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Minimally invasive techniques in the treatment of severe acute pancreatitis

Review Article

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Abstract: Open necrosectomy, the standard surgical treatment of infected pancreatic necrosis (IPN), presents a high rate of postoperative complications and an associated mortality of 20-60%. In the last decade various minimally invasive approaches (MIA) have been proposed for the treatment of IPN and the results seem to improve on those reported with open necrosectomy. These MIA include: percutaneous, retroperitoneal, endoscopic (endoluminal) and laparoscopic (transperitoneal). The adoption of the step-up approach in the management of severe acute pancreatitis (SAP) facilitates the implementation of MIA as the surgical treatment of choice in most cases. Since MIA require the expertise of radiologists, endoscopists and surgeons, patients suffering SAP should be treated by multidisciplinary teams in referral centers. We describe the MIA currently available and discuss their advantages, disadvantages, and results.

Keywords: Acute pancreatitis • Necrosectomy • Minimally invasive surgery • Laparoscopy

1. Introduction

The concept of the surgical treatment of infected pancreatic necrosis (IPN) has been transformed in recent years. While necrosectomy and debridement were traditionally considered the surgical treatment of choice [1], now they are reserved only for cases of poor outcome or poor control of sepsis after previous treatment with percutaneous drainages and antibiotics [2-3]. In most published series, open necrosectomy (ON) is associated with a high rate of postoperative complications and mortality, as well as a frequent need for reoperation [4-7] and high rates of postoperative diabetes. The earlier ON is required during the clinical course of the disease, the poorer the results [6,8]. ON has proved totally insufficient for adequate control of systemic inflammatory response in the early stages of severe acute pancreatitis (SAP) [6,9]. The groups presenting the best results, in terms of both mortality and reoperation, were the ones in which surgery was performed in the late stages of the disease [10]. It seems that the triad comprising a)

control of initial acute inflammatory process, b) control of sepsis and c) delay of definitive surgical treatment are the key factors in the successful management of necrotizing pancreatitis (NP). In this regard, the PANTER study has shown that the key issue is not the resection of the necrosis but the control of the local infection [11].

In 1998, Freeny PC et al. reported the first positive results in the initial management of NP using percutaneous drains inserted under radiological control. They found that subsequent surgery was avoided in 47% of cases [12]. Their results led to the development of a new therapeutic algorithm, coinciding with a gradual rise in the use of endoscopic procedures in other areas of surgery. Interest is now growing in minimally invasive approaches (MIA) for the treatment of SAP. It is recommended that SAP patients should be treated in referral centers by a multidisciplinary team [13]. Currently, good results are obtained with MIA in more than 90% of cases [14,15]. In the past decade many studies of MIA for SAP have been published, with each group adding their own experience. However, the results are often skewed by the characteristics of the study, and so there is a need

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for an update to establish which of the currently available techniques should be used in specific cases of INP. Based on the study of various review articles [16-19], the approaches described can be classified in four broad groups: percutaneous, retroperitoneal, laparoscopic (transperitoneal) and endoscopic (endoluminal). In turn, each of these approaches can be considered as the definitive single treatment or can be used as the initial approach in combination with others [13].

2. Percutaneous approach

Percutaneous drainage of IPN proves effective as a single treatment in 44% of cases. However, rates of complications and associated mortality are around 20% and 28% respectively [16]. Specific complications described include intra-abdominal haemorrhage, colonic perforation, intestinal fistula and pancreatic fistula [11,12,20].

Two different strategies are applied for percutaneous treatment. The first comprises the insertion of CT or ultrasound-guided percutaneous drainages to evacuate infected peripancreatic collections and then, along with the administration of antibiotics, waiting for clinical improvement and complete resolution of the disease [1,12]. Multiple drainages may be inserted and washes can be made through them. They can be replaced as often as necessary. The aim of this strategy, known as the "step-up approach", is to improve the patient's condition and to delay surgery until the IPN is better delimited (Figure 1). Several studies have shown that with the placement of percutaneous drains alone, 23-47% of patients can achieve complete resolution of the acute disease and do not require any additional

Figure 1. A retroperitoneal percutaneous drain has been inserted under radiologic control in our institution. The catheter will be used as a guide for entering into the pancreatic cell in the strategy of the step-up approach using the VARD technique.

procedures [11,21,22]. The second strategy consists in the placement of a percutaneous drainage as a guide to locate the anatomic space where the necrosis should be drained. After placing the drains, the patient is transferred immediately to the operating theater. At that time, using either general anesthesia or local anesthesia with sedation, the tract is progressively dilated until obtaining a diameter (30 F) large enough for the insertion of a rigid nephroscope, through which the necrosis can be washed and fragments removed under direct vision. Large caliber drains are then inserted through the tract to allow continuous washing. This maneuver can be repeated as often as necessary to achieve complete removal of necrosis fragments [15,23].

