REVIEW

Endoscopic ultrasound guided drainage of pancreatic fluid collections: Assessment of the procedure, technical details and review of the literature

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Abstract

Endoscopic ultrasound (EUS) guided drainage of pancreatic fluid collections (PFC) has become increasingly popular and become first line management option in many centers. Use of therapeutic echoendoscopes has greatly increased the applicability of EUS guided transmural drainage. Drainage is indicated in symptomatic PFCs, PFC related infection, bleed, luminal obstruction, fistulization and biliary obstruction. EUS guided transmural drainage of PFCs is preferred in patients with non bulging lesions, portal hypertension, bleeding tendency and in those whom conventional drainage has failed. In the present decade significant progress has been made in minimally invasive endoscopic techniques. There are newer stent designs, access devices and techniques for more efficient drainage of PFCs. In this review, we discuss the EUS guided drainage of PFCs in acute pancreatitis.

Key words: Acute pancreatitis; Pancreatic fluid collections; Endoscopic ultrasound-guided drainage

Core tip: Endoscopic ultrasound guided drainage has become first line option in the management of pancreatic fluid collections in acute pancreatitis. There are many new stent designs and techniques available that has made the procedure and its outcome more impressive. In this manuscript we present a concise review on this topic.

INTRODUCTION

Acute pancreatitis (AP) is sometimes accompanied by

Table 1 Classification of pancreatic fluid collections as per revised Atlanta classification

Acute pancreatitis
  Interstitial edematous pancreatitis
  Necrotizing pancreatitis (pancreatic necrosis and/or peripancreatic
  necrosis)
    Sterile necrosis
    Infected necrosis
Fluid collections during acute pancreatitis
  < 4 wk after onset of acute pancreatitis
    Acute peripancreatic fluid collection
    ANC
  ≥ 4 wk after onset of acute pancreatitis
    Pancreatic pseudocyst
    WOPN

ANC: Acute necrotic collection; WOPN: Walled-off pancreatic necrosis.

local complications in the form of fluid collections and necrosis. The local complications seen with AP include acute pancreatic fluid collections (PFCs), pancreatic pseudocysts, acute necrotic collections (ANCs), and walled off pancreatic necrosis (WOPN). The nature and sites of PFCs are diverse as are the management options. The recent revision of Atlanta classification has reclassified these fluid collections[1]. Acute PFCs develop in the early phase of interstitial edematous AP, and they lack a wall and are confined by the fascial planes (Table 1). They are generally not complicated and usually resolve without intervention[2]. PFCs that persist for longer than 4 wk usually develop a defined wall and are described as pancreatic pseudocysts. Pseudocysts are less commonly seen with AP; they are more common with chronic pancreatitis. ANC refers to those developing in cases of necrotizing pancreatitis. When the ANCs persist for more than 4 wk they develop into WOPN. ANC and WOPN have variable amount of necrosis and the chances of infection and complications are higher. PFCs are also seen with post-operative complications and abdominal trauma[3-6]. In this review, we will confine the discussion to AP related PFC.

There have been a lot of controversies in identifying PFCs that require intervention. The recent data indicate drainage in PFCs that are symptomatic. Other indications include PFC related infection, bleed, luminal obstruction, fistulization, and biliary obstruction[7-11]. Size alone is not a criterion for drainage of PFCs, but those larger than 6 cm are usually symptomatic. The methods of drainage include, percutaneous radiologic, endoscopic and surgical. Each of these modalities has advantages and disadvantages. A recent retrospective study comparing the two nonsurgical techniques; percutaneous radiologic *vs* endoscopic drainage (conventional transluminal drainage by forward-viewing endoscopy or endoscopic ultrasound-guided drainage) in PFC showed no significant difference between technical success rates[12]. However, percutaneous drainage was associated with a higher re-intervention rate, longer hospital stay, and increased number of subsequent abdominal imaging studies[12]. The authors

concluded that, overall endoscopic drainage should be the preferred method. Another recent prospective randomized controlled trial regarding surgical drainage *vs* endoscopic ultrasound (EUS)-guided drainage for symptomatic PFCs revealed that both groups were comparable in treatment success, complications, or re-interventions. But the duration of hospitalization was less, the physical and mental health scores were better, and the total mean costs were lower for the EUS group[13]. There was also no recurrence in PFCs following endoscopic drainage, thereby showing that surgical drainage is not superior in outcome. The authors concluded that, In view of less invasiveness, lower costs, lower re-interventions, and lower morbidity endoscopic drainage should be considered as the first-line method in the management of PFCs.

