



Review article

Management of pancreatic trauma: a literature review[☆]



Patrizio Petrone,^{*} Sara Moral Álvarez, Marta González Pérez,
José Ceballos Esparragón, Corrado P. Marini

Division of Trauma Surgery, Surgical Critical Care & Acute Care Surgery, Department of Surgery New York Medical College,
Westchester Medical Center University Hospital, Valhalla, NY, United States

ARTICLE INFO

Article history:

Received 22 March 2016

Accepted 22 May 2016

Available online 26 April 2017

Keywords:

Pancreas

Trauma

Incidence

Diagnosis

Treatment

A B S T R A C T

Pancreatic injury is an uncommon event often difficult to diagnose at an early stage. After abdominal trauma, the surgeon must always be aware of the possibility of pancreatic trauma due to the complications associated with missed pancreatic injuries. Due to its retroperitoneal position, associated organs and vascular injuries are almost always present, which along with frequent extra abdominal injuries explain the high morbidity and mortality. The aim of this study is to present a concise description of the incidence of these injuries, lesional mechanisms, recommended diagnostic methods, therapeutic indications including nonoperative management, endoscopy and surgery, and an analysis of pancreas-specific complications and mortality rates in these patients based on a 60-year review of the literature, encompassing 6364 patients. Due to pancreatic retroperitoneal position, associated organs and vascular injuries are almost always present, which along with frequent extraabdominal injuries explain the high morbidity and mortality of these patients.

© 2016 AEC. Published by Elsevier España, S.L.U. All rights reserved.

Orientación terapéutica del traumatismo pancreático: revisión de la literatura

R E S U M E N

La lesión pancreática es un evento infrecuente y de difícil diagnóstico en fase temprana, por lo que el cirujano debe tener siempre presente esta posibilidad después de un traumatismo abdominal debido a las consecuencias que acarrearán las lesiones desapercibidas. Dada su localización retroperitoneal es habitual la lesión asociada de otros órganos y estructuras vasculares abdominales, que junto con las lesiones extraabdominales explican la alta morbimortalidad de estos pacientes. El objetivo de este trabajo es presentar una descripción concisa de la incidencia de estas lesiones, los mecanismos lesionales, los métodos diagnósticos recomendados, las indicaciones de las diferentes modalidades terapéuticas conservadoras, endoscópicas y quirúrgicas disponibles, y realizar un análisis de las

Palabras clave:

Páncreas

Traumatismo

Incidencia

Diagnóstico

Tratamiento

[☆] Please cite this article as: Petrone P, Moral Álvarez S, González Pérez M, Ceballos Esparragón J, Marini CP. Traumatismos de páncreas: manejo y revisión de la literatura. Cir Esp. 2017;95:123-130.

^{*} Corresponding author.

E-mail addresses: patrizio.petrone@gmail.com, petronep@wcmc.com (P. Petrone).

complicaciones específicas del páncreas y de la mortalidad en estos pacientes, basándonos en una revisión de la literatura de los últimos 60 años, habiendo identificado 6.364 pacientes. Dada la localización retroperitoneal del páncreas, es habitual la lesión asociada de otros órganos y estructuras vasculares abdominales, que junto con las lesiones extraabdominales explican la alta morbimortalidad de estos pacientes.

© 2016 AEC. Publicado por Elsevier España, S.L.U. Todos los derechos reservados.

Introduction

Pancreatic trauma is uncommon, affecting 0.5%–8% of trauma patients. The first available data were published by Travers in *Lancet* in 1827,^{2,3} where he described the findings from an autopsy.

The aim of this article was to review the literature on pancreatic trauma. A search was conducted with the PubMed and Embase databases, selecting articles published in English and Spanish over the last 60 years (1956–2015). The pediatric population was excluded. A total of 28 series were identified, with a total of 6364 patients (Table 1).

Prevalence

The pancreas presents a low prevalence of traumatic injury, mainly due to its protective retroperitoneal location, which at

the same time hinders and delays diagnosis. From the review of the literature, prevalence was observed to vary from 0.21% to 5.37%. In regions with a higher frequency of violent incidents, most patients were young males.^{1,4–9} Our study observed 82% of males, with a mean age of 32 years (Table 1).

Injury Mechanism

There are some publications that report a greater occurrence of pancreatic injury secondary to penetrating abdominal trauma,^{3,8,10–15} representing between 1% and 12% of cases,^{7,15–17} and about 5% blunt trauma.^{18,19} This distribution varies according to the origin of the series and the type of trauma. For instance, in studies published in the United Kingdom, blunt abdominal trauma is responsible for pancreatic injury in 82% of patients, whereas in studies from the United States and South Africa there is a predominance of penetrating injuries.^{4,14,20} In the review, it was possible to

Table 1 – Incidence by Author, Sex and Age.

