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REVIEW ARTICLE

Percutaneous Catheter Drainage in Infected Pancreatitis Necrosis: a Systematic Review

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Abstract The primary aim of this study was to present the outcomes of percutaneous catheter drainage (PCD) in patients with infected pancreatitis necrosis. A second aim was to focus on disease severity, catheter size, and additional surgical intervention. A literature search of the PubMed/MEDLINE/Cochrane Library (January 1998 to February 2015) databases was conducted. All randomized, non-randomized, and retrospective studies with data on PCD techniques and outcomes in patients with infected pancreatitis necrosis were included. Studies that reported data on PCD along with other interventions without the possibility to discriminate results specific to PCD were excluded. The main outcomes were mortality, major complications, and definitive successful treatment with percutaneous catheter drainage alone. Fifteen studies of 577 patients were included. There was only one randomized, controlled trial, and most others were retrospective case series. Organ failure before PCD occurred in 55.3 % of patients. With PCD alone, definitive successful treatment was 56.2 % of patients. Additional surgical intervention was required after PCD in 38.5 % of patients. The overall mortality rate was 18 % (104 of 577 patients). Complications occurred in 25.1 % of patients, and fistula was the most common complication. PCD is an efficient tool for treatment in the majority of patients with infected pancreatitis necrosis as the only intervention. Multiple organ failures before PCD are negative parameters for the outcome of the disease. Large catheters fail to prove to be more effective for draining necrotic tissue. However, in the extent of multi-morbid patients, to determine one single prognostic factor seems to be difficult.

Keywords Infected pancreatitis necrosis · Percutaneous catheter drainage · Intervention · Systematic

Acute pancreatitis is a common gastrointestinal disorder whose incidence is rising globally. The disease results in 270,000 hospital admissions annually and inpatient costs exceed 2.5 billion dollars in the USA [1]. Necrotizing pancreatitis, which accounts for 10–15 % of all cases of acute pancreatitis, may be sterile or infected. Sterile pancreatic necrosis can be generally managed expectantly while infected pancreatitis necrosis always requires evacuation. The prognosis is much worse for infected necrosis, rather than that of sterile necrosis. Mortality rates of patients with infected pancreatitis necrosis vary from 20 to 30 % [2, 3], and if infected necrosis is accompanied by organ failure, the disease is associated with a mortality of 40 % [3]. Therefore, infected pancreatitis necrosis is always an indication for intervention.

Traditionally, infected pancreatitis necrosis was managed by open necrosectomy, with the goals of wide drainage of infected compartments and removal of necrotic tissue [4]. However, such aggressive treatment is associated with significant complications and mortality in 11–39 % of patients [5–7]. In this context, traditional open necrosectomy gradually

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was replaced by minimally invasive techniques which include percutaneous catheter drainage (PCD), video-assisted restroperitoneal debridement (VARD), endoscopic necrosectomy, and minimally invasive necrosectomy [8, 9]. Over the past two decades, a number of studies of minimally invasive techniques have been published [10–14], and most cases of infected necrosis are feasible for those interventions [15].

In 1998, Freeny first reported 34 patients with infected pancreatitis necrosis exclusively treated by PCD, in which 16 patients (47 %) were cured successfully with only PCD [16]. The largest recent report by Robbert A. Hollema included 113 patients with infected pancreatitis necrosis initially with percutaneous catheter drainage. This observational study of 113 patients undergoing primary percutaneous catheter drainage reported a success rate of 35 % [17]. The only randomized multicenter trial compared a surgical "step-up approach" with primary open necrosectomy in patients with (suspected) infected pancreatitis necrosis, in which PCD was considered as the first step. This trial reported that 35 % of patients were successfully treated with PCD alone [3, 7, 18].

Drainage is the least invasive procedure in the treatment for infected pancreatic necrosis and could help patients to reduce infected fluid under pressure, or at least let them improve as a transition to further surgery. Compared with open surgery, PCD could effectively diminish the hospital stay and average hospital cost and avoid surgically related complications, such as wound infection and incisional hernia [19].

In this study period, we performed a systematic review on percutaneous catheter drainage in infected pancreatitis necrosis. The purpose was to evaluate the effectiveness of PCD according to definitive treatment and identify factors that closely relate to the outcome of PCD, such as mortality, and complications in individual studies for providing further evidence and references for clinical decision.

