

Chapter

Surgical Update on the Management of Necrotizing Pancreatitis: Step-Up Approach

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Abstract

Acute pancreatitis (AP) is an inflammatory condition of the pancreatic gland with or without involvement of peripancreatic tissues and distant organs. The incidence of AP is 20–35 cases per 100,000 inhabitants per year, with an overall mortality of 2–10%. In recent decades, the incidence of AP has increased globally. Most cases follow a mild, self-limiting course, but 10–20% of patients develop a severe form with systemic and local life-threatening complications of pancreatic, and peripancreatic necrosis come about 20–40% of patient with severe AP and aggravate organ functions. The traditional approach to the treatment of necrotizing pancreatitis with secondary infection of necrotic tissue is open necrosectomy to remove the infected necrotic tissue. But this is associated with high rates of complications, death, and pancreatic insufficiency. The benefits of sequential treatment in cases of infected necrosis (“Step an approach”) compared to traditional open necrosectomy, showing less morbidity and lower costs. The sequential treatment is an alternative to open necrosectomy, including percutaneous drainage, endoscopic (transgastric) drainage, and minimally invasive retroperitoneal necrosectomy. With this approach, up to 35% of patients can be treated only with drainage, to avoid necrosectomy and to reduce the percentage of complications.

Keywords: necrotizing pancreatitis step-up approach, acute pancreatitis, percutaneous, endoscopic, necrosectomy

1. Introduction

Acute pancreatitis (AP) is one of the most common causes for gastrointestinal-related office visits and admissions to hospital pancreatitis. AP is an inflammatory condition of the pancreas that may or may not involve surrounding tissues and distant organs [1]. The incidence of AP ranges from 20 to 35 cases per 100,000 people annually, with an overall mortality rate of 2–10% [1]. Over the past few decades, the global incidence of AP has risen and is expected to continue increasing. The most common

cause is gallstone disease, responsible for approximately 40–50% of cases, followed by alcohol use, particularly in males, which accounts for over 30%. In 10–25% of cases, the cause remains unidentified.

Regardless of the underlying etiology, precipitating factors elicit supraphysiological intracellular signaling pathways that culminate in the premature activation of trypsin within zymogen granules. This aberrant enzyme activation leads to acinar cell injury and necrosis, subsequently triggering a cascade of local and systemic inflammatory responses. Most patients experience a mild, self-limiting form of the condition, but 10–20% develop severe pancreatitis [2–6], leading to life-threatening complications such as pancreatic and peripancreatic necrosis. This severe form occurs in 20–40% of cases and can lead to further organ dysfunction.

Infected pancreatic necrosis remains one of the most challenging and potentially life-threatening complications of acute pancreatitis. The progressive nature of this condition, characterized by the presence of necrotic pancreatic tissue and infection, often leads to multi-organ failure and high mortality rates if not properly managed. Surgical intervention holds a critical role in the treatment, particularly when conservative measures, such as antibiotics and drainage, are insufficient.

In recent years, the approach to managing infected pancreatic necrosis has evolved significantly. Advances in imaging techniques, minimally invasive surgery, and endoscopic interventions have revolutionized the way we address this complex condition. The step-up approach, which advocates for a staged escalation of treatment, has become the gold standard for many patients, with initial drainage followed by debridement when necessary. However, selecting the appropriate surgical strategy remains a subject of ongoing debate, as each patient presents unique challenges related to the location and extent of the necrosis.

Infected necrosis [7] is identified by the presence of Gram-positive bacteria in necrotic pancreatic or peripancreatic tissue, detected either by fine-needle aspiration or during initial drainage or surgery, or by the presence of gas in the fluid collection on contrast-enhanced computed tomography (CT). Suspected infected necrosis is characterized by ongoing sepsis or worsening clinical conditions in the intensive care unit without confirmed infected necrosis. Organ failure affects 40% of patients with pancreatic necrosis, though it can occasionally occur in cases without necrosis. Mortality rates rise to 30% when infection is present in the pancreatic or peripancreatic necrosis. Over the past decade, there have been significant advances in understanding the disease's presentation and progression. An expert consensus panel has also redefined how pancreatic fluid collections are categorized (Appendices A and B).

This chapter aims to provide an updated overview of the surgical management of infected pancreatic necrosis, focusing on the latest advancements in techniques, timing, and patient selection. We will explore current evidence-based practices, discuss the benefits and limitations of various surgical approaches, and examine the role of novel technologies in improving patient outcomes. As the field continues to evolve, a comprehensive understanding of these strategies is essential for optimizing.

2. Step-up approach

The “step up” strategy is nowadays the strategy validated by several consensus conferences for the treatment of necrosis infection occurring in severe acute pancreatitis as described [3]. Multicenter randomized clinical trial PANTER [7] demonstrated that a step-up approach for the treatment of necrotizing pancreatitis reduces

mortality, multi-organ failure, healthcare costs, and late surgical complications. The step-up approach involves percutaneous catheter drainage or endoscopic transluminal drainage, followed by minimally invasive necrosectomy only when clinically indicated [8], and is currently the standard of care.

The surgical step-up approach has demonstrated [2] a reduction in the composite outcome of mortality and major complications in patients with infected necrotizing pancreatitis when compared to primary open necrosectomy. Notably, approximately 35% of patients achieve clinical resolution with catheter drainage alone. Despite initial concerns that minimally invasive techniques might lead to higher rates of re-intervention due to residual necrotic collections or delayed complications, subsequent long-term follow-up by the same research group has countered this notion, reinforcing the advantages of a step-up approach. It is important to recognize the significant heterogeneity of necrotizing pancreatitis, which necessitates individualized therapeutic strategies and may still warrant open necrosectomy in select cases. Nevertheless, national data continue to support the long-term efficacy and superiority of minimally invasive step-up interventions [9, 10] in the management of infected necrotizing pancreatitis.

