Indian Journal of Surgery (December 2020) 82(6):1107–1113
https://doi.org/10.1007/s12262-020-02187-x

ORIGINAL ARTICLE

# Percutaneous Catheter Drainage of Pancreatic Fluid Collections in Patients With Acute Pancreatitis

Xiang Li[1] · Luping Wang[1] · Zheng Tan[1] · Yixiao Xu[1] · Fang Yu[1] · Xiaotong Han[1] · Xingwen Zhang[2]

Received: 15 May 2019 / Accepted: 8 April 2020 / Published online: 22 April 2020
© Association of Surgeons of India 2020

## Abstract

In this retrospective study, we aimed to evaluate the efficacy of percutaneous catheter drainage (PCD) in patients with acute pancreatitis (AP) for management of pancreatic fluid collections (PFCs). A total of 111 AP patients were included with 34 patients in conservative treatment group (received nutrition support and liquid resuscitation during hospitalization) and 77 patients in PCD group (accepted PCD during hospitalization). The APACHE II score, CRP value, procalcitonin (PCT) value, and WBC count of included patients were recorded for further comparison. The inflammation response of patients in both groups was assessed by measuring the mean time for the recovery of CRP level, WBC count, and amylase/lipase. Mortality, length of hospital stay, new-onset ICU admission or readmission, and new-onset multi-organ failure were also compared between the two groups. The pre-conditions of patients in both groups indicate the comparison of the two groups. The inflammatory response in PCD group was attenuated when compared with conservative treatment group evidenced by decreased mean time for recovery of CRP level in PCD group. In addition, patients in PCD groups had less complication rate (multi-organ failure and surgical debridement) than that in conservation treatment group. Patients in conservation treatment group had shorter hospital stay, but failed to achieve statistical significance. Evidence supported that PCD is an effective approach for management of PFCs after conservation treatment failure with decreased complication rate and attenuated inflammation responses.

**Keywords** Percutaneous catheter drainage · Pancreatic fluid collections · C-reactive protein level · Multi-organ failure · Mortality

## Introduction

Acute pancreatitis (AP), as a mild and self-limiting illness with entire recovery and integration, is a common acute abdominal disease encountered in various countries, and in recent years, its incidence appears to be rising [1]. Unfortunately, data has shown that over 300,000 people accepted AP-related medical treatment in hospital in USA [2]. Despite improvements in diagnostic and therapeutic techniques, the mortality rate of AP is from 2% to 5%, but that percentage of severe acute pancreatitis (SAP) could be as high as 20% to 30% [3]. Hence, there is an urgent need to understand the pathogenesis of AP at the molecular level.

As an inflammatory disease, a great number of local complications can be triggered by AP including pancreatic fluid collections (PFCs), acute necrotic collection (ANC), pseudocyst, and walled-off necrosis (WOPN) [4]. PFCs are the debris or fluids of the pancreas collected within the retroperitoneum which can be drained by surgery, endoscopic transmural drainage, or radiologically guided percutaneous drainage (PD) [5, 6]. To ensure the therapeutic benefits of AP, early and better management of PFCs is urgently needed.

The treatment option of patients is complicated and shall be determined by several factors, including physical conditions and disease severity. Therefore, conservative treatment is the first choice for some AP patients until intervention was considered to be more appropriate [7]. The conservative treatment for fluid depletion in AP patients includes intensive care, nutrition support, oxygen supplementation, and intravenous hydration [8]. Positive evidence supported that conservative treatment is beneficial for spontaneous resolution of

✉ Xiaotong Han
hanxiaotong9@163.com

✉ Xingwen Zhang
zhangxingwen@163.com

[1] Emergency department (One), Hunan Provincial People's Hospital, Changsha 410005, Hunan, People's Republic of China

[2] Emergency Department (Three), Hunan Provincial People's Hospital, No. 61 Jiefang West Road of Tianxin District, Changsha 410005, Hunan, People's Republic of China

pseudocysts [9]. However, the consensus on fluid type, as well as information regarding fluid administration for PFC management was still undetermined.

