Minimally invasive operations for acute necrotizing pancreatitis: Comparison of minimally invasive retroperitoneal necrosectomy with endoscopic transgastric necrosectomy

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Background. A “step-up” approach is currently the treatment of choice for acute necrotizing pancreatitis. Our aim was to evaluate the outcome of minimally invasive retroperitoneal necrosectomy (MINE) and endoscopic transgastric necrosectomy (ETG) and to compare it to open necrosectomy (ONE).

Methods. Patients with acute pancreatitis admitted to our institution from 1998 to 2010 (n = 334) were identified. From these, patients who underwent either ONE, MINE, or ETG were selected for further analysis. Statistical analysis employed 2-sided Fisher’s exact test and Mann–Whitney U-test.

Results. From 2002 to 2010, 32 patients with acute necrotizing pancreatitis were treated by minimally invasive procedures including MINE (n = 14) and ETG (n = 18) or with the classic technique of ONE (n = 30). Time from onset of symptoms to intervention was less for ONE than for MINE or ETG (median, 11 vs 39 vs 54 days; P < .05). The rate of critically ill patients with sepsis or septic shock was greatest in ONE (93%) and MINE (71%) compared with ETG (17%, P < .05). Problems after ONE and MINE were ongoing sepsis (ONE 73% vs MINE 29% vs ETG 11%) and bleeding requiring intervention (ONE 26% vs MINE 21% vs ETG 17%). A specific complication of ETG was gastric perforation into the peritoneal cavity during the procedure (28%), requiring immediate open pseudocystogastrostomy. Laparotomy was necessary in 21% after MINE and 28% after ETG owing to specific complications or persistent infected necrosis. Overall mortality was greatest after ONE (ONE 63% vs MINE 21% vs ETG 6%; P < .05).

Conclusion. Morbidity and mortality remains high in acute necrotizing pancreatitis. Operative procedures should be delayed as long as possible to decrease morbidity and mortality. Minimally invasive procedures can avoid laparotomy, but also introduce specific complications requiring immediate or secondary open operative treatment. Minimally invasive procedures require unique expertise and therefore should only be performed at specialized centers. (Surgery 2012;152:S128-34.)

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ACUTE PANCREATITIS is a common disorder of the gastrointestinal tract with about 220,000 patients yearly requiring in-patient care in the United States alone. Interstitial edematous pancreatitis is the most common form (85% of patients) of AP, and usually resolves without further intervention.2

About 15% of patients develop necrotizing pancreatitis,3,4 defined by the development of pancreatic and/or peripancreatic necrosis.7 Its clinical course is characterized by early generalized systemic inflammatory response and sterile inflammation. Twenty to 70% of patients later develop infected necrosis,4,5,8,9 often leading to refractory sepsis and multiple organ failure, and account for the substantial morbidity and mortality of 8–39%.3,5,6,8,10–17 Deaths owing to necrotizing pancreatitis occurring within the first 2 weeks after onset are thought to occur owing to sepsis syndrome and multiple organ failure, whereas mortality later in its course is caused by infected necrosis or complications of sterile necrosis.3,11,13-15,18-22

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The necrotic tissue often liquefies partially by 2–4 weeks after the onset of necrotizing pancreatitis, resulting in collections that contain both liquid and solid necrotic material. These collections are surrounded by a thickened wall without an epithelial lining at the interface between the necrosis and the surrounding viable tissue and termed walled-off pancreatic necrosis (WOPN). Patients with WOPN often remain ill with persistent infection, pain, gastric outlet obstruction, biliary obstruction or portal vein compression, persistent pancreatitis, and progressive weight loss. WOPN may be mistaken for pseudocysts, which also comprise of fluid collections surrounded by a well-defined wall but that show little or no associated tissue necrosis within the fluid collection and also develop after severe interstitial edematous pancreatitis.

Traditionally, the treatment of choice for patients with infected pancreatic necrosis is open necrosectomy (ONE) to completely remove all necrotic tissue and thus the septic focus. Necrosectomy usually does not, however, maintain any preexisting abdominal compartmentalization and may therefore cause further intra-abdominal spread of the infection. Necrosectomy is performed as late in the course of the disease as possible (>2 weeks) because of an unacceptably high mortality of up to 56% associated with early intervention (<72 hours).

Several different variations of ONE have been recommended, such as necrosectomy and open packing, necrosectomy with continuous irrigation via indwelling catheters, necrosectomy with planned reoperative necrosectomy, and necrosectomy with closed drainage without irrigation; all these techniques are associated with substantial morbidity and mortality, most likely owing to the inherent properties of the disease.

