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A Standardized Method for Endoscopic Necrosectomy Improves Complication and Mortality Rates

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Conflict of Interest Statement

The following authors have no potential conflicts to disclose: N. Kumar, J. Slattery, T. Clancy, M. Ryan, R. Swanson and D. Conwell. M. Ryou – Is a consultant of Covidien.

P. Banks – Has provided expert testimony in this field.

CC Thompson – Is a consultant of Boston Scientific, Covidien, and Olympus.

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Abstract

Objectives—Endoscopic necrosectomy is effective in the treatment of walled-off necrosis (WON), and is preferred to surgical approaches, however complication and mortality rates remain high with few centers regularly employing the technique. Lack of a standardized approach may also contribute to these limitations.

Methods—Prior to the study, a multidisciplinary team applied standardized care assessment and management plan principles to develop and optimize a systematic approach for the management of WON. Preoperative, postoperative, and endoscopic management were standardized. Patient preparation, room set-up, technical features (EUS-guidance, cold-access with balloon dilation, fragmentation of necrosis on the initial procedure, antibiotic lavage, double pig tail stents), and discontinuation of PPIs to encourage auto-digestion of necrosis were included. This study employed a consecutive prospective clinical registry to assess the clinical outcomes of this standardized approach.

Results—60 consecutive patients underwent 1.58 ± 0.1 necrosectomies, with debridement accomplished on the initial procedure in 98.3%. 39 patients (65%) required only one session. Clinical resolution occurred in 86.7%, with radiologic confirmation. Percutaneous drainage was required in 8 patients during follow-up, and 4 of these later required surgery. Serious adverse events occurred in 3.3% of patients, and there was no mortality.

Conclusions—The standardized technique employed in this series was associated with lower rates of adverse events, morbidity, and mortality than prior large series. Use of a systematic approach, and integrating elements of this method may improve the risk profile of endoscopic necrosectomy and allow broader adoption.

Keywords

Walled-off necrosis (WON); Walled-off Pancreatic Necrosis (WOPN); Necrosectomy; pancreatitis; direct endoscopic necrosectomy (DEN); NOTES, Pseudocyst, necrotic collection, fluid collection

INTRODUCTION

Acute pancreatitis is responsible for over 270,000 admissions annually.¹ Approximately 20% of cases are complicated by pancreatic necrosis, and 30% of these become infected.^{2,3} Infected necrosis and associated systemic illness have a mortality rate approaching 100% without procedural intervention.^{4,5} Although outcomes have improved in recent years due to earlier recognition, improved supportive care, and development of less invasive therapeutic modalities, considerable variability in patient management persists.^{6,7}

The pancreatic and peripancreatic fluid collections associated with acute pancreatitis have been better classified in recent years. Walled-off necrosis (WON) is a well-demarcated, organized collection of necrotic tissue.⁸ Given the morbidity of pancreatic surgery, the

preferred management strategy for WON has been studied intensely, and has changed with study results over time. Open surgical necrosectomy, and more recently minimally invasive surgical necrosectomy, are associated with complication rates as high as 72%.^{9,10} Subsequent studies, including the randomized PANTER trial, have demonstrated that a step-up approach involving initial percutaneous catheter drainage (PCD), followed by minimally invasive surgical necrosectomy if needed, is associated with less morbidity than initial open surgical necrosectomy.¹¹ Direct endoscopic necrosectomy (DEN) is the most recent therapeutic modality to be employed in the management of WON. This technique allows drainage and endoscopic debridement of necrotic tissue through the gastric or duodenal wall.¹² DEN has demonstrated a higher resolution rate for WON than endoscopic drainage alone (88% versus 45%), underscoring the importance of debridement of semi-solid necrotic material.¹³ In the PENGUIN trial, DEN resulted in less new-onset multiorgan failure and a lower major complication rate than surgical necrosectomy.¹⁴ Furthermore, a recent analysis comparing DEN with the step-up approach found a lower need for antibiotic initiation, less new pulmonary failure, less new endocrine insufficiency, shorter length of stay, and lower health care utilization with DEN.¹⁵