2.1 Percutaneous catheter drainage

Infected pancreatic or peripancreatic necrosis can develop within the first 3 weeks following the onset of acute necrotizing pancreatitis. For patients in the early stages of the disease (within 2 to 4 weeks) who have either suspected or confirmed infected necrosis without a walled-off collection and are not responding to conservative treatment, percutaneous drainage may be an effective and safe method for drainage and controlling the infection.

The preferred technique for percutaneous drainage involves accessing the retroperitoneal space on the left side, as this allows for easier minimally invasive surgical intervention if necessary (**Figure 1**). Current data suggests that around 35% of



Figure 1. CT scan revealing a left retroperitoneal collection, which is easily accessible for percutaneous drainage and permits a retroperitoneal laparoscopic approach.

patients receiving percutaneous drainage during the walled-off necrosis (WON) phase do not require further surgical intervention [8]. In some cases, where the drainage catheter size is gradually increased, success rates can reach up to 50%. The necrotic cavity is typically irrigated with saline 3 to 4 times a day, relying on gravity for drainage. Depending on the number, size, and connection of the collections, multiple drainage tubes may be placed. A large multicenter cohort study revealed that 35% of patients managed with primary percutaneous drainage did not need any further treatment [10]. Additionally, two prospective randomized trials [11, 12] comparing various management strategies for symptomatic WON found that percutaneous drainage was successful in 35 and 51% of patients, respectively.

Based on recent evidence, current guidelines recommend using percutaneous drainage when endoscopic options are not available, unsuccessful, or technically infeasible. Another key advantage of percutaneous drainage is that it can serve as an entry point for other minimally invasive debridement procedures, such as video-assisted retroperitoneal debridement (VARD).

The POINTER study [13] is a multicenter, randomized clinical trial comparing long-term outcomes of two treatment approaches in patients with infected necrotizing pancreatitis: immediate drainage and delayed drainage. The objective is to compare long-term outcomes of immediate drainage versus delayed drainage in patients with infected necrotizing pancreatitis. In this study, 104 patients with infected necrotizing pancreatitis were randomly assigned to two groups: Immediate Drainage: Catheter drainage within 24 hours of diagnosis or Delayed Drainage: Initial treatment with antibiotics and catheter drainage only if necessary later. The delayed drainage approach, utilizing antibiotics, resulted in fewer interventions compared to immediate drainage and should be the preferred approach for treating infected necrotizing pancreatitis. Additionally, no significant differences were observed in pancreatic function and long-term quality of life between the two groups. The study suggests that antibiotic treatment may be effective for many patients, reducing the need for invasive interventions.

2.2 Transgastric endoscopic drainage

Endoscopic procedures are especially beneficial for treating central pancreatic collections and pancreatic necrosis (**Figure 2**). Necrosis can occur in the head, body, or tail of the pancreas and can be approached endoscopically either through the stomach (transgastrically) or the duodenum (transduodenally), depending on the size and positioning of the necrotic area relative to these structures. The step-up approach, whether performed surgically or endoscopically, has been evaluated in two major randomized studies. In the TENSION trial [11], it was found that the endoscopic step-up approach did not show superiority over surgery in terms of major complications or mortality; however, the endoscopic group had fewer pancreatic fistulas and a shorter length of hospital stay. Similarly, the MISER trial [14] demonstrated that an endoscopic transluminal approach for infected necrotizing pancreatitis led to fewer complications, reduced costs, and improved quality of life when compared to minimally invasive surgery.

The timing for drainage in patients with walled-off necrosis (WON) remains an area of active research. Traditionally, waiting 4 weeks for necrotic tissue to mature and wall off has been standard practice, influenced by surgical guidelines. Newer evidence, however, supports initiating endoscopic step-up therapy before the four-week mark when appropriate, and this approach has been associated with lower mortality when patients are managed in this manner [15]. As a result, endoscopic management has become the

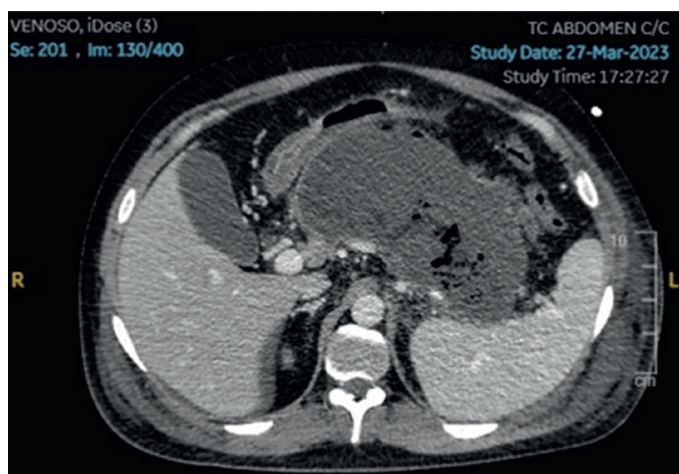


Figure 2.
Abdominal CT scan showing a large retrogastric collection, amenable to transgastric drainage.

recommended approach for infected necrotizing pancreatitis in recent years [16–20]. Large-bore percutaneous drainage, combined with either standard or therapeutic endoscopy, allows for direct removal of necrotic tissue, promoting quicker debridement and less invasive procedures. Nonetheless, this method may not be suitable for all patients, as its effectiveness depends on factors like the anatomical location of necrosis, the availability of specialized equipment, and the expertise of the medical center.

