

# Systematic Review of Endoscopic Cyst Gastrostomy



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## KEYWORDS

- Pancreatic fluid collection • WOPN • LAMs • Cyst gastrostomy • Necrosis
- Necrosectomy • Pseudocyst

## KEY POINTS

- Accurate typification of fluid collection is paramount, as it allows accurate prediction of endoscopic outcome and clinical course.
- Endoscopic ultrasound has become the main therapeutic option for cyst gastrostomy/duodenostomy formation with lower morbidity and higher resolution rates than surgical interventions.
- Pseudocysts without solid debris can be safely and effectively drained using plastic stent placement over the current trend of metal stent insertion.
- Transpapillary drainage may be indicated only if cross-sectional imaging suggests pancreatic duct disruption.
- With the advent of lumen-apposing metal stents, repeated necrosectomy can be carried out, thereby increasing resolution rates of walled-off necrosis.

## INTRODUCTION

Since the original description of pancreatic fluid collection (PFC) in 1761 by Morgagni,<sup>1</sup> the diagnosis, description, and management have continued to evolve. The mainstay of therapy for symptomatic PFCs has been the creation of a communication between a PFC and the stomach (duodenum, jejunum), to enable drainage. Surgical creation of these drainage conduits (cyst gastrostomy, duodenostomy, or jejunostomy) had been the gold standard of therapy; however, there has been a paradigm shift in recent years with an increasing role of endoscopic drainage. The techniques of endoscopic

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drainage have evolved from blind fluid aspiration to include endoscopic necrosectomy and the placement of lumen-apposing metal stents (LAMS).

### REVISED ATLANTA CLASSIFICATION

The Atlanta Classification, originally published in 1992, attempted to offer a global consensus on the classification of acute pancreatitis and PFCs. Understanding that treatment success may differ based on the type of fluid collection, changes to the classification were made in 2012.<sup>2</sup>

The distinction between the 2 forms of acute pancreatitis, interstitial and necrotizing, discerned by cross-sectional imaging, remained. Additional discriminators in the revised classification were the categorizations of PFC in relation to time of onset of symptoms as well as the presence or absence of necrosis within the collection. In a patient who may be classified as having interstitial edematous pancreatitis, a collection that develops less than 4 weeks after symptom onset would be considered an acute PFC and more than 4 weeks a pseudocyst. In a patient with necrosis present, early collections less than 4 weeks are acute necrotic collections (ANC) and more than 4 weeks can be considered walled-off necrosis (WON or WOPN).<sup>2</sup>

The distinction about timing of development also helps delineate the timing of drainage, if indicated. If drainage of a PFC is required, it should be undertaken after at least 4 weeks to allow for encapsulation potentially reducing the risk of adverse events. A study of 242 patients found that mortality was reduced as the time from hospital admission to intervention of the PFC was increased (0–14 days: 56% to >29 days: 15%;  $P < .001$ ).<sup>3</sup>

Approximately 10% to 20% of patients with acute pancreatitis will develop pancreatic necrosis. A third of these patients will become infected.<sup>2,3</sup> There is no clear correlation among the extent of necrosis, the risk of infection, and duration of symptoms.<sup>4</sup> Although it may be difficult to differentiate between ANC and acute PFC at initial presentation, sequential imaging may be useful to characterize the evolution or stability of these acute collections. ANCs may appear loculated, with variable amounts of debris within the fluid. Although acute PFCs appear more homogeneous, WON, which appears more than 4 weeks after the initial pancreatitis, typically will have a mature enhancing wall formed from reactive tissue. These distinctions allow for proper classification of PFCs.<sup>2</sup>

Accurate typification of fluid collection is paramount, as it allows accurate prediction of endoscopic outcome and clinical course. A study of 211 patients who underwent endoscopic drainage of PFCs noted that pseudocysts have a higher drainage success rate and a lower adverse event rate than those patients with WON (93.5% vs 63.2%,  $P < .0001$ , and 15.8% vs 5.2%,  $P = .02$ , respectively).<sup>5</sup>

### INDICATIONS FOR CYST GASTROSTOMY

Most acute PFCs will remain sterile and resolve spontaneously without intervention. As such, PFCs of recent onset that lack a mature encapsulation should not be drained. These collections are considered high risk for peritoneal spillage if drainage is attempted, thus should be managed expectantly. ANCs carry similar risk of adverse event if drainage is carried out before the development of a mature enhancing wall. Overall, the risk associated with the drainage of PFCs decreases with increasing remoteness from the onset of the initial pancreatic injury.<sup>3</sup>

