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ORIGINAL ARTICLE

Focused open necrosectomy in necrotizing pancreatitis

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Abstract

Background: The control of sepsis is the primary goal of surgical intervention in patients with infected necrosis. Simple surgical approaches that are easy to reproduce may improve outcomes when specialists in endoscopy are not available. The aim of the present study was to describe the experience with a focused open necrosectomy (FON) in patients with infected necrosis.

Method: A prospective pilot study conducted to compare a semi-open/closed drainage laparotomy and FON with the assistance of peri-operative ultrasound. The incidence of sepsis, dynamics of C-reactive protein (CRP), intensive care unit (ICU)/hospital stay, complication rate and mortality were compared and analysed.

Results: From a total of 58 patients, 36 patients underwent a conventional open necrosectomy and 22 patients underwent FON. The latter method resulted in a faster resolution of sepsis and a significant decrease in mean CRP on Day 3 after FON, $P = 0.001$. Post-operative bleeding was in 1 versus 7 patients and the incidence of intestinal and pancreatic fistula was 2 versus 8 patients when comparing FON to the conventional approach. The median ICU stay was 11.6 versus 23 days and the hospital stay was significantly shorter, 57 versus 72 days, $P = 0.024$ when comparing FON versus the conventional group. One patient died in the FON group and seven patients died in the laparotomy group, $P = 0.139$.

Discussion: FON can be an alternative method to conventional open necrosectomy in patients with infected necrosis and unresolved sepsis.

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Introduction

The control of sepsis is the primary goal of surgical intervention in patients with infected necrosis. A conventional laparotomy is valuable in patients when exploration of the abdominal cavity is indicated as a result of a differential diagnosis with other abdominal emergencies or when conservative treatment fails to manage the abdominal compartment syndrome; however, the development of endoscopic surgery and laparoscopy has promoted minimally invasive approaches.[1] The need to have a dedicated team of specialists is the main limiting factor against wider implementation of these techniques. At the same time, simple surgical approaches that are easy to reproduce may improve outcomes when endoscopic specialists are not available. While post-operative mortality in patients with necrotizing pancreatitis does not exceed 14%[2] to 20%[3] in specialized centres of excellence, the overall post-operative mortality is reported to reach up to 39% and is associated with high post-operative morbidity.[4] Successful conservative treatment of necrotizing pancreatitis leads to localization of necrosis after the second week from the onset of disease.[5] However, in this period, if surgical treatment is indicated, it would rarely be completed in a single intervention. A complete sequestrectomy and drainage can be achieved after the fourth week from the onset of the disease.[5] The severity of sepsis and completeness of demarcation are crucial in choosing the optimal surgical strategy, which may be different in the case of well-demarcated walled-off infected necrosis or poorly demarcated infected necrotic tissue.[6] Minimally invasive approaches that are less aggressive have been developed as an alternative to conventional open necrosectomy (CON); however, the main outcomes still have to be

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improved.[1] After routine implementation of pre- and intra-operative ultrasonoscopy navigation, FON was implemented using small lumbo-retroperitoneal and subcostal approaches in the surgical treatment of patients with infected necrosis. The aim of this prospective pilot study was to compare semi-open/closed drainage laparotomy or CON with the alternative approach, FON, in the treatment of patients with infected necrosis and progression of sepsis.

Methods

Patients who suffered acute necrotizing pancreatitis that were admitted to Riga East Clinical University hospital 'Gailezers' during the period of June 2004 to November 2011 with a new acute episode of the disease were enrolled prospectively. Repeated ultrasonography was used for dynamic follow-up of local inflammatory changes and localization of fluid collections. Contrast-enhanced computed tomography (CECT) was used for localization of necrosis and mapping of intervention. Peripancreatic air bubbles or abscesses on CECT were indicative of a suspected infection. A fine-needle aspiration biopsy was not used for confirmation of infection. Signs of infection and progression of sepsis were indications for surgical intervention. Repeated sustained elevation of CRP and the procalcitonine test were used as the biochemical marker of suspected sepsis. Sepsis was defined as evidence of systemic inflammatory response syndrome (SIRS) caused by bacterial contamination of the necrotic tissue or inflammatory fluid collections and proved by positive bacteriological culture obtained from the infected tissue. Blood cultures were collected when signs of sepsis were present and positive blood culture was defined as septicaemia. Bacterial cultures were obtained from the percutaneous drainage of the fluid collections and/or abscesses or during the operation. Two types of peripancreatic infections were defined:

