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ORIGINAL ARTICLE

Endoscopic Necrosectomy Through Percutaneous Self-Expanding Metal Stents May Be a Promising Additive in Treatment of Necrotizing Pancreatitis

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Abstract

Background The recommended treatment of infected walled-off necrosis (WON) in necrotizing pancreatitis entails a step-up treatment approach starting with endoscopic necrosectomy (ETDN).

Aims To report a small number of cases from 2013 to 2016 that were not amenable to or failed to respond to ETDN, and to describe a new, minimally invasive technique that may be a promising supplement to ETDN in this difficult patient population.

Methods Using the Seldinger technique, a fully covered self-expanding metal stent (SEMS) was placed percutaneously in order to drain, irrigate, and debride WON. After resolution, the stent was removed. We reviewed electronic patient records and defined clinical success as complete WON resolution with removal of internal as well as percutaneous drains and stents.

Results Five patients underwent treatment with SEMS placement. The mean length of the WON was 33.4 cm. Clinical success was achieved in four patients after an average of 5.75 necrosectomy sessions. One patient died from severe sepsis. Adverse events included severe abdominal pain and productive cutaneous fistulae (two patients).

Conclusions In our small case series, endoscopic necrosectomy through a percutaneous SEMS seemed beneficial and safe in the treatment of infected WON.

Keywords Acute pancreatitis · Walled-off necrosis · WON · Infection · Necrosectomy · Percutaneous endoscopic necrosectomy

Introduction

Approximately 5–10% of patients suffering from acute pancreatitis (AP) develop necrosis of the pancreas or the peripancreatic tissue [5]. According to the Revised Atlanta Classification from 2012, acute necrotic collections may either resolve spontaneously or become encapsulated, forming a walled-off necrosis (WON), which is mature for drainage [5, 24]. In recent decades, minimally invasive necrosectomy (MIN) by either percutaneous or endoscopic route has emerged as the preferred treatment of symptomatic WON not responding to conservative treatment [10, 12, 16, 24]. Three randomized controlled trials (RCTs) have investigated different treatment strategies [4, 25, 26]. In these trials, MIN either covers the modalities of video-assisted retroperitoneal debridement (VARD) or endoscopic transgastric drainage and necrosectomy (ETDN). One RCT has shown a superiority of a step-up approach using VARD over open surgery [26], whereas one small RCT has shown a superiority of ETDN over surgery (VARD or open surgical debridement) [4]. A newly published RCT shows advantages of an endoscopic step-up approach compared to a step-up approach of percutaneous catheter drainage and VARD [25]. Since 2005, our department has served as a tertiary referral center for the treatment of necrotizing pancreatitis and WON. Primarily,

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ETDN has been the treatment of choice in our center [23]. This paper describes a series of patients with infected WON who were not eligible for ETDN or insufficiently treated with ETDN, and required treatment with a percutaneously placed large-caliber fully covered self-expandable metal stent (SEMS).

Materials and Methods

Patients and Baseline Characteristics

We reviewed the electronic charts of all patients who underwent drainage of infected WON with a percutaneous SEMS at our department from January 2013 to December 2016. We defined infected WON according to international recommendations [5, 12, 24]. We collected all electronic patient records from their former, current, and subsequent hospitalizations, including imaging, medication, and laboratory findings. Baseline characteristics of the patients included age, gender, etiology of AP, Charlson comorbidity index [8] (CCI), sequential organ failure assessment score [27] (SOFA score), modified CT severity index [18] (mCTSI), largest diameter of WON measured on one single CT, time between events and information on prior or concurrent ETDN and percutaneous catheter therapy. We retrospectively estimated the SOFA score and computed their CCI and mCTSI at the time of percutaneous SEMS placement.

Outcome Measures

The primary outcome was clinical success defined as complete WON resolution with the removal of internal as well as percutaneous drains and stents. Secondary outcome measures included the number of percutaneous necrosectomies (PEN), time with percutaneous stent, and time between stent removal and discharge.

