ONLINE FIRST

ISSN: 0015-5659

e-ISSN: 1644-3284

Surgical treatment for acute pancreatitis and pancreatic necrosis

Authors: Julia Walkowska, Nicol Zielinska, Piotr Łabętowicz, Bartłomiej Szewczyk, Mariola Głowacka, Janusz Moryś, Ilona Klejbor, Łukasz Olewnik

DOI: 10.5603/fm.102684

Article type: Review article

Submitted: 2024-09-19

Accepted: 2025-01-09

Published online: 2025-03-11

REVIEW ARTICLE

Surgical treatment for acute pancreatitis and pancreatic necrosis

Julia Walkowska[1], Nicol Zielinska[2], Piotr Łabętowicz[3], Bartłomiej Szewczyk[4], Mariola Głowacka[5], Janusz Moryś[6], Ilona Klejbor[7], Łukasz Olewnik[2]

[1]Department of Anatomical Dissection and Donation, Medical University of Lodz, Łódź, Poland
[2]Department of Clinical Anatomy, Masovian Academy in Plock, Płock, Poland
[3]Department of Forensic Medicine Medicine, Pathology and Histology Masovian Academy in Plock, Płock, Poland
[4]Department of Physiology and Pathophysiology, Masovian Academy in Plock, Płock, Poland
[5]Nursing Department, Masovian Academy in Plock, Płock, Poland
[6]Department of Human Anatomy and Physiology, Pomeraniam University in Slupsk, Słupsk, Poland
[7]Department of Anatomy, Institute of Medical Sciences, Jan Kochanowski University, Kielce, Poland

Address for correspondence: Nicol Zielinska, Department of Clinical Anatomy, Masovian Academy in Plock, Plac Dąbrowskiego 2, 09–402 Płock, Poland; e-mail: nicolzielinska@gmail.com

ABSTRACT

Pancreatitis, considered by clinicians as one of the most demanding abdominal disorders, is a life-threatening disease resulting in numerous complications if treated without early diagnosis or specialized medical care. Management is based on supportive care, including rehydration, pain control, continuous monitoring of vital signs and assessment of organ function, and on early oral feeding. However, there are cases such as acute gallstone pancreatitis, necrotising pancreatitis or acute fulminant (hemorrhagic) pancreatitis that require operative or surgical intervention. As the recent years have brought more experience in the treatment of different types and subtypes of pancreatitis, the guidelines concerning the most effective therapeutic methods, including invasive treatment, are now changing.

The aim of the research is to present surgical treatment of acute pancreatitis (AP) in the light of changing patterns of management.
Keywords: pancreatic necrosis, acute pancreatitis, surgical treatment

INTRODUCTION

The pancreas is a glandular, secondary retroperitoneal organ. It is located in the upper part of the abdomen. Macroscopically, the pancreas can be divided into three main parts: the head, the body and the tail [9]. Additionally, some researchers also divide the pancreatic head into the anterior and the posterior part [24]. As for the structure, other parts that may be distinguished are also the neck (isthmus) located above the superior mesenteric artery and vein, and the uncinate process situated in the area below them [9, 24]. The arterial blood that supplies the pancreas comes from the branches of the celiac artery and the superior mesenteric artery, while the venous blood flows into the hepatic portal vein [9].

Anatomical variations of the pancreas and the pancreatic ducts are rare, only occurring in 5.7% of cases [8]. They often remain asymptomatic until adulthood and are detected incidentally on computed tomography (CT), endoscopic retrograde cholangiopancreatography (ERCP), or magnetic resonance cholangiopancreatography (MRCP). The anatomical variations of the organ include agenesis and hypoplasia of the pancreas, annular pancreas, accessory pancreatic lobe, and ectopic pancreas. In addition, the pancreatic ducts also demonstrate a number of anatomical variations and developmental anomalies: configuration variations such as bifid configuration with dominant main pancreatic duct (MPD), dominant accessory pancreatic duct (APD) without divisum, pancreas divisum, absent APD, ansa pancreatica, and cystic dilations of the terminal portions of the MPD and APD, as well as course variations (descending, vertical, sigmoid, loop-shaped and ring-shaped), duplication anomalies and anomalous pancreaticobiliary ductal junction (APBU). The most common varieties of the pancreatic ducts are bifid configuration with a dominant main pancreatic duct (60%) and a descending course of the main pancreatic duct (50%). The less common variations include an absent accessory pancreatic duct (30%), a dominant accessory pancreatic duct without divisium (1%) and ansa pancreatica [8]. It is very important to identify these anomalies since it enables specialists to appropriately plan the course of endoscopic retrograde cholangiopancreatography and surgical procedures. Also, it prevents inadvertent damage to the pancreatic ducts. On the other hand, anatomical variability may be a cause of recurrent pancreatitis or of gastric outlet obstruction [8].

