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RESEARCH

Minimal-invasive percutaneous step-up approach compared to endoscopic procedures in the treatment of walled off pancreatic necrosis: a retrospective study

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Abstract

Background Acute infected necrotizing pancreatitis is characterized by high rates of systemic infection with organ failure and mortality. The step-up approach combining percutaneous drainage with laparoscopic-assisted pancreatic necrosectomy (LAPN) or transgastric necrosectomy shows a lower incidence of complications and mortality than open necrosectomy. This study aimed at comparing minimal-invasive percutaneous and endoscopic step-up approach.

Methods A retrospective analysis of patients undergoing the step-up approach for infected necrotizing pancreatitis between 2019 and 2023 was conducted. Percutaneous treatment involved CT-guided percutaneous drainage followed by LAPN if needed, while the endoscopic approach used transgastric drainage and endoscopic necrosectomy. Primary outcome was a composite of major complications or 6-month mortality. Secondary outcomes included complication rates, number of reinterventions, duration of hospital stay and mortality.

Results The study included 31 patients. Eighteen patients underwent the percutaneous step-up approach, consisting of CT-guided drainage, followed by LAPN in 11 cases (61.1%). Thirteen patients were treated endoscopically which involved transgastric drainage, followed by necrosectomy in 7 cases (53.8%). The composite of major complications or death occurred in 55.6% of the percutaneous group and in 53.8% of the endoscopic group. Postoperative major complications were reported in eight patients in the percutaneous group and five in the endoscopic group. Four patients required LAPN after endoscopic necrosectomy due to insufficient improvement.

Conclusion LAPN and endoscopic necrosectomy are effective in controlling local and systemic infection in severe necrotizing pancreatitis. LAPN remains important in managing extensive infected necrosis, particularly when transgastric methods cannot fully address the necrosis cavity.

Keywords Acute necrotizing pancreatitis · Pancreatic necrosis · Drainage · Laparoscopy · Endoscopy

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Introduction

Acute pancreatitis is one of the most common gastrointestinal disorders, often requiring hospitalization and multiple interventions [1, 2]. In its severe form, the condition can lead to organ failure and necrosis in 10–20% of cases with approximately one third of these necroses becoming infected [3, 4]. This infectious complication significantly contributes to both the elevated disease-related mortality and the substantial costs associated with hospital care [5, 6]. Thanks to the most recent evidence, treatment of severe pancreatitis has dramatically changed over the last decades. High-level evidence was generated throughout the last years for almost every aspect of treating complicated acute pancreatitis. However, complication rates remain high, and the optimal patient-tailored approach has yet to be defined.

The paradigm of open pancreatic necrosectomy for treating walled-off necrosis and superinfection has shifted to a step-up approach that includes drainage followed by necrosectomy (in case of insufficient clinical improvement after drainage only). The minimal-invasive percutaneous step-up approach consists of percutaneous CT-guided drainage followed by retroperitoneal necrosectomy, which can be performed either as video-assisted retroperitoneal debridement with an incision of 50 mm length (VARD) or as a laparoscopic-assisted pancreatic necrosectomy (LAPN) using 12 mm incisions only for laparoscopic trocars with a retroperitoneal dissection [7, 8]. On the other hand, the endoscopic step-up approach consists of a transgastric drainage followed by transgastric necrosectomy if necessary [6]. This step-up approach has led to a significant reduction in postoperative complications and mortality compared to open necrosectomy [6]. The ultimate goal of these less invasive techniques is to control the source of infection and minimize surgical trauma, which could be detrimental in critically ill patients [8, 9]. A randomized study showed that the endoscopic approach is not inferior to the minimal-invasive percutaneous step-up approach with video-assisted retroperitoneal debridement (VARD) regarding major complications or death [9]. To date, only one study has described LAPN as a minimally invasive technique for retroperitoneal necrosectomy using 12 mm incisions only instead of an incision of 50 mm length used in the VARD technique, providing a retrospective analysis of postoperative outcomes but lacking a direct comparison to the endoscopic step-up approach [8]. However, within the step-up approach, it remains unclear whether LAPN should be designated as a second-line treatment reserved as a rescue option following failed or technically unfeasible endoscopic intervention, or if the minimal-invasive percutaneous step-up approach with LAPN can also be proposed as a first-line approach.

