© Pol J Radiol 2021; 86: e359-e365
DOI: https://doi.org/10.5114/pjr.2021.107448

Received: 20.09.2020
Accepted: 23.11.2020
Published: 15.06.2021

Polish Journal of Radiology

http://www.polradiol.com

Original paper

The effectiveness of image-guided percutaneous catheter drainage in the management of acute pancreatitis-associated pancreatic collections

Kifayat H. Ganaie[A,B,C,D,E,F], Naseer A. Choh[A,B,C,D,E,F], Arshed H. Parry[A,B,C,D,E,F], Feroze A. Shaheen[A,B,C,D,E,F], Irfan Robbani[A,B,C,D,E,F], Tariq A. Gojwari[A,B,C,D,E,F], Manjeet Singh[A,B,C,D,E,F], Omar J. Shah[A,B,C,D,E,F]

Sher-i-Kashmir Institute of Medical Sciences, Srinagar, Jammu and Kashmir, India

Abstract

Purpose: Acute pancreatitis is commonly complicated by the development of pancreatic collections (PCs). Symptomatic PCs warrant drainage, and the available options include percutaneous, endoscopic, and open surgical approaches. The study aimed to assess the therapeutic effectiveness and safety of image guided percutaneous catheter drainage (PCD) in the management of acute pancreatitis related PCs.

Material and methods: This was a single-centre prospective study covering a 4-year study period. Acute pancreatitis-related PCs complicated by secondary infection or those producing symptoms due to pressure effect on surrounding structures were enrolled and underwent ultrasound or computed tomography (CT)-guided PCD. The patients were followed to assess the success of PCD (defined as clinical, radiological improvement, and the avoidance of surgery) and any PCD-related complications.

Results: The study included 60 patients (60% males) with a mean age of 43.1 ± 21.2 years. PCD recorded a success rate of 80% (16/20) for acute peripancreatic fluid collections (APFC) and pancreatic pseudocysts (PPs), 75% (12/16) for walled-off necrosis (WON), and 50% (12/24) for acute necrotic collections (ANCs). Post-PCD surgery (necrosectomy ± distal pancreatectomy) was needed in 50% of ANC and 25% of WON. Only 20% of APFCs/PPs patients required surgical/endoscopic treatment post-PCD. Minor procedure-related complications were seen in 4 (6.6%) patients.

Conclusion: PCD is an effective, safe, and minimally invasive therapeutic modality with a good success rate in the management of infected/symptomatic PCs.

Key words: pseudocyst, percutaneous catheter drainage, acute necrotic collection, walled-off necrosis, pancreatic collections.

Introduction

Acute pancreatitis refers to an acute inflammatory disease of the pancreas with or without peri-pancreatic tissue involvement and constitutes one of the commonest causes of hospital admissions for gastrointestinal emergencies [1]. Acute pancreatitis is divided into 2 types based on the presence or absence of pancreatic or peripancreatic necrosis into interstitial oedematous pancreatitis and acute necrotizing pancreatitis. Necrotic pancreatitis typically presents with pancreatic parenchymal necrosis and is usually accompanied with peripancreatic fat necrosis. Less commonly there will be isolated extra pancreatic fat necrosis without pancreatic parenchymal necrosis [2,3].

Acute pancreatitis is frequently complicated by the development of pancreatic collections (PCs). To establish

Correspondence address:
Arshed H. Parry, Sher-i-Kashmir Institute of Medical Sciences, Srinagar, Jammu and Kashmir, India, e-mail: arshedparry@gmail.com

Authors' contribution:
A Study design · **B** Data collection · **C** Statistical analysis · **D** Data interpretation · **E** Manuscript preparation · **F** Literature search · **G** Funds collection

a proper nomenclature in order to guide management, the 2012 revised Atlanta classification [4] classified PCs into 4 categories on the basis of content and duration of the collections. Collections of less than 4 weeks duration do not have a well-defined wall and are subdivided into acute peripancreatic fluid collections (APFC) and acute necrotic collections (ANC). APFC is a homogeneous fluid collection containing enzyme rich fluid contents with no necrotic material inside and is not surrounded by a well-defined wall, whereas ANC is a fluid collection with necrotic debris inside without a well-defined wall. Collections persisting beyond 4 weeks are divided into pancreatic pseudocyst (PP) and walled-off necrosis (WON). PP is defined as a homogenous fluid collection with a well-defined wall with no necrotic tissue in the collection, whereas a walled-off fluid collection with necrotic debris inside persisting >4 weeks is defined as WON. So, APFC and PP strictly consist of enzyme rich fluid without necrotic debris and thus will never develop in the setting of necrotizing pancreatitis. APFC and PP may arise as a result of fluid exudation secondary to pancreatic inflammation or may be associated with disruption of the main pancreatic duct or one of the side branches of the pancreatic duct [5,6].