Unfortunately, while DEN has been shown to have lower morbidity and mortality than surgical approaches, there remains a substantial risk of adverse events and mortality, as well as considerable variability in performance of the procedure. Notably, larger series report a mortality of up to 7.5% and an adverse event rate of 14-26%.^{13,16}

Lack of a standard approach to this complex procedure may contribute to these concerns. Procedural variability is not only evident when comparing studies, but is also present within most published series. Within a given center, and even for a single operator, there is often a lack of consistency regarding technical approach to the procedure. Furthermore, due to the large variety of techniques, and relative small number of procedures in the literature, a direct comparison of methods has not been possible. Studies have reported blind entry using electrosurgical incision into a visible bulge in the stomach or duodenum, endoscopic ultrasound (EUS) guided access, electrocautery for hot access under EUS-guidance, cold access applying balloon dilation over a wire, use or no use of lavage solutions, and some studies have reported initial drainage followed by debridement days to weeks after the initial procedure versus debridement at the index procedure.^{14, 16, 17, 18, 19} Published studies have also reported a range of debridement sessions, from daily to every few days, with 2.5 to 7 sessions in total.^{17,16,20}

In order to address the relatively high adverse event rate and mortality risk associated with DEN, each component of the procedure was analyzed to optimize efficiency, maximize safety, and minimize adverse events. As a prelude to this study, various DEN procedural details were considered and modified over time based on clinical experience and the feedback of a multidisciplinary clinical management group consisting of medical pancreatologists, therapeutic endoscopists, radiologists, and surgeons. Ultimately, a standardized care and assessment management plan (SCAMP) for DEN was developed. In this report, we describe the clinical outcomes of this standardized method for DEN in the treatment of WON.

MATERIALS & METHODS

Patients & study design

This study was performed using a consecutive prospective clinical registry. Institutional Review Board approval was obtained. Inclusion criteria were diagnosis of acute pancreatitis based on the Atlanta classification and presence of symptomatic WON. All patients had computed tomography (CT) of the abdomen and pelvis within 10 days prior to the procedure. Charlson Comorbidity Index was calculated at the time of first procedure (Figure 1). The following data were collected: baseline demographics, etiology of pancreatitis, time interval between onset of pancreatitis and first endoscopic treatment, radiologic features of the collections, microbiologic culture data, procedure characteristics, number and type of interventions performed, course until clinical resolution of WON, and development of sequelae during clinical follow-up.

Procedure methods

All procedures were performed by a single operator (CCT) using a standardized technique developed as per the prior SCAMP process (Table 1). General considerations, major steps for DEN (access, debridement, and drainage), and post-procedure care are detailed below.

General considerations—Cross-sectional imaging was reviewed and repeated when the most recent study was more than 10 days prior to the procedure. Procedures were deferred until collection wall maturation was confirmed on imaging, and there was time for liquefaction of necrosis when clinically possible. Cross-sectional imaging was considered essential to assess collection integrity and wall maturation prior to the procedure, as EUS often cannot interrogate the entire perimeter of larger collections (Figure 2). MRI was used specifically if there was concern for pseudoaneurism. Routine chemistry, blood count, and coagulation were also obtained. A type and cross was performed to ensure that blood was available for transfusion as needed. Anesthesia was consulted to formally evaluate the patient and surgical back-up was arranged for all procedures. All procedures were performed in the endoscopy unit, and in the inpatient setting. All patients were intubated and placed under general anesthesia for the procedure. Intravenous antibiotics were administered. Carbon dioxide was used for insufflation and a blood warmer was present in the room at the start of every case. An equipment checklist was reviewed with the endoscopy team prior to the procedure, and all equipment was prepared and organized on the equipment table (detailed in Table 1). Final procedural details were reviewed with anesthesia and the endoscopy team prior to the start of the case, and a time-out checklist review was performed prior to sedation and intubation.

During the procedure the patients were closely monitored by the anesthesia team. Standard vital signs and all general measures were taken. Additionally, due to the use of carbon dioxide in the abdominal cavity, carbon dioxide levels were closely monitored and the respiratory rate was modulated to control blood levels and prevent acidosis. Fluid balance, including lavage solution, and estimated blood loss was tracked. Due to the use of lavage solution in the abdominal cavity core body temperature was also monitored and body warmers used as necessary.