Author and year (total patients)	Men, n (%)	Females, n (%)	Mean age (range)
Ivatury et al., ⁹ 1990 (103)	90 (87)	13 (13)	27 (13–51)
Young et al., ⁴⁹ 1998 (62)	56 (90)	6 (10)	32 (N/A)
Dubois et al., ⁵⁵ 2001 (4)	N/A	N/A	N/A
Vasquez et al., ⁷ 2001 (62)	54 (87)	8 (13)	28 (16–56)
Ilahi et al., ³⁸ 2002 (40)	30 (75)	10 (25)	35 (N/A)
Lin et al., ¹⁸ 2003 (48)	40 (83)	8 (17)	37 (18–71)
Beyrouiti et al., ⁵⁶ 2005(14)	12(86)	2(14)	24 (N/A)
Rickard et al., ⁴⁸ 2005 (70)	66 (94)	4 (6)	28 (N/A)
Zang et al., ⁵⁷ 2005 (71)	N/A	N/A	N/A
Scollay et al., ⁴ 2006 (111)	83 (75)	28 (25)	32 (14–84)
Cerwenka et al., ¹⁹ 2007 (47)	N/A	N/A	N/A
Teh et al., ³⁷ 2007 (50)	N/A	N/A	N/A
Ouaïssi et al., ⁴⁷ 2008 (40)	30 (75)	10 (25)	29 (15–65)
Petrone et al., ³ 2008 (3465)	N/A	N/A	N/A
Seamon et al., ⁸ 2008 (42)	38 (90)	4 (10)	33 (N/A)
Lochan et al., ⁵⁰ 2009 (11)	7 (64)	4 (34)	30 (13–51)
Antonacci et al., ⁶ 2011 (55)	30 (65)	13 (35)	39 (15–90)
Heuer et al., ¹ 2011 (284)	206 (72)	78 (28)	41 (16–N/A)
Lee et al., ³⁹ 2012 (58)	41 (71)	17 (29)	40 (28–46)
Önder et al., ²⁰ 2012 (26)	20 (77)	6 (13)	25 (15–56)
Jahromi et al., ⁵⁸ 2013 (25)	N/A	N/A	N/A
Yalin et al., ¹⁷ 2013 (95)	81 (85)	14 (15)	33 (17–51)
Memon et al., ¹⁴ 2013 (30)	28 (93)	2 (7)	28 (N/A)
Jeroukhimov et al., ³² 2015 (13)	8 (62)	5 (38)	24 (N/A)
Krige et al., ⁴⁶ 2015 (432)	394 (91)	38 (9)	26 (N/A)
Moschetta et al., ⁵ 2015 (136)	90 (66)	46 (36)	46 (N/A)
Negoi et al., ³⁶ 2015 (942)	N/A	N/A	N/A
Rodriguez et al., ¹⁵ 2015 (28)	26 (93)	2 (7)	30 (22–41)
Total (6.364/1.746)	1430 (82)	316 (18)	32 (13–90)

The total number of patients found was 6364; of these, patient sex was defined in only 1746.

N/A: not available.

Table 2 – Mechanism of Pancreatic Trauma.

Author and year (total patients)	Blunt, n (%)	Penetrating, n (%)
Young et al., ⁴⁹ 1998 (62)	0	62 (5%)
Dubois et al., ⁵⁵ 2001 (4)	4 (0.3%)	0
Lin et al., ¹⁸ 2003 (48)	48 (3.9%)	0
Beyrouiti et al., ⁵⁶ 2005 (14)	13 (1.1%)	1 (0.08%)
Scollay et al., ⁴ 2006 (111)	73 (5.9%)	38 (3%)
Cerwenka et al., ¹⁹ 2007 (38)	31 (2.5%)	7 (0.5%)
Lochan et al., ⁵⁰ 2009 (11)	11 (0.8%)	0
Antonacci et al., ⁶ 2011 (37)	31 (2.5%)	6 (0.4%)
Önder et al., ²⁰ 2012 (26)	5 (0.4%)	21 (1.6%)
Lee et al., ³⁹ 2012 (86)	58 (4.8%)	28 (2.8%)
Yalin et al., ¹⁷ 2013 (95)	95 (7.7%)	0
Xie et al., ²⁴ 2013 (83)	82 (6.7%)	1 (0.08%)
Memon et al., ¹⁴ 2013 (30)	11 (0.8%)	19 (1.5%)
Jahromi et al., ⁵⁸ 2013 (23)	23 (1.8%)	0
Moschetta et al., ⁵ 2015 (136)	136 (11%)	0
Krige et al., ⁴⁶ 2015 (432)	119 (9.6%)	313 (25.3%)
Total (1236 cases)	740 (59.8)	496 (40.2)

identify the mechanism of injury in 1236 cases: 59.8% were due to a blunt mechanism, and 40.2% a penetrating mechanism. Of these, 59% were caused by firearms (Table 2).

Blunt abdominal trauma produces a direct compression of the pancreas against the lumbar vertebrae, which, associated with the lack of displacement of the organ because of its retroperitoneal location, may cause transection of the gland in the region of the superior mesenteric vessels and even rupture of the duct.^{12,13,16,21} It should be noted that the review found articles referring to rare injury mechanisms.^{11,22-27}

Associated Injuries

The presence of associated lesions is more the rule than the exception due to location.^{7,11} Krige et al.¹⁰ reported the presence of isolated lesions in only 11% of cases. The incidence of isolated injuries in blunt trauma varies from 15% to 55%, whereas it is practically null when the mechanism of injury is penetrating trauma.²⁸

In our review, we counted 4559 patients with pancreatic injuries who presented 9110 intra-abdominal lesions (1.9 per patient). The most frequent injuries involved the liver with 1899 lesions (20.9%), followed by 1564 gastric lesions (17.2%) and 1305 major vascular lesions (14.3%) (Table 3). At the same time, 8.5% of associated duodenal lesions were identified, which increased to 12% and 21% when the mechanism of injury was penetrating trauma.^{7,14}

Diagnosis

Diagnostic suspicion is established according to the mechanism of injury and clinical presentation, although it is usually very non-specific.^{29,30} It is important to detect the integrity of the pancreatic duct, thereby reducing the rate of complications,³¹ indicating the most appropriate technique and avoiding unnecessary aggressive treatments. Imaging studies such as ultrasound or Focused Assessment Sonography for

Table 3 – Associated Abdominal and Extra-Abdominal Injuries.

