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The Role of Negative Pressure Wound Therapy in Severe Acute Pancreatitis

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Abstract

The use of negative pressure wound therapy is a well accepted method of choice in the treatment of complicated septic wounds. Beside its excellent effects on wound healing it is more often used in the abdominal-general surgical practice, as well as in acute pancreatitis. The aim of this review is to find evidences and to determine the role of negative pressure wound therapy in the treatment of severe acute pancreatitis based on the PubMed database. Open abdomen therapy with NPWT is the first of choice, when acute pancreatitis related abdominal compartment syndrome develops. In open abdomen -and open bursa- therapy for septic necrosis and intracutaneous fistulas the device can be used as an additional approach. In case of impossible abdominal wall closure, the vacuum therapy also has a beneficial effect. Vacuum therapy in combination with endoscopic transgastric drainage (Endo-VAC therapy) can be helpful in cases of walled-off pancreatic necrosis as a minimally invasive method. Beside the direct effects on wound healing NPWT significantly reduces morbidity and mortality in severe pancreatic necrosis; furthermore it simplifies nursing of patients, in this way reducing ICU and hospital stay. In conclusion, as an additional therapy NPWT is advised in severe acute pancreatitis, complicated with septic necrosis and/or ACS, or entero-atmospheric fistulas in critically ill patients.

Keywords: Acute pancreatitis; Negative pressure wound therapy; Abdominal compartment syndrome

Abbreviations

IAH: Intraabdominal Hypertension; IAP: Intraabdominal Pressure; ACS: Abdominal Compartment Syndrome; APP: Abdominal Perfusion Pressure; MAP: Mean Arterial Pressure; EAF: Entero-Atmospheric Fistula; OA: Open Abdomen; NPWT: Negative Pressure Wound Therapy; VAC: Vacuum Assisted Closure; endo-VAC: Endoluminal Vacuum Assisted Closure; SAP: Severe Acute Pancreatitis; SIRS: Systemic Inflammatory Response Syndrome; MOF: Multiple Organ Failure; TAC: Temporary Abdominal Closure; PR: Peritoneal Resuscitation; CR: Conventional Resuscitation; DCS: Damage Control Surgery

Introduction

The management of acute pancreatitis is mainly conservative, however when conservative therapy fails, surgical intervention may be necessary. The main indications for surgery are septic necrosis and abdominal compartment syndrome but bleeding, bowel necrosis, uncontrolled pain, multiorgan failure or perforation also requires surgical intervention. In rare cases, open abdomen management is also indicated [1-13]. Negative Pressure Wound Therapy (NPWT) or Vacuum-Assisted Closure (VAC) is more often used in general surgical practice since its excellent effect on wound healing. In selected cases, endoluminal transgastric necrosectomy can also be combined with vacuum therapy (endoluminal vacuum therapy, endo-VAC) for debridement evacuation from the necrotic region [14-17]. Furthermore, NPWT is beneficial for prevention and/or treatment of Abdominal Compartment Syndrome (ACS) and Enteroatmospheric Fistulas (EAF) [2-6,8,18-24]. According to the 2013 WSACS guideline, decompressive laparotomy with NPWT is part of the ACS management [13]. Open abdomen (OA) and/or bursa with vacuum therapy is indicated in special cases, when complete necrosectomy is impossible and repeated interventions (laparotomies) are needed [1,2,4,5,7,18,19,21,25]. The challenging abdominal closure after multiple laparotomies is also an indication for NPWT [4,21,24,26-28]. The aim of this article is to provide an overview on the role of NPWT/VAC therapy in the treatment of severe acute pancreatitis.

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Indications for surgical intervention in acute pancreatitis

In severe acute pancreatitis when the step-up approach has failed, surgical intervention is required. The main indication for surgery is septic necrosis. Other indications are abdominal compartment syndrome, acute abdomen (bleeding, perforation), enteroatmospheric fistulas, gastric outlet syndrome and Multiple Organ Failure (MOF) in special, fulminant cases. In selected cases, when multiple operations are required, open abdomen management is recommended. After multiple reoperations, when the primary closure of the abdominal wall is not feasible, plastic surgical interventions are required [29,30].