Before considering drainage of a PFC, a thorough radiologic and/or endosonographic examination should be performed. A multimodality approach will help confirm that the PFC does not represent a cystic neoplasm. Cyst neoplasms should not be

generally drained and can carry significant morbidity if drained into the gastrointestinal tract.<sup>6</sup> Drainage of PFCs (WON and pseudocysts) causing symptoms such as abdominal pain, biliary or gastrointestinal obstruction, and anorexia warrant drainage. Size alone is no longer an indication for drainage.<sup>7</sup>

Infection in the context of a WON, on the other hand, may be a secondary indication for drainage.<sup>8</sup> In severe acute pancreatitis, disturbed gastrointestinal motility may lead to bacterial overgrowth and failure of the structural mucosal barrier, which leads to bacterial translocation.<sup>9</sup> This is thought to be the mechanism by which WON becomes infected. Clinical symptoms of infected necrosis usually become apparent 2 to 4 weeks after onset of pancreatitis. Signs of infected necrosis include new-onset or persistent sepsis, clinical deterioration despite adequate support and no alternative source of infection, or gas bubbles within the PFC on radiologic imaging.<sup>8</sup> With mortality of patients who develop infected WON approaching 40%, it is imperative that these patients undergo endoscopic or surgical debridement. The optimal approach to these collections is discussed in the next section.

### ***What Is the Optimal Approach to Cyst Gastrostomy Creation?***

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#### ***Surgical approach to cyst gastrostomy***

Since the early 1980s, surgery was the gold standard in the management of PFCs.<sup>10</sup> In a cumulative review of 1032 patients, mortality was recorded at 5.8%, with a recurrence rate approaching 5% and a complication rate of 24%.<sup>11</sup> Three main laparoscopic surgical approaches exist: transgastric (anterior) cyst gastrostomy, lesser sac (posterior) cyst gastrostomy, and cyst jejunostomy. Despite improvements in tools and technique, 10% of laparoscopic approaches need to be converted to open procedures.<sup>12</sup>

An anterior gastrostomy is made over the area of maximal bulge by the PFC, usually along the greater curvature of the stomach. An 18-gauge to 22-gauge needle is used to access the pseudocyst and entered into the posterior wall of the stomach. Biopsy of the wall of the cyst is performed to exclude concurrent malignancy. The posterior wall of the stomach is sutured to the pseudocyst and the anterior gastrostomy is sutured closed.<sup>12</sup> A similar approach has been described using intraluminal guidance using an endoscope.<sup>13</sup> Enthusiasm for this approach has been largely tempered by the development of a premature anastomotic stenosis that can be seen following this approach, thus favoring a lesser sac approach.<sup>12</sup>

The lesser sac or posterior approach to laparoscopic cyst gastrostomy has been described as an alternative technique to PFC drainage. Anterior approach necessitates a wide contact surface between the pseudocyst and the posterior gastric wall, lesser sac approach only requires pseudocyst to be in contact with the posterior gastric wall.<sup>12</sup> Several investigators believe that this approach allows for better visibility, less bleeding, larger anastomosis creation, and less premature anastomotic closure.<sup>14</sup>

Cyst jejunostomy is generally reserved for cases in which the pseudocyst is not in close proximity to the stomach. The creation of an enteric-enteric anastomosis and a flexible Roux limb allows juxtaposition of the jejunum to the pseudocyst with minimal tension on the anastomosis.<sup>15</sup> Despite the absence of prospective trials, laparoscopic technique, in comparison with open, offers certain benefits, such as improved pain, decreased length of stay, and decreased wound infections.<sup>12</sup>

Advances in therapeutic endoscopy has pushed surgery to second line, with endoscopy taking center stage, reserving surgery for those patients who fail endoscopic therapy. Although endoscopy and moreover endoscopic ultrasonography (EUS), is just as effective as laparoscopic cystgastrostomy, it has a lower length of stay,

cost, complication rate, and recurrence, as noted in a recent prospective comparison between both techniques.<sup>16</sup> Recent advances in EUS resolution and stent design have started to expand the efficacy gap between these techniques, formulating an easier choice of technique.

There does remain one instance in which surgical management may be the initial therapeutic option, which is when a necrotic collection does not abut the gastric/duodenal wall with retroperitoneal extension into the pelvis. Video-assisted retroperitoneal debridement is indicated and preferred in this particular circumstance. Deep necrotic debridement is conducted under direct visualization, while leaving a drain behind for frequent irrigation.<sup>17</sup> This remains the only preferable instance when surgery is indicated over endoscopic management.