A novel “step-up” approach using minimally invasive techniques for necrosectomy and only resorting to open operation if necessary is emerging currently as the treatment of choice for infected pancreatic necrosis. This approach seems to decrease morbidity, but not mortality in a recent, prospective, randomized trial.

Several minimally invasive techniques have been described over the past decade. Imaging-guided placement of percutaneous drains can be performed safely and easily, but is often ineffective in removing necrotic tissue and may therefore be an ideal bridging therapy early in the course of the disease to delay definitive operative therapy. Retroperitoneoscopy maintains abdominal compartmentalization, results in a minimal access trauma, and permits adequate removal of necrotic tissue. This approach can only be used to access fluid collections close to the lateral abdominal wall, usually in the pancreatic tail or the left paracolic gutter and less frequently for fluid collections of the right paracolic gutter. Endoscopic procedures were developed primarily for the treatment of pancreatic pseudocysts but can also be used for necrosectomy when local conditions are appropriate (apposition of stomach or duodenum with the area of necrosis). These endoscopic approaches result in no excess trauma and allow for sufficient necrosectomy, but these procedures are limited to solitary collections in close proximity to the stomach and duodenum, ideally with bulging of the collection into the lumen and require specialized instruments and experienced endoscopists.

The aim of our study was to compare and evaluate the outcome after minimally invasive retroperitoneal necrosectomy (MINE) and endoscopic transgastric necrosectomy (ETG) for the treatment of necrotizing pancreatitis and to compare it with the results of ONE.

**PATIENTS AND METHODS**

**Definitions and endpoints.** Our study included patients having undergone necrosectomy procedures for acute pancreatitis at our institution. Acute necrotizing pancreatitis, postnecrotic pancreatic fluid collections, WOPN, infected necrosis, and multiple organ failure were defined according to the 2008 revision of the Atlanta classification of acute pancreatitis. Sepsis was defined according to the 1992 ACCS/SCCM criteria. Major complications were defined as any life-threatening condition, postoperative pancreatic fistula requiring intervention, necessary emergency operation, or mortality after the first necrosectomy procedure during the course of the disease.

**Identification of study subjects.** For identification of patients with acute pancreatitis, the electronic records of all patients treated at our institution were searched for the ICD code of acute pancreatitis from 1998 to 2010. All patients who underwent operative or endoscopic treatment were identified by OPS codes and patient records reviewed to identify all patients who received a necrosectomy procedure. For analysis, 3 groups were defined: ONE, minimal MINE, and ETG.

**Data management and statistics.** Data collection was retrospective, and statistical analysis and testing was performed with SPSS Version 17 (SPSS Inc, Chicago, IL). For nominal and rational variables,
2-sided Fisher’s exact test and Kruskal–Wallis test were used, respectively.

Procedures. ONE involved laparotomy, removal of pancreatic or peripancreatic necrosis, intraoperative lavage of the pancreatic bed, and drainage of the abdomen as described previously.69 This approach was accompanied by other procedures as needed, such as large and small bowel resection for perforation or gangrene, as well as open or closed packing. Minimal MINE was performed after computed tomography-guided placement of a large-bore pigtail catheter into the cavity of the WOPN. Using monopolar electrocautery, a fenestration was then cut around the catheter to permit the insertion of a rectoscope into the cavity. Necrosectomy was then performed with laparoscopic grasping forceps. After necrosectomy, 1–3 large-bore, silicone drains were inserted into the cavity and left in place until full resolution of the WOPN was confirmed by computed tomography and then removed.

Endoscopic transgastric drainage and necrosectomy (ETG) was performed as described previously.56 Briefly, a 20-Charrière, percutaneous endoscopic gastrostomy catheter was placed endoscopically and a specially constructed trocar (Storz, Tuttingen, Germany) was inserted into the percutaneous endoscopic gastrostomy catheter. The WOPN was then punctured through the gastric wall and a guide wire was placed into the cavity. If bulging of the collection into the gastric lumen was visible, it was directly punctured; otherwise, transabdominal ultrasonography was used as guidance. Using 3-mm laparoscopic instruments, a 3- to 4-cm fenestration was cut around the guide wire using monopolar electrocautery. Necrosectomy was performed with laparoscopic grasping forceps. After necrosectomy, 1 or 2 large-bore, pigtail catheters were inserted into the cavity through the cystogastrostomy. Pigtail and percutaneous endoscopic gastrostomy catheters were left in place until full resolution of the WOPN was confirmed by computed tomography and then removed endoscopically.

