

Comparative study of abdominal cavity temporary closure techniques for damage control

Estudo comparativo de técnicas de fechamento temporário da cavidade abdominal durante o controle de danos

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ABSTRACT

The damage control surgery, with emphasis on laparostomy, usually results in shrinkage of the aponeurosis and loss of the ability to close the abdominal wall, leading to the formation of ventral incisional hernias. Currently, various techniques offer greater chances of closing the abdominal cavity with less tension. Thus, this study aims to evaluate three temporary closure techniques of the abdominal cavity: the Vacuum-Assisted Closure Therapy - VAC, the Bogotá Bag and the Vacuum-pack. We conducted a systematic review of the literature, selecting 28 articles published in the last 20 years. The techniques of the bag Bogotá and Vacuum-pack had the advantage of easy access to the material in most centers and low cost, contrary to VAC, which, besides presenting high cost, is not available in most hospitals. On the other hand, the VAC technique was more effective in reducing stress at the edges of lesions, removing stagnant fluids and waste, in addition to acting at the cellular level by increasing proliferation and cell division rates, and showed the highest rates of primary closure of the abdominal cavity.

Keywords: Abdomen. Peritonitis. Wounds and Injuries. Abdominal Wall. Infection.

INTRODUCTION

Initially, the surgical principles in the abdominal trauma approach were based on anatomical repairs aimed at primary and final organic repair. In the last decade, more importance was given to correct the physiological problems, leading to the concept of damage control surgery, with special emphasis on maintaining the abdomen open through laparostomy, or peritoneostomy¹. It represents a way to treat the physiological exhaustion and to postpone some procedures that, when performed at the first operative time, only lead to worsening of the patient's physiological condition, with impossibility of recovery¹. At this time the scope is to control bleeding and treat contamination of the cavity to stop the lethal trauma triad.

The main indications for laparostomy are the inability to close the abdominal cavity, documented intra-abdominal hypertension, abdominal compartment syndrome, need for drainage of the abdominal cavity by severe infection, need for relaparotomy, coagulopathy, hypothermia (<35°C) and hemodynamic instability^{2,3}.

During the time the abdomen remains open, there is lateral retraction of the aponeurosis, hindering the closure of the cavity and favoring the appearance of incisional hernias. These lead to the formation of adhesions and make future abdominal surgery more complicated, with increased morbidity and mortality⁴. This, however, can be avoided by employing temporary closure techniques such as: Bogotá bag technique, Barker machines (Vacuum -pack) and Vacuum Assisted closure Therapy (VAC) among others, which allow for closure of the abdominal cavity with less tension.

Edelmuth *et al.*⁴ found that surgery for damage control was efficient in patients with hemodynamic instability due to severe sepsis, massive hemorrhage, acute mesenteric ischemia or necrotizing infections. These factors, together with the need for repeated peritoneal irrigations to eradicate infectious foci and reevaluate sutures and anastomoses, can also be indications for damage control surgery in emergency cases not caused by trauma.

The objective of this study is to compare the three aforementioned temporary closure techniques of

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the abdominal cavity after abdominal surgery resulting from trauma, by reviewing the literature on Medline, Pubmed, SciELO and Lilacs, with selection of 28 articles published on the matter over the past 20 years.

DESCRIPTION OF TECHNIQUES

Bogotá Bag

It was first described in 1984, when using plastic bags containing parenteral solutions to coat the abdominal opening in a patient in the third surgical intervention⁵. It therefore comprises the use of polyvinyl chloride (plastic bag) for maintaining the abdomen open⁵, through its suture directly to the abdominal wall skin or fascia⁶. Initially called the Bogotá Bag or Borráz bag (Figure 1), it can be used in combination with a polypropylene mesh as a way of strengthening and restraint, in an attempt to avoid eviscerations and difficulties in mobilizing the patient, which constitute one of the problems arising from this technique¹.

The Bogotá technical advantages are: low cost, immediate availability, flexibility and high strength, non-adherence to tissues, absence of allergic or inflammatory reactions and quick and easy installation without the need for major surgical experience⁵. It is also considered an efficient protector against water and heat loss⁷.

