Recent advances in the surgical management of necrotizing pancreatitis
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Purpose of review
To summarize advances and new concepts in the surgical management of necrotizing pancreatitis published within the past year with emphasis on the evolving importance of the recognition of abdominal compartment syndrome as a significant contributor to early development of organ failure.

Recent findings
Underdiagnosed and untreated, abdominal compartment syndrome is a potential contributing factor to the development of early organ failure in patients with severe acute pancreatitis and warrants routine measurement of intra-abdominal pressure in patients treated for severe pancreatitis. The current estimate of the prevalence of intra-abdominal hypertension in severe acute pancreatitis is about 40%, with about 10% overall developing abdominal compartment syndrome, associated with increased hospital mortality rates. Early surgical decompression without exploring the pancreas further seems to be the most effective treatment. Primary fascial closure of the abdominal wall following abdominal decompression can be attempted, but in most cases the prolonged inflammatory process in the abdomen and the risk of recurrent abdominal compartment syndrome favors use of gradual closure or delayed reconstruction of the abdominal wall.

Summary
Recent studies confirm the overall validity of the established surgical principles for necrotizing pancreatitis: delayed necrosectomy in patients with infected peripancreatic necrosis, mostly nonoperative management of sterile necrosis, and delayed cholecystectomy in severe gallstone-associated pancreatitis. The role of abdominal compartment syndrome as an important contributing factor to early development of multiple organ failure and the potential benefit of surgical decompression are gaining support from recent reports and should be carefully assessed in future studies.

Keywords
abdominal compartment syndrome, acute pancreatitis, necrosectomy, necrotizing pancreatitis, open abdomen

Abbreviations
ACS abdominal compartment syndrome
IAH intra-abdominal hypertension
IAP intra-abdominal pressure

Introduction
In about 20% of patients with acute pancreatitis, a severe form of the disease ensues characterized by a two-phase systemic disease. The prevailing perception is that during the initial phase, a systemic inflammatory response caused by a complex effect of several proinflammatory mediators activated by pancreatic and peripancreatic necrosis dominates the clinical picture and may lead to early multiple organ failure within the first 72 hours [1]. If the process cannot be limited by natural defense systems or treatment, the second phase ensues, with progression to septic, local pancreatic, or other complication [2]. Infection of the peripancreatic necrosis can be seen in 20%–40% of patients with necrotizing pancreatitis [3]. The late phase of severe pancreatitis (at >4 weeks) may be associated with pancreatic abscesses or pseudocysts.

Although necrotizing pancreatitis is commonly characterized as a ‘surgical’ disease, the bulk of the treatment consists of nonsurgical interventions performed in an intensive care environment including early aggressive fluid resuscitation, invasive monitoring, and support of organ functions, prophylactic antibiotic treatment, early enteral nutrition, and early endoscopic sphincterotomy in patients with common bile duct stone-induced pancreatitis.

The main surgical contribution to the overall management of necrotizing pancreatitis is necrosectomy, the surgical removal of infected or sterile peripancreatic and retroperitoneal necrosis. Other potential surgical or endoscopic interventions include diagnostic laparotomy for acute abdomen revealing unsuspected cases of acute pancreatitis, endoscopic sphincterotomy to treat biliary obstruction in biliary pancreatitis, endoscopic placement of a nasojejunal feeding tube, percutaneous drainage of pancreatic abscesses, management of intestinal or pancreatic fistulas, pseudocysts and hemorrhagic complications, and cholecystectomy following biliary pancreatitis. In addition, recent evidence suggests that the development of abdominal compartment syndrome (ACS) early in the course of the disease is a significant contributor to early organ dysfunction and a potential target for early surgical intervention.
In 2002, the International Association of Pancreatology developed evidence-based guidelines for the surgical management of acute pancreatitis [4]. The 11 recommendations favor nonoperative management of mild acute pancreatitis, use of prophylactic antibiotics, fine-needle aspiration biopsy to identify infected pancreatic necrosis, early cholecystectomy in mild gallstone-associated acute pancreatitis, and delayed cholecystectomy in severe pancreatitis. Surgical or radiologic drainage or necrosectomy should be performed in patients with infected necrosis and clinical signs and symptoms of sepsis. Sterile necrosis should in most cases be treated nonoperatively. Necrosectomy should favor an organ-preserving approach combined with a postoperative management concept that maximizes postoperative evacuation of retroperitoneal debris and exudate. Early surgery, within 14 days after onset of necrotizing pancreatitis, is not recommended unless there are specific indications.

