The open abdomen

Part 2: Management of the open abdomen using temporary abdominal closure

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Abstract

Management of the open abdomen is a complex undertaking, as it not only involves difficult wound healing but also the prevention of many serious local and systemic complications. In this article the different types of temporary wound closure methods and their pros and cons are discussed. It appears from our experience that specific negative-pressure dressings produce the best outcomes with regard to morbidity and mortality, as they are adapted to address the particular needs of different grades of open abdomen.

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Introduction

At times, it is crucial to leave the abdomen open in critically ill patients. This is not a strategy to be taken lightly, as it is a morbid, resource-intensive procedure that carries many high-risk complications. Despite surgical decompression, patients with abdominal compartment syndrome still have a high morbidity and mortality rate.[1-5] It should always be remembered that opening an abdomen necessitates having an immediate plan in place for a specific form of closure, be it short-term, for instance, a modified vacuum dressing; of indeterminate term, for instance, skin grafting; or a definitive method of closure, such as component separation. The complexities of managing an open abdomen are many and vexing, and our approaches continue to evolve rapidly. Many innovations have been devised in an attempt to successfully deal with some of the problems of an open abdomen. These have developed into a concept known as temporary abdominal closure (TAC). TAC is any form of dressing applied to the abdomen after non-suture of the abdominal wall. Well-known versions of TAC include Bogota bags, the Abra® abdominal closure system, and the modified vacuum dressing, otherwise known as the sandwich dressing. As we have gained experience with vacuum-assisted closure, this will be the focus of our discussion.

The short-term aims of an open abdomen are to relieve intra-abdominal pressure, and to achieve source control as in cases of sepsis, haemorrhage and necrosis. During this period, protection of the gut against erosion should be prioritised. In patients where primary closure is not possible or is delayed, an intermediate phase develops, which can be indeterminate in duration. Fistula formation risk is at its highest during this intermediate phase. In our experience, spilt-skin grafting (SSG) is the most practical solution to protect the exposed bowel at this stage. It is easily accessible, maintains the physiological environment, and eventually allows patients to be managed on an outpatient basis. Patients are able to adapt well to the resulting ventral hernia. Definitive closure is still subject to the controversy of optimal timing. This indeterminate phase can be used to optimise wound maturation, normalise nutritional status and improve muscle function, as conditions leading to an open abdomen are often associated with multi-organ failure during the intensive care stay.

The initial choice of abdominal closure type depends largely on the grade of open abdomen, and how well it is likely to achieve the correlating goals. In Part 1 of this article series, why and when an abdomen should be left open was discussed. Here, in Part 2, commonly occurring complications used to delineate the grade of open abdomen, and how best to avoid or manage them with the use of appropriate grade-dependent closure methods (TAC), will be discussed (see Table I). In Part 3, the management of an open abdomen with enteroatmospheric fistulae will be addressed.

Table I: Complications of the open abdomen[6]

Local complications	Systemic complications

• Adhesions
  - Cause stricture formation
  - Form intra-abdominal loculations
• Adhesions of viscera to the abdominal wall and to other visceral organs make primary closure difficult, and preclude subsequent surgery[7]
• Fascial retraction
• Abdominal sepsis
• Fistula formation[8]
	• Derangement of fluid balance
	• Electrolyte disturbances
	• Promotion of a catabolic state
	• Temperature regulation

The ideal temporary abdominal closure method

Taking the aforementioned complications into consideration, aim to utilise a dressing method that:[9,10]

- Is readily available and inexpensive.
- Is easy to apply and remove, allowing access to the abdominal cavity without delay, and without difficulty.
- Does not inhibit nursing care.
- Does not damage the bowel, fascia or skin with repeated

- applications.
- Maintains the abdominal domain (physiological environment).
- Prevents the collection of peritoneal fluid, pus or blood, and allows active clearance of all fluids.
- Serves as a barrier, preventing evisceration and contamination.
- Prevents abdominal compartment syndrome.
- Prevents fascial retraction, and allows for a high rate of subsequent primary fascial closure.
- Prevents fistula formation.
- Allows fistula isolation, if present.
- Prevents adhesion of viscera to the abdominal wall.

