**Name of journal: World Journal of Gastroenterology**

**ESPS Manuscript NO: 18891**

**Manuscript Type: Review**

**Endosonography guided management of pancreatic fluid collections**

Vilmann AS *et al*. EUS-guided management of pancreatic fluid collection

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**Author contributions:** All authors have been involved in the design and conduct of this work. Research was done by Tang SJ and Menachery J; Drafting the article was equally done by Vilmann AS and Menachery J; Critically revision was equally done by all authors; Final version was approved by all authors.

**Conflict-of-interest statement:** Vilmann AS, Menarchy J, Srinivasan I and Tang SJ have no conflict of interest. Vilmann P reported a conflict as a consultant for MediGlobe, GmbH, Grassau, Germany.

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**Telephone:** +45-51-365185

**Received:** April 28, 2015

**Peer-review started:** May 6, 2015

**First decision:** June 2, 2015

**Revised:** June 24, 2015

**Accepted:** August 30, 2015

**Article in press:**

**Published online:**

**Abstract**

The revised Atlanta classification of acute pancreatitis was induced by international consensus and is based on the actual local and systemic determinants of severity. The local determinant includes pancreatic necrosis (sterile or infected) and the systemic determinant involves organ failure. Local complications of pancreatitis include acute peri-pancreatic fluid collection, acute necrotic collection, pseudocyst, and walled-off necrosis. Increasingly, interventional endoscopic ultrasound (EUS) is utilized in the management of these local complications. The authors performed PubMed search and a pre-defined inclusion criteria or filter was then manually applied. The authors reviewed the utility, efficacy and risks of therapeutic EUS and involved EUS devices among these settings, which we grouped as pancreatic fluid collections (PFC). The authors predict a continuing evolution in the management of these PFCs with improved and novel endoscopic devices dedicated for transmural drainage of fluid and necrotic debris: access and patency devices. EUS should become an indispensable part of this procedure for diagnosis and image guided interventions. The amount of necrosis is the most important predictor of successful outcome after drainage of these PFCs, regardless of their different terminologies. Hence it would seem logical to classify these collections based on the percentage of necrotic component or debris under radiological imaging studies or EUS. The authors propose an algorithm in managing these fluid collections based on their size, locations, associated symptoms, internal echogenic patterns and content.

**Key words:** Endoscopic ultrasound; Drainage; Pancreatic fluid collection; Pseudocyst; Patency device; Abscess; Walled of necrosis; Pancreas

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**Core tip:** The revised Atlanta classification of acute pancreatitis was induced by international consensus and is based on the actual local and systemic determinants of severity. Local complications of pancreatitis include acute peri-pancreatic fluid collection, acute necrotic collection, pseudocyst, and walled-off necrosis. Increasingly, interventional endoscopic ultrasound (EUS) is utilized in the management. In this review, the authors reviewed the utility, efficacy and risks of therapeutic EUS and involved EUS devices among these settings. The authors propose an algorithm in managing these fluid collections based on their size, locations, associated symptoms, internal echogenic patterns and content.

Vilmann AS, Menachery J, Tang SJ, Srinivasan I, Vilmann P. Endosonography guided management of pancreatic fluid collections. *World J Gastroenterol* 2015; In press

**Introduction**

In 1992, the Atlanta classification of acute pancreatitis was induced by international consensus. The Atlanta classification aimed to standardize reporting and communication between health care professionals. However, some of the terminologies used are confusing and lack objective description of local complications so that new treatment can be provided. In 2012, the revised Atlanta classification was released after years of web-based consultation among a global panel of experts and international pancreatic associations[1–3]. The new classification is based on the actual local and systemic determinants of severity, rather than description of events that are correlated with severity[1,2]. The local determinant includes pancreatic necrosis (sterile or infected) and the systemic determinant involves organ failure (transient or persistent). Acute pancreatitis is now identified as early and late phases and its severity is classified as mild, moderate or severe. Mild acute pancreatitis has no organ failure, local or systemic complications and usually resolves in the first week. Moderately severe acute pancreatitis has transient organ failure, local complications or exacerbation of co-morbid disease. Severe acute pancreatitis displays persistent organ failure (> 48 h) (Table 1).

Local complications of pancreatitis include acute peri-pancreatic fluid collection, acute necrotic collection (ANC, sterile or infected), pseudocyst, and walled-off necrosis (WON) (sterile or infected). WON is characterized by a distinct rim that forms around the necrosis and adjacent pancreatic parenchyma. Increasingly, interventional endoscopic ultrasound (EUS) is utilized in the management of these local complications[4,5]. In this review, the authors searched the English language medical literature and reviewed the utility, efficacy and risks of therapeutic EUS and involved EUS devices among these settings, which we grouped as pancreatic fluid collections (PFC). The authors propose an algorithm in managing these fluid collections based on their size, locations, associated symptoms, internal echogenic patterns and structures.

**Methods and Review Strategy**

On November 15, 2014, the authors performed PubMed search using following key word sets: EUS in combination with terminologies related to pancreatic fluid collections such as pseudocyst, fluid collection, abscess, and WON. A pre-defined inclusion criteria or filter was then manually applied to PubMed search results (Figure 1). The inclusion criteria were: (1) original reports; (2) case number > 6; and (3) and English language publication only. The authors then performed manual review of these publications and their listed references, i.e. cross-reference search. Finally, each published paper was reviewed by two of these authors together, extracting the important information related to this review.

**Indications and timing for transmural drainage**

The decision to drain a pancreatic fluid collection depends on clinical symptoms, condition of the patient, change in size over time, time from onset of symptoms, infection and other complications. Asymptomatic pancreatic and/or extra-pancreatic fluid collections do not warrant intervention regardless of size, location, and/or extension, drainage is considered only when a collection becomes symptomatic or is infected[6]. Infection is more common in necrotic collections and is suggested by air pockets inside the collection visible on computerized tomography (CT) scan. If the clinical scenario strongly raises the suspicion of an infected collection it may be documented by fine needle aspiration. In case of sterile collections, luminal or biliary obstruction from external compression, persistent abdominal pain requiring narcotics or an undiagnosed sepsis syndrome can be indications for drainage[7]. PFC may be drained surgically, percutaneously or endoscopically.

