HEPATOPANCREATICOBILIARY SURGERY

ANZJSurg.com

Comparison between video-assisted retroperitoneal debridement and small incision pancreatic necrosectomy in infected pancreatic necrosis

Jin-Bao Zhang * and Bei Sun*†

*Department of Pancreatic and Biliary Surgery, The First Affiliated Hospital of Harbin Medical University, Harbin, China and
†Key Laboratory of Hepatosplenic Surgery, Ministry of Education, Harbin, China

Key words
infected pancreatic necrosis, minimally invasive surgery, pancreas, pancreatic necrosectomy, video-assisted retroperitoneal debridement.

Correspondence
Professor Bei Sun, Department of Pancreatic and Biliary Surgery, Key Laboratory of Hepatosplenic Surgery, Ministry of Education, The First Affiliated Hospital of Harbin Medical University, 23 Youzheng Street, Nangang District, Harbin 150001, Heilongjiang Province, China.
Email: sunbei70@tom.com.

J.-B. Zhang MM; **B. Sun** MD, PhD.

Accepted for publication 3 July 2020.

doi: 10.1111/ans.16181

Abstract

Background: Debridement and drainage have always been mainstream treatment for infected pancreatic necrosis (IPN), and the application of minimally invasive necrosectomy is becoming increasingly widespread. However, few studies have compared video-assisted retroperitoneal debridement (VARD) and small incision pancreatic necrosectomy (SIPN) individually. Our aim was to compare VARD and SIPN by evaluating outcomes.
Methods: We retrospectively reviewed patients with IPN who underwent either VARD or SIPN between 2010 and 2019 in China. Data relative to patient demographics, major complications, health care resource utilization and mortality were collected. Statistical analyses used were the two-tailed Student's *t*-test and the chi-squared test.
Results: Of 59 patients, 31 patients underwent SIPN and 28 patients were treated with VARD. SIPN and VARD had similar treatment success and mortality rates. The rate of reintervention due to lack of clinical improvement was significantly lower in the SIPN group (32% versus 61%; $P = 0.028$). In addition, the length of total hospital stay was 60 days in the SIPN group and 72 days in the VARD group ($P < 0.0001$) and mean total costs was significantly less in the SIPN group than in the VARD group ($P = 0.008$).
Conclusion: Given the shorter hospitalization period, lower total cost and lower rate of reinterventions, SIPN may be superior to the step-up approach for patients with IPN than for those with VARD.

Introduction

Acute pancreatitis is a common benign and potentially lethal disease of the digestive system. In the USA, costs reach 2 billion dollars every year and have a 15% mortality rate.[1] The necrosis of pancreatic parenchyma or extra-pancreatic tissues is associated with the severity of disease. Approximately, 10–20% of patients develop pancreatic or peri-pancreatic tissue necrosis, one third of whom present infection of the necrotic tissue.[2] Sterile necrosis is an indication for conservative treatment. However, once infected necrosis has occurred, invasive treatment is first-choice. The surgical step-up approach is the current mainstream treatment for infected necrosis.[3] Over the past 10 years, percutaneous catheter drainage (PCD) has always been the first step in the surgical step-up approach. If PCD fails, minimally invasive necrosectomy (MIN) is an alternative treatment, which has replaced open surgery as the standard treatment.[4] Given the rapid development of surgical treatment of pancreatitis, the endoscopic approach has been proposed. This approach consists of endoscopic transluminal drainage, if necessary, followed by endoscopic transgastric necrosectomy (ETN). A randomized trial of the surgical step-up approach versus the endoscopic step-up approach showed the rate of pancreatic fistulas and length of hospital stay were lower in the endoscopy group.[5]

Currently, MIN mainly incorporates video-assisted retroperitoneal debridement (VARD), small incision pancreatic necrosectomy (SIPN) and ETN. In the past, open pancreatic necrosectomy (OPN) was the main treatment for acute pancreatitis with secondary infection of necrotic tissue, which led to high rates of complications and death. However, OPN as the last step in the surgical step-up approach always plays an important role in the treatment of necrotising pancreatitis. At present, VARD and SIPN have been widely used by surgeons as the intermediate link of surgical step-up approach. Many surgeons have different preferences for the two types of MIN based on their own experience and most of the research to date has focused on the comparison between OPN and MIN. Few studies have compared VARD and SIPN individually.