### ***Endoscopic approach to cyst gastrostomy***

**Pre-procedure** Anticoagulant and antiplatelet medications (other than aspirin) should ideally be discontinued before endoscopy because endoscopic drainage and necrosectomy have been associated with acute and delayed bleeding. A team of interventional radiologists and surgeons should be available if severe bleeding or uncontrolled perforation should ensue.<sup>18</sup>

### ***Endoscopic drainage techniques***

**Transmural “blind” approach** Transmural drainage of a pseudocyst using a gastro-scope involves “blind” puncture technique. The puncture is made beyond the wall at the site of maximum bulge, or cystic compression of the gastrointestinal (GI) tract. The technique does not permit full visual evaluation for presence of vasculature along the trajectory of the puncture needle. In a randomized trial, the use of EUS altered the planned trajectory of the needle in 33% of cases.<sup>19</sup> In another study, EUS was noted to have a higher technical success rate in comparison with the transmural esophago-gastro-duodenoscopy (EGD) approach.<sup>20</sup> Given these results and their generalizability, EUS is preferred and when available should be first-line approach for pseudocyst drainage.

**Is endoscopic retrograde cholangiopancreatography needed before the endoscopic ultrasonography approach?** Historically, endoscopic retrograde cholangiopancreatography (ERCP) has been an essential part of the algorithm to direct the proper endoscopic approach for drainage, whether transmural versus transpapillary. ERCP enables the identification of the pancreatic duct, a ductal communication or obstruction, which provides a clear correlation with the failure and successes of pseudocyst drainage.<sup>21</sup> As the prevalence of post-ERCP pancreatitis rises to 8% and increases in those patients who may be difficult to cannulate, less ductal manipulation is paramount.<sup>22</sup> With refined imaging techniques and the ready availability of MRCP, noninvasive assessment of ductal anatomy is preferred.<sup>23</sup>

**Transpapillary drainage: when is it indicated?** Transpapillary stenting of the pancreatic duct (PD) with or without a sphincterotomy had been routinely attempted, as it was initially thought to assist in pseudocyst drainage. The placement of the stent across the papilla offers a path of least resistance to pancreatic secretions and leads them out of the PD, instead of flowing into the pseudocyst through the ductal disruption, if present. Early studies suggested that transpapillary drainage (TPD) combined with transmural drainage offered best chance at successful resolution of PFC, especially if main PD disruption was noted.<sup>24,25</sup> A study in 2010 echoed these results when they assessed 110 patients who underwent pseudocyst drainage, 40 of whom underwent TPD with stent placement. At 8 weeks, those who underwent PD stent

placement had better resolution (97% vs 80%) than those who had not undergone TPD.<sup>26</sup>

In a recent retrospective study looking at 375 patients who underwent transmural drainage (TMD) versus combined drainage (CD), which consisted of TMD and TPD, TMD alone was performed in 95 (55%) and CD in 79 (45%) pseudocysts. TMD alone was successful in 92 (97%) versus CD in 35 (44%) and there had been no difference in overall symptomatic resolution (69% vs 62%). Therefore, the investigators concluded based on this recent data set that there was no added benefit of TPD to EUS-guided TMD drainage.<sup>27</sup> As Shrode and colleagues<sup>28</sup> noted in 2013, those and only those patients with radiologic or endosonographic evidence of PD disruption should undergo TPD combined with TMD.

**Endoscopic ultrasound-guided cyst gastrostomy or duodenostomy** The EUS-guided approach enables direct visualization and approximation of the pseudocyst or WON with access obtained through the gastric or duodenal wall, depending on location of collection. The tract is then dilated and followed by stent placement. Detailed description of the current technique is defined as follows.

A therapeutic linear echoendoscope (with a 3.7-mm working channel) with color Doppler is preferred for the initial assessment and approximation of the pseudocyst.<sup>29</sup> However, puncturing the gastric wall at a sharp angle may impede the technical success of the procedure. The sharp angle coupled with the force exerted on the needle on insertion may push the gastric wall away from the endoscope. The forward-viewing echoendoscope may be used to overcome these physical factors and has been evaluated in several retrospective studies.<sup>30</sup>

**Initial assessment of the pancreatic fluid collections** The location of the pseudocyst usually can be discerned by endoscopic examination of the gastric cavity and identification of luminal bulge. Using the echoendoscope, the PFC is then examined to confirm the diagnosis, as a homogeneous anechoic structure without septations. This step will also allow for identification of solid debris, which will help decide on the type and number of stents (plastic vs metal) that will be placed and if nasocystic drainage will be needed.