Methods

A literature search was performed in MEDLINE, EMBASE and the Cochrane Library databases for articles published before February 2015. The search included the words acute pancreatitis, pancreatitis, infected pancreatitis necrosis or necrotizing pancreatitis or peripancreatic necrosis, imaging-guided percutaneous catheter drainage. Participants of any age and sex with infected PN were considered. All titles and abstracts of studies were screened to select those patients receiving PCD with infected pancreatitis necrosis and duplicates removed. All cross-references in relevant review articles were screened to further identify studies of potential interest. Two authors independently screened the full texts to assess the eligibility of studies for inclusion (Fig. 1).

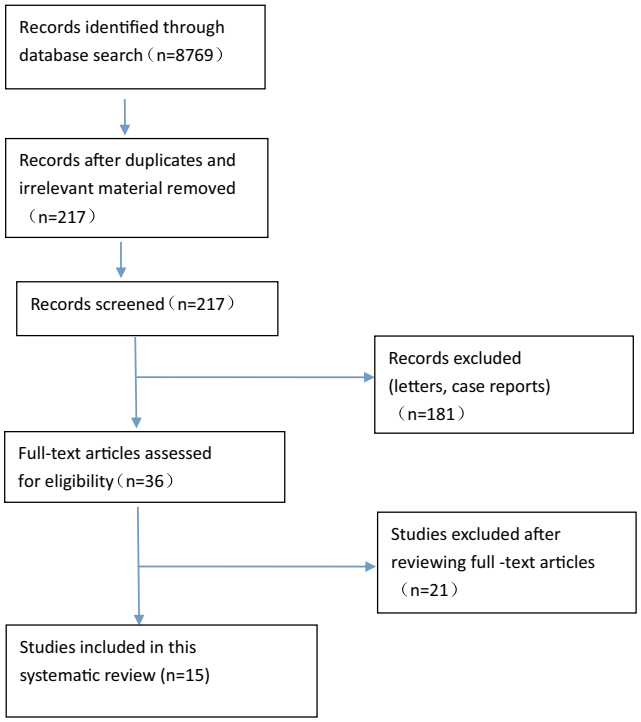

Fig. 1 Study selection flow chart

Inclusion and Exclusion Criteria

The authors read all abstracts of the articles to determine possible inclusion. Inclusion criteria were as follows: (1) sample size larger than $n=5$; (2) patients with infected pancreatitis necrosis undergoing percutaneous catheter drainage; (3) the primary outcomes were reported: additional surgical intervention, complications and mortality.

Exclusion criteria were as follows: (1) studies including patients with chronic pancreatitis or sterile pancreatic necrosis with results for infected pancreatitis necrosis failed to report separately; (2) studies of patients with pseudocysts or pancreatic abscesses with outcomes of infected pancreatitis necrosis not reported respectively; (3) studies that reported data on PCD as well as other interventions (minimally invasive techniques) without the possibility to discriminate results specific to PCD; (4) case reports and reviews were gathered to screen their reference lists for additional relevant articles, but were excluded from the analysis.

Data Extraction

Discrepancies in outcome extraction were resolved by reexamination of the relevant study until consensus was achieved. Two authors extracted data independently from each article including the following: author, year of publication, sample size, study design, etiology, predictive severity scores before

intervention : Ranson score [20]; Acute Physiology And Chronic Health Evaluation-II (APACHE-II) score [21], organ failure before percutaneous catheter drainage, computed tomography severity index (CTSI) scores [22–24], catheter size, time between hospital admission and PCD, definitive successful treatment with PCD alone (defined as no need for additional surgical intervention), number of patients requiring an additional surgical intervention, complications, and mortality.

Results

Fifteen studies of 577 patients undergoing PCD as primary treatment for (suspected) infected necrosis were included in the final analyses. Eleven studies were retrospective non-controlled case series; one was a post hoc analysis and one was a multicenter randomized controlled trial. Sample sizes ranged from 9 to 113. Characteristics of the included studies are presented in Table 1.

All of the patients had infected pancreatic or peripancreatic necrosis. Diagnosis was the presence of gas in the peripancreatic collection on CT or a positive culture at fine-needle aspiration. The etiology of infected pancreatitis necrosis was reported in 9 studies [8, 16, 17, 25, 27, 28, 33–35], in which the most common cause was biliary tract disease. APACHE II scores and CT severity index scores were used in the 10 studies [8, 16, 17, 28, 29, 31, 33–36]; 0.195 (55.3 %) of 352 patients had organ failure before PCD in 9 studies (including single and multiple organ failure) [8, 17, 29, 30, 32–36].