Endoscopic drainage is performed by transmural route or endoscopic retrograde cholangiopancreatography (ERCP) guided transpapillary route. Transmural drainage is done for PFCs close to the lumen and can be performed by conventional method (using duodenoscope) or under EUS guidance[14,15]. The specific advantages of EUS guided intervention are: (1) EUS can confirm the presence of PFCs and distinguish it from cystic neoplasms, true cysts, gall bladder and other lymphovascular structures[16]; (2) EUS can identify the presence of solid necrotic material inside the collection. Extensive necrotic debris warrant more aggressive debridement; (3) EUS can identify the presence of any intervening vessels or organs that can be damaged at the time of puncture of PFC[17,18]; and (4) EUS is of extreme importance in localizing "non-bulging" PFCs and determining the correct site of approach into these lesions. Non-bulging PFC are present in 40% of cases[19,20]. Clinical success occurs in 70% to 87%, and complications in 11% to 34% of patients undergoing EUS drainage[7,21,22]. Improvement in techniques, availability of new accessories, stent designs and development of exchange free access devices have increased the safety and efficacy of EUS guided PFC drainage. Disadvantages of EUS drainage include the complications in the form of bleed, secondary infection, luminal perforation and stent migration. Multiloculated collections may fail to resolve completely with conventional EUS draining techniques. Lesions not close to luminal wall may not be accessible to EUS drainage.

Prerequisites for EUS drainage

The PFCs are considered for endoscopic drainage when they are symptomatic, demonstrate a well-formed wall and are located in an endoscopically accessible location (within 1 cm of the luminal wall)[7-11]. Computed tomography (CT) or magnetic resonance imaging is performed before drainage. They help in delineation of the anatomy and PFC. With expertise PFCs that have failed drainage by other methods and those in unusual locations are also considered for drainage[7,16,23]. Many experts recommend assessment of the main pancreatic duct at the time of PFC drainage with ERCP as uniden-
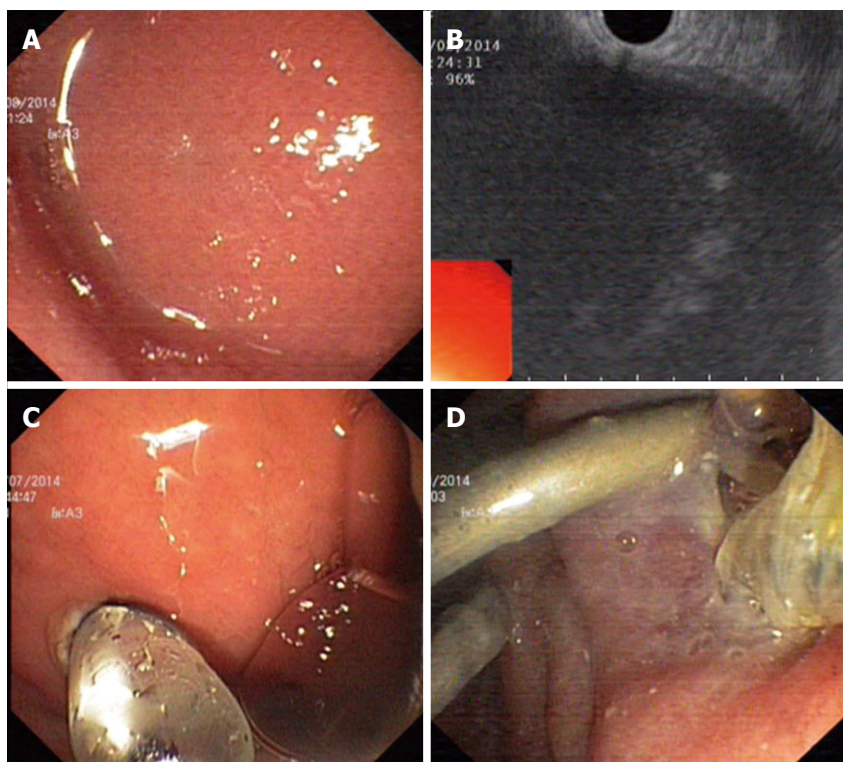
Figure 1 Endoscopic view of intragastric bulge due to pancreatic fluid collections (A), endosonographic view of pancreatic fluid collections (B), Dilation of fistula with Controlled radial expansion (CRE^{TM}) catheter balloon (C), Placement of double pigtail plastic stents through the fistula (D).

tified pancreatic duct stricture or leak may result in failure of resolution or recurrence of PFC[16,24,25].

