ORIGINAL ARTICLE

# Outcome of percutaneous drainage in patients with pancreatic necrosis having organ failure

Anupam K. Singh[1], Jayanta Samanta[1], Ajay Gulati[2], Vikas Gautam[3], Anmol Bhatia[2], Pankaj Gupta[2], Vikas Gupta[4], Thakur D. Yadav[4], Saroj K. Sinha[1] & Rakesh Kochhar[1]

[1]Department of Gastroenterology, [2]Department of Radiology, [3]Department of Microbiology, and [4]Department of GI Surgery, Postgraduate Institute of Medical Education and Research, Chandigarh, 160012, India

## Abstract

**Background:** Percutaneous catheter drainage (PCD) is an effective way of drainage in acute pancreatitis (AP) and its role in persistent organ failure (OF) has not been studied. This study assessed the outcome of severe AP managed with PCD.

**Methods:** We retrospectively analysed outcome of AP patients undergoing PCD for persistent OF with respect to success of PCD, etiology, severity scores, OF, imaging features and PCD parameters. Success of PCD was defined as resolution of with PCD and survived without surgical necrosectomy.

**Results:** Between January 2016 and May 2018, 83 patients underwent PCD for persistent OF at a mean duration of 25.59 ± 21.2 days from pain onset with successful outcome in 47 (56.6%) patients. Among PCD failures, eleven (13.25%) patients underwent surgery. Overall mortality was 31 (37.3%). On multivariate analysis, pancreatic necrosis <50% and absence of extrapancreatic infection (EPI) predicted the success of PCD. Presence of infected necrosis did not affect the outcome of PCD in organ failure.

**Conclusion:** PCD improves the outcome in patients with OF even when done early irrespective of the status of infection of necrosis. Therefore, PCD may be considered early in the course of patients with OF.

Received 20 July 2020; accepted 29 October 2020

## Correspondence

Rakesh Kochhar, Department of Gastroenterology, Postgraduate Institute of Medical Education and Research, Chandigarh, India. E-mail: dr_kochhar@hotmail.com

## Introduction

Acute pancreatitis (AP) is the third most common gastrointestinal disorder requiring hospitalization.[1] Necrotizing pancreatitis occurs in approximately 20% of patients of AP with mortality varying from 8 to 39%.[2] Sterile pancreatic necrosis is usually managed conservatively while infected necrosis (IN) often requires intervention. In the past, open surgical necrosectomy had been considered the preferred treatment for infected acute necrotising pancreatitis with mortality of 20%–42%.[3,4] However, currently a "step-up" approach is preferred with percutaneous or endoscopic drainage being the initial treatment option.

Organ failure (OF) can develop in up to 38% of patients in the presence of necrotising pancreatitis with three-fourths of patients developing multiorgan failure.[5] OF can be early (<2 weeks), due to inflammatory response or later in the course of disease due to secondary infected necrosis and both contribute to increased mortality.[6] Both OF and IN had been shown to predict the outcome of AP and presence of IN and OF was shown to have the highest mortality.[7–10] With improved multidisciplinary management, step-up approach and early identification of IN, outcome of IN has improved and OF remains the major determinant of outcome in AP.[5]

Percutaneous catheter drainage (PCD) was first used by Freeny *et al.*, in 1998 with 47% necrosectomy-free survival rate in necrotising pancreatitis.[11] Studies have shown that with improved drainage strategies and experience in pancreatic interventions, success rates of percutaneous approach have reached 55–64%.[12,13] Therefore, PCD is considered as a simple and effective modality of treatment of pancreatic necrosis.[12–15] Drainage of infected necrosis/collection, with or without OF, is the standard of care worldwide. However the indications of drainage in sterile necrosis are unclear. Guidelines suggest drainage of sterile collections only in the following situations: (i) ongoing OF after four weeks of onset of disease, (ii) gastric outlet obstruction, biliary obstruction or intestinal obstruction due to walled off necrosis (WON), (iii) disconnected pancreatic duct

 

with ongoing symptoms, or (iv) symptomatic or growing pseudocyst.[16,17] Published studies are unable to answer whether severely ill patients with persistent OF should undergo drainage with less than four weeks of disease duration. This is equally important for infected and sterile necrosis as persistent OF can occur in both.

Most of the studies on PCD have primarily included patients with IN and looked at its outcome in the same context. None of the studies have analysed the outcome of PCD keeping OF as the key determinant. The present study was done retrospectively evaluate the outcome of PCD in patients with severe AP i.e. those with OF and try to find predictors of PCD success in this group of patients.

## Patients and methods

### Study protocol

This study was a retrospective analysis of prospectively collected data from January 2016 to May 2018 in the department of Gastroenterology at a tertiary care center in North India. We analysed the outcome of PCD in patients with severe acute pancreatitis i.e. those with persistent OF and also assessed the predictors of successful PCD outcome. The study was approved by the Institute Ethics Committee. We included patients of AP who fulfilled the following criteria: (i) patients with severe acute pancreatitis as per the revised Atlanta classification, (ii) those who presented with fluid collections or developed them on follow up imaging, and (iii) patients requiring PCD for persistent OF, with no history of prior surgical or radiological intervention. We excluded patients with evidence of chronic pancreatitis, pancreatic malignancy, endoscopic retrograde cholangiopancreatography (ERCP) related pancreatitis, those who had received antibiotics in the last 3 days of presentation to our institute, those with PCD in-situ at the time of admission, PCD placed for reasons other than persistent organ failure, pregnant females and patients with significant comorbidities like chronic kidney disease, cardiac disease and on immunosuppressive medications.