Abdominal injuries	n	%
Liver	1899	20.9
Stomach	1564	17.2
Major vascular injury	1305	14.3
Spleen	1094	12
Urological	803	8.8
Colon	791	8.7
Duodenum	773	8.5
Small bowel	553	6
Gallbladder/biliary tract	165	1.8
Diaphragm	163	1.8
Total	9110	100
Extra-abdominal injuries	n	%
Thorax	234	44.5
Musculoskeletal	138	26.2
Head	92	17.5
Neck and spinal column	57	10.8
Heart	5	1
Total (4559 injuries)	526	100

Source: Petrone et al.³; Scollay et al.⁴; Vasquez et al.⁷; Ivatury et al.⁹; Memon et al.¹⁴; Rodríguez et al.¹⁵; Yalin et al.¹⁷; Cerwenka et al.¹⁹; Önder et al.²⁰; Lee et al.³⁹; Krige et al.⁴⁶; Ouaïssi et al.⁴⁷; Young et al.⁴⁹; Krige et al.⁵⁴

Trauma provide few or non-specific data, such as the presence of free intra-abdominal fluid, and are not useful for evaluating the entire gland.

Computed tomography (CT) is the imaging study of choice in patients with hemodynamically stable closed trauma.¹⁶ Both the sensitivity and the specificity of the test are around 85% for the detection of pancreatic injury.¹⁶ However, the sensitivity to detect duct injury is more limited (43%–54%).^{32,33} A disadvantage of the technique is the need to determine the ideal moment, because immediately after blunt trauma the pancreas may appear normal in 20%–40% of cases,¹⁶ and if it is performed after the first 24 h the lesion may go unnoticed due to the absence of inflammatory reaction.³⁴

If CT findings cannot define the injury, or there is a small laceration in the parenchyma, endoscopic retrograde cholangiopancreatography (ERCP) has been shown to be useful and more sensitive³³ in assessing the state of the main duct. It may also reduce the severity of the injury diagnosed by CT or intraoperatively, so it can contribute to eliminate unnecessary procedures or reduce the extent of surgery.^{30,32,34} Another useful test for evaluating the integrity of the main pancreatic duct is magnetic resonance cholangiopancreatography (MRCP). It may also contribute to improve patient selection for conservative treatment.³⁵ Its drawback is that it cannot be used in the initial assessment, and it is not a diagnostic option.¹⁶ One variation is dynamic magnetic resonance pancreatography after secretin stimulation; however, even though it has a high diagnostic specificity, this test is not indicated in patients with multiple injuries because of its long duration.³⁰

Elevated secretin and amylase levels after abdominal trauma were formerly considered indicative of pancreatic injury in general. However, normal initial levels may be

present in up to 35% of patients with complete ductal disconnection, which demonstrates its low sensitivity and specificity.¹⁶ It is currently considered that its elevation 3 h after trauma may indicate pancreatic damage,^{30,36} so a series of controls is recommended.

Finally, the most invasive diagnostic option, which is mandatory in unstable patients, is surgery. During laparotomy, it is important to confirm the condition of the pancreatic duct, as the lesion may be subtle and go unnoticed. The use of intraoperative ultrasound may aid in the diagnosis of a parenchymal or even ductal lesion. In cases where the suspicion of duct injury persists, the administration of secretin can demonstrate its existence by increasing the flow of pancreatic secretion.³⁰

Another intraoperative technique for detecting duct injury is pancreatography with cannulation of Vater's ampulla through a duodenotomy. In cases requiring distal pancreatectomy, it may be retrograde through the orifice of the main duct.^{3,30} The invasive nature of these 2 intraoperative techniques, as well as cholecystocholangiography with gallbladder aspiration used to demonstrate the lack of integrity of the pancreatic duct, make them unattractive and currently very rarely indicated.

According to Subramanian et al.,³⁰ simple examination of the area of the injury for several minutes under magnification is able to demonstrate evidence of any leak of clear pancreatic fluid in most injuries involving the pancreatic duct.

Laparoscopy also plays a role in the diagnosis and treatment of pancreatic lesions, as it can be used to stage the lesion, resect distal lesions or drain proximal lesions.³³

In the study by Teh et al.,³⁷ intraoperative findings confirmed CT findings in 54.5% of cases, while confirming the presence of duct injuries in 91%. In the studies by Moschetta et al.⁵ and Ilahi et al.,³⁸ lesion confirmation during surgery reached 100% of cases. Xie et al.²⁴ also offer a positive correlation between the CT findings and laparotomy, and Lee et al.³⁹ confirmed the presence of the lesion in 100% of the ERCP conducted.

Classification of Injuries

The most extensively used scale for determining the degree of pancreatic injury was established by the *American Association for the Surgery of Trauma (AAST)*⁴⁰ (Table 4).

Historically, the most common trauma injuries have been grade I (60%), grade II (20%), grade III (15%) and grade IV (5%).^{3,28}

Table 5 – Classification of Duct Damage by ERCP.