The role of NPWT in septic necrosis, open abdomen therapy

When conservative and minimal invasive treatment options failed, the most common indication for surgical intervention is infected necrosis. As a result of earlier operations and/or intraperitoneal adhesions, the patients suffering from acute or chronic pancreatitis usually are not suitable for interventional radiological procedures. The gold standard surgical intervention is the pancreatic and peripancreatic necrosectomy (especially the retrocolic and retroduodenal areas) with closed omental bursa drainage [5,7,28]. In selected cases when complete necrosectomy is not possible, open abdomen therapy is indicated [4,5]. In order to avoid the local complications of open abdomen therapy and to increase primary closure rate, a vacuum-assisted open abdomen system was developed [1,2,21]. Following open abdomen management, primary abdominal closure is usually challenging due to significant separation of abdominal wall edges, however the success rate of abdominal closure after NPWT shows encouraging results [25,29]. OA with NPWT is frequently used after repeated laparotomies in Severe Acute Pancreatitis (SAP) [1,4,19,29]. The beneficial effect of NPWT in OA management is the continuous evacuation of septic fluid from the abdominal cavity. Another advantage is the prevention of abdominal wall constriction [1,19,29]. During the dressing change procedures, repeated debridement and washout are always necessary [1,19]. The suggested negative pressure is 100 mmHg to 125 mmHg [4,13,21,25,31]. It is highly advised to perform the dressing change on every second to fifth days [1,18,19,29]. VAC-related complications are rare, but not negligible. The most common complications are bleeding and bowel fistula formation, which can be prevented with precise hemostasis control and lower suction pressure the first few hours of the application [1,29]. Although only a few articles were published about VAC therapy usage in septic necrosis, the results are promising [1,18,19,29]. Whether the abdominal wall should be closed or left open (OA) after retroperitoneal and peripancreatic necrosectomy (with open bursa drainage) still requires further investigation. The COOL-study (Closed or Open after Laparotomy) led by Prof. Kirkpatrick as a prospective randomized controlled trial tries to answer a simple, however very important question: is the open abdomen indicated for intra-abdominal sepsis? By collecting evidential information world-wide, the study will hopefully give useful answers, so that the high mortality rate of intra-abdominal sepsis can further be reduced [32].

Open bursa and NPWT following necrosectomy

Following necrosectomy, viable tissue should be left [29]. If the necrosectomy is incomplete, additional, planned necrosectomy are needed [7,28]. In these cases, selective NPWT of the omental bursa with open abdomen management may have a beneficial therapeutic effect [14]. NPWT not only facilitates the evacuation of peripancreatic fluid and debridement but reduces elevated Intra-Abdominal Pressure (IAP). The suggested place of the dressing is the area of the bursa. The distant necrotic areas can be drained by bridging to the bursal area with soft drains [18]. After positioning the polyethylene protective layer, the foam has to be placed into the open bursa and wound. The next step is hermetic cover and suction adjustment. The suggested negative pressure is 60 mmHg to 125 mmHg. In order to prevent bleeding after closure, lower initial pressure (50 mmHg to 60 mmHg) is suggested [2,18,29]. Continuous or intermittent suction can be used. If the patient has severe pain during continuous VAC therapy, suction should be changed to intermittent mode. Redressing, repeated washout and necrosectomy are necessary every 3 to 5 days [3,18]. The VAC therapy can be finished once the necrosectomy is complete. Advantage of the vacuum-assisted open bursa therapy is the high rate of primary abdominal wall closure (approximately 70% to 80%) in contrast to the conventional open bursa therapy [18]. There are promising results of open bursa VAC therapy in the literature [2,3,14-19].

Endo-VAC therapy for walled-off pancreatic necrosis

Recent studies reported the applicability of intracavitary and endoluminal vacuum assisted wound closure system (endo-VAC) for treatment of anastomotic leaks after esophageal and rectal resections. In cases of Walled-Off Pancreatic Necrosis (WOPN), the endoscopic transgastric necrosectomy is a widely used technique. The combination of endo-VAC with endoscopic transgastric necrosectomy for WOPN is a relatively new method [14-17]. The results are promising by continuous elimination of the septic fluid from the peripancreatic space. Endoscopic treatment with combination of negative pressure therapy can prevent abdominal compartment syndrome by lowering the IAP, improving patient outcome and simplifying the nursing of the patient. Endo-VAC therapy can also reduce the total cost of treatment by shortening the hospital stay, reducing systemic antibiotic therapy and intensive care. On the other hand, major limitations of the endo-VAC system are the need for repeated endoscopic interventions and constant presence of a skilled medical team. Some authors suggested that the endo-VAC method may be ineffective in the course of sepsis [14-17].