### Management of acute pancreatitis

The diagnosis of pancreatitis was based on the revised Atlanta criteria, in the presence of characteristic abdominal pain, increased serum amylase/lipase level (>3 times the upper limit of normal) and imaging evidence of pancreatitis.[18] Organ dysfunction/failure for a particular organ system was defined as per modified Marshall Score $\geq$2 for that particular organ system.[19] All patients were managed according to standard recommendations which included aggressive fluid resuscitation, organ system support, pain alleviation and nutritional support. Patients underwent contrast-enhanced computed tomography (CECT) abdomen after 5-7 days of pain onset. Patients who underwent CT prior to presenting to our center were assessed for requirement of repeat CT and it was done if deemed necessary. Antibiotics were used for IN and extrapancreatic infection (EPI). IN was diagnosed in the presence of microbiological confirmation from the PCD aspirate of necrosis/collection or air in the collection. EPI was defined as infection of urinary tract, respiratory system or bacteremia (in the absence of IN) confirmed by microbiological culture.

Patients with a necrotic collection having persistent OF with or without fever and having failed to improve with conservative management were subjected to PCD. An expert interventional radiologist placed the PCD under image guidance (ultrasonography/computed tomography) choosing the route and size of PCD. Initial catheter placed was of size 12-14Fr. To maintain its patency, the catheter was flushed using sterile normal saline every 8 h. Catheter size was upgraded or additional PCDs were placed in the event of worsening of OF or sepsis, or inadequate drainage despite significant residual collection on imaging.

### Data collection

Data were collected prospectively and included demographic profile, etiology of pancreatitis, clinical and imaging severity scores {Acute Physiology and Chronic Health Evaluation (APACHE)-II Score, Bedside Index of Severity in Acute Pancreatitis (BISAP) score and computed tomography severity index (CTSI) score, C-reactive protein (CRP)}, time of onset and number of OF, PCD parameters (timing, number, upgradations of catheters, and total duration of PCD), outcome parameters (ICU stay, duration of mechanical ventilation, hospital stay, need for surgery and mortality).

Success of PCD was defined as patients who had resolution of OF after PCD and survived without surgical necrosectomy. Patients were divided into two groups, PCD success group and PCD failure group, for comparison. Parameters compared among the two groups included demographic characteristics (age, gender, and etiology), disease severity scores (CRP levels, BISAP score, and APACHE II score), characteristics of organ failures (type of OF and single vs multiple OF), CT characteristics (amount of necrosis and CTSI), presence of sterile vs infected collection (based microbiological culture or radiological evidence), PCD parameters (timing, number, upgradation of catheters, and total duration of drainage), and outcome parameters (ICU stay, duration of mechanical ventilation and duration of hospital stay).

### Complications

Complications of PCD were noted including pain at insertion site, blockage, slippage or bleeding through the catheter and external pancreatic fistula (EPF). Patient with persistent drain output for >3 weeks underwent ERCP and pancreatic duct stenting. Other complications were managed according to the indication.

### Statistical analysis

All the collected data were entered in excel sheet and Statistical Product and Service Solutions (SPSS) software {version 23.0 (Chicago IL), IBM} was used for analysis. Normality of data was checked using Shapiro–Wilk test. Continuous variables were represented as mean ± SD or median (interquartile range) and proportions were expressed as number. Data comparison was done for two groups, PCD success and PCD failure group. Mean among two groups was compared using independent sample t-test for normally distributed variables and Mann–Whitney U test was applied for skewed data. For categorical data comparison, Chi square test/Fisher exact F test with corrections were used. Univariate analysis was done to find significant variable for successful PCD outcome. Multivariable logistic regression analysis was done for all the significant variables on univariate variables to find out the factors predicting PCD success. Results are presented as adjusted odds ratio (OR) with 95% CI. P value of less than 0.05 was statistically significant.

## Results

Between January 2016 to May 2018, 330 patients of AP were admitted under our care. Of these, 104 patients were managed conservatively and 87 had received antibiotics in the preceded 3 days of presentation to our center or already had received PCD at another hospital (Fig. 1). Of the 139 patients subjected to PCD, 83 patients underwent PCD for persistent or worsening OF and were included in the analysis. Table 1 gives characteristics of patients included in the analysis.

A total of 147 PCDs were placed in these 83 patients. The mean number of PCDs placed per patient was 1.77 ± 1.06. The mean number of PCDs, early (<4 weeks of pain) versus late (≥4 weeks of pain) PCD, requirement of single or multiple PCDs and PCD upgradation were comparable among the two groups with PCD success and PCD failure (Table 2). Upgradation of catheter size was done in 27 (32.5%) patients and was not different among the two groups.

Among 83 patients studies, 79 (95.2%) had respiratory failure with successful PCD in 43 (54.4%). Renal failure and cardiovascular failure occurred in 31 (37.3%) and 24 (28.9%) patients with successful PCD in 15 (44.1%) and 9 (36%) respectively. Development of early (<2 weeks of pain) and late onset OF (≥2 weeks of pain) was similar among the two groups. PCD success group had more patients with single OF compared to PCD failure group. Infected collections were confirmed in 30 (36.1%) patients based on microbiological or radiological criteria and were higher in the PCD failure group (Tables 1 and 2).