A recent consensus conference held in April 2004 updated the current evidence-based knowledge into 23 recommendations [5]. The jury recommended against pancreatic debridement or drainage for sterile necrosis, limiting debridement or drainage to those with infected pancreatic necrosis or abscess confirmed by radiologic evidence of gas or results of fine-needle aspirate. Furthermore, the jury recommended that whenever possible, operative necrosectomy or drainage be delayed at least 2–3 weeks to allow for demarcation of the necrotic pancreas.

This review summarizes the advances and new concepts in the surgical management of necrotizing pancreatitis published within the past 12 months with special emphasis on the evolving importance of the recognition of ACS as a significant contributor to early morbidity and mortality from severe acute pancreatitis. Based on a search in the medical literature published in the year 2004, more than 100 articles on acute pancreatitis were identified. Those concentrating on general reviews, epidemiologic, experimental, biochemical, microbiologic, or histologic studies, imaging techniques, nutritional support, general and intensive care unit management, and quality of life are not discussed here.

**Surgical management of peripancreatic necrosis (necrosectomy)**

In an Indian study of 58 patients undergoing necrosectomy and postoperative closed lesser sac lavage, it was possible to start irrigation in 48 patients and continue until disease resolution or death in all but 10 patients. The overall mortality was 29%. There were a fairly large number of postoperative complications including enteric fistulae in 12 patients, residual abscesses in 10, pancreatic fistulae in nine, and bleeding complications in eight patients. Repeat surgery was needed in 16 patients and percutaneous drainage in six [6]. In a preliminary study of six patients undergoing percutaneous video-assisted necrosectomy after failure of radio-guided percutaneous drainage, sepsis control was achieved in all patients in one to four sessions, with no deaths [7].

The main unresolved issues of the role of necrosectomy in severe acute pancreatitis include who requires surgery, when is the optimal time to intervene, and what technique should be used [8]. In a survey sent to members of the International Hepato-Pancreato-Biliary Association with a 38% response rate on surgical strategies for the management of severe acute pancreatitis, 53% of the respondents would operate on a patient with positive results from fine-needle aspiration biopsy, but there was no consensus on optimum timing of surgery [9].

The current best evidence supports a surgical or radiologic intervention in patients with infected peripancreatic necrosis proven radiologically or by fine-needle aspiration biopsy, and it should not be performed earlier than 2–3 weeks from the onset of the disease. The role of surgical intervention in sterile necrosis has not been solved, and how to treat a patient with sterile necrosis 4–6 weeks into the disease not recovering remains unanswered [10].

**Biliary pancreatitis**

A study from Texas with 187 patients who had gallstone-associated acute pancreatitis showed that cholecystectomy should be delayed in patients with moderate to severe pancreatitis and demonstrated peripancreatic fluid collections or pseudocysts until the pseudocysts either resolve or beyond 6 weeks, at which time the pseudocyst drainage can safely be combined with cholecystectomy [11]. This study confirms the consensus recommendation that in severe gallstone-induced acute pancreatitis, cholecystectomy should be delayed until the inflammatory response resolves and clinical recovery occurs [4].

**Surgery for extrapancreatic complications**

Nonseptic surgical complications are common in acute necrotizing pancreatitis. In a Hungarian study of 131 patients, fatal complications included bleeding in seven patients and bowel perforation in three [12].