ANC and WON develop in necrotizing pancreatitis, and these collections are composed of a mixture of enzyme rich fluid and necrotic material. With time (2-6 weeks after onset of pancreatitis), necrotic pancreatic/peripancreatic tissue begins to liquefy and becomes walled off. This walled-off, mature, and clearly demarcated ANC is called WON.

Pancreatic or peripancreatic necrosis typically develops after a delay of 3-5 days after the onset of pancreatitis and thus imaging performed early (< 72 hours) will underestimate the extent of necrosis [7]. Collections with necrotic debris (ANC, WON) usually have a heterogeneous appearance on contrast-enhanced computed tomography (CT) or magnetic resonance imaging (MRI). However, during the initial 1-2 weeks it may not be possible to confidently distinguish APFC from ANC on imaging [8,9].

Better understanding of the pathophysiology and natural course of pancreatitis along with the progress made in endoscopic and percutaneous interventional armamentarium and techniques has led to a paradigm shift in the management of PCs. It was the landmark study of the PANTER trial by the Dutch pancreatitis group [10] that showed that a minimally invasive approach is preferable over surgical open necrosectomy and led to minimally invasive interventions being increasingly used for the management of PCs.

The indication for drainage of PCs has evolved over the years. Not all PCs need drainage. Current guidelines recommend drainage in PCs when they are infected or in case of symptomatic fluid collections [2].

The present study aimed to evaluate the therapeutic effectiveness and safety of image-guided percutaneous catheter drainage (PCD) of PCs.

Material and methods

Study design

This was a single-centre prospective study covering a 4-year study period from August 2015 to September 2019. The study was approved by the Institutional Review Board and was conducted in accordance with the principles of the Declaration of Helsinki. In all cases informed consent was obtained from the patient or his/her attendant before the procedure.

Study population

Sixty patients with acute pancreatitis complicated by the formation of PCs were enrolled in the study. Patients with either of the following 2 conditions were included in the study.

Contrast CT-documented pancreatic necrosis with clinical suspicion of infection suggested by persistence of fever (especially after the first week), persistently elevated white blood cell (WBC) count or C-reactive protein (CRP), persistent sepsis, or deteriorating clinical status or positive blood cultures were considered for drainage of PCs. Unlike some earlier studies that used percutaneous fine needle aspiration to confirm infection in a collection before drainage, we did not resort to this practice, because the use of this practice is still widely debated due to having both advantages and disadvantages.

PCs that were symptomatic due to a pressure effect on surrounding organs (e.g. associated with pressure symptoms like biliary obstruction, gastric outlet, duodenal obstruction, and intractable pain).

All the subjects satisfying the inclusion criteria were carefully worked up in terms of detailed history and clinical examination. Laboratory investigations including complete blood count, prothrombin time, international normalized ratio (INR), and serum amylase/lipase were collected. Baseline imaging including ultrasonography and contrast-enhanced CT was reviewed. Coagulation parameters were checked in all patients before the scheduled procedure to rule out any bleeding disorder. Patients with evidence of coagulopathy received appropriate blood products for correction to acceptable levels of coagulation parameters before undergoing PCD.

Percutaneous catheter drainage

All patients were initially assessed with ultrasound in the procedure room to decide on the modality of image guidance to be used. Collections that were large or close to the parietal wall with no intervening bowel were selected for ultrasound-guided drainage. However, collections that did not have a feasible approach on ultrasound were drained under CT guidance.

The percutaneous treatment procedures were performed on an Aloka Prosound SSD-3500SX USG (Hitachi,

Japan) with 3.5-5 MHz and 7.5 MHz probes in 10 (16.6%) patients in whom large collections close to the parietal wall were seen, and on 16/64 multidetector-row CT scan (Siemens, Somatom Sensation Erlangen, Germany) in 50 (83.4%) patients.

