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Overview on Temporary Abdominal Closure Techniques: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Open abdomen (OA) is becoming more common, primarily to prevent intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS) following emergency abdominal surgery. The purpose of temporary abdominal closure (TAC) techniques is no longer just abdomen coverage; fluid regulation and early fascial closure are now important considerations. TAC techniques for leaving the abdomen open are numerous. The ideal one should be simple to apply and remove, allow for quick access to a surgical second opinion, drain secretions, ease primary closure with

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acceptable morbidity and mortality, allow for easy nursing, and, finally, be readily available and inexpensive. Over the years, several TAC methods have been proposed. In this review, we overview different techniques for temporary abdominal closure and its advantages and disadvantages.

Keywords: Open abdomen (OA); intra-abdominal hypertension (IAH); abdominal compartment syndrome (ACS); temporary abdominal closure (TAC).

1. INTRODUCTION

The open abdomen is associated with significant morbidity and mortality and its management poses a formidable challenge. Critically ill patients with underlying intraabdominal hypertension due to sepsis or injury are often managed with a damage control laparotomy (DCL), which involves the minimum intervention necessary to save the patient's life. Also, in severe peritonitis and deep wound dehiscence an open abdomen may be necessary for different reasons. Bowel distension and abdominal wall edema may prevent tension-free closure forcing the surgeon to leave the abdomen open [1].

The open abdomen (OA) procedure intentionally leaves the fascial edges of the abdomen un-approximated (laparotomy). The abdominal contents are exposed and thus must be protected with a temporary abdominal closure (TAC). Thus, every effort should be exerted to attempt abdominal closure as soon as the patient can physiologically tolerate it [2].

The open abdomen is often complicated by peritoneal contamination, intra-abdominal abscess, fluid losses, ileus, evisceration, and long-term sequelae such as ventral hernia and enterocutaneous fistula. Management of these wounds and indeed of the patient can often be challenging [3].

Temporary abdominal closure techniques in managing open abdomen help to achieve many benefits without incurring much complications. Various methods are available, but negative pressure therapy seems to be best suited to achieve these goals. Fascial approximation techniques prevent lateral retraction of the abdominal muscles and can be combined with TAC techniques. Mesh-mediated vacuum-assisted wound closure is emerging as one of the most promising approaches for OAT [4].

After temporary abdominal closure, the abdominal fascia must be closed primarily. The first goal is delayed primary fascial closure; however, many surgeons do not attempt primary fascial closure at all. Often, they use mesh and/or granulation tissue with split-thickness skin grafting to close the abdominal wound. In case of persistent visceral edema, loss of domain, or lateral retraction, the only option is to close the wound with mesh or granulation tissue with split-thickness skin grafting. In doing so, they create a "planned ventral hernia," which can be corrected at a later stage [5].

1.1 Indications for Temporary Abdominal Closure

The abdomen is left open under the following specific circumstances as part of damage control surgery [6]:

- Severe abdominal infection.
- Infected pancreatic necrosis.
- Vascular (e.g., ruptured abdominal aortic aneurysm, hemorrhage).
- Severe trauma.
- Abdominal compartment syndrome.
- Transplantation with size discrepancy between the recipient's abdomen and the graft.
- Necrotizing infection of abdominal wall.
- Ischemic gut with planned second look laparotomy.
- Damage control surgery.

The most important indication for leaving the abdomen open is the patient who is continuing to decline during the stress of the operation. The decline could be indicated by increasing lactate, which is indicative of worsening shock, increasing acidosis or coagulopathy, or an ongoing transfusion or vasopressor requirement. Once bleeding and contamination are controlled (damage control), the decision must be made whether the patient will be able to tolerate further operative intervention and communicated to the rest of the team urgently [6].

1.2 Temporary Abdominal Closure Techniques

There are several TAC techniques for leaving the abdomen open. The ideal one should be simple to apply and remove, allow for quick access to a surgical second opinion, drain secretions, ease primary closure with acceptable morbidity and mortality, allow for easy nursing, and, last but not least, be readily available and inexpensive. Various TAC methods have been proposed over the years [7]. From late '70s and during '80s, abdominal dressings for OA were quite simple, and the attention during treatment was focused only on protection and control of the bowel outside the abdomen. Through years, the attention of surgeons moved from protection of the ileus to preservation of the peritoneal space and prevention of lateral retraction of the fascia, which are the most important obstacles against the reconstruction of the abdominal wall at the end of the treatment [2].

1.2.1 Abdominal packing

Abdominal packing is a lifesaving technique for temporary control of severe injury and it is used in damage control surgery schedule. This method was used to leave the abdomen open for peritoneal drainage in patients with complicated peritonitis or abscess. At the end of the initial operation, nonadherent wet gauzes or hydrophilic dressings were placed directly on top of the abdominal contents, without the use of any sutures. Widely spaced retention-type sutures are placed, encompassing all layers of the abdominal wall, and are tied above the gauze packing [1].

A wide review of the literature has allowed to emphasize the most common problem of this technique, the adequacy of the particular indications, their evolution, timing, the results in general and particular which multiple critical situations and not always predictable when an intensive diagnostic and methodological approach is necessary [8].