The pancreas is involved in providing and maintaining homeostasis. It is responsible for regulating the digestion of nutrients and blood glucose level [2, 22]. The organ consists of two parts, i.e. the exocrine pancreas and the endocrine islets, which fulfill different functions. The exocrine part of the pancreas secretes digestive juices, which contain *inter alia* enzymes that flow into the duodenum to break down the nutrients. It also contains bicarbonate ions that neutralize the low pH of gastric juice [2, 22, 32]. The endocrine islets maintain glucose homeostasis by secreting insulin, glucagon, somatostatin and pancreatic pancreas, which are produced by beta, alpha, delta and PP cells, respectively [22].

Pancreatitis, an inflammatory disease of the pancreas, results from the dysfunction of the exocrine pancreas [28]. According to clinical data, acute pancreatitis (AP), recurrent acute pancreatitis (RAP), and chronic pancreatitis (CP) are a disease continuum [12]. It has been shown that 30% of patients with AP will develop CP, often with a RAP overlap in the years between [12]. AP develops when the intracellular protective mechanisms of the pancreas that prevent trypsinogen activation or reduce trypsin activity are exceeded [3]. The most common initiating factors are moderate alcohol consumption and gallstones. Pancreatitis is considered not to be caused by infectious agents [28], whereas cases of viral pancreatitis, resulting from mumps, rubella, Epstein-Barr virus, and Hepatitis-A Virus infections, have been reported [6]. Interestingly, there has been a case of a patient suffering from COVID-19 who showed symptoms of acute pancreatitis without other risk factors [31]. Other causes, such as hypertriglyceridemia [28], complication of ERCP [27] or pancreas divisium [28] are infrequent.

There are five subtypes of AP that can be distinguished: mild AP, moderately severe AP, severe AP, interstitial edematous AP and necrotizing AP [17]. The 2012 revision of the Atlanta classification and definitions based on international consensus [3], identifies two phases of AP, i.e. early and late stage. According to this classification, severity is classified as mild, moderate, or severe. Mild AP (interstitial edematous pancreatitis) is not associated with organ failure, local or systemic complications, and it normally resolves in the first week. Moderate AP is characterized by transient (less than 48 hours) organ failure, local complications or exacerbation of co-morbid disease. Severe AP presents persistent (lasting over 48 hours) organ failure [2, 16]. In most cases, the course of the AP is mild. The disease can be managed with supportive measures involving moderate fluid resuscitation, analgesic and antiemetic treatment, as well as early oral feeding, which determine rapid improvement of the clinical condition. On the other hand, in about 20–30% of patients [16], AP can turn into a severe disorder with life-threatening complications, such as insufficiency of respiratory and

cardiovascular systems or kidney failure [12]. Additionally, patients with gallstone pancreatitis or necrotic pancreatitis require endoscopic, percutaneous or more invasive treatment. The aim of the research is to present operative and surgical treatment methods of AP since management methods in some cases have changed recently [16].

SURGICAL AND OPERATIVE TREATMENT FOR ACUTE PANCREATITIS

Percutaneous or endoscopic drainage of pancreatic collections is indicated if clinical deterioration is observed, with signs of infected necrotizing pancreatitis, or a strong suspicion. However, in most patients, sterile necrotizing pancreatitis can be managed by a non-invasive approach. Interventions for necrotizing pancreatitis should preferably be made when the necrosis has become walled off, usually four weeks after the onset of the disease. It is recommended to perform drainage if the following symptoms occur four weeks after the onset of the disease: on-going organ failure without sign of infected necrosis, on-going gastric outlet, biliary, or intestinal obstruction due to a large walled-off necrotic collection, disconnected duct syndrome, and symptomatic or growing pseudocyst. Another indication is on-going pain and/or discomfort persisting for eight weeks following the onset of the disease [16].

The first line of treatment in infected pancreatic necrosis is percutaneous drainage. It allows surgical treatment to be postponed until a more favorable time. In 25–60% of patients, it might even lead to complete resolution of infection. In some cases, in disconnected pancreatic duct or walled-off necrosis, transgastric endoscopic necrosectomy- a minimally invasive single-stage surgical strategy, might be considered. Although it requires more interventions, it reduces the risk of new-onset organ failure after the operation [16].

The updated Atlanta classification 2012 [3] specifies two types of the peripancreatic collections associated with necrosis, namely acute necrotic collection (ANC) and walled-off necrosis (WON). ANC contains a variable amount of fluid and necrotic tissue, including the pancreatic parenchyma and/or peripancreatic tissues. This type of collection occurs in the first four weeks. In contrast, WON manifests as a mature, encapsulated collection of pancreatic and/or peripancreatic necrosis covered by a well-defined, enhanced inflammatory wall. It develops within four or more weeks after the onset of AP [16].