As necrotising pancreatitis is often associated with multiple organ failure, the application of MIN is more extensive than OPN. Therefore, this study aimed to compare and evaluate outcomes after VARD and SIPN for the treatment of necrotising pancreatitis in order to find a better approach.

Methods

Patients

We performed a retrospective analysis of all patients who had undergone VARD and SIPN for the treatment of necrotising pancreatitis at a tertiary centre in Dalian, China, from 1 January 2010 to 31 December 2019. The data were collected with the consent of the ethics committee at the first affiliated hospital of Dalian Medical University. Based on the type of intervention, the patients were categorized into two groups: 'VARD' and 'SIPN'; no patients received both VARD and SIPN in both groups. The indications for VARD/SIPN that were delayed up to 4 weeks after onset included patients who did not improve with PCD, as evident by persistent/worsening sepsis after PCD, inadequate drainage of collection and necrosis, and persistently raised leukocyte count/increasing trend of leukocyte count. The choice of VARD and SIPN mainly depends on the surgeon's judgement and the location of the lesion. If the necrotic infected area is located in the bilateral retroperitoneal space of the colon, both SIPN and VARD can be considered. When the necrotic infected area is located in the peripancreatic space and lesser omental sac, the SIPN is usually chosen over VARD. Patients were excluded if they met one or more of the following criteria: (i) they had received PCD only; (ii) they had directly received exploratory laparotomy for necrosectomy; (iii) they had received intervention for infected pancreatic necrosis (IPN) in other hospitals before admitting to our institute; or (iv) the treatment strategy was not based on the Minimally Invasive Step-up Approach.

Classification, pathological type, staging, severity and complications of acute pancreatitis including post necrotic pancreatic fluid collections, walled of pancreatic necrosis, infected necrosis and multiple organ failure were defined and diagnosed according to the 2012 revision of the Atlanta Classification of Acute Pancreatitis.[6] Inclusion criteria were clinically definite IPN that can be diagnosed in three ways:

(1) Gas within the areas of pancreatic necrosis on imaging.
(2) A positive Gram stain from percutaneous sampling of the necrotic collection for culture.
(3) Lack of clinical improvement despite optimal medical management.

Persistent fevers, increasing inflammatory markers or new/persistent organ failure indicated clinical suspicion of infection.[7] Sepsis was defined according to the 1992ACCS/SCCM criteria.[8]

The primary endpoint was a composite of major complications (i.e. organ failure or systemic inflammatory response syndrome (SIRS), pancreatic fistula or visceral perforation, or intraabdominal bleeding requiring intervention), or death during admission or during the 3 months after discharge (Table 2). The secondary endpoint also included other complications, health-care resource utilization, and total medical costs from admission until 6 months after discharge (Table 2).

Minimally invasive step-up approach

Most patients in the VARD group and the SIPN group both underwent PCD as the first step. The preferred route was through the left retroperitoneum whenever possible, thereby facilitating MIN at a later stage, if necessary. The treatment effect was evaluated 72 h after PCD. If symptoms persisted aggravation or necrotic tissue continued to form, or if the position of the drain (or drains) was inadequate, a second drainage procedure was performed. If the drainage was effective but there was no clinical improvement (persistence or recurrence of a fever, elevated white blood cell counts, the presence of ongoing necrosis), and IPN persisted more than 4 weeks, which meant that the boundary between normal tissue and necrotic tissue had been clearly demarcated. The second step, VARD or SIPN was performed after an additional 72 h. In both groups, additional MIN as well as percutaneous drainage were allowed. If the above treatment was still ineffective, OPN was decisively performed.