Grade	Description
I	Normal main pancreatic duct on ERCP
IIa	Injury to the branches of the main pancreatic duct on ERCP with extravasation of contrast arterial within the parenchyma
IIb	Injury to the branches of the main pancreatic duct with extravasation of the contrast to the retroperitoneal space
IIIa	Injury to the main pancreatic duct on ERCP in the body or tail of the pancreas
IIIb	Injury to the main pancreatic duct on ERCP in the head of the pancreas

ERCP: endoscopic retrograde cholangiopancreatography.
Source: Takishima et al.⁴¹

In the review of 18 series of cases with a total of 1631 patients, in which the injury grade was specified in 1212, the most frequent pancreatic injury grade was III (275 patients, 23%), followed by grade II (196, 16%), grade I (111, 9%), grade IV (92, 8%) and grade V (35, 3%). In 503 of these patients (41.5%), the authors divided the grades into 2 categories, unifying grades I and II (304, 25%) and grades III, IV and V (199, 16%).

In our review, the anatomical location of the injury was only reported in 7 of these series; the body of the pancreas was the most frequent location (33.2%), followed by the tail (29.1%), head (26.8%) and neck (5.7%). In 5.2% of the remaining cases, the lesion was grouped in the neck and body. In a total of 95 patients, the degree of duct injury was reported as grade I duct damage in 15%, grade IIa 19%, IIb 23%, IIIa 32% and IIIb 11%. This gradation is defined by ERCP findings⁴¹ (Table 5).

Treatment

In general, grades I and II can be resolved with conservative treatment, while above grade III surgical treatment is indicated.^{3,16,19,28,33}

Initially, the use of ERCP was only diagnostic, but recently its use has increased as a therapeutic tool both safely and satisfactorily,^{29,35} thereby shortening hospital stay,⁴² and it has been shown to be an effective option in the treatment of late-onset complications.³⁵

Surgical treatment, however, is not only relegated to grade III or higher lesions,^{16,36} but also to patients who present signs of peritoneal irritation or hemodynamic instability. Factors that determine the choice of surgical technique include

Table 4 – American Association for the Surgery of Trauma (AAST) Scale for Pancreatic Injury.

Grade	Type of injury	Description of the injury
I	Hematoma	Minor contusion without duct damage
	Laceration	Superficial laceration without duct damage
II	Hematoma	Major contusion without duct damage or loss of tissue
	Laceration	Major laceration without duct damage or loss of tissue
III	Laceration	Distal division or parenchymal damage with duct injury
IV	Laceration	Proximal division or parenchymal damage affecting the ampulla of Vater
V	Laceration	Massive disruption of the head of the pancreas

Source: Moree et al.⁴⁰

patient stability, injury grade, possible existence of associated lesions, integrity of the pancreatic duct, anatomical location and extension of the injury.^{30,42}

During laparotomy, it is essential to control any active bleeding and intestinal contamination.^{3,30} In penetrating trauma, it may be sufficient to expose the pancreatic region of the injury pathway,³⁰ while in blunt trauma complete exposure of the organ is necessary. The extended Kocher maneuver provides access to the anterior and posterior sides of the head and neck of the pancreas. In order to examine the anterior side of the body and tail, the gastrocolic ligament is divided and the lesser sac is accessed. With the division of the gastrohepatic ligament, the upper edge of the pancreas and the vascular elements of the splenic axis can be inspected. By releasing the adhesions below the retroperitoneum and elevating the lower edge, the back posterior side can be visualized, where the main pancreatic duct passes. For complete exposure of the tail, it is necessary to mobilize the spleen by means of blunt dissection.

The presence of saponification, clear fluid in the pancreatic bed, penetrating central lesion or deep wounds in the parenchyma are signs that indicate the high probability of injury to the pancreatic duct.⁴³ Hematomas should be explored as they may hide a section of the duct, even if the pancreatic injuries are isolated. The main principles of treatment include hemostasis, debridement of necrotic tissue, anatomical resection and drainage.³⁰

The most widely used surgical techniques include: External drainage: provides treatment for more than 60% of injuries.³ Closed drainage systems are preferable,³⁰ as they are withdrawn when the discharge is minimal and the patient tolerates enteral nutrition. Pancreatography and drainage: a portion of viable greater omentum is sutured over the lesion. It is necessary to use a drain tube due to the high risk of developing a fistula.³⁰ Distal pancreatectomy: used in grades III and IV,^{2,10,16,30,36,44} with spleen preservation. In this trauma situation, spleen preservation is debatable as it involves a longer surgical time. The expected benefits should be considered in light of the consequences of a prolonged surgery in terms of the patient's *physiological and hemodynamic reserve* and age. In order to consider spleen preservation associated with distal pancreatectomy in non-elective surgery, the patient should be hemodynamically stable and normothermic, and the injury should be limited to the pancreas. The

body of the pancreas should be released with ligation of the gastric vessels and completion of the pancreatic division. Placement of closed suction drains is recommended in the pancreatic bed and in the left hypochondrium. Ductal repair is determined by intraoperative findings and the extent of the injury.^{10,45} Pancreatojejunostomy or pancreaticogastrostomy: applicable in cases of partial transection of the area of the neck or in grade IV injuries,¹⁶ with an attempt to preserve pancreatic tissue and prevent the development of pancreatic insufficiency. Roux-en-Y distal pancreaticojejunostomy: stable patients with grade IV injuries in the neck of the pancreas and few associated lesions, if any.³⁰ The pancreatic resection is completed by ligating and dividing the residual elements and the duct is individualized for subsequent closure. A Roux-en-Y is created with a jejunal segment pulled up in a transmesocolic position to complete the anastomosis. Drains are placed at the level of the anastomosis and the stump. Pancreaticoduodenectomy: with the development of damage control surgeries, the Whipple procedure has been relegated to the last surgical option² and is recommended in cases of massive disruption of the head of the pancreas associated with uncontrollable hemorrhage of the vena cava or portal vein, significant associated duodenal damage or destruction of the ampulla of Vater.^{2,16,30,44} Isolated duct damage in the head of the pancreas is not an indication to perform an emergency Whipple procedure; instead it should be drained through a duct stent.² This should be conducted in a stepwise manner ("damage control surgery"), with an initial intervention for hemostatic control/contamination. After patient recovery, the second surgery for reconstruction is performed after 24–48 h. This procedure associates important morbidity and mortality rates when performed due to trauma; mortality rates reach 30%–40%.^{3,16,30} Some reviews consider that only 10% of patients undergoing pancreaticoduodenectomy for pancreatic trauma actually have an indication for this procedure.¹⁶

