Minimally Invasive Techniques in Pancreatic Necrosis

Udayakumar Navaneethan, MD,* Santhi Swaroop Vege, MD,† Suresh T. Chari, MD,† and Todd H. Baron, MD†

Abstract: Traditional open surgical necrosectomy for treatment of infected pancreatic necrosis is associated with high morbidity and mortality, leading to a shift toward minimally invasive endoscopic, radiologic, and laparoscopic approaches. Percutaneous drainage is useful as a temporizing method to control sepsis and as an adjunctive treatment to surgical intervention. It is limited because of the requirement for frequent catheter care and the need for repeated procedures. Endoscopic transgastric or transduodenal therapies with endoscopic debridement/necrosectomy have recently been described and are highly successful in carefully selected patients. It avoids the need for open necrosectomy and can be used in poor operative candidates. Laparoscopic necrosectomy is also promising for treatment of pancreatic necrosis. However, the need for inducing a pseudocyst and the potential risk of infection limit its usefulness in patients with critical illness. Retroperitoneal access with a nephroscope is used to directly approach the necrosis with complete removal of a seques tum. Retroperitoneal drainage using the delay-until-liquefaction strategy also appears to be successful to treat pancreatic necrosis. The anatomic location of the necrosis, clinical comorbidities, and operator experience determine the best approach for a particular patient. Tertiary care centers with sufficient expertise are increasingly using minimally invasive procedures to manage pancreatic necrosis.

Key Words: pancreatic necrosis, minimally invasive, endoscopy, percutaneous, infected

Abbreviations: CT - computed tomography, EUS - endoscopic ultrasound, PANTER - pancreatitis necrosectomy versus step-up approach, PCD - percutaneous drainage, PEG - percutaneous endoscopic gastrostomy, RCT - randomized controlled trials, SAP - severe acute pancreatitis, WOPN - walled-off pancreatic necrosis

In recent years, there has been increased interest in the development of modern minimally invasive techniques in every field of medicine, particularly in management of gastrointestinal disorders. Acute pancreatitis is no exception to this rule. For example, endoscopic treatment is now well established for drainage of pancreatic pseudocysts and abscesses. However, the use of nonsurgical approaches for debridement of pancreatic necrosis is still evolving.

Acute pancreatitis is classified as interstitial in 85% of cases, characterized by limited inflammation and swelling of the pancreatic parenchyma. The remainder has pancreatic necrosis.† Pancreatic necrosis is defined as a diffuse or focal area of nonviable pancreatic tissue that occurs early in the course of pancreatitis, usually at the onset of an acute attack. Necrotizing pancreatitis may be associated with organ failure and/or local complications, such as hemorrhage or infection.2–4

The initial treatment of severe acute pancreatitis (SAP) has shifted toward providing aggressive intensive care rather than early surgery. Of the 210,000 admissions due to acute pancreatitis in the United States every year,† about 15% have SAP. In contrast to mild acute pancreatitis, which has a mortality rate lower than 1%, the death rate for SAP is much higher: 12% with sterile and 30% with infected pancreatic necrosis.†

Pancreatic necrosis develops within the first 4 days after the onset of symptoms to their maximum extent, and most patients who have severe early organ dysfunction usually have pancreatic necrosis on computed tomographic (CT) scan. In initially, the necrosis is sterile, and if it remains so, the mortality is approximately 12%. Infected necrosis develops in 40% to 70% of cases and is responsible for late deterioration of organ dysfunction in the second to the third week after admission. The mortality increases to 30%. Despite advances in supportive care, infected pancreatic necrosis is still the major cause of sepsis-related multiorgan failure and the main life-threatening complication of SAP after the first week of onset of acute pancreatitis.5,8,9