Disconnected pancreatic duct syndrome (DPDS) can also occur due to a loss of the integrity and continuity of the pancreatic duct, generally within the head or the body of the pancreas, following local necrosis. This causes extraductal leakage of pancreatic secretions and subsequent destruction of the pancreatic tissue surrounding the affected duct, or chemical

pancreatic ascites if the secretions leak into the peritoneal cavity. The most common non-iatrogenic causes of DPDS are acute or chronic necrotizing pancreatitis and trauma [1].

Where percutaneous or endoscopic procedures have not improved the patient's condition, it is recommended that further surgical strategies be considered [16]. The indications for surgical interventions concern bowel ischemia or acute necrotizing cholecystitis during acute pancreatitis, bowel fistula extending into a peripancreatic collection, acute on-going bleeding when the endovascular approach is unsuccessful, continuum in a step-up approach after percutaneous/endoscopic procedure with the same indications, and abdominal compartment syndrome [16]. According to a study by the Eastern Association for the Surgery of Trauma [19], postponing surgical intervention for at least four weeks following the onset of the disease is associated with lower mortality. This is due to gradual separation of necrotic tissue from vital tissue; this reduces damage to vital tissues and bleeding, and ensures a more effective necrosectomy [16]. It is recommended to avoid the open-abdomen method when other treatments can be used to alleviate or treat severe intra-abdominal hypertension in SAP. However, in the case of patients with severe acute pancreatitis who are unresponsive to conservative management of intra-abdominal hypertension/abdominal compartment syndrome, it has been found that open abdomen approach and surgical decompression are effective in treating abdominal compartment syndrome [16].

Summary

Appropriate and accurate primary intervention using percutaneous techniques, namely sinus tract endoscopy and percutaneous necrosectomy, reducing the risk of exacerbation by avoiding numerous surgical explorations. Moreover it has been suggested that minimally-invasive surgical techniques, used in the management of secondary infection in AP, consistently offer advantages over equivalent open surgery, such as lower activation of the inflammatory response and reduced incidence of local sepsis [25].

Despite this, while accumulations may be removed during secondary surgical exploration, in many cases, only a small amount of necrotic tissue is evacuated. Additionally, it often happens that percutaneous techniques do not provide adequate or complete removal of necrotic tissues, which is unfavorable in the long term [25].

MANAGEMENT OF ACUTE GALLSTONE PANCREATITIS

Surgical treatment of acute pancreatitis involves cholecystectomy with operative cholangiography [7, 26, 29]. According to the guidelines of the International Association of

Pancreatology (IAP), this procedure is performed to prevent the recurrence of gallstone-associated acute pancreatitis [26]. Surgical treatment is not used in most patients with acute pancreatitis, whereas many of them eventually undergo cholecystectomy [30].

According to the IAP recommendations, mild AP is not an indication for pancreatic surgery; however, cholecystectomy is recommended in mild gallstone-associated AP, preferably during the same hospitalization, after the patient has returned to a relatively stable condition. Furthermore, the guidelines indicate that in severe gallstone-associated acute pancreatitis, cholecystectomy should be postponed until the inflammatory response has sufficiently resolved and clinical improvement can be observed in patients [26]. Another reason for deferring cholecystectomy in acute gallstone pancreatitis is peripancreatic fluid collections. The treatment should be performed when fluid collections resolve or stabilize [16]. Occasionally, acute pancreatitis is diagnosed accidentally during an emergency laparotomy performed due to suspected peritonitis. However, since imaging methods such as computed tomography have been used increasingly frequently, unnecessary laparotomy is not performed, and a CT scan ensures preoperative diagnosis. If possible, gallstones localized in the common bile duct (CBD) should be removed, and an external tube drainage of the CBD should be instituted [30]. In patients who are ineligible for surgery, endoscopic sphincterotomy is an alternative to cholecystectomy aimed at reducing the risk of gallstone-associated acute pancreatitis recurrence [26].

ERCP

Routine ERCP is not recommended to manage acute gallstone pancreatitis [16]. In addition, ERCP is not indicated by predicted severe acute gallstone pancreatitis without CBD obstruction or cholangitis at this stage [16]. However, therapeutic ERCP should be performed urgently in patients with acute pancreatitis, with confirmed or suspected gallstones, or who fulfil the criteria for current or predicted acute pancreatitis, or who present jaundice, CBD dilatation, or cholangitis [30].

These recommendations are based on studies by Fan et al. [10] and Neoptolemos et al. [20] comparing endoscopic sphincterotomy with conventional treatment of acute gallstone pancreatitis. They report a reduced incidence of complications, such as biliary sepsis, and hospital mortality associated with emergency ERCP. According to the guidelines, the above procedure should preferably be performed within the first 72 hours following the onset of pain.

