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REVIEWS

Abdominal and thoracic cavity closure: damage control surgery's cinderella

El cierre de la pared abdominal y torácica: La cenicienta en la cirugía control de daños

Fernando Rodríguez-Holguín,[1] Adolfo González Hadad,[2,3,4] David Mejia,[5,6] Alberto García,[1,2,7] Cecibel Cevallos,[8,9] Amber Nicole Himmler,[10] Yaset Caicedo,[11] Alexander Salcedo,[1,2,3,7] José Julián Serna,[1,2,3,7] Mario Alain Herrera,[2,3] Luis Fernando Pino,[2,3] Michael W. Parra,[12] Carlos A. Ordoñez[1,2,11]
ordonezcarlosa@gmail.com, carlos.ordonez@fvl.org.co

1 Fundación Valle del Lili. Department of Surgery. Division of Trauma and Acute Care Surgery, Cali, Colombia **2** Universidad del Valle, Facultad de Salud, Escuela de Medicina, Department of Surgery. Division of Trauma and Acute Care Surgery, Cali, Colombia., **3** Hospital Universitario del Valle, Department of Surgery. Division of Trauma and Acute Care Surgery, Cali, Colombia., **4** Centro Médico Imbanaco, Cali, Colombia., **5** Hospital Pablo Tobon Uribe, Department of Surgery, Medellín, Colombia., **6** Universidad de Antioquia, Department of Surgery, Medellín, Colombia. , **7** Universidad Icesi, Cali, Colombia. **8** Hospital Vicente Corral Moscoso. Department of Surgery. Division of Trauma and Acute Care Surgery, Cuenca, Ecuador. , **9** Universidad de Cuenca. Cuenca, Ecuador., Universidad de Cuenca, Universidad de Cuenca, Cuenca, Ecuador, **10** Medstar Georgetown University Hospital and Washington Hospital Center. Department of Surgery, Washington, D.C., USA. **11 ,** Fundación Valle del Lili, Centro de Investigaciones Clínicas (CIC)Cali, Colombia, **12** Broward General Level I Trauma Center, Department of Trauma Critical Care, Fort Lauderdale, FL - USA,

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Abstract

Damage control surgery principles allow delayed management of traumatic lesions and early metabolic resuscitation by performing abbreviated procedures and prompt resuscitation maneuvers in severely injured trauma patients. However, the initial physiological response to trauma and surgery, along with the hemostatic resuscitation efforts, causes important side effects on intracavitary organs such as tissue edema, increased cavity pressure, and hemodynamic collapse. Consequently, different techniques have been developed over the years for a delayed cavity closure. Nonetheless, the optimal management of abdominal and thoracic surgical closure remains controversial. This article aims to describe the indications and surgical techniques for delayed abdominal or thoracic closure following damage control surgery in severely injured trauma patients, based on the experience obtained by the Trauma and Emergency Surgery Group (CTE) of Cali, Colombia. We recommend negative pressure dressing as the gold standard technique for delayed cavity closure, associated with higher wall closure success rates and lower complication and mortality rates.

Conflicts of interest:

The authors declare that they have no conflict of interest.

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Corresponding author:

Carlos A. Ordonez, MD, FACS.
Division of Trauma and Acute Care Surgery, Department of Surgery. Fundación Valle del Lili. Cali, Colombia; Division of Trauma and Acute Care Surgery, Department of Surgery, Universidad del Valle, Cali, Colombia; Universidad Icesi, Cali, Colombia.
Email: ordonezcarlosa@gmail.com, carlos.ordonez@fvl.org.co

Resumen

Los principios de la cirugía de control de daños consisten en realizar procedimientos abreviados que permiten diferir el manejo de la lesión traumática para lograr una resucitación metabólica temprana en pacientes severamente comprometidos en su fisiología. Sin embargo, la respuesta fisiológica inicial al trauma y a la cirugía, junto con los esfuerzos de resucitación hemostática, pueden generar edema en los órganos abdominales o torácicos, aumento de la presión en la cavidad visceral y repercusiones hemodinámicas. En consecuencia, con el paso de los años se han desarrollado técnicas para el cierre diferido de la cavidad; aunque, existen controversias sobre la técnica más adecuada para el cierre quirúrgico tanto del abdomen, como del tórax. El objetivo de este artículo es presentar las indicaciones y técnicas quirúrgicas para el cierre diferido del abdomen y tórax respecto a la cirugía de control de daños del paciente con trauma severo, a partir de la experiencia del grupo de cirugía de Trauma y Emergencias de Cali, Colombia. Se recomienda el uso de los sistemas de presión negativa como la estrategia ideal para el cierre diferido de la pared abdominal o torácica, que se asocia con una mayor tasa de cierre definitivo, una menor tasa de complicaciones y mejores resultados clínicos.

Remark

1) Why was this study conducted?

The aim of this article is to describe the indications and surgical techniques for delayed abdominal or thoracic closure following damage control surgery in severely injured trauma patients, based on the experience obtained by the Trauma and Emergency Surgery Group (CTE) of Cali, Colombia.

2) What were the most relevant results of the study?

We recommend negative pressure dressing as the gold standard technique for delayed cavity closure, which has been associated to higher wall closure success rates and lower complication and mortality rates.

3) What do these results contribute?

In the context of damage control surgery, deferred closure of the abdominal or thoracic cavity should be a bridge to definitive management with allows the prevention of compartment syndrome, contamination control and good healing. The use of negative pressure systems should be the main strategy in deferred closure.

Introduction

Damage control surgery principles allow delayed management of traumatic lesions and early metabolic resuscitation in severely injured trauma patients. This strategy consists of abbreviated procedures and prompt resuscitation maneuvers for temporary damage, bleeding and/or contamination control [1-4]. However, the initial physiological response to trauma and surgery, along with the hemostatic resuscitation efforts, causes significant side effects on intracavitary organs such as tissue edema, increased cavity pressure and hemodynamic collapse [1,5]. For this reason, abdominal and thoracic/mediastinal compartment syndromes have been described as phenomena that impact the morbidity and mortality of trauma patients [6,7]. Consequently, different techniques have been developed over the years for delayed cavity closure, using plastics or negative pressure dressings that also contain and drain the cavity. However, the optimal management of abdominal and thoracic surgical closure remains controversial [8,9]. This article aims to describe the indications and surgical techniques for delayed abdominal or thoracic closure following damage control surgery in severely injured trauma patients.