RESULTS

Patients and procedures. A total of 334 patients with acute pancreatitis were treated at our institution from 1998 to 2010. Of these, 268 patients did not require any intervention, 33 were treated by ONE, and 33 were treated primarily by a minimally invasive approach. Four patients were excluded because of a lack of available data owing to primary treatment in other departments. In the remaining patients, MINE was used in 14 patients and ETG in 18 patients as the minimally invasive approach.

The 3 groups were comparable concerning age, gender, and presence of infected necrosis at the time of intervention (Table I). The main etiologic factors for acute pancreatitis were alcohol (12/62), gallstones (13/62), and post-endoscopic retrograde cholangiopancreatography pancreatitis (5/62). In about one third of cases (28/62), the etiology could not be assessed, in particular in the ONE group (19/30).

Patients treated with minimally invasive procedures did not differ markedly in most baseline parameters assessed, but patients treated with MINE had a greater rate of sepsis compared with patients treated with ETG (71% vs 17%) at the time of the first procedure. This observation explains the higher blood urea nitrogen, a marker for more severe pancreatitis,70 in the MINE group compared with the ETG group (Table 1).

There were significant differences between patients treated with ONE and minimally invasive procedures. Ninety-three percent of patients treated with ONE were septic at the time of the first procedure, and 73% had multiple organ failure, compared with only 6% in the minimally invasive group, indicating a greater percentage of patients with severe pancreatitis in the ONE group. Consequently, markers of infection, such as white cell count, serum C-reactive protein levels, and blood urea nitrogen were also significantly increased in the ONE group (Table I).

ONE was performed in 53% of the cases to treat ongoing sepsis or during the treatment of other life-threatening complications of severe necrotizing pancreatitis, such as hollow viscous perforation (17%), potentially even as a salvage procedure. In contrast, the majority of MINE (12/14) and ETG (14/18) were performed for necrosis with suspected infection. Supporting this notion, ONE was performed predominantly early in the course of pancreatitis, only 11 days after its onset, whereas both MINE (39 days) and ETG (54 days) were performed much later in the course of the disease.

Outcomes. Pancreatic necrosis was treated successfully in 45% of all patients (ONE, 37%; MINE, 57%; ETG, 50%). Treatment with ETG resulted in the least intensive care and hospital stays (2 and 21 days) compared with MINE (9 and 63 days) and ONE (44 and 52 days). The ostensibly short stay of patients treated with ONE is most likely owing to their high mortality of 63%, which was significantly greater than for both MINE (21%) or ETG (6%) treated patients. The major cause of death was sepsis with multiple organ failure in 91% of
patients; only 2 died from other complications (1 from hemorrhage and 1 from aspiration). Given
the large proportion of patients with severe necrotizing pancreatitis with concomitant sepsis and
multiple organ failure (Table I), it is not surprising that major complications (66%) were frequent,
and overall mortality was high (37%).

Sixty-nine percent of patients required additional procedures or interventional treatment
(32%) after the first necrosectomy. The planned renecrosectomy rate did not differentiate groups,
but unplanned renecrosectomies had to be performed for ongoing sepsis frequently after ONE
(22/30), whereas MINE (4/14) and ETG (2/18) rarely required unplanned renecrosectomies
(Table II).

MINE patients did not suffer from hollow viscous perforation, whereas it was frequently observed
after ONE (14/30), typically occurring in the form of small bowel fistula or large bowel gangrene.

In the case of ETG, about one third (5/18) of procedures caused perforation of the stomach,
leading to immediate open operation (Table II). This complication occurred more frequently when
there was no bulge (4/7) of the walled-off necrosis into the stomach lumen, whereas only 1 of 6 ETG
with bulging of the WOPN resulted in stomach perforation during ETG.