TECHNIQUE OF EUS GUIDED DRAINAGE OF PFC

EUS guided PFC drainage is performed under conscious sedation in the left lateral position or under general anesthesia (Figures 1 and 2). Most endoscopists prefer fluoroscopy suite for procedure, since in some cases the radiologic view can be helpful either for insertion of the stent or for completing the drainage with cyst irrigation and/or additional stent placement. After identification of cyst in relation to luminal wall, evaluate the cyst with the linear array echoendoscope (with a channel size of at least 3 mm to allow placement of 10 French stents) looking for a site with optimal contact with the gastric or duodenal wall, assess with doppler to eliminate interposition of large vessels, evaluate distance of PFC to the gut wall, presence of solid debris inside the cyst, evidence of portal hypertension, communication of the cyst with the pancreatic duct and presence of coexistent biliary disease (such as common bile duct stones)[25]. After this, identify an adequate point to puncture; where there are no intervening blood vessels and the distance between the gut lumen and the PFC is less than one centimeter. Thereafter a 19 G needle (Wilson-Cook, Winston-Salem, NC, United States) is introduced through the working channel of the endoscope and pseudocyst is punctured under real-time guidance, it is preferable to have a fixed and

straightened position of echoendoscope. After removing the needle stylet, aspirate at least ten cc of pseudocyst contents for Grams stain, culture and analysis for determination of amylase, carcino embryonic antigen levels, and other tests as per the clinical indication.

Afterwards, introduce a guide-wire (Jagwire, Boston Scientific Corp, Natick, MA, United States) through the needle under real-time ultrasonographic and fluoroscopic guidance. Without losing the endoscope position we remove the needle, leaving the guide-wire in place, and a 6 F cystotome is passed over guide-wire to puncture bowel wall and cyst wall, this establishes a fistula. Some authors have used tapered cannula or needle knife. This fistula track is further dilated with either a 6 or 8 mm biliary balloon dilatation catheter (Hurricane Rx, Boston Scientific Corp, Cork, Ireland) over the wire or 12-15 mm CRE balloon (Boston Scientific Corp, Cork, Ireland) under endoscopic or EUS view[20]. After obliteration of waist, the balloon is deflated and a lot of pseudocyst contents usually drains into the stomach and it must be aspirated. Once there is a clear vision of the fistula, a double pigtail stent (Solus, Cook Medical, Limerick, Ireland) are inserted over the wire and placed through the fistula, connecting the pseudocyst and the gastric lumen or appropriately sized self-expandable metal stents (SEMS) are placed depending on cyst contents. In order to insert more stents, we have to re cannulate the fistula and again insert the guide wire into the cyst to be able to introduce a second stent or a nasocystic catheter. We repeat this maneuver as many times as the number of
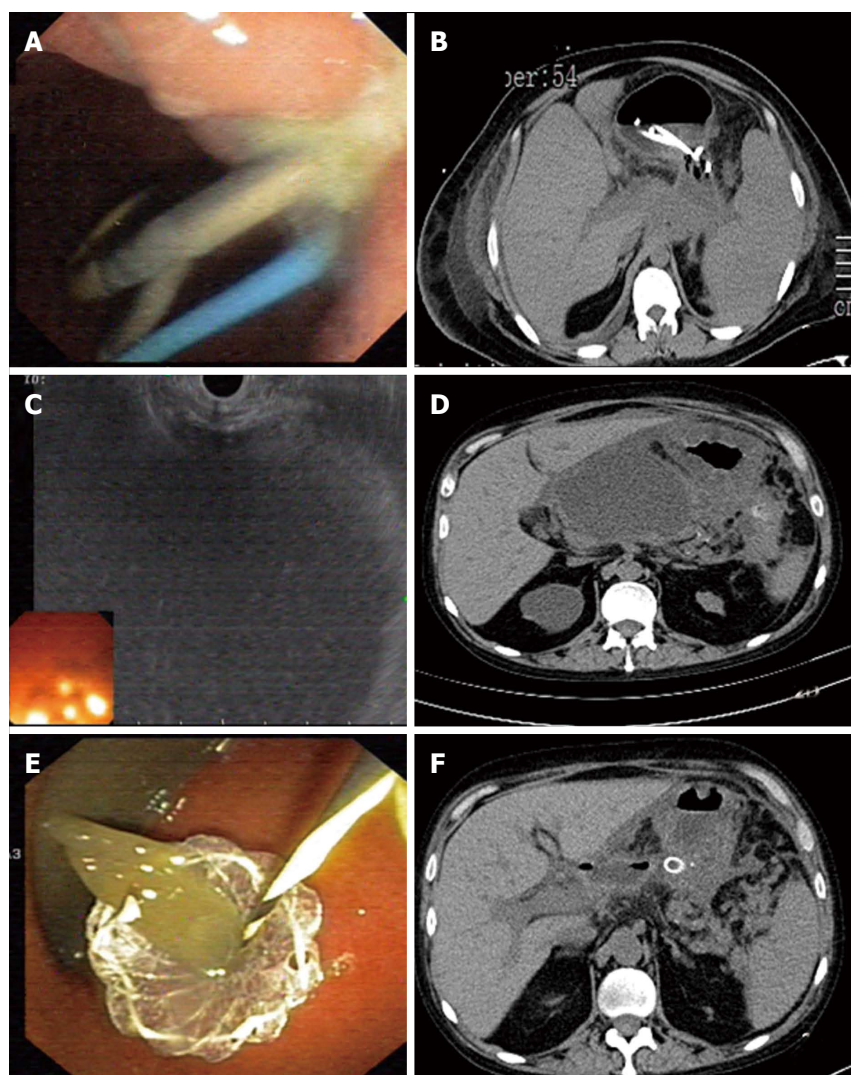
Figure 2 Placement of double pigtail plastic stent and nasocystic drain (A), computed tomography view of pancreatic fluid collections after insertion of stent and nasocystic drain (B), endosonographic view of pancreatic fluid collections before drainage (C), computed tomography view of pancreatic fluid collections before drainage (D), Placement of NAGI stent into pancreatic fluid collections (E), computed tomography view after placement of NAGI stent (F).