The aim of this study was to assess different therapy options for pancreatic walled-off necrosis within a step-up approach.

Methods

Patient selection, data collection, and outcomes

At our institution, we conducted a retrospective search of our digital medical records to identify patients over the age of 18 years with severe pancreatitis and infected walled-off necrosis. The search covered the period from 2019 to 2023. We excluded patients with recurrent pancreatitis, pancreatic neoplasms, and those with a history of previous pancreatic or gastric surgery.

Data collection included demographic and clinical characteristics such as age, sex, body mass index (BMI), American Society of Anesthesiology (ASA) score, cause of pancreatitis, Ranson score at admission and after 48 h, intensive care unit admission, length of stay in intensive care unit, antibiotic treatment, type of intervention (e.g., CT-guided drainage, video-assisted retroperitoneal debridement, transgastric drainage, or transgastric necrosectomy), intraoperative and postoperative complications according to the Clavien-Dindo classification [10], Comprehensive Complication Index (CCI) and need for re-intervention, length of hospital stay, and discharge destination with assessment of the first 6 months after onset of the present pancreatitis episode.

All patients were treated as part of a step-up approach for severe acute pancreatitis. Patients were allocated into two groups according to the intention to treat: either minimal-invasive percutaneous surgical treatment (CT-guided drainage followed by LAPN) or endoscopic treatment (transgastric drainage followed by endoscopic necrosectomy). The decision to drain, either percutaneously or transgastrically, was made in cases of suspected infection of a peripancreatic collection. The type of initial intervention was chosen after a multidisciplinary discussion considering factors such as the patient's general condition, the anatomical characteristics of the peripancreatic collection, and the availability of radiological, gastroenterological, and surgical expertise. The inclusion criteria for endoscopic approach were necrosis cavities located directly opposite the posterior gastric wall or the duodenum (Fig. 1) whereas a feasible retroperitoneal drainage route without the risk of an organ lesion was the indication for the percutaneous treatment (Fig. 2).

The primary outcome was composite and combined post-interventional major complications (Clavien-Dindo grade ≥ 3) or mortality within 6 months after the onset of pancreatitis. Secondary outcomes were rate of complications, the need for re-intervention, and the length of hospital stay.

Fig. 1 Inclusion criteria for endoscopic approach: Necrosis cavity directly opposite the posterior gastric wall

We defined walled-off necrosis as a well-circumscribed, encapsulated necrotic tissue that occurs as a late complication, four weeks after the onset of severe acute pancreatitis and contains both solid and fluid components. Superinfection of the pancreatic collections was defined based on a combination of clinical, radiological, and microbiological findings such as fever, signs of systemic infection, elevated inflammatory markers, the presence of gas bubbles in the pancreatic fluid collection, marked contrast enhancement of the collection wall or signs of surrounding inflammation, and positive blood or fluid cultures [3].

As part of the minimal-invasive percutaneous step-up approach, a percutaneous drainage was first placed in the peripancreatic collection under CT-guidance. Drainage placement was planned by senior radiologists and senior surgeons together to provide a feasible retroperitoneal route