The clinical outcomes after PCD in the included studies were shown in Table 2. Seven studies reported the mean length of hospital stay [16, 27–29, 31–33], which ranged from 3 to 241 days. Eight studies reported the mean length of initial treatment with PCD after hospital admission [8, 16, 17, 25, 28, 29, 32, 35]. The success rate of PCD, defined as the recovery of patients without additional surgical intervention, was 56.2 % (324 of 577 patients). Two hundred twenty-two of the 577 patients (38.5 %) underwent additional intervention after initial treatment with PCD. Additional intervention was percutaneous necrosectomy in 18 patients, elective surgery in 13 patients, VARD in 24 patients, surgical in 87 patients, retroperitoneal necrosectomy in 3 patients, and surgical necrosectomy in 98 patients. The average (mean or median) time interval between the first PCD and surgery was reported in 8 series [8, 16, 17, 27, 29, 30, 32, 35] and ranged from 1 to 600 days.

The complication rate was described in 11 series [8, 16, 25, 26, 28, 33, 36], 96 of 382 patients (25.1 %) had reported complications. The majority of complication was fistulas (43; 44.8 % of 96 patients), one study described severe clinical complications (24; 71 % of 34 patients) [16], including respiratory and renal failure.

The overall mortality rate was 18 % (104 of 577 patients). Five series described the cause of death, and the most common reason was multiorgan failure (34; 75.6 % of 45 patients) [16, 28, 34, 35].

Technical details of PCD in the included studies were shown in Table 3. Of the total 15 articles, 12 studies reported the size of catheters, which ranged from 6 to 32 French [16, 17, 25–29, 31–35]. Moreover, most of the radiological interventions were CT guided. Five studies showed that the large bore (>20 F) was the final size of the catheter achieved after up-sizing the initial small bore catheters [16, 17, 29, 31, 32]. On the other side, two studies considered the catheters were selected on the basis of the characteristics of the fluid [25, 33]. One study deemed that the viscous fluid and fluid that contained particles should be drained by using large catheters while low-viscosity fluid should be drained by using small bore catheters [25]. Nine articles reported the mean number of catheters per patient [16, 25, 27–29, 32–35]. Three studies showed that the catheter placement was accomplished by means of the trocar technique via the most direct transperitoneal route, avoiding intervening bowel and solid organs [16, 27, 32]. Two studies preferred an approach which was retroperitoneal through the left lumbar access with the path located between the left kidney and the descending colon [31, 35]. Six studies suggested the nursing staff should routinely irrigate the catheters with normal saline solution every 8 h to drain viscous fluid or fluid with particles [16, 17, 25, 29, 30, 34]. Five studies emphasized the data of catheter exchange [16, 25, 28, 30, 32].

Three studies showed detailed information regarding CT imaging features for those 38.5 % of the cases who did not respond to the PCD and further required surgical interventions [16, 34, 35]. Two of the studies mentioned the CT severity index scores [16, 34], and one study found no statistical difference in the CT severity index scores among patients who were cured with PCD alone and those who required additional surgical interventions [16]. One study found the group requiring further surgical interventions revealed higher mean CT density compared with the PCD success group [34]. The extent of necrosis was greater than 50 % in 6 patients who were initially managed with PCD, requiring eventual crossover to surgical interventions [35]. The details are shown in Table 4.

Discussion

This systematic review shows the outcome of PCD in patients with infected pancreatic necrosis, and we considered that PCD is a safe and effective minimally invasive treatment. As a sole treatment, the recovery of PCD is 56.4 % in patients reviewed here. Considering that some populations in including studies represented a seriously ill subset of patients, a mortality rate of 18.1 %, a complication rate of 22.4 and 8.5 % of patients

