Optimizing the step-up approach for infected necrotizing pancreatitis

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CHAPTER 7

Timing of catheter drainage in infected necrotizing pancreatitis

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Abstract

Acute pancreatitis is the most common gastrointestinal indication for hospital admission, and infected pancreatic and/or extrapancreatic necrosis is a potentially lethal complication. Current standard treatment of infected necrosis is a step-up approach, consisting of catheter drainage followed, if necessary, by minimally invasive necrosectomy. International guidelines recommend postponing catheter drainage until the stage of ‘walled-off necrosis’ has been reached, a process which typically takes 4 weeks after onset of acute pancreatitis. This recommendation stems from the era of primary surgical necrosectomy. However, postponement of catheter drainage might not be necessary, and earlier detection and subsequent earlier drainage of infected necrosis could improve outcome. Strong data and consensus among international expert pancreatologists are lacking. Future clinical, preferably randomized, studies should focus on timing of catheter drainage in patients with infected necrotizing pancreatitis. In this Perspectives, we discuss challenges in the invasive treatment of patients with infected necrotizing pancreatitis, focusing on timing of catheter drainage.
Introduction

Acute pancreatitis is the most common gastrointestinal indication requiring acute hospitalization [1]. The main causes are gallstone disease, alcohol, medication or idiopathic. Acute pancreatitis is usually a self-limiting disease and most patients recover without serious complications [2]. The management of acute pancreatitis has been outlined in updated evidence-based and consensus-based guidelines [3-5]. The cornerstones of early treatment are fluid resuscitation, pain management and enteral nutrition. Despite adequate early treatment, ~20% of patients will develop necrosis of the pancreatic parenchyma, the peripancreatic tissue or both (that is, necrotizing pancreatitis) [6, 7]. Depending on the presence of persistent organ failure, necrotizing pancreatitis is considered moderately severe or severe, with mortality rates exceeding 30% [2, 8]. In two-thirds of patients the necrosis remains sterile and no invasive intervention is needed [3]. However, one-third of patients develop an infection of the necrosis [6]. Infected necrosis is thought to be caused by bacterial translocation from the gut. Translocation is provoked by disturbed intestinal motility which leads to small bowel bacterial overgrowth, and increased mucosal permeability by intestinal hypoperfusion [9-12]. The standard invasive treatment for patients with (suspected) infected necrotizing pancreatitis is the so-called ‘step-up’ approach [3-5]. This approach can be performed surgically (which involves percutaneous drainage) or endoscopically (which involves endoscopic, usually transgastric, drainage) [13, 14]. Current guidelines state that an invasive intervention should be postponed until the collection with infected (extra)pancreatic necrosis has become ‘walled-off ’ [3-5], a process which usually takes 3–4 weeks from onset of disease [2]. Debridement of non-walled-off necrosis is technically difficult, with a risk of bleeding and perforation of adjacent hollow organs. During this period of 3–4 weeks, patients are often severely ill and admitted to the intensive care unit; however, catheter drainage would technically be feasible in most of these patients. Whether catheter drainage should be performed before the stage of walled-off necrosis is reached is a pertinent question, particularly as at least 30% of patients seem to recover after catheter drainage without the need for additional necrosectomy [15]. In the era of catheter drainage as the first step in a step-up approach, postponement of catheter drainage until encapsulation might not be necessary, and this delay could in fact slow down recovery. Earlier detection of infected necrosis and subsequent earlier catheter drainage of infected necrosis could have the potential to improve outcome, but strong data are lacking. In this Perspectives, we discuss challenges in diagnosing infected necrosis and timing of catheter drainage in patients with infected necrotizing pancreatitis.
Diagnosing infected necrosis

As infected necrotizing pancreatitis has a very high mortality and morbidity [16], it nearly always requires intervention. Prompt and accurate diagnosis of infected necrosis is, therefore, very important. Moreover, catheter drainage of sterile necrosis carries a serious risk of introducing infection, which usually necessitates additional interventions and could theoretically increase the risk of mortality [17]. Indications for intervention in sterile necrotizing pancreatitis (4-8 weeks after onset of pancreatitis) are persistent gastric outlet, intestinal or biliary obstruction, other persistent symptoms such as pain, or disconnected pancreatic duct syndrome [3].