Regardless of the presence or absence of gallstones in the bile duct, endoscopic sphincterotomy is required in all patients undergoing early ERCP for severe gall stone pancreatitis. The procedure involves creating a small incision in the major duodenal papilla to open the pancreatic-biliary tract, and consequently removing gallstones or improving the drainage. If a patient has symptoms of cholangitis, an endoscopic sphincterotomy can be performed, or stenting of narrowed or obstructed bile ducts, to improve duct drainage. Further management of biliary pancreatitis consists of either providing the patient with ultimate treatment for cholelithiasis during the same hospitalization or a definitive treatment plan within two weeks [30].

Cholecystectomy

The definitive treatment of gallstones includes laparoscopic or open cholecystectomy with operative cholangiography. The procedure is not performed in patients with serious risk factors for surgical treatment. Additionally, in patients with severe AP, who present lung injury and systemic disturbance, cholecystectomy should be postponed until resolution of symptoms, whereas, in the case of unfit patients, endoscopic sphincterotomy is a sufficient therapy. A delay in treatment puts the patient at risk of potentially fatal RAP. Definitive treatment should be provided in individuals with gallstones following an attack of mild pancreatitis, in order to prevent the recurrence of pancreatitis and subsequent acute pancreatitis, which might be severe and life-threatening [30]. Additionally, ERCP and sphincterotomy performed during the index admission, minimize the risk for recurrent pancreatitis; nevertheless, same-admission cholecystectomy is still recommended to counter the increased risk of complications affecting the biliary tract [16].

MANAGEMENT OF PANCREATIC NECROSIS

It is only recommended to perform early surgery within 14 days following the disease onset if specific indications occur in patients with necrotizing pancreatitis. The decision to undertake interventional treatment in the course of pancreatic necrosis depends on the clinical picture, i.e. symptoms of sepsis, and the visualization of pancreatic and peripancreatic necrosis in computed tomography. Presence of gas in pancreatic collections or fine needle aspiration (FNA) is used for diagnosing infection in necrotizing pancreatitis. To obtain material for culture, image-guided fine-needle aspiration is recommended in patients with persistent symptoms of acute pancreatitis, and necrosis affecting more than 30% of the pancreatic volume, and those with smaller areas of necrosis and clinical suspicion of sepsis; this should

be performed 7–14 days following the disease onset [30]. Aspiration of material for bacteriological examination allows sterile material to be distinguished from infected pancreatic necrosis in patients with septic syndrome, and for consecutive implementation of proper treatment. Approximately 20–40% of patients with severe acute pancreatitis develop infection of pancreatic and peripancreatic necrosis, which is related with a worsening of organ dysfunction [16].

FNA is characterized by good safety, and high sensitivity and specificity in terms of infection detection, and few complications [4, 13, 19]. According to the IAP guidelines, computed tomography-proven necrotizing pancreatitis is associated with reduced infection rates owing to the use of prophylactic broad-spectrum antibiotics, with no improvement in survival [26]. In patients suffering from infected pancreatic necrosis with clinical signs and symptoms of sepsis, intervention based on surgical necrosectomy or radiological drainage is required to provide thorough and complete debridement of all cavities containing necrotic material [7, 26, 29, 30]. According to standard surgical practice, necrosectomy should be performed in all patients with infected necrosis. However, this has been questioned by retrospective studies which indicate good outcome in patients treated with percutaneous drains [30].

Pancreatic abscess

One of the infectious complications of acute pancreatitis are pancreatic abscesses which most often arise from progressive liquefaction of necrotic pancreatic and peripancreatic tissues. However, some abscesses develop from infection of the parapancreatic fluid or collections located in the peritoneal cavity. They may also appear after surgical debridement and drainage of necrotic material from the pancreas [18]. Abscesses, which frequently turn out to be lobulated abscesses, often contain incompletely softened and liquefied necrotic tissue, which may affect the choice of surgical technique and the effectiveness of the procedure itself. Pancreatic abscesses are diagnosed based on images of accumulations, obtained with ultrasonographic or tomographic techniques, and swinging pyrexia. Pancreatic abscesses require surgery. As soon as the diagnosis is made, surgical drainage is immediately indicated. Indeed, debridement, necrosectomy and closed drainage yield very good results [14].

One study comparing interventional and surgical treatment of pancreatic abscesses found percutaneous catheter drainage of abscesses to be effective in some cases, such as achieving initial stabilization in patients with sepsis, drainage of newly developed abscesses after surgical intervention (especially in the case of difficult access to reoperation), abscesses

distant from the pancreas and selected unilocular accumulations (after an appropriate intermission after necrotizing pancreatitis, in order to allow sufficient liquefaction) [18].

Freeny et. al. [11] conclude that percutaneous catheter drainage is safe and efficient in the case of the initial therapy of infected acute necrotizing pancreatitis. These findings demonstrate that percutaneous drainage with broad opening is an effective and adequate treatment for infected pancreatic necrosis. Nevertheless, many surgeons question the possibility of solid necrotic tissue evacuation along drain of any size; however, this is definitely possible after softening and liquefaction of necrotic tissue, as in the case of a pancreatic abscess [30].