Sinus tract endoscopy is a special variant of percutaneous treatment which forms part of the "step-down approach" strategy. It is used as adjunctive therapy following a previous ON, and is preferably performed via the retroperitoneal open approach [24]. Through the drains inserted during surgery for postoperative lavage, a flexible endoscope is introduced and the remaining fragments of necrosis are removed under direct vision. This can be done at the patient's bedside without general anesthesia and may be repeated as many times as necessary. The main advantage is that necrotic tissue can be removed without the need for formal reoperation.

3. Retroperitoneal approach

The retroperitoneal approach in pancreatic necrosis is not new and has been described in detail elsewhere [25], but it is not as widely used as the anterior approach [26,28]. The use of MIA techniques has ushered in a new era in which the retroperitoneal approach is becoming as popular as the transperitoneal one. As many as 88% of the cases operated via a minimally invasive retroperitoneal approach (MIRA) do not require subsequent ON. Overall mortality is around 17%. The overall complication rate, as in all other techniques, remains high (46%). Specific complications related to MIRA are colonic fistula, gastric and duodenal perforation, enteric fistula, pancreatic fistula and retroperitoneal hemorrhage [16]. MIRA is mainly indicated in cases in which pancreatic and peripancreatic necrosis are located primarily in the left pancreas, the most common site in current clinical practice.

The technique was first described by Gamibez et al. in 1998 [22]. A small 6 cm incision is performed below the 12th rib. The pancreatic cell is reached via the left retroperitoneal access without opening the peritoneum, and by passing behind the splenic flexure of the colon and the spleen. This dissection is performed bluntly

under digital control. Once lodged into the pancreatic cell, a laparoscopic camera is inserted through the small incision to obtain a depth direct vision of the area. Using suction and forceps, the necrotic tissue is grasped and removed. This technique was first described by Horvath et al. in 2001 [28] as VARD (video-assisted retroperitoneal debridement) and established by van Santvoort HC et al. 2007 [29]. In a multicenter prospective trial published in 2010, Horvath et al. observed that VARD was feasible in as many as 60% of patients requiring surgical treatment. In 81% of cases this single new procedure was sufficient and ON was not required. Thirty-day mortality was 2.5%, postoperative hemorrhage occurred in 7.5% and enteric fistulas in 17.5% [21]. However, it was the PANTER multicenter prospective randomized study published in 2010 by the Dutch Pancreatitis Study Group that firmly established the VARD technique [11]. Used as part of the step-up approach, this technique has been shown to be superior to ON, the standard approach (Figures 1 and 2).

4. Endoscopic (endoluminal) approach

The endoscopic (endoluminal) approach represents a promising option today for the management of patients with IPN [30]. Although the results reported in the literature show a reduction in mortality of 5.6% and an overall complication rate of 28%, it should be noted that this technique is performed only in selected cases or in patients with sterile necrosis or post-inflammatory pseudocysts [16,17,31]. As with all other techniques, serious specific complications have been reported, such as bleeding, perforation of abdominal cavity and peritonitis [5,31,32]. Although the endoscopic approach route via the duodenum has been described, in practice the transgastric route is the most commonly used. The technique was initially defined in 1996 by Baron TH et

al. [33]. Since then, different groups have introduced changes. It is generally performed under general anaesthesia, but can also be performed using sedation with Midazolam and Fentanyl [30]. Via endoscopic ultrasound, the post-inflammatory pancreatic necrosis behind the posterior wall of the stomach is located and punctured. With successive balloon dilatations a window up to 2 cm in length is obtained, through which direct lavage can be performed. A gastroscope can be introduced through this window and then the necrosis can be manipulated with forceps under direct vision. This procedure is laborious, since the graspers used are the same as for endoscopic biopsies and polypectomies. It takes an average of 3.5 hours to complete [32]. At the end of the procedure a nasal-cystic drainage is inserted for continuous lavage, thus promoting the release of new fragments of necrosis. Optionally, additional transgastric drainages may be inserted to facilitate drainage. One drawback of this technique is that at least three procedures are usually required because of the reduced size of the window made in the gastric wall and the poor capacity of the devices for grasping the necrosis [16, 30]. Similarly, because of its complexity, it is performed at only a few centers, including tertiary referral centers, and it is heavily reliant on the endoscopist's experience. The published results seem satisfactory and mortality is very low; however, up to 40% of patients require additional placement of percutaneous drainages to eliminate new areas of necrosis or collections, and between 20-28% require other surgical treatment [5,30,31].