In clinical practice infected necrosis is diagnosed by gas in the necrotic collection on imaging, positive culture of a fine-needle aspiration (FNA), or unequivocal clinical signs of infection. The presence of gas in a necrotic collection on imaging (for example, contrast-enhanced CT of the abdomen) is considered pathognomonic for infected necrosis. This diagnosis can be made regardless of the cause of the gas, which could be related to gas-forming bacteria or to loss of integrity of the gastrointestinal tract. Collections containing gas are reported in up to 42% of patients with infected necrotizing pancreatitis [18] and can occur in every phase of the disease [19]. A positive culture or gram stain of fluid obtained via FNA can also confirm infected necrosis. Although FNA in these patients has a very low false-positive rate, false-negative rates up to 20% have been reported [20-22]. Currently, most experts only use FNA in selected cases [23]. In current practice where nearly all invasive interventions are postponed until the stage of walled-off necrosis there is usually no clinical need to detect infection early on and hence FNA is rarely performed. In a study published in 2014, infected necrosis was confirmed by FNA in 86% of 28 patients. However, the diagnostic performance of gas on imaging (94% of 88 patients) or clinical symptoms only (80% of 92 patients, P = 0.07) was similar [18].

Patients with necrotizing pancreatitis and clinical signs of infection (such as raised temperature, elevated levels of inflammatory serum markers or new-onset organ failure) with no other infectious focus, are suspected of having infected necrosis. Diagnosing infected necrosis on clinical symptoms alone does has certain limitations, especially in the first 2 weeks of pancreatitis when many patients often have systemic inflammatory response syndrome (SIRS). The symptoms of SIRS can mimic signs of infection. Differentiating between SIRS and sepsis in the first 2 weeks of pancreatitis, if desired, might be facilitated by FNA [19]. FIG. 1 describes an algorithm to diagnose and treat infected necrosis [24].
Timing of catheter drainage in infected necrotizing pancreatitis

Minimally invasive interventions

As for many other gastrointestinal disorders, the use of minimally invasive interventions for infected necrotizing pancreatitis has increased [25-27]. Open surgical necrosectomy has been the standard treatment of infected necrotizing pancreatitis for decades, with the goal to remove all the necrosis [28, 29]. Open necrosectomy is associated with high mortality (~40%) and morbidity rates (up to 95%), including bleeding, gastrointestinal fistulas and pancreatic insufficiency [30-34]. In the past decade, there has been a trend towards minimally invasive retroperitoneal surgical techniques, for instance sinus tract endoscopy [35, 36]. In this and other derivative procedures, a percutaneous catheter drainage (PCD) is initially performed (FIG. 2). In cases of insufficient clinical improvement, the PCD tract is dilated under general anaesthesia and the necrosis is removed with grasping forceps, followed by continuous postoperative lavage. A videoscopic-assisted retroperitoneal debridement (VARD) is another minimally invasive necrosectomy procedure that can be performed in patients with ongoing sepsis after primary PCD. This technique is a hybrid of the classic lumbotomy and sinus tract endoscopy [37, 38]. By making a subcostal incision of 5 cm in length, larger pieces of solid debris...
can be removed [39]. VARD also seems to be easier to perform than sinus tract endoscopy as owing to the small incision there is more working space, particularly as necrotizing pancreatitis is a relatively rare condition and these procedures are not performed routinely. In the randomized PANTER trial, the minimally invasive step-up approach (including VARD) was superior in terms of outcome compared with primary open necrosectomy [13]. The current hypothesis is that minimally invasive surgical necrosectomy induces a smaller proinflammatory response than open surgery.