Debridement of necrotic tissue

An accurate debridement of necrotic tissue is necessary in the course of any surgical intervention. Therefore, the abdomen may be packed and left open, closed over drains, or closed over drains and the pancreatic cavity should be irrigated. There have been no studies providing that one of the above-mentioned techniques is more effective than the other. Actually, based on clear evidence, it is suggested that there is a similarity in the overall mortality rate when the above techniques are used, whereas the postoperative mortality rate is affected by operation selection criteria. A prospective study by [25] found that lesser sac drainage, with or without lavage influenced several early predictors and outcomes in patients with severe acute necrotizing pancreatitis. Based on seven prognostic indicators, *viz.* base excess, CRP, blood glucose, hematocrit, immunoreactive phospholipase A2 concentration, serum creatinine and white blood cells, lavage showed no predominance over drainage in the first four days after surgery. Moreover, the study did not indicate that lavage had any positive effect on mortality or on septic complications in the course of acute necrotizing pancreatitis. Moreover, patients treated with closed drainage and irrigation experienced more complications than patients managed with closed drainage only.

The surgical technique should be selected based on clinical experience and local knowledge [30]. Infection occurs in 8–12% of cases of acute pancreatitis, and in up to 70% of cases of necrotic pancreatitis. Additionally, the occurrence of infection increases mortality in the case of surgical intervention being delayed [5]. A new technique for the surgical debridement of infected necrosis, by reaching the cavity along the path of a percutaneously inserted drain, has the potential to debride necrotic tissue with insignificant systemic disturbance. After reaching the cavity with the drain, an operating necroscope is used to debride the cavity thoroughly and fragmentarily.

In order to achieve complete debridement, several sessions may be required. The cavity is constantly irrigated after the surgery [30]. Until the 1970s, open surgical debridement of necrotic tissue and simple postoperative drainage represented the standard treatment of infection in acute pancreatitis and acute necrotizing pancreatitis. However, the mortality rate was high, mainly due to recurrent sepsis that required reoperation.

The open surgical debridement technique applied for the last 20 years includes open laparostomies, 'second-look' procedures, necrosectomy with simple drainage, and necrosectomy with postoperative lavage with packing. Thanks to the development of surgical techniques such as open packing and the usage of prolonged postoperative lavage, the death rate for surgical interventions in acute pancreatitis has decreased. However, the death rate for these techniques in infected necrotic acute pancreatitis might exceed 60% [25].

Carter et al. [5] examine the use of minimally-invasive techniques for the debridement of necrotic tissues, and the procedure used for continuous postoperative lavage of the abscess cavity. The study included patients with infected necrosis secondary to acute pancreatitis. In some of the individuals with secondary sepsis, sinus tract endoscopy was provided along a drainage tract following open necrosectomy. The rest of the patients diagnosed with sepsis underwent primary debridement during percutaneous necrosectomy. In patients who develop a secondary infection in severe AP, multiple surgical interventions were required in approximately 25–35% of cases.

Each surgical procedure carries a risk of clinical aggravation, which may eventually lead to the death of the patient before improvement occurs; as such, it is important to minimize the negative impact of subsequent operations. Therefore, appropriate primary surgery involving thorough debridement and creation of a fluid-filled cavity in the retroperitoneum should be performed with the use of lavage.

Sterile necrotizing pancreatitis

The treatment of sterile necrotizing pancreatitis, i.e. negative fine-needle aspiration for bacteriology, consists of conservative treatment, with interventional procedures in selected cases [26]. Dervenis et al. [7] report that surgical debridement is often necessary in infected pancreatic necrosis, but less often needed in the case of sterile necrosis. Surgical treatment and other forms of interventional management should be performed using a method that prevents adjacent tissues and organs from injury, that is based on the organ-preserving approach. It includes debridement or necrosectomy, and postoperative management that aims to maximize the postoperative evacuation of retroperitoneal exudate and debris [26].

However, the type of surgical technique used during necrosectomy, as well as the consecutive postoperative treatment, depend on the competence of the attending physician and available means [16].

RESECTION IN PANCREATITIS

Most published papers indicating pancreatic resection as a surgical method of treating pancreatitis concern recurrent acute pancreatitis and chronic pancreatitis. The associated recurrent and chronic inflammation lead to progressive and irreversible damage of the pancreas, which consequently loses its exocrine and endocrine functions. Removal of the inactive injured pancreatic tissue is then justified. In acute pancreatitis, the inflammatory process leads to life-threatening complications such as peritonitis, sepsis and intra-abdominal hemorrhage. Acute necrotizing pancreatitis can become infected, also leading to dangerous septic complications. However, as progressive inflammation within the pancreas significantly limits pancreatic function, resection is performed only in certain severe cases, such as acute fulminant pancreatitis. In this case, the inflammation is a source of toxic agents that cause distant organ complications. Other intervention techniques that can be used in the management of AP include cholecystectomy and ERCP in the case of acute gallstone pancreatitis, or surgical necrosectomy or radiological drainage of necrotic tissue in the case of necrotic pancreatitis [15, 23].