Infected pancreatic necrosis is either diagnosed by fine needle aspiration or when there is direct CT evidence of gas in the peritoneum.9,11,12 Therapeutic approaches to infected necrosis are directed toward mechanical removal of as much necrotic tissue as possible. Traditional open surgical approaches carry a variable mortality rate of 12% to 56%. In a recently reported meta-analysis, the median mortality rate of surgical intervention was 25% (range, 12%–56%). However, the mortality rate in patients with established organ failure is even higher. In the only prospective randomized trial comparing early (within 72 hours of symptoms) with late (after 12 days after onset of symptoms) pancreatic resection/debridement, mortality rates were high: 56% in the early group in contrast to 27% in the late group, and the trial was stopped early because of concerns of high mortality in the early surgery group.15

Intervention is indicated in pancreatic necrosis if symptoms of persistent pain requiring narcotics, suspicion of infected necrosis, gastric outlet or biliary obstruction, inability to eat, and/or failure to thrive are present. Intervention should be delayed until the necrosis is organized and is termed walled-off pancreatic necrosis (WOPN) (Fig. 1). This requires a period of at least 3 to 4 weeks, and intervention before this period should be avoided if possible. Even when surgical interventions are undertaken, a delay of 2 to 4 weeks is warranted. In fact, in a recent retrospective study of 53 patients, delaying necrosectomy until 30 days after initial admission was associated with decreased mortality when compared with interventions in the first 2 weeks and from weeks 2 to 4.15

The management of pancreatic necrosis has evolved over the years with improvements in critical care and nutrition and an understanding of the pathogenesis of the local and systemic complications. Minimally invasive techniques have been used recently in multiple studies to gain access to organized pancreatic necrosis, which is also termed WOPN. Percutaneous,
laparoscopic, endoscopic, and retroperitoneal approaches to access pancreatic necrosis have been used as alternatives to open surgery to manage patients with critical illness. Initially, these approaches were reserved for patients considered unfit for laparotomy, but in recent years, their use has expanded to good operative patients because of the high mortality of infected pancreatic necrosis despite surgical intervention. The arguments in favor of minimally invasive approaches are the high success rates seen in tertiary care centers with sufficient expertise and the lower mortality rate compared with those reported in surgical studies. However, the data supporting their use is limited because of lack of well-designed clinical trials that are difficult to perform because of the lack of widespread expertise for such techniques, the variation in techniques in different institutions, and the sample size of the study population that is required to show a significant difference in outcome. Their extension to routine clinical practice is not possible, except in specialized tertiary care centers, and surgery continues to be the major treatment modality for pancreatic necrosis. We attempt to address this controversial area using the available evidence and suggest a treatment algorithm for the management of patients with pancreatic necrosis.

In October 2008, a MEDLINE search of the literature from 1980 to the present was performed using the Medical Subject Headings terms SAP, acute necrotizing pancreatitis, alcoholic pancreatitis, minimally invasive techniques, and pancreatitis and the key word pancreatitis. Full articles and abstracts without language restrictions were included.

**PERCUTANEOUS DRAINAGE**

The various principles of percutaneous drainage (PCD) involve drainage alone, a combination of aggressive irrigation and drainage, and PCD with the use of accessories such as snares and baskets for debridement. Because pancreatic necrosis has solid components, the principle of debridement combined with drainage is the optimal approach in resolving pancreatic necrosis. In various studies reported thus far, PCD has obviated the need for surgical intervention in 30% to 100% of patients with infected necrosis. Freeny et al first described successful PCD of infected pancreatic necrosis. They used the principle of aggressive irrigation and drainage alone for the treatment of pancreatic necrosis. In this report of 34 patients with infected necrosis, the combined technique of PCD with active necrosectomy was achieved by placement of multiple large-bore catheters and aggressive irrigation. Each patient required 3 separate catheter sites and 4 exchanges for removal of necrotic material. Surgery was avoided in 16 patients (47%), which included 12 patients with necrosis confined exclusively to the body and tail of the pancreas. Although 9 patients required surgery, the requirement for surgery was postponed in patients with critical illness until they stabilized. The overall mortality rate was 12%, and all patients who died were critically ill with multiorgan failure (Table 1). The main drawback of this technique is the need for repeated procedures. This approach is not easily implemented in routine clinical practice. In addition, patients with central gland necrosis respond poorly to PCD. In fact, in this series, PCD was successful in only 4 (29%) of 14 patients with central gland necrosis. This is because patients with central gland necrosis almost always have disruption of the main pancreatic duct, thus separating the pancreatic duct in the head from the rest of the pancreas. This results in the accumulation of pancreatic enzymes in the central cavity, complicated with fistula formation, which usually does not heal, and distal pancreatectomy is often required.