This article is a consensus that synthesizes the experience earned during the past 30 years in trauma critical care and management of the severely injured patient from the Trauma and Emergency Surgery Group (CTE) of Cali, Colombia which is made up of experts from the University Hospital Fundación Valle del Lili, the University Hospital del Valle "Evaristo García", the Universidad del Valle and Universidad Icesi, the Asociación Colombiana de Cirugía, the Pan-American Trauma Society and the collaboration of international specialists of the United States of America, Europe, Japan, South Africa, and Latin America.

Epidemiology

The reported experience regarding abdominal and thoracic delayed closure techniques is variable. Hu et al., conducted a retrospective analysis of 239 patients with abdominal trauma who underwent damage control surgery. The most prevalent closure technique was primary skin closure (58%), followed by Bogotá bag (25%), ABThera™ VAC System (15%) and Barker's vacuum-pack (2%). They found that those with primary skin closure had lower lactate and base excess levels, and those with Bogotá bag had less fascial closure than those with the ABThera™ VAC System. However, there were no significant differences in mortality rates, hospital length of stay or complications between the groups [10].

O'Connor et al. reported a series of 44 patients with thoracic trauma treated with damage control surgery between 2002-2012. The surgical management of choice was chest tube placement and thoracic packing, except for two patients who were managed with a negative pressure dressing. In addition, they reported that one patient managed with chest tube and thoracic packing developed compartment syndrome [11].

A clinical trial conducted at Hospital Universitario San Vicente Fundación in Medellin, Colombia, compared 37 patients with double Bogotá Bag and surgical mesh vs. 38 patients treated with Backer type (non-commercial) negative pressure dressing. There were no significant differences in time or rate of fascial closure, hospital length of stay, complications or mortality rates. The most frequently associated complications were abdominal abscess, anastomosis dehiscence and/or fistula formation [12].

The Trauma and Emergency Surgery Group (CTE) of Cali, Colombia treated over 7 years a total of 73 severely injured trauma patients with damage control surgery (Table 1).

Abdominal wall closure techniques were negative pressure dressing (52%), Wittmann's patch (25%), primary skin closure (12%) and Bogotá bag (11%) (Figure 1). The most common complications were persistent surgical bleeding and/or peritonitis, abdominal compartment syndrome and fistula formation. The overall in-hospital mortality was 22%.

Table 1. Baseline characteristics of patients with damage control surgery and delayed cavity closure treated by the Trauma and Emergency Surgery Group (CTE) of Cali, Colombia.

Damage Control Surgery and Delayed abdominal Closure	(n = 73)
Age, years old, median (IQR)	26 (22-38)
Masculine, n (%)	66 (90.4)
Injury Severity Score, median (IQR)	25 (18-34)
Abdominal Trauma Index, median (IQR)	33 (20-43)
Trauma Mechanism	
Penetrating, n (%)	64 (87.7)
Blunt, n (%)	9 (12.3)
Anatomic Injury	
Cerebral, n (%)	4 (5.5)
Neck, n (%)	5 (6.8)
Chest, n (%)	42 (60)
Abdomen, n (%)	68 (93.2)
Limb, n (%)	25 (34.2)
Surgical Intervention	
Packing, n (%)	55 (75.3)
Duration, days, median (IQR)	3 (2-4)
Closure Technique	
Vacuum Pack, n (%)	38 (52.1)
Wittmann Patch, n (%)	18 (24.7)
Bogotá Bag, n (%)	8 (11)
Skin Closure, n (%)	9 (12.3)
Complications	
Re-Bleeding, n (%)	35 (47.9)
Persistent Peritonitis, n (%)	29 (39.7)
Abdominal Compartment Syndrome, n (%)	29 (39.7)
Fistula, n (%)	9 (12.3)
Evisceration, n (%)	4 (5.5)
Definitive Abdominal Closure, n (%)	46 (63)
Re-intervention, median (IQR)	4 (2-5)
In-hospital Mortality, n (%)	16 (21.3)
ICU Length of Stay, days, median (IQR)	10 (6-17)
Hospital Length of Stay, days, median (IQR)	19 (8-30)

Pathophysiological Considerations

Abdominal Wall Closure

Successful closure of the abdominal wall may be influenced by pathophysiological phenomena such as peritoneal inflammation, increased intra-abdominal volume, peritoneal adherences, scarring and/or retraction of the wound edges. In addition, the intestinal microcirculation may be altered by hypoxia or inflammation, which in turn increases the cellular permeability and decreases the protective capacity of the intestinal barrier. These events produce intestinal edema and a third space that accumulates bacteria and necrotic tissue, leading to loss of mesothelial cells and peritoneal adherences that may result in mechanical obstruction. This third space contains a wealth of cytokines and inflammatory mediators that may produce intra-abdominal infections and systemic inflammatory response [13-15].

These phenomena may contribute to the development of abdominal hypertension, which is defined as the pathological and sustained elevation of intra-abdominal pressure > 12 mm Hg. In the worst scenario, an abdominal compartment syndrome could be developed, defined as sustained intra-abdominal pressure > 20 mm Hg that may be associated with impaired ventilatory mechanics and/or decreased venous return/preload [16].