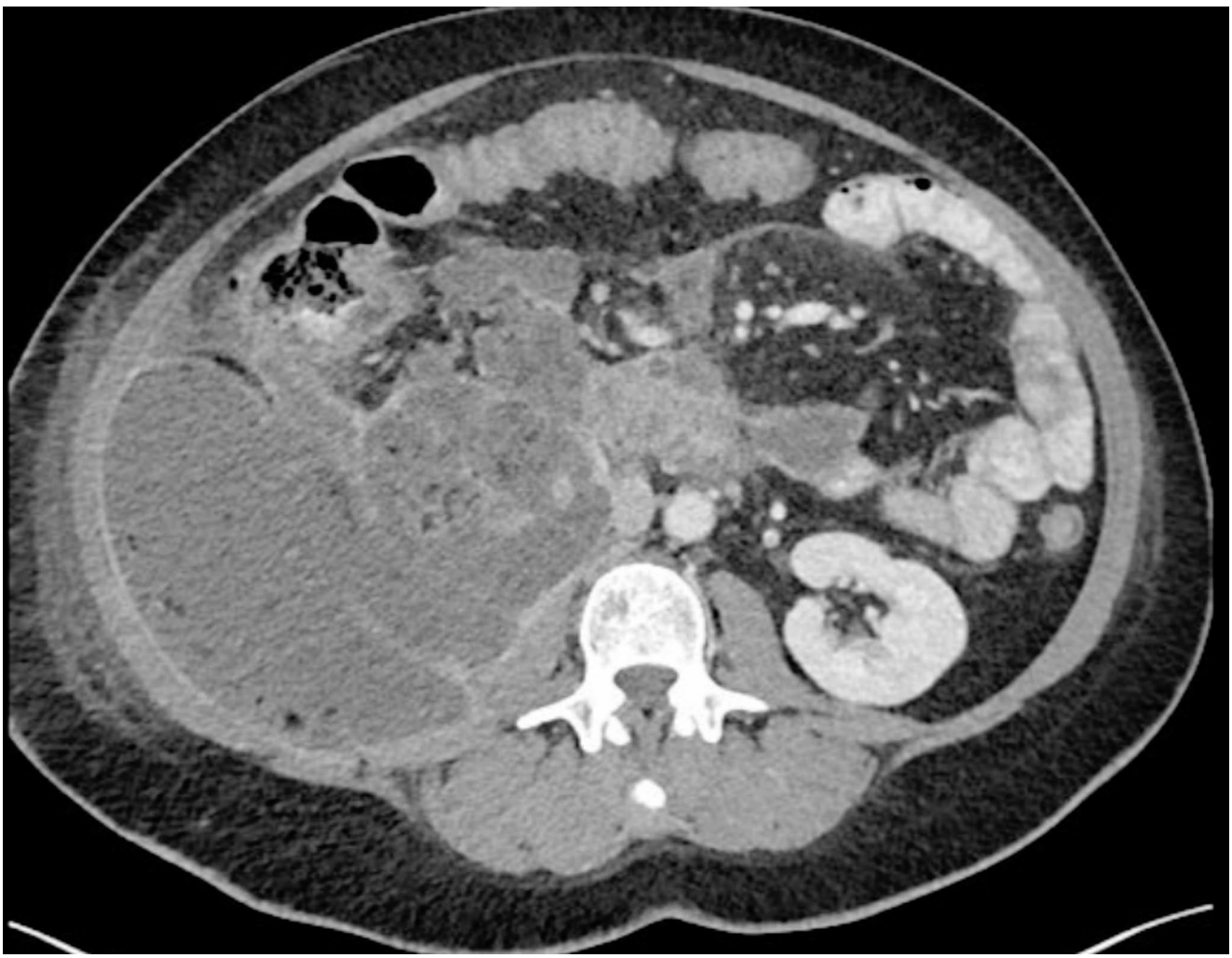

Fig. 2 Inclusion criteria for percutaneous approach: Retroperitoneal necrosis cavity distant from the gastric wall

for the subsequent video-assisted retroperitoneal debridement, avoiding other organs as well as the thoracic cavity. If possible two pigtail catheters were used. If there was no clinical improvement of the patient's condition, a LAPN was performed by a senior surgeon. A 12 mm transparent trocar was inserted under visualization with a 30°-degree laparoscope. The necrotic cavity was safely reached by dissecting along the retroperitoneal drainage route under visualization (Figs. 3, 4, 5 and 6) [11].

In the endoscopic step-up approach, transgastric drainage was placed endoscopically by senior gastroenterologists. This technique required the necrosis cavity to be directly opposite to the posterior gastric wall or the duodenum [12]. The cavity was localized by endoscopic ultrasound and a stent and/or drainage were placed for further drainage or reintervention. Endoscopic transluminal necrosectomy was performed if there was insufficient clinical improvement after a few days.

