Closure of Massive Abdominal Wall Defects

A Case Report Using the Abdominal Reapproximation Anchor (ABRA) System

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Abstract:
Closure of massive abdominal wounds can be a challenging surgical problem. Presented here is a novel technique for reconstitution of the abdominal wall after severe internal injuries complicated by sepsis required a prolonged period of open abdominal dressing changes. By using an innovative and effective progressive tension band system, the fascial edges could be reapproximated over time allowing primary wound closure. This system is recommended as an effective instrument to accomplish closure of these difficult wounds.

Key Words: abdominal wound, hernia

Multiple approaches for repair of massive abdominal wall hernias have been described. Some involve tissue expansion1,2; others, separation of native abdominal wall musculature3,4; and still others involve mesh,5 pedicled flaps,6 and even free-tissue transfers.7,8 This article describes an innovative approach designed to restore lost abdominal domain and achieve closure of large wounds using a continuous dynamic tension device called the abdominal reapproximation anchor (ABRA) system (Canica Design, Almonte, Ontario, Canada). This system consists of a variable number of anchor-pulley-elastomer units designed to apply closing tension to the wound (Fig. 1). The surgical approach includes initial application of the device, followed by incremental bedside reapproximation of wound edges using continuous tension elastic bands, which are adjusted daily. Once the wound edges are nearly approximated, complete surgical repair of all layers of the abdominal wall is performed. In this fashion, restoration of abdominal domain and complete repair of the musculofascial support of the abdominal wall with a primarily closed wound are achieved.

CASE REPORT

A healthy 33-year-old male civilian contractor was involved in an incendiary explosive device detonation and ensuing vehicle rollover while working in Baghdad, Iraq. As a result, he suffered multiple rib fractures; bilateral pneumothoraces and pulmonary contusions; splenic, pancreatic, and liver lacerations; clavicle and scapular fractures; and bilateral adrenal hematomas. He underwent an initial exploratory laparotomy with splenectomy and distal pancreatectomy, and the abdominal wound was left open to facilitate easy access needed for multiple explorations and debridements. After stabilization of the abdominal injuries, a regimen of open abdominal dressing changes was instituted, which included the placement of a vacuum-assisted closure (VAC) device. This VAC dressing was changed every 2 days until the bed was well granulated. During this time, recurrent intra-abdominal abscesses were drained percutaneously using computed tomography (CT) guidance. After 3 weeks of conservative wound management, considerable edema was present in the intestinal visceras, which protruded markedly through the open midline abdominal wound (Fig. 2A, B). With contraction of the surrounding musculature, herniation of the abdominal contents through the wound was exacerbated, leading to early loss of abdominal domain. The wound measured 35 by 25 cm and involved all layers of the abdominal wall. The large and small bowel protruded through the midline abdominal defect and presented as a matted and granulated mass. At this point, plastic surgery was consulted for definitive wound management.

Operative Technique

Stage 1
To restore abdominal domain and decrease the swelling present in the visceras, the ABRA system was applied to the edges of the midline abdominal wound. Under general anesthesia, a series of transversely oriented sturdy elastic bands was placed percutaneously across the wound. In all, 9 elastics were inserted through the full thickness of the abdominal wall, including skin, fascia, muscle, and peritoneum, such that they entered the skin and pierced the peritoneum 5 cm distant from the wound edge (Fig. 3A–C). This necessitated...
the freeing up of the granulated bowel away from the undersurface of the wound edges to prevent inadvertent injury to the bowel. In the central portion of the wound, where it was anticipated there would be maximal tension, the elastics were doubled to provide additional support. Each elastic band was then secured into position with the aid of a specifically designed button-pulley unit attached to each end, which

FIGURE 1. Display of the ABRA system including the elastomers and buttons.

FIGURE 2. A, B, AP and lateral view of the massive abdominal wound measuring 35 × 25 cm. The bowel has granulated and protrudes significantly through the midline fascial opening.

FIGURE 3. A, AP view of the abdomen after 9 elastic bands have been placed across the defect. The middle 6 bands have been doubled to provide extra support to the wound edges in the area of maximal tension. B, C, AP and lateral view of the abdomen after complete insertion of the 9 elastomers and their respective buttons, side supporting adhesive tapes, and the silicone gel sheeting to protect the bowel. Note on the lateral view that the abdominal viscera are already largely reduced back into the peritoneal cavity.

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provided a narrow channel into which the elastic band could be seated. By securing the 2 ends of the elastic band on either side of the wound to these buttons, tension was applied across the wound in a continuous and controlled fashion. An additional adhesive tape was secured to a small loop located on the lateral aspect of each button and applied under slight tension to the lateral aspect of the abdominal wall to help hold the buttons in position and relieve some of the tension on the button-skin interface. To prevent the elastic bands from eroding into the underlying bowel, Silastic sheeting was placed under the elastic bands and on top of the viscera. This more evenly applied the force of the elastics to a larger surface area and protected the bowel from any potential direct and concentrated pressure, which might lead to localized ischemic necrosis with bowel perforation. With initial placement of the device and modest tension on the elastic bands, the herniated viscera were completely relocated back into the abdominal cavity. Three days after placement, gradual tightening of the elastic bands was begun at the bedside by reseating each elastic band at a slightly higher tension within the channel of each button. Marks on the elastic bands themselves helped guide the setting of correct tension based on how much these marks elongated as the elastic band was stretched. Tension was adjusted daily based on the response of the tissues to the pressure applied by the elastic bands and the buttons as they pressed against the skin edges (Fig. 4A, B). Wound approximation was actually achieved by day 17, but definitive closure was delayed secondary to concerns about continued fevers with leukocytosis.