Thoracic Wall Closure

Similarly, a Thoracic / Mediastinal Compartment Syndrome has been described following sternal closure in patients who underwent major cardiovascular surgery and/or trauma procedures [17,18]. The patients who developed an abnormal increase in mediastinum pressure presented with decreased cardiac output and impaired ventilatory mechanics during the

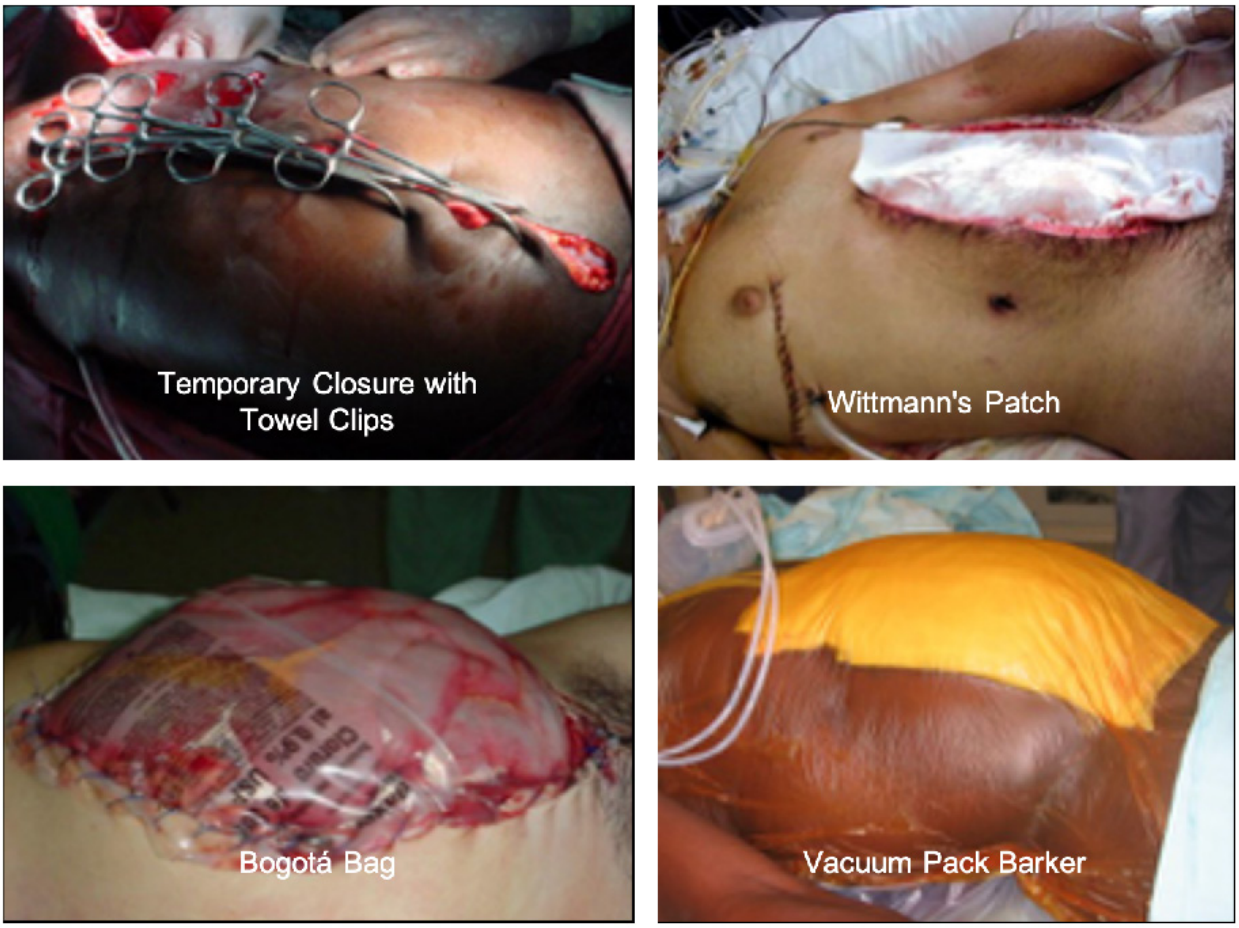

Figure 1. Temporary abdominal wall closure techniques. **(A)** Temporal Closure with Towel Clips, **(B)** Wittmann's Patch, **(C)** Bogotá Bag, **(D)** Vacuum Pack Barker.

postoperative period. Thoracic hypertension syndrome has been defined as the hemodynamic collapse caused by increased pressure on the airway and decreased venous return/preload and cardiac output. When this phenomenon persists leads to cardiac tamponade with hypotension, subendocardial ischemia and multiorgan failure [17,19,20].

Indications for Temporary Closure

Following damage control surgery, the thoracic and abdominal cavity could be temporarily closed in [8,20,21]:

- Hemodynamically unstable or non-transient responder patient (persistent systolic blood pressure < 90 mm Hg) with massive transfusion requirement
- Severely injured trauma patient requiring immediate abdominal and/or thoracic surgery
- Patient undergoing damage control surgery who requires a second surgical time for definitive management of injuries
- Inability to close the cavity due to visceral edema or increased risk of abdominal or thoracic hypertension
- Persistent cavity bleeding despite hemostatic maneuvers

Table 2. Use of Negative Pressure System Therapy vs Bogota Bag in the deferred abdominal closure.

Type of Surgical Treatment and Pathologies	Negative Pressure Wound Therapy				Bogota Bag			
	n	Compartment Syndrome (intra abdominal pressure)	Control of contamination	Wound healing	n	Compartment Syndrome (intra abdominal pressure)	Control of contamination	Wound healing
RCT:Decompressive laparotomy by compartment syndrome related trauma or abdominal surgery[26]	20	IAP Day 1 POP: 7.6±2.9 mm Hg / Day 14: 3.5±1.6mm Hg*	Sepsis 2/20 patients	Time to definitive closure: 16.9±3.2 days*	20	IAP 1 Day: 8.4±3.4 mm Hg/ 14 Day: 5.1+2.5 mm Hg*	Sepsis 4/20 patients	Time to definitive closure: 20.5±9.9 days*
PCS: Deferred abdominal closure by trauma, sepsis, or vascular abdominal disease[25]	35	IAP measures reduced faster in the VAC group		Time of Open Abdomen: 4(3-5) days **	31	IAP measures reduced faster in the VAC group		Time of Open Abdomen: 6(3-8) days **
PCS: Deferred abdominal closure by trauma, sepsis, or vascular abdominal disease [24]	9	IAP on admission: 10±3 mm Hg/ 48 h: 11±3 mm Hg*			13	IAP on admission: 13±5 mm Hg / 48h 11±3 mm Hg*		
PCS: Deferred abdominal closure by trauma or abdominal disease [23]	163			Time of Open Abdomen: 5±4.1dias* Closure of Fascia: 98/163 patients	117			Time of Open Abdomen 5±4.4 days* Closure of Fascia: 83/163 patients
RS:Deferred abdominal closure by damage control surgery [10]	36		Intraabdominal abscess 10/36 patients Surgical site infection: 2/36 patients	Time of Open Abdomen: 4.6±3.8 days* Closure of Fascia: 34/36 patients	60		Intraabdominal abscess: 24/60 patients Surgical site infection: 13/60 patients	Time of Open Abdomen: 5.7±5.5 days* Closure of Fascia: 50/60 patients
RS:Deferred abdominal closure [22]	15			Time of Open Abdomen: 5(2-69) days ***	49			Time of Open Abdomen: 4(1-24) days***