Procedure- Access—A Convex Curvilinear Echoendoscope (EUS) with Doppler (GIF UC-240P, Olympus, Tokyo, Japan) was employed to characterize the collection. EUS is critical in assessing continuity of the gastric wall with the collection and degree of liquification, after maturation has been established by cross-sectional imaging. Pressure was applied to the gastric wall and movement of the collection wall was visualized using EUS. Collections were not accessed if the collection moved independently from the gastric wall. The entry site into the collection was optimized to avoid injury to vasculature. Additionally, a straight endoscope position on fluoroscopy, with minimal tip deflection, was emphasized to facilitate later deep access into the collection. The wall was then punctured using a 19-gauge fine needle aspiration (FNA) needle. To facilitate subsequent balloon access, constant suction was maintained with minimal endoscope movement, and a fixed position was maintained with a straight path from the endoscope channel to the collection. Collection contents were aspirated and sent for Gram stain and culture. Contrast was injected into the cavity, replacing all fluid removed and injecting an additional 5-10 mL at minimum to increase collection wall tension. Overfilling the cavity is critical as it stretches and thins-out the capsule, and also provides counter pressure, to make access more efficient and eliminate the need to employ a variety of access devices. A soft-tipped stiff 0.035 inch $\times$ 450 cm guidewire was inserted into the cavity through the needle under fluoroscopic visualization and looped at least three times when possible, although this may be difficult in smaller collections. This wire was left in place for the duration of the procedure. The FNA needle was exchanged over the wire for a stiff balloon catheter (4-8 mm) with a stainless steel stylet (Hurricane balloon, Boston Scientific, Natick, MA). The balloon was dilated until waist obliteration. This was exchanged for an 18-19-20 mm controlled radial expansion (CRE) balloon (Boston Scientific, Natick, MA). At this point, suction was released and the balloon was visualized and positioned such that it was seen crossing from mucosa into the cavity. This was emphasized to avoid a submucosal dome, which can cause problems with later endoscope access, and to allow better visualization of possible hemorrhage. The balloon was then gradually dilated until the waist dissipated at 20 mm. No electrocautery was used during WON entry.

Procedure- Debridement—The echoendoscope was exchanged for either a large single-channel (GIF XTQ-160, Olympus, Tokyo, Japan) or a double-channel endoscope (GIF 2T-160, Olympus, Tokyo, Japan). The endoscope was advanced adjacent to the original guidewire, and the wire was clipped to the mouth guard with a surgical forceps and left in place to serve as an access site indicator. A direct suction accessory was attached for use when necessary (BioVac, US Endoscopy, Mentor, OH). The endoscope was advanced into the collection and all fluid in the cavity was aspirated. Endoscopic debridement of necrotic tissue was performed during the initial procedure in all cases. The goal of debridement was not complete removal of necrotic debris from the cavity, but rather fragmentation of necrosis with disruption of septations to create a unified, contiguous cavity. Debridement was performed by mechanical fragmentation using large forceps, and copious lavage with aspiration of debris as possible. Additionally, nets, baskets, large forceps, and snares were utilized to remove larger sections of necrotic tissue as needed. A one hour time limit was set for this portion of the procedure. During debridement, the collection was aggressively lavaged with 1-2L warmed Bacitracin-saline solution (25,000 units/L).

Procedure- Drainage—Two to four 10 French double-pigtail stents (Solus; Cook, Bloomington, IN) were placed between the gastrointestinal lumen and the collection, over a separate wire, with stent length being dependent on size and shape of the collection. In collections with irregular geometry, or in collections which crossed the spine, stents were positioned to ensure adequate drainage of all areas. The guidewire used to mark access site location was removed at the conclusion of stent placement. No nasocystic drains were placed in any cases.

Post-procedure care—Intravenous antibiotics were administered prior to the procedure and oral antibiotics for 14 days after. Proton pump inhibitors were held to facilitate digestion of remaining necrotic tissue. Advancement of diet was started the next day. Clinical follow-up was scheduled for the week after discharge. Cross-sectional imaging was performed four weeks after the procedure, and subsequently as needed, until WON resolution. Follow-up endoscopy was performed for stent removal, with repeat DEN performed only if indicated by persistent or recurrent symptoms or persistent collection on imaging. Patients without resolution, or with inaccessible residual collections, were referred for percutaneous drainage or surgical management.