The drainage approaches for PFCs include endoscopic drainage (ED), percutaneous catheter drainage (PCD), or surgical drainage [5, 6]. Particularly, PCD is a minimally invasive technique with the application of single or multiple catheters in direct percutaneous necrosectomy [10]. There is increasing evidence advocating the minimal invasive technique such as PCD; however, whether PCD can decrease mortality and minimize AP patients' adverse-effect profiles remain controversial. In this regard, we aim to investigate the efficacy of PCD approach in depletion of PFCs in AP patients and by comparison with parameters in patients who received conservative treatment, we try to conclude the merits and demerits of PCD.

## Materials and Methods

### Patients

The search on SAP database in Hunan Provincial People's Hospital with a span of time of over 28 months identified 111 AP patients. Institutional review board approval was obtained, and the requirement for informed consent was waived for the retrospective portion of the study. The patients chosen in this study were more than 19 years old, and CT imaging showed that PFCs were larger than 6 cm in size. Patients who received culture-positive drain fluid at initial PCD treatment, gas on CT scan, or necrosectomy were excluded. According to their therapy strategy, all patients included were divided into conservative treatment group ($n = 34$) and PCD treatment group ($n = 44$) during their hospitalization. All the patients with AP received initially conservative treatment including nutritional support, intravenous fluids, and other treatments in selected cases, and then PCD treatment was considered if patients cannot or failed to receive conservative treatment. Demographic (age, sex), clinical (length of hospital stay, admittance to intensive care unit, etiology of pancreatitis, diagnostic and conservative therapeutic approaches), laboratory data, and characteristics of surgical procedures were collected by evaluating patient charts.

The diagnosis of AP was based on two of the following three features: (1) abdominal pain consistent with AP feature; (2) serum lipase activity (or amylase activity) at least three times greater than the upper limit of normal; and (3) characteristic findings of AP on contrast-enhanced computed tomography (CECT) and less commonly magnetic resonance imaging (MRI) or trans-abdominal ultrasonography. The severity of disease is graded into mild, moderate, and severe AP according to the revised Atlanta classification 2012. Patients with mild AP had no organ dysfunction, different complications, or PFCs, so patients with mild AP was not included in our study. Patients present with PFCs and without persistent organ failure were divided into moderate group. If organ failure persists more than 48 h, patients were upgraded to severe group [4].

### Conservative Treatment

The initial management included fluid resuscitation, pain control, and nutritional support. Antibiotics were initiated when an infection was suspected and the antibiotics were continued to use if an infection source was identified or cultures were positive. Not all patients in our series were indicated for PCD. The indication of PCD was conservative management failure complicated with the following features: refractory abdominal pain, worsening PFCs on CT scan, persistent inflammatory markers including C-reactive protein (CRP) and procalcitonin (PCT), persistent elevation of lipase and/or amylase, and radiological evidence of infected PFCs such as presence of peripancreatic gas.

### Ultrasound-guided PCD

Patient was laid down and draped in a sterile fashion. Local anesthesia was applied to alleviate patient's discomfort. The size (ranging from 8 to 10 Fr) of catheters was determined according to the PFC size. The catheters were introduced transperitoneally under ultrasound guidance. The content, color, and cultures of drainage were recorded daily. Antibiotics were prescribed if the Gram stain and/or cultures were positive for infection. When repeated ultrasound and CT of the pancreas were conducted to evaluate necrotic cavities, additional catheters were considered when necessary to increase drainage. The catheters were removed when fluid drainage identified by CT was no longer significant. Recovery was measured by the following factors: sepsis under control (no fever or white blood cells return to normal), absence of fluid collection, or necrosis.

### Surgical Debridement

Radiological or surgical intervention was postponed as long as possible to allow maximal demarcation and liquefaction of the devitalized pancreatic and peripancreatic tissues. Fine-needle aspiration (FNA) for recognition of pancreatic infection is not practiced routinely in our institution and the necessity of the intervention was based on clinical, radiological, and laboratory grounds. Surgical debridement was only performed when PCD with large-bore catheters failed to achieve any improvement or complication required surgery intervention.

### Outcome Measures

Mortality, length of hospital stay, new-onset ICU admission or re-admission, and new-onset multi-organ failure of patients in conservative treatment group and PCD group were recorded. During hospitalization, blood samples from the patients were checked daily and the CRP level, WBC count, and amylase/lipase in serum samples were measured.

### Statistical Analysis

SPSS 20.0 statistical software (IBM Corp., Armonk, NY, USA) was used for statistical analysis. Measurement data were in terms of $x \pm s$ and using $t$ test for statistical analysis. Counting data were expressed in terms of percentage (%) and compared using $\chi^2$ test. $P < 0.05$ was statistically significant for the difference.