RCT: Randomized clinical trial
PCS: Prospective Cohort Study
RS: Retrospective Study

Table 3. Baseline characteristics of patients with abdominal trauma underwent delayed management with negative presTablesure wound therapy

	Artisanal Negative Pressure System	Commercial Negative Pressure System	Total
n (%)	75 (40.8)	109 (59.2)	184 (100.0)
Age, years, median (IQR)	28 (23 - 38)	30 (23 - 42)	29 (23 - 41)
Male, n (%)	68 (90.7)	97 (89.0)	165 (89.7)
Penetrating Trauma, n (%)	65 (86.7)	93 (85.3)	158 (85.99
Injury Severity Score (ISS), median (IQR)	25 (17 - 33)	21 (16 - 26)	25 (16 - 31)
New-Injury Severity Score (NISS), median (IQR)	34 (25 - 50)	38 (25 - 59)	36 (25 - 50)
Multiple Organ Dysfunction Syndrome, n (%)	30 (40.0)	42 (39.3)	72 (39.6)
Peritonitis, n (%)	10 (13.3)	17 (16.0)	27 (14.9)
Intestinal Fistula, n (%)	11 (14.7)	15 (13.9)	26 (14.2)
Time to definitive closure, days, median (IQR)	3 (4 - 11)	3 (4 - 10)	3 (4 - 11)
Intrahospital mortality, n (%)	1 (1.3)	4 (3.7)	5 (2.7)

- Scheduled or unscheduled surgical intervention due to evidence of bleeding or persistent contamination
- Patient with surgical criteria of monitoring abdominal or thoracic organ viability during the next 24-48 hours.

Cavity closure goals

Delayed cavity closure in damage control surgery must be a bridge to definitive management. Regardless of the technique used for abdominal or thoracic cavity closure, the surgeon must keep in mind that this procedure must achieve the following goals:

A. Compartment syndrome prevention

B. Control of contamination

C. Wound healing and deferred cavity closure

The studies that compare negative pressure systems versus Bogota Bag are inconclusive (Table 2). However, the patients that were managed with Bogota bags were associated with higher intra-abdominal pressure and delay in definitive closure. On the other hand, those with negative pressure systems had sooner definitive closure and better outcomes [10,22-26]. Thus, negative pressure systems achieve the three management goals, whereas the Bogotá bag has disadvantages in control of contamination and wound healing.

Negative pressure systems can be artisanal or commercial. The artisanal devices have an uncontrolled continuous suction system (Wittman patch or the Barker Vacuum pack) [27,28] and the commercial devices had the availability of continuous and intermittent pressure therapy and use adhesives that decrease the risk of tissue injury. We evaluated abdominal trauma patients undergoing temporary abdominal closure with commercial vs. artisanal negative pressure systems between 2011 and 2020. There were no significant differences in complications, mortality or time to definitive wound closure (Table 3) (Figure 2).

Given these data and the fulfillment of the proposed management goals, this article proposes that the strategy for deferred management should be through the use of negative pressure systems.

Surgical Management

STEP 1 - Damage Control Surgery: All sources of ongoing surgical bleeding and bowel contamination should be controlled, along with hemostatic resuscitation efforts. In addition, damage control techniques should be applied to the organs or vascular structures that have been compromised.

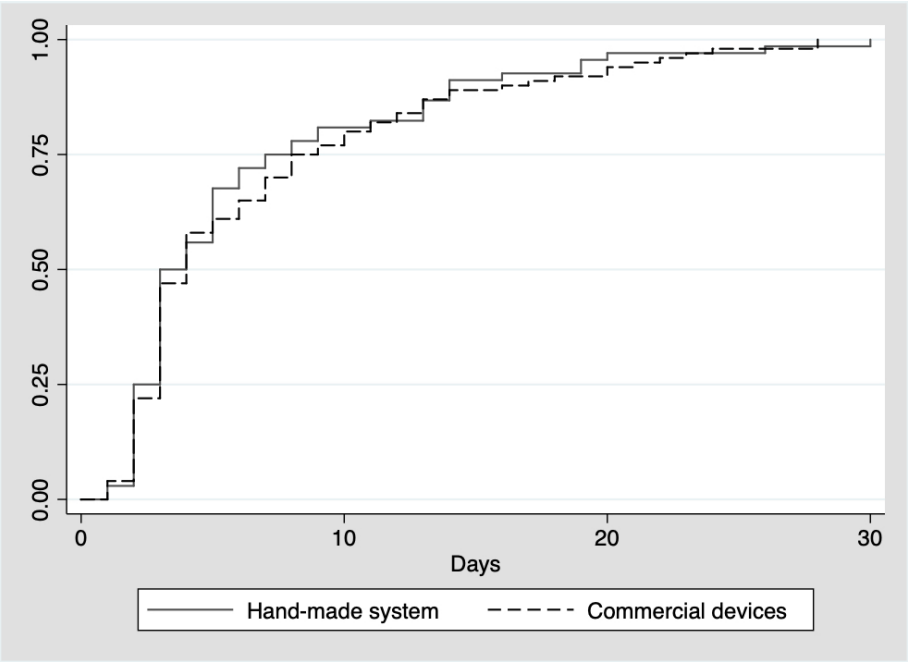

Figure 2. Kaplan-Meier analysis of time to definitive closure regarding the use of commercial or artisanal negative pressure system. Time to definitive closure is not statistically different between pressure negative systems (Log-Rank Test 0.439).