Eleven (13.25%) patients underwent surgery for persistent OF or persistence of fever despite PCD and a total of 31 (37.3%) patients died including 6 patients after surgery.

### Predictors of successful PCD outcome

Out of 83 patients with OF who underwent PCD, 47 (56.6%) had PCD success while 36 (43.4%) had PCD failure. Baselines characteristics including age, gender ratio, etiology of pancreatitis, presence of fever, comorbidities, interval between admission and PCD were comparable among the two groups (Table 2). On univariate analysis, parameters found significant for predicting success of PCD were APACHE II score, pancreatic necrosis <50%, presence of single OF, absence of IN, absence of EPI, and baseline procalcitonin. Other parameters (i.e. presence of ascites, intra-abdominal hypertension at presentation, baseline TLC,

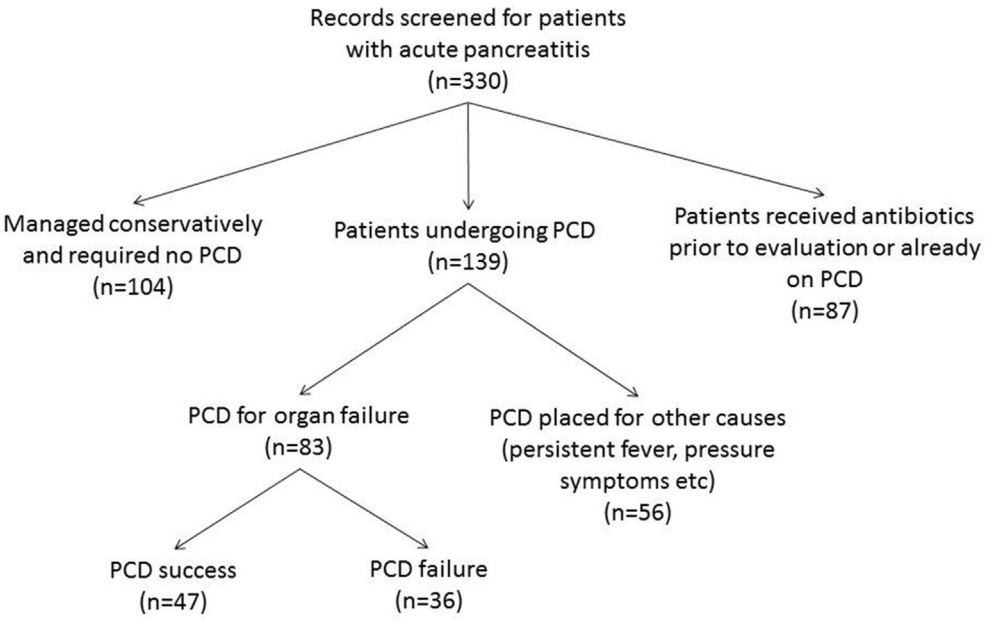


**Figure 1** Flowchart showing the management of patients included in the study

Table 1 Baseline parameters of the patients and outcome, n = 83

| PARAMETERS | RESULTS |
|---|---|
| **Age (years)** | 38.24 ± 12.55 |
| **Males (%)** | 62 (74.7%) |
| **Other comorbidities** | 24 (28.9%) |
| **Etiology of pancreatitis** | |
| Alcohol | 40 (48.2%) |
| Gallstones | 27 (32.5%) |
| Alcohol + Gallstones | 4 (4.8%) |
| Others | 12 (14.5%) |
| **Severity parameters** | |
| BISAP ≥2 | 73 (88%) |
| APACHE II score | 10.40 ± 4.06 |
| CTSI Score | 8.73 ± 1.87 |
| **Site of collections**[a] | |
| Central (peripancreatic) | 30 (38%) |
| Distant peripancreatic | 19 (24%) |
| Peripancreatic + distant | 30 (38%) |
| **Infected necrosis (culture positive)** | 30 (36.1%) |
| **Interval between pain and first PCD (days)** | 25.59 ± 21.20 |
| **Mean number of PCD per patient** | 1.77 ± 1.06 |
| **PCD complications** | |
| *Overall* | 34 (40.9%) |
| Secondary infection of collection | 31 (37.5%) |
| External pancreatic fistula | 16 (19.3%) |
| Slippage of PCD | 9 (10.8%) |
| GI bleed | 3 (3.6%) |
| Bowel fistula | 3 (3.6%) |
| **Surgery** | 11 (13.3%) |
| **Mortality** | 31 (37.3%) |

APACHE II: Acute physiology and chronic health evaluation, BISAP: Bedside index of severity in Acute Pancreatitis, CTSI: CT severity index, PCD: percutaneous catheter drain.
[a] Missing data of 4 patients.

CRP before PCD, early versus late PCD, hospital and ICU stay) were comparable among the two groups. On multivariable logistic regression analysis, pancreatic necrosis <50% (OR 8.164, 95% CI 2.112–31.554) and EPI (OR 0.236, 95% CI 0.056–0.990) were independent predictors of PCD outcome (Table 3).