**Figure 2**

Surgical step-up approach. a | Cross-sectional image and torso depicting a peripancreatic collection with fluid and necrosis. The first step of the surgical step-up approach is percutaneous catheter drainage. The preferred access route is through the left retroperitoneal space between the left kidney, dorsal spleen and descending colon. If necessary, percutaneous catheter drainage is followed by a minimally invasive surgical necrosectomy, for example videoscopic-assisted retroperitoneal debridement. b | Enlargement of the area of detail shown in part a of the figure. c | A 5 cm subcostal incision is made, and the previously placed percutaneous drain is used as a guide into the retroperitoneum to enter the necrotic collection. The first necrosis is removed under direct vision with a long grasping forceps. d | Further debridement is performed under videoscopic assistance. Reprinted from van Brunschot, S. et al. Treatment of necrotizing pancreatitis. Clin. Gastroenterol. Hepatol. 10, 1190–1201 (2012), with permission from Elsevier ©, and adapted from John Wiley and Sons © da Costa, D. W. et al. Br. J. Surg. 101, e65–e79 (2014).
surgical necrosectomy and is therefore associated with a lower rate of new-onset organ failure in these already critically ill patients. In addition to minimally invasive surgical approaches, a transluminal endoscopic approach is gaining popularity [26, 40]. Data from the pilot PENGUIN trial showed a reduction in pro-inflammatory response (serum IL-6 levels) in patients treated with transluminal endoscopic necrosectomy versus a (preferably) minimally invasive surgical necrosectomy. Also, a trend towards less new-onset multi-organ failure (0% versus 50%) and reduced rate of pancreatic fistulas (10% versus 70%) was seen [41]. The endoscopic approach can also be performed as a step-up approach [39] (FIG. 3). Under endoscopic ultrasonography guidance, the necrotic collection is punctured through the gastric wall, followed by balloon dilatation of the tract. Thereafter, plastic or metal stents are placed through the opening including a nasocystic catheter for irrigation of the necrotic collection. If necessary, endoscopic drainage is followed by an endoscopic necrosectomy. The necrotic tissue can be evacuated under endoscopic vision with a basket, net or snare [14]. No solid evidence exists yet on the superiority of either the percutaneous and surgical techniques versus the endoscopic approach. Results of

Figure 3

Endoscopic step-up approach. a | The first step of the endoscopic step-up approach is endoscopic transluminal drainage. The preferred access route for endoscopic transluminal treatment is through the posterior wall of the stomach. The necrotic collection often bulges into the stomach, facilitating endoscopic transluminal treatment. The collection is punctured through the gastric wall, followed by balloon dilatation of the tract. Two double-pigtail stents and a nasocystic catheter are placed for continuous postoperative irrigation. b | If necessary, the cystostomy tract is further dilated, the collection is entered by a forward viewing endoscope, and necrosectomy is performed. Reprinted from van Brunschot, S. et al. Treatment of necrotizing pancreatitis. Clin. Gastroenterol. Hepatol. 10, 1190–1201 (2012), with permission from Elsevier ©, and permission obtained from John Wiley and Sons © da Costa, D. W. et al. Br. J. Surg. 101, e65–e79 (2014).
the TENSION trial, comparing these two step-up approaches, are expected in 2016 [14]. The theoretical pros and cons of both approaches are summarized in TABLE 1. Given the fact that at least 30% of patients can be successfully treated with catheter drainage only, without the need to undergo additional necrosectomy, drainage of infected necrosis should be the initial step [13, 15]. A survey published in 2015 showed excellent implementation of the step-up approach, with 87% acceptance among expert pancreatologists [23]. Catheter drainage is technically feasible in >95% of patients, often via the preferred left-sided retroperitoneal route [13, 27]. The rationale of catheter drainage is to treat infected necrosis as an abscess and drain infected fluid under pressure. This approach initially aims to control the source of infection without removal of the infected necrosis. Drainage of the infected fluid may temporize sepsis, improve the patient’s clinical condition and allow further encapsulation.

**Table 1** Pros and cons of the surgical and endoscopic step-up approach

<table>
<thead>
<tr>
<th>Status</th>
<th>Surgical step-up approach</th>
<th>Endoscopic step-up approach</th>
</tr>
</thead>
</table>
| Pros   | - Necrotic collection is nearly always percutaneously accessible (95% of patients)  
        - High effectiveness of surgical necrosectomy (large pieces of necrosis can be removed) | - Reduced proinflammatory response (e.g. IL-6)  
        - Avoids abdominal wall incision and thus related complications (e.g. external pancreatic fistula, incisional hernia and wound infection) |
| Cons   | - Risk of chronic external pancreatic fistula  
        - General anaesthesia is a prerequisite for surgical necrosectomy | - Some necrotic collections are not endoscopically accessible (e.g. distant from the stomach or not fully walled-off necrosis)  
        - Several endoscopic procedures are needed for full necrosectomy (small pieces of necrosis can be removed)  
        - Availability of expertise |
Timing of catheter drainage