stents we want to place.

Normally 2 to 3 stents, 10 F diameter and 5 cm long are placed into the PFC. The patient resumes oral feeding several hours after the exploration and is discharged 48-72 h later if there are no procedure-related complications. Patients needs follow up on four weekly basis with cross sectional imaging. All the stents can be removed after confirmation of the resolution of collection and after ensuring the integrity of pancreatic duct[23]. We routinely remove stent at three months and SEMS at 8 wk. New accessories include modified access needles (19 G needle, Grosse, Daldorf, Germany, loaded with a modified 7- or 10-Fr stent and a Teflon pusher catheter, Wilson-Cook)[25,26], exchange free access design, NAVIX (Xlumena Inc., Mountain View, CA, United States)[27,28] and Giovannini Needle Wire Oasis a needle wire device (Cook Endoscopy, Winston-Salem, NC, United States)[29]. Some authors recommend placement of a nasocystic catheter in the presence of solid debris inside the cyst that allows

nasocystic lavage[30].

REVIEW OF LITERATURE

There are reports of PFC drainage through stomach that date back to early 1990s (Table 2). Grimm *et al*[31] successfully created a fistula between the stomach and a cyst with a linear echoendoscope. Binmoeller *et al*[21] in 1995 had reported a series (*n* = 27) of EUS guided drainage of pancreatic pseudocysts with a success rate of 78%. Over years the technique and accessories evolved and with the advent of the therapeutic linear echoendoscope with larger working channels of 3.7 or 3.8 mm, successful drainage with placement of multiple large-bore stents without changing the scope became feasible. In 2001, Giovannini *et al*[32] reported 88.5% success rate (*n* = 35) in patients undergoing the drainage of pseudocyst or pancreatic abscess. One patient had pneumo-peritoneum that resolved with conservative care and four had failure

Table 2 Summary of technical success, clinical success and complications with endoscopic ultrasound-guided drainage of pancreatic fluid collection