In cases where necrotic collections are large or extend into the pelvic or paracolic regions, a combined approach involving both endoscopic transluminal and percutaneous drainage (dual-modality drainage) may be necessary. Currently, metal stents are most commonly used for endoscopic drainage between the stomach and infected collections. Although originally developed in 2011, these stents have since been replaced by plastic stents, which have a wider lumen that



Figure 3.
Abdominal CT image demonstrating transgastric drainage of an acute necrotic collection.

facilitates better drainage and improves access for transluminal necrosectomy. A randomized trial comparing metal and plastic stents (**Figure 3**) for drainage in infected pancreatic necrosis found no significant differences in hospital stay length, readmissions, or procedure numbers [21]. However, metal stents were more costly and associated with complications like stent migration. Therefore, current guidelines [21, 22] recommend the use of either metallic stents or double-pigtail plastic stents for endoscopic drainage, with stent removal typically occurring after 4 weeks to minimize risks.

3. Phased approach in the surgical treatment of necrotizing pancreatitis

For a long time, surgical resections with pancreatic were the first treatment option for acute necrotizing pancreatitis as a desperate measure to change the lethal course of the disease and its high mortality. Over time, scientific evidence showed that despite the aggressiveness of such management, mortality and morbidity rates remained high. This causes a change in the handling towards a more conservative and personalized form creating specific indications for surgical treatment.

3.1 Surgery is needed in the first hours of admission for severe necrotizing pancreatitis

In the early phase of pancreatitis, pancreas surgery is not usually performed, although many visceral complications may require urgent surgery: intestinal necrosis, hemorrhage, and abdominal compartment syndrome.

3.1.1 Abdominal compartment syndrome (ACS)

Abdominal Compartment Syndrome (ACS) is an uncommon but severe complication of acute pancreatitis. Increased intra-abdominal pressure (IAP), or high intra-abdominal pressure (HIAP), refers to the pathological, sustained, or recurrent rise in IAP above 12 mmHg. ACS is characterized by a persistent increase in IAP exceeding 20 mmHg, accompanied by the onset of organ failure. When conservative measures fail, and IAP remains above 25 mmHg with associated organ dysfunction or failure, emergency abdominal surgical decompression is warranted. Common conservative interventions include nasogastric tubes, rectal tubes, epidural catheters for pain management, and percutaneous intra-abdominal catheters. Although percutaneous drainage of pancreatic ascites can temporarily reduce IAP in some instances, surgical decompression [23] remains the definitive approach to relieve HIAP and restore organ function, particularly in the pulmonary, cardiovascular, and renal systems. Laparotomy may be necessary for patients with abdominal hypertension, although conservative management is the preferred approach at present. The DECOMPRESS [24] study aims to assess whether decompressive laparotomy with temporary abdominal closure reduces mortality and major morbidity compared to percutaneous abdominal catheter placement in ACS patients.

There are three primary surgical options for decompression in patients without an incision. The long vertical midline incision is the most employed technique, shown to effectively reduce IAP. It is quick and simple to perform; however, it carries a risk of intestinal fistula formation and often results in failure to close the fascia, necessitating complex reconstructive surgery at a later stage [25]. Transverse laparostomy

[26] offers a promising alternative, with isolated reports demonstrating its efficacy in lowering IAP and improving access to pancreatic tissue for necrosectomy when necessary. Although it requires slightly more time to perform than a midline laparostomy, the same principles for managing the open abdomen apply.

A third option, used primarily in severe acute pancreatitis (SAP), is the subcutaneous linea alba fasciotomy [27], where the fascia is incised through three small skin incisions, leaving the skin and peritoneum intact. However, this approach invariably results in a ventral hernia that will require subsequent repair.

Various temporary abdominal closure (TAC) methods have been proposed for managing an open abdomen [28]. The ideal method should be simple to implement and remove, provide quick access for subsequent surgical procedures, facilitate drainage of abdominal secretions, support primary closure, and result in acceptable morbidity and mortality rates. One of the most straightforward and cost-effective approaches is simply approximating the skin with a continuous running suture or using towel clips. Another common method is the plastic silo, often referred to as the Bogotá bag (**Figure 4**), which involves a non-adherent plastic sheet, typically derived from a sterile 3-liter urology irrigation bag, being sutured between the fascial edges or over the skin.

In 1995, Barker and his team introduced the vacuum pack technique [8], where a perforated plastic sheet is placed over the viscera, with sterile surgical towels filling the wound and a drain attached to continuous negative pressure. This system was further refined with the introduction of a polyurethane sponge and an adjustable pump (**Figure 5**), allowing for precise control of negative pressure. This modification has several benefits, including fewer dressing changes, improved vascularization of the wound, reduced bacterial growth, and prolonged opportunities for definitive closure of the fascia.

A further advancement involved the use of a spider-like sponge, which not only enhances fluid drainage but also improves wound contraction. This technique has been associated with a primary fascial closure rate of 89% [29, 30]. Acosta, in turn, described a combined approach that utilized the VAC system alongside a polypropylene mesh placed along the fascial edges to maintain traction, leading to a fascial closure rate of 76.6% [31]. While many modifications of these techniques have been

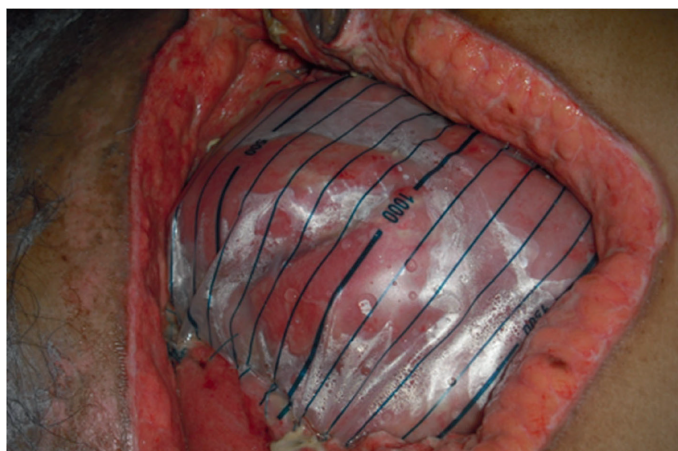


Figure 4.
Temporary closure of abdominal wall by means of bogota bag is shown.