### PCD complications

PCD complications developed in 34 (40.9%) patients. 31 (37.5%) patients developed secondary infection of the collection(s) (Table 1). Other complications were gastrointestinal fistula (3, 3.6%) (1 duodenal and 2 colonic), EPF (16, 19.3%) and minor bleed from the PCD site (3, 3.6%). Patients with EPF underwent ERCP plus pancreatic duct stenting. Transmural plastic stents were placed endoscopically for duodenal fistulae while the patients with colonic fistula required surgical intervention and minor bleeds were managed conservatively.

## Discussion

In this single center, retrospective study, we analysed the successful outcome of PCD in 83 patients of AP having persistent OF who were managed using "step-up" approach. 47 (56.6%) patients had successful outcome with resolution of OF without the need of surgical intervention. On multivariate logistic regression analysis, presence of limited pancreatic necrosis (<50%) and absence of EPI predicted the success of PCD. Other factors including IN, baseline APACHE II and CTSI scores had no effect on the PCD success.

Percutaneous and endoscopic drainage are considered as the initial treatment methods in the step-up approach followed by upgradation to video-assisted retroperitoneal debridement (VARD)/endoscopic necrosectomy and open surgery.[20] However in patients with persistent OF, especially early in the course of the disease, endoscopic procedures are difficult to perform and PCD remains the initial method of choice. Percutaneous approach has shown variable success rates of 33.3%–66.6%.[12,13,20–23] Improvement in patients with pancreatic necrosis/fluid collection after PCD has been explained by multiple mechanisms. In IN, source control via drainage of infected fluid is believed to act as the principal mode of action and catheter drainage of pancreatic enzyme rich necrotic fluid helps by reducing inflammation, and endotoxins are also reduced.[21,24] Studies by Li *et al.*[25] and our group[26] have shown that PCD results in a decrease in inflammatory markers denoting a reduction of inflammatory cytokine drive. We had suggested that PCD results in a possible halt in macrophage stimulation by IL-6 which is followed by a decrease in CRP production.[26] In another study, we showed that PCD lowers intra-abdominal pressure, which reverses the pathophysiology set into motion by elevated intra-abdominal pressure, namely cytokines release, poor abdominal perfusion and secondary infection.[27] Resultantly PCD improves OF in both sterile and infected necrosis. In an earlier study, we had shown equal success of PCD in patients with sterile and infected necrosis.[23]

Most available studies predicting successful outcome of PCD had included both severe and moderately severe acute pancreatitis,[21,22,28] and no data is available when drainage was done primarily for persistent OF. In the current study, we included only severe AP patients where the indication of drainage was persistent OF which had failed to improve with conservative measures and PCD was done irrespective of the presence or absence of IN.

Timing of PCD for pancreatic necrosis has always been controversial, more so in the presence of persistent OF. In the present study, 56 (67.4%) of our patients underwent PCD for persistent OF within 4 weeks of illness. We found no significant

**Table 2** Comparison between successful and failed PCD groups

| Parameter | | PCD success (47) | PCD failure (36) | P value |
|---|---|---|---|---|
| Age (mean ± SD) yrs | | 38.55 ± 11.36 | 37.83 ± 11.10 | 0.797 |
| Gender | Male | 36 (76.6%) | 26 (72.2%) | 0.650 |
| Interval between onset of pain and hospitalization, Mean ± SD | | 20.36 ± 20.82 | 14.03 ± 21.41 | 0.116 |
| Etiology of pancreatitis | Alcohol | 23 (48.9%) | 17 (47.2%) | 0.890 |
| | Gallstone | 15 (31.9%) | 12 (33.3%) | |
| | Both alcohol and gallstone | 3 (6.4%) | 1 (2.8%) | |
| | Others | 6 (12.8%) | 6 (16.7%) | |
| Fever | | 29/39 (74.4%) | 26/34 (76.5%) | 0.835 |
| Comorbidities | | 13 (28.3%) | 11 (30.6%) | 0.821 |
| SIRS (at admission) | | 47 (100%) | 35 (97.2%) | 0.434 |
| BISAP ≥2 | | 41/47 (87.2%) | 32/34 (94.1%) | 0.457 |
| APACHE II score | | 9.40 ± 3.00 | 11.69 ± 4.87 | **0.026** |
| CTSI | | 8.37 ± 2.08 | 9.18 ± 1.48 | **0.046** |
| Pancreatic necrosis | <50% | 26/41 (63.4%) | 9/34 (26.5%) | **0.001** |
| | >50% | 15/41 (36.6%) | 25/34 (73.5%) | |
| Organ failure | Single OF | 35 (74.5%) | 18 (50%) | **0.021** |
| | Multiple OF | 12 (25.5%) | 18 (50%) | |
| | ALI | 43 (91.5%) | 36 (100%) | 0.129 |
| | AKI | 15 (31.9%) | 16 (44.4%) | 0.242 |
| | CVS failure | 9 (19.1%) | 15 (41.7%) | **0.025** |
| Intra-abdominal hypertension | | 18/38 (47.4%) | 20/32 (60.6%) | 0.206 |
| Extra-pancreatic infection | | 6 (12.8%) | 15 (41.7%) | **0.003** |
| Total leucocyte count | | 16,554 ± 7453 | 17,233 ± 9663 | 0.978 |
| CRP before PCD (mg/dL) | | 542.67 ± 567.43 | 569.97 ± 545.38 | 0.871 |
| Procalcitonin (ng/ml) | | 1.41 ± 2.39 | 5.60 ± 15.73 | **0.003** |
| Infected collection (culture positive) | | 10 (21.3%) | 20 (55.6%) | **0.001** |
| PCD parameters | Early PCD (<4weeks) | 28 (59.6%) | 28 (77.8%) | 0.079 |
| | Mean number of PCD | 1.64 ± 0.73 | 1.94 ± 1.37 | 0.489 |
| | Single PCD | 24 (51.1%) | 16 (44.4%) | 0.550 |
| | ≥2PCDs | 23 (48.9%) | 20 (55.6%) | |
| | Upgradation of PCD | 15 (31.9%) | 12 (33.3%) | 0.891 |
| | Duration of PCD (days) | 41.81 ± 36.56 | 28.21 ± 21.23 | 0.074 |
| OF resolution after PCD (days) | | 7.20 ± 4.65 | 12.18 ± 9.17 | 0.087 |
| Hospital stay (days) | | 32.24 ± 19.13 | 33.89 ± 23.57 | 0.902 |
| Duration of ICU stay (days) | | 11.87 ± 8.97 | 19.85 ± 14.12 | **0.011** |
| Duration of mechanical ventilation (days) | | 8.00 ± 2.944 | 13.52 ± 13.81 | 0.842 |