Outcomes

The primary outcome was clinical resolution of symptomatic WON after DEN, defined as resolution of primary symptom and absence of abdominal pain, nausea, vomiting, fever, leukocytosis, and sepsis. Secondary outcomes were radiologic resolution (defined by complete resolution of necrosis or near-complete resolution not requiring further imaging), procedural complication rate, new-onset organ failure, mortality during the procedure or prior to clinical resolution, number of DEN sessions required, length of stay (LOS), and development of endocrine or exocrine insufficiency. Procedural complications were defined as bleeding requiring subsequent endoscopic or radiologic procedures for hemostasis, capsule perforation, or new sepsis. Additional complications included organ failure as defined per the Marshall scoring system used in the Atlanta classification of acute pancreatitis.²¹ Endocrine insufficiency was defined as poor glycemic regulation requiring treatment with insulin or antidiabetic medication during the follow-up period. Exocrine insufficiency was defined as poorly formed bowel movements, diarrhea, or steatorrhea requiring treatment with pancreatic enzymes during the follow-up period.

Statistics

Statistics are reported as mean $\pm$ standard error. Student's *t*-test was used to compare means and the Fisher's Exact test was used to compare proportions. *P*-values ≤ 0.05 were considered significant. The statistical analyses were performed using Stata 12 (StataCorp, College Station, TX).

RESULTS

60 consecutive patients (60% male, age 53.5 ± 1.9 y) were included. Baseline characteristics are summarized in Table 2. Patients commonly had alcohol- or gallstone-induced pancreatitis. Mean Charlson comorbidity index was 2.1 ± 0.3 . DEN patients each underwent

1.58 $\pm$ 0.1 necrosectomies with 39 patients (65%) requiring only one procedure. Mean time to DEN was 10.4 weeks, with nine cases presenting after resolution of initial pancreatitis. These patients required readmission for symptomatic WON and DEN. Dilation of the cystgastrostomy tract to 20 mm was performed in each case, with successful debridement during the initial procedure in 59/60 cases (98.3%). Two of sixty patients (3.3%) had a significant procedure related complication. One patient had bleeding that required further therapy (a hemorrhage during stent deployment that required angiographic embolization). Another patient with prior attempted surgical necrosectomy experienced capsule perforation during our DEN, and was not debrided during the index procedure. The collection was drained and the stomach was endoscopically sutured closed during this index case.²² Debridement of the collection was performed in a subsequent procedure. In addition, seven patients had limited bleeding that was controlled endoscopically during the index procedure, without the need for blood transfusion or subsequent procedure. No other complications occurred.

Clinical resolution occurred in 86.7% of DEN patients, all of whom had radiologic resolution. Mean clinical follow-up was 67.8 $\pm$ 9.9 weeks. 10% of patients had lack of clinical resolution with persistent necrosis on imaging, and the remainder reported symptomatic improvement without complete resolution, despite radiologic resolution. Percutaneous drainage was required in 8 patients during the follow-up period (6 to reach collections inaccessible by DEN, and 2 to address collections drained during DEN). Four patients in whom DEN and PCD were not successful required surgical management. There was no mortality associated with DEN.

DISCUSSION

The standardized technique employed in this series was systematically developed to address the most serious complications of DEN as identified in our prior experience and as documented in published series. This represents the largest single-center series to date, and is the only large series employing a uniform and standardized method for DEN. In this series, DEN was associated with substantially lower rates of adverse events, morbidity, and mortality than reported in other large series. The baseline patient characteristics and clinical endpoints were similar to those reported in the literature. Clinical resolution after DEN in this study was 86.7%, compared to 80-91% in other recent series.^{16,23} An additional small percentage of subjects had radiologic resolution, with improvement of symptoms, but without complete resolution of symptoms. Reasons for this are not clear and this may represent an element of chronic pancreatitis, development of scar tissue, or a slower healing process in some individuals.