Timing is critical for successful endoscopic drainage in necrotizing pancreatitis. Interventions within the first few weeks for necrotizing pancreatitis are generally associated with poor outcomes. The guiding principle for timing of debridement is to delay, any intervention until the collection has become encapsulated and the content liquefied as much as possible. Typically encapsulation does not occur until at least 4 weeks after the initial injury.

Endoscopic treatment has been shown to have comparable efficacy to surgical drainage albeit with shorter hospital stays, better physical and mental health of patients and lower cost[8]. Percutaneous drainage requires the patient to have an external drain for an extended period of time. This may lead to development of pancreatico-cutaneous fistulas especially in those cases with ductal disruption. When compared to percutaneous drainage endoscopic approach allows placement of multiple drainage modalities through a single puncture site.

EUS permits visualization of the entire cavity, assesses the maturity of the wall, measures the distance of the collection from the luminal wall and also identifies intervening vessels (collaterals) along the puncture site (Figures 2 and 3). EUS guided drainage of PFC has been shown to have higher technical success when compared to conventional transmural endoscopic drainage without EUS guidance[9]. EUS guided drainage is the preferred modality when there is no visible luminal bulge or when there is a clinical suspicion of portal hypertension and collateral formation or in patients with coagulopathy[4,6,7].

**Should ERCP and trans-papillary drainage be performed on these patients?**

Endoscopic drainage of PFCs may be performed either during endoscopic retrograde cholangiopancreatography (ERCP) with drainage through the main ampulla of Vater or *via* a transmural route, either *via* the duodenum or the stomach. There are at present no comparative or randomized studies from which solid data can be extracted regarding the preferred method for drainage. Only case series with inconsistency of methods and guidelines based on expert opinions have been published[10,11]. According to these transpapillary drainage is preferred to EUS guided transmural drainage as a first step procedure for small collections communicating with the main pancreatic duct in the head or body of the pancreas (Figure 4). In most publications with EUS guided drainage there is no description whether all patients had undergone ERCP prior to EUS guided drainage. In a series of 116 patients of which 15 had transpapillary drainage, 60 transmural and 41 both methods, successful drainage was achieved in 88% of the patients[12]. There was no difference in success between the methods. Hence, the recommendation statement that a pancreatic fluid collection preferably should be drained *via* the pancreatic papilla and the pancreatic duct is based on very low evidence.

**Does location of the fluid collection matter**

Transmural drainage has been attempted in pancreatic pseudocysts (Figure 5A). and WON (Figure 5B). of suitable size located in the head, body or tail of pancreas provided the distance between the lumen wall and cyst is less than 1 cm. Due to their location in the lesser sac or extension to the pararenal space, PFC in the pancreatic tail do not cause a luminal compression and can be accessed only by EUS. Varadarajalu *et al*[13]have noted that the location of the pseudocyst is not a predictor for treatment success. However 2 cases of perforation have been described when transgastric drainage was attempted for pseudocysts located in the uncinate process of pancreas. This complication did not occur in uncinate pseudocysts when the drainage was attempted from the duodenum. Following transmural stenting, the pseudocyst hanging low from the uncinate region gets decompressed and probably disconnect from the stomach wall, leading to perforation[14].

**Does the amount of internal debris matter**

In the context of drainage of PFCs, technical success refers to achieving access and placement of transmural stents whereas clinical success would mean resolution of the collection. Very high clinical success rates between 90%-100% have been achieved in drainage of pseudocysts[9,12,15]. However in cases of walled off pancreatic necrosis, the results for clinical resolution are generally poor. In a recent study of 211 patients with symptomatic PFCs, whereas the rate of treatment success for sterile and infective pseudocysts was 93.5%, it was only 63.2% for WON[13]. Baron *et al*[16] showed that the success rate of pseudocyst drainage was 92%, compared to 72% in patients with necrosis. Although this study utilized non-EUS-guided endoscopic drainage, it illustrates the principle that the outcome of endoscopic drainage for pseudocysts was superior to drainage of infected necrosis. In another study, drainage of necrosis resulted in clinical success in only 25% and technical success in 50% of the cases[12]. If an aggressive endoscopic approach using endoscopic necrosectomy is adopted, success rates up to 81% can be achieved in WON[17]. Adjunctive surgical and percutaneous drainage may be needed. Varadarajalu *et al.* suggested multiple transluminal gateway treatment (MTGT) for WON by which they could attain successful response in 92% of patients. Two or three transmural tracts were created by using EUS guidance between the necrotic cavity and the gastrointestinal lumen. While one tract was used to flush normal saline solution *via* a nasocystic catheter, multiple stents were deployed in others to facilitate drainage of necrotic contents[18].

As the necrotic component in the collection increases the success rate decreases progressively unless aggressive endoscopic necrosectomy or concomitant percutaneous drainage is also used. The progression to surgery is also more common in these groups. The revised Atlanta classification suggests that WON is a well encapsulated fluid collection which occurs 4 weeks in the setting of a necrotic pancreatitis. However, this may not always be true as necrotic collections can liquefy over time. An Indian study with follow-up EUS at 6 weeks, 3 months and 6 months after the onset of acute necrotic pancreatitis demonstrated that all the fluid collections following acute necrotic pancreatitis may not have solid necrotic content and over a period of time the collections tend to decrease in size and the solid content tends to liquefy with almost half of PFCs completely liquefying at 6 months[19].

Another study from the same group looked at 43 patients with symptomatic WON who were treated by endoscopic drainage[20]. They divided the patients into three groups. The mean size of WON was 9.95 ± 2.75 cm with < 10%, 10%-40% and > 40% solid debris being present in 6, 33, and 4 patients, respectively. Patients with < 10% necrotic debris needed only single session of endoscopic drainage, whereas patients with 10%-40% solid debris needed two or more sessions. Patients with > 40% solid debris either needed direct endoscopic debridement or surgical necrosectomy. The extent of necrosis correlated significantly (*r* = 0.703, *P* < 0.001) with the type of treatment received by the patient.

