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Managing The Open Abdomen

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Abstract

The management of patients with an open abdomen is challenging. Control of intra-abdominal fluid secretion, facilitation of abdominal exploration and preservation of fascia for abdominal wall closure can test even the most experienced surgeon. Over the years various techniques have been tried to minimise complications and expedite closure with VAC® therapy (KCI Medical, Witney, Oxford UK) being the newest. This article provides an overview of the techniques available for the management of the open abdomen from towel clips to VAC®.

Introduction

The open abdomen is becoming an increasingly common problem for the general surgeon to manage. Whilst abdominal dehiscence not amenable to closure and loss of abdominal wall volume by necrotising infections still occur it is the upsurge in abdominal trauma (and the consequent development of damage control surgery) and the recognition of the abdominal compartment syndrome that have left the abdominal surgeon with a requirement for a range of techniques in their armamentarium for management of the open abdomen. This article reviews the available methods for temporary abdominal closure, including vacuum assisted closure - a relatively new technique which appears to have some advantages over other methods.

Damage Control Surgery

Prolonged laparotomy in critically ill trauma victims has a high mortality, principally by worsening the synergistic effects of the vicious triad of trauma - hypothermia, acidosis and coagulopathy (1,2). In an effort to reduce this mortality Rotondo *et al* (3) introduced the concept of damage control surgery (DCS) - an abbreviated laparotomy to control haemorrhage and limit contamination and placement of the patient on the intensive care unit for aggressive restoration of normal physiology before a 2nd laparotomy 24-48 hours later. In this situation temporary abdominal closure is quick to apply and remove, limits heat and fluid losses and simplifies nursing care.

Abdominal Compartment Syndrome

Abdominal compartment (ACS) syndrome is considered a new phenomenon but was first reported in 1876 (4). It is defined by intra-abdominal hypertension (> 20 mmHg) with end organ dysfunction. Both occur as a sequelae of a rapid rise in intra-abdominal pressure against a closed abdominal wall decreasing visceral blood flow. ACS may develop following an intra-abdominal surgical procedure (primary ACS) or following third space accumulation secondary to aggressive resuscitation (secondary ACS) in conditions such as pancreatitis and burns. The development of organ dysfunction is initially at a cellular level but becomes overt when prolonged (5) and may involve nearly all organ systems. Reduced venous return lowers cardiac output and increases heart rate and the falsely elevated central venous pressure leads to under resuscitation. Direct compression of the renal and splanchnic vasculature gives rise to oliguria and gut ischaemia respectively and increased airway pressures and splinted diaphragms decrease dynamic pulmonary compliance and reduce gas exchange leading to hypercarbia and hypoxia. Treatment requires early recognition of intra-abdominal hypertension followed by decompression before the onset of Multi Organ Dysfunction Syndrome (MODS)- even then the 30 day mortality rate is a depressing 59% (6). Thus early decompression for abdominal pressures >25mmHg is recommended and the abdomen left open (7). In those at risk of ACS, fascial closure may be deferred (8,9) and the abdomen closed temporarily by any method that will allow easy re-exploration.

The Consequence Of An Open Abdomen

Temporary closure of the abdomen in these situations allows restoration of normal physiology whilst minimising the risks associated with an open abdomen. These include a high rate of intra-abdominal abscesses, fistula rates of up to 38% when intestinal anastomoses are present and abdominal wall hernia rates of about 25% (10). There is a 20-30% rate of development of a degree of MODS (11) with an open abdomen, possibly due to the activation and absorption of pro-inflammatory cytokines.