It is, however, a procedure which requires increased use of drains and repeated cleansing, presenting risk of evisceration and difficulty in mobilizing the patient⁸.

It can also generate lacerations of the skin, gut adhesion to the abdominal wall, difficulties in reproaching the abdomen and the need for sterilization of the bag before use. Moreover, it allows the output of peritoneal fluids between the bag and the skin.

Vacuum-Pack

Described in 1995 it uses vacuum dressings for temporary closure of the abdominal cavity and has since been called the "vacum-pack" (VP) or Barker technique⁹. It is low cost and simple¹⁰⁻¹². It consists in placing a fenestrated polyethylene sheet between the abdominal viscera and the anterior parietal peritoneum, a moist surgical compress on the sheet with two suction drains, and an adhesive sheet over the entire wound including a wide margin surrounding skin. The drains are then connected to a suction device, which can provide 100-150 mmHg continuous negative pressure¹³ (Figure 2).

This technique prevents damage to the abdominal wall by not using sutures, preserving it for future approaches or permanent closure by maintaining the integrity of the fascia for later closing, and allows a quick rapprochement to the abdominal cavity. The material in contact with the abdominal viscera – the polyethylene sheet – is non-adherent, and this technique allows secure control of the amount of fluid produced¹².

Regarding the primary fascial closure with the use of this technique, in 1997 a study obtained success in 61% of cases. The patients, who were trauma victims

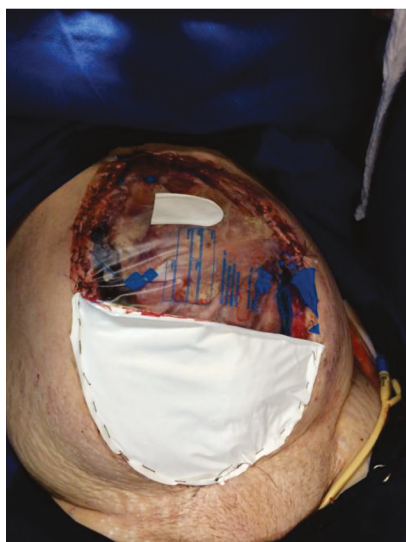


Figure 1. Bogotá bag technique.



Figure 2. Barker Technique.

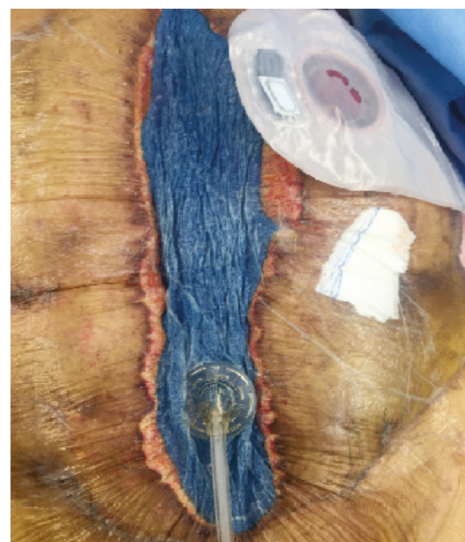


Figure 3. Vacuum-Assisted Closure – VAC.

subjected to the Barker technique, had primary fascial closure at the second laparotomy¹³. Other studies had success rates of 29-100%^{11,14-16}. The permanent closure of the abdominal cavity after the 8th day of laparotomy was associated with higher incidence of complications¹⁷.

Barker *et al.* presented their experience using this technique in intestinal lesions undergoing resection, a study that lasted 11 years. There was no difference between patients who used the Barker technique or other techniques in relation to fistulas or anastomotic leaks. Other studies, however, reported fistula rates of 3% to 5%^{14,18,19}. A combined study of victims of trauma and other causes of open abdomen reported as complications related to the use of this technique: abdominal abscess/infection, abdominal compartment syndrome, dehiscence, anastomotic leak, coagulopathy, deep vein thrombosis, fascial necrosis, ischemia/gastrointestinal necrosis, intestinal fistula, intestinal obstruction, pulmonary embolism and multiple organ failure²⁰. The complication rates reported by Barker *et al.* are 15%¹¹.