Table 1 Characteristics of patients in included studies

Author	Cases	Year	Study design	Etiology	APACHE II score	CTSI	Organ failure
Freeny et al. [16]	34	1998	Retrospective analysis	Alcoholic 7 Biliary 12 Other 15	NR	8.2	NR
Fotoohi et al. [25]	44	1999	Retrospective non-controlled case series	Alcoholic 20 Biliary 6 Other 34	NR	NR	NR
Baril et al. [26]	25	2000	Retrospective non-controlled case series	NR	NR Ranson: 4(0–9)	NR	NR
Navalho et al. [27]	30	2006	Retrospective non-controlled case series	Alcoholic 9 Biliary 17 Other 4	NR Ranson: 5.4 (1–10)	NR	NR
Bruennler et al. [28]	80	2008	Retrospective analysis	Alcoholic 32 Biliary 26 Other 22	18 (1–38) Ranson: 2 (0–4)	6 (4–10)	NR
Mortele et al. [29]	13	2009	Retrospective analysis	NR	NR	9.6	1
Rocha et al. [30]	9	2009	Retrospective analysis	NR	NR	NR	3
Van Santvoort et al. [8]	39	2010	RCT	Alcoholic 3 Biliary 26 Other 14	15	8 (4–10)	36
Horvath et al. [31]	9	2010	NR	NR	8 (5.1)	NR	NR
Baudin et al. [32]	48	2011	Retrospective analysis	NR	NR Ranson: 3.5 ± 1.4(1–6)	NR	35
Zerem et al. [33]	69	2011	Retrospective cohort study	Alcoholic 39 Biliary 26 Other 21	15.5 (2–36) Ranson: 3.4 (1–8)	8 (6–10)	59
Tong et al. [34]	34	2012	Retrospective analysis	Alcoholic 12 Biliary 19 Other 3	11.26 ± 3.41 12.73 ± 3.85	7.63 ± 1.57 8.07 ± 1.71	18
Wroński et al. [35]	18	2013	NR	Alcoholic 13 Biliary 3 Other 2	NR	9(4–10)	1
Solanki et al. [36]	12	2013	Retrospective analysis	NR	6.92 + 3.45	7.71 + 2.39	2
Hollemans.et al. [17]	113	2015	Post hoc analysis	Alcoholic25 Biliary 66 Other 39	13.2	6.8	40

CT computed tomography, *RCT* randomized controlled trial, *NR* not reported, *CTSI* CT Severity Index, *Ranson* severity score for acute pancreatitis, *APACHE* acute physiology and chronic health evaluation

requiring surgical intervention are the acceptable outcomes. Comparing with former systematic review, this study concentrated on patients with only infected pancreatic necrosis removed patients with sterile pancreatic necrosis. Moreover, we described more details in the aspect of predictive factors, catheter size, and additional surgical intervention.

The theoretical basis of PCD is that critical patients with infected pancreatic necrosis might not tolerate open surgery, but image-guided PCD can improve their seriously clinical condition and postpone surgical intervention in selected patients who are too unstable for the operating room. It is also usually regarded as a safe technique with only a few non-lethal major complications; in addition, this technique was regarded as the first step of minimally invasive treatment for patients with diagnosed, or suspected, infected pancreatitis necrosis [37].

Diagnosis of infected necrosis in the majority of patients was mainly based on the results of contrast-enhanced CT and clinical and laboratory findings. It can be also confirmed by fine needle aspiration (FNA); however, there is a risk of false-negative results. A study reported that 53 patients (73.6 %) had proven positive results of culture sensitivity tests obtained by FNA culture [5, 33]. Although parts of the patients' culture were negative, interventional therapy was still initiated because of the results of imaging signs like gas in peripancreatic collections and clinical signs such as persistent fever and increasing inflammatory markers strongly suggested infection [18].

We found that the different mortality rate and outcome in reported series depends on the difference of population condition. The main fact is that the severe level of disease in the population varies. Some predictive factors, such as the

Table 2 Outcome of percutaneous catheter drainage as primary treatment for infected pancreatitis necrosis in the included studies