Drainage Technique

A 7-French percutaneous pigtail catheter was first installed in the WON by a radiologist using ultrasound guidance. After catheter placement, fluid was aspirated for microbiological culturing. Later, the pigtail catheter was replaced by a SEMS using the Seldinger technique as described below (Fig. 1):

- The WON was visualized by contrast injection through the pigtail catheter under fluoroscopy. For future reference, we call this procedure cystography.
- A guidewire (0,035″ Dreamwire; Boston Scientific) was then inserted through the pigtail catheter (Fig. 1a), and the pigtail catheter was removed, leaving the wire in place.
- A dilatation balloon (CRE Wireguided 12–20 mm; Boston Scientific) was used to dilate the tract over the guidewire under fluoroscopic guidance (Fig. 1b).
- The balloon was removed, and a fully covered esophageal SEMS (Niti-S; TaeWoong Medical or Evolution; Cook Medical) was inserted over the guidewire into the sinus tract and cavity (Fig. 1c, d). The stent diameter was 20 mm, and the length ranged from 80 to 120 mm.
- A flexible gastroscope (Olympus GIF-1TQ160/XTQ160) was introduced through the SEMS (Fig. 1e), and a 7-French irrigation catheter (Olympus; nasal biliary drainage catheter) was inserted into the collection (Fig. 1e, f).
- Endoscopic necrosectomy was later performed through the stent using either tripods, stone retrieval baskets, or polypectomy snares.
- The SEMS placement was done under conscious sedation or general anesthesia depending on the condition of the patient.
- We repeated necrosectomy once a week until resolution, but expedited the sessions on demand, if the course of the infection required it.

Results

Patients

A total of five patients underwent drainage by a percutaneous SEMS in this period. Baseline characteristics and outcome measures are shown in Tables 1 and 2. The mean time from onset of AP to a MIN procedure was 32.8 days. Three patients were treated with percutaneous catheter drainage before MIN. Mean scores of CCI, SOFA, mCTSI were 0.8, 8.2, 8.4, respectively. The average largest diameter of WON was 33.4 cm. All patients had a course in the intermediate- (IMCU) or intensive care unit (ICU). On average, the surviving patients carried a SEMS for 37.5 days, underwent 5.75 endoscopic sessions, and were discharged 60.75 days after percutaneous SEMS removal. Counting all patients, an average of 6.4 days passed between endoscopic sessions. Two patients were treated with ETDN before turning to PEN.

Clinical success was obtained in four patients, who survived the course of the disease and were eventually discharged without significant sequela. One patient died from severe sepsis 12 days after percutaneous stent placement. Adverse events from the percutaneous stent included severe abdominal pain in all cases and formation of cutaneous fistula in two cases. The fistulization will be addressed in detail during the case descriptions. In the following, all five cases