STEP 2 - Definition of cavity problems: The surgeon should evaluate the presence of ongoing surgical bleeding despite damage control techniques. Within the thoracic cavity, bleeding could arise from bone structures (vertebral bodies, ribs, or sternum) which can be controlled by packing the wound and hemostatic bone wax (Surgicel ®). However, if the bleeding persists, a Foley catheter should be inserted directly into the bone wound, then inflated and gently retracted until hemorrhage control is achieved (Figure 3). Within the abdominal cavity, any injured organ should be packed to achieve a compressive and hemostatic effect.

STEP 3 - Temporary cavity closure: To define the cavity closure technique, a decision must be made between a negative pressure dressing, cavity packing, skin closure or Bogotá bag. We propose the negative pressure dressing placement as the method of choice for temporary cavity closure.

- *Abdominal Closure:* Steps for the placement of a negative pressure dressing:

    1. A plastic interface is placed over intra-abdominal organs, separating them from the abdominal wall. This plastic must be permeable with linear perforations not longer than 5 mm to avoid micro-herniations of intestinal loops. Polypropylene plastic bags for tissue collection from pathology specimens can be adapted to this end by previously sterilizing and perforating them. The plastic should be extended over the entire cavity covering the recesses completely (Figure 4). The ABThera™ VAC negative pressure dressing contains an open-pore polyurethane ether foam sponge for this purpose, which should not be downsized because this might interfere with the negative pressure circuit (Figure 5).

    2. If negative pressure dressing systems are not available, it is recommended to install a Bogotá bag following this step.

    3. The foam sponge or dressings transmitting the negative pressure should be placed into the open wound and over the fenestrated plastic. It is not recommended to use gauzes or towels under the foam sponge to affect the system´s performance (Figure

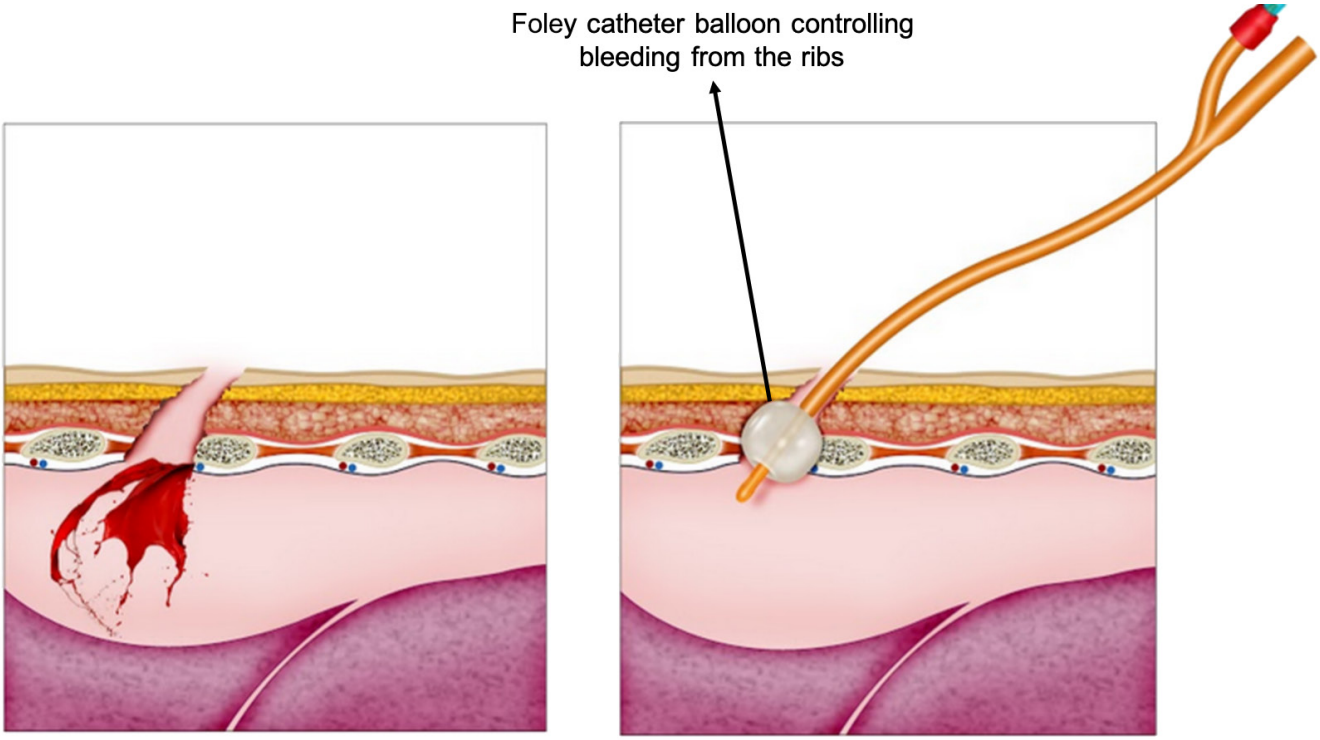

Figure 3. Hemostatic effect over the thoracic wall using a Foley catheter. To control persisting surgical bleeding from thoracic wall bone structures (vertebral bodies, ribs, or sternum), a Foley catheter should be inserted directly into the bone wound, then inflated and gently retracted until hemorrhage control is achieved.

5). The ABThera™ VAC system has its foam sponge, which must be used ideally without size adjustments. Then, a second foam sponge could be placed over the first one, trimming it to fit the size of the open wound and lying at the same level of the abdominal wall (Figure 6).