Among the series analyzed, the most frequently performed procedure was drainage in 377 (38.1%) patients, while the Whipple technique was carried out in 39 (4.1%) patients with grades IV and V injuries (Table 6).

Current evidence does not recommend the use of somatostatin in trauma, and level I studies are required to justify its use. Furthermore, adequate nutritional support is crucial in this type of patients. Enteral nutrition based on a peptide

Table 6 – Surgical Treatment According to AAST Pancreatic Injury Score.

	I n (%)	II n (%)	III n (%)	IV n (%)	V n (%)	Grade N/A n (%)	Total n (%)
Drainage	59 (6)	84 (8.6)	11 (1.1)	14 (1.4)	3 (0.3)	206 (21.2)	377 (38.8)
Suture ± drain	10 (1)	15 (1.5)	–	–	–	6 (0.6)	31 (26.3)
Damage control	8 (0.8)	14 (1.4)	2 (0.2)	5 (0.5)	5 (0.5)	13 (1.3)	47 (20.5)
PcD + D	–	2 (0.2)	44 (4.5)	4 (0.4)	–	93 (0.9)	143 (14.6)
Whipple	–	–	–	9 (0.9)	11 (1.1)	19 (1.9)	39 (4)
Drain + desb	1 (0.1)	3 (0.3)	–	–	–	34 (3.5)	38 (3.9)
Roux-en-Y PJ	–	–	3 (0.3)	31 (3.2)	1 (0.1)	3 (0.3)	38 (3.9)
Surgery N/A	–	–	–	3 (0.3)	4 (0.4)	16 (1.6)	23 (2.4)
Total	78 (8)	130 (13.4)	151 (15.4)	69 (7)	24 (2.4)	520 (53.5)	972

Drain + desb: drainage and debridement; N/A: not available; PcD + S: distal pancreatectomy with splenectomy; Roux-en-Y PJ: Roux-en-Y pancreaticojejunostomy; suture ± drain: suture with or without drainage.

formula with an elemental diet using a nasojejunal tube is ideal. Another alternative is percutaneous jejunostomy. Total parenteral nutrition is more expensive, but it can be useful if the distal enteral access is not feasible.

Morbidity

Thirteen series with 1009 patients^{7,14,15,17-20,39,46-50} reported the complications associated with pancreatic trauma and found a general rate of complications ranging from 35% to 80% and pancreas-related complications in 30%–36%. The most frequent organ-specific complications were acute pancreatitis (15%), pseudocysts (9%), abscesses (6%) and pancreatic fistulas (4%).²⁸

According to the Krige et al.⁴⁶ study of 432 consecutive cases of pancreatic trauma, the predictors for morbidity were the AAST grade and re-laparotomies. However, other groups have defined risk factors, including surgical time, complexity of surgery (bypass with poorer prognosis than resection), cardiorespiratory arrest in the operating room,¹⁷ delays in diagnosis of over 24 h^{18,51} and inappropriate initial treatment.⁵²

The incidence of pancreatic fistula (PF) ranges greatly due to the variability of definitions among authors. The *International Study Group for Pancreatic Fistula*⁵³ proposed as a definition the abnormal communication between the pancreatic duct epithelium and another epithelial surface, and in the case of it being postoperative or after trauma, exteriorization through the drain tube. The discharge is any measurable volume after the third day post-op, with a level of amylase 3 times higher than in serum, and no need for radiological confirmation. The incidence of PF observed in our series was 11%. According to the experience of Young et al.,⁴⁹ more PF occur during management with only drainage than after procedures with resection. More than 90% close in 8 weeks, and only 10% require surgery.¹⁶

Abscesses were found in 8.3%, usually in association with major duct injury. In most cases, their location was peripancreatic, subhepatic or subphrenic and could be resolved with percutaneous drainage. Intraparenchymal abscesses are uncommon and usually require surgical drainage.¹²

Pancreatitis can reach 18% of postoperative cases,¹⁶ and is generally mild. In case of recurrence, ERCP or MRCP¹² is recommended. The evolution to necrohemorrhagic pancreatitis occurs only in 10%–15%,^{19,51} and its mortality rate is 80%.^{12,19}

Long-term complications include pseudocysts and pancreatic duct stenosis. Pseudocysts occur in 5.6% of the patients analyzed. The treatment is endoscopic with ERCP when it originates in the main duct. However, injuries to the secondary branches resolve spontaneously or by percutaneous drainage. Only 3 studies reported duct stenosis: Lin et al.¹⁸ 9%, Ouaissi et al.³⁹ 2% and Krige et al.⁵² 0.2%.