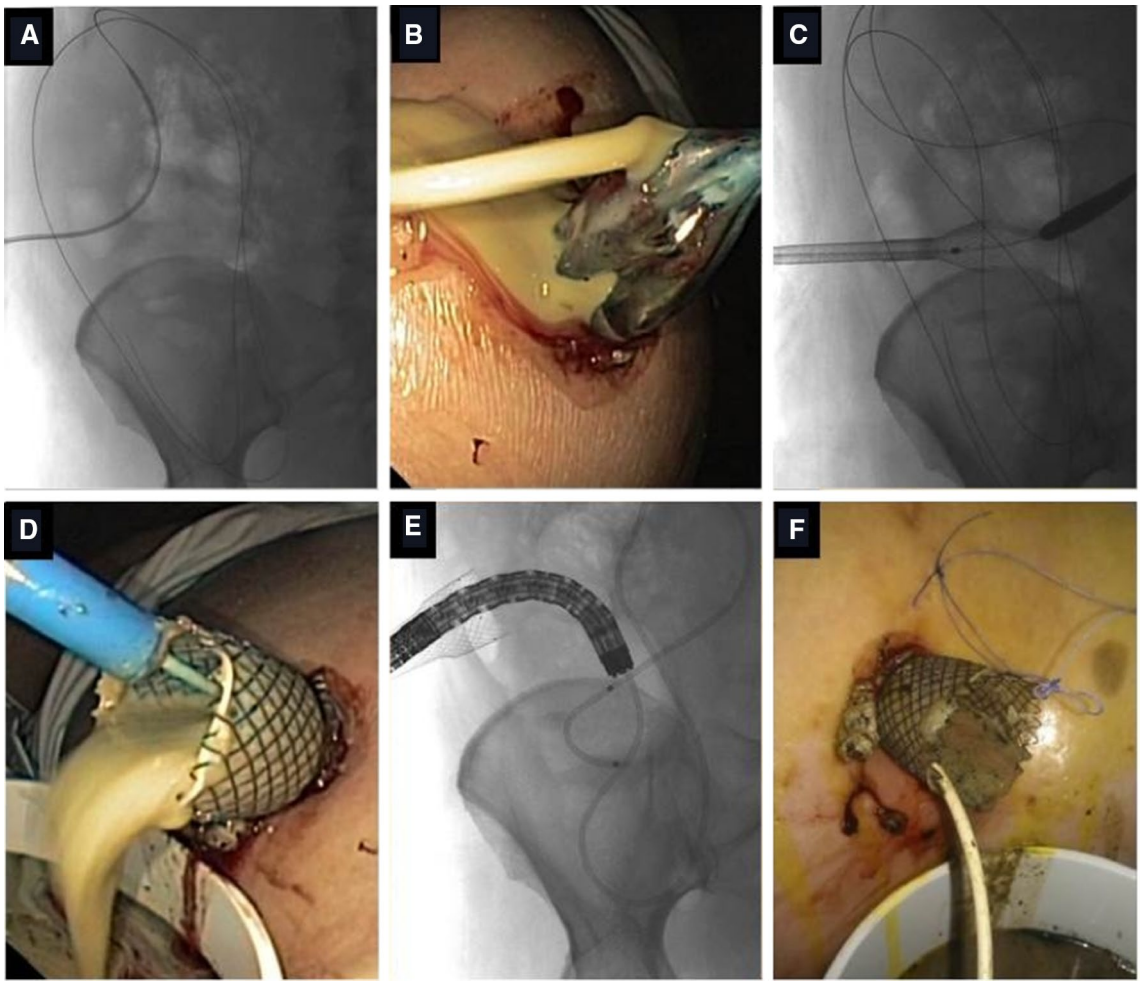

Fig. 1 Technique of percutaneous placement of self-expandable metal stent (SEMS): **a** exchange of small-caliber plastic drain over guidewire. **b** Flow of pus through balloon-dilated tract. **c** Deployment of SEMS. **d** Flow of pus and necrotic debris through SEMS. **e** Endoscopy through SEMS with placement of irrigation catheter. **f** SEMS (sutured to skin) and irrigation catheter in place

are described in terms of indication for placing the percutaneous SEMS, the clinical course, and the outcome.

Case 1

Two weeks after onset, a 48-year-old woman with gallstone-induced acute pancreatitis was transferred to our department. At this time, CT imaging exposed extensive necrosis stretching from pancreas through both paracolic gutters and into the pelvic region. ETDN was initiated, as the patient had become severely septic, based on vital parameters and need for vasoactive agents. Blood cultures were negative, but both *Enterococcus faecium* and *Candida albicans* were cultured from the collection. Eleven weeks later, the patient had not recovered despite aggressive treatment. Imaging showed a 26-cm large undrained collection stretching from the right kidney to the urinary bladder with no communication to the area earlier drained by ETDN (Fig. 2). PEN through SEMS in the right side of the abdomen was performed. From this point, the patient quickly recovered. When the percutaneous SEMS was removed, a harmonica drain and two percutaneous catheters were installed and left for 2 months. Lavage was performed daily, partly in an outpatient setting. During hospitalization, the patient experienced septic shock and abdominal compartment syndrome, but was discharged without significant sequela. No recurrence or complications have been observed since discharge, and she completed a biliary sphincterotomy, cholecystectomy, and removal of the internal transgastric stent 3, 8, and 13 months after the discharge, respectively.