Ref. (number of cases)	Type of study	Technical Success (%)	Clinical Success (%)	Complications (%)	Complications
Grimm *et al*[31], 1992 (1)	Retrospective	100	100	0	Nil
Binmoeller *et al*[21], 1995 (27)	Retrospective	93	78	7	Bleeding (*n* = 2)
Giovannini *et al*[32], 2001 (35)	Prospective	100	89	3	Pneumoperitoneum (*n* = 1)
Azar *et al*[33], 2006 (23)	Retrospective	91	82	4	Pneumoperitoneum (*n* = 1)
Antillon *et al*[19], 2006 (33)	Prospective	94	87	15	Bleeding (*n* = 4), pneumoperitoneum (*n* = 1)
Krüger *et al*[34], 2006 (35)	Prospective	94	88	0	Nil
Kahaleh *et al*[35], 2006 (46)	Prospective	100	93.5	20	Superinfection (*n* = 4), bleeding (*n* = 2), pneumoperitoneum (*n* = 2) stent migration (*n* = 1)
Hookey *et al*[22], 2006 (32)	Retrospective	96	93	9	Pneumoperitoneum (*n* = 2), bleeding (*n* = 1)
Lopes *et al*[36], 2007 (51)	Retrospective	94	84	4	Pneumoperitoneum (*n* = 1), migration (*n* = 1)
Varadarajulu *et al*[37], 2007(21)	Prospective	100	95	0	None
Barthet *et al*[38], 2008 (28)	Prospective	100	89	18	Superinfection (*n* = 5)
Varadarajulu *et al*[39], 2008 (24)	Randomized controlled trial	100	96	0	Nil
Park *et al*[40], 2009 (31)	Randomized controlled trial	94	89	7	Minor bleeding (*n* = 1), stent migration (*n* = 1)
Zheng *et al*[41], 2011 (21)	Retrospective	90.5	90.5	19	Stent blockade (*n* = 2), Infection (*n* = 2)
Varadarajulu *et al*[42], 2011 (148)	Prospective	100	98	5	Infection (*n* = 4), perforation (*n* = 2), bleeding (*n* = 1), stent migration (*n* = 1)
Bakker *et al*[43], 2012 (10)	Randomized controlled trial	90	80	20	Pancreatic fistula (*n* = 1), death from multiorgan failure (*n* = 1)
Seewald *et al*[44], 2012 (80)	Retrospective	97	84	26	Bleeding (*n* = 12), perforation (*n* = 7), portal air embolism (*n* = 1), ogilvie syndrome (*n* = 1)
Fabbri *et al*[45], 2012 (22)	Prospective	100	77	14	Superinfection (*n* = 1), superinfection and stent migration (*n* = 1), failed stent removal (*n* = 1)
Itoi *et al*[46], 2012 (15)	Retrospective	100	100	7	Stent migration (*n* = 1)
Berzosa *et al*[47], 2012 (7)	Retrospective	100	100	0	None
Penn *et al*[48], 2012 (20)	Prospective	100	85	15	Superinfection (*n* = 2), pancreatitis (*n* = 1)
Mangiavillano *et al*[49], 2012 (21)	Prospective	85.7	81	4.8	Bleeding (*n* = 1)
Weilert *et al*[27], 2012 (18)	Prospective	100	77.8	5.6	Tract dehiscence (*n* = 1)
Gornals *et al*[28], 2012 (9)	Prospective	89	89	11.1	Tension pneumothorax (*n* = 1)
Puri *et al*[50], 2012 (40)	Prospective	100	97	5	Pneumoperitoneum n-1, infection (*n* = 1)
Siddiqui *et al*[51], 2013 (87)	Retrospective	99	79	18	Stent occlusion (*n* = 16)
Lin *et al*[52], 2014 (93)	Retrospective	95	95	12	Secondary infection (*n* = 11)

Table modified from the tables described by Fabri *et al*[8] and Singhal *et al*[25].

requiring surgery[32]. None of the patients developed bleed. In 2006, Azar *et al*[33] using a therapeutic linear echoendoscope described a new technique of introducing a 19-gauge needle and guide-wire into the PFC followed by creation of a fistula with a cystoenterostome. Maximum upto four stents were placed through the tract after balloon dilation. They reported successful drainage (*n* = 23) of pancreatic pseudocysts in 91.3% patients with only a single case of significant pneumo-peritoneum. Another study by Krüger *et al*[34] described EUS-guided drainage with placement of 8.5 Fr stents (*n* = 34). The procedure was successful in 88%. There was recurrence (12%) over next 2 years, and cyst resolution of pseudocyst was increased in 30% with cyst irrigation. Hookey *et al*[22] described EUS-guided drainage of PFC (*n* = 116) which included acute pseudocysts, necrosis, and abscess. They noted 29/32 (90.6%) success. Of these patients, 20 had non bulging lesions. 4 (12.5%) patients had recurrence and 3 (9.4%) had complications[22].

In 2006, Kahaleh *et al*[35] reported a prospective comparative study of non EUS guided *vs* EUS guided drainage. 53/99 patients underwent non EUS guided, and rest EUS guided drainage. Those with visible bulge and no portal hypertension were included in the former group. The outcomes at 6 mo (84% *vs* 91%) and overall complications (18% *vs* 19%) were comparable in the two groups. They reported that the choice between these two techniques, therefore, depends on individual patient characteristics and availability of skilled EUS intervention. They recommended EUS guided drainage for non-bulging collections and those at risk for bleeding[35]. Another study by Varadarajulu *et al*[39] in 2008 compared EUS and conventional transmural drainage of pancreatic pseudocysts. Only 5/15 patients had successful drainage with the conventional method, and all of them had complete drainage on cross over to EUS. Major procedure related bleed was seen in 2 patients in the conventional drainage group. The authors concluded that EUS

guided drainage should be the first option.