Other complications, although infrequent, include secondary bleeding from the pancreas or surrounding vessels due to retroperitoneal autodigestion, pancreatic insufficiency after resective surgery and pseudoaneurysms, mainly of the splenic artery.¹⁹

Mortality

After analyzing 14 series and 1354 patients, the observed mortality rate was 18%, which is in agreement with data from the literature (10%–30%).^{1,4,17} In the articles analyzed, factors for a poor prognosis included advanced age, hemodynamic instability, blunt trauma and associated injuries.³⁶ Other influences include the degree of pancreatic duct injury, infra-staging of the lesions, and delayed diagnosis.^{18,19}

According to Heuer et al.,¹ more than 70% of deaths after pancreatic trauma occur in the first 24 h, due to large vessel injuries or severe lesions of adjacent organs.²⁰ In fact, patients with hemodynamic shock on admission have a mortality rate of 35%, which drops to 3.7% if they arrive in stable condition.⁴⁶ Many studies exclude deaths in the first 24 h or prior to surgery, which could explain the great variability seen in published mortality rates. The publication by Scollay et al.⁴ reports the highest mortality rate (46%), including patients diagnosed by autopsy after death in the emergency room. When these cases were excluded, the remaining mortality rate was 34%, which is comparable to reports by other groups.

The mortality rate related with pancreatic injury is low. Out of the 6 series^{7,14,20,39,47,48} that defined this mortality subgroup, pancreatic trauma represents only 11% of the total mortality. Late mortality is also not attributed to pancreatic injury, as it is secondary to pancreatic duct injury²⁰ with development of intra-abdominal sepsis and multiple organ failure.

A German multicenter study¹ has found a 10% decrease in mortality since 2000, which is attributed to improved prehospital care. On the other hand, the introduction in the last 2 decades of the concept of damage control surgery has improved the survival of the most severe patients.¹⁵ Seamon et al.⁸ retrospectively studied 42 patients undergoing damage control surgery after pancreatic trauma, concluding that the presence of shock or major vascular injury dictates the extension of the surgery and results in lower mortality when shorter interventions are performed based on packing and drainage.

Conclusions

In cases of suspected pancreatic injury, the major pancreatic duct should be evaluated meticulously since the main predictor of morbidity and mortality is duct damage,^{18,36,50} which will define the treatment to be followed:

- Non-surgical treatment is recommended when duct injury has been ruled out by CT, ERCP,³⁰ or MRCP, with AAST grade I and III injuries secondary to blunt trauma³⁶ and in patients with hemodynamic stability.
- In grades IV and V lesions with no damage to the duodenum or the ampulla of Vater, drain placement is recommended.³⁶
- In hemodynamically unstable patients, damage control surgery is recommended¹⁶ because quick control of the hemorrhage and recovery from hemodynamic shock is essential to reduce high immediate mortality.⁴⁶

- In non-bleeding pancreatic lesions with important associated injuries, one therapeutic option would be the placement of a closed suction drain in the lesser sac.²
- If there is duct injury or late-onset complications, the placement of a transpapillary stent by means of ERCP or a nasopancreatic drain tube favors healing, especially if the placement is done in early stages,³⁰ interrupting the leak point and blocking the discharge of pancreatic juices, or with the conversion of a high-low pressure system in the duct by opening the sphincter.³⁵
- In the case of pseudocysts, currently the technique of choice is pseudocyst-gastric drainage using endoscopic ultrasound. It has shown greater efficacy, especially in small lesions or with a poor window, and even when changing the therapeutic approach in more than one-third of cases.⁵² Simple radio-guided transabdominal drainage is a useful alternative.
- The presence of pseudoaneurysms should be ruled out in patients with necrotizing pancreatitis to thereby prevent bleeding due to their rupture. If any are found, they should be angioembolized.

Conflict of Interests

The authors have no conflict of interests to declare.