1.3 Vacuum-Assisted Closure

Negative pressure therapy (NPT) has been shown to increase local blood perfusion and nutrient delivery to the wound, accelerate growth of granulation tissues, and decrease wound bacterial concentrations. It also reduces bowel edema and the application of mechanical stress to the wound accelerates cellular proliferation and angiogenesis. The negative pressure therapy, by the principle of reverse tissue expansion in the wound, brings together the wound edges [9].

Vacuum-assisted closure of the open abdomen entails the use of a non-adherent sheet covering the exposed viscera, as well as a sponge, placed under negative pressure. The system is based on the principles of traction and countertraction in that the suction provides the traction on the abdominal wall while the sponge creates countertraction [10]. The principles of a protective, non-adherent layer between fascia and bowel and the early initiation of partial sutures to achieve higher fascial closure rates were used by others, achieving high fascial closure rates of 65–100% [11].

Overall, the system effectively performs the goals of expanding the abdominal cavity, protecting the viscera from heat and evaporative losses, controlling, and quantifying peritoneal fluid and actively removes potentially detrimental contaminated fluid from deep within the abdomen. Early abdominal fascial closure before 8 days has been shown to be associated with fewer complications [12]. Another advantage is the relatively clean and efficient removal of infected peritoneal fluid and quantification of that loss. However, these systems could achieve primary facial closure by extending the timing of abdominal closure to be beyond 7 days, generally to 20–40 days [13].

1.4 Vacuum Packing

The vacuum pack technique is similar to vacuum closure concept and design. The vac-pack is a three-layer, sutureless dressing with a vacuum seal. The first layer, abutting the abdominal viscera, is a polyethylene sheet placed under the peritoneum of the abdominal wall. A moist, sterile surgical towel is placed over the polyethylene sheet. Two drains are placed on top of the towel and tunneled underneath the skin approximately 4-5 cm away from the wound [14]. A polyester sheet backed with acrylic adhesive is placed on the skin after it has been painted with tincture of benzoin or a similar adhesive. A Y-shaped adapter is connected to the drains, and suction is maintained at −100 to −150 mm Hg. The abdominal contents are free to expand from visceral and retroperitoneal edema during the acute phase of resuscitation, with minimal chance of abdominal compartment syndrome. Multiple operations are facilitated by this design

as well, and there is a reported low rate of bowel fistula formation, retraction of the abdominal wall fascia, and intestinal adherence to the prosthesis [14].

One of the main advantages is that it prevents injury to the abdominal wall by not suturing it, preserving it for later closure. It also is safe, inexpensive, and controls fluid loss. The use of a sterile surgical gown or gauzes wrapped in adhesive drape instead of the fenestrated polyethylene sheet has also been reported. A disadvantage of the technique is that the prevention of loss of abdominal domain seems limited. In a systematic review, vacuum pack showed a 52% primary fascial closure rate [15].

1.5 The Bogota Bag

To perform this technique, a sterile plastic 3-L genitourinary irrigation fluid bag is sutured to the fascial edges for TAC. After the initial operation, a presterilized, soft 3-L IV bag is cut to an oval shape and stapled with a standard skin stapling device or sutured with monofilament suture to the skin edges of the wound. Sterile, antibiotic soaked towels are placed over the silo, which is then covered with an iodine-impregnated adhesive plastic drape [16]. The wound is inspected and the dressing is changed every 24 hours. IV bag silos may be replaced in the intensive care unit setting using standard sterile surgical techniques and equipment. This is a variation of the silo closure used for repair of gastroschisis and omphalocele. Visualization is possible through the bag, allowing monitoring of intra-abdominal contents for ischemia [17].

The advantage of this technique is it can be performed with minimal resources in almost any operating room. This technique, however, does not preserve the fascia and might not prevent IAH [18]. In a systematic review, it showed a weighted mortality rate of 41% [19]. Several modifications of the technique have therefore been reported, including the use of double sheets and suction tubes, with good results but continuous IAP measurement is necessary. Other alternatives include bowel bag, Steri-Drape, or Silastic cloth [20, 21].

1.6 Skin-Only Closure with Towel Clipping

The temporary skin-only closure techniques use the skin to provide some abdominal wall stability with containment of abdominal viscera. These techniques use a series of towel clips or a rapid monofilament running suture. Towel clips are placed 1 cm apart and 1 cm away from each side of the skin edge. As many as 30 standard perforating towel clips may be required to close an incision. The incision may then be covered with an adherent plastic drape (eg, Vi-Drape, Steri-Drape). Covering the incision decreases manipulation of the towel clips while the patient is being transferred [6].

This technique may be used in the rapid temporary closure of thoracic or groin incisions in patients with trauma injuries who are in unstable condition and in patients undergoing general surgery. Because of the high complication rates, including that of ACS, which varies from 13% to 36%, these techniques have largely been abandoned now [22].

1.7 Wittman Patch or Artificial Burr

The Wittmann Patch (STARSURGICAL, Inc., Burlington, WI) was designed to allow adjustment in the laxity or redundancy of the closure material to accommodate changes in intra-abdominal pressure and prevent abdominal compartment syndrome. As described by Wittmann et al. in 1993, the patch consists of sheets of biocompatible polyamide and polypropylene, one containing multiple micro-mushrooms (hooks) and the other multiple slings (loops), enabling them to stick together similar to Velcro® [23].