The procedures were performed in strict sterile conditions under local anaesthesia and light sedation. The procedures were performed by a trained interventional radiologist assisted by residents. Access routes were determined by the preliminary imaging, and patients were positioned on the table to allow easy and safe access into the collection. For example, a left anterior pararenal approach was used for collections in the pancreatic tail region and through the gastrocolic ligament for those in the pancreatic head and body. Depending on the location of the collection, other routes, like transgastric route or right pararenal space or transmesocolic routes, were used to gain access to the collection to avoid the intervening bowel and solid organs. The Seldinger technique, consisting of a stepwise approach of needle placement followed by the placement of a 0.038-inch angled-tip stiff guidewire (Amplatz stiff guidewire) into the collection, was employed. The tract was sequentially dilated over the guidewire using fascial dilators. One or more catheters (depending on the size, number, and intercommunication between adjacent collections) ranging in size from 8-18 French (Pigtail or Malecot catheters) were placed in the collections. In patients with thick and viscous collections and necrosis the initially placed catheters of smaller size (e.g. 12 F) were up-sized after 2-3 days to a larger size (e.g. 16 F) after securing the track with a stiff guidewire. Active aspiration and intermittent saline irrigation of the catheters were performed in the ward or intensive care unit where the patient was admitted. The drained collections were sent for Gram staining and culture examination. Total and differential leukocyte counts and amylase levels were also determined.

Endpoints for catheter removal included no further drainage, and no recurrence at follow-up imaging after the catheter was clamped for 2-3 days.

Follow-up

All the patients were followed up to assess the time needed for clinical improvement, avoidance of surgery, length of hospital stay, and development of hospital complications. Inspection of the catheter entry site, evaluation of catheter output, and assessment of the clinical response to drainage were all important aspects of follow-up care in these patients. Serial imaging was performed continuously during hospital stay and imaging follow-up was continued for an average of 63.2 ± 27 days post-hospital discharge. Imaging follow-up was performed by USG in all cases, and in some it was supplemented by CT or MRI. The percutaneous catheter drainage was considered successful if all the following criteria were met:

- the patients improved clinically (subsidence of fever, local signs and symptoms, and normalization of elevated counts and CRP levels),
- serial imaging showed resolution of collections,
- no evidence of relapse or recurrence of collections seen during follow-up imaging performed after discharge from the hospital (average of 63.2 ± 27 days post-hospital discharge),
- avoidance of surgery for PC.

Statistical analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, version 21.0). Continuous variables were expressed as means and standard deviations. Categorical variables were expressed as counts and percentages.

Results

A total of 60 patients, consisting of consisting of 36 (60%) males and 24 (40%) females, were enrolled in the study. The mean age of the patients was 43.1 ± 21.2 years. Gallstones (30; 50%) were the commonest cause of pancreatitis followed by idiopathic (10; 16.7%) and alcohol (10; 16.7%). In 10 (16.7%) patients other causes including ERCP, trauma, hyperlipidaemia, hypercalcaemia, and anatomical causes were identified.

Indication for percutaneous catheter drainage and the type of pancreatic collection drained

The dominant clinical indication for PCD was uncontrolled sepsis (38/60; 63.33%) followed by pressure symptoms like intractable pain, jaundice, breathlessness, gastric outlet obstruction (14/60; 23.33%), and clinical deterioration (persistent organ failure) refractory to medical treatment (8/60; 13.33%).

ANC was the most common type of PC, seen in 24 (40%) patients. WON was seen in 16 (26.7%) patients, whereas APFC was seen in 6 (10%), and PP accounted for 14 (23.3%) patients.

A total of 102 catheters were used in 60 patients. A single catheter was used in 8/24 (33.3%) of ANC, 10/16 (62.5%) of WON, and 18/20 (90%) of APFC/PPs. A majority of the patients with ANC (16/24; 66.7%) and WON (6/16; 37.5%) required up-sizing of catheters. However, only 2 (10%) patients in the APFC/PP group required up-sizing of the catheter (Table 1). Catheters of various sizes were used for PCD of PCs, ranging in size from 8F to 18F (Table 2).

Table 3 summarizes the number of days the catheters were in place in different PCs. We had 6 patients of APFC and 14 patients with pseudocysts; however, for the sake of convenience we grouped them together because both were managed with similar number and calibre of catheters and with similar indwelling time of catheters.