Mann et al described a different method of PCD. They used the principle of using assist devices for debridement along with drainage. They initially combined the use of percutaneous necrosectomy and fragmentation of necrotic pancreatic and peripancreatic tissue with snare and Dormia baskets followed by continuous lavage in a single patient and avoided surgical intervention. They then extended this to a series of patients and reported their observations. Using CT guidance, large-bore (20–28F) catheters were placed retroperitoneally. Under fluoroscopic control, necrotic material was fragmented and removed with the aspiration and the snare techniques. Daily lavage was performed using saline solution, and 25 of 29 patients were successfully cured of infection. Three patients required elective surgery at a later date. Nine patients who underwent PCD successfully were followed up for a median of 30 months and were evaluated for quality of life and morphology assessments by CT scan. The quality of life overall was excellent, and only 2 patients showed morphological pancreatic changes on CT.

In yet another series by Echenique et al, smaller (14–16F) catheters were used along with stone retrieval baskets

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**TABLE 1. Percutaneous Drainage for Pancreatic Necrosis**

<table>
<thead>
<tr>
<th>Studies</th>
<th>Patients, n</th>
<th>Infected, %</th>
<th>Mortality, n (%)</th>
<th>Success, n (%)</th>
<th>Complications, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeny et al</td>
<td>34</td>
<td>100</td>
<td>4 (12)</td>
<td>16 (47)</td>
<td>Fistulas, 23.5*</td>
</tr>
<tr>
<td>Mann et al</td>
<td>29</td>
<td>100</td>
<td>8 (27)</td>
<td>20 (69)</td>
<td>Fistulas, 8</td>
</tr>
<tr>
<td>Echenique et al</td>
<td>20</td>
<td>100</td>
<td>0</td>
<td>20 (100)</td>
<td>Fistulas, 50</td>
</tr>
<tr>
<td>Gouzi et al</td>
<td>32</td>
<td>81</td>
<td>5 (15)</td>
<td>21 (65)</td>
<td>Fistulas, 53</td>
</tr>
<tr>
<td>Szentkereszty et al</td>
<td>24</td>
<td>Not stated</td>
<td>3 (12.5)</td>
<td>3 (12.5)</td>
<td>None</td>
</tr>
</tbody>
</table>

*Eight patients had fistula formation, although the relation to catheter drainage could not be proven conclusively.
Endoscopic Therapy for Pancreatic Necrosis

<table>
<thead>
<tr>
<th>Studies</th>
<th>Patients, n</th>
<th>Infected, %</th>
<th>Mortality, %</th>
<th>Success, n (%)</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baron and Morgan&lt;sup&gt;2&lt;/sup&gt;</td>
<td>11</td>
<td>27</td>
<td>0</td>
<td>9 (81)</td>
<td>Bleeding, 9%; infection, 36</td>
</tr>
<tr>
<td>Papachristou et al&lt;sup&gt;33&lt;/sup&gt;</td>
<td>53</td>
<td>49</td>
<td>0</td>
<td>43 (81)</td>
<td>11 (21%); bleeding, n = 9</td>
</tr>
<tr>
<td>Charnley et al&lt;sup&gt;37&lt;/sup&gt;</td>
<td>13</td>
<td>85</td>
<td>0</td>
<td>12 (92)</td>
<td>None</td>
</tr>
<tr>
<td>Voermans et al&lt;sup&gt;40&lt;/sup&gt;</td>
<td>25</td>
<td>100</td>
<td>0</td>
<td>23 (93)</td>
<td>Major bleeding, 4%; minor bleeding, 30%</td>
</tr>
<tr>
<td>Gardner et al&lt;sup&gt;35&lt;/sup&gt;</td>
<td>25</td>
<td>24</td>
<td>0</td>
<td>22 (88)</td>
<td>Bleeding, 32%</td>
</tr>
<tr>
<td>Navaneethan et al&lt;sup&gt;42&lt;/sup&gt;</td>
<td>8</td>
<td>50</td>
<td>12.5</td>
<td>7 (87.5)</td>
<td>Perforation of cyst wall, 12.5%</td>
</tr>
<tr>
<td>Mathew et al&lt;sup&gt;33&lt;/sup&gt;</td>
<td>6</td>
<td>100</td>
<td>0</td>
<td>5 (83.3)</td>
<td>None</td>
</tr>
</tbody>
</table>