4. If a Bogotá bag is implemented, the translucent plastic should be sutured to the edges of the cavity wall.

5. The foam is secured beneath an adhesive sheet avoiding traction of the wound edges. Most commercial systems are equipped with enough sheets to place a double layer of adhesive film, which guarantees an adequate sealing and protection of the device (Figures 4 y 5).

6. Install the suction device over the adhesive film by cutting out a 3 to 3.5 cm diameter circle, exposing the foam sponge. Then, place the suction device in the exposed area, ensuring that the suction port/tube and all sensor channels are in full contact with the foam and the adhesive sheet. The tubing extends into a disposable collection canister (Figures 4 y 5).

7. Programming and connection of the suction source must be carried out. The suction tubing should be connected to a portable pump which will apply negative pressure. The pressure parameters range between -50 to -150 mm Hg. We recommend a pressure of -125 mm Hg ideally. Some systems provide additional control of suction intensity and/or suction flow. However, the devices do not guarantee precise or constant pressure and for that reason, these patients should be closely monitored. The absence of drainage with evidence of distention or abdominal pain should raise suspicion that the system is obstructed.

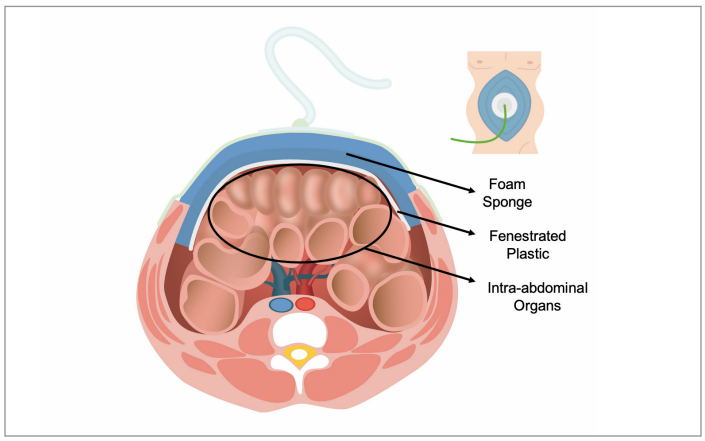

Figure 4. Negative pressure dressing with a fenestrated plastic interface. A plastic with linear perforations not longer than 5 mm should be extended over the entire cavity covering the recesses completely and separating intra-abdominal organs from the abdominal wall.

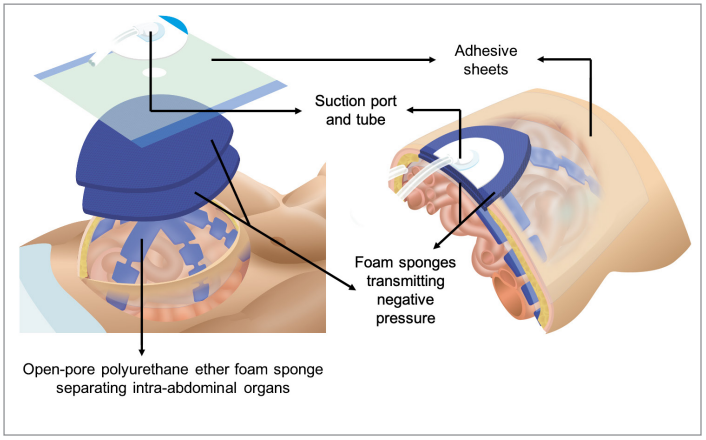

Figure 5. ABThera™ VAC System. This negative pressure dressing contains an open-pore polyurethane ether foam sponge that separates intra-abdominal organs, 2 additional foam sponges transmitting the negative pressure, various adhesive sheets for system sealing and a suction tube which extends into a disposable collection canister.

- *Thoracic Wall Closure:* The negative pressure dressing should be placed, ensuring that the foam sponge covers all the surgical fields, including muscles, subcutaneous cellular tissue and skin. In a thoracotomy approach, the foam should cover the posterior thoracotomy recess formed by intercostals, serratus and latissimus dorsi muscles; the entire length of the upper and lower ribs; pectoralis muscles; subcutaneous cellular tissue; and skin. This foam should be placed directly over the injured area and secured beneath an adhesive sheet, then connected to the suction source. If foam is not available, surgical compresses can be used as a negative pressure system, without closing the skin.

- On the other hand, the sternotomy approach requires placing a fenestrated plastic sheet over the heart, followed by a first foam that covers the entire mediastinum and a second foam covering the two edges of the sternotomy the space between them. Finally, the system is sealed with an adhesive sheet connected to the suction tube by a hole cut in the adhesive film. The suction pressure maintains the hemostasis and the surgeon must ensure that it is not interrupted during the patient's transfer or care at the intensive care unit (Figure 7).