According to the latest evidence-based guidelines, all forms of invasive interventions in patients with infected necrosis should be ideally postponed until walled-off necrosis is present. Intravenous antibiotic treatment is the current standard treatment to bridge the period between acute necrotic collection and the formation of walled-off necrosis. Once an infection focus is determined, targeted antibiotics should be given or, in cases of no positive culture and persistent deterioration, broad spectrum antibiotics with optimal penetration must be started empirically. The latter usually consists of meropenem or imipenem, based on the local antibiotics protocol [3,4]. Antibiotic treatment itself may obviate the need for invasive interventions, with reported success rates varying from 3% (11 of 397 patients) [16] to 50% (14 of 28 patients) in selected patients [42]. The current advice to postpone invasive interventions preferably until 4 weeks after start of the disease stems from studies on timing of primary open surgical necrosectomy. The outcome of patients undergoing a late necrosectomy in walled-off necrosis seemed superior to patients undergoing early necrosectomy, including lower mortality [37,43-45]. As the initial management of infected necrotizing pancreatitis shifted from laparotomy to catheter drainage, the question arises whether catheter drainage should also be postponed. In the minimally invasive approach, encapsulation of necrosis might theoretically not be so relevant. Technically, there is often no need for postponing catheter drainage, especially PCD. In other abdominal conditions requiring PCD it is already common practice to drain before the stage of encapsulation. A systematic literature search was carried out to identify studies focusing on timing of catheter drainage in patients with infected necrotizing pancreatitis (see Supplementary information S1 (box)). No randomized studies currently exist. Several observational cohort studies reported on the timing of catheter drainage as a first intervention in patients with necrotizing pancreatitis [13, 46-58] (TABLE 2). These studies varied from seven to 117 patients, with rates of infected necrosis from 47% to 100%, confirmed either by the presence of gas in the collection on CT or a positive culture from fluid obtained by FNA or catheter drainage. PCD was the most often used intervention. Two studies also included a small subset of patients with endoscopic transluminal drainage as the primary treatment [13, 48]. Another two studies used dual-modality drainage of both primary PCD and endoscopic drainage [51, 58]. The studies reported a widespread time window of the first catheter drainage procedure, varying from a median of 9 to 75 days after onset of disease. A formal comparison or assessment of methodological quality could not be performed because the studies did not provide enough details. The proportion of patients who underwent additional necrosectomy (0% to 100%) and the number of patients with a bleeding complication (0% to 50%)
could not be related to the timing of catheter drainage. In addition, mortality rates ranged from 0% to 29%, with no evident relation with the timing of first intervention. Duration of drainage varied widely, but was shorter in the series with more patients who underwent additional necrosectomy. Nine studies provided data about length of hospital stay (37 to 96 admission days), but again no relation was seen with timing of the first catheter drainage. A few studies described other complications. For example, endocrine pancreatic insufficiency occurred in 26% of patients in the early drainage cohort of Freeny et al. [46] (median of 9 days) versus in 58% of patients in the late drainage cohort of Kumar et al. [57] (median of 36 days). However, exocrine insufficiency occurred in 32% of the early drainage cohort of Freeny et al. [46] versus in 7% of patients in the late drainage cohort of van Santvoort et al. [13] (median of 30 days).

Table 2  
Studies of timing of catheter drainage in patients with (suspected) infected necrotizing pancreatitis