Author	Cases	Hospital stay	Time from admission until PCD	Successful PCD	Need for additional surgery	Time between PCD and necrosectomy (days)	Patients with one or more complications	Deaths
Freeny et al. [16]	34	45 (5–95)	9 (1–48)	16	1:surgery 8: necrosectomy 9:elective surgery	32 (6–78)	24	3
Fotoohi et al. [25]	44	NR	17 (10–25)	41	3:surgery	NR	6	3
Baril et al. [26]	25	NR	NR	18	6:surgery	NR	1	2
Navalho et al. [27]	30	55	NR	19	10:surgery	18	NR	5
Bruennler et al. [28]	80	51 (3–241)	3.5 (1–40	34	6:surgery 4:elective surgery 18:percutaneous necrosectomy (10: surgery necrosectomy later)	NR	23	27
Mortele et al. [29]	13	33 (11–48)	41 (11–121)	6	7:surgery	24 (3–120)	3	1
Rocha et al. [30]	9	NR	NR	3	6:surgery	109 (1–600)	2	4
Van Santvoort et al. [8]	39	NR	30 (11–71)	13	24:VARD 2:surgery	10 (1–52)	17	7
Horvath et al. [31]	9	48 (25–50)	NR	9	0	NR	5	1
Baudin et al. [32]	48	83 ± 48 (range, 10–222)	19.8 ± 15.7 (range, 2–90)	31	9:surgery	10.2 ± 6 (2–19)	2	14
Zerem et al. [33]	69	13 (9–47)	NR	58	11:surgery	NR	5	6
Tong et al. [34]	34	NR	NR	19	15:surgery	NR	NR	1
Wroński et al. [35]	18	NR	33 (27–46)	6	5:surgery 3:retroperitoneal necrosectomy 4: necrosectomy	25 (8–116)	NR	3
Solanki et al. [36]	12	NR	NR	6	6:surgery	NR	8	1
Hollemans et al. [17]	113	NR	28 (21–41)	45	76:necrosectomy	43	NR	26

PCD percutaneous catheter drainage, *NR* not reported

APACHE II scores, CT scores, and organ failure, can be used to evacuate the condition of a patient and might influence mortality or clinical success rates. However, many studies deemed that the CTSI scores did not show a good correlation with patient outcome [7, 16, 28]. Guillaume Baudin considered that CT scores did not appear to influence mortality or clinical success rates [32]. T Bruennler also showed the result that in the multivariate model the CTSI was as the only not significant variable included in adjusting for the extent of necrosis. He deemed that the CTSI is not a good parameter to predict outcome in patients with infected pancreatic necrosis [28]. This phenomenon is certainly related to two major reasons: the retrospective research has limits in our included studies, and the population is linked to the homogeneity in the study.

Several studies have proposed organ failure as a significant factor to stratify the severity of disease, and it was closely associated with mortality in infected pancreatic necrosis [30, 38–41]. In this systematic review, 53.6 % of patients had organ failure, with nine reported single and multisystem organ failures (MSOF) in our study. One study reported the fact that the mortality was 0 % in patients without organ failure, 13 % in patients with single-organ failure, and 38 % in patients with MSOF [30]. In another study, among 11 patients with multisystem organ failure, the mortality was 45 % [32]. Furthermore, in previous literature, the multisystem organ failure in acute necrotizing pancreatitis has been reported to be 54 % [32]. Therefore, although PCD have ameliorated condition and improved outcome in most patients, it potentially negatively reduces mortality among patients with multisystem organ failure. However, it is difficult to determine one single prognostic determinant in these multimorbid patients.

In the past, the correlation between drainage size and outcomes of disease is equivocal. Generally, pancreatic or peripancreatic necroses contain solid debris. Some authors considered the hypothesis that large bore catheters (up to 28 F) might be more effective for draining solid tissue [10, 13, 16, 28]. However, in our present review, the size of the drains used varied from 6 to 32 F, and no studies mentioned the fact that large bore drainages prove to be more effective in controlling complications. Moreover, many studies reported no significant correlation between drainage catheter size and outcome of disease, and researchers found that number and size of tubes had no impact on PCD outcome [28, 32, 34]. The