Colonic involvement in acute pancreatitis is associated with high mortality, as shown in a study from The Netherlands in which 11 of 16 patients with acute pancreatitis and colonic complications died. All patients underwent colonic resection, although only four had a macroscopic perforation during operation. Blinded evaluation by a radiologist demonstrated retroperitoneal spread of the necrotizing process to colon in all 10 reviewed CT scans, and a blinded pathologist’s evaluation of all 14 microscopically examined specimens showed fat necrosis and pericolitis, but only four had ischemia and eight had intact mucosa, submucosa, and smooth muscle layers [13]. Although the authors
recommend a low threshold for colonic resection due to unreliable detection of ischemia or imminent perforation by outside inspection during surgery, it is expected that the necrotizing process involves the outer layers of the nearby colon. The natural history and the true incidence of colonic perforation remain unknown, however.

**Abdominal compartment syndrome**

Recent data from the Meilahti Hospital, University of Helsinki, Finland, show that although the mortality rates in patients with severe acute pancreatitis and multiple organ failure have improved considerably in the past 15 years, there is little improvement in the early (within 14 days) mortality rate (Halonen and Leppäniemi, unpublished data 2004). Clinical evidence is increasing that many of the deaths in the early phase of the disease, previously thought to be caused by an overwhelming acute inflammatory reaction leading to ‘early multiple organ failure’, are associated with undiagnosed and untreated ACS. Much of this information is derived from the abstracts presented during the recent World Congress of Abdominal Compartment Syndrome in Noosa, Australia in December 2004.

In a study comparing patients with or without ACS (intra-abdominal pressure [IAP] > 25 mm Hg) treated in the intensive care unit for severe acute pancreatitis, the hospital mortality rate for patients with ACS was 50% compared with 15% in patients without ACS (Keskinen et al., paper presented at Inaugural World Congress on Abdominal Compartment Syndrome; December 6–8, 2004; Noosa, Australia). There was a clear correlation between the maximum IAP value within the first 2 weeks and the mortality rate. In a logistic regression analysis, however, only the maximal Sequential Organ Failure Assessment score was an independent risk factor for hospital mortality.

A study from China with 297 patients with severe acute pancreatitis showed that those who developed organ dysfunction within 72 hours after the onset of symptoms had a 78% incidence of intra-abdominal hypertension (IAH > 15 mm Hg) compared with 23% in patients with severe acute pancreatitis without early organ dysfunction. The overall mortality rates in patients with and without early onset organ failures were 43.4% and 2.6%, respectively. Comparing nonsurvivors with survivors in the group with early-onset organ failures, the prevalence of ACS was higher among the nonsurvivors (90.0% vs 56.4%) (Keskinen et al.). The development of ACS in patients with severe acute pancreatitis seems to occur most commonly in the early course of the disease and is probably caused by the combined effects of the aggressive fluid resuscitation and inflammatory process in the retroperitoneum leading to the development of visceral edema and pancreatic ascites (Gonzales Santamaria et al. and Lisi et al., papers presented at Inaugural World Congress on Abdominal Compartment Syndrome; December 6–8, 2004; Noosa, Australia).

The prevalence of IAH in patients with severe acute pancreatitis is not known. In a study of 41 patients with severe acute pancreatitis, 44% of the patients had IAP levels higher than 12 mm Hg, and four patients (10%) had IAP levels higher than 25 mm Hg with severe organ dysfunction and undergoing abdominal decompression (De Waele et al., paper presented at Inaugural World Congress on Abdominal Compartment Syndrome; December 6–8, 2004; Noosa, Australia). In another study of 37 patients treated in the intensive care unit for severe acute pancreatitis, 10 patients (27%) had IAP levels higher than 25 mm Hg, with an overall frequency of 10 of 120 (8%) when all patients with severe acute pancreatitis treated in other units (surgical intensive care unit, high-dependency unit) were included (Keskinen et al.). Thus, it can be estimated that the overall prevalence of IAH in patients with severe acute pancreatitis is about 40%, and the frequency of ACS requiring surgical decompression about 10%. Due to the more aggressive fluid resuscitation policy in the early phase of severe acute pancreatitis, and the decreasing proportion of patients requiring necrosectomy, it is likely that the incidences of both early-onset and late-onset ACS, respectively, are higher today than in the past.