**Identification of the ideal puncture site** Ideal position is with the gastric wall juxtaposed to the pseudocyst or WON wall no more than 6.0 mm apart without vascular structures in the puncture site, using Doppler flow. If that cannot be obtained, other stations should be assessed to see if a more ideal puncture site may exist in the duodenum.

**Puncture with a 19-gauge needle** Once the initial assessment confirms that there is no vasculature at the puncture site, a 19-gauge needle is inserted through the instrument channel and under endosonographic visualization, with a quick jab, the needle is introduced through the gastric (or duodenal) wall into the cystic cavity. Once access is obtained, aspiration of fluid should be obtained to confirm diagnosis of pseudocyst and ruling out malignancy with cytology and carcinoembryonic antigen level.<sup>31</sup> If suspicion of cystic neoplasm exists, no further drainage should be carried out. Assessment for infection or hemorrhage by examination of cystic fluid appearance is also helpful.

**Passage of guidewire into the cystic cavity** Passage of a 0.035-inch guidewire into the cyst, confirmation can be confirmed using fluoroscopy or endosonography. Once confirmed, enough of the guidewire should be passed into the cyst to allow for coiling. The needle is withdrawn, leaving the guidewire in place, bridging the lumen and the

cystic structure. If in step 1, multiple stents are deemed necessary for successful drainage, a biliary brush catheter with the brush removed can be used to facilitate multiple guidewire insertion through one puncture site.<sup>32</sup>

**Dilation of the tract** Balloons of 8 to 10 mm are used to dilate the fistula tract to allow for passage of one or multiple plastic stents (PSs).<sup>33</sup> If larger stents are indicated or being used, larger dilation may be needed. After the initial dilation, one may observe a spurt of cystic fluid into the gastrointestinal lumen. Several variations to balloon dilation exist, namely cystotome,<sup>34</sup> needle knife,<sup>35</sup> modified needle wire,<sup>36</sup> fistulotome,<sup>37</sup> or graded dilators.<sup>38</sup>

**Insertion of double-pigtail plastic stent(s)** After the tract has been dilated, a double-pigtail stent is passed over the guidewire. One pigtail is then deployed in the cystic cavity with the proximal pigtail in the GI tract lumen, thereby keep the stent anchored in place. Stent size between 7 and 10 French are used to facilitate proper cyst drainage. Although most endoscopists will place more than one stent, there appears to be no relationship between the technical success rate and the number or characteristic of stents used in patients undergoing endoscopic transmural drainage of uncomplicated pancreatic pseudocysts.<sup>39</sup> If a nasocystic drainage catheter is being deployed to irrigate the cavity to remove necrotic debris, then 100 mL of normal saline is flushed until the aspirate is clear.<sup>40</sup>

**Repeat cross-sectional imaging** Repeat imaging 4 to 6 weeks after stent placement to confirm resolution of PFC. Once resolution of PFC is confirmed on radiologic imaging, EGD may be scheduled for removal of the stents placed. During EGD, Rat Tooth forceps or cold snare can be used to remove each stent that had been placed. No repeat imaging is needed unless clinical deterioration is noted.

### ***Evolution of stent technology: does it matter?***

Transluminal drainage is effective only if the fistula tract is kept patent by placement of stents through the tract under EUS, fluoroscopic, and endoscopic guidance. Traditionally, double-pigtail PSs have been used for this purpose, but fully covered self-expanding metal stents (FcSEMS) have been increasingly used instead, and recently LAMS that are specifically designed for PFC drainage have been introduced. With the overall efficacy of transmural stenting with a PS more than 90%,<sup>16</sup> are other stents needed to ensure proper PFC drainage?