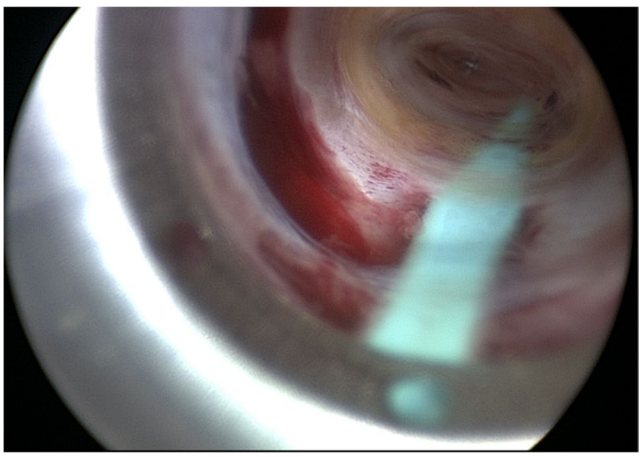

Fig. 3 Surgical approach in LAPN with the insertion of a 12 mm transparent trocar along the retroperitoneal drainage (blue)

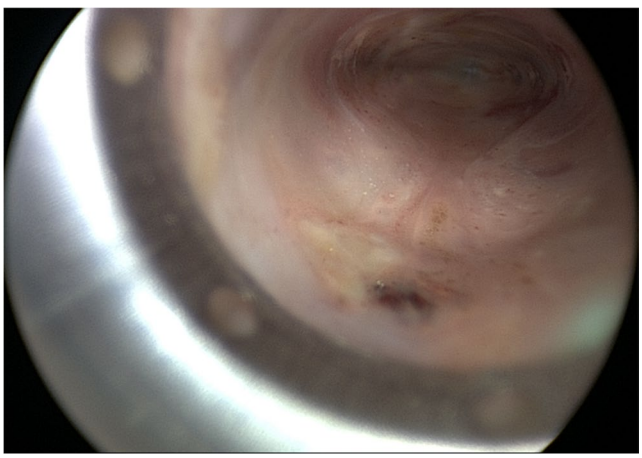

Fig. 4 Reaching the necrosis cavity dissecting along the retroperitoneal drainage route under visualization

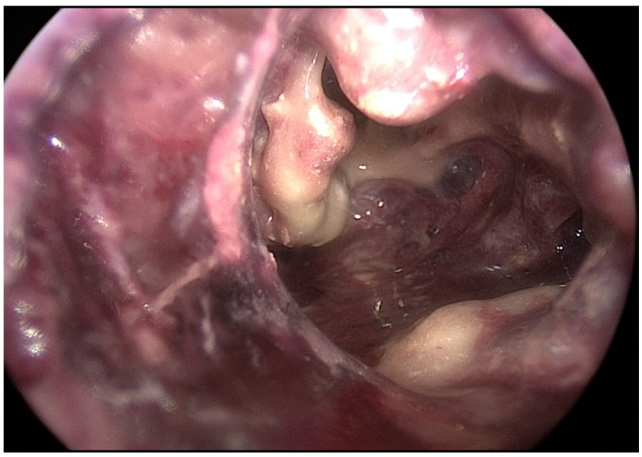

Fig. 5 Debridement after insertion of a second 12 mm trocar

Ethical statement

The study was approved by the ethics committee EKNZ Switzerland (proposal number 2023 − 00470). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement was followed [13].

Statistical analysis

Descriptive statistics were presented as frequencies for categorical variables and as means with standard deviations (SD) for continuous variables. The chi-square test was used to compare dichotomous variables, while the Student t-test was employed for continuous variables. All analyses were conducted using MedCalc® Statistical Software version 22.032 (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2024).

Results

During the study period, 956 patients suffering from acute pancreatitis were treated at our institution, of which 31 patients with necrotizing pancreatitis and infected peripancreatic collections requiring invasive intervention were identified and included in the present study. The mean age was 60.7 ± 14.2 years; 19 (61.3%) patients were male, the mean BMI was 25.7 ± 6.5 kg/m², and 27 (87.1%) patients were classified with an ASA score ≥ 3. Eighteen patients were treated with the minimal-invasive percutaneous step-up approach and underwent initial CT-guided drainage, followed by LAPN in 11 patients (61.1%), while 13 patients were treated with the endoscopic step-up approach and underwent transgastric drainage, followed by endoscopic necrosectomy in 7 patients (53.8%). The two step-up