1 Primary infection: when patients received only conservative treatment and it failed to prevent sepsis. Positive bacterial cultures were obtained during the percutaneous drainage of the fluid collections or purulent contents or during the surgical intervention for the first time.
2 Secondary infection (drain related infection): contamination of the necrotic tissue and fluid collections was a consequence of the early operation or percutaneous drainage of non-infected collections. Drains were the main gateway for commensal infection in this category of patients. An indication for surgical intervention was based on the clinical decision when the patient's condition was worsening, inflammatory markers demonstrated a constant increase and a CECT or ultrasound scan detected a potential focus of infection that should be drained. CON was provided through the longitudinal midline or bilateral subcostal transperitoneal approaches adhering to semiopen or closed drainage principles providing examination of the abdominal cavity, peripancreatic and paracolic spaces and providing proper necrosectomy using blunt finger dissection combined with suction and drainage.[1] Pre-operative CECT and ultrasound mapping and/or intra-operative ultrasonoscopy navigation were used to prepare for FON. Necrosectomy and drainage were performed through small focused lumbo-retroperitoneal or subcostal incisions accessing infected necrotic tissue and/or fluid collections. Percutaneous catheter drainage of 8.5 to 14 Fr (2.83 to 4.67 mm) inserted before surgery for temporary sepsis control served as a guide and helped to perform less traumatic intervention. In patients with several distant localizations of infected necrosis or fluid collections, a step-up approach was used providing necrosectomy and drainage in several steps. Repeated interventions were provided to achieve full drainage and removal of sequesters, when it was necessary. Treatment results were analysed to compare the data collected prospectively over a 7-year period when FON was used as an alternative to the conventional surgical approach routinely used by other surgeons. The two methods were analysed to compare incidence of organ dysfunction, infection rate, the need for renal replacement therapy (mainly continuous veno-venous haemofiltration), the main complication rate and outcomes. A deep venous thrombosis was verified using compression ultrasound examination. Pulmonary artery thromboembolism (PATE) was detected on computed tomography (CT) angiography of the pulmonary artery. Gastrointestinal (GI) bleeding from the upper GI tract requiring endoscopy and post-operative bleeding from the peripancreatic of the retroperitoneal area requiring invasive manipulations were taken into account. A pancreatic fistula was defined as persistent discharge of highly enzymatic content from drains or the wound. Fistulae of small or large intestines were proved by X-ray examination using contrast media. Approval by the local institutional board was obtained before study. A special patient informed consent other than the standard consent for the operation was not required. During the study period, antibacterial treatment and percutaneous drainage were successful in 11 patients who did not need further surgical intervention and were excluded from the study.

Continuous data were presented in median values (range). Statistical comparison was done with a non-parametric method using the Mann–Whitney *U*-test. Categorical data were analysed with the chi-square and Fisher's exact test. Statistical significance was considered at the *P*-value level of ≤ 0.05, with confidence interval 95%. Statistical analysis was done on SPSS version 17.0 statistical software (SPSS Inc., Chicago, IL, USA).

Results

In total, 58 patients with necrotizing pancreatitis needed surgical intervention and were operated during the study period. Prior to surgical intervention, all patients received prophylactic antibacterial treatment for a median of 29 (8–59) days in the FON group and 32 (15–60) days in the CON group, $P = 0.388$. The median number of antibiotic courses was 3 (1–5; 1–7), $P = 0.351$, in both

Table 1 Comparison of the physiological response, severity of disease, extent of necrosis and infection profile in the focused open necrosectomy (FON) versus the conventional open necrosectomy (CON) groups

	FON *n* = 22	CON *n* = 36	*P*
Median age, years (range)	51 (29–80)	43 (27–77)	0.389
Median time of admission, hours from onset (range)	15 (1–107)	24 (1–126)	0.261
Median APACHE II before operation, points (range)	8 (3–25)	10 (2–27)	0.349
MODS at admission, no. of patients	8	21	0.175
Preoperative MODS, no. of patients	6	13	0.572
Need for [a]RRT, no. (%)	12 (54.5%)	26 (72.2%)	0.255
Patients treated in ICU prior to surgery, no. of patients (%)	13 (59.1%)	25 (69.4%)	0.570
Median percentage of necrosis by CECT, %	30 (30–80)	40 (30–90)	0.410
Median CTSI, points	8 (3–10)	9 (4–10)	0.328
Primary infection, no. of patients	15	17	0.174
Secondary infection, no. of patients	7	19	0.174
Sepsis before operation, no. of patients	14	16	0.184
Septicaemia, no. of patients	3	7	0.727

[a]RRT, renal replacement therapy, continuous veno-venous haemofiltration was used in most patients.
MODS, multiple organ dysfunction syndrome; ICU, intensive care unit; CECT, contrast-enhanced computed tomography; CTSI, computed tomography severity index.