**choice of transmural access devices**

EUS-guided PFC drainage is limited by the lack of dedicated accessories, which necessitates multiple steps for transluminal stent placement. At first the fluid collection is visualized using a linear echoendoscope. Any intervening vessel in the line of puncture is ruled out using Doppler technology. The PFC is then punctured under vision. Puncture of the cyst wall could be performed in one of three ways: (1) a 19-gauge FNA needle; (2) a cystostome; or (3) a needle wire followed by the insertion of a 0.035 guide wire. When multiple stents need to be placed some authors prefer a double guide wire approach in which two guide wires are simultaneously inserted after the first puncture[21]. Recently, a novel lumen-apposing self-expandable metal stent (AXIOSTM system, Xlumina, Mountain View, CA, United States) has been developed that can be deployed in a single step (Figures 6 and 7). The stent has a dumbbell-shaped configuration that foreshortens on deployment, there­by minimizing the possibility of leak or perforation[22].

**Cystoenterotomy patency devices**

A variety of stents have been used to maintain patency of the fistulous tract between the gut lumen and the PFC. Single plastic stents (straight or double pigtail), multiple plastic stents, nasocystic drainage catheters, enteral metal stents and biliary metal stents have been tried. Some studies have also described a combination of modalities like plastic stents in combination with nasocystic drainage catheters or double pigtail stents axially placed through a metal stent. The available literature contain studies with heterogenous nature and there is no clear evidence to suggest metal stents are better than plastic stents or one type of plastic stent is better than another.

***Pseudocysts***

Lopez *et al* used single plastic stents for draining pseudocysts. The drainage was successful in 93% patients with a recurrence noted in 25% cases. They also noted that straight stents had a trend for higher complications as compared to double pigtail stents even though the difference was not statistically significant[23]. The straight stents do not have anchorage and may migrate more easily as compared to double pigtail stents. Straight stents have also been reported to cause bleeding and perforation.

In a single centre prospective cohort study Antillon *et al*[24] looked at the efficacy of single-step EUS-guided transmural drainage of pseudocysts. Complete resolution of the pseudocyst was achieved in 27 (82%) of the 33 patients at the index procedure. Four additional patients (12%) had only partial resolution (50% reduction in cyst size), accompanied by symptom resolution. Recurrence was observed in only 1 patient over a median follow-up of 46 wk.

In a retrospective study 87 consecutive patients with pancreatic pseudocysts were managed by EUS-guided drainage: those with solid debris who underwent drainage *via* nasocystic drains alongside stents (*n =* 63) and those with solid debris who underwent drainage *via* transmural stents only (*n =* 24). The patients with viscous solid debris-laden fluid whose pseudocysts were drained by both stents and nasocystic tubes had a 3 times greater short-term success rate compared with those who had drainage by stents alone (OR = 3.6; 95%CI: 1.2-10.7; *P =* 0.03). Long-term follow-up showed a non-significant trend toward better resolution of pseudocyst with debris drainage *via* nasocystic drains alongside stents compared with stents alone (79% *vs* 58% respectively, OR = 2.7; *P =* 0.059). The rate of stent occlusion was higher in cysts with debris drained by stents alone compared with those drained *via* nasocystic drains alongside stents (33% *vs* 13%; *P =* 0.03)[25].

A single step, simultaneous double-wire technique with a prototype device was introduced by Seewald *et al*[21] Eight patients with symptomatic pseudocysts underwent drainage. After puncture two 0.035-inch guide wires were simultaneously inserted into the cyst cavity followed by transmural stenting with an 8.5F double pigtail stent and insertion of a 7 French nasocystic catheter. The cavity was irrigated with a total of 1500 mL of saline solution daily through the nasocystic catheter to prevent accumulation of pus and debris. The nasocystic catheter was used to provide irrigation over a range of 7 to 21 d. Complete resolution of the pseudocysts was achieved in all patients as determined by follow-up CT scan. There was no pseudocyst recurrence during the follow-up period, which ranged from 6 to 16 mo.

Due *et al* described 10 cases of pancreatic pseudocyst drainage out of which 7 patients received a 10 mm × 20 mm covered double-flanged metal stent[26]. Three patients had sepsis due to stent blockage and one patient had a persistent leak. Two patients with stent blockage and the one patient with leak ultimately required surgical intervention. Fabbry *et al*[27] reported the drainage of 20 cases of infected fluid collection using covered self expanding metal stents (SEMS). Either 4cms or 6cms long SEMS were used with a diameter of 10 mm. The procedure was technically successful in all and the treatment success was 90%. The stents were removed after 1 mo. Removal was successful in all except one case and one stent was found to be migrated. One patient required surgery. There have been attempts to provide better anchorage to metal stents by deploying plastic stents through them thereby reducing chances of SEMS migration. Talreja *et al*[28] described a series of seventeen patients with PFC who underwent endoscopic drainage. 10 mm × 60 mm SEMS were used and double pigtail plastic stents were deployed through or along the side of the metal stents to provide better anchorage. They had reported 95% treatment response with stent migration reported in only one patient. Comparable results were noted by Penn *et al*[29] when they used this technique for pseudocyst drainage.

A study from California evaluated EUS guided drainage of PFCs using a one-step access device (NAVIXTM, Xlumina) followed by placement of a fully covered SEMS. Eighteen patients with PFC with indeterminate adherence were enrolled. After 7–10 d, the fully covered SEMSs were removed and exchanged for double-pigtail stents. When indicated, tract dilation and endoscopy-guided cyst debridement was performed. Fully covered SEMS placement was technically successful in all patients without complications. Median procedure time was 37.5 min. Cyst resolution was achieved in 78% of patients[30]. Berzosa *et al*[31] also showed 100% technical and clinical success with SEMS. No instance of stent migration was reported in this study. Most of these SEMS’s were tubular stents designed for transluminal drainage, such as bile duct drainage. When used for transmural drainage, these SEMSs have some limitations, including a high risk of stent migration and may cause tissue injury and bleeding. Therefore, a novel large-diameter SEMS with bilateral flanges, the AXIOS stent, has been designed especially for transmural drainage. It consists of a barbell-shaped, flexible, fully covered, self-expanding nitinol stent housed within a catheter-based delivery system. The stents are available in 2 sizes: 10 mm × 10 mm and 15 mm × 10 mm. The 10 mm saddle length is designed to appose the stomach or duodenum to the PFC wall. In 2012, Itoi *et al*[32] first described the use of AXIOS stents in a series of 15 patients with symptomatic pseudocysts who underwent drainage. All stents were successfully deployed without complications, with a median time to removal of 35 d. All pseudocysts resolved after a single drainage procedure. One stent migrated into the stomach, and the remaining 14 were found to be patent at the time of removal. There was no pseudocyst recurrence during the 11-month median follow-up period. In 2013, a Spanish study reported the usage of AXIOS stents for pseudocyst drainage[33]. They had a technical success of 88% (8/9) as there was failure of the delivery system in one case. No stent migration was reported and all stents were removed easily. All patients had a successful treatment outcome achieving complete cyst resolution.