Necrosectomy in centers where sufficient endoscopic expertise is not available and as an adjunct to endoscopic drainage.<sup>32,39</sup>

ENDOSCOPIC THERAPY

Per oral, endoscopic, transgastric, or transduodenal (transmural) access using flexible endoscopes offers yet another way of minimal access approach for drainage/debridement of necrosis in carefully selected patients. The techniques used are similar to those used for drainage of pancreatic pseudocysts. Endoscopic drainage of pancreatic necrosis was initially reported by Baron et al<sup>30</sup> where transgastric or transduodenal catheters (10F) and a nasopancreatic irrigation tube were inserted under endoscopic guidance into the retroperitoneum. A nasopancreatic catheter was placed for a mean duration of 19 days. A total of 2 to 4 procedures were required for resolution. The success rate reported was around 80%, and no mortality was reported. However, 9% of patients developed bleeding complications, and 36% of patients developed infections after the procedure. The other drawback was that around 60% of patients who were successfully treated initially developed further collections in the next 2 years.<sup>31</sup>

To avoid the need for nasopancreatic catheters, Baron et al<sup>32</sup> then placed a percutaneous endoscopic jejunostomy tube through a percutaneous endoscopic gastrostomy (PEG) tube and, subsequently, through a transgastric route to the necrotic pancreas. This technique was advantageous in avoiding nasopancreatic catheter placement and also the risk of pancreatic fistulas as that which occurs with the PCD technique (Table 2).

In a recent series published by Baron et al,<sup>32</sup> 53 patients’ successful resolution of symptomatic, sterile, infected necrosis was achieved in 81% using a minimal-access endoscopic approach.<sup>33</sup> In this series by Baron et al, initial endoscopies were performed using a therapeutic, side-viewing video duodendoscope. The localization of the most appropriate access site from within the gastric or duodenal lumen was done either by extrinsic compression of the gastric or duodenal wall that was determined endoscopically, comparing the most recent CT, or in a small number, by endoscopic ultrasound (EUS). Direct endoscopic necrosectomy was then performed using a forward-viewing therapeutic gastroscope after dilatation of the transmural access tract. An adjulant PCD was necessary in 40% of the patients, especially when the necrosis extended to paracolic gutters or pelvis. A median of 3 endoscopic procedures per patient was performed. Operative intervention for failed endoscopic treatment was required in approximately 23% of the patients. A 7F, pigtail nasobiliary tube was used to irrigate in 70% of the patients, and a PEG tube was used in 19% of the patients. Lavage was done with 0.9% NaCl every 2 hours for the first 2 days and then every 4 to 6 hours for the ensuing 4 to 6 weeks as necessary. It was a retrospective analysis; in the