In a prospective randomized controlled trial by Park *et al*[40], patients with pancreatic pseudocysts (*n* = 60) were randomly allotted to conventional drainage (*n* = 29) and EUS guided drainage groups (*n* = 31). In an intention-to-treat analysis, the technical success of the procedure was more for EUS guided drainage (94%) than for conventional drainage (72%, *P* = 0.039). With the failure of conventional drainage (n = 8), crossover to EUS guided drainage was made, which was successful in all. Complications in both groups were comparable (7% *vs* 10%, *P* = 0.67). Long term clinical success on per protocol analysis was comparable in both groups (89% *vs* 86%, *P* = 0.69). The authors concluded that EUS guided drainage, and conventional transmural drainage can both be considered first-line methods, but with non bulging cysts the former should be preferred.

In another study by Varadarajulu *et al*[42] (*n* = 148) to evaluate complications in patients undergoing EUS-guided PFC drainage, authors reported low rates of complications; perforation (*n* = 2) bleeding (*n* = 1) infection (*n* = 4) and stent migration (*n* = 1). Both cases of perforation occurred in pseudocysts in uncinate process. Most of the patients could be managed conservatively, 2 with perforation and 2 with infection required surgery. They concluded that most of the complications during EUS drainage can be managed successfully, and EUS guided drainage should be the first option in places with expertise.

Seewald *et al*[44] in a retrospective analysis of 80 patients with symptomatic PFC (mean diameter: 11.7 cm, range 3-20 cm; pseudocysts: 24/80, abscess: 20/80, infected WOPN: 36/80) observed clinical success in 83% initial for PFC drainage. The long-term clinical success over 21 mo followup was 72.5%. There was recurrence in 9 patients due to failure of endoscopic treatment of pancreatic duct abnormalities. They concluded that EUS drainage is safe and effective. They emphasized that EUS guidance is important for reduced bleeding related complications, and surgical or endoscopic treatment of pancreatic ductal lesion is extremely important for complete resolution of PFCs.

We had studied the role of combined EUS-guided drainage (with placement of double pigtail stents) and nasocystic drainage in a series of 40 patients who had non bulging pancreatic pseudocysts, 32 had no evidence of infection and 8 had infection. All 32 patients without infection and 7 out of 8 patients with infection had complete drainage. One patient had to undergo surgery due to bleeding in the pseudocyst[50]. Siddiqui *et al*[51] reported drainage of pseudocysts with viscous solid debris by combination of stents and nasocystic tubes (*n* = 63) *vs* stents alone (*n* = 24). They found three times higher short-term success rate for combined group with both stents and nasocystic tube (*P* = 0.03). After 1 year of follow up, they found that with nasocystic drain there was higher occurrence

of complete resolution (79% *vs* 58%, *P* = 0.59), lower occurrence of stent occlusion (13% *vs* 33%, *P* = 0.03)[51]. Authors recommended combining both nasocystic drain and transmural stents in EUS guided drainage of pseudocysts with viscous debris-laden fluid.

Lin *et al*[52] in a retrospective study to define the number of stents required for successful drainage of PFCs evaluated 93 patients [acute pseudocyst (*n* = 67), chronic pseudocyst (*n* = 9), and WOPN (*n* = 17)]. There was no difference in the outcome based on the type of collection. Clinical success for single-stent drainage was 93.9% (46/49) *vs* 97.4% (37/38) for multiple stent drainage (*P* = 0.799). The occurrence of secondary infection for single-stent drainage was 18.4% (9/49) *vs* 5.3% (2/38) for multiple-stent drainage (*P* = 0.134). Secondary infection for stent diameter less than or equal to 8.5 F was 3.4% (1/29). It was 17.2% (10/58) for stent diameter larger than or equal to 10 F (*P* = 0.138). The authors concluded that during EUS-guided transmural drainage of PFCs, single-stent transmural drainage of PFCs is sufficient, and the number of stents or its size does not seem to influence clinical success or occurrence of secondary infection. In a similar study Bang *et al*[53] retrospectively studied 122 patients; 45 (36.9%) had 10Fr stents of which 30 patients (66.7%) had more than one stent, 77 (63.1%) patients had 7 Fr stents of which 56 (72.7%) had more than one stent. The overall treatment success was 94.3%. On multiple logistic regression analysis, the stent size (OR = 1.54; 95%CI: 0.23-10.4) and number of stents inserted (OR = 1.15; 95%CI: 0.25-5.25) were not associated with the number of interventions required for treatment success. Authors concluded that the number of interventions required and stent characteristics in patients undergoing endoscopic transmural drainage of uncomplicated pancreatic pseudocysts does not influence the clinical outcome[53].