Planning once the abdomen is opened

The choice of TAC is never a simple or standard decision. Each grade of open abdomen has specific goals. The dressing used must be best suited to fulfill these goals. Therefore, the appropriate choice of TAC is dependent on the grade of open abdomen (Table II). However, the patient's clinical condition may also influence the choice of TAC. Therefore, it is crucial to plan the closure method at the onset, taking into consideration the grade of open abdomen and the patient's clinical condition.

Table II: Working grades of the open abdomen[10]

Grade 1a	Clean abdomen without adherence of viscera to the abdominal wall
Grade 1b	Contaminated abdomen without adherence of viscera to the abdominal wall
Grade 2a	Clean abdomen with adherence of viscera to the abdominal wall
Grade 2b	Contaminated abdomen with adherence of viscera to the abdominal wall
Grade 3	Open abdomen with visceral fistula
Grade 4	Frozen abdomen (with or without enteroatmospheric fistulae)

Dressing Grades 1a-2b will be discussed in this article, and dressing an abdomen with an enteroatmospheric fistula will be discussed in the subsequent article.

From our experience, the initial management of the open abdomen typically involves short-term TAC with the aim of early definitive closure (see Figure 1). Early definitive closure is commonly accepted as the primary fascial closure of the abdomen within seven days.[11] If you foresee abdominal closure within a very short time, for instance within 48 hours, cost vs. benefit of choice of TAC becomes an important consideration. In this case, a non-specific vacuum dressing is useful, easily accessible and inexpensive. A more durable and robust dressing may be necessary in management for longer than 48 hours.

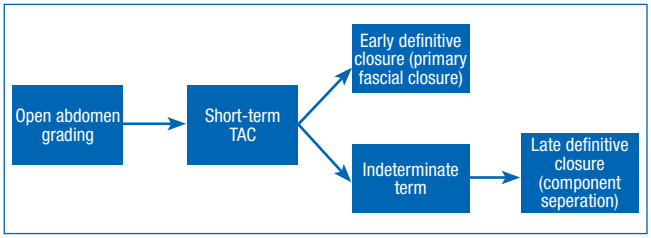


Figure 1: How to plan the management of an open abdomen

If closure within seven days is not feasible, short-term TAC is planned with the aim of indeterminate-term closure, such as SSG. Grafting is then part of a planned ventral hernia strategy.[10] If the patient's condition does not reach a stage that allows for repeat surgery, then indeterminate-term closure may effectively become the definitive closure method.

Provided that the patient recovers adequately from the initial insult, indeterminate closure may be followed by late definitive closure, for example by component separation.[12] However, adequate nutrition has proved to be a major difficulty during this recovery period, and it may take months or years to reach this point.[6] Time for wound maturation is also needed.

To illustrate this, consider the following two cases who were recently admitted to our intensive care unit (ICU):

Patient A is a 40-year-old male whose abdomen was decompressed for abdominal compartment syndrome (ACS) after elective repair of an abdominal aortic aneurysm (Grade 1a open abdomen). His general health was good, and his long-term prognosis was expected to be fair.

Patient B is a 40-year-old male whose abdomen was decompressed for ACS that developed after a laparotomy for bowel obstruction (also Grade 1a open abdomen). On laparotomy, a malignancy was found in the rectum. The patient was HIV positive with a CD4 count of 30, and had multidrug-resistant pulmonary tuberculosis. His general health was poor, and even with appropriate treatment, his prognosis was worse than that of patient A.

Patient A's general condition allowed for early definitive closure or SSG. If SSG was performed, definitive closure could still be considered at a later stage. We opted for an ABThera® dressing, and SSG was later performed.

Patient B's general condition did not allow for any surgery. Even SSG was not considered to be feasible, and our only option was vacuum-assisted dressings.

Available temporary abdominal closure methods

Knowledge of the available TAC methods enables the most appropriate choice to be made (see Table III).[13]

In accordance with the literature, Table IV is a comparison of available TAC methods, and Table V, of their outcomes.

Making the appropriate choice of TAC can be challenging. From our experience, it also appears that specific negative-pressure TAC methods yield the best results, and seem to be superior to the non-specific negative-pressure dressings. This can be explained by the fact that specific negative-pressure dressings have been adapted to cater for the precise requirements and goals of managing different types of open abdomens.