Case 2

A 30-year-old cholecystectomized woman developed post-ERCP acute pancreatitis in our unit. Seven days after the onset, she developed infection of the necrosis and

Table 1 Baseline characteristics

ID/sex/age (years)	Cause of AP	Onset of AP to SEMS (days)	First PC to MIN (days)	CCI	SOFA	mCTSI	WON diameter (cm)	IMCU + ICU before/after SEMS (days)	Number of PC before/during/after SEMS	ETDN to SEMS (days)	Number of transgastric necrosectomies before/after SEMS
1/F/48	Gallstone	95	–	0	4	8	26	70/0	6/0/2	77	7/0
2/F/30	ERCP	25 and 45	18	0	4	6	33	58/10	4/4/0	–	–
3/F/72	ERCP	36	17	3	14	10	29	34/168	3/0/1	–	–
4/F/42	Gallstone	69	–	1	17	10	54	7/12	1/1/–	30	4/1
5/M/29	Alcohol	46	25	0	2	8	26	3/0	2/0/0	–	–

The table illustrates the baseline characteristics

ID case number, *AP* acute pancreatitis, *SEMS* fully covered self-expandable metal stent, *CCI* Charlson comorbidity index, *SOFA* Sequential Organ Assessment Score, *mCTSI* modified CT severity index, *WON* walled-off necrosis, *IMCU* intermediate care unit, *ICU* intensive care unit, *PC* percutaneous catheter, *ETDN* endoscopic transgastric drainage and necrosectomy

Table 2 Outcome measures

ID	Clinical success	Number of PEN sessions	SEMS time (days)	SEMS removal to discharge (days)
1	Yes	6	29	22
2	Yes	7	35	21
3	Yes	7	65	196
4	No	2	–	–
5	Yes	3	21	3

The table illustrates the primary and secondary outcome measures

ID case number, *PEN* percutaneous endoscopic necrosectomy, *SEMS* fully covered self-expandable metal stent

conservative treatment was initiated. Twenty-five days after the onset, a computer tomography (CT) demonstrated a 33-cm large WON without apposition to the stomach. It stretched from the left diaphragm around the spleen to the left pelvis and also crossed the midline to right upper quadrant (Fig. 3a). Due to the location, ETDN was technically impossible, and PEN through SEMS in the left side of the abdomen was carried out. Three weeks later, a cystography showed the necrotic collection had split into two separate entities with little to no communication (Fig. 3b) necessitating placement of another SEMS in the right side of the abdomen (Fig. 3c). From this point, the patient quickly recovered. After the discharge, the patient was treated for 3 months with lavage catheters in an outpatient setting. No complications or recurrence was observed since discharge. The disease course was complicated with clostridium difficile enteritis, lung empyema, and a purulent fistula to the vagina.

Case 3

Two weeks after the onset of a post-ERCP pancreatitis, a 72-year-old woman was referred to our department. At the time of arrival, she was septic and CT imaging revealed a widespread acute necrotic collection. Three weeks after onset, ETDN was attempted and failed with perforation of both the stomach and the colon. The patient underwent acute explorative laparotomy with closure of the perforations and construction of an ileostomy. Five weeks after the onset, CT imaging was carried out showing progression of a now 29-cm large WON, which stretched from the liver hilum, around the right kidney, to the urinary bladder, with no apposition to the stomach (Fig. 4). PEN through SEMS was then performed. The SEMS was removed 65 days later. During the disease course, the patient required mechanical ventilation, hemofiltration, use of inotropics, and temporary pacemaker treatment. Further, polypectomy of a randomly discovered colorectal cancer was carried out. The discharge was delayed due to a protracted rehabilitation course, complicated with critical illness neuropathy, aspiration