APACHE II: Acute physiology and chronic health evaluation, ALI: acute lung injury, AKI: Acute kidney injury, BISAP: Bedside index of severity in Acute Pancreatitis, CRP: C-reactive protein, CTSI: CT severity index, CVS: cardiovascular system, ICU: Intensive care unit, OF: organ failure, PCD: percutaneous catheter drain, SIRS: Systemic inflammatory response syndrome.
Bold figures had $p < 0.05$.

difference in PCD success with drainage done before or after 4 weeks.Though the current recommendations are to delay the drainage as much as possible for atleast 4 weeks from onset, a number of researchers have shown that patients with persistent OF or IN do benefit from PCD done as early 9–14 days.[11,29,30] We had also shown that outcome and complications of PCD were similar for both acute necrotic collection (ANC) and WON.[23] However, the exact timing of drainage continues to be an unsolved question and the ongoing POINTER trial (ISRCTN 33682933), one Chinese trial (ISRCTN 91106416) and our trial (CTRI/2019/08/020873) on early and aggressive percutaneous drainage may help in answering this question.

**Table 3** Multivariate analysis to identify the predictors for success of PCD

| Variable | Odds ratios | P value | Confidence interval |
|---|---|---|---|
| Pancreatic necrosis <50% | 8.164 | **0.002** | 2.112–31.554 |
| Extrapancreatic infection | 0.236 | **0.048** | 0.056–0.990 |
| APACHE II > 8.5 | 1.206 | 0.794 | 0.295–4.925 |
| Multiple organ failure | 0.645 | 0.520 | 0.170–2.454 |
| Procalcitonin >0.55 ng/mL | 0.319 | 0.093 | 0.084–1.212 |
| CT severity index | 1.051 | 0.788 | 0.732–1.508 |
| Infected necrosis | 0.230 | 0.050 | 0.053–1.001 |

APACHE II: Acute physiology and chronic health evaluation.
Bold figures had p < 0.05.

Predictors of successful outcome of PCD are important so as to identify the subset of patients who will benefit the most from PCD and conversely to identify the group of patients with PCD failure who might require aggressive early step-up management. Various definitions used by different authors to define the success of PCD include survival without the need of surgical necrosectomy,[24] drainage of collection without need for surgery,[31] improvement after initial PCD without need for necrosectomy, major complication or death[25] and clinical deterioration in spite of PCD.[28] In the present study, we defined the success of PCD as resolution of OF with survival and without need for surgical necrosectomy.[24] Some studies found that presence of persistent OF (>48 h) and multiple OF predicted failure of PCD.[21,24] Among imaging variables, higher CTSI score (score >7), higher pancreatic necrosis (>50%), multiple infected collections and presence of heterogeneous collections were found to predict failure of PCD.[21,24] Cao *et al.* showed that volume reduction of collection(s) by >50% of initial size predicted successful outcome with PCD, an observation supported by our previous work.[22,28] In the present study, we identified presence of limited necrosis (<50%) as a positive predictor of PCD success and EPI as a negative predictor of outcome. On univariate analysis, culture positive IN had higher PCD failure rate. Additionally when we analysed our data based on sterile and infected necrosis, the latter had higher PCD failure, need for surgery and mortality (Table 4). However on multivariate analysis, presence of IN was not found to affect the outcome of PCD as has been