However, one must acknowledge that, with open abdomens where one foresees closure within a short period of time, e.g. 48 hours, the cost of using a specific negative-pressure dressing may not be warranted, and this is an important consideration.

The two specific negative-pressure dressings with which we have experience are the ABThera® and the KCI "black" VAC®, as they cater

Table III: Commonly used temporary abdominal closure methods.

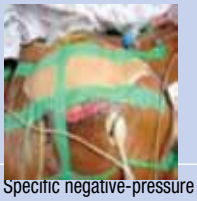
Temporary abdominal closure	Description	Pros	Cons
Bogota bag 	A three-litre plastic irrigation bag is emptied and cut open so it lies flat. An X-ray film bag can also be used. The edges are trimmed and sutured to the skin.	It is inexpensive. It is transparent. It is available in the operating room. It allows ease of application. It is strong and able to prevent evisceration of pendulous viscera.	It requires suturing of the peri-wound tissue, resulting in tissue trauma. It allows adherence of the bowel to the abdominal wall.[14] There is no abdominal stabilisation.[14] It usually results in loss of fascia, necessitating subsequent surgical intervention for hernia repair.[14] Lack of fluid containment results in overall tissue damage. Leakage from under the bag can leave the bed wet, and increase the risk of worsening hypothermia. This makes nursing care difficult. There is a high rate of fistula formation.[14]
Retention sutures (Abra®) 	These are specifically manufactured for use in laparostomes: silicone sheets, abdominal wall closure sets, and elastomer retainers.	They allow easy access into the abdomen. The sutures can be tightened at sequential dressings, preventing fascial retraction.[15] Primary fascial closure is facilitated.[15]	They are expensive. Measurement of the intra-abdominal pressure is required. There is potential damage to the peri-wound integrity. There is no active removal of the fluids. There is no protection of the visceral integrity. There is a high risk of fistula formation. They need to be used in conjunction with another dressing. There is no abdominal stabilisation.
Wittmann® patch 	Two velcro-like sheets are sutured to the opposing fascia to fit the opening. Manual closure is achieved via tension on the sheet during the dressing change.	It prevents fascial retraction. It allows stepwise reapproximation of the fascial edges. It permits final fascia-to-fascia closure.[16] It reduces the need for hernia repair.[16] It allows easy access to the abdomen for further surgical procedures.	There is no active removal of fluids. Measurement of the intra-abdominal pressure is required. There is no stabilisation of the internal contents. Suturing of the friable fascia is required. Additional dressing is needed to maintain the rectus abdominus and for dermal and epidermal reapproximation. Lack of fluid containment results in overall tissue damage. Linear pressure is placed on the abdominal wall and could lead to fascial necrosis. It is expensive. Sepsis can result.[16]
Mesh closure 	A variety of products are available, either absorbable or non-absorbable, and either with or without a zipper for re-exploration. Materials include: polypropylene, poly-tetrafluoroethylene, Vicryl®, Marlex®, Dexcon® polyglycolic acid, GORE-TEX® and AlloDerm®.	It allows for ease of placement. It permits re-exploration. It is possible to open and close the abdomen at the bedside. It gives increased strength, compared to Bogota. A permanent feeding tube can be placed.[13]	There is risk of fistula formation.[17] It is rigid and irregular. Adherence of the mesh to the viscera complicates further management. There is a very high rate of sepsis (up to 100% has been reported in some studies). It does not allow for removal of fluids. There is delayed primary fascial closure. It is expensive. There is mesh extrusion.[18] There is damage to the surrounding fascia.[13]
Non-specific negative-pressure dressing (i.e. sandwich/conventional negative-pressure) 	A fenestrated, non-adherent polyethylene sheet is placed over the viscera and covered with moist sterile towels or a sponge, e.g. Ligasano®. Two 10 French silicone drains are placed, and the wound is sealed with an adhesive dressing. Wall suction is applied and it is sealed with surgical drape.	It is inexpensive. Nursing care is easy. It is intended for rapid closure. Re-exploration is possible at the bedside. It is made from common materials found in the operating room.	It does not adequately deliver or regulate negative-pressure. On negative suction, the swabs become very hard and can be injurious.[19] There is a risk of fistula formation.[19] It does not quantify drainage. There are no alarms, as compared to regulation that is provided with VAC® therapy. This places the responsibility of ensuring that negative-pressure is maintained on the nursing staff. For much of the time, grafting is required for the closure. Adherence of the bowels to the fascia is probable.
Specific negative-pressure dressing 	This is specifically designed for laparostomy. A fenestrated, non-adhesive dressing covers the viscera (between the abdominal wall and the viscera). It is followed by a fenestrated sponge. It is covered by sterile adhesive drape. Negative suction is applied and maintained.	It prevents adhesion of the viscera to the abdominal wall. It prevents fistula formation.[13] It promotes granulation to prepare the wound bed. There is decreased oedema. It clears the fluids. It provides a closed, moist wound healing environment. It enhances perfusion. It draws the wound closed. It allows for fistula isolation. It protects the surrounding fascia.[13]	It is expensive.[13] Experience in using the equipment is required. There is a learning curve. The dressing must be applied precisely. There is increased responsibility on the nursing staff to ensure that constant suction at set pressures is maintained (the system is equipped with alarms). It is not translucent.