## Results

A total of 111 patients (69 male and 42 female) were included in this study. The etiologies of AP included alcohol in 55 cases (49.5%), cholelithiasis in 16 cases (14.4%), and idiopathic factors in 40 cases (36.0%). Among the 111 patients with AP complicated by PFCs, 67 (60.4%) were classified as moderate AP while 44 (39.6%) were SAP.

Patients were categorized based on whether they underwent ultrasound-guided PCD during the hospitalization stay. The PCD group comprised of 77 patients (69.4%), while the conservative group consisted of 34 patients (30.6%) with only medical managements. Comparisons on age ($P = 0.59$), sex ($P = 0.67$), etiology ($P = 0.32$), and disease severity ($P = 0.70$) between conservative group and PCD group have no significant difference, indicating the comparability of the two groups.

During the progression of AP, systemic complications can be triggered, including systemic inflammatory response syndrome (SIRS) and multiple organ dysfunction syndrome (MODS). We concluded that both the occurrence rate of MODS and SIRS between the two groups have no significant difference.

Besides, APACHE II scores and CTSI scores can be used to evacuate the condition of AP patient and might influence mortality or clinical recovery rates [11]. Herein, our study presented that APACHE II score between the two groups showed no significant difference with $P = 0.59$. Furthermore, some studies found that CTSI scores are negative indicators for patient outcomes [12–14], however, our study found that CTSI score between the two groups showed difference but the $P$ value was 0.048, therefore, we do not consider CTSI score as an influence factor in this study.

Additionally, PCT is an inflammatory factor, and continuously releasing of PCT may cause systemic inflammatory response syndrome. Before treatment, PCT has significant difference between the two groups, which may be high level of PCT in individuals in each group. For example, the highest PCT level in conservative group was 18.9 ng/mL, while the highest PCT level in PCD group was 106.7 ng/mL.

CRP level and WBC count can be used to diagnose and predict the severity of AP [15, 16]. Therefore, our study showed that there was no significant difference in the pre-treatment CRP level (226 mg/L vs 224.6 mg/L, $P = 0.67$) and WBC count ($17.0 \times 10^9$/L vs $15.2 \times 10^9$/L, $P = 0.08$) between the conservative and PCD groups. Demographics of patients in conservative and PCD treatment groups are summarized in Table 1.

### Timing and Indications for PCD

PCD was performed at a median of 17 days (range 2–63 days) after the onset of SAP. The indications (could be overlapped) to perform PCD for patients are as follows: increasing fluid collection on CT scan ($n = 29$, 37.7%), intractable abdominal pain despite narcotic use ($n = 8$, 10.4%), persistent elevation or increasing amylase/lipase ($n = 14$, 18.2%), persistent elevation of PCT and/or CRP ($n = 23$, 29.9%), and organ failure that persists > 48 h in spite of advanced treatment ($n = 33$, 42.9%).

### Catheter Placement and Complications

Catheter was placed through transperitoneal route preferentially in 63 patients (81.8%) and retroperitoneal route in 14 patients (18.2%). The catheter size varied from 8 to 24 Fr with median of 14 Fr. Patients required an average of one catheter (range from 1 to 4). Three patients required a second procedure because of clogged catheter. In six (7.9%) patients, catheter drains were upsized to larger catheter drains. The median duration of drainage was 20 days ranging from 6 to 50 days. The drainage volume over the first 24 h ranged from 60 to 2500 mL with a median of 980 mL. Pseudocysts occurred in four patients treated with PCD, but all recovered.

### Surgical Debridement

In PCD group, no patient was required to receive surgical debridement. In the conservative treatment group, 14 patients with necrotic pancreatic tissue needed debridement, but for certain reasons, they cannot receive PCD surgery, therefore, surgical debridement was performed in these 14 patients. In six of these 14 patients, the treating surgeon preferred open surgical debridement. In other six patients, percutaneous access to the necrosis was regarded technically impossible due to bowel interposition or abundant gas within the necrotic collection that precluded a safe placement of the catheter. In one patient, the

