and Complications
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Pancreatitis may be acute or chronic. Although they can be caused by similar aetiologies, they tend to follow distinct natural histories. Around 80% of acute pancreatitis (AP) diagnoses occur as secondary to gallstone disease and alcohol misuse. This disease is commonly associated with the sudden onset of upper abdominal that is usually severe enough to warrant the patient seeking urgent medical attention. Overall, 10 to 25% of AP episodes are classified as severe, leading to an associated mortality rate of 7 to 30%. Treatment is conservative and consists of general medical support performed by experienced teams, sometimes in ICUs. Although most cases of acute pancreatitis are uncomplicated and resolve spontaneously, the presence of complications has significant prognostic importance. Necrosis, hemorrhage, and infection convey rates of up to 25%, 50%, and 80% mortality, respectively. Other complications such as pseudocyst formation, pseudoaneurysm formation, or venous thrombosis increase morbidity and mortality to a lesser degree. The presence of pancreatic infection must be avoided.

InTech Europe
University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China
Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

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