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Management Options For The Open Abdomen

The choice of technique of temporary abdominal closure depends on the situation - in DCS with a planned re-look laparotomy, a minimally traumatic rapid closure is ideal, whereas in decompression of ACS, increased abdominal volume is necessary whilst controlling the abdominal contents and minimising heat and fluid loss. In addition, the need for further multiple laparotomies and the presence of ongoing peritoneal sepsis may influence the choice of technique. In each instance maintenance of fascial integrity to facilitate ultimate direct closure and limitation of the incidence of ventral hernia is the ideal

Direct Closures

In DCS laparotomies where the skin will approximate a rapid and easily removed closure is needed. The simplest is a continuous non-absorbable subcuticular suture to the skin alone, leaving the fascial edges untouched. An alternative is to close the skin with a row of towel clips approximately 1-2cm apart, which are then covered with a sterile towel and an adhesive drape. This method may take as little as 60 seconds to close an abdomen (12) but does not allow inspection of the wounds, may traumatise the skin (and bowel that can prolapse between clips) and may still allow the development of ACS. In situations where direct skin approximation is not possible or desirable (post-ACS), an alternative method is necessary.

Indirect Closures

These all address the problem by using synthetic material to bridge the gap between the widely separated fascial edges and effectively increase the volume of the abdominal cavity, thereby reducing the pressure. The most famous of these methods is the "Bogota bag" (13,14), initially developed in the cost constrained environment of Colombia where more expensive temporary closure systems weren't available (15). A sterile plastic sheet is used as a silo - Steri-Drape, bowel bags and Silastic sheets have all been used (16), but the name Bogota bag is largely synonymous with the use of an opened out sterile intravenous fluid bag. It may be sutured to the fascia or clipped to the abdominal wall skin and acts to retain the abdominal contents, pending definitive closure. It does not however form a watertight seal and peritoneal fluid may seep onto the abdominal skin causing irritation which can be problematical particularly if there are associated stomas. If delayed primary closure is impossible and the bag is left in situ for a prolonged period there is granulation of the gut beneath which is then ultimately covered by a split thickness skin graft. Patients may then live with a planned ventral hernia or may subsequently have it repaired using a combination of synthetic meshes and advanced plastic surgical techniques (17). Long term management in this manner results in a prolonged hospital stay with a requirement for a heavy nursing input and overall cost.

Abdominal cavity volume may be increased by the use of a synthetic mesh sutured to either fascia or skin, although skin suturing allows fascial retraction which may make subsequent closure difficult. The choice of mesh varies between absorbable ones (Vicyl™ and Dexon™) or non-absorbable (such as Gore-Tex™). The absorbable ones may be left in situ, are relatively resistant to infection (18) and improve early bursting strength (19). Non-absorbable meshes like prolene have up to a 3% risk of enterocutaneous fistula formation (20). It has also been postulated that because of the decreased fibroblastic reaction with absorbable meshes, an increased late hernia recurrence rate might be expected (21). In addition, absorbable meshes do not easily allow frequent relook laparotomy, as they need to be replaced each time, traumatising the fascia. Use of a non-absorbable mesh may be combined with an abdominal zipper to facilitate abdominal re-entry but risks mesh infection. A recent alternative that seems to combine many of the positive features from these mesh closures is the Wittman patch™ used as part of the STAR technique (Staged Abdominal Repair). At an early stage of open abdominal management two sheets of synthetic fabric - essentially large sheets of velcro - are sutured to the opposing fascial edges and then pressed together. This allows traction to be applied on the fascia to prevent retraction, easy re-exploration by simply pulling the sheets apart and minimal fascial trauma as the sheets are trimmed in the midline to shorten them as abdominal visceral oedema settles and the need for greater abdominal volume reduces. Thus as the abdominal volume lessens, the patch is serially shortened, pulling the fascia together until direct sutured closure is achievable (22). Wittman reports excellent results using this technique with no cases of fistula formation in over 200 cases (23). Its major disadvantage would appear to the cost of the patented device.