**Table 1** Demographics of acute pancreatitis patients in conservative group and PCD group

| Parameters | Conservative ($n = 34$) | PCD ($n = 77$) | $P$ value |
|---|---|---|---|
| Age [median (range)] | 51 (22~78) | 49 (24~76) | 0.59 |
| Sex [male (%)] | 22 (64.7%) | 47 (61%) | 0.67 |
| BMI (kg/m$^2$) [median (range)] | 26.7 (18.3~33.5) | 27.3 (19.4~34.8) | 0.62 |
| Etiology: | | | |
| Alcohol/binge eating | 18 (52.9%) | 37 (48.0%) | 0.32 |
| Gallstone | 4 (11.8%) | 12 (15.6%) | |
| Idiopathic | 12 (35.3%) | 28 (36.4%) | |
| Disease severity: | | | |
| Moderate | 23 (67.6%) | 44 (57.1%) | 0.7 |
| Severe | 11 (32.4%) | 33 (42.9%) | |
| SIRS | 30 (88.2%) | 66 (85.7%) | 0.58 |
| MODS | 14 (41.2%) | 38 (49.4%) | 0.12 |
| CTSI [median (range)] | 4 (3–10) | 6 (2–10) | 0.048 |
| Maximal diameter of collections (mm) [median (range)] | 59 (35–149) | 75 (32~200) | 0.032 |
| Necrosis | 14 (41.1%) | 29 (37.8%) | 0.21 |
| APACHE II [median (range)] | 15 (9–26) | 14 (8~54) | 0.59 |
| APACHE II score > 20 | 6 (17.6%) | 10 (13.0%) | 0.16 |
| Albumin (g/dL) [mean (range)] | 3.10 (2.29~3.89) | 3.04 (2.61~4.07) | 0.12 |
| PCT (ng/mL) [mean (range)] | 8.07 (0.37~18.9) | 11.8 (0.06~106.7) | < 0.001 |
| CRP (mg/L) [mean (range)] | 226.0 (82.9~410) | 224.6 (63.2~439) | 0.67 |
| WBC (× 10$^9$/L) [mean (range)] | 17.0 (2.71~26.3) | 15.2 (7.11~40.9) | 0.08 |

Note: *PCD* percutaneous catheter drainage, *SIRS* systemic inflammatory response syndrome, *MODS* multiple organ dysfunction syndrome, *CTSI* CT severity index, *APACHE II* acute physiology and chronic health evaluation APACHE II, *PCT* procalcitonin, *CRP* C-reactive protein, *WBC* white blood cell

main indication for surgical intervention was a concomitant toxic megacolon secondary to severe *Clostridium difficile* infection. In another patient, open surgical debridement was indicated because of active bleeding into the collection.

## Treatment Outcome

The comparison of treatment outcome between the conservative and PCD treatment groups was then assessed. As depicted in Table 2, two patients required surgical necrosectomy after PCD and none of the patients in conservative treatment group required necrosectomy. A total of eight patients (7.2%) died with three patients in conservative treatment group (8.8%) and five patients in PCD group (6.5%). No statistical difference was detected in necrosectomy requiring ($P = 0.35$) and mortality ($P = 0.65$).

The PCD group had a longer length of hospital stay (median, 38 days; range, 4–59 days) compared to conservative treatment group (median, 32 days; range, 2–73 days), but failed to achieve statistical difference ($P = 0.11$). Both groups did not differ in new-onset ICU admission ($P = 0.40$) or in ICU re-admission ($P = 0.99$). CRP can reflect the inflammation condition of patients, and the mean time for the recovery of CRP level was much longer in the conservative treatment group than in the PCD group (26 vs 18, $P = 0.006$). However, no significant difference was noted in time to WBC count ($P = 0.32$) and amylase/lipase ($P = 0.68$) recovery. Fewer patients had new-onset multi-organ failure in the PCD group, six patients (17.65%) in the PCD group versus six patients (3.90%) in conservative treatment group ($P = 0.014$).

Besides, we analyzed the pre-treatment CRP level and post-treatment CRP level (after treatment for the 1, 7, 14, 21, and 28 days). The baseline parameters are represented in Table 3. As a result, we found that the CRP value decreased dramatically in the first week after treatment, and the PCD group decreased faster than conservative treatment group. The two groups showed significant difference from 7 days after treatment. The normal level of CRP value is less than 10 mg/L, and the conservative treatment group and PCD group returns to normal CRP level in post-treatment 28 days and post-treatment 16 days, respectively. Together, the results showed that PCD could alleviate symptoms quickly and relieve systemic inflammation as well as prevent or alleviate organ function damage, giving rise to a good physiological environment for the later recovery of patients.