Figure 5.
Temporary open abdomen closure system type VAC is shown.

documented, a standardized approach for managing patients with an open abdomen remains elusive.

3.1.2 Visceral complications: Intestinal necrosis and perforations

The anatomical relationships between the large intestine and the pancreas (**Figure 6**) play a significant role in the development and localization of related lesions. Enzymatic inflammation and ischemic processes are frequently implicated

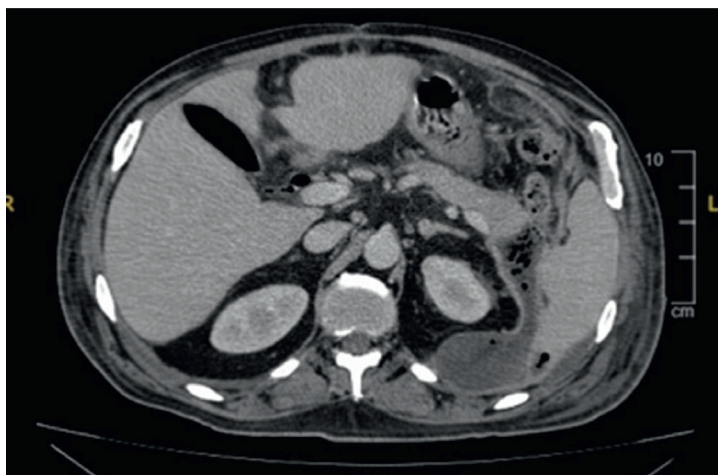


Figure 6.
Abdominal CT scan revealing a collection in the left flank with air, secondary to perforation of the splenic flexure of the colon, due to its proximity to the pancreatic tail.

in most theoretical models. Acute necrotizing pancreatitis can lead to a range of complications, with colonic perforation being a relatively rare occurrence [32]. The site of perforation can involve nearly any segment of the colon, although it is most seen at the splenic flexure [33, 34]. In addition to colonic perforation, other instances of perforations within the intestinal tract, such as those in the duodenum [35], have been documented, albeit infrequently. In some cases, dual perforations involving both the colon and duodenum have been reported, and there are instances of concomitant gastric and colonic perforations in the same patient.

In the presence of intestinal ischemia or perforation of hollow viscera, laparotomy is essential (**Figures 7 and 8**). Many patients require ostomies, multiple surgical interventions, and the application of open abdominal techniques.

3.1.3 Hemorrhage

The most frequent cause of hemorrhage in acute pancreatitis is the formation of arterial pseudoaneurysms. An arterial pseudoaneurysm, also known as a false aneurysm, is a collection of blood that forms due to partial disruption of the arterial wall, resulting in hemorrhage contained within a sac formed by perivascular tissue or surrounding structures, rather than by the layers of the arterial wall itself. The development of arterial pseudoaneurysms in the context of pancreatitis is a rare yet serious complication (**Figure 9**) [36]. A ruptured pseudoaneurysm leading to bleeding into the gastrointestinal tract, pancreatic duct, retroperitoneum, or peritoneal cavity constitutes one of the most rapidly fatal complications associated with pancreatitis. Visceral arteries exposed to proteolytic pancreatic enzymes often exhibit localized arteritis and damage to the vessel wall, potentially resulting in pseudoaneurysm formation or hemorrhage into an existing pseudocyst. Arterial complications in pancreatitis are observed in approximately 4–10% of patients, with an untreated mortality rate reaching 90%.

Management options include operative treatment and interventional procedures, either used alone or as a temporizing measure before a definitive operation. Coil embolization should be the first approach, provided the patient is hemodynamically



Figure 7. Ischemic small intestine segment is shown by enzymatic reaction of acute pancreatitis.

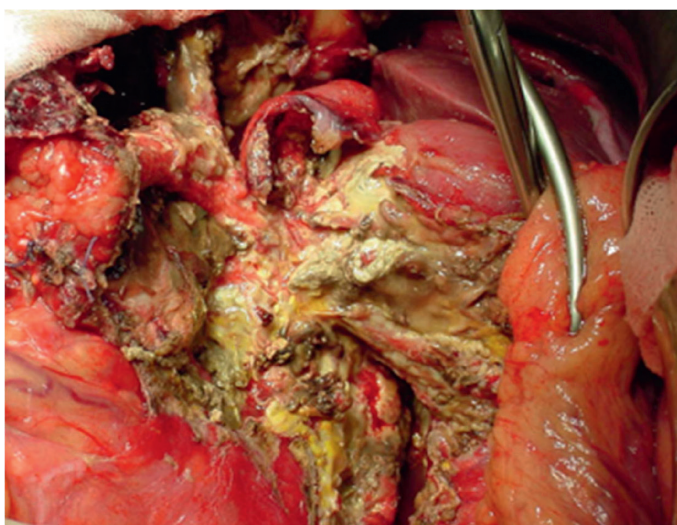


Figure 8.
Is shown enzymatic reaction of pancreatitis that has completely digested the vessels of the meso colon.



Figure 9.
Abdominal CT scan showing a large pseudosplenic artery aneurysm in the context of necrotizing pancreatitis.

stable (**Figure 10**). If embolization proves successful, no further intervention may be necessary. However, failure of embolization warrants surgical intervention. If the patient's overall condition and the inflammatory state of the pancreas permit, partial pancreatectomy is generally preferred over vessel ligation.