***Walled-off necrosis***

WON often leads to severe clinical deterioration necessitating open debridement or endoscopic necrosectomy. Infection is a common complication in the endoscopic drainage of pancreatic fluid collections. It is more commonly observed in WON than in pseudocysts presumably due to stent occlusion by the solid debris and subsequent bacterial colonization. Hence the general opinion is in favor of placing multiple stents especially in WON. In MTGT, 2 or 3 transmural tracts were created by using EUS guidance between the necrotic cavity and the gastrointestinal lumen. While one tract was used to flush normal saline solution *via* a nasocystic catheter, multiple stents were deployed in others to facilitate drainage of necrotic contents. Varadarajalu *et al* compared MTGT with conventional EUS guided drainage. Of 60 patients with symptomatic WON, 12 were managed by MTGT and 48 by conventional drainage. Treatment was successful in 11 of 12 (91.7%) patients managed by MTGT *vs* 25 of 48 (52.1%) managed by conventional drainage (*P =* 0.01). Although 1 patient in the MTGT cohort required endoscopic necrosectomy, in the conventional drainage cohort, 17 required surgery, 3 underwent endoscopic necrosectomy, and 3 died of multiple-organ failure[18].

A multicentre prospective study from United States evaluated the outcomes of AXIOS stent placement in 33 patients with symptomatic pancreatic pseudocysts and WON[22]. The devices were placed successfully under endoscopic ultrasound guidance in 30 patients (91%); the remaining 3 patients received 2 double-pigtail stents. One subject could not be evaluated because of a pseudoaneurysm. In the patients receiving AXIOS stents, PFCs resolved in 27 of 29 (93%). Stent migration was noted only in one patient. In a large multicentre trial involving 15 European centers, 61 patients with either pseudocyst (*n =* 46, 75%) or WON (*n =* 15, 25%) were drained using AXIOS stents. Stent placement was technically successful in 60 patients (98%). Clinical success, defined as resolution of clinical symptoms in combination with a decrease in the PFC size to ≤ 2 cm on imaging, was achieved in 93% of patients with a pancreatic pseudocyst and in 81% of patients with WON. Treatment failure occurred in nine patients (16%) including four patients who required surgical intervention. Stent removal was performed in 82% of patients after a median of 32 days and was rated as easy in all but one patient. In 10 patients, endoscopic stent removal was not performed because of stent migration (*n =* 3), stent dislodgement during necrosectomy (*n =* 3), stent removal during surgery (*n =* 2), or refusal by the patient (*n =* 2).

**Single or multiple stents**

In cases of pseudocysts there is no randomized control trial, which has looked at the question whether a single plastic stent or multiple plastic stents or a metal stent is better. However retrospective studies have shown that even single stents have given high rates of clinical resolution. This is probably because stent occlusion may not have occurred as there is no solid necrotic debris. In a recent meta-analysis, 14 studies involving 698 patients were evaluated and no difference was detected in the rates of treatment success between patients managed with mul­tiple plastic stents *vs* metal stents at 89% (95%CI: 87-91) *vs* 87% (95%CI: 76 to 91; *P =* 0.22), re­spectively. Also, there was no difference in the rates of ad­verse events or pseudocyst recurrence between the two cohorts[34]. However in cases of WON this may not be applicable as stent occlusion and consequent treatment failure are very much likely and it should be stressed that the chance of clinical resolution and success is depended on adequate drainage. This is underlined by the success of MTGT technique for WON proposed by Varadarajalu *et al* where placement of multiple stents at different sites along with a nasocystic drain achieved clinical resolution in more than 90% cases[18].

**Definition of clinical and radiological success**

Technical success is defined as the ability to access and drain the pancreatic pseudocyst by the placement of a stent. Treatment success involves both clinical and radiologic improvement. Clinical success refers to the resolution of the symptoms that prompted the intervention. Radiologic success refers to the decrease in size or resolution of the cyst. In a randomized clinical trial which compared endoscopic and surgical drainage for pseudocysts, treatment success for endoscopy was defined as complete resolution or a decrease in size of the fluid collection to 2 cm or smaller on CT scan in association with resolution of symptoms at the 8 weeks outpatient follow up evaluation[8]. Follow up is usually done with upper endoscopies and imaging which could be either CT scan or abdominal ultrasound.

**Efficacy of EUS guided drainage of pancreatic fluid collections**

Very high clinical success rates between 90%-100% have been achieved in drainage of pseudocysts[9,12,23]. The data on abscess drainage are more limited than pseudocyst drainage. High treatment success rates ranging from 80%[35] to greater than 90%[12] have been reported. However in cases of WON, the results for clinical resolution are generally poor. In a recent study of 211 patients with symptomatic PFCs, whereas the rate of treatment success for sterile and infected pseudocysts was 93.5%, it was only 63.2% for WON[36]. If an aggressive endoscopic approach using endoscopic necrosectomy is adopted, success rates up to 81%[17] can be achieved in WON. Adjunctive surgical and percutaneous drainage may be needed. Varadarajalu *et al* suggested multiple transluminal gateway treatment for WON by which they could attain successful response in 92% of patients[18]. In a retrospective review of 31 patients who underwent EUS guided drainage of fluid collections after pancreatic resection, EUS guided drainage was performed effectively with a technical success rate of 100%. Clinical success was achieved in 29 of 31 patients (93%)[37].