Table 1. Number of catheters used per patient for the drainage of pancreatic collections

No. of catheters used	ANC	WON	APFC/PP
1	8	8	18
2	4	4	2
3	12	4	–
Mean	2.16	1.75	1.1

ANC – acute necrotic collection, WON – walled-off necrosis, APFC – acute pancreatic fluid collection, PP – pseudocyst

Table 2. Size of catheter (initial and up-sized) used for percutaneous catheter drainage of pancreatic collections

Catheter size	ANC	WON	APFC/PP
8F	–	–	6
10F	10	6	10
12F	16	12	4
14F	16	8	2
16F	6	2	–
18F	4	–	–

ANC – acute necrotic collection, WON – walled-off necrosis, APFC – acute pancreatic fluid collection, PP – pseudocyst

Table 3. Total number of days for which the catheter remained in-situ

No. of days the catheter remained in-situ	ANC	WON	APFC/PP
< 10	–	–	–
10-20	–	4 (25%)	12 (60%)
21-30	–	8 (50%)	6 (30%)
31-40	10 (41.7%)	–	2 (10%)
41-50	6 (25%)	4 (25%)	–
51-60	4 (16.7%)	–	–
61-70	4 (16.7%)	–	–
Mean (days)	46.8	28.5	21

ANC – acute necrotic collection, WON – walled-off necrosis, APFC – acute pancreatic fluid collection, PP – pseudocyst

Table 4. Outcome of percutaneous catheter drainage (PCD) and need for post-PCD surgery

	Recovered with PCD alone	Needed surgery post PCD
ANC	12 (50%)	12 (50%)
WON	12 (75%)	4 (25%)
APFC/PP	16 (80%)	4 (20%)
Total	40 (66.7%)	20 (33.3%)

ANC – acute necrotic collection, WON – walled-off necrosis, APFC – acute pancreatic fluid collection, PP – pseudocyst

Clinical and radiological improvement was achieved in the majority of patients with APFCs/PP (80%). However, in ANC only 50% of the patients showed recovery with PCD alone and the remaining 50% required surgery in the form of necrosectomy or necrosectomy with distal pancreatectomy (Figures 1-3). One patient among the 12 requiring post-PCD surgery expired. In WON 62.5% of patients recovered with PCD alone and 37.5% required surgery (Table 4). Clinical improvement was defined as subsidence of fever, local signs, and symptoms and normalization of elevated counts, and radiological improvement was defined as resolution of collection on serial imaging. Microbiological examination of drained fluid revealed infection in 26 (43.3%) patients.

Out of the 60 patients who were included in the study, 3 (5%) developed minor complications in the form of clogging and slippage of catheter, and 1 patient had minor bleeding, which settled spontaneously. None of the patients developed external pancreatic fistula.

Discussion

Acute pancreatitis is an unpredictable disease accompanied by numerous local and systemic complications, with a varying clinical course. Management includes mainly supportive measures with intervention required only for local complications. Interventional radiology has an important role to play in the management of local complications of PCs, which can occur at varying times throughout the course of acute pancreatitis [1,2].

The present study evaluated 60 patients of acute pancreatitis complicated by the development of PCs, to evaluate the therapeutic effectiveness of PCD in their management and avoidance of surgery.

APFC and PP, although common complications of pancreatitis, are less commonly referred for PCD because most of them resolve spontaneously without treatment, are less liable to become infected, and are managed conservatively with intervention required only in larger symptomatic cases. On the other hand, patients with ANC and WON have serious illness with associated organ failure and hence are frequently referred for PCD [11,12].

The size of catheter, number of catheters per patient, and up-sizing of catheters depended on the nature of the collection and number of collections per patient. Large catheters and higher number of catheters (mean 2.16) per patient were used in cases of ANC followed by WON (mean number 1.75).

The larger catheter size and frequent up-sizing of catheters in ANC and WON was due to their thick and highly viscous nature and associated solid components in necrotic collections, which made drainage of contents difficult. Multiple catheters per patient were used in the case of ANC and WON because most of these patients had more than one collection at the time of PCD.

Van Baal *et al.* [13] in a systematic review found that PCD is an effective modality in the management of acute necrotic pancreatitis-related collections and helps in the avoidance of surgery in approximately 55.7% of patients.