3.2 Surgical necrosectomy

Surgical debridement should be considered for patients with infected pancreatic necrosis or for those with sterile necrosis who develop persistent organ dysfunction.

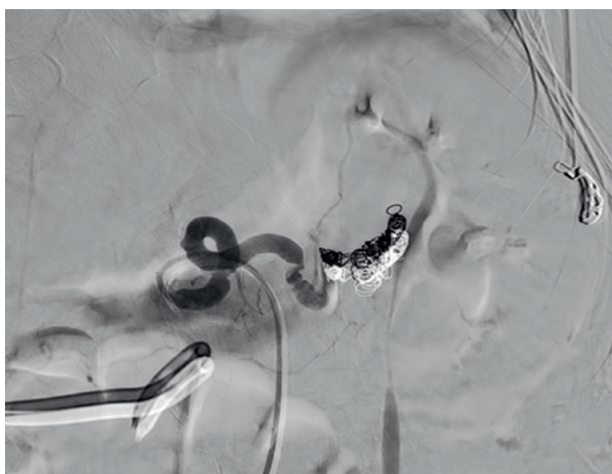


Figure 10.
Aortografía image with pseudoaneurysm of splenic artery embolized by metal coils.

While percutaneous or endoscopic drainage alone may lead to improvement in 23–47% of cases, surgery is often necessary for patients with continuing disease [7, 37, 38]. The primary objectives of debridement are to eliminate the infection source, reduce necrotic tissue, and limit the inflammatory response in critically ill patients. In recent years, there has been a shift towards less invasive techniques. Available surgical options include VARD (step-up approach), laparoscopic or open transgastric debridement, and traditional open debridement. Each approach offers its own set of benefits and challenges, which should be assessed individually for each patient.

The timing of the procedure plays a critical role in patient outcomes [12]. Performing surgery early in the course of acute pancreatitis—before the patient enters the subacute phase (within 2–4 weeks of onset)—has been linked to higher mortality rates compared to waiting for the disease to stabilize. Ultimately, the goal of surgical debridement is to manage infection, alleviate necrotic tissue, and minimize the inflammatory response to the procedure.

3.2.1 Video-assisted retroperitoneal debridement (VARD) in infected necrotizing pancreatitis

How we have seen so far: The step-up approach includes percutaneous drainage combined with other minimally invasive techniques such as endoscopic necrosectomy or video-assisted retroperitoneal debridement (VARD).

Several techniques have been described, including video-assisted retroperitoneal access, which has been associated with significantly lower rates of abdominal complications compared to more traditional methods. This technique utilizes radiological drainage as a guide to the collection, with an emphasis on positioning the drainage on the left side whenever possible. The tract formed by the anterior drain is then used to access the retroperitoneal space for intracavitary video-assisted necrosectomy (**Figure 11**). A 15 mm optical trocar, equipped with a zero-degree, 5 mm or 10 mm scope, is used. The trocar is advanced into the retroperitoneum, following the path of the drain, which remains in place. When pancreatic necrosis is encountered and resistance to advancing the trocar is lost, this indicates entry into the necrotic cavity. Traditional laparoscopic instruments are then used under direct visualization (**Figure 12**). Cavity insufflation may

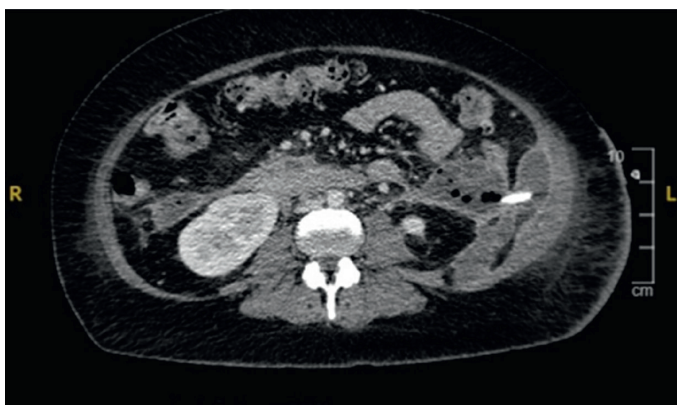


Figure 11. *Abdominal CT scan image showing percutaneous drainage within the necrotic collection, which serves as a guide for performing the VARD procedure.*



Figure 12. *Guided by left retroperitoneal percutaneous drainage, we can access the area using a minimally invasive approach. A laparoscopic trocar was observed through which we introduced the camera, suction device, and laparoscopic forcep.*

be employed during debridement but is typically intermittent, mainly used for inspection. Laparoscopic forceps are inserted through the trocar alongside the scope and used to gently debride the necrotic pancreatic tissue. Direct observation should be maintained during the debridement whenever possible. Once satisfactory debridement is achieved, a Silastic® drain is placed in the cavity (**Figure 13**). This drain is anchored to the skin with a nonabsorbable suture to prevent displacement. Irrigation should be initiated as soon as possible to avoid drain occlusion and ensure proper drainage. Well-positioned

drains allow effective washing, and the procedure may be repeated if necessary to further remove infected pancreatic necrosis.

It is important to note that the VARD approach is more effective for treating infected pancreatic necrosis located centrally or extending into the left paracolic gutter. Accessing necrosis located to the right of the mesenteric vessels is more challenging, although our team has successfully performed the procedure on right-sided collections with increased complexity and caution required (**Figure 14**) (is explained in detail in **Figure C1** of Annex C).