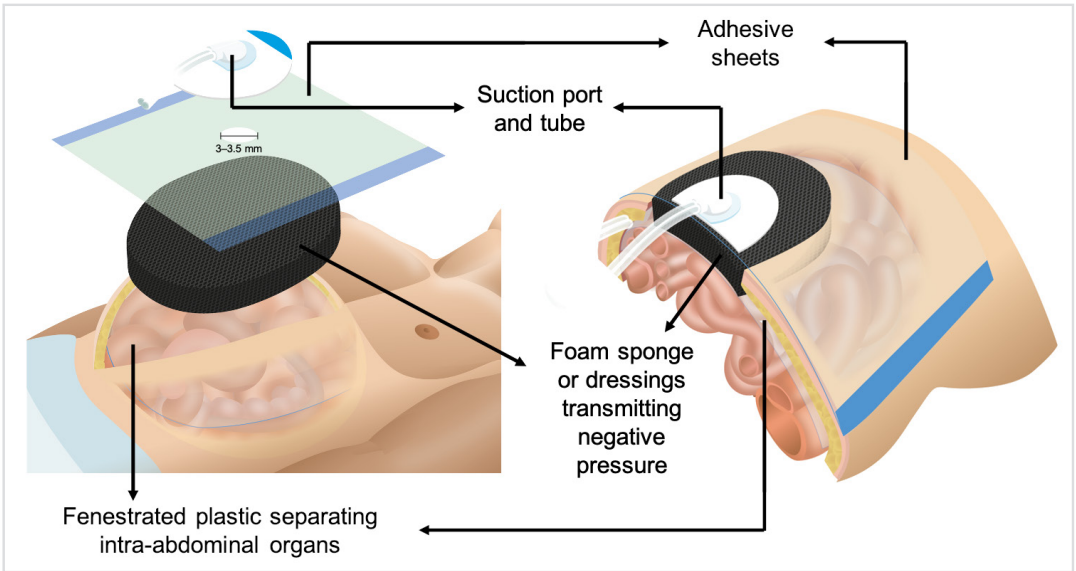

Figure 6. Negative pressure dressing system placement. A fenestrated plastic separates intra-abdominal organs, while foam sponges or dressings are placed over it and secured beneath a double layer of adhesive sheets. The suction device is installed over the adhesive film by cutting out a 3 to 3.5 cm diameter circle.

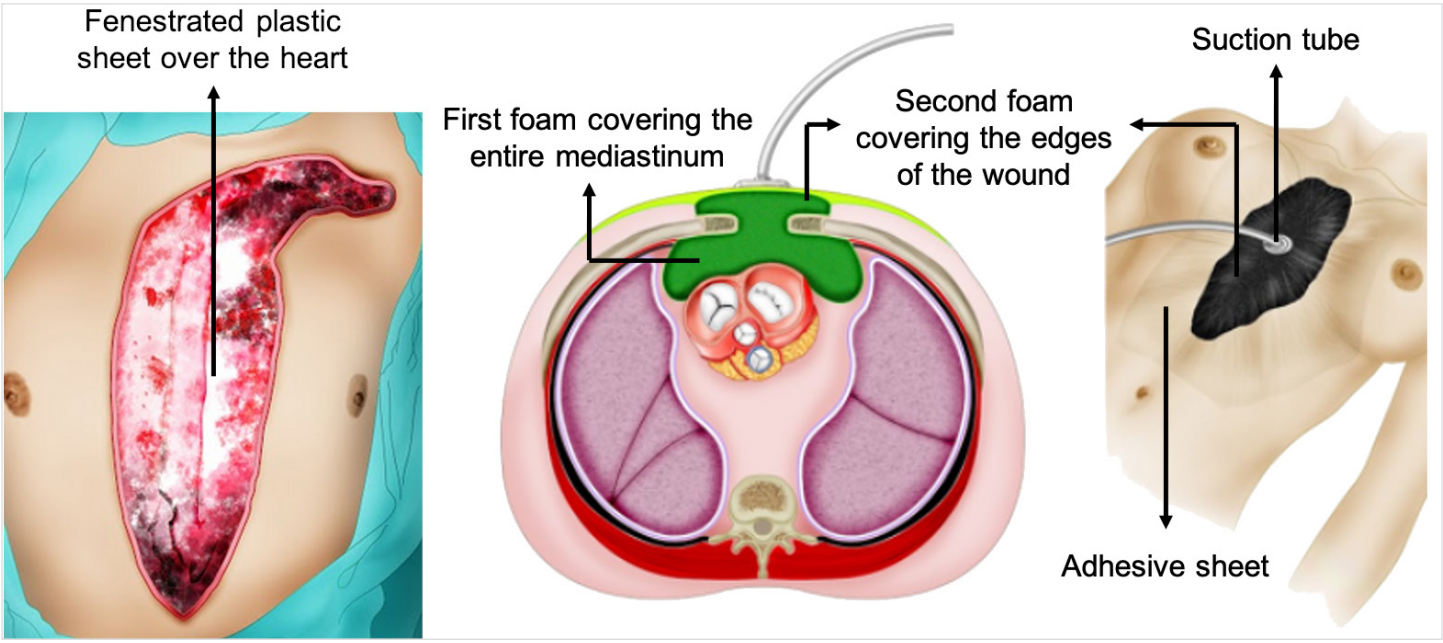

Figure 7. Negative Pressure Dressing Placement Following Sternotomy Approach. A fenestrated plastic sheet is placed over the heart, followed by a first foam that covers the entire mediastinum and a second foam covering the two edges of the sternotomy and the space between them. The system is sealed with an adhesive sheet, which is connected to the suction tube by a hole cut in the adhesive film.

- If a negative pressure dressing system is not available, a temporary closure can be achieved by means of cavity packing. In the thoracotomy approach, the surgeon should pack the source of bleeding first, which usually corresponds to the ribs, intercostals, serratus and latissimus dorsi muscles. The upper and lower ribs should also be packed using an entire compress to wrap each of them. Then, a continuous suture is performed over the skin, starting at the medial edge and using non-absorbable polypropylene 1-0 suture. As the skin suture progresses, a fifth compress is introduced to control the bleeding from the skin, subcutaneous cellular tissue and pectoralis muscles (Figure 8).

- In the sternotomy approach, surgical compresses are placed directly on the heart and mediastinum until it is completely occupied. The surgeon should always monitor for hemodynamic changes associated with the packing. Then, a drain (small caliber chest tube or #20 Levin probe) should be placed. Finally, the edges of the sternotomy should be embraced with two compresses and the space between them should also be packed before skin closure is performed (Figure 9). Another alternative is to cover the wound with a waterproof dressing, leaving the sternum open with the drain to suction.

STEP 4 - Temporary closure care: According to the trauma severity, a second surgical time should be scheduled within 48-72 hours. During this period, the patient should be transferred to the intensive care unit for lethal diamond (acidosis, hypothermia, coagulopathy and hypocalcemia) correction and identification of signs suggesting abdominal or thoracic hypertension syndrome. In addition, the abdominal compartment syndrome must be assessed with intra-abdominal pressure monitoring to identify early respiratory, renal, and cardiovascular dysfunction. There is no consensus on the evaluation for thoracic hypertension, so the physician should be attentive to signs of organ dysfunction different to those associated with hemorrhage or infectious processes.