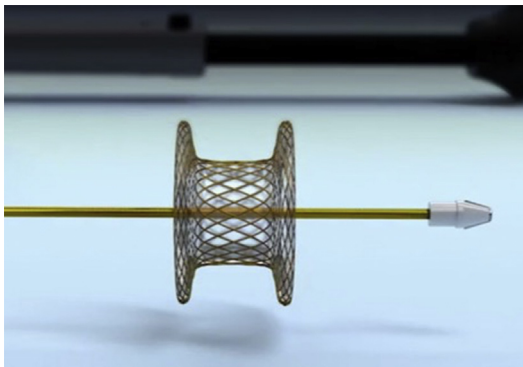
Biliary FcSEMS have been added to the armamentarium for the treatment of PFC, both pseudocysts and WON. With their larger diameter (10 mm), FcSEMS offer a larger tract for drainage while needing only 1 stent instead of multiple PSs. Use of FcSEMS also reduces the overall steps of the procedure.<sup>41</sup> Stent migration is still a major complication of the use of FcSEMS. To overcome this risk, stents with anti-migratory fins have been developed.<sup>42</sup> The placement of a double-pigtail stent across a FcSEMS has also been described to prevent stent migration (Fig. 1).<sup>43</sup> Despite all these innovations, a recent randomized study failed to demonstrate superiority of FcSEMS over PS for pseudocyst drainage (91% vs 87%, respectively,  $P = .97$ ).<sup>44</sup> A meta-analysis further confirmed these results, looking at 881 patients, noting a similar treatment success rate between PS and metal stents (85% vs 83%, respectively).<sup>45</sup> Without significant increase of treatment success with the use of FcSEMS, the cost and risk of migration, which approaches 15%,<sup>43</sup> does not seem to represent an improvement over current PS technology, and therefore for simple pseudocysts should not be used. On the other hand, FcSEMS do have a role in the treatment success of WON and will be discussed later.



**Fig. 1.** Cyst gastrostomy with FcSEMS with double-pigtail stent anchor. (From Lee BU, Song TJ, Lee SS, et al. Newly designed fully covered metal stents for endoscopic ultrasound (EUS)-guided transmural drainage of peripancreatic fluid collections: a prospective randomized study. *Endoscopy* 2012;46:1078–84; with permission.)

To address some of the concerns raised by the FcSEMS, LAMS with a unique dumbbell shape, recruits the walls of the collection and the lumen to stabilize the position of the stent. In animal studies before the approval of the stents by the Food and Drug Administration, Binmoeller and Shah<sup>46</sup> demonstrated in animal models that the stent withstood various vector forces without migration. The stent was also noted to be easily removed without tissue damage. The stent is currently approved for the 10-mm and 15-mm diameters, with the 15-mm diameter better for those pseudocysts with necrotic debris (Fig. 2).<sup>47</sup>

In 2012, the initial retrospective study that noted clinical success of PFC resolution in all 15 patients who underwent LAMS (AXIOS) placement.<sup>48</sup> Follow-up larger studies noted similar clinical success rates of pseudocyst drainage in 93% of patients attempted, with a complication rate up to 10% to 15%.<sup>47</sup> A similar study was conducted using a NAGI stent in a European cohort noted 93% successful drainage of PFC



**Fig. 2.** AXIOS lumen-apposing metal stent. (Courtesy of Boston Scientific, Marlborough, MA; with permission.)

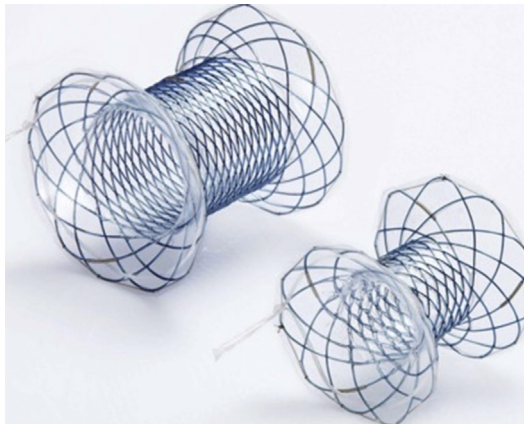
(Fig. 3).<sup>49</sup> The AXIOS stent is a LAMS approved in the United States, whereas the NAGI stent is approved in Europe, Asia, and the Middle East. Despite impressive clinical success rates and diminished procedure times, should LAMS replace PS in the drainage of homogeneous pseudocysts?<sup>50</sup> Due to cost, complication rate, and equal success rate to PSs, PSs are still favored for homogeneous pseudocysts without evidence of necrotic debris, where repeated endoscopies are not warranted.

### ***Walled-off necrosis***

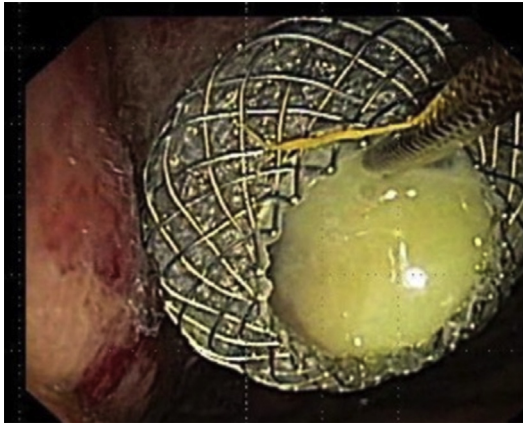
Necrotic fluid collections necessitate both the creation of a cyst gastrostomy (or duodenostomy) and maintenance of the tract for repeat endoscopic debridement procedures. This requirement has become the most actively researched aspect of PFCs. As noted previously, with current stents there exists a disparity between clinical success between pseudocyst and WON drainage (93.5% vs 63.2%, respectively).<sup>5</sup> The advancement in stent technology has helped increase the clinical success rate for WON to 87%.<sup>51</sup>