The role of NPWT in abdominal compartment syndrome

Normal intra-abdominal pressure is between 5 mmHg and 10 mmHg at rest. If Intra-Abdominal Hypertension (IAH) with pressure above 20 mmHg is associated with a new organ dysfunction and the Abdominal Perfusion Pressure (APP) is lower than 60 mmHg, the diagnostic criteria of Abdominal Compartment Syndrome (ACS) are fulfilled. APP is calculated from the Mean Arterial Pressure (MAP) and IAP (APP=MAP-IAP). During the early course of SAP, multiple organ failure usually develops due to IAH/ACS, requiring close observation and adequate treatment [5-9,13,25,27,30,33,34]. According to the present WSACS guideline, routine measurement of intra-abdominal pressure is recommended in patients with acute pancreatitis [7,13,34]. The development and pathophysiology of ACS are particularly complex. Pancreatic inflammation is believed to be the origin of the cascade and includes retroperitoneal and visceral edema, gastric paralysis, peripancreatic fluid collection, capillary leakage, paralytic ileus and ascites as aggravating factors. Besides these factors, over dosage of crystalloids and colloids can also be part of the cascade. Extreme elevation of Intra-Abdominal Pressure (IAP) may induce an irreversible deterioration of tissue perfusion and later, organ failure. Prevention is extremely important due to the high mortality rate

[3,5,8-10,28,33-35]. Based on the above-mentioned mechanisms, elevated IAP significantly declines the prognosis of patients with acute pancreatitis. The main aspect of the therapy in ACS is conservative (controlled fluid resuscitation, diuretics, adequate pain management, muscle relaxants) or minimally invasive (percutaneous drainage), however, when the conservative way fails, surgical intervention is inevitable [3,5,8-10,28,33-35]. There are many surgical approaches for decompression, such as full thickness (laparotomy with delayed closure) and non-full thickness techniques (subcutaneous linea alba or rectus abdominis incision) [12,13,27]. The open abdomen therapy is described as the most effective one, however, many difficulties are also reported using this method [25,27]. Furthermore, closure of the abdominal wound is often problematic, the primary closure rate of "conventional" full thickness decompressive laparotomy is low [13,25,36]. The VAC is a relatively new method for decompressive surgery in ACS, which is the combination of full thickness laparotomy and open abdomen with the use of continuous suction [13,25,27]. Based on several comparative studies, the use of NPWT with open abdomen management in cases of acute pancreatitis has significant benefits compared to Temporary Abdominal Closure (TAC) [4,36]. It is reported that NPWT may reduce mortality, the length of hospital stays and intensive care, and facilitate an earlier primary abdominal closure. The NPWT device, developed by Brock et al. in 1995, is now included in the 2013 WSACS guideline as a grade 1B recommendation for open abdomen management [13]. In addition to its evident benefits, NPWT promotes the elimination of abdominal fluid and ascites (which contains a great amount of proinflammatory cytokines) thus decreasing bowel and retroperitoneal edema, preventing over infection of the abdomen and the constriction of the abdominal wall. Moreover, it prevents adhesion formation between the abdominal wall and the organs. NPWT alone is able to reduce IAP by 2.5 mmHg on average [6]. It was reported by several authors that NPWT can reduce organ dysfunction and the development of systemic inflammatory response syndrome (SIRS) [25,27]. Abdominal closure is recommended when the abdominal pressure remains in the normal range for at least 24 h [27,30]. The primary abdominal closure rate following VAC therapy is 70% to 100% [11,13,26,27,30]. In order to facilitate tension-free abdominal closure, there are several types of meshes available to use in combination with NPWT. Mesh mediated closure provides almost 100% success rate even with significantly separated abdominal edges or when primary abdominal reconstruction is not feasible [27]. It was suspected that NPWT may provoke IAH/ACS or it may lead to enteroatmospheric fistula development due to the intermittent negative pressure, nevertheless these suspicions were not confirmed [2].

Challenges of abdominal wall closure: The role of NPWT

Abdominal wall closure is often impossible after open abdomen therapy and multiple repeated laparotomies. In these cases, mesh mediated closure combined with ABTHERA or other plastic surgical interventions are needed [1,2,4,25-28,36]. NPWT has beneficial effects on preventing the constriction of the abdominal wall. The negative pressure system helps facilitate angiogenesis, enhance blood supply and as a result, avoid necrosis of the edges of the wall. In septic cases, NPWT is also suitable for abdominal wound debridement [25,26]. Due to the rigidity and constriction of the abdominal wall, the primary closure in most cases is impossible and requires two-step (or more) procedures, increasing the hospital stay and the cost of the treatment significantly [11,26]. Patients undergoing open abdomen management without NPWT often require mesh implantation or multiple plastic surgeries due to the extensive abdominal wall defect [26-28]. NPWT can be an alternative solution for primary abdominal wall reconstruction. Zanus et al. reported a case of infected pancreatic necrosis treated successfully with NPWT after open abdomen management [29]. According to their study, primary abdominal closure may be attempted in grade 1 or 2 open abdomen; however, NPWT alone may also be satisfactory without reducing the dehiscence using sutures. On the contrary, abdominal wall suture was found more effective and necessary in grade 3 and 4 open abdomen, even with NPWT [29,35]. Rasilainen et al. reported a series with a relatively high number of patients treated with VAC and mesh-mediated fascial closure, resulting in a high rate of primary fascial closure in SAP. Although the control group was not homogenous, the reported results were promising [36]. Similarly, Acosta et al. noted good results with this method in a multicentre, prospective study [28]. In NPWT mediated open abdomen treatment the success rate of primary closure is relatively high (70% to 100%) [11,13,26,27,34]. In acute pancreatitis sometimes multiple laparotomies are needed due to septic or other (bleeding, bowel perforation, necrosis) complications of the disease. Typically, after the third or fourth laparotomy, primary abdominal closure cannot be accomplished any more due to abdominal wall necrosis and the changes in the statics and constriction of the abdominal wall and surrounding tissues [35]. In these cases, NPWT has a significant role in the so-called "restoration" of the septic, necrotic and stricture abdominal wall. As a benefit, by routinely using the NPWT, the abdominal wall can be closed primarily in numerous patients. [28,29,35,36].