Surgical protocol

Small incision pancreatic necrosectomy

In general, the access position differs according to the lesion location. If the necrotic infection area is located at the bilateral retroperitoneal space of the colon, the position of the retroperitoneal access is the centre of the PCD drainage tube in the bilateral lumbodorsal region or the body area closest to abscess cavity. Under general anaesthesia, a small longitudinal or horizontal incision was made of about 3–6 cm at the abdominal wall of the PCD drainage tube, and the skin was dissected as was the superficial fascia, muscle and transverse fascia layer by layer into the retroperitoneal space. The peritoneum was moved inward and separated from the abscess cavity guided by the PCD tube in the Toldt's space between kidney and colon in order to aspirate fluid. The necrotic tissue could be dissected bluntly by fingers to avoid bleeding during the operation. When the necrotic infection area was located in the peripancreatic space and the lesser omental sac, the chosen incision was to be the closest to the body surface. Under general anaesthesia, a small horizontal incision of about 5–8 cm was made in the position of abscess cavity, and the tissue was dissected layer by layer including the parietal peritoneum. After separating the surrounding ligaments along the PCD drainage tube, the wall of the abscess cavity was sliced and the necrotic tissue was dissected bluntly using the fingers. Injury of the stomach was avoided while handling the abscess cavity. Puncture by a 10 mL syringe was effective to identify the location of the abscess cavity without guideline of the PCD drainage tube. Finally, it was necessary to irrigate the cavity continuously with 0.9% saline solution and to allow insertion of the drainage tubes into the cavity. Because the necrotic tissue was still forming, it was impossible to completely remove the necrotic tissue during the surgery. Positive pressure irrigation with 0.9% saline solution and continuous negative pressure suction were necessary to prevent the necrotic tissue from blocking the drainage tube.

Video-assisted retroperitoneal debridement

The patient was placed in a partial lateral decubitus position with a 30°–40° angle. A subcostal incision of 5 cm close to the percutaneous drain was made at the mid-axillary line. With the help of the preoperative computed tomography scan, the fascia and the peritoneum could be dissected under the guide of PCD tube. When the cavity was entered, necrotic liquid and tissue could be removed with the use of a standard suction device and long grasping forceps. As the process of debridement reached deeper into the cavity, it was difficult to perform under direct vision. Therefore, a single extra-long laparoscopic port and laparoscopic graspers were used for debridement under the video monitor of 0° videoscope. During the whole process, the percutaneous drain was infused with CO_2 gas in order to inflate the cavity, thereby enhancing vision. It was impossible to completely remove the necrotic tissue during the surgery, so debridement avoided haemorrhage with the premise of tearing blood vessels as little as possible. Laparotomy or angiographic coiling could be considered in the event of persistent haemorrhage. The cavity was irrigated with 0.9% saline solution after removing the bulk of necrosis, and two large-bore single-lumen drains were inserted instead of the PCD tube. Positive pressure irrigation with 0.9% saline solution and continuous negative pressure suction were necessary until the effluent was clear.

Statistical analysis

The baseline characteristics were summarized in Table 1 and the clinical outcomes after VARD or SIPN collected for evaluation were Primary endpoints and Secondary endpoints (Table 2). Data collection was retrospective, and SPSS Version 24 (IBM Corp, Armonk, NY, USA) was used for the statistical analysis. Descriptive statistics including categorical data were presented as frequencies and proportions, and continuous data presented as median and interquartile range. Continuous variables were analysed with the two-tailed Student's *t*-test or Mann–Whitney *U*-test and the qualitative variables with the chi-squared test or Fisher exact test. *P*-values <0.05 were considered statistically significant.

Results

Patient demographic and clinical characteristics

The SIPN and VARD groups accommodated four patients and 2 patients from 2010 to 2013, 13 patients and 10 patients from 2014 to 2016, and 14 patients and 16 patients from 2017 to 2019, respectively; there was no statistically significant difference between the two groups ($P = 0.59$). Of 59 patients, 31 patients underwent SIPN and 28 patients were treated with VARD, mean age was 54 years (range 37–73) and 46.5 years (range 40.5–70.5) with a male sex ratio of 1.8 and 0.86, respectively. The commonest aetiologies between the two groups were biliary and hypertriglyceridaemia. Illness severity, including American Society of Anesthesiologists class and computed tomography severity index, were similar between groups. Time to initial intervention was 34 days in the SIPN group and 38 days in the VARD group. There was a significant difference in percutaneous catheter *in situ* prior to intervention (74% versus 100%; $P = 0.005$). The SIPN and VARD groups were not dissimilar in disease severity, and had no statistically significant differences in C-reactive protein and white blood cell level, acute physiology and chronic health evaluation II score, SIRS, intensive care unit /high-acuity care or organ failure. In additional, antibiotic treatment and nutritional support were compared between the groups, and no statistically significant differences were found.