Table 2 Clinical course and complications in patients who underwent a focused open necrosectomy (FON) and a conventional open necrosectomy (CON)

	FON *n* = 22	CON *n* = 36	*P*
Percutaneous drainage, no. of patients	10	4	0.005
Need for repeated drainage, no. of patients	12	16	0.589
Median no. of interventions (range)	2 (1–4)	2 (1–6)	0.381
Median time of first intervention, days from onset (range)	17 (9–33)	11.5 (6–33)	0.009
MODS during the treatment, no. of patients	10	27	0.028
Deep venous thrombosis, no. of patients	1	2	1.000
PATE, no. of patients	1	1	1.000
GI bleeding, no. of patients	3	3	0.664
[a]Post-operative bleeding, no. of patients	1	7	0.139
Intestinal fistulae, no. of patients	2	8	0.290
[b]Pancreatic fistulae, no. of patients	2	8	0.290
Wound dehiscence, no. of patients	0	1	1.000
Sepsis after surgery, no. of patients	4	17	0.047
MODS post-operative, no. of patients	2	8	0.290

[a]Post-operative bleeding – bleeding from the intervention site.
[b]Pancreatic fistula – low output.
MODS, multiple organ dysfunction syndrome; PATE, pulmonary artery thromboembolism; GI, gastrointestinal.

Table 3 Peri-operative dynamics of C-reactive protein (CRP) by group [focused open necrosectomy (FON) versus conventional open necrosectomy (CON)]

	FON *n* = 22	CON *n* = 36	*P*
Median CRP pre-operative, mg/l (range)	190 (75–444)	231 (24–465)	0.879
Median CRP on 3rd post-operative day, mg/l (range)	149 (51–277)	216 (45–496)	0.001
Median CRP on 7th post-operative day, mg/l (range)	75 (5.2–295)	122 (30–546)	0.02

groups considering all treatment periods. Patients from both groups were admitted at similar time points from the onset of disease and were comparable, Table 1. CON was performed in 36 patients after conservative treatment failed to prevent progression of sepsis or gastrointestinal ileus. The decision to perform an intervention through laparotomy was based on the surgeon's personal experience. Temporary alleviation of sepsis was achieved by percutaneous drainage of the infected fluid collections, Table 2. The inserted catheters helped as a guide wire during the surgical intervention later. Successful conservative treatment resulted in definitive demarcation of necrotic tissue and inflammatory fluid collections delaying sepsis and providing the possibility for FON approach. The clinical course and complications of the two groups are shown in Tables 1 and 2. The dynamics of post-operative CRP by group are shown in Table 3. In total, 152 positive bacteriological cultures were obtained from study patients, Table 4. Post-operative outcomes are shown in Table 5.

Discussion

A conservative approach unless there is proven infected necrosis or life-threatening complications is currently the established therapy for patients who suffer necrotizing pancreatitis. In those where surgery is indicated, delaying until for as long as possible is commonly accepted.[1] Contrary to the laparotomy approach, the authors' aim was to avoid exploration of the infracolic compartment of the abdominal cavity thus preserving homeostasis of a large part of the abdominal compartment. This approach protects the peritoneal defence mechanism and minimizes the

Table 4 The most common bacterial cultures from infected necrosis

Number of isolates	FON *n* = 49	CON *n* = 103
Gram-negative bacteria		
Klebsiella spp.	5 (10.2%)	10 (9.7%)
Pseudomonas aeruginosa	3 (6.1%)	8 (7.8%)
Escherichia coli	3 (6.1%)	7 (6.8%)
Proteus spp.	3 (6.1%)	2 (1.9%)
Enterobacter spp.	2 (4.1%)	1 (1.0%)
Multi-resistant Acinetobacter baumanii	2 (4.1%)	0
Citrobacter spp.	2 (4.1%)	3 (2.9%)
Acinetobacter baumannii	0	5 (4.9%)
Stenotrophomona maltophilia	0	2 (1.9%)
Totally	**40.8%**	**36.9%**
Anaerobes		
Bacteroides spp.	0	6 (5.8%)
Gram-positive bacteria		
Enterococcus spp.	10 (20.4%)	31 (30.1%)
Coagulase negative staphylococci	7 (14.3%)	14 (13.6%)
Streptococcus spp.	4 (8.2%)	4 (3.9%)
Staphylococcus aureus	4 (8.2%)	1 (1.0%)
Corynebacterium spp.	1 (2.0%)	3 (2.9%)
Methicillin-resistant *S. aureus*	0	2 (1.9%)
Total	**53.1%**	**53.4%**
Yeast		
Candida spp.	3 (6.1%)	4 (3.9%)

FON, focused open necrosectomy; CON, conventional open necrosectomy.