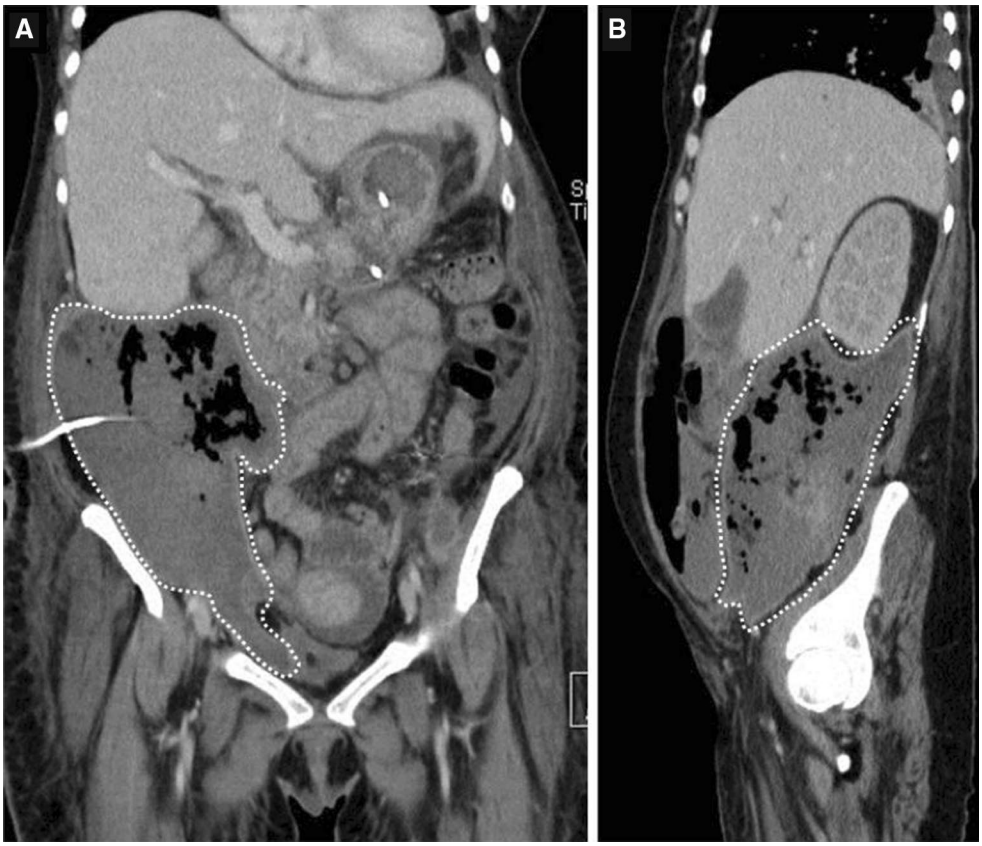

Fig. 2 Case #1. **a** Coronal CT image of right-sided walled-off necrosis (dotted line) with percutaneous plastic drain. **b** Sagittal image of WON

pneumonia, depression, PEG-tubation, and malnutrition. An abscess occurred in fossa Douglasi 4 months after SEMS removal. It resolved after 1 month with percutaneous catheter drainage and antibiotics. Five months after discharge, the patient underwent surgery due to a productive cutaneous fistula involving the gallbladder, the retroperitoneal space, the pelvic region, and gallstones at these sites.

Case 4

Six weeks after onset, a 42-year-old woman with gallstone-induced acute pancreatitis was referred to our department. She had a history of prior stroke without significant sequela. At arrival, she was septic and CT imaging revealed a large WON. The patient underwent ETDN the day after arrival with technical success. After few weeks and several necrosectomy sessions, CT imaging showed regression of some of the collections, but progression of others. Additional percutaneous catheters were installed in the caudal collections. Subsequently, the patient developed septic shock and was resuscitated after two cardiac arrests. CT imaging showed progression of the collections through the pelvis region into the left thigh (Fig. 5). As the patient was not fit for major surgery, PEN through SEMS was attempted to overcome the life-threatening descending collections. One week later, the patient developed compartment syndrome, muscle necrosis of the left thigh, and septic shock (*Escherichia coli*, *Serratia marcescens* and *Candida albicans* in blood, and *Eschericia coli*, *Enterococcus faecium*, *Candida albicans*, *Enterobacter aerogenes*, *Enterobacter cloacae* and *Citrobacter freundii* in the collection). Orthopedic surgical revision was carried out, but the day after the patient became severely septic, and further surgical resection or amputation was futile. The patient died 81 days after the onset of symptoms and 12 days after percutaneous SEMS installation. No direct complications to the percutaneous SEMS were observed.