Table 3 Technical details of PCD

Author	Number	Catheter size (French)	First size (French)	Last or final size (French)	Exchange (times)	Exchange (days)	Catheter irrigation (h)
Freeny et al. [16]	3 (1–4)	10–28	10–14	24–28	4 (1–12)	NR	8
Fotoohi et al. [25]	2 (1–11)	8–24	8–10 12–24	NR	NR	7–10	8 (or 4–6)
Navalho al [27]	2 (1–6)	12–14	NR	NR	NR	NR	NR
Bruennler et al. [28]	2 (1–14)	8–24	NR	NR	2(1–9)	NR	NR
Mortele et al. [29]	2.6 (1–9)	12 (7–22)	7–14	NR	NR	NR	8
Rocha et al. [30]	NR	NR	NR	NR	NR	9(1–48)	8
Horvath et al. [31]	NR	10 (8–12)	10 (8–12)	20 (16–20)	NR	NR	NR
Baudin et al. [32]	1.8 ± 0.8 (1–4)	24.4 ± 4.4 (14–30)	12–16	28–30	7.5 ± 4.1	4.6 ± 1.2 (1.5–7)	NR
Zerem et al. [33]	1.68 (0–5)	8–20	NR	NR	NR	NR	NR
Tong et al. [34]	2.74 ± 0.99 3.20 ± 1.01	14.7 ± 0.99 (PCD success group) 14.5 ± 0.92 (PCD alteration group)	NR	NR	NR	NR	4–8
Wroński et al. [35]	1 (1–3)	14 (9–32)	NR	NR	NR	NR	NR
Hollemans.et al. [17]	NR	6–24	6–24	7–40	NR	NR	8
Baril et al. [26]	NR	10–12	NR	NR	NR	NR	NR

NR not reported, *PCD* percutaneous catheter drainage

rationale for those points was that the natural course of infected pancreatitis necrosis is associated with a transition from solid debris to more liquid contents, which avail the evacuating of the necrotic tissue from the cavities, regardless of the catheter size. In addition, aggressive irrigation can accelerate the process of transition from solid necrotic tissue to more liquid content. Furthermore, various sizes and types of drainage catheters provided from different companies were used. Therefore, the use of preferential types of catheter, size, and management is guided more by the experience of each team rather than by merely bibliographic evidence [32].

27.6 % of patients had one or more complications in present review. Comparing with other common surgical interventions, studies on surgical necrosectomy show a considerably higher complication rate, ranging from 34 to 68 % [42, 43], and series on endoscopic transluminal necrosectomy reported a complication rate of 36 % [44]. The major complication in our review was fistulas, which accounts for 8.2 %, with ten articles reporting this complication. In addition, one study described other severe clinical complications including respiratory and renal failure, which were not directly related to the percutaneous placed catheters either [16]. A potential limitation here is that mostly only early complications were described in our included studies. Although RCT reported a result of late complications, it could not be directly related to the PCD owing to the "step-up approach" present in other techniques.

In this review, 38.5 % percent of patients still needed other surgical interventions. The most common reason was that the necrotic tissue could not be effectively removed in a seriously ill subset of patients despite a prolonged percutaneous drainage. The main additional intervention is surgery and also includes other minimal- invasive interventional approaches, such as percutaneous necrosectomy, video-assisted

Table 4 CT imaging features of patients who did not respond to the PCD and further required surgical interventions

Author	Number	CTSI	Site of necrosis	CT mean density (*n*)	>50 % necrosis, *n* (%)
Freeny et al. [16]	18	8.3	Body-tail necrosis 7 Central necrosis 10	NR	NR
Tong et al. [34]	15	NR	NR	<20 HU 2 20–30 HU 5 <30 HU 8	NR
Wroński et al. [35]	12	10	NR	NR	6 (50)

CTSI CT Severity Index, *NR* not reported

restroperitoneal debridement (VARD), and retroperitoneal necrosectomy. Those patients required surgical intervention for control of sepsis. Some authors considered that distribution of CT scan reflects the range of infected pancreatic necrosis. Greater distribution range indicates that it may be inappropriate for PCD [34]. Therefore, additional surgical intervention mostly lies on the condition of patients and the experience of each group.

There are still some shortcomings within this systematic review. First, most data are retrospective analyses from a single center and many of the included studies were small; second, owing to the fact that most literatures did not provide enough detailed information, a formal assessment of methodological quality could not be accomplished [45]. It is undisputed that the lack of uniform patient selection criteria led to selection bias. Lastly, the condition of patients are heterogeneous and to a certain extent incomparable among the studies because of the clinical characteristics and the severity of the included patients are various, according to the different authors.

In conclusion, imaging-guided percutaneous catheter drainage is an efficient tool for treatment in the majority of patients with infected pancreatitis necrosis with acceptably low mortality and less non-lethal complications as the first and only intervention. Multiple organ failure is a negative parameter for the success of catheter drainage and the outcome of the disease. Large bore drainages fail to prove to be more effective in draining necrotic tissue. However, in the extent of multimorbid patients, to determine a single prognostic factor seems to be difficult.

Compliance with Ethical Standards

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

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