Table 5 Comparison of main outcomes and mortality by group [focused open necrosectomy (FON) versus conventional open necrosectomy (CON)]

	FON *n* = 22	CON *n* = 36	
Median hospital stay, days (range)	57 (13–106)	72 (22–149)	0.024
Median ICU stay, days (range)	6 (0–50)	23 (0–61)	0.884
Median post-operative stay, days (range)	22 (7–79)	41 (12–78)	0.001
Mortality, no. of patients	1	7	0.139

ICU, intensive care unit.

post-operative small bowel motility dysfunction important for maintenance of the gastrointestinal barrier and active generation of the immune system response.[7] Violation of the abdominal cavity in the phase of severe systemic inflammation leads to visceral and retroperitoneal oedema and elevation of the intra-abdominal pressure releasing cytokines, which fuel SIRS.[8] A routine laparotomy approach is associated with prolonged wound healing and patients' immobility. Thus, development of less aggressive surgical techniques may considerably improve treatment results.[4,9] The present study provides some evidence that FON could be an appropriate alternative to the conventional surgical approach in achieving adequate debridement, drainage and post-operative alleviation of sepsis reducing post-operative morbidity and mortality. This statement is supported by the finding that the CRP level significantly decreased in the FON group on the third and the seventh post-operative day, reflecting a balanced systemic response and effective control of sepsis. One can argue that more systemic derangements were seen in patients who underwent early conventional surgery before the operation, considering the higher rate of multiple organ dysfunction syndrome and the need for renal replacement therapy. The FON group had a higher rate of sepsis but a lower rate of organ dysfunction before the surgical intervention, which provided better grounds for successful sepsis control in the post-operative period. Percutaneous catheter drainage recommended recently as a step that alleviates sepsis and could be the bridging procedure before surgical intervention[10] was successfully used in FON patients. The advantage of this minimally invasive step-up approach was demonstrated in the PANTER trial.[11] Study patients underwent percutaneous drainage of the pleural, intra-abdominal exudates and infected fluid collections for temporary sepsis relief. After this treatment, the majority of patients from the FON group had better localized infected necrosis, and it was possible to access necrotic tissue and infected fluid collections through focused retroperitoneal or subcostal incisions. Although groups were different considering the extent of demarcation of necrotic tissue which was more prominent in FON group, this approach could be successfully applied in selected cases of localized lesions.

The main drawback of catheter drainage is prolongation of hospital stay, nevertheless image-guided catheter drainage of fluid collections in the retroperitoneum around the pancreas is an important therapeutic option either alone or as an adjunct to surgery in patients with acute necrotizing pancreatitis.[12] Several alternatives to a laparotomy have been recommended. These have included long and wide lumbo-retroperitoneal access with extension of the incision from 12th rib to the anterior superior iliac spine.[13] A delayed mini-retroperitoneal approach has been used for patients in whom conservative treatment was provided until liquefaction of necrotic tissue.[14] Minimally invasive techniques included endoscopic and laparoscopic approaches in performing sequestrectomy and appropriate drainage.[6,15–18] Endoscopy has also been used via the translumbar retroperitoneal approach.[19] The laparoscopic technique included the retroperitoneal flank approach,[20] the trans-abdominal infracolic approach[21] or even the trans gastric approach.[22] However, convincing evidence is lacking with regards to the preferred procedure for treatment of the infected necrosis.[23]FON is closer to the minimally invasive intervention, because it does not cause a severe systemic host response. Relatively small incisions do not affect the integrity of the abdominal wall and do not violate the abdominal cavity below the transverse colon, compared with a laparotomy. In the situation of

multiple lesions with a different degree of sequestration there is the possibility to repeat the intervention. The distinct feature of FON is simplicity. This intervention can be potentially adopted by surgeons with experience in hepato-pancreato-biliary surgery, compared with endoscopic or laparoscopic techniques demanding special expertise. Recently published data demonstrate really good results using conventional laparotomy access and the closed drainage technique.[24] However, an agreement is reached regarding the procedures aimed to alleviate sepsis in critical patients bridging more definitive surgical intervention in the future and integrating different techniques.[11,25,26] The limited number of patients does not allow definitive conclusions regarding the true validity of the described method in the spectrum of minimally invasive treatment modalities, nevertheless FON could be one of the alternatives to the open surgical approach.

Conclusions

A focused open necrosectomy would appear a reasonable alternative to conventional open necrosectomy and endoscopic surgery in patients with walled-off pancreatic necrosis and well-localized lesions when infection causes progression of sepsis in necrotizing pancreatitis.

Authors' contributions

G.P. is author of the concept, provided the major part of surgical interventions and drafted the article.

V.F. provided percutaneous drainage providing the base for step-up approach bridging the definitive surgical intervention.

K.Z. provided clinical control of sepsis and management of the patients.

H.P. assisted in surgical procedures and provided surgical intervention in part of patients.

A.S. and N.D. collected clinical data and bacteriological laboratory results and provided the base for statistical analysis.

V.B., the senior consultant, participated in decision making and the selection of patients for the step-up approach.

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Conflicts of interest

None declared.

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