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Table IV: A comparison of available temporary abdominal closures

	Bogota bag	Retention sutures	Witmann® patch	Mesh closure	Non-specific negative pressure	Specific negative pressure
Inexpensive	√				√	
Freely available	√				√	
Easy application	√			√	√	√
Transparency	√					
Easy abdominal access	√	√	√	√	√	√
Prevents fascial retraction		√	√	√	Partial	Partial
Preserves skin and fascia integrity (multiple applications)					√	√
Eases nursing care					√	√
Clears fluids					√	√
Prevents fistula formation						√
Allows fistula isolation						√

Table V: A comparison of temporary abdominal closure outcomes[20]

Technique	Papers	Patients	Trauma	Mortality	Fascial closure	Fistula
Total	**22**	**1,891**	**1,480**	**706**	**451**	**131**
Bogota bag	4	553	446	293	48	35
Polypropylene (non-absorbable)	5	175	126	46	44	28
Polyglactin/polyglycolic (absorbable)	5	667	584	279	129	87
Non-specific negative pressure	4	245	211	80	120	11
Specific negative pressure	4	251	251	80	135	4

for all grades of open abdomen. Similar dressings are supplied by companies such as Smith and Nephew. However, these dressings are not problem free. We will discuss these problems now, with the dressing protocol (Figure 2).

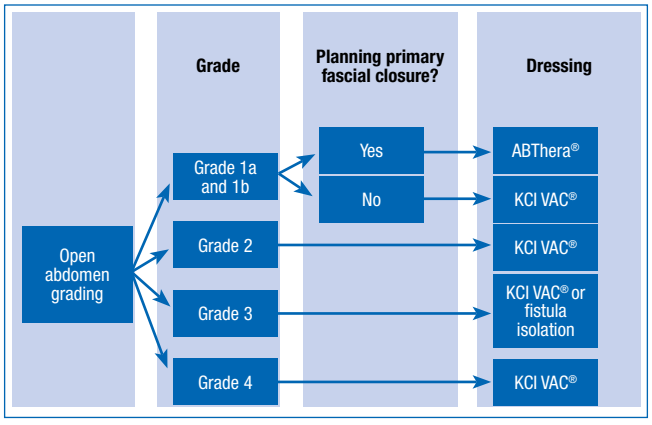

Figure 2: Dressing protocol

Dressing Grade 1a and 1b

When dressing the Grade 1a and 1b open abdomen, the aim is to maintain the intra-abdominal environment to such a degree that early primary fascial closure is possible. To achieve this, it is crucial to preserve the paracolic gutters to prevent adherence of the viscera to the abdominal wall, and prevent fistula formation. Added to that, fluids should be drained, and sepsis prevented at all cost. Our preference is the ABThera® dressing (Figure 3), the application of which will be described in a step-by-step manner (Figures 4a-g).

The ABThera® dressing comprises five parts: (See Figures 3a-3h)

- A perforated, visceral sponge drape, colloquially known as the "spider drape". This envelops the viscera by extending deep into the paracolic gutters, and drains fluid from the gutters, and from between loops of bowel.