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early phase of this series (1998–2001), the transmural tract was dilated with an 8-mm balloon, and larger diameter balloons (up to 20 mm) were used subsequently to dilate the tract. Bleeding at the site of the endoscopic debridement occurred in 9 patients and controlled with local measures in 7 patients, whereas 2 patients required blood transfusion. The irrigation catheter was removed at a median of 31 days (range, 9–100 days). The study also helped to identify the type of necrosis that can be endoscopically managed, particularly necrosis involving primarily the area of the lesser sac because this area is most accessible endoscopically, either through the stomach or the duodenum. In addition, the necrosis needs to be walled off to be successfully managed. A new term has recently been used to describe these later types of collections, walled-off pancreatic necrosis. In addition to other techniques, Baron et al incorporated the use of an upper endoscope, which was advanced through the gastric or duodenal wall into the necrotic fluid collection, so that direct endoscopic debridement/necrosectomy could be performed, as has been described by Seewald et al. A recent study from Baron’s group compared direct endoscopic necrosectomy with conventional transmural endoscopic drainage for the treatment of WOPN. In patients undergoing EUS, initial transmural entry puncture was performed under direct EUS guidance, with use of color flow to help avoid disruption of mural blood vessels at the time of wall puncture. However, the use of EUS did not prevent bleeding complications either at the time of initial cavity puncture or during necrosectomy. Similar to the previous study from the same group, 7F pigtail nasobiliary tube was used for aggressive irrigation. The median ± SD duration of tube placement was 13 ± 14 days. The tract was dilated to 20 mm in all patients. Successful resolution defined by more than 90% resolution of the cavity with only the endoscopic technique was accomplished in 88% who underwent direct endoscopic necrosectomy in comparison with 45% of patients who received standard endoscopic drainage without an increase in the total number of procedures. In addition, in the standard drainage group, 30% of patients eventually needed operative drainage, compared with only 4% of the direct necrosectomy group. Although bleeding was seen in 32% of the patients, it was controlled with local measures including coagulation, hemoclipping, or epinephrine injection.

Advantages of a minimal access, transoral/transmural endoscopic approach is avoiding the morbidity of open necrosectomy, avoidance of external fistulae, and their therapeutic potential in poor operative candidates. Disadvantages, however, include the necessity for the necrosis to be walled off; the often limited ability to evacuate large areas of less well-liquefied necrotic debris, and the need for repeated procedures for adequate drainage. The advantages and disadvantages of the different approaches are summarized in Figure 2. Although it was initially believed that endoscopic therapy had limited ability to access necrosis in the paracolic, retroduodenal, and perinephric spaces, it appears that the endoscope can be passed into these areas that are usually contiguous and best demonstrated by coronal CT.

**FIGURE 2.** Various therapeutic approaches in pancreatic necrosis.
necrosis not approachable from the posterior stomach/medial duodenal wall, or multiple pockets of pus and necrosis that is not organized are often not suitable for endoscopic treatment. Extension into the paracolic gutters may require adjuvant percutaneous/retroperitoneal techniques. However, in a recent study by the Dutch study group on the feasibility of minimally invasive procedures in infected pancreatic necrosis, most peripancreatic fluid collections (84%) were deemed to be accessible to a minimally invasive approach. This highlights the high therapeutic potential of the endoscopic approach.  

The results are even more promising with the recent data from Europe. In a retrospective study of 25 patients (27 procedures undergone), to evaluate the safety and efficacy of endoscopic debridement of organized pancreatic necrosis from the Dutch group, endoscopic drainage was done through the gastric or duodenal wall under EUS guidance.  

Recent studies from the UK have demonstrated the clinical success rate with relatively few endoscopic procedures and without additional treatment in all but 2 patients. Similarly, in a smaller series of 8 patients with infected pancreatic necrosis, successful resolution of the necrotic collection and the presenting symptoms was 93%. This is by far the largest study cohort where endoscopic technique was demonstrated to have more than 90% clinical success rate with relatively few endoscopic procedures and without additional treatment in all but 2 patients. Similarly, in a smaller series of 8 patients with infected pancreatic necrosis, successful resolution of necrosis was accomplished by EUS-guided transgastric necrosectomy in 6 of 8 patients.