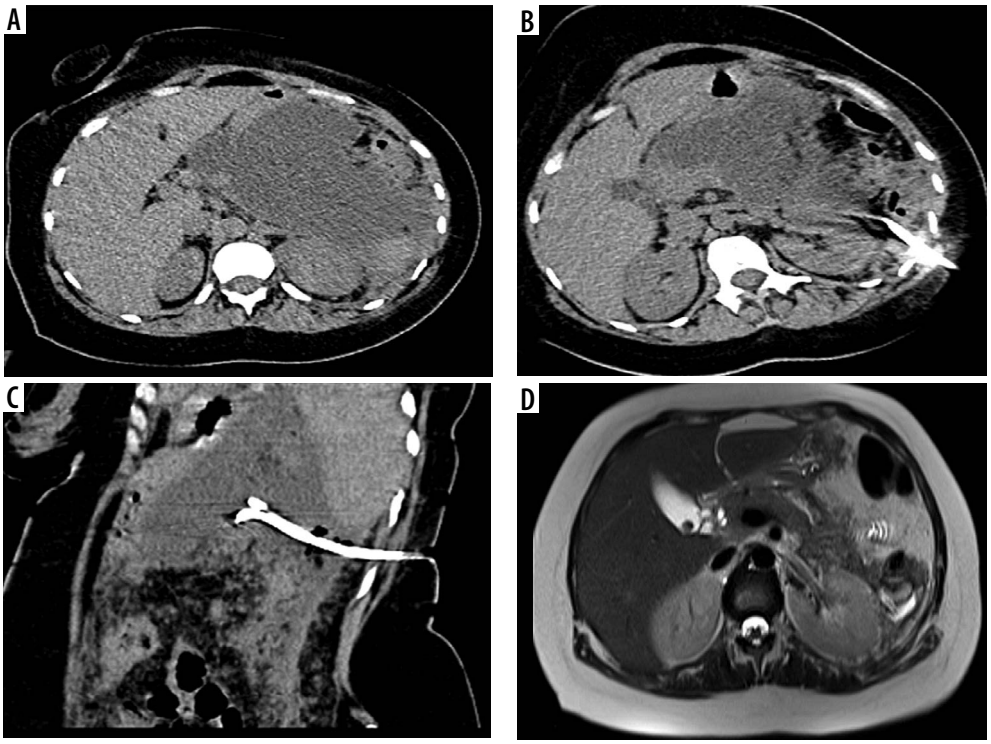

Figure 1. Non-contrast axial computed tomography (CT) image (**A**) through the upper abdomen showing a large peripancreatic acute necrotic collections in a 46-year old female patient of gallstone induced severe acute pancreatitis. Axial (**B**) and sagittal reformatted (**C**) CT images show a pigtail catheter placed within the collection. Follow-up axial magnetic resonance image (**D**) shows complete resolution of the collection