**Stage 2**

Three weeks after application of the ABRA device, the condition of the patient was dramatically improved. The patient was returned to surgery where, under general anesthesia, the Silastic sheet was removed and the wound edges were debrided and primary reapproximation of the fascia and muscle in the midline was performed using numerous interrupted figure of 8 #1 permanent monofilament sutures (Fig. 5A–C). The closure was reinforced using a running suture technique through the anterior rectus sheath along the length of the wound. No mesh was used as the closure of the fascia was accomplished easily without the creation of undue tension. The skin was then simply debrided and reapproximated in the midline. It should be noted that no attempt to remove the granulation tissue adherent to the bowel was made other than gentle scraping of the surface. Drains were placed in the subfascial and subcutaneous spaces (Fig. 5D). Localized areas of pressure necrosis of the skin under several of the buttons were noted and treated conservatively with dressing changes. The remainder of the postoperative course was uncomplicated, and the patient was subsequently transferred to a rehabilitation facility 1 week after final closure. Wound healing proceeded uneventfully and the drains were subsequently removed. He presented 6 weeks later with a deep intra-abdominal abscess unrelated to the granulated surface of the previously exposed abdominal viscera that was drained percutaneously without the need for formal operative intervention. At follow-up 9 months after definitive wound closure, the patient has a competent abdomen, with no evidence of hernia, and excellent abdominal strength (Fig. 6A, B). He has since resumed his normal daily activities and is without disability.

**DISCUSSION**

Lifesaving management of catastrophic intra-abdominal trauma often involves a period of open abdominal wound management. Using this strategy, prevention of abscess formation and exposure for additional debridement and abdominal irrigation are greatly facilitated. Once the life-threatening injuries have been effectively managed, the full-thickness open wound of the abdomen then provides a significant reconstructive challenge. As in this case, the abdominal viscera are often edematous and can protrude significantly through the wound in a manner which precludes primary wound closure.9 As well, particularly in patients who have undergone a lengthy recovery process, loss of intra-abdominal volume or abdominal domain due to contraction of the abdominal cavity can severely hamper attempts to replace the abdominal viscera back into the peritoneal cavity.
For these reasons, previous strategies for management of these types of patients have included simply closing the skin over the exposed viscera or even skin grafting the granulated surface of the bowel. While these strategies can result in a healed cutaneous wound, the significant abdominal hernia which results can be a difficult reconstructive challenge at a later date as the degree of contraction of the abdominal cavity can progress, resulting in an irreversible loss of abdominal domain. Repair of the hernia may then necessitate the use of alternative techniques of repair including the use of mesh or collagen frameworks such as AlloDerm (LifeCell, Branchburg, NJ), tissue expansion and relaxing incisions, separation of abdominal wall components, pedicled flaps, or free-tissue transfer. An algorithm for closure of difficult abdominal wounds has been previously presented by Rohrich et al.

In designing the strategy used in this case report, several treatment goals were defined. The major obstacle to a complication-free wound closure was deemed to be the defect in the abdominal wall. Left unrepaired, it was feared that this defect would expand and a significant loss of abdominal domain would result, making subsequent repair difficult. It was felt that the best way to prevent this from happening was to reverse the effect of the initial clinical situation, where the protrusion of the abdominal contents through the midline was actually being worsened with each contraction of the surrounding musculature. As well, a strategy for edema resolution in the viscera needed to be developed to allow the swollen bowel to fit back into the peritoneal cavity. Clearly, the clinical condition of the patient precluded a direct surgical approach. However, with gradual restoration of normal 3-dimensional tissue relationships in the abdomen, it was felt that these obstacles to direct closure could be overcome using the concept of progressive and continuous tension. This is the concept behind the ABRA system. By developing a unique method of fixation using the buttons and the tension-reducing adhesive strips, elastic bands can be used to span the defect.
and gradually overcome the effects of injury and edema. This makes logical sense as no tissue was actually lost as a result of the patient’s injuries. By overcoming the effects of edema, direct closure of the fascia in the midline should be possible. Certainly direct reconstitution of the abdominal wall is the best option for long-term function and prevention of hernia.

In this case, there was no difficulty noted at all in directly closing the midline muscle and fascia as the wound edges came together without undue tension. However, despite the ease with which the fascia was closed, concerns remain with regard to the intra-abdominal sequelae of closing the fascia over the granulated bowel as there exists the potential for the development of recurrent infection and intra-abdominal abscess formation.14 In this case, the intra-abdominal drain placed directly under the fascia removed only serous fluid until it was discontinued. The late deeper intra-abdominal abscess which developed was related to previous injuries and the unusual organisms which were present and assumed to be related to the unique flora of Iraq. When using this technique, it is highly recommended to place a drain between the granulated surface of the bowel and the underside of the abdominal wall when closing a wound such as this.9 Not only will the drain remove fluid which could become potentially contaminated, but the quality and consistency of the drainage fluid can help identify or rule out potential infectious sources should postoperative fevers or septic symptoms develop. Also related to these infectious concerns is the concept of mesh reinforcement of the wound. If at all possible, mesh products or collagen framework sheeting such as AlloDerm are probably best avoided in contaminated wounds such as these, and they are best used only when necessary to achieve a strong and stable fascial closure.

One complication related to the use of the buttons was pressure necrosis of the skin where the elastic band and the button were joined on the skin surface. This was likely secondary to overzealous tightening of the elastic bands. Attention to skin hygiene and a more gradual stretching of the elastic bands can completely eliminate this problem.

**Summary**

Massive open abdominal wounds present a challenging surgical problem, and many approaches and techniques for repair have been reported. This article describes an innovative approach for restoration of lost abdominal domain with primary wound closure using a dynamic tension device called the ABRA system. The ease of application and the effectiveness of the technique make it an attractive option for restoration of abdominal wall integrity.

**REFERENCES**