Of note, we experienced a procedural complication rate of 3.3%, with only 1/60 patients requiring a separate procedure (angiographic embolization) for complication management. Overall, our major complication rate compares favorably with the 26% reported by Seifert et al and 14% reported by Gardner et al.^{16,17} Furthermore, there was no procedure related mortality in this series, compared with a reported 1.9-7.5% rate in other series.^{16,17,23-26}

The standardized method employed in this series was specifically designed to emphasize safety. Prior experience and literature review were used to identify major procedural risks, and a multidisciplinary team then agreed upon measures to limit these risks. CO₂ insufflation was employed to limit the established risk of air embolism, EUS-guidance was used to limit the risk of perforation and bleeding, and cold-access was used to minimize bleeding seen with electrocautery. Other measures were incorporated based on surgical principles or anecdotal experience. Injection of contrast was used to stretch the capsule and provide less resistance to cold-access. Use of a safety wire was used to mark the access site. Aggressive fragmentation of necrosis rather than extensive removal of debris from the cavity was applied to maximize efficiency and minimize trauma to the access site. Copious lavage of antibacterial solution was employed to remove bacterial biofilm and assist with debridement. Debridement was performed on the initial procedure in all cases, as the best way to prevent adverse events from a subsequent procedure is to avoid that procedure entirely. Additional measures, such as discontinuing acid suppression medications to encourage auto-digestion of the necrosis and to further address potential infectious complications, were included to reduce the need for repeat procedures and thus further limit risk. Collectively, it was felt that consistent application of these measures would limit adverse events, and that application of a rigorous standardized process to such a complex multistep procedure would increase team efficiency and minimize errors.

Collection access has been a focal point for the adverse events in most published series. Previous series, largely without EUS, reported bleeding rates of 17% to 20% requiring hemostasis.^{16,17} Bleeding in our series was limited to the debridement process; no bleeding occurred during access. The tenets of safe access in this technique include EUS evaluation and guided needle placement, injection of contrast for capsule distension, and balloon dilation of the access tract without the use of electrocautery. EUS evaluation is performed to ensure that the collection is adjacent to the gastrointestinal tract, and that they move concurrently during respiration, circulation, and endoscope manipulation. We have found that proximity between the gastrointestinal lumen and the collection is less significant than evidence that they are mechanically dependent. FNA needle placement under Doppler EUS is important to avoid injury to blood vessels. Once fluid has been aspirated for microbiologic analysis, it is essential to inject contrast into the collection, 5-10 mL more than was removed, to create capsule tension. This facilitates subsequent entry and dilation with a stiff balloon catheter (over the guidewire), avoiding electrocautery for capsule incision. The tract is serially dilated to 20 mm. This admittedly large caliber appears safe, and may allow gastric acid to enter the cavity and further digest residual necrotic material. A guidewire was coiled in the cavity, clipped to the mouth guard, and left in place along-side the endoscope for the duration of the procedure, as we found the access site could be challenging to locate in our earlier experience.

We performed maximal safe fragmentation of necrotic tissue with disruption of septations during the initial procedure, with aggressive lavage using an antibiotic solution, rather than complete removal of necrosis. In other series, cystgastrostomy was performed with necrosectomy during a separate session, with lower rates of necrosectomy during the initial procedure (49% reported by Gardner, 0% reported by Seifert). In our series, the number of DEN sessions required per patient (1.58 ± 0.1) was lower than reported by other series

(2.5-7).^{16,20,23} The most effective way to reduce the adverse events associated with subsequent DEN procedures is to avoid them entirely. Although there may be reason to avoid a lengthy initial DEN procedure in the septic or critically ill patient, efficient access as described above allows more time for safe and effective debridement during the index procedure in most ill patients. Delayed debridement should be the exception, and not the standard approach, as subsequent procedures carry additive risk. Additionally, proton pump inhibitors were avoided after the procedure to promote digestion of necrotic material and to decrease the likelihood of subsequent infection.

After debridement was complete, drainage was achieved with two to four 10 French double pigtail stents. In collections with irregular geometry or collections which crossed the spine, drainage was optimized by placement of the internal pigtail into all recesses when possible. We did not resort to nasocystic drainage catheters given the high rate of resolution after the initial DEN procedure.