It consists of 2 adhering sheets of biocompatible polymeric material with hooks on one side and a meshwork of loops on the other. The sheets are sutured to opposite fascial edges; to close the abdomen, the overlapping sheets are compressed to stick together. The sheets are covered by a surgical towel, a suction tube, and an adherent plastic drape. The suction tube is connected to a suction source to create negative pressure. The sheets can be easily pulled apart to allow for re-exploration and tightened every time to allow for gradual closure of the abdominal wall. In a systematic review, it had the highest fascial closure rate (90%) [24].

The major advantage of this approach is the ease of access for repeated surgical interventions and the capacity for applying tension to the midline fascia, which helps prevent lateral retraction of the aponeurotic edges, permitting definitive delayed primary closure in most cases. However, the major complication associated with this technique is bowel

fistulation. As such, great care must be taken to interpose a layer of non-adherent material between the device and the bowel [25].

1.8 Synthetic Mesh Closure

- **Absorbable synthetic mesh:** Absorbable mesh options include polyglactin 910 (Vicryl; Ethicon, Norderstedt, Germany) and polyglycolic acid (Dexon; Braun-Dexon, Spangenberg, Germany). The choice between polyglactin mesh and polyglycolic acid mesh is primarily determined by the surgeon's preference. Polyglycolic acid mesh has wider interstices, which Brasel et al believe may allow more efficient drainage of intra-abdominal fluid and thus may decrease potential delayed complications (eg, abdominal distention, ileus, and abscess) [26].

Many surgeons apply a split-thickness skin graft to cover the bowels more safely. Polyglycolic acid mesh has wider interstices and reportedly allows more efficient drainage of infected abdominal fluid. As a result, some authors recommend its use in the infected abdomen. Another benefit of absorbable mesh in the setting of infection is its ability to stimulate fibrous granulation tissue and ultimate epidermal cell proliferation as it is hydrolyzed [27]. Even when infection would prevent definitive closure of the abdominal wall, regeneration of native abdominal wall fibrous tissue continues. With the use of either absorbable mesh, the reported rates of enterocutaneous fistulae range from 8.3% in patients with a definitive peritonitis to 23% in multi-injured trauma patients

These absorbable meshes differ from non-absorbable meshes in an infected abdomen in that they lose a significant amount of their strength via degradation in approximately three weeks and generally are absorbed by about six weeks. Absorbable mesh is not designed to be used to approximate the fascial edges serially but it is designed to form a granulation tissue bed for future skin grafting [14].

- **Non-absorbable synthetic mesh:** Non-absorbable mesh has demonstrated utility in keeping the rate of abdominal compartment syndrome (ACS) low. Non-absorbable mesh options include polytetrafluoroethylene (PTFE) and PP. PTFE is hydrophobic, whereas PP is hydrophilic. It has been suggested that hydrophobic material may initially repel bacteria-laden fluids, but ultimately, any such property is likely to be overcome by integration via the fibroblastic response [28].

Nonabsorbable meshes can be initially sutured to the abdominal fascia loosely, allowing visceral swelling and thus preventing the development of ACS. As visceral edema resolves, the mesh can then be excised in the medial portion and the two edges resutured to sequentially result in fascial approximation. The use of nonabsorbable meshes improves the primary closure rates, which range from 33 to 89% [29].

Reported fistula rates differ widely with use of non-absorbable mesh in infected abdomens, from 4% to 75%. In one series of closures with nonabsorbable mesh in the presence of abdominal fecal contamination, relatively low surgical site infection rates (7%) and fistulae (3.4%) were noted [30]. Similarly, in patients with intra-abdominal sepsis or abdominal compartment syndrome, after definitive closure with mesh, 3% of patients developed enterocutaneous fistulae. However, other authors have reported fistula rates as high as 75% [31]. Some authors report success in lowering fistula and mesh (PP) infection rates by placement of omentum between the bowel and the mesh in contaminated abdominal wall defects caused by necrotizing fasciitis after radical debridement [29]. Because of these complications, the placement of nonabsorbable synthetic mesh in the setting of an active infection usually is a temporary measure, and the mesh is removed prior to definitive fascia-to-fascia closure.

- **Zipper technique:** A mesh or sheet with a sterilized zipper is sutured between the fascial edges. This technique is comparable to the mesh/sheet and allows for easy access [32].

2. CONCLUSION

Temporary abdominal closure techniques are of the most significant advancements in latest generations, and it has become a standard procedure in both traumatic and general surgery. One of the primary goals of OA treatment is to close the facial defect as quickly as clinically possible while maintaining intra-abdominal pressure normal during the initial hospitalisation. Multiple techniques have been shown to be effective in increasing the rate of primary

abdominal fascial closure. There have been few high-quality comparative studies to assist clinicians in selecting among the available techniques. It is the clinician's responsibility to apply the basic principles of OA management judiciously in order to obtain the greatest benefit for their patients.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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