**Complications and risks of EUS guided transmural drainage**

The rate of complications range from 1%-18%[12,24,36,38–40], most commonly in the form of bleeding, perforation, secondary infection and stent migration. A retrospective study, by Varadarajulu *et al* reported a significantly higher complication frequency in cases of pancreatic necrosis (15%) compared with pseudocysts and abscess (5%)[13]. Secondary infection is caused by contamination of an incompletely drained WON or pseudocyst from premature stent occlusion or uneven collapse. The frequency of secondary infection is up to 10%. The perforation risk increases when the pseudocyst wall is poorly defined or has a distance of more than 1 cm from the intestinal lumen. Very few cases of procedure related mortality have been reported mainly related to bleeding[12,41,42]. Surgery is required in up to 5%-11% of the cases, thus most complications are managed conservatively, by interventional radiologist or by endoscopy[43]. Complication such as pneumothorax, air embolism and intra-abdominal abscess are seldom reported.

**When consider surgery**

Surgical management of walled-off pancreatic collections can be performed with an open surgical procedure or with a laparoscopic approach. Most of the surgical literature is based on open surgical drainage procedures. Open surgical drainage can be accomplished *via* cystgastrostomy, cystenterostomy (direct drainage or *via* a Roux limb), or resection. Drainage can also be accomplished laparoscopically. Laparoscopic cystgastrostomy can be performed *via* an anterior transgastric approach or a posterior approach through the lesser sac requiring only a single gastrotomy in continuity with the walled-off pancreatic fluid collection. Over the last 10 years endoscopic drainage has come to the forefront and has been shown to have comparable efficacy to surgical drainage with lesser treatment costs and shorter hospital stay.

Surgical drainage is a multidisciplinary decision and should only be considered for patients with endoscopic failures, recurrence following successful endoscopic drainage or those not meeting criteria for endoscopic or percutaneous drainage. In 2011 Seewald *et al*[44] published the long term results of endoscopic drainage of PFCs. The data of 80 patients with symptomatic PFCs were analyzed retrospectively. Clinical resolution of the collections was achieved endoscopically in 67/80 (83.8%), with surgery required in 13/80 (perforation: four; endoscopically inaccessible areas: two; inadequate drainage: seven). Within 6 mo five patients required surgery due to recurrent fluid collections. Over a mean follow up of 31 months, surgery was required in four more patients due to recurrent collections as a consequence of underlying pancreatic duct abnormalities that could not be treated endoscopically. The long-term success of endoscopic treatment was 58/80 (72.5%) and surgery was required in 28% of patients.

The traditional approach to the treatment of necrotizing pancreatitis with secondary infection of necrotic tissue is open necrosectomy to completely remove the infected necrotic tissue. This invasive approach is associated with high rates of complications and death (11%-39%) and with a risk of long-term pancreatic insufficiency. The Dutch pancreatitis study group has shown that a step up approach consisting of percutaneous drainage followed, if necessary, by minimally invasive retroperitoneal necrosectomy is a better treatment strategy than open necrosectomy in patients with necrotizing pancreatitis and secondary infection[45]. New-onset multiple-organ failure occurred less often in patients assigned to the step-up approach than in those assigned to open necrosectomy (12% *vs* 40%, *P =* 0.002).

**Future directions**

The revised Atlanta classification of acute pancreatitis better defines the local complications associated with pancreatitis: acute PFC, acute necrotic collection, pseudocyst, and WON. In the past decades, interventional EUS is increasingly utilized in the management of these local complications. The authors predict a continuing evolution in the management of these PFCs with improved and novel endoscopic devices dedicated for transmural drainage of fluid and necrotic debris: access and patency devices. EUS should become an indispensable part of this procedure for diagnosis and image guided interventions.

As the authors have extensively reviewed and outlined the evidence, the amount of necrosis is the most important predictor of successful outcome after drainage of these PFCs, regardless of their different terminologies. Hence it would seem logical to classify these collections based on the percentage of necrotic component or debris under radiological imaging studies or EUS. We would like to propose a classification system where these fluid collections can be categorized into 3 groups, those with solid component < 20%, those with solid component between 20%-50% and those with solid component > 50%. As the clinical outcomes are directly related to the type of fluid collection being treated, accurate distinction is important before undertaking any inter­vention. The authors proposed a management algorithm based on the amount of internal debris (Figure 8). For PFCs with internal debris < 20%, transmural drainage with 1-2 double pigtail plastic stents or lumen apposing metal stent is probably enough. For PFCs with internal debris > 50%, endoscopic necrosectomy with multiple plastic stents or lumen apposing metal stent placement is needed. Trans-papillary drainage through ERCP, if the pancreatic duct is connected to the cyst, can be performed on all these patients at the discretion of the endoscopists.