Although the protocol resulting from the prior SCAMP process was stable throughout this series, we did subsequently add some equipment to address potential adverse events as it became available. Initially, we employed hot biopsy forceps to address intraprocedural bleeding; however, we now ensure that coagulation graspers are available prior to the start of the case. Additionally, we maintain availability of a double channel endoscope and endoscopic suturing device to address perforation should the need arise.

This study has limitations. Patients were typically referred for DEN rather than percutaneous drainage or surgical management after discussion and consensus at a multidisciplinary case conference including radiologists, medical pancreatologists, therapeutic endoscopists, and surgeons. This likely optimized patient selection, and may have introduced the possibility of referral bias. All procedures were performed by a single endoscopist, possibly limiting generalizability; however, a uniform and easily replicated standardized method was employed.

As new technology becomes available for DEN the efficiency of access, debridement, and drainage should continue to improve and the equipment list may be simplified. Nevertheless, it is essential to have all equipment identified and prepared at the start of the case and to maintain a consistent procedural flow. Additionally, as newer lumen apposing metal stents are evaluated in the treatment of WON procedure steps may be simplified, however, pigtail stents may still be needed in certain cases to assure adequate drainage of all portions of the collection. Furthermore, certain basic tenants will likely remain important as newer systems are developed - such as aggressive lavage, some fragmentation of necrotic tissue, and minimizing the number of repeat procedures.

The endoscopic management of WON is still in its infancy. There is a lack of procedural consistency within and across centers, and within most published series. As the management strategy and procedure become better defined there will be a more uniform approach to this condition. A more consistent approach will in turn allow a more rigorous evaluation of specific techniques and procedural elements, which is not possible when there is a wide variety of methods and lack of consistency across nearly all procedural steps. For instance,

the effectiveness of antibiotic lavage cannot be fully understood if there is no consistency in access technique, use of EUS, amount of debridement, method of drainage, post procedure antibiotics, use of PPI, or other important steps. These studies are in turn needed to develop valid consensus statements and guidelines, and will further encourage the safe adoption of this procedure by centers that currently do not perform necrosectomy.

An element of procedural consistency is also important in the development of training programs and milestones. An organized approach is essential in training advanced fellows, over a one year period, with a goal of them being competent and comfortable in the independent performance of the procedure. Furthermore, this is even more critical in training the practicing clinician, in a truncated period of time. Looking ahead, we must consider the role of simulation, hands-on courses, and other means to facilitate training, and in competency assessment.

In conclusion, the standardized technique for DEN described in this study was associated with lower rates of adverse events, morbidity, and mortality than prior large series, while maintaining a similar success rate. Use of a standardized approach and integrating elements of this method, such as EUS-guided cold access, early fragmentation, aggressive lavage, and cessation of PPIs, may improve the risk profile of DEN and allow broader adoption.

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Charlson Comorbidity Index Scoring System

Score	Condition
1	Myocardial infarction (history, not ECG changes only) Congestive heart failure Peripheral vascular disease (includes aortic aneurysm ≥ 6 cm) Cerebrovascular disease: CVA with mild or no residua or TIA Dementia Chronic pulmonary disease Connective tissue disease Peptic ulcer disease Mild liver disease (without portal hypertension, includes chronic hepatitis) Diabetes without end-organ damage (excludes diet-controlled alone)
2	Hemiplegia Moderate or severe renal disease Diabetes with end-organ damage (retinopathy, neuropathy, nephropathy, or brittle diabetes) Tumor without metastases (exclude if >5 y from diagnosis) Leukemia (acute or chronic) Lymphoma
3	Moderate or severe liver disease
6	Metastatic solid tumor AIDS (not just HIV positive)

NOTE. For each decade > 40 years of age, a score of 1 is added to the above score.

Abbreviations: ECG, electrocardiogram; CVA, cerebrovascular accident; TIA, transient ischemic attack; AIDS, acquired immunodeficiency syndrome; HIV, human immunodeficiency virus.

Figure 1. Charlson Comorbidity Index Scoring System

Reprinted from American Journal of Kidney Diseases, 32(2), Fried L, Bernardini J, Piraino B, Charlson Comorbidity Index as a Predictor of Outcomes in Incident Peritoneal Dialysis Patients, 338, 2001, with permission from Elsevier.