**Table 4** Comparison of baseline and outcome parameters between infected and sterile pancreatic necrosis groups

| Parameter | | Infected necrosis (30) | Sterile necrosis (53) | P value |
|---|---|---|---|---|
| Age (mean ± SD) yrs | | 37.1 ± 12.67 | 38.89 ± 12.55 | 0.536 |
| Gender | Male | 24 (80%) | 38 (71.1%) | 0.403 |
| Interval between onset of pain and hospitalization, Mean ± SD | | 19.7 ± 25.18 | 16.43 ± 18.71 | 0.249 |
| Fever | | 23/28 (82.1%) | 32/45 (71.1%) | 0.288 |
| Comorbidities | | 9 (30%) | 15 (28.8%) | 0.912 |
| SIRS (at admission) | | 30 (100%) | 53 (98.1%) | 1 |
| BISAP ≥2 | | 28/29 (96.6%) | 45/52 (86.5%) | 0.248 |
| APACHE II score | | 11.47 ± 4.70 | 9.79 ± 3.55 | 0.071 |
| CTSI | | 9.72 ± 0.88 | 8.13 ± 2.059 | **<0.001** |
| Pancreatic necrosis | <50% | 14/29 (48.3%) | 21/46 (45.7%) | 0.824 |
| | >50% | 15/29 (51.7%) | 25/46 (54.3%) | |
| Organ failure | Single OF | 18 (60%) | 35 (66%) | 0.582 |
| | Multiple OF | 12 (40%) | 18 (34%) | |
| | ALI | 30 (100%) | 49 (92.5%) | 0.291 |
| | AKI | 12 (40%) | 19 (35.8%) | 0.707 |
| | CVS failure | 9 (30%) | 15 (28.3%) | 0.870 |
| IAH | | 12/22 (54.5%) | 26/48 (54.2%) | 0.976 |
| Extra-pancreatic infection | | 14 (46.7%) | 7 (13.2%) | **0.001** |
| Total leucocyte counts | | 17,766 ± 10,027 | 16,325 ± 7438 | 0.634 |
| CRP before PCD (mg/dL) | | 546.87 ± 556.89 | 557.66 ± 559.02 | 0.905 |
| Procalcitonin (ng/ml) | | 6.13 ± 17.21 | 1.58 ± 2.39 | 0.242 |
| PCD parameters | Single PCD | 13 (43.3%) | 27 (50.9%) | 0.505 |
| | ≥2PCDs | 17 (56.7%) | 26 (49.1%) | |
| | Upgradation of PCD/s | 14 (46.7%) | 13 (24.5%) | **0.039** |
| | Duration of PCD (days) | 37.8 ± 39.61 | 34.84 ± 26.67 | 0.787 |

(*continued on next page*)

Table 4 (*continued*)

| Parameter | Infected necrosis (30) | Sterile necrosis (53) | P value |
|---|---|---|---|
| OF resolution after PCD/s (days) | 11.83 ± 8.38 | 7.18 ± 4.93 | 0.052 |
| Hospital stay (days) | 41.21 ± 28.47 | 28.38 ± 13.86 | 0.087 |
| Duration of ICU stay (days) | 18.58 ± 14.68 | 14.42 ± 10.74 | 0.270 |
| PCD success | 10 (33.3%) | 37 (63.9%) | **0.001** |
| Surgery | 8 (26.7%) | 3 (5.7%) | **0.015** |
| Mortality | 17 (56.7%) | 14 (26.4%) | **0.006** |

APACHE II: Acute physiology and chronic health evaluation, ALI: acute lung injury, AKI: Acute kidney injury, BISAP: Bedside index of severity in Acute Pancreatitis, CRP: C-reactive protein, CTSI: CT severity index, CVS: cardiovascular system, ICU: Intensive care unit, OF: organ failure, PCD: percutaneous catheter drain, SIRS: Systemic inflammatory response syndrome.
Bold figures had $p < 0.05$.

observed by the others too[5,32] Recent studies have also identified OF as the single most important predictor and noted no increased mortality in patients with combined OF and IN compared to only OF.[5,32]

We noted acceptable rates of complications of PCD, in line with result of other studies.[22,33,34] PCD slipped in 10.8% of our patients requiring catheter reinsertion. EPF, bleeding and fistula formation were observed in 19.3%, 3.6% and 3.6% of patients respectively and none of such patients had mortality due to the complication. Reinfection of the fluid collection was noted in 37.5% of patients following PCD and was not different for sterile and infected collections. This reinfection rate is in agreement with the available literature.[22,33] The possible risk of increased mortality after secondary infection following PCD for sterile fluid collections is no doubt a major concern. However, limited data available from two studies by Wang *et al.*[33] and Walser *et al.*[35] shows that PCD in patients with sterile necrosis is not associated with increased mortality. The presence of sparse data on secondary infection after PCD in sterile collections provides an opportunity for conducting an RCT to evaluate benefits of PCD in sterile collections and to assess its harms compared to conservative management.

The retrospective design was an important limitation of our study although the data were recorded prospectively. Due to the retrospective nature, some data were not retrievable i.e. number and sites of collections, solid component in collections and pre and post-PCD volume of collections, and could not be analysed. Also, our center is a high volume, referral center and the availability of experienced interventional radiologists at our center may not be ensured at lower volume centers. We also did not have details of antibiotics used before referral in some of the patients. This might overestimate the number of sterile collections and the effect of infected necrosis on PCD success or mortality may not be truly representative. Despite these limitations, the study for the first time has looked at predictors of success of PCD in patients with persistent OF managed with percutaneous step-up approach in a prospective manner. In the present study, the timing of PCD was also decided by the clinical need, which is at odds with the current recommendation of delayed drainage.

In conclusion the data from our study suggest that PCD improves the outcome of patients with OF, irrespective of status of infection and even when done early. Therefore, it is suggested that PCD may be considered early in the course of the disease in patients with predicted severe AP even in the absence of overt infection.