Treatment of enteroatmospheric fistulas with NPWT in pancreas necrosis

By definition, Enteroatmospheric Fistula (EAF) is a pathological direct connection between the intestinal lumen and the external atmosphere [20,21,23]. In patients with severe acute pancreatitis, EAF can develop secondary to the direct or ischemic necrosis of the duodenum, small intestine or large bowel. These fistulas are not covered with connective tissue and the chance of spontaneous regression is rather low, therefore surgical closure is necessary in most cases [20,21,23]. Although the most efficient treatment would be the resection of the affected intestinal part, it is generally impossible due to peritoneal adhesions (frozen abdomen), so a bridging therapy is required until definitive management is feasible [20,24]. Besides many approaches, floating stoma or soft silicone baby bottle nipple was used successfully in the treatment of EAF [22]. One of the most successful treatment options is NPWT. There are numerous published approaches with NPWT for bowel fistula closure. All of them include a foam (with large pore size) placed in the surrounding wound to isolate the external orifice of the fistula. The positive therapeutic effect is based on the use of continuous or intermittent negative pressure [10,23,28]. Diongi et al. reported three cases of fistula closure, using negative pressure within a range of 75 mmHg to 125 mmHg [24]. Fitzgerald et al. reported that 125 mmHg negative pressure was beneficial in the treatment of an enteroatmospheric fistula due to acute pancreatitis [1]. Wirth et al. also noted positive results using NPWT for the treatment of enteroatmospheric fistulas according to pancreatitis in three cases [23]. Using NPWT, full recovery was achieved in a shorter time and while facilitating the elimination of pathologic abdominal fluid, the device also provides a better quality of life during the recovery [20,21,23]. Generally, the final surgical intervention (fistula closure) is postponed for 6 or even 12 months until the acute inflammation is reduced, intra-abdominal status is

relieved and thus the risk of intestinal injury and complications are decreased [20,21,23,37].

Peritoneal resuscitation in severe acute pancreatitis

A novel technique, the Peritoneal Resuscitation (PR) in critically ill, polytraumatized patients has very promising results compared with Conventional Resuscitation (CR), when Damage Control Surgery (DCS) is needed. The application of PR can be beneficial in SAP requiring OA therapy as well, due to the similar complications. DCS often results in open abdominal wounds, as well as SAP when ACS develops. Smith et al. found in a prospective RCT, that after DCS the time to definitive abdominal closure was reduced, primary fascial closure rate was higher and the rate of intra-abdominal complications, such as intra-abdominal abscess formation was lower by applying the PR procedure, resulting in a lowered 30 days mortality after the injury. PR with continuous abdominal lavage (2.5% glucose-based peritoneal dialysis solution) can also reduce systemic inflammation. The patients treated with PR had lower serum IL-6 and TNF-α levels compared to CR only, with improved overall survival [38]. In another, retrospective case-matched study patients underwent damage control surgery for hemorrhagic shock secondary to trauma between January 2005 and December 2008 [39]. The authors demonstrated a statistically significant decrease in the time to definitive abdominal closure in patients receiving PR, despite having no substantial difference in the resuscitative volume required. The patients undergoing PR had a substantial decrease in the intra-abdominal complication rate and a higher rate of primary fascial closure compared with control subjects. This promising new method can be effectively used in SAP in order to facilitate OA therapy, to increase primary fascial closure rate, to decrease the primary abdominal wall closure time or to reduce the systemic inflammation.

Discussion

In conclusion, NPWT is highly advised in SAP, complicated with septic necrosis and/or ACS. As a result of this procedure, significantly shorter ICU and hospital stay can be achieved. The success rate of primary abdominal closure is also higher with NPWT application. NPWT has beneficial effects on the treatment of many extremely challenging acute surgical conditions such as catastrophic abdomen management and enteroatmospheric fistula management.

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