V. A. C. System

This system uses crosslinked polyurethane foam (PU) or polyvinyl alcohol (PVA), with pores of 400-600 micrometers, applied and held in place by an adhesive (Figure 3). A plastic film interface sits between the viscera and the foam, and adjusts the same to the edges of the lesion^{19,21}. The foam is covered with adhesive, which is coupled to the skin with a margin of 3 to 5 cm from the wound. In this adhesive, a small hole of about 2cm in diameter is created in the center and a TRAC^{TM-DAP} adhesive (device leading the discharge to the reservoir) is coupled to it. Thus, the system connects to a pump (vacuum) generating continuous or intermittent subatmospheric pressure. The pressure is generally set at 125mmHg and distributed uniformly over the entire wound through the sponge pores^{19,21-23}.

The vacuum-assisted closure is also known as negative pressure therapy, sub-atmospheric pressure or vacuum sealing technique. Argenta *et al.*, in 1997, published an experimental work with the VAC system using acute wounds in pigs. In this work, they postulated that the VAC system has a multimodal mechanism of

action^{19,24}. Its effectiveness in severe traumatic wounds caused to evolve an area that belonged mainly to plastic and reconstructive surgery¹⁹.

The purpose of the VAC system is to remove the stagnant fluid and debris and to optimize the supply of blood and matrix deposition. Thus, the partial pressure of oxygen within the tissues increases and proliferation of bacteria is reduced. Also, there is a local increase of interleukin-8 and vascular endothelial growth factor, which may cause the accumulation of neutrophils and angiogenesis²⁵.

The complications of VAC therapy are infrequent when the system is used correctly. The rates of most complications reported in the literature stem from previous co-morbidities of the patient and skin irritation by the adhesive use. Complications such as pain, bleeding and infection are more difficult to occur. Situations such as toxic shock syndrome, anaerobic sepsis, or thrombosis have also been described as a result of this technique, but are very rare²¹.

The total cost of VAC therapy is greater than that of other techniques. However, when analyzing the time involvement and costs with the nursing staff, there is a considerable reduction of the total cost. The advantage of comfort for patients is described in many studies as a relevant factor in choosing this therapy²⁶.

DISCUSSION

The realization of laparostomy has been recommended since 1979. This technique allows extensive drainage of purulent secretion through the wall opening and also facilitates cleaning of the peritoneal cavity through scheduled or demand reoperations⁷. In this procedure, the abdominal wall plans are not completely approximated, allowing a regular inspection of intracavitary content. It can be used in the treatment of abdominal sepsis, abdominal compartment syndrome and damage control operation⁷. The optimum technical requirements: protection of abdominal contents; prevention against evisceration; preservation of the fascia; minimal damage to the viscera; allowing to quantifying the loss of fluid to the third space; allow selective tamponade; minimize loss

of domain; control the infection and inflammation and facilitate patient's management⁷.

Comparison between the different techniques for damage control.

Comparing the use of VAC to other methods, several studies have shown a better performance of this in relation to others. A prospective study conducted by Batacchi *et al.*²⁷ in 2009 performed the comparison between abdominal trauma patients treated with Bogotá bags and the VAC technique during the temporary closing stage of the abdominal cavity. Treatment with VAC was more effective in better controlling intra-abdominal pressure ($p < 0.01$) and normalization of serum lactate ($p < 0.001$), as well as displaying shorter mechanical ventilation time, faster abdominal closure, and consequently lower time in the intensive care unit (ICU) and hospital. The scores 'Sequential Organ Failure Assessment' (SOFA) and the mortality rate did not differ significantly.

Kaplan *et al.*⁶, in 2005, concluded that VAC is the technique that can meet the requirements of an ideal material for satisfactory temporary closure. The Bogotá technique showed 53% mortality, and the techniques of Barker and VAC displayed rates of 31 and 30%, respectively. Regarding the occurrence of complications such as fistulas, the VAC technique presented a rate of 2.6%, as opposed to 7% of the Barker technique and 13% of the Bogotá technique. The fascial closure was achieved in 79% of patients undergoing VAC, while in 58% with the Barker technique and 18% with Bogotá technique⁶.