The steps needed to establish access to WON is similar to those described previously in cyst gastrostomy for pseudocyst drainage. Where the steps differ is with the type of stent inserted to keep the fistula tract open to allow for future endoscopic debridement sessions. Recent data suggest that the use of PSs is insufficient for this requirement.<sup>52</sup> Once the guide wire is in place and the tract is dilated, either an FcSEMS is placed creating the cyst gastrostomy or an LAMS is deployed bringing the 2 lumens together. With FcSEMS reporting high migration rates that seem to be reduced with LAMS, LAMS seem to be a preferred choice for fistula creation in patients who require repeat endoscopic intervention.<sup>52</sup> Following successful placement of an LAMS and observed egress of necrotic fluid (Fig. 4), most endoscopists will dilate the stent to its maximum diameter (at either 10 or 15 mm). Current recommendation is to dilate the tract and allow time for the stent to mold to the tissue before performing endoscopic intervention, decreasing risk of inadvertent dislodgement.<sup>53</sup>

Multiple recent studies have demonstrated improved outcomes for the treatment of WON with LAMS, fewer endoscopic necrosectomy sessions required to achieve resolution, reduced surgical interventions, and fewer adverse events. The largest retrospective trial looking at utilization of LAMS for WON was conducted including 17 hospitals between 2014 and 2015. A total of 107 (87.6%) of the 124 patients enrolled in the study obtained clinical success with WON resolution at the end of a 4-month



**Fig. 3.** NAGI lumen-apposing metal stent. (Courtesy of Taewoong Medical Co, Gyeonggi-do, South Korea; with permission.)



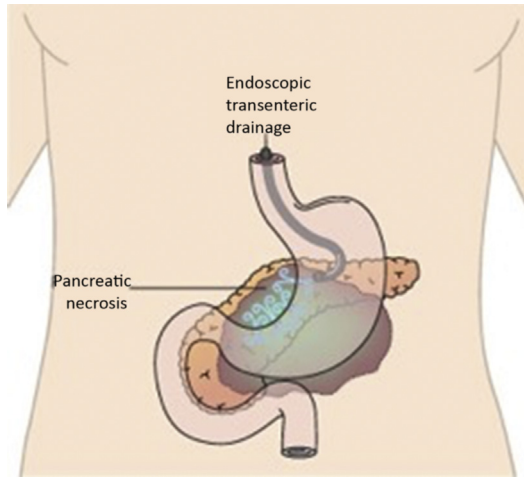
**Fig. 4.** EUS-guided cyst gastrostomy with drainage of infected collection with purulent debris.

period. Higher resolution rate was noted with the use of 15-mm LAMS then a 10 mm. The adverse event rate was 11.3% for fewer than 30 days after placement and 7.2% for more than 30 days post placement, and this consisted of mostly stent occlusion. Stent migration recorded at 5.6%.<sup>51</sup> Similar data had been published in a mixed cohort of patients, but a subset analysis noted clinical success in 85.7% with WON with use of LAMS.<sup>53</sup> An interim audit in one randomized study has raised some serious concerns; adverse event rate after enrolling 12 patients in the LAMS group was 50%. This consisted of 3 patients with significant upper GI bleeding, 2 patients with buried stent syndrome, and 1 with obstructive jaundice due to CBD compression by stent.<sup>54</sup> Although these are preliminary results, one will have to wait to full enrollment before judging overall efficacy and safety of LAMS in treatment of WON. Based on published clinical data, the use of LAMS for cyst gastrostomy in WON is the most efficacious stent in clinical practice.

Another technique described that may offer a higher clinical success rate is multiple transluminal gateway technique (MTGT), which involves creating multiple transmural tracts, with one reserved for nasocystic lavage (**Fig. 5**). Multiple stents are placed into the other tracts to allow for proper drainage of necrotic debris. A study of 60 patients with WON found that MTGT demonstrated a higher rate of clinical success compared with single orifice stenting, which also included nasocystic lavage (91.7% vs 52.1%  $P = .01$ ).<sup>55</sup> Follow-up study attempted to replicate the results; however, they used the MTGT technique with multiple LAMS. One stent was placed transmurally in the stomach and the second tract established in the duodenum. Reported clinical success rate was 87.1% compared with 91.7% in the single LAMS group.<sup>56</sup> Larger studies will be needed to comment on whether increasing the number of transmural tracts will increase rates of clinical success; however, at this time, this approach incurs a higher cost without offering a higher clinical success to standard techniques.