Primary endpoint

The overall complication rate in each group was low, and we observed no significant differences in postoperative SIRS, organ failure, pancreatic fistula, visceral perforation or surgical site infection. Compared with the SIPN group, abdominal bleeding occurred more frequently in the VARD, although the difference was not statistically significant (6% versus 18%; $P = 0.34$). The rate of conversion to OPN between the two study groups did not differ significantly ($P = 0.85$). The rate of reinterventions due to lack of clinical improvement was significantly lower in the SIPN group (32% versus 61%; $P = 0.028$).

Secondary endpoint

There was no statistical difference in length of intensive care unit stay between the two groups, but the length of the total hospital stay was 60 days in the SIPN group and 72 days in the VARD group ($P < 0.0001$). Mean total costs were significantly less in the SIPN group than in the VARD group ($P = 0.008$). After a follow-up period, we observed no differences in secondary endpoints including incisional hernia, endocrine, or exocrine pancreatic insufficiency.

Discussion

Our study demonstrated that both VARD and SIPN could be used to treat patients with necrotising pancreatitis successfully, and it suggested that SIPN may be superior to the step-up approach for management of pancreatitis with suspected or established infection. Mortality in IPN in our study was 16% and 18%, respectively, in the VARD and SIPN groups, which is comparable to that of other recent studies, which range from 7% to 25%.[4,5,9] We analysed clinical data of all consecutive patients treated by VARD and SIPN, so the samples in this study were representative. In this study, SIPN can significantly reduce the rate of reinterventions due to lack of clinical improvement (32% versus 61%), and this may be related to more thorough debridement during the surgical procedure. Compared to VARD, SIPN can remove a large amount of infected necrotic tissue in a single operation, which effectively relieves sepsis. The purpose of SIPN is to achieve debridement and drainage of peripheral pancreatic necrotic tissue using the smallest incision, which is an improvement based on conventional OPN. However, due to the limitation of space, VARD often requires multiple reinterventions. In addition, SIPN was associated with a shorter length of hospital stay and lower total costs than VARD in patients with IPN. In the absence of complications, this is due to a

Table 1 Baseline characteristics of the patients

Characteristic	SIPN (n = 31)	VARD (n = 28)	P-value
Age, median (IQR) (years)	54 (37–73)	46.5 (40.5–70.5)	0.62
Male sex, n (%)	20 (64)	13 (46)	0.16
Cause of pancreatitis, n (%)			0.74
Biliary	11 (35)	14 (50)	
Alcohol abuse	6 (19)	3 (10)	
Hypertriglyceridaemia	10 (32)	9 (32)	
Post ERCP	2 (7)	1 (4)	
Others	2 (7)	1 (4)	
BMI, median (IQR) (kg/m^2)	26 (25–29)	27 (25–31)	0.41
ASA class, n (%)			0.72
I (healthy)	0	0	
II (mild-systemic)	13 (42)	13 (46)	
III (severe-systemic)	18 (58)	15 (54)	
Coexisting conditions, n (%)			0.84
Cardiovascular disease	14 (45)	10 (36)	
Pulmonary disease	12 (39)	10 (36)	
Renal insufficiency	3 (10)	4 (14)	
Diabetes	14 (45)	15 (54)	
CT severity index, n (%)			0.82
0–2	0	0	
4–6	5 (16)	3 (11)	
8–10	26 (84)	25 (89)	
Type of necrotic collection, n (%)			0.99
Walled-off necrosis	21 (68)	19 (68)	
Acute necrotic collection	10 (32)	9 (32)	
Time to initial intervention, median (IQR) (days)	34 (31–42)	38 (31.25–55.25)	0.10
Percutaneous catheter *in situ* prior to intervention, n (%)	23 (74)	28 (100)	0.005*
Disease severity, n (%)			
SIRS	21 (68)	18 (64)	0.77
ICU/high acuity care	24 (77)	21 (75)	0.82
Single-organ failure	16 (52)	15 (54)	0.88
Multiple organ failure	11 (35)	9 (32)	0.78
APACHE II score	20 (18–26)	21 (19–25.75)	0.92
CRP, median (IQR) (mg/L)	216 (189–286)	231 (189.8–295.3)	0.99
WBC, median (IQR) (×10^9/L)	14.37 (12.33–16.11)	15.57 (12.64–17.54)	0.43
Antibiotic treatment, n (%)	25 (81)	24 (82)	0.99
Nutritional support, n (%)			0.77
Enteral feeding only	16 (51)	17 (61)	
Parenteral feeding only	3 (10)	1 (3)	
Enteral and parenteral feeding	9 (29)	8 (29)	
Oral diet	3 (10)	2 (7)	