The Dutch Pancreatitis Study Group compared the step-up approach with open necrosectomy in a prospective randomized multicenter trial (PANTER) [7] and found equivalent mortality rates between the two approaches. However, the open necrosectomy group had a higher incidence of multiple-organ failure (40 vs. 12%). The VARD technique is particularly suitable for patients with centrally distributed necrosis [40] extending into the left paracolic gutter.

The VARD technique is not without complications. VARD is accompanied with the risk of vascular injury, external pancreatico-cutaneous, or enterocutaneous fistulae. Some authors have included fluorescence imaging with indocyanine green (ICG) during VARD [41]. This modified technique—ICG-guided video-assisted retroperitoneal debridement (VARD)—offers enhanced visualization of tissue planes during necrosectomy, potentially reducing the risk of vascular or enteric injury. By delineating viable and necrotic tissues more clearly, ICG guidance may enable surgeons to perform debridement with greater precision and safety in the management of severe acute necrotizing pancreatitis.

3.2.2 Surgical transgastric debridement

The concept is analogous to endoscopic transgastric drainage and can be performed either via an open or laparoscopic approach. A gastrostomy is made on the anterior wall of the stomach to access its posterior aspect and subsequently the infected cavity. This approach is particularly beneficial for central collections that do not extend to the flanks (**Figure 15**). Studies with small sample sizes [42–44] have demonstrated the efficacy of the technique, showing low morbidity rates.

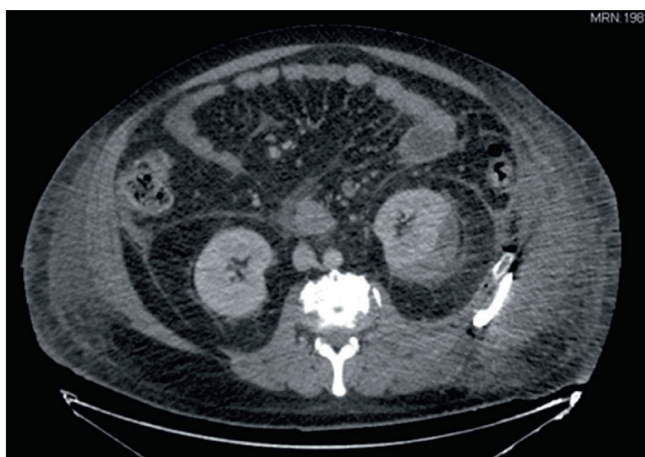


Figure 13.
Image of CT scan that objective retroperitoneal necrotic collection with drainage inside placed by laparoscopic retroperitoneal access.



Figure 14.
CT scan demonstrating surgical drainage on the right flank via laparoscopic retroperitoneal access.

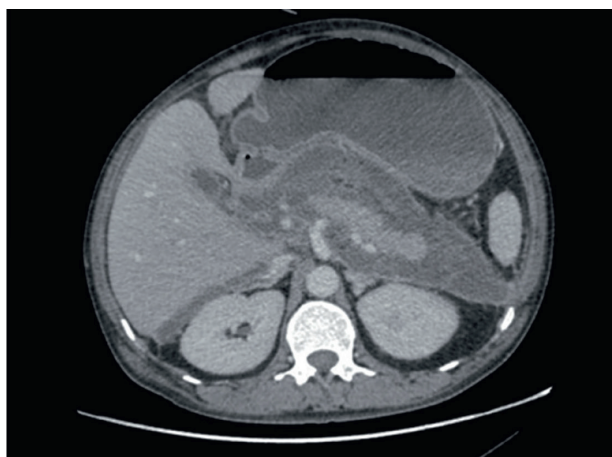


Figure 15.
CT scan image showing collection near the gastric posterior wall that would allow a transgastric approach.

Additionally, simultaneous cholecystectomy can be performed in patients with biliary pancreatitis. In cases of disconnected pancreatic duct syndrome, the relatively large size of the cystgastrostomy offers the potential advantage of providing a durable route for enteric drainage of a pancreatic fistula.

A clinical trial [45] published in 2020 compared endoscopic and laparoscopic transgastric debridement, concluding that both techniques exhibit similar efficacy for internal drainage of appropriate pancreatic fluid collections with less than 30% debris. The choice of procedure should be based on available expertise and tailored to the individual characteristics of each case.

A current randomized controlled trial [46] compared transperitoneal laparoscopic drainage with endoscopic drainage, using either lumen-apposing metal stents (LAMS) or plastic stents, depending on the amount of necrotic tissue. The trial found that laparoscopic drainage was not superior to endoscopic transmural drainage with stent placement, but the hospital stay was shorter with the endoscopic approach.

Our technique involves a standard laparoscopic approach with the patient in the French position. An optical umbilical trocar is inserted, along with two paraumbilical trocars of 11 or 12 mm. The anterior surface of the stomach is incised, and endoscopic drainage is performed if necessary. Intraoperative ultrasound may be used for guidance. The drainage hole is enlarged, and the necrotic tissue is removed. The procedure then proceeds with irrigation, drainage, and necrosectomy. Finally, the anterior stomach wall is closed with a 3/0 barbed suture, and a nasogastric tube is placed near the transgastric communication (**Figure 16**).

3.2.3 Open surgical necrosectomy

If the methods fail to control the infectious process, and the patient continues to deteriorate despite adequate drainage, including minimally invasive techniques, an open surgical approach should be considered. The mortality rate for patients with infected pancreatic necrosis exceeds 30%. As previously mentioned, delaying surgery as long as possible tends to be more beneficial for the patient in terms of reducing both mortality and morbidity. Early surgical intervention [35, 36], particularly in cases of sterile necrosis, has been associated with a significant increase in mortality. Thus, these surgical techniques are typically reserved for situations where all other options have proven ineffective.