REFERENCES

1. Heuer M, Hussmann B, Lefering R, Taeger G, Kaiser GM, Paul A, et al. Pancreatic injury in 284 patients with severe abdominal trauma: outcome, course, and treatment algorithm. *Arch Surg*. 2011;396:1067-76.
2. Schechter WP, Hirshberg A. Pancreatic and duodenal injuries. In: Jarnagin WR, editor. *Blumgart's surgery of the liver, biliary tract and pancreas 5th ed.* Philadelphia, PA: Saunders, Elsevier; 2012; p. 1815-21.
3. Petrone P, Asensio JA, Pardo M, Kimbrell B, Kuncir E. Traumatismos de páncreas: diagnóstico y tratamiento. *Rev Colomb Cir*. 2008;23:44-52.
4. Scollay JM, Yip VSK, Garden OJ, Parks RW. A population-based study of pancreatic trauma in Scotland. *World J Surg*. 2006;30:2136-41.
5. Moschetta M, Telegrafo M, Malagnino V, Mappa L, Amato A, Ianora S, et al. Pancreatic trauma: the role of computed tomography for guiding therapeutic approach. *World J Radiol*. 2015;7:415-20.
6. Antonacci N, Di Saverio S, Ciaroni V, Biscardi A, Giugni A, Cancellieri F. Prognosis and treatment of pancreaticoduodenal traumatic injuries: which factors are predictors of outcome? *J Hepatobiliary Pancreat Sci*. 2011;18:195-201.
7. Vasquez JC, Coimbra R, Hoyt DB, Fortlage D. Management of penetrating pancreatic trauma: an 11-year experience of a level-1 trauma center. *Injury*. 2001;32:753-9.
8. Seamon MJ, Kim PK, Stawicki SP, Dabrowski GP, Goldberg AJ, Reilly PM, et al. Pancreatic injury in damage control laparotomies: is pancreatic resection safe during the initial laparotomy? *Injury*. 2009;40:61-5.
9. Ivatury RR, Nallathambi M, Rao P, Stahl WM. Penetrating pancreatic injuries. *Am Surg*. 1990;56:90-4.
10. Krige JEJ, Kotze UK, Nicol AJ, Navsaria PH. Isolated pancreatic injuries: an analysis of 49 consecutive patients treated at a level 1 trauma centre. *J Visc Surg*. 2015;152:349-55.
11. Søreide K. Pancreas injury: the good, the bad and the ugly. *Injury*. 2015;46:827-9.
12. Degiannis E, Glapa M, Loukogeorgakis SP, Smith MD. Management of pancreatic trauma. *Injury*. 2008;39:21-9.
13. Nikolaidis P, Meranda J, Miller FH, Summers AL, Gabriel H, Talamonti M, et al. Pancreatic trauma and surgery. In: Gore RM, Levin MS, editors. *Textbook of gastrointestinal radiology 4th ed.* Philadelphia, PA: Saunders Elsevier; 2015; p. 1856-71.
14. Memon AA, Zafar H, Raza R, Murtaza G. Traumatic pancreatic injury – an elusive diagnosis: experience from a developing country urban trauma referral centre. *J Pak Med Assoc*. 2013;63:440-4.
15. Rodríguez F, García A, Ordoñez C, Vernaza C, Herrera JP, Puyana JC. Trauma pancreático penetrante severo-revisión retrospectiva de una serie de casos manejados con una estrategia simplificada en un centro de trauma nivel 1. *Panamerican J Trauma Crit Care Emerg Surg*. 2015;4:147-54.
16. Fisher M, Brasel K. Evolving management of pancreatic injury. *Curr Opin Crit Care*. 2011;17:613-7.
17. Yalin K, Xiaojun H, Chengli L, Gang Z, Mei X, Yuying Z, et al. Grading-therapeutic strategy for pancreatic injury after blunt abdominal trauma: therapy based on the condition of pancreatic duct and report of 95 cases. *Hepatogastroenterology*. 2013;60:1497-503.
18. Lin BC, Chen RJ, Fang JF, Hsu YP, Kao YC, Kao JL. Management of blunt major pancreatic injury. *J Trauma*. 2004;56:774-8.
19. Cerwenka H, Bacher H, El-Shabrawi A, Komprat P, Lemmerer M, Portugaller HR, et al. Management of pancreatic trauma and its consequences – guidelines or individual therapy? *Hepatogastroenterology*. 2007;54:581-4.
20. Önder A, Gümüş M, Kapan M, Böyük A, Arikanoglu Z, Gırgın S. Associated organ injuries in pancreatic injuries, morbidity, and mortality. *Turk J Med Sci*. 2012;42:559-66.
21. Duchesne JC, Simms ER, McSwain N. Pancreatic and duodenal injuries and current surgical therapies. In: Cameron JL, Cameron AM, editors. *Current surgical therapy 11th ed.* Philadelphia, PA: Saunders Elsevier; 2014; p. 1036-104.
22. Deras P, Manzanera J, Millet I, Charbit J, Capdevila X. Fatal pancreatic injury due to trauma after successful cardiopulmonary resuscitation with automatic mechanical chest compression. *Anesthesiology*. 2014;120:1038-41.
23. Feeney SN, Pegoli W, Gestring ML. Pancreatic transection as a complication of the Heimlich maneuver. Case report and literature review. *J Trauma*. 2007;62:252-4.
24. Xie KL, Liu J, Pan G, Hu WM, Wan MH, Tang WF. Pancreatic injuries in earthquake victims: what have we learnt? *Pancreatol*. 2013;13:605-9.
25. Redmond CE, McEvoy SH, Ryan ER, Hoti E. Pancreatic transection as a result of a high-pressure water jet injury. *BMJ Case Rep*. 2013. <http://dx.doi.org/10.1136/bcr-2013-200403>. pii:bcr2013200403.
26. Kulaylat AN, Pastor DM, Santos MC. Isolated pediatric pancreatic transection secondary to ocean-related trauma. *JOP*. 2013;14:203-6.
27. Hudkins JR, Hamlin KE, Smith JL. Partial pancreatic transection due to chiropractic manipulation. *Am Surg*. 2012;78:393-5.
28. Iacono C, Zicari M, Conci S, Valdegamberi A, de Angelis M, Pedrazzani C, et al. Management of pancreatic trauma: a pancreatic surgeon's point of view. *Pancreatol*. 2016;16:302-8.