If clinical signs of infection or persistent cavity bleeding are developed, immediate re-intervention is indicated to achieve surgical bleeding or contamination control. The patient under a negative pressure dressing system should be followed up by quantification and description of fluid production. In addition, the surgeon should closely monitor the negative pressure system for leaks, obstructions or electrical problems.

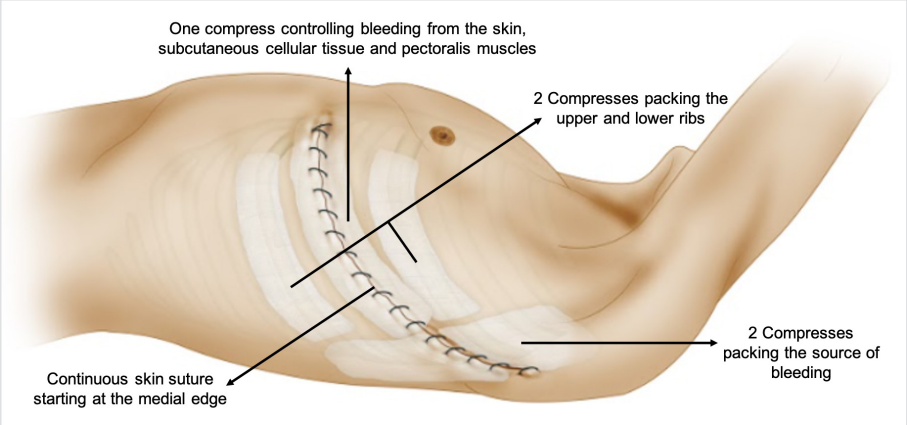

Figure 8. Thoracic Packing Following Thoracotomy. The source of bleeding (usually ribs, intercostals, serratus and latissimus dorsi muscles) is first packed, followed by the upper and lower ribs. The cavity is then closed with a continuous suture starting at the medial edge and a fifth compress is introduced into the wound as the skin suture progresses.

STEP 5 - Definitive cavity closure: The foam sponge or compresses may adhere to the underlying granulation tissue. During re-interventions, the risk of re-bleeding should be avoided by irrigating the packed cavity with abundant hot saline before carefully removing the foam sponge or compresses from the cavity. Requirements for a definitive and safe cavity closure are:

- Definitive management of thoracic or abdominal injuries
- Correction of the patient's physiological derangement
- Viability of abdominal or thoracic organs
- Control of any abdominal or thoracic contamination focus
- Closure of the cavity without tension

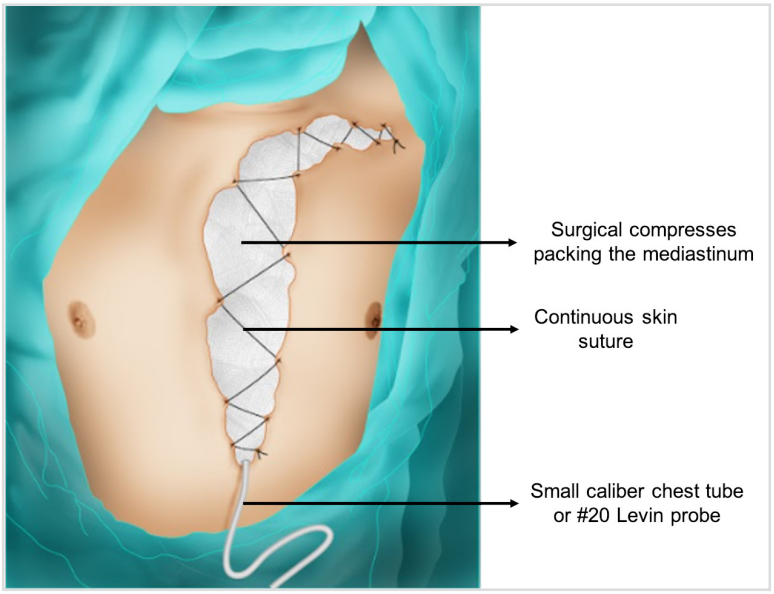

Figure 9. Thoracic Packing Following Medium Sternotomy. Surgical compresses are placed directly on the heart and mediastinum until it is completely occupied, always monitoring for hemodynamic changes. Then, a drain is placed and the edges of the sternotomy and the space between them are also packed before skin closure is performed.

Discussion

Over the last few years, major technological advances have been achieved in negative pressure dressings improving their function and availability. There are multiple reports about the implementation of this technology, especially in the management of patients with an open abdomen. A sub-analysis of the International Register of Open Abdomen (IROA) reported that the negative pressure dressing was the most widely used technique for open abdomen management in approximately 50% of the cases, followed by the Bogotá Bag in 28% achieving definitive closure of the abdominal wall in 82% of the cases [29]. Poilluci et al. conducted a retrospective study reporting a lower mortality rate at 30-day follow up (40.3% negative pressure dressing vs. 51.7% other systems), as well as a lower colostomy rate in colorectal trauma patients that were managed with a negative pressure dressing system vs those in which this technology was not applied [30]. Similarly, Sibaja et al compared patients that were conventionally managed with a Bogotá bag or Wittmann's patch vs those in which a negative pressure dressing was used. They reported higher rate of fascial closure (96%) and a lower mortality rate (8%) in the group of negative pressure dressing [31].

The literature on chest packing as a thoracic damage control technique and its potential impact on the cardiorespiratory system is scarce [11,20,32,33]. A retrospective cohort of 61 patients found that the peak airway pressure was significantly lower in those managed with chest packing than those with definitive wound closure [32]. However, late complications such as pneumonia, empyema, mediastinitis, superficial or deep surgical site infection, organ dysfunction, coagulopathy, or acute renal failure have been associated with chest packing. The risk factors associated with the development of complications were prolonged surgical time, delay in establishing packing, and re-bleeding after hemostatic maneuvers [34].

Conclusions

In damage control surgery, deferred closure of the abdominal or thoracic cavity should be a bridge to definitive management that allows the prevention of compartment syndrome, contamination control, and good healing. Therefore, the use of negative pressure systems should be the main strategy in deferred closure.

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