## Discussion

In the above study, we have elucidated that PFC was one kind of complication of AP, and its therapy was significant for AP

**Table 2** Comparisons on treatment outcomes in acute pancreatitis patients in conservative group and PCD group

| | Conservative ($n = 34$) | PCD ($n = 77$) | *P* value |
|---|---|---|---|
| Necrosectomy | 0 | 2 | 0.35 |
| Mortality | 3 (8.8%) | 5 (6.5%) | 0.67 |
| Length of hospital stay [median (range)] | 32 (2~73) | 38 (4~59) | 0.11 |
| New-onset ICU admission | 16 (47.1%) | 43 (55.8%) | 0.4 |
| ICU readmission | 4 (11.8%) | 9 (11.7%) | 0.99 |
| Mean time for the recovery of CRP level | 26 days | 18 days | 0.006 |
| Mean time for the recovery of WBC count | 23 days | 21 days | 0.32 |
| Mean time for the recovery of amylase/lipase | 23 days | 22 days | 0.68 |
| New-onset multi organ failure | 6 (17.65%) | 3 (3.90%) | 0.014 |

Note: *CRP* C-reactive protein, *WBC* white blood cells, *PCD* percutaneous catheter drainage

patients. In retrospective of our study, we compared PCD and conservative treatment in certain aspects, for example, the complication occurrence rate was lower in PCD group than that in conservative treatment group. Moreover, the average time for the recovery of CRP level was much longer in conservative treatment group than that in PCD group. In addition, length of hospital stay of PCD group was longer than that in conservative treatment group, but has no statistical meaning.

For one thing, a significant method such as conservative treatment should be considered. The advantages of conservative treatment have been reported previously [17], and thus we analyzed the conservative treatment in AP. For another, we also have analyzed the advantages of PCD, however, there were no consistent opinions on PCD treatment. Therefore, our study has made a comparison between PCD and conservative treatment in PFCs [5]. As a prospective therapy for PFCs, the conservative treatment could postpone surgery after AP occurred, and thus benefited for AP patients' survival [17]. One previous study proved that as one mean of complication, enteral nutrition was good for therapy of AP. Enteral feeding decreased disease mortality, infectious complications, and organ failure [18]. In our study, patients received PCD had a longer length of hospital stay compared with conservative treatment group, despite the failure to achieve statistical significance. The possible reason may be that the physical condition of patients in conservation group was improved much faster due to the absence of surgical trauma. However, the limitation was that conservative treatment may not be an optimal approach as necrosis increases the morbidity and mortality risk of SAP for its association with organ failure and infectious complications [2]. In this case, a more aggressive approach, such as debridement, shall be adopted to remove the debris or necrosis. Therefore, conservation treatment is more suitable in the initial stages of SAP and is associated with an increased re-intervention rate.

PCD, a minimally invasive approach is developed to increase the rates of treatment success in SAP patients. Our results indicated that SAP patients that received PCD had decreased recovery time of CRP level. According to a previous study, CRP level, seemed as a factor, can evaluate severity of AP, and AP patients were divided into mild AP or severe AP [19]. Infected pancreatic necrosis or WOPN usually happened in SAP and needs various operations to realize entire debridement of the whole infected necrosis [2], which consequently would bring about operative wound for patients. Freeny and other scholars initially represented a group of AP patients who were mainly accepted with imaging-guided PCD to replace necrosectomy [10]. Based on a prior study, PCD has plenty of advantages. Firstly, PCD treatment could delay early-stage intervention of PFCs thus might ameliorate the disease progression of AP [20]. Second, PCD treatment could postpone, or to a greater extent, prevent surgical necrosectomy

**Table 3** Comparisons on pre-treatment and post-treatment CRP levels in acute pancreatitis patients in conservative group and PCD group

| Time | Conservative group (mg/L) | PCD group (mg/L) | *P* value |
|---|---|---|---|
| Pre-treatment | 226.0 ± 17.3 | 224.6 ± 16.8 | > 0.05 |
| Post-treatment 1 day | 196.0 ± 33.4 | 188.5 ± 20.6 | > 0.05 |
| Post-treatment 7 days | 106 ± 18.5 | 68.4 ± 9.7 | < 0.05 |
| Post-treatment 14 days | 64.3 ± 8.6 | 19.9 ± 5.2 | < 0.05 |
| Post-treatment 21 days | 22.7 ± 4.8 | 8.5 ± 2.1 | < 0.05 |
| Post-treatment 28 days | 8.9 ± 2.3 | 8.1 ± 1.6 | > 0.05 |