Unfortunately none of the techniques described so far controls the egress of the often large volumes of exudate that are liberated from the partially exposed oedematous bowel. In order to address this worry wall suction was utilised to extract the fluid from beneath a temporary abdominal closure - so called 'Vac pack' therapy. The application of negative pressure was also postulated to increase closure rates (24). The abdominal wound was packed with a surgical towel or a fenestrated plastic bag,

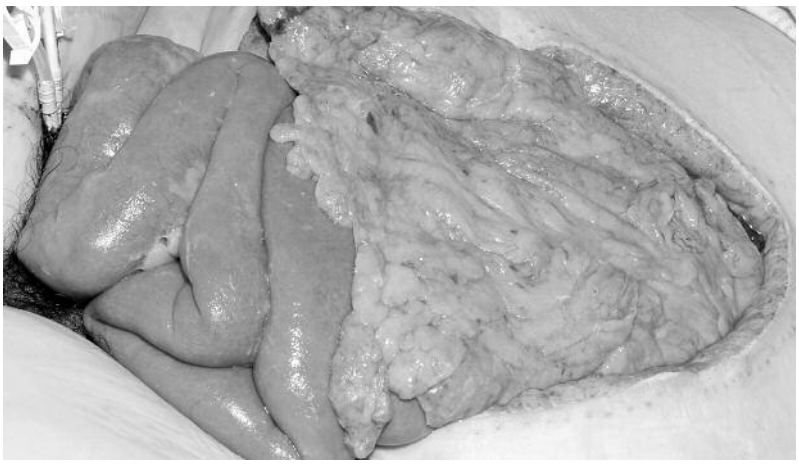

Figure 1: Open abdomen after wound dehiscence prior to commencement of VAC® therapy.

Figure 2: Abdominal wound after one week of VAC®.

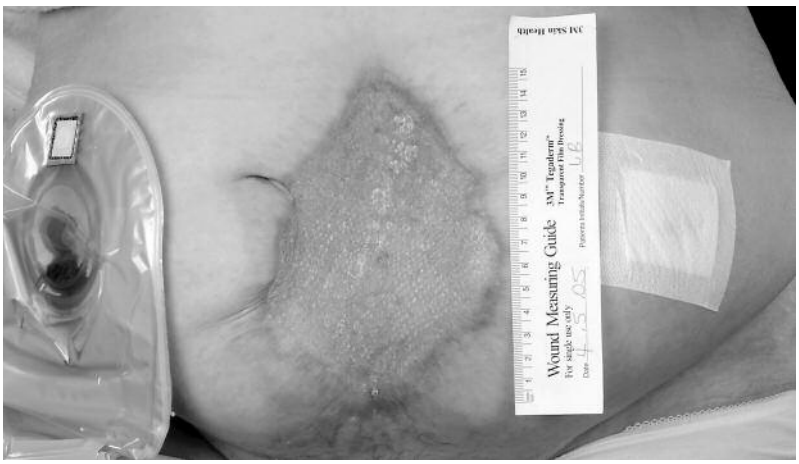

Figure 2: Abdominal wound at the end of four weeks of VAC®.

Figure 4: Eventual appearance after full recovery.

suction drains placed over it and the whole thing sealed with adhesive drapes before connecting the drains to wall suction. Barker *et al* reported a series of 112 patients treated in this manner over a 7 year period with a 55% primary fascial closure rate, although if the patients who died before abdominal closure was attempted are excluded this rises to 69%. The enterocutaneous fistula rate was 4.5% (24). Delays beyond 6 days from injury were however associated with a much lower chance of success of primary closure, because of fascial retraction and adherence of the abdominal viscera to the abdominal wall.

VAC therapy

Vacuum-assisted closure (VAC®) (KCI Medical, Witney, Oxford UK) therapy is an evolution of the 'do-it-yourself' vacuum dressings that utilised subatmospheric pressure to manage a variety of acute and chronic wounds including the open abdomen (Figures 1-4). A purpose made fenestrated non-adherent sheet is placed over the abdominal cavity to retain the contents and prevent the formation of adhesions to the abdominal wall. The defect between the two fascial edges of the abdominal wall is then filled with a foam sponge cut by the surgeon to fit precisely. The whole abdomen is then covered by an adhesive drape for at least 5cm beyond the wound edges and the end of a length of suction tubing is embedded in the sponge through a small cut in the top drape. The tubing is connected to a portable suction device. When switched on a negative pressure is created and the sponge shrinks, fits the irregularities of the wound and draws the abdominal wall edges together. The level of vacuum can be altered, although best results have been demonstrated with a pressure of 125mmHg: blood flow to the wound is maximal when suction is applied intermittently rather than continuously (25). Intermittent suction increased the amount of granulation tissue in a healing wound by 103% compared to continuous suction. The majority of the evidence for VAC therapy comes from small non-randomised trials, animal studies or experimental data relating to VAC for chronic wound management, although some of the advantages so demonstrated may also be applicable to open abdominal wounds.