## Authors' contribution

**AKS:** Study design, acquisition and analysis of data, initial draft of the manuscript and approval to final version.

**JS:** Interpretation of data, critical revision of manuscript and approval to final version.

**AG:** Study design, acquisition of data, critical revision of manuscript and approval to final version.

**VGa:** Study design, acquisition of data, critical revision of manuscript and approval to final version.

**AB:** Study design, acquisition of data, critical revision of manuscript and approval to final version.

**PG:** Study design, radiological interventions and approval of final version.

**VGu:** Analysis and interpretation of data, critical revision of manuscript and approval to final version.

**TDY:** Analysis and interpretation of data, critical revision of manuscript and approval to final version.

**SKS:** Conception and design of study, critical revision of manuscript and approval to final version.

**RK:** Conception and design of study, analysis and interpretation of data, critical revision of manuscript and approval to final version.

## Guarantor of the article

Rakesh Kochhar.

**Acknowledgement**
None.

**Financial support**
None.

**Conflict of interest**
None declared.

**References**

1. Shaheen NJ, Hansen RA, Morgan DR, Gangarosa LM, Ringel Y, Thiny MT *et al*. (2006 Sep) The burden of gastrointestinal and liver diseases, 2006. *Am J Gastroenterol* 101:2128–2138.
2. Banks PA, Freeman ML. (2006 Oct) Practice parameters committee of the American college of Gastroenterology. Practice guidelines in acute pancreatitis. *Am J Gastroenterol* 101:2379–2400.
3. Rau B, Uhl W, Buchler MW, Beger HG. (1997 Feb) Surgical treatment of infected necrosis. *World J Surg* 21:155–161.
4. Tsiotos GG, Luque-de León E, Sarr MG. (1998 Dec) Long-term outcome of necrotizing pancreatitis treated by necrosectomy. *Br J Surg* 85: 1650–1653.
5. Schepers NJ, Bakker OJ, Besselink MG, Ahmed Ali U, Bollen TL, Gooszen HG *et al*. (2019 Jun) Impact of characteristics of organ failure and infected necrosis on mortality in necrotising pancreatitis. *Gut* 68: 1044–1051.
6. Padhan RK, Jain S, Agarwal S, Harikrishnan S, Vadiraja P, Behera S *et al*. (2018 Mar) Primary and secondary organ failures cause mortality differentially in acute pancreatitis and should be distinguished. *Pancreas* 47:302–307.
7. Thandassery RB, Yadav TD, Dutta U, Appasani S, Singh K, Kochhar R. (2013 Jul) Dynamic nature of organ failure in severe acute pancreatitis: the impact of persistent and deteriorating organ failure. *HPB* 15:523–528.
8. Petrov MS, Shanbhag S, Chakraborty M, Phillips AR, Windsor JA. (2010 Sep) Organ failure and infection of pancreatic necrosis as determinants of mortality in patients with acute pancreatitis. *Gastroenterology* 139: 813–820.
9. Besselink MG, van Santvoort HC, Boermeester MA, Nieuwenhuijs VB, van Goor H, Dejong CH *et al*. (2009 Mar) Timing and impact of infections in acute pancreatitis. *Br J Surg* 96:267–273.
10. Werge M, Novovic S, Schmidt PN, Gluud LL. (2016 Sep-Oct) Infection increases mortality in necrotizing pancreatitis: a systematic review and meta-analysis. *Pancreatology* 16:698–707.
11. Freeny PC, Hauptmann E, Althaus SJ, Traverso LW, Sinanan M. (1998 Apr) Percutaneous CT-guided catheter drainage of infected acute necrotizing pancreatitis: techniques and results. *AJR Am J Roentgenol* 170:969–975.
12. Mouli VP, Sreenivas V, Garg PK. (2013 Feb) Efficacy of conservative treatment, without necrosectomy, for infected pancreatic necrosis: a systematic review and meta-analysis. *Gastroenterology* 144:333–340.
13. van Baal MC, van Santvoort HC, Bollen TL, Bakker OJ, Besselink MG, Gooszen HG *et al*. (2011 Jan) Systematic review of percutaneous catheter drainage as primary treatment for necrotizing pancreatitis. *Br J Surg* 98:18–27.
14. Baudin G, Chassang M, Gelsi E, Novellas S, Bernardin G, Hébuterne X *et al*. (2012 Jul) CT-guided percutaneous catheter drainage of acute infectious necrotizing pancreatitis: assessment of effectiveness and safety. *AJR Am J Roentgenol* 199:192–199.
15. Freeman ML, Werner J, van Santvoort HC, Baron TH, Besselink MG, Windsor JA *et al*. (2012 Nov) Interventions for necrotizing pancreatitis: summary of a multidisciplinary consensus conference. *Pancreas* 41: 1176–1194.
16. Leppäniemi A, Tolonen M, Tarasconi A, Segovia-Lohse H, Gamberini E, Kirkpatrick AW *et al*. (2019 Jun 13) 2019 WSES guidelines for the management of severe acute pancreatitis. *World J Emerg Surg* 14:27.
17. Trikudanathan G, Wolbrink DRJ, van Santvoort HC, Mallery S, Freeman M, Besselink MG. (2019 May) Current concepts in severe acute and necrotizing pancreatitis: an evidence-based approach. *Gastroenterology* 156:1994–2007.
18. Banks PA, Bollen TL, Dervenis C, Gooszen HG, Johnson CD, Sarr MG *et al*. (2013) Classification of acute pancreatitis-2012: revision of the Atlanta classification and definitions by international consensus. *Gut* 62: 102–111.
19. Marshall JC, Cook DJ, Christou NV, Bernard GR, Sprung CL, Sibbald WJ. (1995 Oct) Multiple organ dysfunction score: a reliable descriptor of a complex clinical outcome. *Crit Care Med* 23:1638–1652.
20. van Brunschot S, van Grinsven J, van Santvoort HC, Bakker OJ, Besselink MG, Boermeester MA *et al*. (2018 Jan 6) Endoscopic or surgical step-up approach for infected necrotising pancreatitis: a multicentre randomised trial. *Lancet* 391:51–58.
21. Li A, Cao F, Li J, Fang Y, Wang X, Liu DG *et al*. (2016 Jul-Aug) Step-up mini-invasive surgery for infected pancreatic necrosis: results from prospective cohort study. *Pancreatology* 16:508–514.
22. Bellam BL, Samanta J, Gupta P, Kumar MP, Sharma V, Dhaka N *et al*. (2019 Jul) Predictors of outcome of percutaneous catheter drainage in patients with acute pancreatitis having acute fluid collection and development of a predictive model. *Pancreatology* 19:658–664.
23. Mallick B, Dhaka N, Gupta P, Gulati A, Malik S, Sinha SK *et al*. (2018 Oct) An audit of percutaneous drainage for acute necrotic collections and walled off necrosis in patients with acute pancreatitis. *Pancreatology* 18:727–733.
24. Hollemans RA, Bollen TL, van Brunschot S, Bakker OJ, Ahmed Ali U, van Goor H *et al*. (2016 Apr) Predicting success of catheter drainage in infected necrotizing pancreatitis. *Ann Surg* 263:787–792.
25. Liu WH, Wang T, Yan HT, Chen T, Xu C, Ye P *et al*. (2015 Feb 6) Predictors of percutaneous catheter drainage (PCD) after abdominal paracentesis drainage (APD) in patients with moderately severe or severe acute pancreatitis along with fluid collections. *PloS One* 10e0115348.
26. Mallick B, Tomer S, Arora SK, Lal A, Dhaka N, Samanta J *et al*. (2019 Mar 12) Change in serum levels of inflammatory markers reflects response of percutaneous catheter drainage in symptomatic fluid collections in patients with acute pancreatitis. *JGH Open* 3:295–301.
27. Singh AK, Samanta J, Dawra S, Gupta P, Rana A, Sharma V *et al*. (2020 Jun) Reduction of intra-abdominal pressure after percutaneous catheter drainage of pancreatic fluid collection predicts survival. *Pancreatology* 20:772–777.
28. Cao X, Cao F, Li A, Gao X, Wang XH, Liu DG *et al*. (2017 Nov) Predictive factors of pancreatic necrosectomy following percutaneous catheter drainage as a primary treatment of patients with infected necrotizing pancreatitis. *Exp Ther Med* 14:4397–4404.
29. Mukund A, Singla N, Bhatia V, Arora A, Patidar Y, Sarin SK. (2019 Dec) Safety and efficacy of early image-guided percutaneous interventions in acute severe necrotizing pancreatitis: a single-center retrospective study. *Indian J Gastroenterol* 38:480–487.