Case 5

Nineteen days after the onset, a 29-year-old man with acute alcoholic pancreatitis and central venous catheter infection was referred to our department. The patient did not respond adequately to antibiotics and CT imaging revealed a 25-cm large WON stretching from the pancreatic tail around the left kidney and deep into the pelvis (Fig. 6). The imaging also revealed portal vein thrombosis, and antithrombotic treatment was initiated. ETDN was attempted without puncture, as numerous venous collaterals contraindicated

Fig. 3 Case #2. **a** Sagittal CT image of bilateral walled-off necrosis (WON; dotted line). **b** Plain abdominal X-ray showing WON with plastic drain (right upper quadrant) and metal stent with irrigation catheter (lower left quadrant). **c** Plain abdominal X-ray with regression of WON after placement of bilateral metal stents and irrigation catheters

the procedure. Treatment with percutaneous drainage was continued for 26 days without notable improvement. PEN through SEMS in the left side of the abdomen was then performed. From this point, the patient recovered fast and was discharged without significant sequela. The patient was discharged with newly acquired diabetes, and a productive cutaneous fistula formed by the former SEMS tract. The daily secretion decreased spontaneously from 300 ml to zero over 5 months.

Discussion

Necrotizing pancreatitis complicated by infection is a field of ongoing research. Current evidence points toward a step-up approach as the ideal strategy, but many questions remain unanswered [10, 12, 16, 24]. The picture is especially blurred by the heterogeneous patient group and the different ways of executing the modalities of the treatment strategies [1]. We believe our method is a supplement to the treatment pallet in centers practicing ETDN and an alternative to VARD. We describe a case series of five patients in which ETDN was either contraindicated, insufficient, or technically impossible. ETDN requires the presence of an avascular area with apposition to the stomach. Many patients with AP demonstrate splanchnic vein thrombosis with collaterals impeding ETDN [23]. The immediate alternatives to ETDN are VARD or open surgical debridement. In one randomized clinical trial of 88 patients, open surgical debridement appeared to be inferior to a step-up regime with catheter drainage and VARD in terms of total costs, major complications, and long-term complications, but no significant difference in death was observed [26]. Another randomized clinical trial of 22 patients showed superiority of ETDN to surgical intervention in terms of IL-6 response and complications [4]. In this trial, surgical intervention covered laparotomy and VARD. The newly published Tension trial showed no significant difference between the two modalities in terms of major complications or death, though the rate of pancreatic fistulas and the length of hospital stay were lower in the endoscopy group [25].

In our case series, five patients underwent PEN through SEMS with clinical success in four of five cases. One patient died from severe sepsis 12 days after percutaneous SEMS placement. Adverse events were pain and cutaneous fistulae. The patients constitute a subgroup of the 125 patients who

Fig. 4 Case #3. **a** Coronal CT image of right-sided walled-off necrosis (WON; dotted line). **b** Sagittal CT image of WON