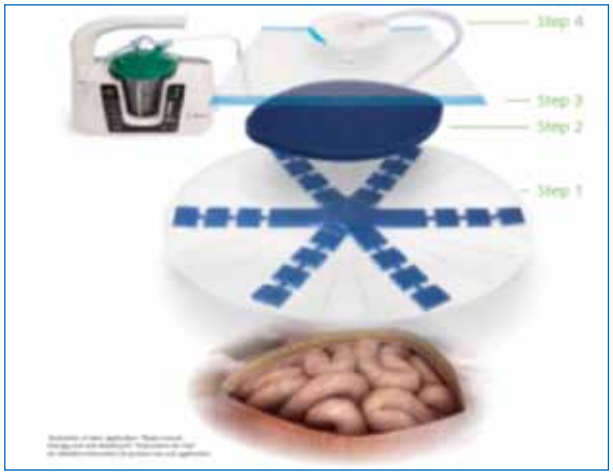

Figure 3: Components of the ABThera® dressing for Grades 1a and 1b open abdomen.
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Figure 4a: Start by preparing the abdomen for dressing. No drains are necessary, unless there is a collection or an abscess that the perforated visceral drape cannot reach, for example, posterior to the liver, or in the pouch of Douglas.

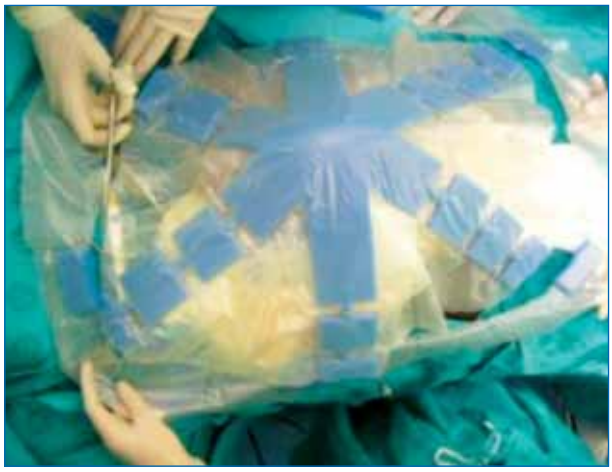

Figure 4b: Cut the "spider drape" to fit the paracolic gutters, pelvis and subcostal spaces. It is important to cut through the blocks of blue sponge (not the thin interblock connections), and remove the remaining half, so that there is no sponge that is directly in contact with the viscera.

Figure 4c: Insert the "spider drape" into the abdomen using retractors. If necessary, suction the periphery of the dressing onto a Yankauer suction tip to assist insertion. Ensure that there is no folding of the drape in the gutters.

Figure 4d: Protect the exposed wound edges with a non-adhesive cover such as paraffinated gauze.

Figure 4e: Shape the top cover sponge. Employ ample hands to assist in positioning.

Figure 4f: Cover the total dressing with adhesive drape, and be careful not to pull the drape too tightly, as this inhibits adhesion.

Figure 4g: Cut a small circular hole in the adhesive drape in a dependent position, and attach the TRAC pad so that it lies over the circular hole, and then apply negative suction at -125 mmHg.

- An oval-shaped sponge that fits on top of the exposed viscera, occupying the space between the two edges of the open abdominal wall.
- A large adhesive drape to create a perfect airtight seal.
- A connecting device, called a TRAC pad, that allows for negative suction, and drains away excess fluid.
- A controlled suction unit with alarms and a translucent, calibrated canister that collects drainage.

If a Grade 1 open abdomen is dressed with the aim of primary fascial closure, and this is not achieved within seven days, it is in the interest of general care and cost to revise the planned strategy. There is debate about whether or not continuation of the use of dressings to maintain paracolic gutters lessens the risk of abscess formation. However, it is currently commonly acceptable to change to a Grade 2 type dressing, the KCl VAC®, as this reduces cost, and allows for easier dressing changes. The patient will also not require as much visceral manipulation, and it is more reasonable to do these dressings outside of theatre, and in an ICU environment.