*$P < 0.05$.

APACHE, acute physiology and chronic health evaluation; ASA, American Society of Anesthesiologists; BMI, body mass index; CRP, C-reactive protein; ICU, intensive care unit; IQR, interquartile range; SIPN, small incision pancreatic necrosectomy; SIRS, systemic inflammatory response syndrome; VARD, video-assisted retroperitoneal debridement; WBC, white blood cell count.

significant reduction in the number of procedures, which was associated with a shorter length of hospital stay and lower costs. Conversely, a shorter length of hospital stay and cheaper surgical instruments can also reduce hospital costs.

There was a significant difference in percutaneous catheter *in situ* prior to intervention. Compared with VARD, the position of the access in the SIPN approach was more flexible according to lesion locations. The access of VARD, in our experience, must be under the guide of the PCD tube. Thus, a percutaneous catheter *in situ* prior to the intervention for VARD is critical. The timing of the surgical intervention in for IPN has changed over the last two decades. In this study, the median time to initial intervention was 34 days in the SIPN group and 38 days in the VARD group, respectively, which is consistent with current research. The current consensus advocates that surgical intervention must be postponed up to 4 weeks after symptoms onset, because after that time the pancreatic necrosis is delimited.[10,11] In terms of treatment success, SIPN and VARD are both an effective treatment for IPN. Within 30 days of intervention, 68% of patients survived and clinical improvement in each group. In line with this finding, Raraty *et al.*[12] performed a retrospective analysis and follow-up of 394 patients, and concluded that the success rate of MIN was approximately 69.5%.

If symptoms worsen after MIN, conversion to OPN should be considered. In our study, the rate of conversion to OPN was almost equivalent between the two groups. Compared with OPN, MIN has huge advantages on reducing major complications, and the overall complication rate in each group was low. Abdominal bleeding occurred more frequently in the VARD than that in SIPN group, although this was no statistical difference (6% versus 18%). The advantage of VARD is that necrotic tissue can be removed under

Table 2 Outcomes and complications of interventions

Characteristic	SIPN (n = 31)	VARD (n = 28)	P-value
Primary endpoint, n (%)			
Treatment success†	21 (68)	19 (68)	0.99
Death	5 (16)	5 (18)	0.85
SIRS‡	14 (45)	9 (32)	0.30
Organ failure	5 (16)	6 (21)	0.60
Pancreatic fistula	5 (16)	3 (11)	0.82
Visceral perforation	2 (6)	2 (7)	0.67
Abdominal bleeding	2 (6)	5 (18)	0.34
Surgical site infection	2 (6)	1 (4)	0.92
Conversion to OPN	5 (16)	5 (18)	0.85
Reinterventions due to lack of clinical improvement§	10 (32)	17 (61)	0.028*
Secondary endpoint			
Incisional hernia, n (%)	2 (6)	1 (4)	0.92
New onset diabetes¶, n (%)	4 (13)	3 (11)	0.88
New diagnosis of pancreatic insufficiency, n (%)††	3 (10)	2 (7)	0.90
Length of ICU stay, median (IQR) (days)	13 (9–18)	13.5 (8–22.5)	0.55
Total hospital stay, median (IQR) (days)	60 (52–71)	72 (59.5–87)	0.008*
Mean total costs, mean ± SD (CNY)	176 473 ± 77 057	271 218 ± 74 063	<0.0001*

*$P < 0.05$.