At the University of Cincinnati Pancreas Center, endoscopic necrosectomy of WOPN has been very successful with success defined by complete resolution seen in 7 of 8 patients who underwent the procedure. Only 2 of 8 patients required a second endoscopic procedure for successful drainage. Endoscopic necrosectomy was done through the gastric wall in all the 8 patients. Endoscopic ultrasound was done in only 2 patients to localize the drainage site. In addition, nasocystic catheters were not used because complete debridement was

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**FIGURE 3.** Endoscopic view from the stomach showing pancreatic necrosis.

Recently, a group from England published their retrospective evaluation of the use of endoscopic necrosectomy for treatment of patients with necrosis that could be accessed through the posterior wall of the stomach. Thirteen patients (9 men and 4 women; mean age, 53 years), 11 with infected necrosis, underwent attempted endoscopic necrosectomy. All but 1 patient had EUS performed before the necrosectomy to exclude the presence of blood vessels in the wall to decrease the risk of bleeding. The tract was dilated to 8 mm in this study. Six patients had postprocedure nasocavity irrigation. A combination of gastroscope and duodenoscope was used in this study to access the necrosis. Necrosis was successfully treated endoscopically in 12 patients. However, a mean of 4 endoscopic interventions were required; 1 patient required open surgery, 2 patients required adjuvant percutaneous necrosectomy, and 1 patient required laparoscopic drainage.

Multiple studies have demonstrated that the anatomic location of the necrosis plays a vital role in considering the route of intervention to approach the necrosis. Necrosis that is closely adhered to the posterior gastric wall or medial duodenal wall is often ideal for endoscopic necrosectomy (Fig. 3 shows an endoscopic view of the necrosis from the stomach). Endoscopic ultrasound helps us in exactly imaging the necrosis location, making sure that the necrosis can be approached safely from the posterior stomach/medial duodenal wall. Chahal et al., however, in their recent study of 94 patients, of whom 45 had organized pancreatic necrosis, highlighted that endoscopic transmural drainage of pancreatic fluid collections can be performed as safely and effectively via the Seldinger technique without EUS guidance.

The extent of necrosis removal is often followed serially by CT scan and/or imaging during the endoscopic procedure. However, patients with extensive extrapancreatic necrosis, Table 3. Laparoscopic Technique for Pancreatic Necrosis

<table>
<thead>
<tr>
<th>Studies</th>
<th>Patients, n</th>
<th>Infected, %</th>
<th>Mortality, n (%)</th>
<th>Success, n (%)</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhu et al⁴⁷</td>
<td>10</td>
<td>0</td>
<td>1 (10)</td>
<td>9 (90)</td>
<td>Bleeding, 9%; infection, 36%</td>
</tr>
<tr>
<td>Parekh⁴⁹</td>
<td>19</td>
<td>95</td>
<td>2 (11)</td>
<td>43 (81)</td>
<td>No direct complications related to the procedure</td>
</tr>
<tr>
<td>Bucher et al⁵²</td>
<td>8</td>
<td>100</td>
<td>0</td>
<td>8 (100)</td>
<td>None</td>
</tr>
</tbody>
</table>

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achieved in most patients and multiple stents were placed across the gastric wall to facilitate drainage. None of the patients encountered bleeding as a complication. Only 1 patient had failed endoscopic treatment and required surgery.

Recently, a case series reported successful resolution of pancreatic necrosis/abscess by a single-session endoscopic necrosectomy in 5 of 6 patients. Although endoscopic therapy has been successfully used in multiple studies as reported previously, it may be applicable only in centers with expertise in endoscopic techniques, and in the absence of randomized controlled trial (RCT), it would be difficult to perpetuate this method for replacing surgery. An RCT, although the only way of legitimizing endoscopic therapy, is unlikely to be done in view of the need of expertise and the sample size of the study population required to show a significant difference. Endoscopic debridement is effective only in organized pancreatic necrosis, and selecting the optimal patient is vital to success. At present, endoscopic therapy will remain limited in its use in centers of expertise that deal with pancreatic necrosis day in and day out.