### **Necrosectomy**

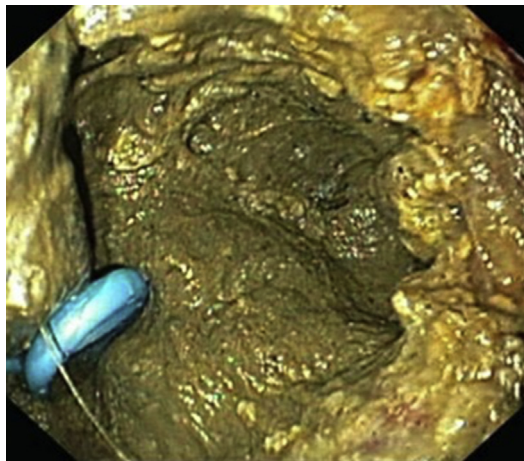
Creation of the cyst gastrostomy is simply an initial step when treating WON. The preponderance of necrotic material within a WON is adherent and not freely mobile, and as such will not drain spontaneously. This is in contrast to the smaller fraction of freely mobile debris that will drain spontaneously via the fistula. Historically, surgical debridement carried up to a 39% mortality, through recent advancements the



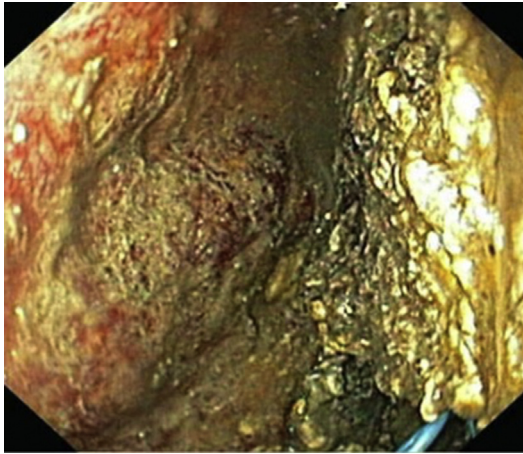
**Fig. 5.** MTGT. (From Varadarajulu S, Phadnis MA, Christein JD, et al. Multiple transluminal gateway technique for EUS-guided drainage of symptomatic walled off pancreatic necrosis. *Gastrointest Endosc* 2011;74:74–80; with permission.)

mortality has decreased but still remains high at 10%.<sup>12</sup> In 1996, Baron and colleagues<sup>40</sup> described the first series of successful endoscopic drainage of necrotic PFCs. The cavity is entered through the created fistula, preferably with a forward-viewing endoscope, and the necrotic pancreatic tissue is removed from the cavity (Figs. 6 and 7). Careful removal of necrotic debris needs to be performed, as the splenic vein and artery course closely to the body and tail of the pancreas, and damage to such structures can cause massive hemorrhage.<sup>57</sup>

Sharaiha and colleagues<sup>51</sup> and Siddiqui and colleagues<sup>53</sup> conducted 2 large multi-center studies that evaluated the utility of EUS-inserted LAMS (AXIOS) to create a cyst gastrostomy. The aim of each study was to evaluate LAMS for necrosectomy in the treatment of WON. A technical success rate of 100% and 85.7%, respectively, was



**Fig. 6.** Walled-off pancreatic necrosis before endoscopic necrosectomy. (From Voermans RP, Besselink MG, Fockens P. Endoscopic management of walled-off pancreatic necrosis. *J Hepatobiliary Pancreat Sci* 2015;22:20–6; with permission.)



**Fig. 7.** Walled-off pancreatic necrosis cavity after endoscopic necrosectomy. (From Voermans RP, Besselink MG, Fockens P. Endoscopic management of walled-off pancreatic necrosis. *J Hepatobiliary Pancreat Sci* 2015;22:20–6; with permission.)

noted with a clinical resolution rate of 86.7% and 100%, respectively. The studies prove that the use of LAMS in the setting of WON is both cost-effective and highly efficacious, findings not reproduced with the treatment of pseudocysts.<sup>52,53</sup>

The necessity of debridement has been a longstanding debate. In 2009, Gardner and colleagues<sup>58</sup> conducted a study to examine the difference in WON resolution between active debridement using forceps, snares, and tripods versus just creating the cyst gastrostomy and allowing debris to drain passively. Clinical resolution was accomplished in 88% of the active group compared with 45% of the passive group; concluding that direct endoscopic necrosectomy achieves higher rates of resolution, without a concomitant change in the number of endoscopic procedures, complication rate, or time to resolution.