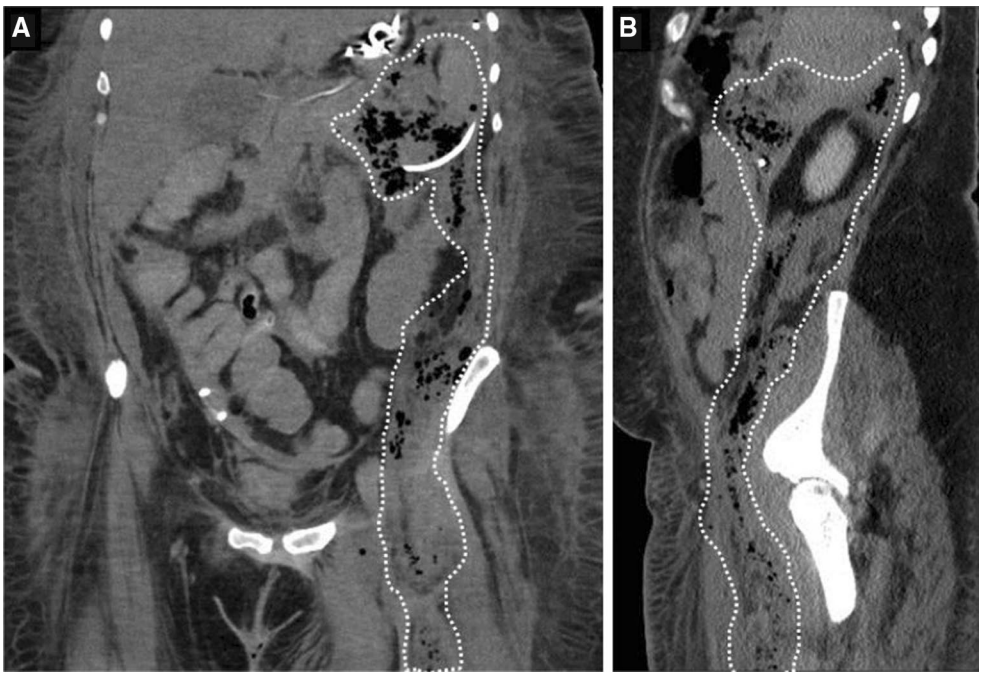

Fig. 5 Case #4. **a** Coronal CT image of left-sided walled-off necrosis (WON; dotted line). **b** Sagittal CT image of WON. Note extension of WON into left thigh

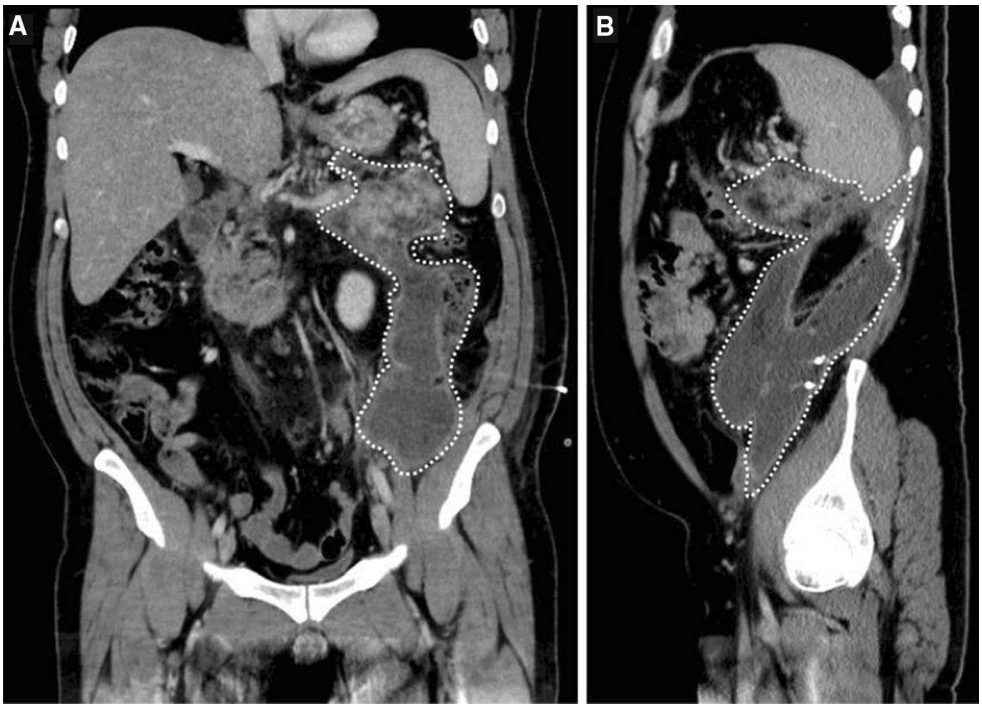

Fig. 6 Case #5. **a** Coronal CT image of left-sided walled-off necrosis (WON; dotted line). **b** Sagittal CT image of WON

were eligible for endoscopic intervention for infected WON in our center in the same period, thus illustrating the relative rare indication for SEMS placement.

A literature search resulted in eight studies describing the use of PEN through a percutaneous SEMS in the treatment of necrotizing pancreatitis, including a single case series and seven case descriptions. The contents of these studies are summarized in Table 3.