In a recently published systematic review of the current guidelines to review the evidence for recommending the role of percutaneous techniques/endoscopy in the management of infected pancreatic necrosis, there was insufficient evidence or consensus to recommend a particular technique in the management of pancreatic necrosis. Most of the guidelines did not include the levels of evidence supporting their recommendation, although endoscopic technique was recommended in 10 of 16 guidelines for infected pancreatic necrosis.

**LAPAROSCOPY**

Laparoscopic debridement and necrosectomy was initially described by Gagner et al for treating pancreatic necrosis using 3 different minimally invasive approaches: transgastric, retrogastric, and retrocolic debridements, and a full retroperitoneoscopic technique. Several case series have reported the successful use of laparoscopic transgastric pancreatic necrosectomy for infected necrosis, suggesting effective debridement and internal drainage in selected patients (Table 3).

Zhu et al, in their study of the laparoscopic approach, 10 patients with acute necrotizing pancreatitis without infection had a mortality rate of 10%, highlighting the risk of infection transmission through the peritoneal cavity and injury to the bowel.

Transperitoneal laparoscopic pancreatic debridement using traditional laparoscopic surgery through a retrocolic access to the lesser sac had been reported. Parekh studied 23 patients with necrotizing pancreatitis, 19 of whom underwent pancreatic debridement through a laparoscopic infracolic approach. Fourteen patients were successfully treated by laparoscopic necrosectomy.

**TABLE 4. Retroperitoneal Approach for Pancreatic Necrosis**

<table>
<thead>
<tr>
<th>Studies</th>
<th>Patients, n</th>
<th>Infected, %</th>
<th>Mortality, %</th>
<th>Success, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gambiez et al</td>
<td>20</td>
<td>65</td>
<td>10</td>
<td>75</td>
</tr>
<tr>
<td>Carter</td>
<td>10</td>
<td>100</td>
<td>20</td>
<td>80</td>
</tr>
<tr>
<td>Harvath et al</td>
<td>6</td>
<td>100</td>
<td>0</td>
<td>66</td>
</tr>
<tr>
<td>Castellanos et al</td>
<td>15</td>
<td>100</td>
<td>27</td>
<td>Not stated</td>
</tr>
<tr>
<td>Connor et al</td>
<td>24</td>
<td>100</td>
<td>25</td>
<td>67</td>
</tr>
<tr>
<td>Chang et al</td>
<td>19</td>
<td>15</td>
<td>15.8</td>
<td>89.5</td>
</tr>
</tbody>
</table>

**FIGURE 4. Approach to pancreatic necrosis in SAP.**
The traditional laparoscopic approach has several advantages compared with minimal access retroperitoneal approaches, which use videoscopic and endoscopic techniques. Persistence of the residual sequestrum after conservative treatment with a pancreatic fistula is the usual cause of continuing sepsis and/or symptoms in patients with severe pancreatitis and sepsis. Therefore, complete removal of the sequestrum is extremely important. Parekh et al argued that a major limitation of the retroperitoneal videoscopic and endoscopic techniques is the failure to completely remove the sequestrum. However, with the development of new endoscopic techniques that allow complete resolution, this argument can be challenged. A transperitoneal approach, however, allows access to areas inaccessible by an endoscope, including the right and the left paracolic gutters, the perinephric space, the retroduodenal space, and the root of the mesentery.

Bucher et al reported a single large-port laparoscopic necrosectomy for infected necrotizing pancreatitis in a series of 8 patients not responding to radiological drainage. Laparoscopic necrosectomy was successful in all patients, and 7 of 8 patients required 1 session to remove the necrosis. Similarly, in a series of 6 patients with WOPN, Fischer et al combined upper endoscopy and percutaneous transgastric puncture with laparoscopic debridement with successful resolution in 5 of 6 patients.