†Within 30 days of intervention, patients survived and clinical improvement.

‡SIRS persisted 3 days after operation.

§Persistence or recurrence of a fever, elevated white blood cell counts, the presence of ongoing necrosis.

¶Insulin or oral antidiabetic drugs required 6 months after discharge; this requirement was not present before onset of pancreatitis.

††Oral pancreatic-enzyme supplementation required to treat clinical symptoms of steatorrhea 6 months after discharge; this requirement was not present before onset of pancreatitis.

CNY, Chinese Yuan; ICU, intensive care unit; IQR, interquartile range; OPN, open pancreatic necrosectomy; SD, standard deviation; SIPN, small incision pancreatic necrosectomy; SIRS, systemic inflammatory response syndrome; VARD, video-assisted retroperitoneal debridement.

direct vision, but there is a higher risk of bleeding. This is related to the possibility of tearing or rupturing blood vessels wrapped in necrotic tissue with forceps during the operation. During SIPN, the use of fingers could avoid sharp injuries of important organs and blood vessels. In fact, VARD and SIPN have always been an important part in the concept of step up approach and are the most classic minimally invasive techniques. In our experience, both processes of debridement are very similar to OPN, and do not need additional devices. Furthermore, it is easy to convert from SIPN/VARD to OPN, if the patient's condition does not improve.

While we did not compare ETN in this study, it is critical to understand how to make a reasonable choice about optimal necrosectomy technique. ETN was first described by Seifert *et al.*[13] in 2000. Since then, ETN has become increasingly popular and various studies about ETN have been emerging. Some researchers even considered ETN to be the best surgical debridement approach at that time. Sandra *et al.*[14] reported that more than 80% of patients were treated successfully with ETN alone. ETN has been shown to reduce complications and it can be performed without an external drainage system and general anaesthesia. In cases of biliary pancreatitis, surgical transgastric necrosectomy, and cholecystectomy can be performed simultaneously to obviate the need for multiple procedures. However, there are still some disadvantages about ETN. On one hand, ETN is more restrictive and a preferred route from the posterior stomach to the necrosis cavity. On the other, endoscopic debridement often faces the dilemma of residual infection and necrotic lesions that require multiple debridement. In order to avoid the limitations of the debridement route, some medical centres have combined endoscopic transluminal drainage with PCD, that is to say, a new concept of dual modality drainage (DMD) is being proposed. In the original description of DMD, none of the patients required surgical necrosectomy or surgical treatment of DMD-related adverse events.[15]

At present, MIN has been raised to an unprecedented level. Excessively minimally invasive treatment and relatively inadequate surgical intervention has caused the patient's condition to be delayed, and even irreversible sepsis. OPN, as the ultimate procedure of the step-up approach, still needs to be considered rationally. About 10–20% of patients with IPN can be treated successfully by OPN.[16,17] Today's OPN is no longer the 'first choice' of the past, but rather follows the concept of step-up approach under the condition of reasonable indications and timing. This approach is safer and more feasible than traditional OPN, and its value cannot be ignored. Gomatos *et al.*[18] suggested that the conversion from minimal access retroperitoneal pancreatic necrosectomy to OPN was an independent risk factor for death in patients with IPN. The cause of death may be related to the metabolic deterioration and deprivation of physiological reserve caused by persistent sepsis. Therefore, the wise and timely use of OPN is necessary to reduce mortality.

Our study has some limitations. First, a retrospective study with a small sample size likely affected the statistical power of the results, especially in terms of mortality and rate of treatment

success. Second, this was a non-randomized controlled trial at a single centre, so selection bias seemed to be unavoidable. Third, the study represented our initial experience with MIN for IPN. Our study specifically compared two treatment strategies and did not provide a direct comparison of VARD and minimal access retroperitoneal pancreatic necrosectomy. Compared to VARD, SIPN could be performed in vastly different ways based on the lesion locations, which meant it was more of a concept rather than a real technique. Therefore, compared with a 'technique', the application of 'concept' is more extensive and flexible. On the contrary, this also provides clinicians with more choices.