Figure 2. CT Scan showing WOPN

TABLE 1
DEN standardized care assessment and management plan for WON

General considerations	
☐	Type and screen
☐	Labs: INR / coagulation status, CBC, routine chemistry
☐	Cross-sectional imaging within 10 days
☐	IV antibiotics
☐	Anesthesia consultation
☐	Surgical and interventional radiology backup arranged
Room setup and necessary equipment	
☐	General anesthesia equipment
☐	Fluoroscopy
☐	Endoscopic ultrasound
☐	Upper endoscope (therapeutic / large-channel)
☐	Blood warmer (for lavage solution and blood as needed)
☐	Carbon dioxide insufflation
☐	BioVac direct external suction
☐	19-G FNA EUS needle
☐	Contrast
☐	Microbiology culture bottles / sterile container
☐	0.035 × 450 cm guide-wire (×2)
☐	Hemostat (Kelly surgical clamp)
☐	Endoscopic balloons (stiff 4-8 mm × 4 cm, CRE 20 mm)
☐	Debridement accessories: large (rat tooth) forceps, nets, baskets, and snares
☐	Endoscopic hemostasis: epinephrine, coagulation graspers
☐	Warmed Bacitracin-saline solution (25,000 units/L), 2L
☐	Double pigtail stents
Access	
EUS evaluation to confirm unity of movement between collection and GI tract, and with Doppler to avoid vessels	
Confirm straight scope position on fluoroscopy, and maintain position using continuous suction and minimal movement until final balloon dilation	
Aspiration for culture	
Injection of contrast to distend collection and create wall tension for access	
Stiff guidewire looped in cavity (also used to mark access site for duration of case)	
Entry into collection with stiff balloon catheter (no electrocautery)	
Tract dilation to 4-8 mm and then to 20 mm	

Guidewire maintained in cavity throughout procedure (adjacent to the endoscope used for debridement)
Debridement (always planned in first session, 1 hour limit)
Exchange for large-channel endoscope +/- external BioVac suction device
Fragmentation and septation disruption emphasized over complete removal of necrosis
Aggressive lavage with large-volume warmed antibiotic solution
Avoid electrocautery in cavity when possible
Drainage
Placement of pigtail stents to drain all areas of collection (plan placement of 3 stents)
Remove guidewire marking access site under fluoroscopy after last stent placed
Post Procedure
Avoid PPI to encourage digestion of remaining necrosis
Start advancing diet next day
Intravenous antibiotics for 14 days
Clinic follow-up at 1 week after discharge
Cross-sectional imaging after 4 weeks with clinical follow-up

TABLE 2
Baseline characteristics (n=60)

Age (mean $\pm$ SEM [range])	52.8 $\pm$ 2.0 y [15-90]
BMI, kg/m ² (mean $\pm$ SEM)	27.6 $\pm$ 0.9
Charlson score (mean $\pm$ SEM)	2.1 $\pm$ 0.3
Etiology (% (n))	
• Gallstone	40.0% (24)
• Alcoholic	28.3% (17)
• Other / unknown	31.7% (19)
Male (% (n))	60% (36)
Diabetes mellitus	28.3% (17)
Exocrine pancreatic insufficiency	33.3% (20)
Mean weeks from acute pancreatitis to first endoscopic intervention	10.4 $\pm$ 1.4
Direct procedure indication (% (n))	
• Nausea, vomiting	15.0% (9)
• Abdominal pain	38.3% (23)
• Nausea, vomiting, abdominal pain	13.3% (8)
• Infection	30.0% (18)
• Organ failure	1.7% (1)

TABLE 3**Clinical outcomes**

Characteristic	
Procedure time (min)	83.3 ±7.5
Total in-hospital days after initial drainage (mean ±SEM, d)	6.8 ±1.0
Procedures per patient	1.58 ±0.1
Successful resolution (% (n))	86.7% (52)
Need for further therapy (% (n))	13.3% (8)
PCD	13.3% (8)
Operative debridement (% (n))	6.7% (4)
New endocrine insufficiency (% (n))	10% (6)
New exocrine insufficiency (% (n))	23.3% (14)
Mortality (%)	0%