An extraordinarily serious disease is acute fulminant (hemorrhagic) pancreatitis, with a mortality rate exceeding 80% when conventional supportive treatment is administered. In such cases, various more aggressive therapeutic approaches are recommended, such as lavation of the peritoneal cavity and ablative surgery of the diseased pancreas. The above-mentioned techniques are useful since the injured pancreas releases toxins, such as histamine-releasing agent, phospholipase A, or vasoactive kinins, into the peritoneal cavity and circulation. These, in turn, unfavorably affect the organ systems, leading to complications of the remote organs and ultimately to the death of the patient. Subtotal pancreatectomy, i.e. distal pancreatic resection that includes the neck/body and tail of the pancreas, is justified in the active phase of the disease: during this period, relatively normal pancreatic tissue may release toxic substances when inflamed, and may be more harmful than devitalized tissue. However, it has been suggested that peritoneal lavation may wash out toxins, which may alleviate remote organ complications associated with this disease, as well as decrease mortality. Previous studies have compared non-operative peritoneal lavage with early

pancreatic resection to determine their effectiveness in the early treatment of acute fulminant pancreatitis [15, 23].

Kivilaakso et al. [15] suggested that pancreatic resection is more effective in treating acute fulminant pancreatitis than peritoneal lavation: patients who underwent pancreatectomy showed a significantly lower mortality rate. However, the difference was not significant due to the relatively small size of the study group. The most common cause of death among patients was the incidence of septic complications with multiple organ failure. Other causes of death were complications affecting the airways, followed by respiratory failure and cardiac arrest, failure of the respiratory, renal, cardiovascular and other vital organ systems due to a prolonged and complicated course of disease [15].

Another advantage of resection of the pancreas is the lower incidence of complications. However, the incidence of septic complications, i.e., sepsis and/or intra-abdominal abscesses, did not differ between patients treated with pancreatectomy and those managed with peritoneal lavation. Nevertheless, the lavation group demonstrated a higher incidence of pulmonary and renal complications, with slightly higher severity. Additionally, reoperation was found to be required more frequently among the subjects managed with peritoneal lavation [15].

The two groups demonstrated similar lengths of hospitalization. Interestingly, the study shows that patients who undergo pancreatic resection may develop diabetes, which is usually mild and easy to treat: most patients only require oral medications and a proper diet. The post-peritoneal lavage patients did not develop diabetes. In general, the study proves the superiority of pancreatic resection over peritoneal lavation. However, the procedure of pancreatic resection is more demanding due to longer operation time, greater blood loss, and requires a trained team of surgeons [15].

Additionally, the benefits of this procedure, such as a greater survival and reduced risk of complications, are achieved at the cost of a higher incidence of postoperative diabetes [15]. On the other hand, Schroder et al. [25] indicate that the use of intensive conservative treatment in initial therapy, even in the most severe AP cases, is justified. Early pancreatectomy did not eliminate the development of necrosis, neither in the remaining part of the pancreas after resection, nor in the peripancreatic area. Moreover, pancreatic resection significantly extended treatment time in the intensive care unit (25.9 days) compared to peritoneal lavage (16.2 days) and hospitalization time (56.1 days in the resection group and 44.3 days in the lavage group). Serious complications occurred with the same frequency in

both groups of the patients. Furthermore, the mortality rate was higher in the resection group. The cause of death in all the patients was multiple organ failure.

In conclusion, considering the contradictory results of the studies presented above, the choice of intervention technique in the course of acute fulminant pancreatitis should be made based on the knowledge and experience of the clinician.

CONCLUSIONS

It is important for the clinician to be aware of the anatomical variants of the pancreas to ensure appropriate planning of surgical procedures, and to prevent inadvertent damage to the pancreatic ducts. In addition, these variations may increase the chance of recurrent pancreatitis or gastric outlet obstruction. The use of appropriate and accurately-performed non-invasive interventions using percutaneous or endoscopic techniques can avoid numerous surgical explorations, thus reducing the risk of exacerbation. Moreover, minimally-invasive surgical techniques, used in management of secondary infection in AP, consistently present advantages over open surgery, such as slighter activation of the inflammatory response and reduced incidence of local sepsis. Nevertheless, these operating techniques also have disadvantages, such as inadequate or incomplete evacuation of necrotic tissue. In patients with sterile necrosis, it is recommended to avoid surgeries, adopt a more conservative approach to infected necrosis with delayed endoscopic or surgical interventions, and manage acute gallstone pancreatitis by preventive cholecystectomy. Most importantly, the method of surgical or operative treatment should be adapted to the clinical condition.

ARTICLE INFORMATION AND DECLARATIONS

Availability of data and materials

Please contact authors for data requests (Nicol Zielinska).