The great advantage of this technique is that it is the only one that completely avoids incisions because it applies the concept of natural orifice transluminal endoscopic surgery (NOTES) [34]. Moreover, the pancreatic juice drains directly into the gastric lumen, so the rate of pancreatic fistula is reduced to less than 10% [30].

5. Laparoscopic (transperitoneal) approach

This is the least used MIA. Its main drawback is that the patient must be in a stable clinical situation to allow adequate tolerance of pneumoperitoneum. Furthermore, the large inflammatory component of omental and mesenteric fat may hinder access to the lesser sac and retroperitoneum. As most published studies include retrospective series of fewer than 10 selected patients and many do not report relevant data, their results should be assessed with caution. The technique is always performed under general anesthesia. It consists in a conventional exploratory laparoscopy with three or four ports, reaching the pancreatic cell to complete the

Figure 2. Minimally invasive technique of VARD used in our institution. A system of drains are placed for continuous postoperative lavage.

necrosectomy and inserting large caliber drains for post-operative lavage [35,36] (Figure 3).The preferred route for accessing the pancreatic cell is via the gastro-colic ligament and greater omentum [37]. In a variant of this technique, a device is used for hand-assisted surgery to allow performance of the necrosectomy by digital blunt dissection [38].

The results appear to show that the laparoscopic technique is feasible in most cases. The rate of open conversion is below 20% [36–38]. Based on the data reported in the literature, 80% of cases operated by laparoscopic approach will not require additional surgical procedures. The mortality rate reported is near 10% [16]. Compared with conventional ON, the laparoscopic transperitoneal approach achieves a lower overall complication rate (particularly with regard to pancreatic fistula), lower wound infection, and shorter postoperative stay [37].

Table 1 shows the main differences of all these different MIAs, comparing indications and possible advantages and disadvantages.

6. Discussion

ON remains the most widely used surgical treatment for IPN. Although classically associated with a high rate of complications and mortality [4], recent results appear to show a clear improvement, reducing mortality rates by 12% [39,40]. The prognostic factor most consistently

Figure 3. 82 years-old woman operated because of early infected pancreatic necrosis by laparoscopic transperitoneal approach (3 ports) in our institution. After removing necrotic tissue, a system of drains is placed through the ports for continuous postoperative lavage.

linked with mortality in severe acute pancreatitis is early onset of organ failure during the clinical course of the disease; the earlier it is established, the higher the mortality [8]. In most cases, organ failure is independent of the infection of the pancreatic necrosis and is related only to the associated systemic inflammatory response. No benefits of early surgical treatment of sterile or infected SAP have been demonstrated; in fact, the outcome of early treatment has been found to be unfavourable [6]. Even in cases of infected SAP, delaying surgical treatment has been associated with a clear improvement in the results, and is feasible in most cases [13]. Several authors have shown the effectiveness of radiology-guided percutaneous drainages to control the initial phase of the sepsis [1,12,14,41] and thus to delay definitive surgical treatment as long as possible. The drains are so effective that in as many as 30% of cases no subsequent surgery is required [11,14].

Once the initial inflammatory phase of the disease has passed and the patient is stabilized, surgical management is performed by MIA. The more mature the necrosis and the more delimited the retroperitoneal space that is to be drained, the more selective the surgical approach can be, acting only on targeted areas. ON remains important in patients in whom no clinical improvement is achieved even through the percutaneous placement of drains. This scenario currently represents as many as 50% of all cases [5,11] and its associated mortality is as high as 60% [4-6,8]. The type of MIA chosen will depend primarily on two factors. The first, and the most important, is the experience of each center with the use of the techniques. While the placement of a percutaneous drainage can be performed at all referral centers, MIA are not always available because they require the presence of endoscopists specialized in advanced endoluminal techniques and surgeons trained in minimally invasive retroperitoneal and laparoscopic management. The second factor is the location of the necrosis and the time elapsed since the onset of symptoms. The retroperitoneal approach is the best suited in cases where there is necrosis in the body and tail of the pancreas with extension into the left retroperitoneal fat. In contrast, the endoscopic approach is more appropriate in cases in which post-inflammatory necrosis and collections are mainly located in the retrogastric space with a large contact area with the posterior wall of the stomach and lesser involvement of the pararenal and pericolonic retroperitoneal fat. It should be noted that the different approaches are not mutually exclusive, and may be used complementarily and sequentially. For this reason, and because of the large variability in the presentation of cases, each case must be handled on an individual basis and it is difficult to obtain homogeneous