As for the control of intra-abdominal pressure (IAP), Batacchi *et al.*²⁷, in 2009, compared the use of the Bogotá bag with the VAC system and concluded that the latter was more effective in controlling the IAP ($p < 0.01$) and lactate levels ($p < 0.001$) during the first 24 hours after surgical decompression. These patients had faster abdominal closure and discharge from ICU in less time, but mortality rates did not differ between the two groups.

Cheatham *et al.*²⁰, in 2013, compared the use of VAC with the Barker technique, showing that both had similar rates of complications such as the development of abdominal compartment syndrome (8% in both techniques) and fistulas (4% in both techniques). The

VAC was associated with a primary fascial closing rate significantly higher at 30 days (73% versus 27% for the Barker technique) and lower mortality in the same period in patients who required open abdomen for at least 48 hours. Differences in mortality rates between the VAC and the Barker technique significantly increased during the first 30 days, due to the subsequent development of multiple organ failure in patients undergoing Barker technique due to better removal of rich peritoneal fluid cytokine (which increase organ dysfunction) at VAC.

Bruhin *et al.*²⁸, in a recent study comparing the various techniques through aspects such as contamination, fistula, mortality among others, obtained higher primary fascial closure rates after the use of VAC in combination with the technique of "dynamic closure" (mesh mediated traction, dynamic retention sutures or ABRA™) when compared with other techniques. In patients without contamination, this treatment resulted in a 81% closure, having been 72% with the exclusive use of VAC and 58% by the Barker technique. Data on the Bogotá bag technique were insufficient. In infected lesions, the combined technique resulted in the greater abdominal closure rate (74.6%), followed by its exclusive use (48%), by the Barker technique (35%) and the Bogotá bag technique (27%). Regarding the presence of fistulas and mortality rate, the VAC technique was the one with the lowest incidences.

CONCLUSION

The Bogotá bag technique was less efficient, but still is widely used due to its lower cost and greater ease of access to the material. The Barker technique may represent a reasonable cost alternative for patients who are subjected to damage control surgery for trauma, considering that 60% of cases will have the cavity closed after the first reapproach. The VAC therapy was superior compared with other techniques, with greater control of the liquid of the third space, a lower rate of complications such as fistulas, lower mortality rates, lower rates of infection and greater ease in the primary closure of the abdominal cavity, and should be, whenever possible, the therapy of choice for the cases where one opts for maintaining laparostomy.

R E S U M O

A cirurgia de controle de danos, com ênfase em peritoneostomia, geralmente resulta em retração da aponeurose e perda da capacidade de fechar a parede abdominal, levando à formação de hérnias ventrais incisionais. Atualmente, várias técnicas oferecem maiores chances de fechamento da cavidade abdominal, com menor tensão. Deste modo, este estudo tem por objetivo avaliar três técnicas de fechamento temporário da cavidade abdominal: fechamento a vácuo (*Vacuum-Assisted Closure Therapy* – VAC), Bolsa de Bogotá e Vacuum-pack. Realizou-se uma revisão sistemática da literatura com seleção de 28 artigos publicados nos últimos 20 anos. As técnicas de Bolsa de Bogotá e Vacuum-pack tiveram como vantagem o acesso fácil ao material, na maioria dos centros, e baixo custo, ao contrário do que se observa na terapia a vácuo, VAC, que além de apresentar alto custo, não está disponível em grande parte dos hospitais. A técnica VAC, por outro lado, foi mais eficaz na redução da tensão nas bordas das lesões, ao remover fluidos estagnados e detritos, além de exercer ação a nível celular, aumentando as taxas de proliferação e divisão celular, e apresentou as maiores taxas de fechamento primário da cavidade abdominal.

Descritores: Abdome. Peritonite. Ferimentos e Lesões. Parede Abdominal. Infecção.

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