<table>
<thead>
<tr>
<th>Study</th>
<th>Timing of first catheter drainage (days after onset of disease)</th>
<th>Patients (n)</th>
<th>Proven InP* (%</th>
<th>Approach</th>
<th>Mortality (%)</th>
<th>Necrosectomy (%)</th>
<th>Bleeding (%)</th>
<th>Duration of drainage in days (range)</th>
<th>Hospital LOS in days (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeny et al. (1998)⁴⁶</td>
<td>9 (1-48)</td>
<td>34</td>
<td>100</td>
<td>PCD</td>
<td>12</td>
<td>24</td>
<td>15</td>
<td>85 (25-152)</td>
<td>45 (5-95)</td>
</tr>
<tr>
<td>Navalho et al. (2006)⁴⁷</td>
<td>18</td>
<td>30</td>
<td>100</td>
<td>PCD</td>
<td>17</td>
<td>33</td>
<td>NR</td>
<td>24 (5-94)</td>
<td>55</td>
</tr>
<tr>
<td>Lee et al (2007)⁴⁸</td>
<td>10 PCD (1-58)</td>
<td>23</td>
<td>100</td>
<td>18 PCD</td>
<td>4</td>
<td>17</td>
<td>0</td>
<td>NR</td>
<td>37.7 ± 28.5</td>
</tr>
<tr>
<td>Bruennler et al. (2008)⁴⁹</td>
<td>3.5 + median 7 days transfer</td>
<td>80</td>
<td>65</td>
<td>PCD</td>
<td>23</td>
<td>23</td>
<td>0</td>
<td>36.5 (1-260)</td>
<td>51 (3-241)</td>
</tr>
<tr>
<td>Mortelé et al. (2009)⁵⁰</td>
<td>12 (2-33)</td>
<td>13</td>
<td>100</td>
<td>PCD</td>
<td>8</td>
<td>54</td>
<td>8</td>
<td>NR</td>
<td>33 (11-68)</td>
</tr>
<tr>
<td>Becker et al. (2009)⁵¹</td>
<td>24 (18-30)</td>
<td>7</td>
<td>100</td>
<td>PCD + ETD</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>101 (8-154)</td>
<td>78 (45-150)</td>
</tr>
<tr>
<td>Bala et al. (2009)⁵²</td>
<td>26 (18-88)</td>
<td>8</td>
<td>100</td>
<td>PCD</td>
<td>13</td>
<td>100</td>
<td>0</td>
<td>71.5 (39-90)</td>
<td>96 (38-131)</td>
</tr>
<tr>
<td>van Santvoort et al. (2010)¹³</td>
<td>30 (11-71)</td>
<td>43</td>
<td>91</td>
<td>41 PCD</td>
<td>19</td>
<td>60</td>
<td>16</td>
<td>NR</td>
<td>50 (1-287)</td>
</tr>
<tr>
<td>Baudin et al. (2012)⁵³</td>
<td>19.8 ± 15.7</td>
<td>48</td>
<td>100</td>
<td>PCD</td>
<td>29</td>
<td>19</td>
<td>4</td>
<td>48 ± 22</td>
<td>83 ± 48</td>
</tr>
</tbody>
</table>
Future perspectives

Whereas the incidence of infected necrosis has remained stable [6, 16], treatment of necrotizing pancreatitis has changed considerably in the past decade. Current guidelines advise postponing all forms of invasive intervention in patients with infected necrosis, preferably until 4 weeks after onset of disease [3-5]. The step-up approach has been implemented as the strategy of choice internationally for treating these patients [23]. Catheter drainage is used as a first step to control sepsis and delay or even avoid necrosectomy. For that reason, timing of catheter drainage has become a particularly relevant topic. A rationale exists for postponing catheter drainage in patients with infected necrotizing pancreatitis. First, antibiotic treatment alone might suffice as treatment. Second, diagnosing infected necrotizing pancreatitis is often easier in a later stage of the disease, when all other sources of infection or SIRS have been ruled out. Third, catheter drainage can be easier once the stage of walled-off necrosis has been reached and a collection has become more liquefied. Fourth, endoscopic transluminal drainage requires a walled-off collection. In an international survey, 55% of expert pancreatologists postponed catheter drainage in infected necrotizing pancreatitis using antibiotics, whereas the other 45% drained immediately after diagnosing infected necrosis [23]. Although the step-up approach was routinely used by 87% of pancreatologists, the timing of intervention varied hugely, especially catheter drainage. Disagreement was most notable when infected necrosis was diagnosed 2 or 3 weeks after onset of disease, which is the period between the SIRS phase and encapsulation (walled-off necrosis). The findings of this survey are comparable to
the results of the studies discussed in this article. Timing of catheter drainage varied greatly, both between and within studies. The available studies are retrospective and included a mixed group of patients, infected necrosis had not always been proven, and often insufficient information about severity of illness was provided. This lack of data hampers comparisons to determine the best time to perform catheter drainage. On the other hand, no clear evidence from clinical studies was seen to suggest superiority for the current standard practice of postponed catheter drainage. From a theoretical standpoint it is not always mandatory to wait several weeks until full encapsulation of the peripancreatic collections and (percutaneous) catheter drainage can be performed safely and successfully in the first weeks after onset of disease. For several other conditions, such as drainage of peripancreatic collections after pancreatic resection, (percutaneous) catheter drainage is also safely performed early in ‘non-walled-off’ collections [59]. If there is no technical reason for postponing catheter drainage, patients with infected necrotizing pancreatitis may benefit from earlier catheter drainage by reducing complications and length of hospital stay. Future clinical studies should evaluate whether it is better to postpone catheter drainage until there is walled-off necrosis or if it should be performed immediately after infected necrosis has been diagnosed. The Dutch Pancreatitis Study Group has designed such a randomized controlled trial. The POINTER trial (ISRCTN33682933) will compare immediate and delayed catheter drainage in an attempt to further improve the outcome of these severely ill patients [60].