Another technique to increase clinical success rate in placement of a nasocystic irrigation catheter, this will provide constant irrigation to the cystic cavity. Normal or sterile saline will be flushed through the catheter 100 mL at a time until the effluent returns clear. This may be particularly helpful if the necrosis is infected. A retrospective study examining the difference between nasocystic drainage plus PS and PS alone, noted a higher resolution rate with nasocystic catheter placement (85% vs 63%, respectively), with a lower rate of stent occlusion (13% vs 33%).<sup>59</sup> It is unclear if this will offer any advantage to drainage with use of a large-diameter LAMS. LAMS alone increases resolution by approximately 10% to 15% as compared with PS (95% vs 80%).<sup>60</sup> Two small case series noted that endoscopic irrigation of the necrotic debris with a solution of hydrogen peroxide has demonstrated a reduction in the need for mechanical debridement by breaking up necrotic and devascularized tissue.<sup>61,62</sup>

A small case series described a novel technique to assist with WON cavity closure that has since fallen by the wayside for pancreatic necrosis, but has gained traction in the treatment of postsurgical leaks: an endoscopic-deployed vacuum-assisted closure system using a surgical sponge attached to Salem sump attached to suction.<sup>63</sup> This apparatus is deployed to the cavity after necrosectomy; suction allows for collapse of the cavity and formation of granulation tissue. Downsizing of the sponge every 2 to 3 days allows for stepwise closure of the cavity (see: <https://www.bbraun.com/en/products/b0/endo-sponge.html>).<sup>64</sup>

Upper GI bleeding is a not infrequent adverse event during endoscopic cyst gastrostomy and necrosectomy for WON, occurring in up to 20% of the procedures. Careful Doppler survey at initial assessment for regional vasculature minimizes bleeding risk. Most of the bleeding events occur during the fistula creation and dilation of the tract and can be controlled with injection of epinephrine, APC, or hemoclip placement. The rate of bleeding has decreased substantially with the introduction of the Hot AXIOS delivery system, which delivers the initial puncture of the AXIOS system with a cutting current.<sup>65</sup>

### Outcomes

**Pseudocyst** Outcomes after attempted drainage of pseudocysts are greatly dependent on the type of collection drained and the expertise of the endoscopist. In the hands of an experienced endoscopist, treatment success ranges from 82% to 100%, with complication rates of 15% and recurrence rates up to 10%.<sup>40,66</sup> A randomized trial comparing 20 patients undergoing surgical cyst gastrostomy and 20 patients undergoing endoscopic cyst gastrostomy found no recurrence in the endoscopic group and 1 recurrence in the surgical group. The endoscopic group had a lower length of stay and a much lower cost (\$7000 vs \$15,000).<sup>16</sup> Although the new innovative stents marginally increase the clinical success of pseudocyst gastrostomy formation, PS insertion should be favored (90% vs 93%).<sup>16,47</sup>

**Walled-off necrosis** WON is the more difficult PFC to treat, as the frequent need for repeat procedures for necrosectomy. Historically, what had been a poor clinical success rate of 63.2%, now, with recent innovations in stent structure, has increased the clinical success rate to 87.6%.<sup>5,51</sup> A randomized controlled trial of 22 patients with infected necrotizing pancreatitis found that patients treated with endoscopic necrosectomy had a much-reduced inflammatory response, a significantly reduced incidence of new-onset multiple-organ failure, and a significant reduction in the number of pancreatic fistulas compared with the surgically treated group.<sup>67</sup> The role of LAMS within the meshwork of a multimodality approach may prove to yield the highest clinical success rate and has yet to be defined.

### SUMMARY

EUS-guided formation of cyst gastrostomy or duodenostomy has become the mainstay of treatment for symptomatic PFCs or WON. Recent advances in stent design (FcSEMS and LAMS) has allowed for quicker, more effective resolution of WON. These stents also allow for repeat access to gastrostomy cavity for prudent necrotic debridement. Simple PFCs can effectively be drained with the use of double-pigtail PSs. Surgery is reserved for those necrotic collections that do not abut the gastrointestinal tract and may be found in the retroperitoneal space. More randomized studies with larger numbers of patients need to be conducted to further evaluate the role of combined approaches.

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