Authors' contributions

Project development: JW. Management: JW, ŁO. Data collection: JW. Data analysis: JW, NZ, BS, PŁ, MG, JM, IK, ŁO. Data management: JW. Manuscript writing: JW. Manuscript editing: NZ, BS, PŁ, MG, JM, IK, ŁO.

Ethical approval and consent to participate

Not applicable.

Funding

The authors have no financial or personal relationship with any third party whose interests could be positively or negatively influenced by the article's content. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors declare that they have no competing interests.

REFERENCES

1. Alsaad AA, Dhannoon SM, Phillips MB. Disconnected pancreatic duct syndrome: a multidisciplinary management dilemma. BMJ Case Rep. 2016; 2016, doi: 10.1136/bcr-2016-217099, indexed in Pubmed: 27803085.
2. Arsenijevic T, Perret J, Van Laethem JL, et al. Aquaporins involvement in pancreas physiology and in pancreatic diseases. Int J Mol Sci. 2019; 20(20), doi: 10.3390/ijms20205052, indexed in Pubmed: 31614661.
3. Banks PA, Bollen TL, Dervenis C, et al. Acute Pancreatitis Classification Working Group. Classification of acute pancreatitis — 2012: revision of the Atlanta classification and definitions by international consensus. Gut. 2013; 62(1): 102–111, doi: 10.1136/gutjnl-2012-302779, indexed in Pubmed: 23100216.
4. Banks PA, Gerzof SG, Langevin RE, et al. CT-guided aspiration of suspected pancreatic infection: bacteriology and clinical outcome. Int J Pancreatol. 1995; 18(3): 265–270, doi: 10.1007/BF02784951, indexed in Pubmed: 8708399.
5. Carter CR, McKay CJ, Imrie CW. Percutaneous necrosectomy and sinus tract endoscopy in the management of infected pancreatic necrosis: an initial experience. Ann Surg. 2000; 232(2): 175–180, doi: 10.1097/00000658-200008000-00004, indexed in Pubmed: 10903593.
6. Cordemans C, De Laet I, Van Regenmortel N, et al. Fluid management in critically ill patients: the role of extravascular lung water, abdominal hypertension, capillary leak, and fluid balance. Ann Intensive Care. 2012; 2(Suppl. 1): S1, doi: 10.1186/2110-5820-2-S1-S1, indexed in Pubmed: 22873410.
7. Dervenis C, Johnson CD, Bassi C, et al. Diagnosis, objective assessment of severity, and management of acute pancreatitis. Santorini consensus conference. Int J Pancreatol. 1999; 25(3): 195–210, doi: 10.1007/BF02925968, indexed in Pubmed: 10453421.

8. Dimitriou I, Katsourakis A, Nikolaidou E, et al. The main anatomical variations of the pancreatic duct system: review of the literature and its importance in surgical practice. J Clin Med Res. 2018; 10(5): 370–375, doi: 10.14740/jocmr3344w, indexed in Pubmed: 29581798.

9. Dolenšek J, Rupnik MS, Stožer A. Structural similarities and differences between the human and the mouse pancreas. Islets. 2015; 7(1): e1024405, doi: 10.1080/19382014.2015.1024405, indexed in Pubmed: 26030186.

10. Fan ST, Lai EC, Mok FP, et al. Early treatment of acute biliary pancreatitis by endoscopic papillotomy. N Engl J Med. 1993; 328(4): 228–232, doi: 10.1056/NEJM199301283280402, indexed in Pubmed: 8418402.

11. Freeny PC, Hauptmann E, Althaus SJ, et al. Percutaneous CT-guided catheter drainage of infected acute necrotizing pancreatitis: techniques and results. AJR Am J Roentgenol. 1998; 170(4): 969–975, doi: 10.2214/ajr.170.4.9530046, indexed in Pubmed: 9530046.

12. Gao YJ, Li YQ, Wang Q, et al. Analysis of the clinical features of recurrent acute pancreatitis in China. J Gastroenterol. 2006; 41(7): 681–685, doi: 10.1007/s00535-006-1820-3, indexed in Pubmed: 16933006.

13. Gerzof SG, Banks PA, Robbins AH, et al. Early diagnosis of pancreatic infection by computed tomography-guided aspiration. Gastroenterology. 1987; 93(6): 1315–1320, doi: 10.1016/0016-5085(87)90261-7, indexed in Pubmed: 3678750.

14. Johnson CD. Timing of intervention in acute pancreatitis. Postgrad Med J. 1993; 69(813): 509–515, doi: 10.1136/pgmj.69.813.509, indexed in Pubmed: 8415340.

15. Kivilaakso E, Lempinen M, Mäkeläinen A, et al. Pancreatic resection versus peritoneal lavation for acute fulminant pancreatitis. A randomized prospective study. Ann Surg. 1984; 199(4): 426–431, doi: 10.1097/00000658-198404000-00009, indexed in Pubmed: 6712318.