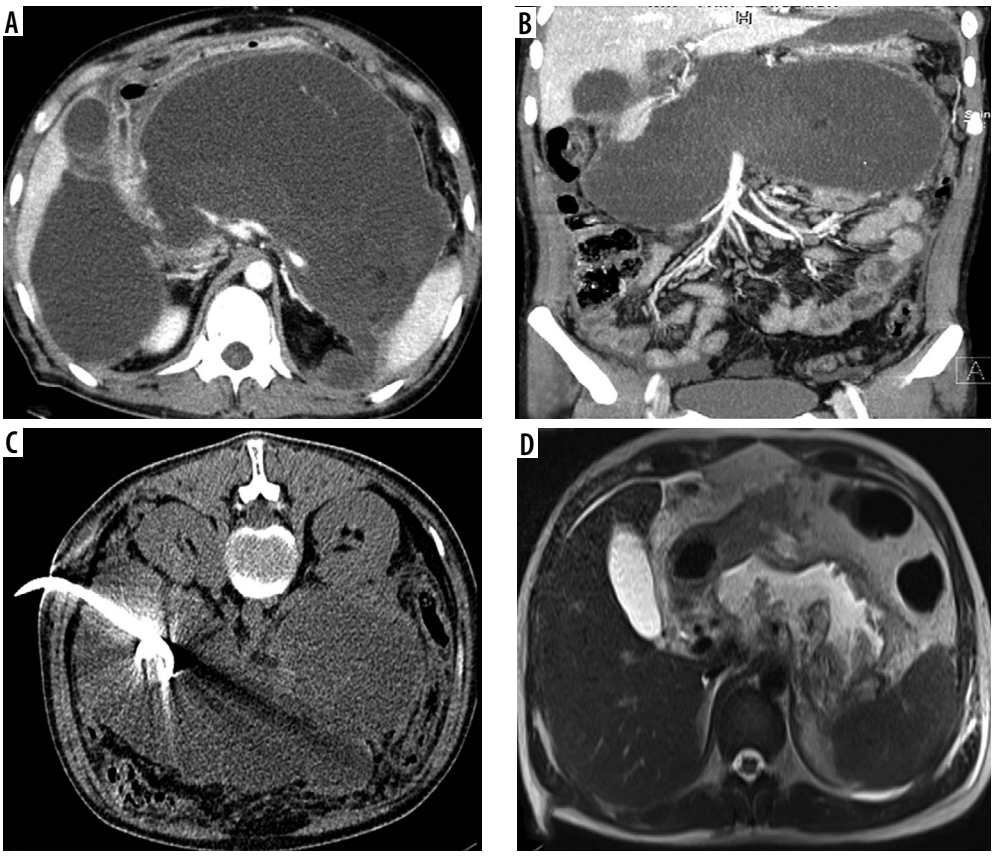

Figure 2. Axial and coronal reformatted contrast-enhanced computed tomography (CT) images (**A, B**) of abdomen reveal a large pancreatic and peripancreatic acute necrotic collections with non-enhancement of almost whole of pancreas. Axial non-contrast CT image in prone position (**C**) acquired during catheter placement shows a pigtail catheter in-situ. Follow-up axial magnetic resonance image (**D**) of abdomen shows partial resolution of collection

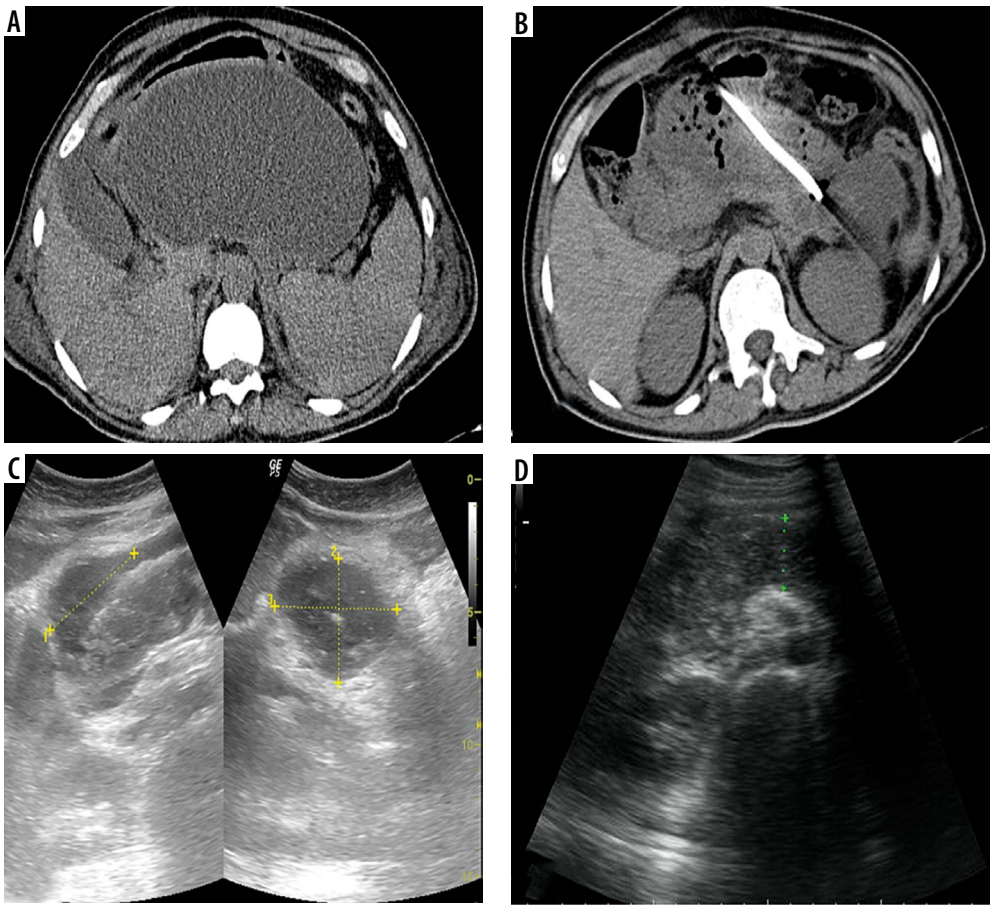

Figure 3. Axial non-contrast computed tomography (CT) image (**A**) of upper abdomen reveals a large pancreatic/peripancreatic acute necrotic collections with a pigtail catheter placed within the collection (**B**). First follow-up USG (**C**) shows reduction in the size of collection and second follow-up USG (**D**) shows complete resolution of collection

In our study PCD of acute necrotic pancreatitis-related collections could avoid surgery in 60% of patients and 40% needed post-PCD surgery.