Proposed advantages of VAC in chronic wounds

Wound healing is a complex process and is promoted by cellular proliferation in the wound edges accompanied by angiogenesis and the removal of cellular debris and bacteria. VAC therapy removes wound exudate and reduces tissue oedema which in turn increases capillary blood flow by reduction of interstitial hydrostatic pressure (26,27).

Rapid removal of tissue exudate also decreases the concentration of many proteolytic enzymes and inflammatory cytokines which may inhibit wound healing. There is a concomitant reduction in bacterial colonisation compared to standard dressings which may be attributed to the decreased wound oedema, improved microvascular oxygenation and a reduced ingress of environmental contamination by using a closed system (28). *In vivo* studies suggest that VAC induces some degree of tissue stretching - a stimulus to increased proliferation, angiogenesis and promotion of matrix synthesis (29,30). Overall these positive effects of VAC therapy have been shown to speed wound healing (31,32) and may contribute to the benefits attributed to it in open abdomen management

Contraindications, complications and efficacy

The principle worry when using VAC over exposed bowel is one of enterocutaneous fistula, especially if there are exposed intestinal anastomoses, given that fistula in these circumstances rarely heal with conservative management compared to 80% healing rates seen when the abdominal wall is intact (33). Early series of vacuum treatment of open abdomens reported fistula rates of up to 25% (34), but Millers group from North Carolina recently reported only a single fistula in 53 successive patients treated with the commercial VAC system (35). Paradoxically there are now occasional reports of VAC equipment being tailored to control troublesome high-output enterocutaneous fistula with success (36,37). The overwhelming aim of VAC therapy however is to improve management of the open abdomen and decrease the rate of planned ventral hernia requiring subsequent reconstruction surgery by maximising the rate of delayed primary fascial closure.

There are three significant series reporting the use of VAC in the open abdomen. In 2001 Garner *et al* reported 14 cases of open abdomens - all bar one achieved delayed primary fascial closure in approximately 10 days with no complications (38). A much larger retrospective series of 148 patients with open abdomens was published from North Carolina (39). Although a large series overall, only 56% of patients survived - 24 had planned ventral herniae and 59 achieved fascial closure although only details of the 22/34 cases that utilised VAC and were closed later than 9 days after initial laparotomy are further analysed. Two of these 22 subsequently dehisced. The same group have recently reported a prospective series of 53 open abdomens managed with VAC. They had an 88% fascial closure rate which is the highest yet reported, with nearly half of them closed after the watershed of 9 days. There was a single enterocutaneous fistula and 2 dehiscences which were successfully resutured. A single patient developed a ventral hernia after discharge

Conclusion

Managing the open abdomen has evolved over several decades yet remains a significant challenge even to an experienced surgeon. The chosen technique should be based on the patient's condition and local expertise available and may change as the patient's abdominal condition progresses - prevention of infection and the planning of delayed closure are key principles. The Bogota bag is an easily initial step and is cheap and repeatable. Temporary placement of synthetic mesh creates an increased volume to accommodate oedematous bowel. Since the early 1990's occlusive dressings coupled with negative pressure suction have improved management as they tend to prevent fascial retraction. A commercial kit is now available for vacuum assisted closure and in the few reports of its efficacy in open abdomen management it has demonstrated excellent late fascial closure rates with minimal complications.

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