Type of minimally invasive approach	Anaesthesia	Pros	Cons
Percutaneous	General or Local ± Sedation	Specially indicated when necrosis/collections are primarily localized in the left pancreas and left pararenal space Possible in unstable patients Not required a well delimited necrosis/Can be done in the early phases of the disease Possible in patients with severe abdominal hypertension Considered as a bridge to definitive treatment (Step-up approach) A definitive treatment in up to 40% of the patients Can be performed in the radiologist floor or at the bedside of the patient in Intensive Care Unit in many patients	Usually multiple attempts required or multiple concomitant drains placed Usually not a definitive technique Risk of intraabdominal haemorrhage during the procedure Risk of colonic perforation during the procedure Establishment of an external pancreatic fistula Difficult to do when necrosis/collections are localized in the body and head of the pancreas
Retroperitoneal	General	Possible in unstable patients Extensive removal of infected necrotic tissue Specially indicated when necrosis/collections are primarily localized in the left pancreas and left pararenal space Necrosectomy is performed under "view" control Frequently is required only one procedure Integrity of abdominal cavity is maintained / Avoids adhesions from previous transabdominal procedures / Facilitates futures transabdominal approaches	Establishment of a postoperative external pancreatic fistula Risk of postoperative haemorrhage Risk of postoperative enteric fistula Difficult access when central mesenteric fat is affected
Laparoscopic	General	Complete exploration of the abdominal cavity and surrounding organs Access to different intraabdominal spaces at the same intervention (right, left, supramesocolic, inframesocoli, mesenteric fat) Adequate for drainage of multiple infected different areas Possibility of concomitant definitive cholecystectomy if biliary aetiology	Need of an expert surgeon in laparoscopy No recommended in unstable patients Stable clinical situation required for adequate tolerance to pneumoperitoneum No possible when established severe abdominal hypertension Enlargement of greater omentum and mesenteric fat reduces accessibility to the retroperitoneum
Endoscopic	General or Sedation	No scares/Pure NOTES Avoids external pancreatic fistulas Main indication when necrosis/collections are mainly localized in the middle body of the pancreas Specially indicated for infected well delimited wall-off necrosis	Need of an expert endoscopist No recommended in unstable patients Only possible in the late phases of the disease when collections and/or necrosis are well delimited Usually multiple attempts required

Table 1. Possible advantages and disadvantages of different minimally invasive approaches in severe acute pancreatitis.

groups from which to draw conclusions. Only one prospective randomized study has compared endoscopic and retroperitoneal approaches; although the results are broadly similar, they seem to favor the endoscopic approach in view of the lower incidence of postoperative pancreatic fistula [30].

The transperitoneal laparoscopic approach is the least used because of its greater technical difficulty

in critically ill patients, but it may be advantageous in cases in which it is important to position a washing system along the entire cell or when a complete exploration of the abdomen is required to rule out other related complications (acute cholecystitis, intestinal ischemia). Although no prospective randomized studies have been performed, compared with ON the laparoscopic approach has a lower incidence of pancreatic fistula, wound infection and hemorrhage, and patients have a shorter postoperative stay [37].

Figure 4 shows the algorithm proposed for the management of IPN using MIA (Figure 4).

In conclusion, while ON is still the most widely used and accepted treatment for the surgical management of IPN, convincing arguments are emerging in favor of using MIA (percutaneous, endoscopic, retroperitoneal and laparoscopic) and applying a step-up approach. In the hands of experienced multidisciplinary teams at referral centers, the use of MIA techniques can substantially improve outcomes and quality of care for these patients.

Conflict of interest statement

Authors state no conflict of interest.

Figure 4. Algorithm for modern management of infected pancreatic necrosis.

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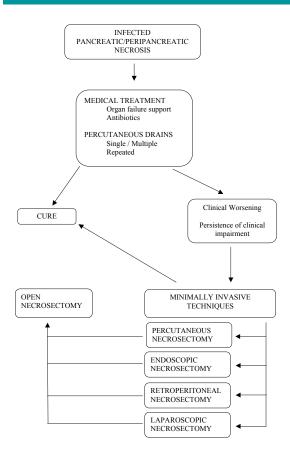
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