Panamonta *et al*[54] reported a meta-analysis of (2 randomized-controlled trials and two prospective studies, 229 patients) comparing conventional transmural drainage and EUS guided drainage They found that the technical success rate was significantly higher for EUS group than for conventional drainage group (RR = 12.38, 95%CI: 1.39-110.22). A crossover to EUS drainage with failure of conventional drainage of non-bulging lesions (*n* = 18) was successful in all 16 cases. All patients with portal hypertension and bleeding tendency underwent EUS guided drainage to avoid severe complications. The authors found that the outcome of EUS drainage was comparable to conventional drainage in terms of short-term success (RR = 1.03, 95%CI: 0.95-1.11), long-term success (RR = 0.98, 95%CI: 0.76-1.25) and occurrence of complications (RR = 0.98, 95%CI: 0.52-1.86). They concluded that, either EUS drainage or conventional drainage are equally good for bulging pseudocysts and EUS guided drainage should be preferred for those with non-bulging pseudocysts, portal hypertension, or

coagulopathy.

The promising results of these studies on EUS drainage has increased the application of EUS guided PFC drainage world over. Yusuf *et al*[55] reported the results of a web-based survey of United States and International members of the American Society for Gastrointestinal Endoscopy. Of the 266 replies they received 198 performed pseudocyst drainage. A baseline CT scan was performed by 95% of responders. Endoscopic ultrasound was used before drainage by 70% of United States endoscopists and 59% of International endoscopists and EUS guided drainage was used by 56% and 43% of endoscopists respectively. The most common access route was transgastric (65%), and 1 to 5 stents were placed for drain.

USE OF COVERED SELF-EXPANDING METAL STENTS

Most of the studies reported the use of plastic double pigtail stents of varying size and nasocystic drains[35,56]. There are a few studies that have reported the use of metal stents for drainage of PFC. They are wide bore stents and tend to stabilize the pseudocyst wall at the site of insertion by applying radial expansive force. Talreja *et al*[57] reported drainage of PFC (*n* = 18) with covered self-expandable metal stents (covered SEMS; VIABIL; Conmed, Utica, NY, United States). Seventeen patients had a successful response, and 14 achieved complete resolution of their fluid collection (median number of sessions, *n* = 1, range 1-4). There were only a few complications in the form of superinfection (5), bleeding (2), and inner migration (1). There was no group with plastic stents for comparing the results.

Fabbri *et al*[45] reported 22 patients with infected PFC (mean size, 13.2 cm) of which 20 underwent EUS guided transmural drainage with covered SEMS. Early complications (superinfection, *n* = 1 and stent migration, *n* = 1) were seen in 2 patients. In the remaining 18 patients, stents could be removed easily in 17 patients (after a median of 26 d). In one patient stent had to be removed surgically due to inflammatory tissue in growth. Resolution of PFC was achieved in 17 patients (mean follow-up of 610 d) with only one symptomatic recurrence. Penn *et al*[48] reported use of combining double pigtail stent with covered SEMS (*n* = 20) to prevent migration of the latter. Partial migration occurred in 2 patients and the double pigtail prevented complete migration of covered SEMS. Initial success was reported in 17/20patients (1 patient had complete migration), with recurrence of PFC in three patients after stent removal. Weilert *et al*[27] in another study of 18 patients reported a success rate of 14 (78%) with the use of fully covered SEMS and only 1 patient required repeat stent placement. There are no randomized controlled trials that have shown the superiority of these stents over plastic stents.