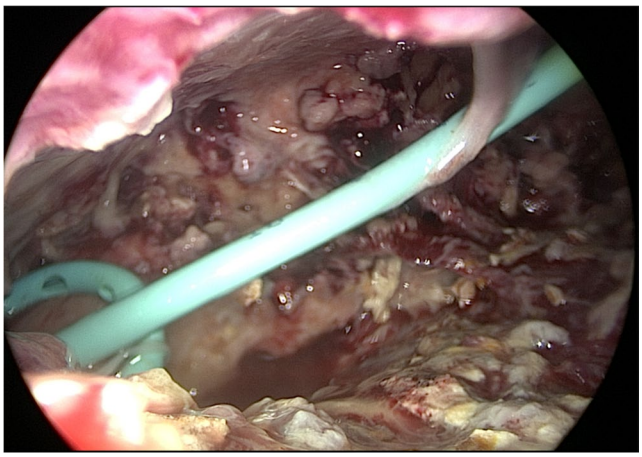

Fig. 6 Visualization of the necrosis cavity after debridement

approaches are represented as flow chart in Fig. 7. Patient's characteristics, divided into the two groups, are reported in Table 1. There was no clinically meaningful difference in both groups except for the etiology of pancreatitis. 27.8% of patients in the minimal-invasive percutaneous surgical group were diagnosed with gallstones compared to 53.8% in the endoscopic treatment group. Post-ERCP pancreatitis occurred in 33.3% of the minimal-invasive percutaneous surgical group and none of the endoscopic treatment group. Characteristics of the peripancreatic fluid collections are reported in Table 2.

Regarding the primary endpoint, eight patients (44.4%) in the minimal-invasive percutaneous surgical group (five patients received a LAPN, and three patients underwent CT-guided drainage only) and five patients (38.5%) in the transgastric group (three patients received endoscopic necrosectomy, two patients underwent transgastric drainage only) experienced a major complication. Mortality was 11.1% in the minimal-invasive percutaneous group (one patient underwent LAPN and one patient received CT-guided drainage only) and 15.4% in the endoscopic treatment group (one patient received endoscopic necrosectomy and one patient CT-guided drainage only). A composite of major complications or death within six months after pancreatitis occurred in 55.6% of the minimal-invasive percutaneous group and in 53.8% of the endoscopic treatment group.

In all patients, indication for drainage of the peripancreatic collections was made after a mean of 12.8±9.8 days after diagnosis of a necrotizing pancreatitis: 14.9±10.8 days in the percutaneous surgical group and 9.9±7.8 days in the transgastric group. After CT-guided drainage, patients underwent LAPN after a mean of 23.0±15.0 days, whereas following transgastric drainage, endoscopic necrosectomy was performed after 4.0±1.2 days ($p<0.001$). The complications are reported in Table 3. Seven patients in the percutaneous group were treated with CT-guided drainage only. Of those patients, five experienced a complication: one Clavien-Dindo grade 5 (death due to multi organ failure), one Clavien-Dindo grade 4a (single organ dysfunction), two Clavien-Dindo grade 3a (pleural empyema, pancreatic vessel coiling) and one Clavien-Dindo grade 2 (blood transfusion). In the LAPN group, patients underwent an average of 5.9±3.5 procedures, with an operative time of 73±19 min. There was one intraoperative complication in the LAPN group with pancreatic vascular bleeding requiring coiling. Postoperatively, there was one case (9.1%) of multiorgan dysfunction and two single organ dysfunction (18.1%) recorded, and a total of ten (90.9%) complications occurred: one Clavien-Dindo grade 5 (death), one Clavien-Dindo grade 4b (septic shock), two Clavien-Dindo grade