In a study by Wig *et al.* [14] use of percutaneous catheter drainage helped avoid or delay surgery in two-fifths of the patients with severe acute pancreatitis.

Freeny *et al.* [11] reported that 16 (47%) out of 34 patients with infected pancreatic necrosis were cured with only percutaneous catheter drainage, and in an additional 9 (26.4%) sepsis was controlled, allowing elective surgery later on.

In another study to evaluate the effectiveness of PCD in infectious necrotizing pancreatitis Baudin *et al.* [13] reported clinical success in 64.6% of patients.

Mehta *et al.* [15] also reported a success rate of 45% for PCD in pancreatitis-associated ANCs, of which the majority (80%) were un-infected.

The famous randomized controlled PANTER trial in 2010 reported that a minimally invasive step-up approach improved the short-term survival and reduced short-term morbidity and mortality in infected acute necrotizing pancreatitis with 35% patients successfully treated with PCD only [10]. The same group of 73 patients as originally enrolled in the PANTER trial were followed up for a mean period of 7 years and 2 months, and it was found that minimally invasive PCD was superior to open surgical necrosectomy in the long run in terms of more deaths in the surgical group, more frequent incisional hernias, and pancreatic exocrine and endocrine insufficiency in the open necrosectomy group compared to the PCD group (all p-values < 0.05) [16].

In our study, a cumulative 66.7% of patients with PCs recovered with PCD alone and did not need any further surgical intervention. This included a success rate of 50% in case of ANC, 75% in case of WON, and 80% in case of APFC/PP. Thus, surgery could be obviated in a significant proportion of patients by PCD. Our study recorded either comparable or a marginally higher success rate compared to other studies [11,15]. The improved success rate in our study may, in part, be due to the higher proportion (33.3%) of APFC/PP cases in comparison to other studies that mainly had patients of ANC and WON [10,11,15]. Patients were frequently assessed after the initial catheter placement and vigorous manual irrigation and removal of necrotic debris was performed. Multiple catheter checks and frequent catheter exchanges along with up-sizing of catheters were performed when drainage and removal of debris were unsatisfactory, which may also have contributed to a higher success rate.

The relatively low success rates in cases of ANC can be attributed to numerous factors like the presence of solid components hampering the chances of satisfactory

drainage, associated multiorgan failure and shock, and the presence of central pancreatic necrosis causing disruption of the pancreatic duct with continuous leakage of pancreatic enzymes and subsequent fistula formation, thus necessitating distal pancreatectomy for effective treatment. Although PCD was ineffective in this group of patients with central gland necrosis and pancreatic duct disruption, surgery was not performed emergently.

PCD helps in the stabilization of critically ill acute pancreatitis patients with PCs and helps in the improvement of vital functions including cardiovascular, respiratory, and renal functions [15]. It helps in the reduction of inflammatory markers like C-reactive protein [15]. PCD may alone prove to be a successful treatment modality or may help buy time to plan surgery at a later date, thus acting as a bridge to surgery. Early surgical intervention in cases of ANC is associated with high mortality rates of 60-65% [15,17]. Usually by 4 weeks there is clear demarcation between the necrotic tissue and normal tissue because the necrotic process is usually complete by this time. Thus, PCD buys time to facilitate surgery at a later date when the patient is relatively stable, which reduces the operative morbidity and mortality [18-20].

PCD is a relatively safe procedure with a low complication rate. We recorded PCD-related minor complications in only 4 patients, presumably owing to proper patient selection, thorough pre-procedure evaluation and planning, expertise of the faculty, and proper aftercare of PCD.

PCD also reduces the duration of hospital stay in these patients, which translates into low rates of nosocomial infections and a reduced overall cost of treatment [20].