Several studies show the association between IAH and development of organ dysfunction in severe acute pancreatitis (Keskinen et al., De Waele et al., and Snippe et al., papers presented at the Inaugural World Congress on Abdominal Compartment Syndrome; December 6–8, 2004; Noosa, Australia). De Waele et al. showed that there was a 94% incidence of respiratory failure, 94% cardiovascular, and 89% renal failure rate in patients with IAP higher than 12 mm Hg. Because the pathophysiologic responses to the cellular events early in the course of the disease have the ability to induce organ dysfunction even without the presence of ACS, more studies are needed to characterize the exact mechanisms, role, and magnitude of ACS leading to early organ failure in severe acute pancreatitis.

Decompressive laparotomy and temporary abdominal closure with a Bogota bag or equivalent seem to be the most effective way of treating ACS in severe acute pancreatitis [14*] (Gonzales Santamaria et al. and De Waele et al.). A standard vertical midline laparotomy incision is the most commonly used procedure for decompressive laparotomy, but it is associated with significant wound-related early and late morbidity and with the need for reconstructive surgery for the ‘planned’ ventral hernia. If a bilateral subcostal incision is able to provide sufficient decompression, it could reduce morbidity and increase the proportion of patients with successful fascial closure during the initial hospitalization period, although there are no research data supporting this.

Due to the potential risk of introducing infection to the peripancreatic necrotic tissue with any open abdomen
method for treating ACS, an alternative could be to perform a bilateral endoscopic anterior rectus fasciotomy, which has been suggested as an optional method to decrease IAP and avoid open abdomen altogether [15]. There are, however, no clinical data to support that a sufficient decompression effect can be achieved in humans.

In some cases with ultrasound-proven presence of large volumes of pancreatic ascites, the first-vacuum-assisted closure has been percutaneous drainage of the intraperitoneal exudate, which can lead to a significant drop in IAP (Lisi et al.).

The surgical management of ACS in patients with severe acute pancreatitis raises several unresolved issues, such as the relation of early decompression to eventual necrosectomy, potential increase in infected peripancreatic necrosis rates, and the difficult management of open abdomen in a situation in which the disease process is likely to continue for weeks. Current limited evidence supports the concept of not exploring the pancreas further but limiting the operation to decompression and drainage of ascites (Gonzales Santamaria et al.). One study showed that premature exploration of the peripancreatic area can lead to fatal retroperitoneal bleeding (De Waele et al.). A case report from Germany described the use of vacuum-assisted closure in a patient with severe pancreatitis utilizing an auxiliary, independently open vacuum system positioned intra-abdominally [16]. Primary closure of the abdominal wall was finally achieved after 30 reoperations, 72 days later. There were no bowel fistulas or intra-abdominal abscesses.

Conclusion

The established surgical principles in the management of severe acute pancreatitis have changed little over the past few years. In contrast, new and accumulating evidence indicates that the ‘early multiple organ failure’ sometimes seen in severe pancreatitis can at least in some patients be the result of undiagnosed ACS associated with the extensive inflammatory process in the retroperitoneum and the aggressive fluid resuscitation applied early in the course of the disease. Most centers measure IAP routinely in all patients with severe acute pancreatitis and perform early decompression in full-blown ACS. Carefully designed studies are needed to solve the challenges related to ACS in this high-risk patient group.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:
• of special interest
•• of outstanding interest

6 An international consensus conference developed 23 evidence-based recommendations to address specific questions in the management of severe acute pancreatitis.
15 This paper identifies a large proportion of patients with ACS among 297 patients with severe pancreatitis.
17 A potentially useful technique for abdominal decompression in severe acute pancreatitis was studied in an animal model.