NEW DEVELOPMENTS IN ACCESS DEVICES STENTS AND TECHNIQUES

One limitation of EUS guided drainage in many settings is dependence on fluroscopy and anesthesia. Schneider *et al*[58] evaluated the short and long-term outcomes of PFC drainage with endoscopic ultrasound guidance without fluoroscopy or anesthesia support. They studied 80 consecutive patients with symptomatic fluid collections ($\leqslant$ 6 cm in size and located < 2 cm from the gastrointestinal wall). PFCs were approached through gastric or duodenal wall, and those with estimated > 40% debris were excluded unless the features of sepsis. EUS was performed under conscious sedation with midazolam (2.5-10 mg) and fentanyl (100-300 μg). Procedural success was achieved in 74/80 (93%) with re-interventions in 16/74 (22%) cases and complications in only 11% (2 severe bleeding, 4 free perforations, 1 stent-related pressure ulcer, 1 minor bleed, 1 stent migration).

NAVIX access device is a multifunction, exchange-free system. It has a 3.5 mm switch blade to provide easy access across through the luminal wall. It has an 8 mm anchor balloon to maintain the catheter position in the pseudocyst, a 10-mm dilating balloon, and 2 guide-wire ports[27]. It was described for successful placement of fully covered SEMS (*n* = 18 patients) for drainage of PFC[27]. Gornals *et al*[28] used NAVIX system and reported a shorter median procedure duration (22 min; range, 10-30) compared to exchange devices (40 min; range, 25-55)[25,28].

Anchoring covered SEMSs have been recently introduced for improved drainage of PFCs. Itoi *et al*[46] first reported the use of Xlumena Mountain view CA (AXIOS) stent; a lumen-apposing fully covered, 10-mm diameter, nitinol, braided stent. The cyst wall and luminal wall are held together by anchoring flanges. This study involved 15 patients with symptomatic pancreatic pseudocysts who underwent 12 transgastric and three transduodenal pseudocyst drainage procedures. They showed that the AXIOS stents were successful in all cases with just one case of migration into stomach without any complications (median follow-up time of 11.4 mo). NAGI stent, a novel covered self-expanding metallic stent (Taewoong-Medical Co, Seoul, South Korea, with a 10 mm diameter in the center and 20 mm ends, for an endoscopic cystogastric anastomosis) prevents stent migration and ensures safe and effective of PFCs. It can be deployed in a single step procedure and a larger fistula diameter in the endoscopic cystogastric anastomosis. Téllez-Ávila *et al*[59] reported the use of NAGI stent in successful drainage of PFC and reported complete resolution of the PFC at 6 mo follow up. In another study AXIOS stent was compared with plastic double pigtail stents and found similar technical and clinical success rates[28]. But with multiple plastic stents, they noted increased number of adverse events, use of increased

number of stents and increased mean procedure duration. One patient however developed a tension pneumothorax secondary to trans-esophageal AXIOS placement. AXIOS stent placement in esophagus is technically challenging due to its large size. These new stents provide stent stability, minimize the risk of migration due to the anchoring effect, and maintain the larger SEMS lumen which helps in easy passage of echoendoscope into the cavity of PFC.

The different studies described so far followed single transluminal gateway drainage using transmural stenting (single or multiple plastic stents or SEMSs). It is usually successful in complete resolution of unilocular or uncomplicated PFCs. In the presence of multilocular or huge infected PFCs, particularly WOPN, a new approach by multiple transluminal gateway drainage has been described[60,61]. In this technique, the caudal part of the WOPN is first drained initially with two 7Fr stents. For WOPN between 6-12 cm only one transluminal tract and those between 12 and 15 cm atleast 2 transmural tract and those more than 15 cm multiple tracts (3-6) are made. An 18 Fr nasogastric tube is placed in cranial part of collection to help irrigation[62]. Combination of transluminal and percutaneous drainage techniques can help in accessing all the subcavities in certain cases. Patients who fail to respond clinically to these drainage methods require endoscopic necrosectomy or surgery. Dhingra *et al*[63] has recently described percutaneous endoscopic necrosectomy (PEN) in patients with infected pancreatic necrosis who had failed to per-cutaneous catheter drainage. In their study 14 of 15 patients improved (mean of 5 sessions) after single or multiport PEN, with only minor side effects in two patients (self-limiting bleeding and pancreatic fistula in 1 patient each) and death in one patient.

CONCLUSION

The use of EUS in drainage of pancreatic fluid col-lections has increased over the last few years. Many new techniques and stent designs have increased the applicability of this method. Compared to conventional transmural drainage there are some clear advantages for EUS-guided drainage over as in accessing non-bulging cysts and in patients with portal hypertension and bleeding tendency. Covered SEMS and anchoring covered SEMS are shown to drain PFCs successfully. Prospective randomized trials are required to establish the exact role of covered SEMS as compared to the plastic stents. Further experience will enable us to utilize EUS guided techniques for more successful drainage of PFCs with fewer complications.

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