**30.** Mortelé KJ, Girshman J, Szejnfeld D, Ashley SW, Erturk SM, Banks PA *et al*. (2009 Jan) CT-guided percutaneous catheter drainage of acute necrotizing pancreatitis: clinical experience and observations in patients with sterile and infected necrosis. *AJR Am J Roentgenol* 192:110–116.

**31.** Horvath K, Freeny P, Escallon J, Heagerty P, Comstock B, Glickerman DJ *et al*. (2010 Sep) Safety and efficacy of video-assisted retroperitoneal debridement for infected pancreatic collections: a multicenter, prospective, single-arm phase 2 study. *Arch Surg* 145: 817–825.

**32.** Shi N, Liu T, de la Iglesia-Garcia D, Deng L, Jin T, Lan L *et al*. (2020) Duration of organ failure impacts mortality in acute pancreatitis. *Gut* 69: 604–605.

**33.** Walser EM, Nealon WH, Marroquin S, Raza S, Hernandez JA, Vasek J. (2006 Jan-Feb) Sterile fluid collections in acute pancreatitis: catheter drainage versus simple aspiration. *Cardiovasc Intervent Radiol* 29: 102–107.

**34.** van Santvoort HC, Besselink MG, Bakker OJ, Hofker HS, Boermeester MA, Dejong CH *et al*. (2010 Apr 22) A step-up approach or open necrosectomy for necrotizing pancreatitis. *N Engl J Med* 362: 1491–1502.

**35.** Wang T, Liu LY, Luo H, Dai RW, Liang HY, Chen T *et al*. (2016 Jan) Intra-abdominal pressure reduction after percutaneous catheter drainage is a protective factor for severe pancreatitis patients with sterile fluid collections. *Pancreas* 45:127–133.