The case series from Saumoy et al. [22] reported nine patients with infected WON. The average length of the

Table 3 An overview of existing literature on PEN through SEMS

Study and year of publication	No. of patients	Mean age	Etiology	Technical success	Clinical success	Complications	Mean number of percutaneous necrosectomy sessions	Mean days with percutaneous stent
Saumoy (2017) [22]	9	61.8	Mixed	100%	89%	No	3.25[a]	14.7
D'Souza (2011) [9]	1	32	Alcohol	Yes	Yes	No	1	
Sato (2016) [21]	1	13	Lupus	Yes	Yes	No	3	17
Cerecedo (2014) [7]	1	46	Alcohol	Yes	Yes	No	7	21
Kedia (2015) [14]	1			Yes	Yes	No	2	
Navarrete (2011) [20]	1	37		Yes	Yes	No	4	12
Bakken (2011) [2]	1	65		Yes	Yes	Yes	4	45
Bakken (2011) [2]	1	74		Yes	Yes	No	1	5
Bakken (2011) [3]	1	75	ERCP	Yes	Yes	No		

The table summarizes the data extracted from the literature search. A blank cell is present when no information is provided

No. number, *ERCP* endoscopic retrograde cholangiopancreatography

[a]Patients dying with a stent is not included in the mean number of PEN sessions

collections was 10.1 cm. They practiced a step-up approach with mean time between catheter drainage and MIN of 15.2 days. Clinical success, defined as resolution of WON and removal of all drains, was accomplished in all but one patient, who died of MODS as a consequence of acute pancreatitis. Clinical success was achieved with a mean number of 3.25 necrosectomies and mean stent time of 14.7 days. None of the patients experienced complications to the procedure. ETDN was used in 6 of 9 patients and always initiated simultaneously with percutaneous necrosectomy, thus approaching the index necrosectomy more aggressively than in our case series. In addition, lavage with hydrogen peroxide solution was used during the endoscopic procedures.

Comparing our outcome measures to the results from the literature search, it is strikingly that we required more PEN sessions than in the case series from *Saumoy* et al. and in all of the case reports except one. The same applies to the average time with percutaneous SEMS. This may be explained by the difference in WON size, as the average collection length in our case series is more than three times greater than in the case series by *Saumoy* et al. Further comparison is difficult as the studies do not provide data on the presence or severity of organ failure or sepsis, which has been proven to influence the mortality significantly [28]. The methods used in the case descriptions do not differ notably from our method. The method used by *Saumoy* et al., however, is more aggressive than our method, as they practiced the use of hydrogen peroxide during necrosectomies and ETDN was initiated simultaneously with percutaneous SEMS in six of nine patients.

Interestingly, PEN without the use of SEMS has also been described in the treatment of infected WON. Four studies and five case reports comprising a total of 61 patients have been published on this matter [6, 11, 13, 15, 17, 19, 29–31]. The typical method is sinus tract endoscopy, in which the endoscope is inserted directly into the dilated percutaneous canal without any wall stabilizing device. In the study from *Bruennler* et al., they use a peel-away sheath to stabilize the wall during PEN. In the case descriptions from *Lam* et al. and *Jerger* et al., a trocar was used as a stabilizing device. In all of the studies, one or more percutaneous catheters were used between the sessions in order to sustain the patency of the tract. The diameter of the operating endoscope ranged from 4.9 to 9.9 mm.

Theoretical benefits from using our method compared to VARD include permanent access to the collection and the use of a flexible endoscope making it easier to reach distant parts of the collection. Compared to ETDN, theoretical benefits include easier observation of drainage site and output between necrosectomy procedures, no need for gastrointestinal instrumentation, and the possibility of evacuating collections located far from the gastrointestinal tract. Theoretical disadvantages include more pain, risk of stent dislocation, fistulization, and scarring. Also, the question of possible infection access through a large bore stent is a matter of concern. Theoretical benefits from using a SEMS instead of catheters to sustain the patency of the tract are no need for re-dilatation during subsequent sessions and allowing a permanent wide duct for drainage. Our study is retrospective has only few patients, and the patients constitute a non-representative critically ill subgroup; thus, our study can only bring allusions to our current knowledge. We find PEN through a percutaneous SEMS in infected WON to be a feasible therapy when ETDN is contraindicated, insufficient, or technically impossible. Considering their critical illness, our patients only experienced tolerable adverse events from our method. The sparse literature on the subject suggests likewise. Further studies are required to examine whether our method is superior to other types of MIN, especially VARD and ETDN, and to examine whether a SEMS is the ideal wall stabilizing agent.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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