Note: *CRP* C-reactive protein, *PCD* percutaneous catheter drainage

so that AP patients would not suffer from operative trauma or wound infection, therefore, PCD is more effective and safer [20]. Third, clinical symptom might be alleviated after PCD, and the necrotic tissue may successfully be dealt with by the patient's immune system [21]. These findings were similar with the results of our study that PCD could alleviate symptoms quickly with a concomitant reduction in systemic inflammation, prevention or alleviation in organ function failure.

In conclusion, we have discussed that PCD, as a significant therapy approach, can be performed to successfully treat PFCs in AP, with the feature of decreased complication rate and attenuated inflammation responses, but failed to decrease mortality of patients with AP. In view of our limited time and inadequate data in clinical database, we only compared the efficacy of PCD and conservative treatment in few respects, such as in inhibiting AP relative inflammation and in reducing occurrence of complication. So the contrast between PCD and conservative treatment was not sufficient. Therefore, further studies are required to verify and extend the results of the present study.

**Acknowledgments** Thanks for all the support and contributions of participators.

**Funding** This work was supported by a project of the Health Commission of Hunan Province (B2019068) and project of Administration of Traditional Chinese Medicine of Hunan province (201783).

## Compliance with Ethical Standards

**Conflict of interest** The authors declare that there is no conflict of interest.

## References

1. Yang ZW, Meng XX, Xu P (2015) Central role of neutrophil in the pathogenesis of severe acute pancreatitis. J Cell Mol Med 19(11): 2513–2520. https://doi.org/10.1111/jcmm.12639
2. Chua TY, Walsh RM, Baker ME, Stevens T (2017) Necrotizing pancreatitis: diagnose, treat, consult. Cleve Clin J Med 84(8):639–648. https://doi.org/10.3949/ccjm.84a.16052
3. Zhang J, Shahbaz M, Fang R, Liang B, Gao C, Gao H, Ijaz M, Peng C, Wang B, Niu Z, Niu J (2014) Comparison of the BISAP scores for predicting the severity of acute pancreatitis in Chinese patients according to the latest Atlanta classification. J Hepatobiliary Pancreat Sci 21(9):689–694. https://doi.org/10.1002/jhbp.118
4. Banks PA, Bollen TL, Dervenis C, Gooszen HG, Johnson CD, Sarr MG, Tsiotos GG, Vege SS, Acute Pancreatitis Classification Working G (2013) Classification of acute pancreatitis–2012: revision of the Atlanta classification and definitions by international consensus. Gut 62(1):102–111. https://doi.org/10.1136/gutjnl-2012-302779
5. Keane MG, Sze SF, Cieplik N, Murray S, Johnson GJ, Webster GJ, Thorburn D, Pereira SP (2016) Endoscopic versus percutaneous drainage of symptomatic pancreatic fluid collections: a 14-year experience from a tertiary hepatobiliary centre. Surg Endosc 30(9):3730–3740. https://doi.org/10.1007/s00464-015-4668-x
6. Tyberg A, Karia K, Gabr M, Desai A, Doshi R, Gaidhane M, Sharaiha RZ, Kahaleh M (2016) Management of pancreatic fluid collections: a comprehensive review of the literature. World J Gastroenterol 22(7):2256–2270. https://doi.org/10.3748/wjg.v22.i7.2256
7. Baron TH, Harewood GC, Morgan DE, Yates MR (2002) Outcome differences after endoscopic drainage of pancreatic necrosis, acute pancreatic pseudocysts, and chronic pancreatic pseudocysts. Gastrointest Endosc 56(1):7–17
8. Aggarwal A, Manrai M, Kochhar R (2014) Fluid resuscitation in acute pancreatitis. World J Gastroenterol 20(48):18092–18103. https://doi.org/10.3748/wjg.v20.i48.18092