**DISCUSSION**

Our study demonstrates that both ETG and MINE can be used to treat selected patients with
necrotizing pancreatitis successfully, thus avoiding open surgery. Caution, however, must be exercised
when comparing minimally invasive treated patients with those treated with ONE. In this study,
the latter group consisted primarily of sicker patients with refractory sepsis and multiple organ
failure. Necrosectomy was used primarily as a salvage therapy or during operation for major

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>All (n = 62)</th>
<th>ONE (n = 30)</th>
<th>MINE (n = 14)</th>
<th>ETG (n = 18)</th>
<th>ONE vs MINE + ETG (P value)</th>
<th>MINE vs ETG (P value)</th>
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</thead>
<tbody>
<tr>
<td>Age (yrs), median (range)</td>
<td>62 (15–88)</td>
<td>64 (25–88)</td>
<td>61 (20–75)</td>
<td>58 (15–84)</td>
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<td>.779</td>
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<td>Gender (male:female)</td>
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<td>17:13</td>
<td>11:3</td>
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<td>.473</td>
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<td>4</td>
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<td>Biliary</td>
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<td>19</td>
<td>2</td>
<td>7</td>
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<td>3</td>
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<td>11 (2–15)</td>
<td>9 (4–26)</td>
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<td>217 (3–570)</td>
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<td>.259</td>
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<td>Hematocrit (%), median (range)</td>
<td>33 (22–50)</td>
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<td>62 (17–262)</td>
<td>44 (20–68)</td>
<td>26 (6–67)</td>
<td>.001</td>
<td>.014</td>
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<td>Serum creatinine (mg/dL), median (range)</td>
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<td>1.7 (0.4–7.4)</td>
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<td>Sepsis at time of first procedure, n</td>
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<td>28</td>
<td>10</td>
<td>3</td>
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<td>.003</td>
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<td>24</td>
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<td>.183</td>
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<td>Days from onset of symptoms to first procedure, n</td>
<td>32 (0–134)</td>
<td>11 (0–77)</td>
<td>39 (15–184)</td>
<td>54 (8–194)</td>
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<td>.193</td>
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<td>Infected necrosis, n</td>
<td>51</td>
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<td>13</td>
<td>13</td>
<td>1.000</td>
<td>.196</td>
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<td>Indications, n</td>
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<td>—</td>
<td>—</td>
<td>.000</td>
<td>.069</td>
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<tr>
<td>Sepsis</td>
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<td>16</td>
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<td>—</td>
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<tr>
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<td>12</td>
<td>13</td>
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<td>Local symptoms</td>
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<td>0</td>
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<td>Other</td>
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<td>8</td>
<td>0</td>
<td>1</td>
<td>—</td>
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*ERCP: Endoscopic retrograde cholangiopancreatography; ETG, endoscopic transgastric necrosectomy; MINE, minimally invasive necrosectomy; ONE, open necrosectomy.*
complications of necrotizing pancreatitis, such as hollow viscous perforation or gangrene. Whereas patients treated with ETG and MINE also had predominantly infected necrosis, their disease was already organized and presented clinically as WOPN. Consequently, this cohort was less sick and had almost no organ failure associated with the disease. Previous studies often either included only a small number of patients or may have unintentionally used patients in their control group of open necrosectomies who probably were candidates better suited for minimally invasive techniques.52

Although ETG was ideal treatment that resolved symptoms and prevented ONE, resulting in lesser intensive care and hospital stays, the same was less true for the MINE group. This difference may in part be explained by the slightly different indications for the 2 procedures. MINE was used to treat patients earlier in the course of the disease who still suffered from sepsis in more than half of the cases. Consequently, these patients also required additional interventions after the initial procedure, such as placement of percutaneous drains to treat additional postnecrotic peripancreatic fluid collection.

In contrast, ETG was used later in the course of the disease, and no patient suffered from sepsis, resulting in fewer interventions. Our data demonstrate that, in patients undergoing ETG, one has to carefully select patients for the procedure. Patients without visible bulging of the necrotic collection into the stomach at the time of the procedure or too little contact of the cyst wall to the stomach had a high risk of stomach perforation requiring immediate and open operative intervention.

In summary, both minimally invasive procedures require a specialized multidisciplinary team and considerable experience to be used safely and effectively. In the appropriate setting, both procedures result in minimal trauma, maintain abdominal compartmentalization, and may avoid open