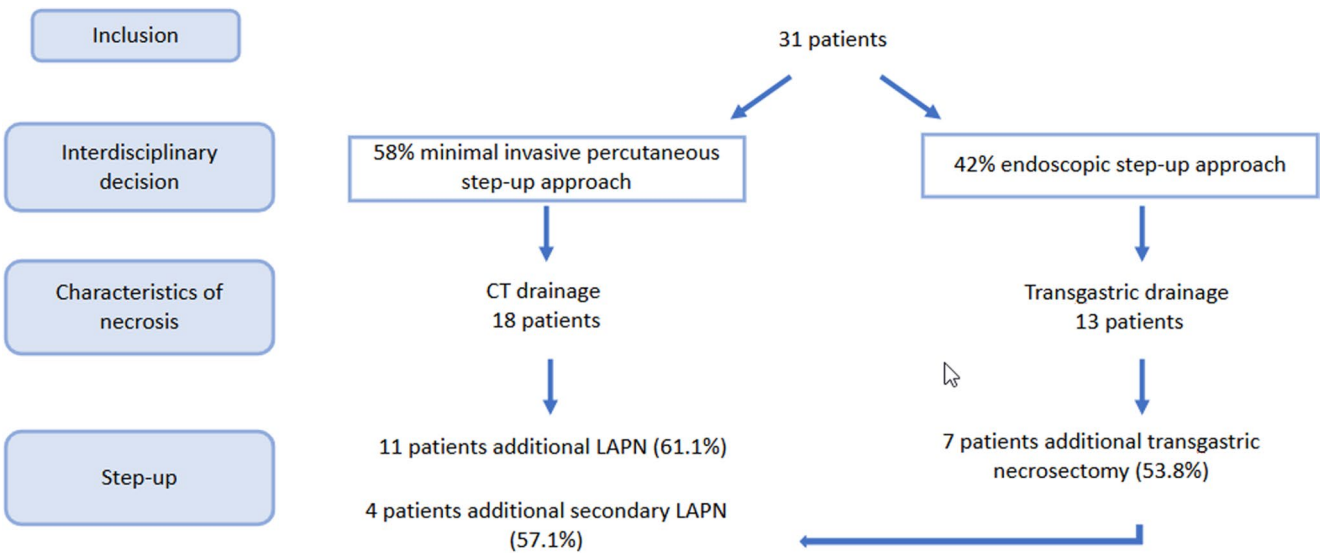

Fig. 7 The two step-up approaches as flow chart

Table 1 Patients' characteristics

	Percutaneous drainage +/- LAPN *N*=18	Transgastric drainage +/- necrosectomy *N*=13	*p*
Age, years	59.5 (17.6)	62.5 (7.8)	0.576
Sex, female	8 (44.4)	4 (30.8)	0.448
Body mass index, kg/m^2	25.5 (5.6)	25.9 (7.8)	0.881
ASA score			
• 2	1 (5.6)	3 (23.1)	0.254
• 3	11 (61.1)	8 (61.5)	
• 4	6 (33.3)	2 (15.4)	
Pancreatitis etiology			
• Gallstones	5 (27.8)	7 (53.8)	0.021
• Alcohol	2 (11.1)	5 (38.5)	
• Post-ERCP	6 (33.3)	0	
• Unknown	5 (27.8)	1 (7.7)	
Ranson score			
• On admission	2.3 (1.5)	1.7 (1.0)	0.231
• After 48 h	2.8 (2.0)	1.6 (1.4)	0.166
Intensive care admission	12 (66.7)	5 (38.5)	0.126

Categorical variables are expressed as n (%), continuous variables were expressed as means with standard deviations (SD)

ERCP endoscopic retrograde cholangiopancreatography, *LAPN* laparoscopic-assisted pancreatic necrosectomy

Table 2 Characteristics of peripancreatic fluid collections

	Percutaneous drainage +/- LAPN *N*=18	Transgastric drainage +/- necrosectomy *N*=13	*p*
Diameter 1	10.6 (4.0)	11.2 (4.5)	0.366
Diameter 2	6.2 (2.2)	7.4 (3.2)	0.214
Area [cm ^{2}]	55.7 (33.6)	78.1 (55.9)	0.174
Type of collection content			
• Fluid	9 (50.0)	9 (69.2)	0.292
• Necrosis	9 (50.0)	4 (30.8)	
Contact between the collection and stomach	8 (44.4)	13 (100)	0.001

Categorical variables are expressed as n (%), continuous variables were expressed as means with standard deviations (SD)

LAPN laparoscopic-assisted pancreatic necrosectomy

4a (single organ dysfunction) two Clavien-Dindo grade 3 (pneumothorax, colonic fistula), three Clavien-Dindo grade 2 (aspiration pneumonia, superior mesenteric vein thrombosis, paralytic ileus) and one Clavien-Dindo grade 1.