A retrospective study conducted at Helsinki University Hospital [47], which analyzed 109 patients who underwent open necrosectomy over a 12-year period, revealed that the mortality rate was 10.6% when necrosectomy was delayed for 4 weeks following the onset of symptoms. Risk factors for 90-day mortality included age over 60, preexisting comorbidities, necrosectomy within 4 weeks, multiorgan failure, elevated white blood cell count, and prolonged organ failure or deterioration, which necessitated necrosectomy. In contrast, when fewer risk factors were present, open necrosectomy did not lead to increased mortality.

Another study [48] explored an innovative approach combining open necrosectomy with continuous positive drainage and prophylactic ileostomy for managing late-stage infected pancreatic necrosis. This strategy resulted in faster recovery of



Figure 16.
Intraoperative image by laparoscopic approach, anterior face opening with transgastric endoscopic drainage exposure.

organ function, fewer colonic complications, shorter hospital stays, and reduced costs when compared to other groups.

Open surgical debridement continues to play a critical role in the management of pancreatic necrosis. A common surgical approach involves an upper transverse subcostal laparotomy, providing optimal exposure to the necrotic areas. However, midline laparotomy may be selectively employed, particularly in patients who have undergone laparotomy for abdominal compartment syndrome or when bowel resection is anticipated.

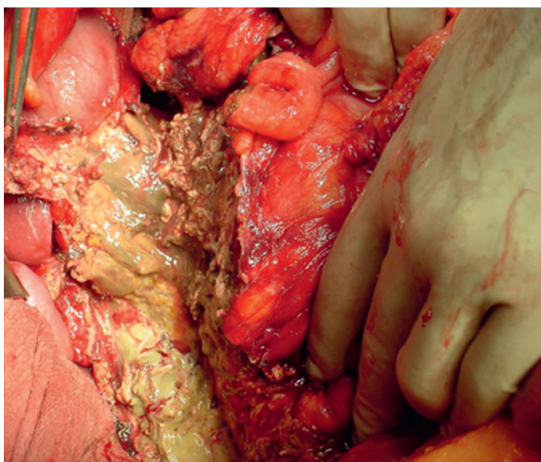


Figure 17. *Surgical image following the opening of the transcavity in epiploic pancreatic necrosis and peripancreatic necrosis.*

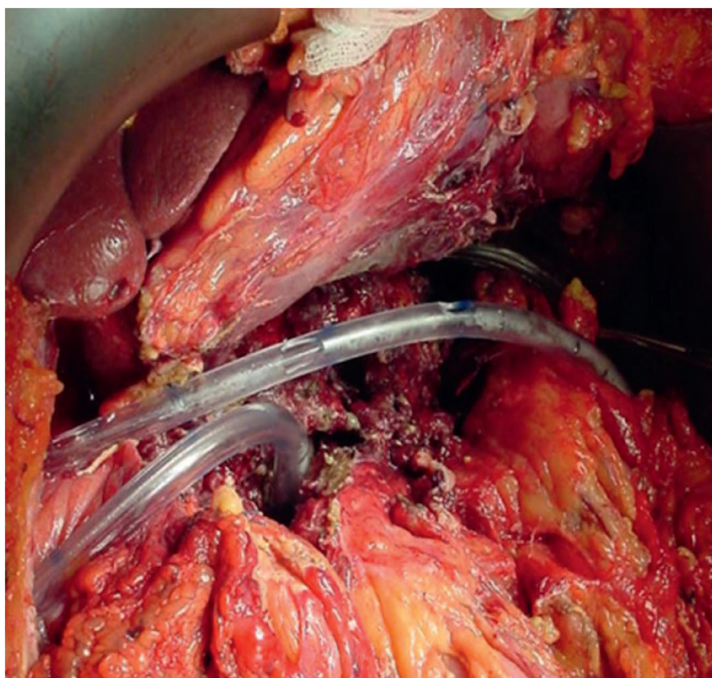


Figure 18. *Following the open necrosectomy, large-bore drains are placed for postoperative drainage.*

The necrosis is typically approached through the gastrocolic ligament. Necrosectomy is performed using blunt manual dissection, with careful suction to minimize trauma to surrounding vital tissues (**Figure 17**). Microbiological samples from necrotic tissue are routinely collected during the procedure. In cases of biliary pancreatitis, cholecystectomy can be performed concurrently. Large-bore drains are left in place postoperatively for lavage and to manage potential fistulas, if needed (**Figure 18**).

While several open necrosectomy techniques have been described, none have been definitively shown to be superior, largely due to the absence of randomized trials. For localized necrosis, necrosectomy with closure of the abdominal wall may be performed. Most patients will require multiple necrosectomies and external scrubbing in the intensive care unit. The use of open abdomen techniques significantly increases patient morbidity [31]. In cases where abdominal closure is not possible or in instances of abdominal compartment syndrome, Vacuum Assisted Closure therapy is employed as a temporary measure. Open debridement is indicated for patients with extensive necrosis spread diffusely throughout the abdomen, particularly in those who do not respond to staged interventions.

Appendix A

Decision tree outlining the acute- and late-phase management of patients with severe acute pancreatitis and necrosis, including a multidisciplinary approach to drainage and/or debridement when required (**Figure A1**) [13].