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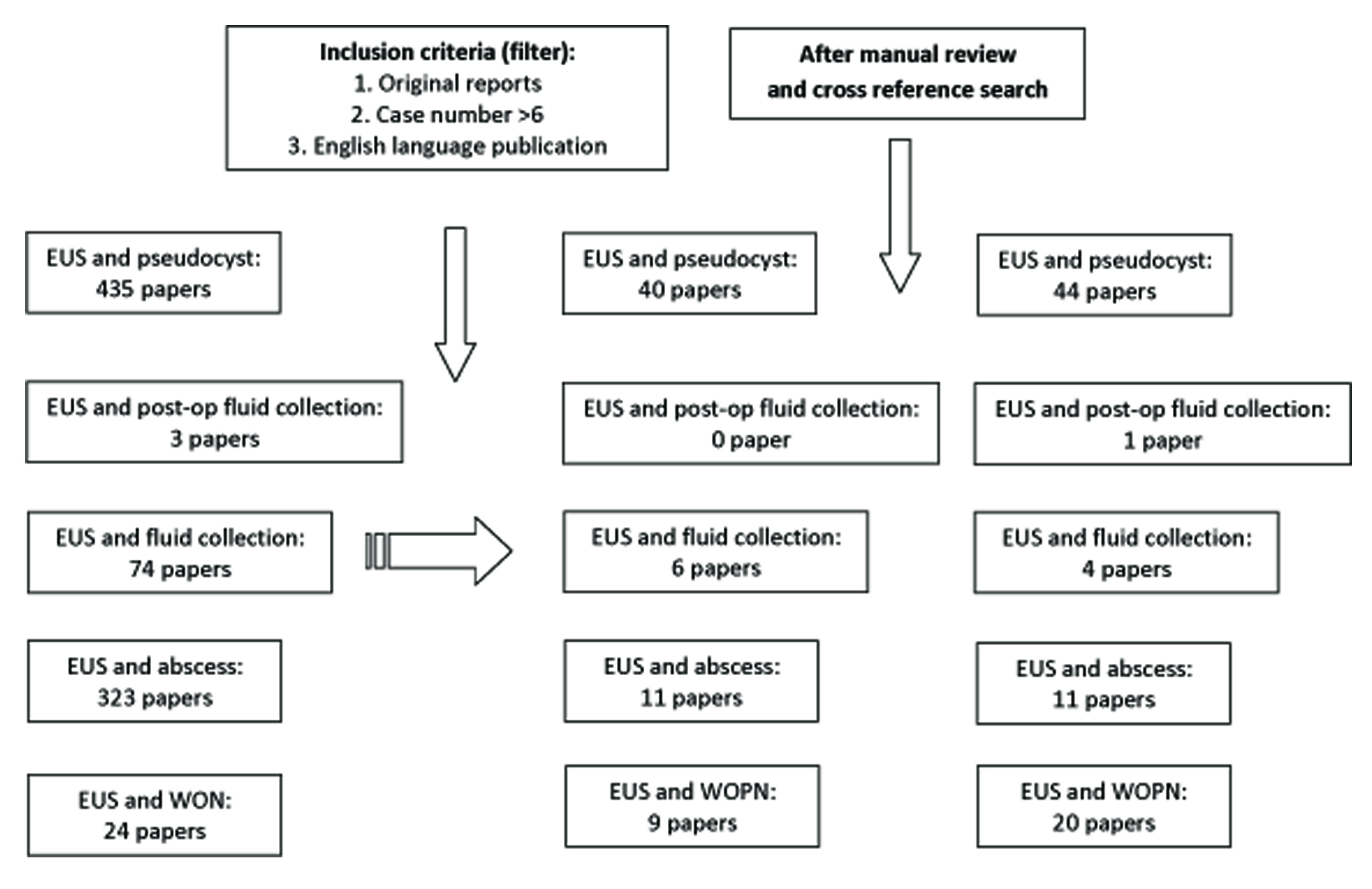
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**P-Reviewer:** Tomizawa m, Wilcox cm **S-Editor:** Ma YJ **L-Editor:** **E-Editor:**

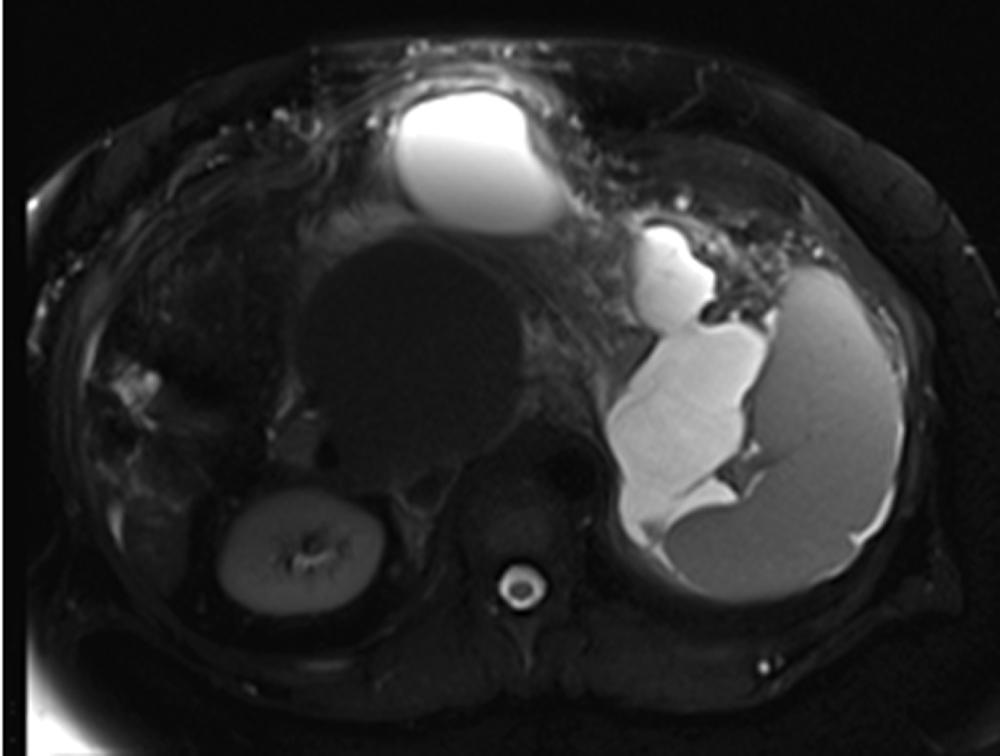
**Table 1 Revised Atlanta classification (2012) of pancreatic/peripancreatic fluid collections**

|  |  |  |  |
| --- | --- | --- | --- |
| **Type of pancreatic or peripancreatic fluid collection** | **Etiology** | **Capsule** | **Specific features** |
| Acute peripancreatic fluid collection, APFC | ≤ 4 wk after onset of acute interstitial-edematous  Pancreatitis | - | Homogeneous, liquid, infection +/-, no features of a pseudocyst, usually spontaneous resolution |
| Pancreatic pseudocyst, PPC | > 4 wk after onset of acute interstitial-edematous  Pancreatitis | + | Round/ oval,  Liquid, no non-liquid contents, persistent |
| Acute necrotic collection, ANC | Acute necrotizing pancreatitis | - | Heterogeneous, liquid and necrotic contents, usually spontaneous resolution |
| Walled-off pancreatic necrosis, WOPN | > 4 wk after onset of necrotizing Pancreatitis | + | Heterogeneous, liquid and necrotic contents, infection +/- |