In the endoscopic necrosectomy group, patients underwent an average of 4.7±3.1 procedures, similar to the LAPN group. One intraoperative complication occurred in the endoscopic treatment group, also involving pancreatic vascular bleeding requiring coiling. In two cases, transgastric drainage failed due to anatomical concerns. In addition, four patients required LAPN as a rescue procedure to treat more extensive peripancreatic necrosis after undergoing multiple endoscopic necrosectomies. Four postoperative complications occurred after endoscopic drainage: one Clavien-Dindo grade 5 (death after septic shock), two Clavien-Dindo grade 3a (pleural effusion, ascites) and one Clavien-Dindo grade 1. Six postoperative complications (85.7%) occurred after endoscopic necrosectomy: one Clavien-Dindo grade 5 (after pancreatic vessel coiling, the patient developed colon transversum ischemia and perforation, leading to multiorgan dysfunction and death), one Clavien-Dindo grade 4a (respiratory distress syndrome), one Clavien-Dindo grade 3b (pancreatic vessel coiling), one Clavien-Dindo grade 3a (small bowel perforation), and two Clavien-Dindo grade 2 (portal vein thrombosis and splenic vein thrombosis, atrial fibrillation). The mean CCI at discharge, after 3 and 6 months is reported in Table 4. After 6 months the mean CCI was 40.9 in the minimal-invasive percutaneous and 40.8 in the endoscopic treatment group.

Finally, the intensive care unit stay was 16.5±16.4 days in the minimal-invasive percutaneous/surgical treatment group and 27.6±31.4 days in the endoscopic treatment group (p=0.340). The total length of hospital stay was 81.1±36.3 days in the minimal-invasive percutaneous treatment group and 60.7±50.7 days in the endoscopic treatment group (p=0.333).

Discussion

Our study shows that even within a step-up approach, acute severe pancreatitis is associated with a high rate of major complications. Patients who require only percutaneous or transgastric drainage are likely to have the most favorable outcomes. The multidisciplinary decision to assign patients to a minimal-invasive percutaneous surgical or transgastric approach should be tailored to the characteristics/localisation of the pancreatic collections and the patient's clinical condition. Both approaches were effective in controlling the source of infection, with LAPN serving not only as a rescue procedure for extensive peripancreatic necrosis but also as a feasible method for primary infected peripancreatic collection treatment. A combination of these approaches should therefore be considered in individual cases. The current data provides limited evidence to significantly favor one approach over the other.

Our results are consistent with those of the Dutch Pancreatitis Study Group. In their series of studies (PANTER Trial, TENSION Trial and Extension Study) there was no superiority of the endoscopic step-up approach over the percutaneous approach [6, 9, 14]. These findings were consistent in a 7-years follow-up, regarding mortality and major complications. However, there were fewer pancreatic fistulas and a

Table 3 Postoperative complications (Clavien-Dindo classification)

	Percutaneous				Endoscopic			
	CT	LAPN	all	%	drain	necrosectomy	all	%
number of patients	7	11	18	100	6	7	13	100
CD 0	2	1	3	16.7	2	1	3	23.1
CD 1	0	1	1	5.6	1	0	1	7.7
CD 2	1	3	4	22.2	0	2	2	15.4
CD 3a	2	2	4	22.2	2	1	3	23.1
CD 3b	0	0	0	0	0	1	2	15.4
CD 4a	1	2	3	16.7	0	1	0	0
CD 4b	0	1	1	5.6	0	0	0	0
CD 5/death	1	1	2	11.1	1	1	2	15.4
intraoperative	0	1	1	5.6	0	1	1	7.7
postoperative (CD 1–5)	5	10	15	83.3	4	6	10	76.9
major complications (CD≥3)	3	5	8	44.4	2	3	5	38.5
composite endpoint (major complications & death)	4	6	10	55.6	3	4	7	53.8

Table 4 Postoperative complications (Comprehensive complication Index)

	percutaneous			endoscopic		
mean CCI	CT drain	LAPN	all	drain	necrosectomy	all
CCI at discharge	34.5	40.3	38	8.1	42	26.4
CCI after 3 months	37.3	42.2	40.3	15.1	47.9	32.8
CCI after 6 months	37.3	43.3	40.9	30.9	49.2	40.8

lower reintervention rate in the endoscopic treatment group at a 6-month follow-up. There has only been an analysis of the results of VARD using a 50 mm incision as a technique, while a randomized trial of LAPN using 12mm incisions only as a surgical method is still missing.