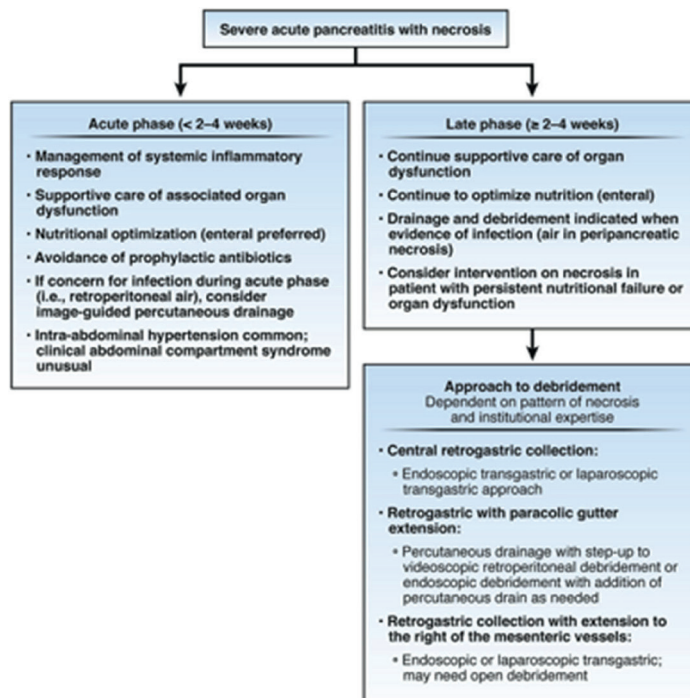


Figure A1. Clinical decision algorithm detailing the acute and late-phase management of severe acute pancreatitis with necrosis, emphasizing a multidisciplinary approach to interventional drainage and/or surgical debridement as clinically indicated [49].

Appendix B

Classification of acute pancreatitis and associated fluid collections. Based on international consensus according to the Acute Pancreatitis Classification Working Group (revised Atlanta criteria). From Trikudanathan et al. (Figure B1) [13, 15].


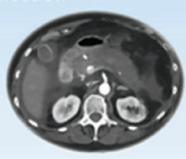
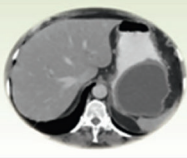
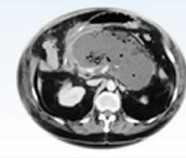
	Interstitial edematous pancreatitis	Necrotizing pancreatitis
< 4 weeks	<p style="text-align: center;">Acute (peri)pancreatic fluid collection</p> <p>Homogenous fluid adjacent to pancreas without a recognizable wall</p> 	<p style="text-align: center;">Acute necrotic collection</p> <p>Intra and/or extra pancreatic necrotic collection without a well-defined wall</p> 
≥ 4 weeks	<p style="text-align: center;">Pancreatic pseudocyst</p> <p>An encapsulated, well-defined, usually extrapancreatic fluid collection with minimal solids</p> 	<p style="text-align: center;">Walled off necrosis</p> <p>Intra and/or extra pancreatic necrotic collection with a well-defined wall</p> 

Figure B1. Classification of acute pancreatitis and related fluid collections, based on the international consensus established by the Acute Pancreatitis Classification Working Group (revised Atlanta criteria) [49].

Appendix C

Video-assisted retroperitoneal debridement (VARD) and laparoscopic-assisted pancreatic necrosectomy (LAPN) operative techniques(a). Pancreatic necrosum with a percutaneous drain in place, the initial component of step-up approach for necrotizing pancreatitis (b). Depiction of the VARD operative approach, utilizing a 5cm incision; (c). Depiction of the LAPN operative approach, utilizing a 12 mm trocar (Figure C1) [41].

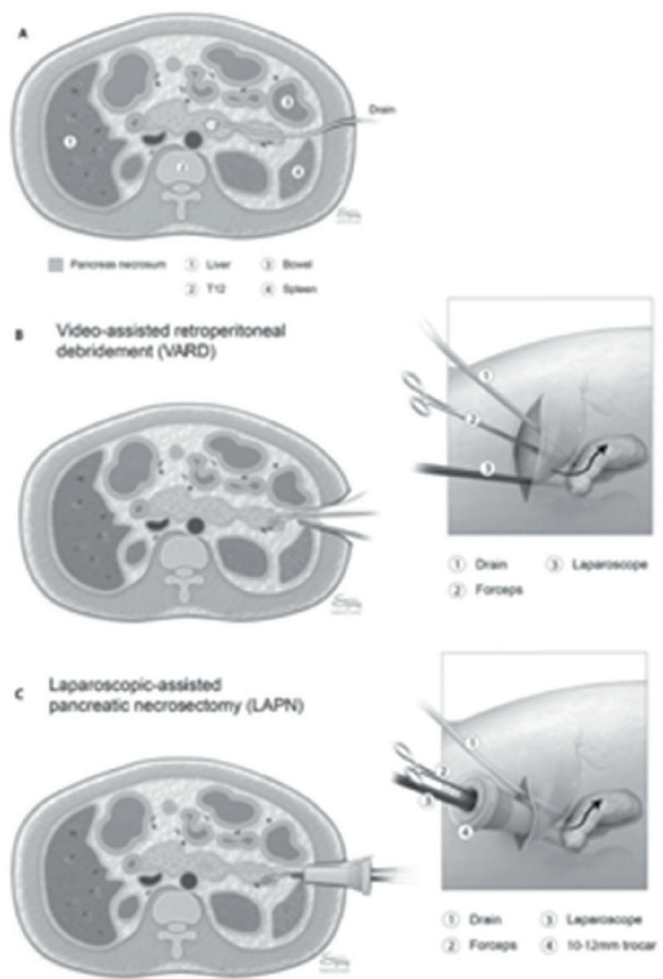



Figure C1. Operative techniques for video-assisted retroperitoneal debridement (VARD) and laparoscopic-assisted pancreatic necrosectomy (LAPN): (a) Pancreatic necrosis with a percutaneous drain in place, representing the initial step of the step-up approach for necrotizing pancreatitis; (b) illustration of the VARD technique, performed through a 5 cm incision; (c) illustration of the LAPN technique, utilizing a 12 mm trocar [39].

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