16. Leppäniemi A, Tolonen M, Tarasconi A, et al. 2019 WSES guidelines for the management of severe acute pancreatitis. World J Emerg Surg. 2019; 14: 27, doi: 10.1186/s13017-019-0247-0, indexed in Pubmed: 31210778.

17. Machicado JD, Yadav D. Epidemiology of recurrent acute and chronic pancreatitis: similarities and differences. Dig Dis Sci. 2017; 62(7): 1683–1691, doi: 10.1007/s10620-017-4510-5, indexed in Pubmed: 28281168.

18. Mithöfer K, Mueller PR, Warshaw AL. Interventional and surgical treatment of pancreatic abscess. World J Surg. 1997; 21(2): 162–168, doi: 10.1007/s002689900209, indexed in Pubmed: 8995072.

19. Mowery NT, Bruns BR, MacNew HG, et al. Surgical management of pancreatic necrosis: A practice management guideline from the Eastern Association for the Surgery of Trauma. J Trauma Acute Care Surg. 2017; 83(2): 316–327, doi: 10.1097/TA.0000000000001510, indexed in Pubmed: 28452889.

20. Neoptolemos JP, Carr-Locke DL, London NJ, et al. Controlled trial of urgent endoscopic retrograde cholangiopancreatography and endoscopic sphincterotomy versus conservative treatment for acute pancreatitis due to gallstones. Lancet. 1988; 2(8618): 979–983, doi: 10.1016/s0140-6736(88)90740-4, indexed in Pubmed: 2902491.

21. Rau B, Pralle U, Mayer JM, et al. Role of ultrasonographically guided fine-needle aspiration cytology in the diagnosis of infected pancreatic necrosis. Br J Surg. 1998; 85(2): 179–184, doi: 10.1046/j.1365-2168.1998.00707.x, indexed in Pubmed: 9501810.

22. Röder PV, Wu B, Liu Y, et al. Pancreatic regulation of glucose homeostasis. Exp Mol Med. 2016; 48(3): e219, doi: 10.1038/emm.2016.6, indexed in Pubmed: 26964835.

23. Schröder T, Sainio V, Kivisaari L, et al. Pancreatic resection versus peritoneal lavage in acute necrotizing pancreatitis. A prospective randomized trial. Ann Surg. 1991; 214(6): 663–666, doi: 10.1097/00000658-199112000-00004, indexed in Pubmed: 1741645.

24. Suda K, Nobukawa B, Takase M, et al. Pancreatic segmentation on an embryological and anatomical basis. J Hepatobiliary Pancreat Surg. 2006; 13(2): 146–148, doi: 10.1007/s00534-005-1039-3, indexed in Pubmed: 16547676.

25. Teerenhovi O, Nordback I, Eskola J. High volume lesser sac lavage in acute necrotizing pancreatitis. Br J Surg. 1989; 76(4): 370–373, doi: 10.1002/bjs.1800760418, indexed in Pubmed: 2655822.

26. Uhl W, Warshaw A, Imrie C, et al. IAP Guidelines for the surgical management of acute pancreatitis. Pancreatology. 2002; 2(6): 565–573, doi: 10.1159/000067684.

27. Wang GJ, Gao CF, Wei D, et al. Acute pancreatitis: etiology and common pathogenesis. World J Gastroenterol. 2009; 15(12): 1427–1430, doi: 10.3748/wjg.15.1427, indexed in Pubmed: 19322914.

28. Weiss FU, Laemmerhirt F, Lerch MM. Etiology and risk factors of acute and chronic pancreatitis. Visc Med. 2019; 35(2): 73–81, doi: 10.1159/000499138, indexed in Pubmed: 31192240.

29. Working Group IAP/APA Acute Pancreatitis Guidelines. IAP/APA evidence-based guidelines for the management of acute pancreatitis. Pancreatology. 2013; 13(4 Suppl 2): e1–15, doi: 10.1016/j.pan.2013.07.063, indexed in Pubmed: 24054878.

30. Working Party of the British Society of Gastroenterology, Association of Surgeons of Great Britain and Ireland, Pancreatic Society of Great Britain and Ireland, Association of Upper GI Surgeons of Great Britain and Ireland. UK guidelines for the management of acute pancreatitis. Gut. 2005; 54 Suppl 3(Suppl 3): iii1–iii9, doi: 10.1136/gut.2004.057026, indexed in Pubmed: 15831893.

31. Wu X, Zheng R, Lin H, et al. [Effect of transpulmonary pressure-directed mechanical ventilation on respiration in severe acute pancreatitis patient with intraabdominal hypertension]. Zhonghua Yi Xue Za Zhi. 2015; 95(39): 3168–3172, indexed in Pubmed: 26814111.

32. Zhou Q, Melton D. Pancreas regeneration. Nature. 2018; 557(7705): 351–358, doi: 10.1038/s41586-018-0088-0.