In 2021, the Dutch Pancreatitis study group compared immediate drainage within 24 h of diagnosis, with delayed intervention for infected necrosis. Drainage delayed until the collection was largely "walled-off" showed no superiority in outcome over early treatment. The postponed intervention group, however, received fewer reinterventions [15]. Van Santvoort et al. showed in their study, that an earlier intervention was associated with a higher morbidity and mortality [16]. In our study, patients in the transgastric group underwent drainage earlier than those in the percutaneous group. Additionally, the interval between drainage and endoscopic necrosectomy was much shorter than in the LAPN procedure. These findings align with those reported by van Brunschot et al. in their multicentric randomized trial [9]. They attributed this difference to the higher threshold for performing LAPN, as the surgeon must follow a drain-guided route established by a radiologist. In endoscopic necrosectomy, on the other hand, the same gastroenterologist follows the same drainage route that he or she has established. In our study, drainage was placed with a median of 12 days after the diagnosis of a necrotizing pancreatitis, but the time after the initial diagnosis of pancreatitis was not analysed. In conclusion, the ideal point of time for intervention after diagnosis has yet to be defined. In our study the LAPN procedure was performed in four patients as a rescue procedure after already receiving multiple endoscopic interventions due to a lack of clinical improvement. The additional percutaneous necrosectomies were associated with an even higher rate of severe complications in these patients. In the TENSION Trial a similarly small number of patients in the endoscopy group received an additional LAPN procedure [9]. However, no additional endoscopic necrosectomy was required in the surgical percutaneous group.

This study has several limitations. We conducted a retrospective analysis, and only a relatively small number of patients were included. Due to the limited sample size, further statistical analyses (e.g., multivariable analysis, propensity score matching, or time-dependent analyses) could not be performed. Data is heterogeneous, and patients were allocated to either the minimal-invasive percutaneous surgical or endoscopic treatment group based on multidisciplinary assessment. Most patients underwent multiple procedures, and four patients initially treated with endoscopic necrosectomy required a LAPN due to extensive peripancreatic necrosis that could not be addressed transgastrically.

Despite these limitations, our study provides a detailed description of different approaches within a step-up treatment for acute severe pancreatitis involving a high number of the relatively new LAPN procedure in this rare disease. These findings are relevant and applicable to surgeons, gastroenterologists, radiologists, and centers managing

acute severe pancreatitis within a step-up approach. The experience of the surgical, endoscopic and interventional radiology specialists in treating necrotizing pancreatitis is important for success, as each treatment requires a learning curve.

Conclusion

Our findings indicate that, even within a step-up approach, acute severe pancreatitis is associated with a high morbidity. Patients requiring only percutaneous or transgastric drainage tend to have the most favorable outcomes. Both video-assisted and endoscopic peripancreatic necrosectomy effectively controlled the source of infection, LAPN may serve not only as a rescue procedure for more extensive infected necrosis, but also as a primary approach in cases where direct contact between the infected collections and the gastric wall is missing. However, current data provides limited evidence as to significantly favor one approach over the other.

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Author contributions VK - Study conception and design, Acquisition of data, Drafting of manuscript, Critical revision of manuscript HP - Study conception and design, Acquisition of data, Drafting of manuscript JM - Study conception and design, Drafting of manuscript, Critical revision of manuscript AS - Critical revision of manuscript SB - Critical revision of manuscript STB - Critical revision of ma nuscript JM - Critical revision of manuscript MB - Critical revision of manuscript FM- Study conception and design, Analysis and interpretation of data, Critical revision of manuscript JMG - Study conception and design, Analysis and interpretation of data, Drafting of manuscript, Critical revision of manuscript.

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Data availability The data that support the findings of this study are available from the authors, but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available. The data are, however, available from the authors upon reasonable request.

Declarations

Ethics approval The study was approved by the ethics committee EKNZ Switzerland (proposal number 2023 − 00470).

Competing interests Stephan Baumeler received a speaking fee from Schwabe pharmaceutics and is member of the committee of the Swiss society for coloproctology. Simon Bütikofer received a fee for consulting Fujifilm Europe and a support for attending the UEGW Copenhagen and the ESGE Days in Berlin from Tillots Pharma and Alfasigma. He is member of the Advi-sory Board for Eosinophilic Esophagitis. The other authors have no relevant financial or non-financial interests to disclose.

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