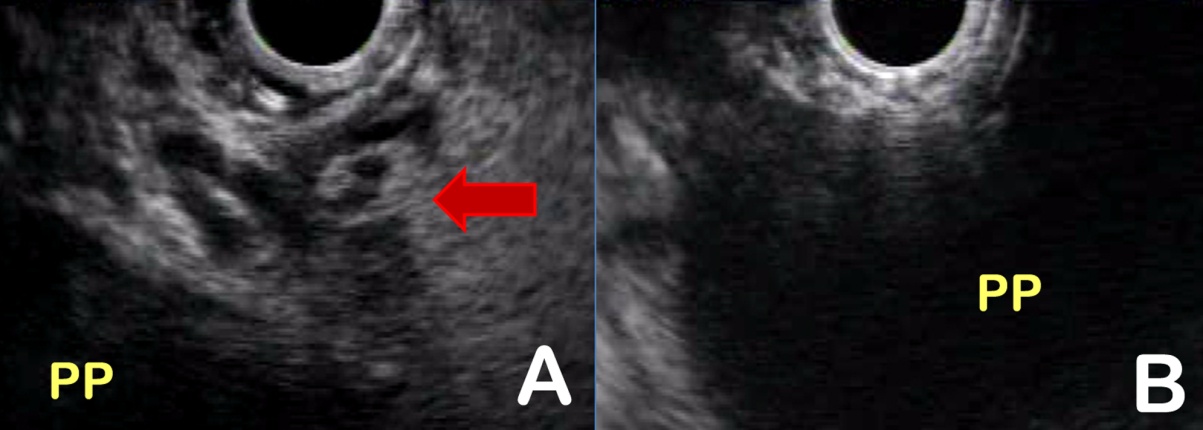
ANC: acute necrotic collection.



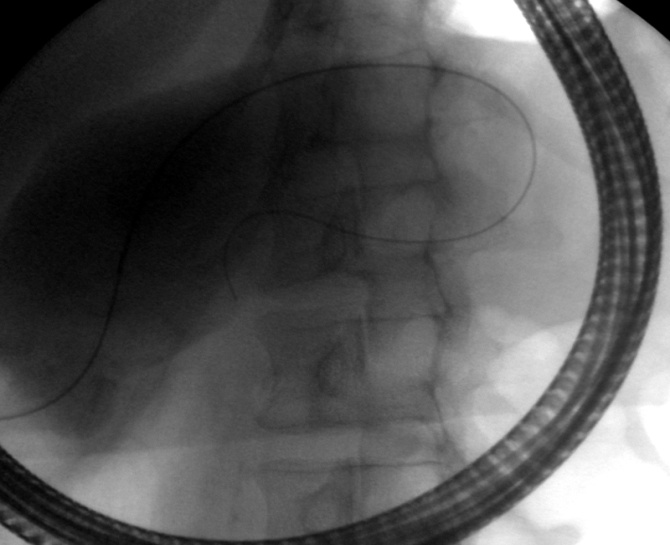
**Figure 1** **On November 15, 2014, the authors performed PubMed search using following key word sets: endoscopic ultrasound in combination with terminologies related to pancreatic fluid collections such as pseudocyst, fluid collection, abscess, and walled off necrosis.** Each published paper was reviewed by two of these authors together, extracting the important information related to this review. EUS: Endoscopic ultrasound; WON: Walled off necrosis.



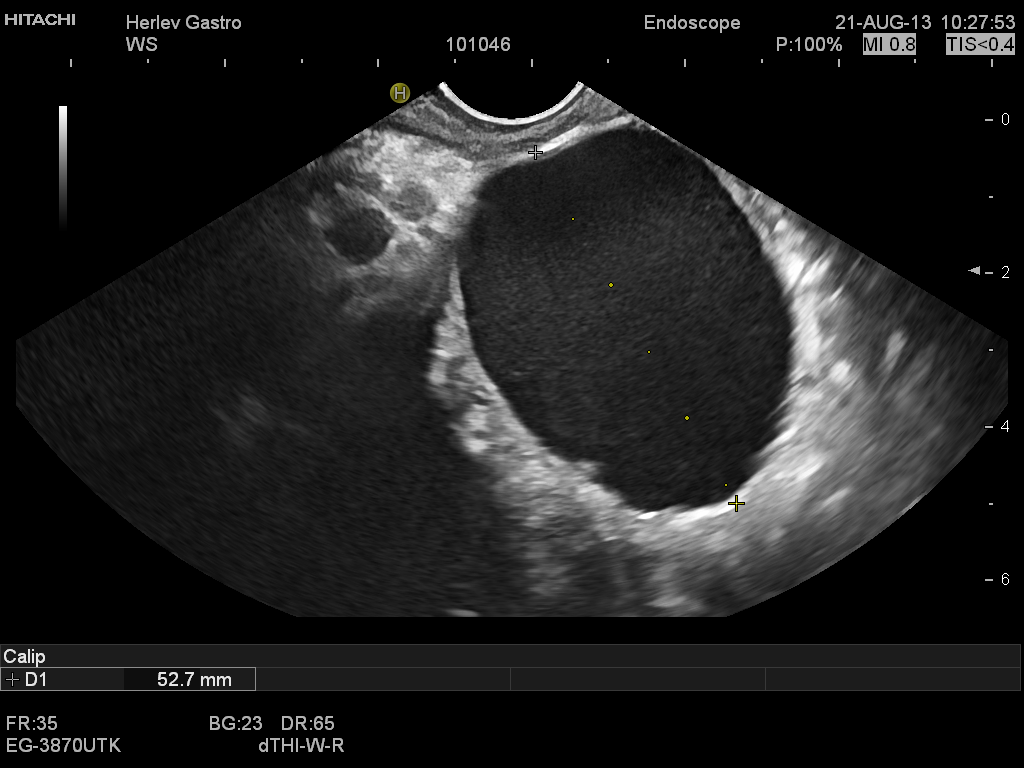
**Figure 2 selected magnetic resonance imaging frame showing a large peri-pancreatic pseudocyst extending from the pancreatic tail to the anterior abdominal wall in a patient with pancreatitis and splenic vein thrombosis.**



**Figure 3** **In the same patient, endoscopic ultrasound permits visualization of the pancreatic pseudocyst, assesses the maturity of the wall, measures the distance of the collection from the luminal wall, identifies intervening vessels or collaterals (red arrow) (A), and selects the optimal puncture site (B).** PP: pancreatic pseudocyst.