Dressing Grade 2a and 2b, and Grade 4 (without fistula)

When dressing a Grade 2 or a Grade 4 open abdomen, the method and timing of definitive closure will differ from Grade 1a and 1b dressings, due to established adherence of the viscera to the abdominal wall. The goals are to drain fluids, prevent sepsis, prevent fistula formation, and especially to achieve wound bed preparation for split skin grafting, as this is now a priority.

Figure 5: The components of the KCl "black" VAC® for dressing Grades 2a, 2b and 4
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Figure 6a: Prepare the open abdomen for dressing. This includes wound bed irrigation, cleaning the surrounding skin with soap and water, and applying a skin-protective adhesive solution. Cover all the viscera and the wound edges with a non-adhesive dressing, such as paraffinated gauze.

The dressing type illustrated in Figure 5 is the KCl black sponge system, but alternatives to this are available. It is similar to the ABThera® in most regards, except for the absence of the perforated, visceral sponge drape. Step-by-step application is described in Figures 6a-d.

Figure 6b: Cover the entire abdomen with the sponge that has been cut and shaped to size.

Figure 6c: Cover the sponge with an adhesive drape, as with the dressing of the Grade 1 open abdomen.

Figure 6d: Place the adhesive drape, ensuring an airtight seal. Cut a small circular hole in the adhesive drape in a dependent position. Attach the TRAC pad so that it lies over the circular hole. Apply negative suction at -125 mmHg. Maintenance of the seal is essential to aid wound bed preparation, drainage of fluid and sepsis prevention.

Split-skin grafting

Once the wound bed has granulated sufficiently, SSG should be carried out on the wound. This should be done as early as possible, keeping in mind that skin takes to bowel very well, as it is highly vascular. The viscera and the abdominal wall can be grafted separately, or together, as illustrated in Figures 7a and 7b. The latter can cause a problem with adherence of the graft, as the viscera and abdominal wall move independently of one another with respiration. Vacuum dressing should be applied to the freshly grafted wound. This will keep the graft in place and clear excess fluid, if present. Remove this dressing after four to five days, or if soiled.

Figure 7a: Granulated open abdomen prepared for split skin grafting

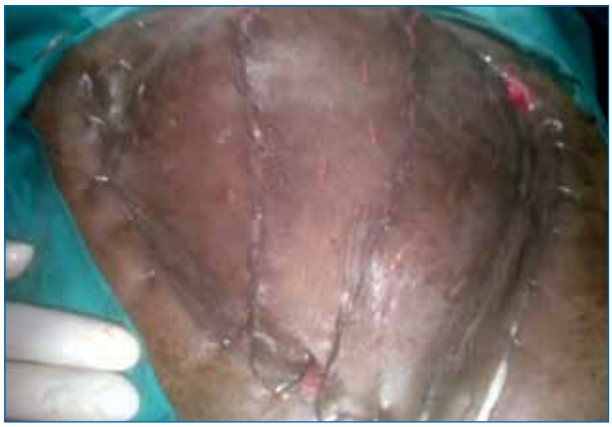

Figure 7b: Open abdomen after split-skin grafting

Dressing changes

Dressing changes are governed by the clinical scenario. If a patient still needs procedures in the operating room, such as bowel anastomoses, removal of packs or re-look laparotomy, the dressing should be changed in theatre. It will then be carried out as frequently as the procedures are necessary. If a patient only needs simple washouts or inspection, the dressing may be changed in the ICU, provided that appropriate equipment and anaesthesia are available. Changing the dressing every five to seven days is advised, but if the abdomen is septic, more frequent changing is preferable.

Conclusion

An open abdomen is difficult to manage. Many different TAC methods have been proposed in an attempt to deal with the morbidity and complications of this condition. In our experience, it appears that specific negative-pressure dressings are the most effective form of TAC. They can be adapted to the needs of the various grades of open abdomen, and offer essential, practical advantages. These include fluid removal, the promotion of wound bed granulation, and the prevention of sepsis and fistulation. This promotes successful closure of the open abdomen.

Author disclosure

The authors have no relevant affiliation or financial involvement with any organisation or entity with a financial interest or financial conflict with the subject matter of or material discussed in this article.

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