29. Björnsson B, Kullman E, Gasslander T, Sandström P. Early endoscopic treatment of blunt traumatic pancreatic injury. *Scand J Gastroenterol.* 2015;50:1435-43.
30. Subramanian A, Dente CJ, Feliciano DV. The management of pancreatic trauma in the modern era. *Surg Clin N Am.* 2007;87:1515-32.
31. Berni GA, Bandyk DF, Oreskovich MR, Carrico CJ. Role of intraoperative pancreatography in patients with injury to the pancreas. *Am J Surg.* 1982;143:602-5.
32. Jeroukhimov I, Zoarets I, Wisner I, Shapira Z, Abramovich D, Nesterenko V, et al. Diagnostic use of endoscopic retrograde cholangiopancreatography for pancreatic duct injury in trauma patients. *Isr Med Assoc J.* 2015;17:401-4.
33. Vijay A, Abdelrahman H, El-Menyar A, Al-Thani H. Early laparoscopic approach to pancreatic injury following blunt abdominal trauma. *J Surg Case Rep.* 2014;12:1-3.
34. Rogers SJ, Cello JP, Schecter WP. Endoscopic retrograde cholangiopancreatography in patients with pancreatic trauma. *J Trauma.* 2010;68:538-44.
35. Thomson DA, Krige JEJ, Thomson SR, Bornman PC. The role of endoscopic retrograde pancreatography in pancreatic trauma: a critical appraisal of 48 patients treated at a tertiary institution. *J Trauma Acute Care Surg.* 2014;76:1362-6.
36. Negoii I, Paun S, Stoica B, Tanase I, Hostiuic S, Beuran M. High grade penetrating pancreatic trauma – case report and review of the literature. *Chirurgia (Bucur).* 2015;110:554-8.
37. Teh SH, Sheppard BC, Mullins RJ, Schreiber MA, Mayberry JC. Diagnosis and management of blunt pancreatic ductal injury in the era of high-resolution computed axial tomography. *Am J Surg.* 2007;193:641-3.
38. Ilahi O, Bochicchio GV, Scalea TM. Efficacy of computed tomography in the diagnosis of pancreatic injury in adult blunt trauma patients: a single-institutional study. *Am Surg.* 2002;68:704-7.
39. Lee PH, Lee SK, Kim GH, Hong SK, Kim JH, Hyun YS, et al. Outcomes of hemodynamically stable patients with pancreatic injury after blunt abdominal trauma. *Pancreatol.* 2012;12:487-92.
40. Moree EE, Cogbill TH, Malangoni MA, Jurkovich GJ, Champion HR, Gennarelli TA, et al. Organ injury scaling, II: pancreas, duodenum, small bowel, colon and rectum. *J Trauma.* 1990;30:1427-9.
41. Takishima T, Hirata M, Kataoka Y, Asari Y, Sato K, Ohwada T, et al. Pancreatographic classification of pancreatic ductal injuries caused by blunt injury to the pancreas. *J Trauma.* 2000;48:745-52.
42. Bhasin DK, Rana SS, Rao C, Gupta R, Verma GR, Kang M, et al. Endoscopic management of pancreatic injury due to abdominal trauma. *J Pancreas.* 2012;13:187-92.
43. Evans HL, Jurkovich GJ. Pancreatic injury. In: Cioffi A, editor. *Atlas of trauma/emergency surgical techniques* 1st ed. Philadelphia, PA: Saunders Elsevier; 2013; p. 173-90.
44. Dahiya D, Rana SS, Kaman L, Behera A. Conservative surgery for pancreatic neck transection. *Pol Przegl Chir.* 2015;87:315-9.
45. Martin GM, Morillas PJ, Pino JC, Canis JM, Argente FX. Reconstruction after pancreatic trauma by pancreaticogastrostomy. *Int J Surg Case Rep.* 2015;9:92-4.
46. Krige JEJ, Kotze UK, Setshedi M, Nicol AJ, Navsaria PH. Prognostic factors, morbidity and mortality in pancreatic trauma: a critical appraisal of 432 consecutive patients treated at a level 1 trauma centre. *Injury.* 2015;46:830-6.
47. Ouaiissi M, Sielezneff I, Chaix JB, Mardion RB, Pirró N, Berdah S, et al. Experience of two trauma-centers with pancreatic injuries requiring immediate surgery. *Hepatogastroenterology.* 2008;55:817-20.
48. Rickard MJ, Brohi K, Bautz PC. Pancreatic and duodenal injuries: keep it simple. *ANZ J Surg.* 2005;75:581-6.
49. Young PR, Meredith JW, Baker CC, Thomason MH, Chang MC. Pancreatic injuries resulting from penetrating trauma: a multi-institution review. *Am Surg.* 1998;64:838-43.
50. Lochan R, Sen G, Barrett AM, Scott J, Charnley RM. Management strategies in isolated pancreatic trauma. *J Hepatobiliary Pancreat Surg.* 2009;16:189-96.
51. Stawicki SP, Schwab CW. Pancreatic trauma: demographics, diagnosis, and management. *Am Surg.* 2008;74:1133-45.
52. Krige JEJ, Kotze UK, Navsaria PH, Nicol AJ. Endoscopic and operative treatment of delayed complications after pancreatic trauma: an analysis of 27 civilians treated in an academic level 1 trauma centre. *Pancreatol.* 2015;15:563-9.
53. Bassi C, Dervenis C, Butturini G, Fingerhut A, Yeo C, Izbicki J, et al. Postoperative pancreatic fistula: an international study group (ISGPF) definition. *Surgery.* 2005;138:8-13.
54. Krige JEJ, Kotze UK, Nicol AJ, Navsaria PH. Morbidity and mortality after distal pancreatectomy for trauma: a critical appraisal of 107 consecutive patients undergoing resection at a level 1 trauma centre. *Injury.* 2014;45:1401-8.
55. Dubois J, Porcheron J, Lacroix M, Menaoui N. Pancreatic neck rupture. *Ann Chir.* 2001;126:863-8.
56. Beyrouiti MI, Beyrouiti R, Kchaoui I, Gharbi W, Elleuch S, Tafech I, et al. Duodeno-pancreatic trauma. About 14 cases. *Tunis Med.* 2005;83:273-82.
57. Zhang SH, Wang SM, Li JW. Diagnosis and treatment of pancreatic trauma. *Chin J Traumatol.* 2005;8:303-5.
58. Jahromi AH, D'Agostino HR, Zibari GB, Chu QD, Clark C, Shokouh-Amiri H. Surgical versus nonsurgical management of traumatic major pancreatic duct transection. *Pancreas.* 2013;42:76-87.