Besides diagnosing infected necrosis and timing of catheter drainage, other factors might also be of interest when attempting to improve the quality of interventions and thereby the outcomes of patients with infected necrotizing pancreatitis. For example, for PCD little is known about the ideal lavage strategy, optimal initial catheter size or the benefit of upsizing primary percutaneous drains. Equally, in addition to the surgical (or percutaneous) approach, the endoscopic transluminal approach is gaining popularity. In the PENGUIN randomized controlled trial, which compared endoscopic transluminal necrosectomy with minimally invasive surgical necrosectomy, endoscopic transluminal necrosectomy significantly reduced the pro-inflammatory response measured by IL-6 levels, as well as the composite clinical end point consisting of complications and mortality [41]. The TENSION trial will answer the question of whether the endoscopic step-up approach, starting with endoscopic transluminal drainage, is superior compared with the surgical step-up approach, starting with PCD, in terms of mortality and major morbidity. The results of this trial are expected at the beginning of 2016 [14].
Conclusions

As the step-up approach has been accepted as the treatment strategy of choice in patients with infected necrotizing pancreatitis, the question when to start catheter drainage (being the first step of the step-up approach) has become more relevant. The timing and technical details of catheter drainage in these patients should be further optimized. With this new approach in a ‘drainage-first’ era of necrotizing pancreatitis treatment, a shift from a more reactive strategy towards a more proactive strategy for diagnosing infected necrosis might be necessary.
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Supplements

Review criteria
A systematic literature search was performed in MEDLINE, EMBASE and the Cochrane Library. Details of the literature search criteria are provided in Supplementary Box 1 online.

Supplementary information is linked to the online version of the paper at www.nature.com/nrgastro

Supplementary Box 1. Literature search
On 23rd January 2015 a systematic literature search was performed in MEDLINE, EMBASE and the Cochrane Library. Terms on timing [Instant/Immediate/Early or Postponed/Delayed] or on infected necrosis [Infected or Infection] were not used in order to achieve broad search results.

MEDLINE

EMBASE
‘pancreas necrosis’/exp OR ‘acute hemorrhagic pancreatitis’/exp OR (‘acute pancreatitis’/exp OR ‘pancreatitis’/exp OR ‘pancreas’/exp OR pancreatitis*:ab,ti OR pancreas:ab,ti AND (‘necrosis’/exp OR necrot*:ab,ti OR necros*:ab,ti)) OR ((severe OR complicated) NEAR/2 pancreatitis):ab,ti AND (‘surgical drainage’/exp OR drain*:ab,ti OR drainage:ab,ti OR ‘catheter’/exp OR ‘catheterization’/exp OR catheter*:ab,ti OR “step up”:ab,ti OR ((endoscopic OR percutaneous OR radiologic*) NEXT/1 intervention*):ab,ti OR ‘minimally invasive’:ab,ti)
Cochrane Library
((pancreat*:ab,ti or pancreas:ab,ti) and (necrot*:ab,ti or necros*:ab,ti)) or ((severe or complicated) near/2 pancreat*):ab,ti) AND (drain*:ab,ti or drainage:ab,ti or catheter*:ab,ti or ‘step up’:ab,ti or ((endoscopic or percutaneous or radiologic*) next/1 intervention*):ab,ti) or ‘minimally invasive’:ab,ti)

Methodological filters
Languages: restricted to English, Dutch, German, French and Spanish
Date: >1 January 1992, because no universally accepted definitions for acute pancreatitis and pancreatic collections were available before 1992, confounding the comparison of studies
For EMBASE: NOT [conference abstract]/lim

Inclusion criteria
Cohort of patients with acute necrotizing pancreatitis
Indication for intervention: (suspected or documented) infected necrosis
Catheter drainage as primary invasive intervention

Exclusion criteria
No timing of first catheter drainage reported
Included patients with chronic pancreatitis, pseudocysts, pancreatic abscesses and/or exclusively sterile pancreatic necrosis, and outcomes for necrotizing pancreatitis not reported separately
Primary catheter drainage combined with another minimally invasive strategy, and outcomes for solely primary catheter drainage not reported separately
Fewer than five patients
No full text available