Table II. Outcomes

<table>
<thead>
<tr>
<th></th>
<th>All</th>
<th>ONE</th>
<th>MINE</th>
<th>ETG</th>
<th>ONE vs MINE + ETG (P value)</th>
<th>MINE vs ETG (P value)</th>
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</thead>
<tbody>
<tr>
<td>Success,* n</td>
<td>28 (n = 62)</td>
<td>11 (n = 30)</td>
<td>8 (n = 14)</td>
<td>9 (n = 18)</td>
<td>.213</td>
<td>.735</td>
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<tr>
<td>Major complications,† n</td>
<td>41 (n = 62)</td>
<td>27 (n = 30)</td>
<td>6 (n = 14)</td>
<td>8 (n = 18)</td>
<td>.000</td>
<td>.289</td>
</tr>
<tr>
<td></td>
<td>14 (n = 62)</td>
<td>8 (n = 30)</td>
<td>3 (n = 14)</td>
<td>3 (n = 18)</td>
<td>.550</td>
<td>1.000</td>
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<tr>
<td>Hollow viscous perforation</td>
<td>19 (n = 62)</td>
<td>14 (n = 30)</td>
<td>0 (n = 14)</td>
<td>5 (n = 18)</td>
<td>.013</td>
<td>.052</td>
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<td>Pancreatic fistula</td>
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<td>2 (n = 14)</td>
<td>0 (n = 18)</td>
<td>.249</td>
<td>.098</td>
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<td>Other</td>
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<td>1 (n = 14)</td>
<td>0 (n = 18)</td>
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<tr>
<td>Mortality, n</td>
<td>23 (n = 62)</td>
<td>19 (n = 30)</td>
<td>3 (n = 14)</td>
<td>1 (n = 18)</td>
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<td>.295</td>
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<td>Septic shock</td>
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<td>19 (n = 30)</td>
<td>2 (n = 14)</td>
<td>0 (n = 18)</td>
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<td>Bleeding</td>
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<td>0 (n = 14)</td>
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<td>Aspiration</td>
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<td>1 (n = 14)</td>
<td>0 (n = 18)</td>
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<td>—</td>
</tr>
<tr>
<td>Additional procedures, n</td>
<td>43 (n = 62)</td>
<td>23 (n = 30)</td>
<td>7 (n = 14)</td>
<td>13 (n = 18)</td>
<td>.277</td>
<td>.277</td>
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<td>Planned renecrosectomy, n</td>
<td>26 (n = 62)</td>
<td>17 (n = 30)</td>
<td>4 (n = 14)</td>
<td>5 (n = 18)</td>
<td>.039</td>
<td>1.000</td>
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<td>Renecrosectomy for sepsis, n</td>
<td>28 (n = 62)</td>
<td>22 (n = 30)</td>
<td>4 (n = 14)</td>
<td>2 (n = 18)</td>
<td>.000</td>
<td>.365</td>
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<td>Open procedure after minimal invasive procedure, n</td>
<td>10 (n = 62)</td>
<td>3 (n = 30)</td>
<td>7 (n = 14)</td>
<td>— (n = 18)</td>
<td>.446</td>
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<td></td>
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<td>Persistent necrosis</td>
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<td>Other</td>
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<td>— (n = 18)</td>
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<td>—</td>
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<tr>
<td>Intervention after procedure, n</td>
<td>20 (n = 62)</td>
<td>10 (n = 30)</td>
<td>8 (n = 14)</td>
<td>2 (n = 18)</td>
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<td>.008</td>
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<td>Percutaneous drain</td>
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<td>6 (n = 14)</td>
<td>1 (n = 18)</td>
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<td>—</td>
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<tr>
<td>Angiography</td>
<td>3 (n = 62)</td>
<td>1 (n = 30)</td>
<td>1 (n = 14)</td>
<td>1 (n = 18)</td>
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<tr>
<td>Endoscopic pancreatic duct stenting</td>
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<td>1 (n = 30)</td>
<td>1 (n = 14)</td>
<td>0 (n = 18)</td>
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<tr>
<td>Other</td>
<td>4 (n = 62)</td>
<td>4 (n = 30)</td>
<td>0 (n = 14)</td>
<td>0 (n = 18)</td>
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<tr>
<td>Days in hospital, median (range)</td>
<td>46 (1–236)</td>
<td>52 (1–236)</td>
<td>65 (14–124)</td>
<td>21 (8–55)</td>
<td>.028</td>
<td>.000</td>
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<tr>
<td>Days in intensive care, median (range)</td>
<td>9 (0–227)</td>
<td>44 (1–227)</td>
<td>9 (1–64)</td>
<td>2 (0–9)</td>
<td>.000</td>
<td>.003</td>
</tr>
</tbody>
</table>

*No mortality, no second open surgery.
†Life-threatening condition, postoperative pancreatic fistula requiring intervention, necessary emergency surgery, mortality after the first necrosectomy.
ETG, Endoscopic transgastric necrosectomy; MINE, minimally invasive necrosectomy; ONE, open necrosectomy.
operative interventions, thereby decreasing days spent in hospital and intensive care.

REFERENCES