There are a few limitations to this study. There was no control group, which could have helped to comparatively evaluate the effectiveness of PCD. The small number of patients is also a limitation.

Conclusions

PCD is an effective treatment modality in the management of PCs and obviates the need for surgery in approximately 63% patients, with a low complication rate.

Conflict of interest

The authors report no conflict of interest.

References

1. Tyberg A, Karia K, Gabr M, et al. Management of pancreatic fluid collections: a comprehensive review of the literature. World J Gastroenterol 2016; 22: 2256.
2. Mahapatra SJ, Garg PK. Management of pancreatic fluid collections in patients with acute pancreatitis. J Pancreatol 2019; 2: 82-90.
3. Bakker OJ, van Santvoort H, Besselink MG, et al. Extrapancreatic necrosis without pancreatic parenchymal necrosis: a separate entity in necrotising pancreatitis? Gut 2013; 62: 1475-1480.
4. Banks PA, Bollen TL, Dervenis C, et al. Classification of acute pancreatitis – 2012: revision of the Atlanta classification and definitions by international consensus. Gut 2013; 62: 102-111.
5. Türkvatan A, Erden A, Seçil M, Türkoğlu MA. Fluid collections associated with acute pancreatitis: a pictorial essay. Can Assoc Radiol J 2014; 65: 260-266.
6. Bezmarević M, van Dijk SM, Voermans RP, et al.; Dutch Pancreatitis Study Group. Management of (peri) pancreatic collections in acute pancreatitis. Visceral Medicine 2019; 35: 91-96.
7. Zhao K, Adam SZ, Keswani RN, et al. Acute pancreatitis: revised Atlanta classification and the role of cross-sectional imaging. Am J Roentgenol 2015; 205: W32-41.
8. Zerem E, Hauser G, Loga-Zec S, et al. Minimally invasive treatment of pancreatic pseudocysts. World J Gastroenterol 2015; 21: 6850.
9. Ke L, Li J, Hu P, et al. Percutaneous catheter drainage in infected pancreatitis necrosis: a systematic review. Indian J Surg 2016; 78: 221-228.
10. van Santvoort HC, Besselink MG, Bakker OJ, et al. A step-up approach or open necrosectomy for necrotizing pancreatitis. N Engl J Med 2010; 362: 1491-1502.
11. Freeny PC, Hauptmann E, Althaus S, et al. Percutaneous CT-guided catheter drainage of infected acute necrotizing pancreatitis: techniques and results. AJR Am J Roentgenol 1998; 170: 969-975.
12. Baudin G, Chassang M, Gelsi E, et al. CT-guided percutaneous catheter drainage of acute infectious necrotizing pancreatitis: assessment of effectiveness and safety. Am J Roentgenol 2012; 199: 192-199.
13. van Baal MC, van Santvoort HC, Bollen TL, et al. Systematic review of percutaneous catheter drainage as primary treatment for necrotizing pancreatitis. Br J Surg 2011; 98: 18-27.
14. Wig JD, Gupta V, Kochhar R, et al. The role of non-operative strategies in the management of severe acute pancreatitis. J Pancreas 2010; 11: 553-559.
15. Mehta V, Kumar R, Parkash S, et al. Role of percutaneous catheter drainage as primary treatment of necrotizing pancreatitis. Turk J Gastroenterol 2019; 30: 184.
16. Hollemans RA, Bakker OJ, Boermeester MA, et al. Superiority of step-up approach vs open necrosectomy in long-term follow-up of patients with necrotizing pancreatitis. Gastroenterology 2019; 156: 1016-1026.
17. Ai X, Qian X, Pan W, et al. Ultrasound-guided percutaneous drainage may decrease the mortality of severe acute pancreatitis. J Gastroenterol 2010; 45: 77-85.
18. Garg PK, Sharma M, Madan K, et al. Primary conservative treatment results in mortality comparable to surgery in patients with infected pancreatic necrosis. Clin Gastroenterol Hepatol 2010; 8: 1089-1094.
19. Zerem E, Imamović G, Sušić A, Haračić B. Step-up approach to infected necrotising pancreatitis: a 20-year experience of percutaneous drainage in a single centre. Digestive and Liver Disease 2011; 43: 478-483.
20. Solanki R, Thumma V, Sastry RA, Bheerappa N. The role of image guided percutaneous drainage in multidisciplinary management of necrotizing pancreatitis. Trop Gastroenterol 2013; 34: 25-30.