In summary, SIPN has some advantages in the treatment of IPN, and it is safe and effective. Given the shorter hospitalization period, lower health care utilization, and lower rate of reinterventions, SIPN may be superior to the step-up approach for patients with IPN. This was a retrospective study and the sample size was small. Therefore, more randomized controlled trials are needed to confirm these advantages.

Conflicts of interest

None declared.

References

1. Fagenholz PJ, Fernández-del Castillo C, Harris NS, Pelletier AJ, Camargo CA Jr. National study of United States emergency department visits for acute pancreatitis, 1993-2003. *BMC Emerg. Med.* 2007; **7**:1
2. van Santvoort HC, Bakker OJ, Bollen TL *et al*. A conservative and minimally invasive approach to necrotizing pancreatitis improves outcome. *Gastroenterology* 2011; **141**: 1254–63.
3. Working Group IAP/APA Acute Pancreatitis Guidelines. IAP/APA evidence-based guidelines for the management of acute pancreatitis. *Pancreatology* 2013; **13**: e1–15.
4. van Santvoort HC, Besselink MG, Bakker OJ *et al*. A step-up approach, or open necrosectomy for necrotizing pancreatitis. *N. Engl. J. Med.* 2010; **363**: 1286–7.
5. van Brunschot S, van Grinsven J, van Santvoort HC *et al*. Endoscopic or surgical step-up approach for infected necrotising pancreatitis: a multicentre randomised trial. *Lancet* 2018; **391**: 51–8.
6. 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**: 102–11.
7. van Dijk SM, Hallensleben N, van Santvoort HC *et al*. Acute pancreatitis: recent advances through randomised trials. *Gut* 2017; **66**: 2024–32.
8. Knaus WA, Sun X, Nystrom O, Wagner DP. Evaluation of definitions for sepsis. *Chest* 1992; **101**: 1656–62.
9. Nemoto Y, Attam R, Arain MA *et al*. Interventions for walled off necrosis using an algorithm based endoscopic step-up approach: outcomes in a large cohort of patients. *Pancreatology* 2017; **17**: 663–8.
10. Forsmark CE, Vege SS, Wilcox CM. Acute pancreatitis. *N. Engl. J. Med.* 2016; **375**: 1972–81.
11. Freeman ML, Werner J, van Santvoort HC *et al*. Interventions for necrotizing pancreatitis: summary of a multidisciplinary consensus conference. *Pancreas* 2012; **41**: 1176–94.
12. Raraty MG, Halloran CM, Dodd S *et al*. Minimal access retroperitoneal pancreatic necrosectomy: improvement in morbidity and mortality with a less invasive approach. *Ann. Surg.* 2010; **251**: 787–93.
13. Seifert H, Wehrmann T, Schmitt T, Zeuzem S, Caspary WF. Retroperitoneal endoscopic debridement for infected peripancreatic necrosis. *Lancet* 2000; **356**: 653–5.
14. van Brunschot S, Fockens P, Bakker OJ *et al*. Endoscopic transluminal necrosectomy in necrotising pancreatitis: a systematic review. *Surg. Endosc.* 2014; **28**: 1425–38.
15. Ross AS, Irani S, Gan SI *et al*. Dual-modality drainage of infected and symptomatic walled-off pancreatic necrosis: long-term clinical outcomes. *Gastrointest. Endosc.* 2014; **79**: 929–35.
16. Madenci AL, Michailidou M, Chiou G, Thabet A, Fernández-del Castillo C, Fagenholz PJ. A contemporary series of patients undergoing open debridement for necrotizing pancreatitis. *Am. J. Surg.* 2014; **208**: 324–31.
17. Doctor N, Philip S, Gandhi V, Hussain M, Barreto SG. Analysis of the delayed approach to the management of infected pancreatic necrosis. *World J. Gastroenterol.* 2011; **17**: 366–71.
18. Gomatos IP, Halloran CM, Ghaneh P, Raraty MGT, Neoptolemos JP. Outcomes from minimal access retroperitoneal and open pancreatic necrosectomy in 394 patients with necrotizing pancreatitis. *Ann. Surg.* 2015; **43**: 992.