9. Cui ML, Kim KH, Kim HG, Han J, Kim H, Cho KB, Jung MK, Cho CM, Kim TN (2014) Incidence, risk factors and clinical course of pancreatic fluid collections in acute pancreatitis. Dig Dis Sci 59(5):1055–1062. https://doi.org/10.1007/s10620-013-2967-4
10. Trikudanathan G, Arain M, Attam R, Freeman ML (2013) Interventions for necrotizing pancreatitis: an overview of current approaches. Expert Rev Gastroenterol Hepatol 7(5):463–475. https://doi.org/10.1586/17474124.2013.811055
11. Ke L, Li J, Hu P, Wang L, Chen H, Zhu Y (2016) Percutaneous catheter drainage in infected pancreatitis necrosis: a systematic review. Indian J Surg 78(3):221–228. https://doi.org/10.1007/s12262-016-1495-9
12. Freeny PC, Hauptmann E, Althaus SJ, Traverso LW, Sinanan M (1998) Percutaneous CT-guided catheter drainage of infected acute necrotizing pancreatitis: techniques and results. AJR Am J Roentgenol 170(4):969–975. https://doi.org/10.2214/ajr.170.4.9530046
13. Tsiotos GG, Luque-de Leon E, Sarr MG (1998) Long-term outcome of necrotizing pancreatitis treated by necrosectomy. Br J Surg 85(12):1650–1653. https://doi.org/10.1046/j.1365-2168.1998.00950.x
14. Bruennler T, Langgartner J, Lang S, Wrede CE, Klebl F, Zierhut S, Siebig S, Mandraka F, Rockmann F, Salzberger B, Feuerbach S, Schoelmerich J, Hamer OW (2008) Outcome of patients with acute, necrotizing pancreatitis requiring drainage-does drainage size matter? World J Gastroenterol 14(5):725–730
15. Yilmaz EM, Kandemir A (2018) Significance of red blood cell distribution width and C-reactive protein/albumin levels in predicting prognosis of acute pancreatitis. Ulus Travma Acil Cerrahi Derg 24(6):528–531. https://doi.org/10.5505/tjtes.2018.98583
16. Huang L, Chen C, Yang L, Wan R, Hu G (2019) Neutrophil-to-lymphocyte ratio can specifically predict the severity of hypertriglyceridemia-induced acute pancreatitis compared with white blood cell. J Clin Lab Anal:e22839. https://doi.org/10.1002/jcla.22839
17. Kiss L, Sarbu G, Bereanu A, Kiss R (2014) Surgical strategies in severe acute pancreatitis (SAP): indications, complications and surgical approaches. Chirurgia (Bucur) 109(6):774–782
18. Olah A, Romics L Jr (2014) Enteral nutrition in acute pancreatitis: a review of the current evidence. World J Gastroenterol 20(43): 16123–16131. https://doi.org/10.3748/wjg.v20.i43.16123
19. Rotstein OD (2014) Circulating cytokines in predicting development of severe acute pancreatitis. Crit Care 18(5):575. https://doi.org/10.1186/s13054-014-0575-0
20. Yokoi Y, Kikuyama M, Kurokami T, Sato T (2016) Early dual drainage combining transpapillary endotherapy and percutaneous catheter drainage in patients with pancreatic fistula associated with severe acute pancreatitis. Pancreatology 16(4):497–507. https://doi.org/10.1016/j.pan.2016.03.007
21. Besselink MG, van Santvoort HC, Nieuwenhuijs VB, Boermeester MA, Bollen TL, Buskens E, Dejong CH, van Eijck CH, van Goor

H, Hofker SS, Lameris JS, van Leeuwen MS, Ploeg RJ, van Ramshorst B, Schaapherder AF, Cuesta MA, Consten EC, Gouma DJ, van der Harst E, Hesselink EJ, Houdijk LP, Karsten TM, van Laarhoven CJ, Pierie JP, Rosman C, Bilgen EJ, Timmer R, van der Tweel I, de Wit RJ, Witteman BJ, Gooszen HG, Dutch Acute Pancreatitis Study G (2006) Minimally invasive 'step-up approach' versus maximal necrosectomy in patients with acute necrotising pancreatitis (PANTER trial): design and rationale of a randomised controlled multicenter trial [ISRCTN13975868]. BMC Surg 6:6. https://doi.org/10.1186/1471-2482-6-6

**Publisher's Note** Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.