However, laparoscopy requires the need for inducing a pneumoperitoneum, which may have adverse effects in patients with critical illness and hemodynamic instability. In addition, there is definitely the risk of infection transmission through the peritoneal cavity and bowel injury during the procedure. The use of hand-assisted laparoscopic surgery used by Parekh et al has the advantages over traditional laparoscopic surgery, which allows the removal of necrotic tissue by the minimal access route that would otherwise be limited. Laparoscopic access to pancreatic necrosis seems to be a promising minimal access approach.

**RETROPERITONEAL APPROACH**

The difficulties encountered in the laparoscopic approach for pancreatic debridement in patients with critical illness have led to the development of alternative minimal access retroperitoneal debridement approaches. The necrosis is approached directly with a retroperitoneoscope or by intraoperative dilation of a drain that had been placed preoperatively under CT guidance. Gambiez et al was the first to use this approach in the management of infected pancreatic necrosis. In his series of 20 patients, mortality was 10%, and the procedure was successful in 75% of the patients (Table 4). Subsequently, Carter et al reported on 10 patients in whom percutaneous access to the necrosis cavity was obtained; the cavity was dilated to a final size of 30F, allowing the insertion of an operating nephroscope to remove necrotic material in a piecemeal fashion. Multiple procedures were generally required to adequately drain all the necrotic tissue with this. Harvath et al later reported on a promising videoscopic assisted retroperitoneal approach in which a small subcostal flank incision was made to access the retroperitoneal space through which a videoscope was inserted through a port. Debridement was accomplished with hydrodissection and long laparoscopic spoon forceps inserted through a second port. Since then, a number of studies have been performed by Castellanos et al and Connor et al. The success rate has varied from 66% to 80%; and mortality, from 0% to 27%. Recently, a group from Taiwan used a delayed mini-retroperitoneal approach for acute necrotizing pancreatitis without debridement or drainage in 19 patients. Surgery was delayed until the retroperitoneal necrosis liquefied and reached the left flank. A sump drain was then placed through a small incision and remained in place for a period of 120.6 days (range, 60–250). The authors reported success in 17 (89.5%) of 19 patients. This approach hold promise for the treatment of pancreatic necrosis because it avoids the need for dilatation procedures, multiple procedures, and debridement. The effectiveness of this approach needs to be confirmed in subsequent studies before it can be recommended.

Some surgeons have challenged minimally invasive procedures because of the lack of proof in an RCT. For sterile necrotizing pancreatitis, there is strong evidence for supportive treatment without debridement. In addition, infected necrosis has been shown to resolve with antibiotic treatment alone in some patients. Therefore, evidence shows that debridement is not absolutely necessary for necrotizing pancreatitis, and the surgical procedures followed now for acute necrotizing pancreatitis, all of which focus on debridement, may be challenged in the future with more and more developments in interventional techniques. With advances in intensive care, the causes of mortality are no longer the toxic effects of necrotic tissue but rather the infectious complications and the physiologic alterations caused by the surgery itself. Although all the minimally invasive approaches have shown good benefits, their use at present is only limited to centers where sufficient expertise is available. A suggested algorithmic approach to patients with pancreatic necrosis is highlighted in Figure 4. However, we must understand that this is variable, depending on the expertise available in the center.

**CONCLUSIONS**

The exact role of minimal access procedures in the management of patients with necrotizing pancreatitis remains uncertain in the absence of sufficient data. There are many factors that make it difficult to compare the efficacy of a particular approach. These include differences in diagnostic modalities, small numbers of patients, retrospective nature of the studies, patients with varying degrees of disease severity and comorbid illnesses, and the variability in techniques/operator experiences. In the absence of well-designed clinical trials, it is not appropriate to propagate a particular drainage approach in a patient. Until the results of the only ongoing RCT, the PANTER trial, are available, we recommend the approach to an individual patient based upon the available expertise within each center. Minimally invasive approaches should be considered in centers where sufficient expertise and dedicated staff are available.

**REFERENCES**