**Figure 4 fluoroscopic image showing transpapillary drainage of a pancreatic pseudocyst that is communicated with the main pancreatic duct.**

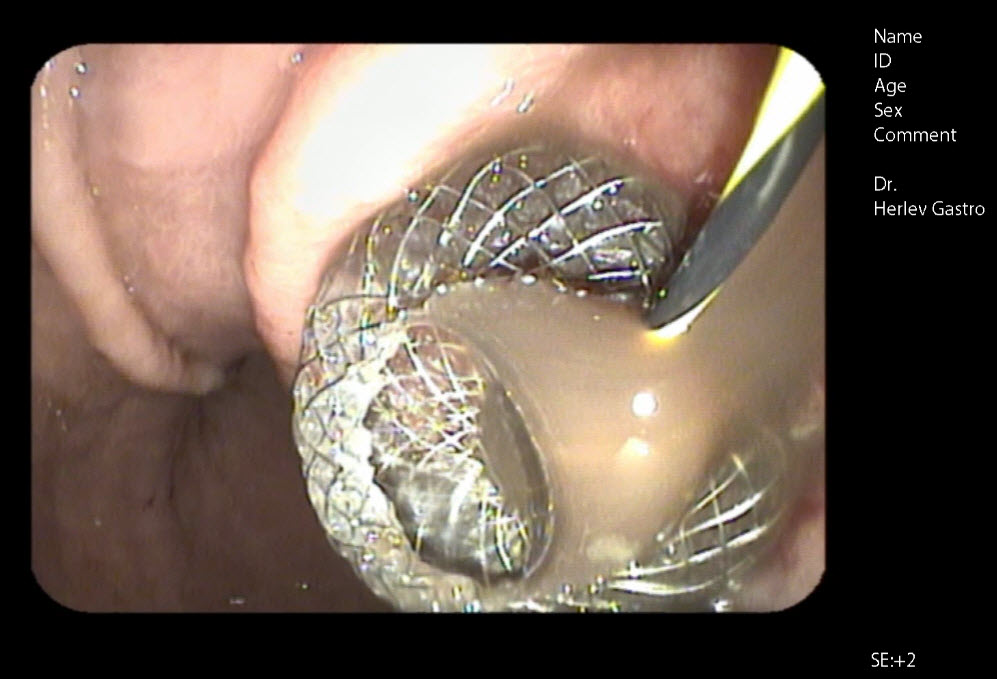


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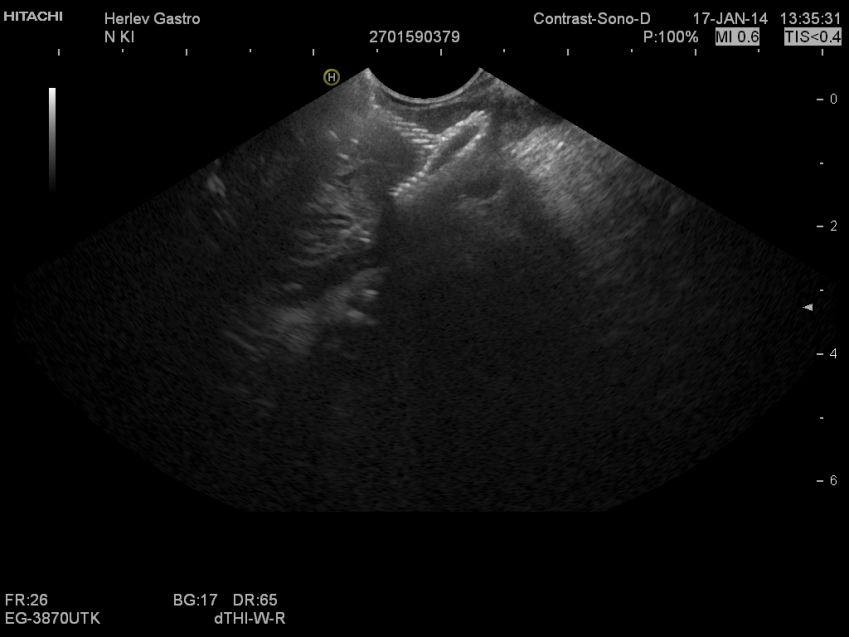


B

**Figure 5 Endoscopic ultrasound image of a 5 cm chronic pseudocyst with a thin wall (A) or a 7.8 cm irregular pseudocyst with walled off necrosis**



**Figure 6** **Endoscopic image of a self-expandable metal stent immediately after endoscopic ultrasound guided drainage (AXIOSTM system, Xlumina, Mountain View, CA, United States).** Note the fluid floating through the stent opening. A guidewire is still visible extending through the stent lumen.

****

**Figure 7** **Corresponding endoscopic ultrasound image of a collapsed pancreatic psuedocyst immediately after drainage.** Note reflexions from the stent mesh inside the collapsed cyst.

**Pancreatic fluid collections**

(acute pancreatic fluid collection, acute necrotic collection, pseudocyst, and walled-off necrosis

**Pancreatic fluid collections**

with solid debris < 20%

**Pancreatic fluid collections**

with solid debris > 50%

**Pancreatic fluid collections**

with solid debris 20%-50%

1. Transmural drainage with 1-2 double pigtail plastic stents or lumen apposing metal stent

or

1. Trans-papillary drainage through ERCP if pancreatic duct involved
2. Lumen apposing metal stent placement

or

1. Transmural drainage with multiple (> 2) double pigtail plastic stents at single site or multiple sites

+/- Transmural drainage with nasocystic drainage

1. Endoscopic necrosectomy
2. Transmural drainage with multiple (> 2) double pigtail plastic stents at single site or multiple sites or Lumen apposing metal stent placement

+/- Transmural drainage with nasocystic drainage

+/- Transcutaneus ultrasound drainage depending on size location and content

**Figure 8 authors' proposed endoscopic ultrasound guided management algorithm based on the amount of internal debris inside the pancreatic fluid collections.**