Chapter 16

Abdominal Wall Reconstruction

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Anterior abdominal wall defects can be difficult and daunting problems to solve anywhere in the world. These musculofascial defects may range from simple incisional hernias following previous laparotomy to complex open abdominal wounds with exposed viscera and enteric fistulas following traumatic injury or necrotizing fasciitis. These latter wounds are commonly associated with significant functional disability that may limit the patient’s ability to care for themselves as well as place a burden on their family both physically and economically. Repair of such defects may be complicated by the formation of adhesions between the viscera and abdominal wall/hernia sac, lateralization of the rectus muscles and/or loss of skin and fascia, ileus, presence of enteric fistulae, and frequent malnutrition. Successful management and repair of such defects can be time-consuming, resource intensive, and economically challenging for both surgeon and hospital. This chapter will discuss a variety of techniques for managing and repairing abdominal wall defects. Frequently the reconstructive surgeon will be called to assist in such surgery.

Key Principles in Abdominal Wall Repair

The avoidance of abdominal hernias and complex abdominal wall defects should always be a primary goal for any surgeon. One of the most basic of all surgical principles is tension-free apposition of tissue edges. An abdominal wall that is brought together under tension is commonly made ischemic, dooming the patient’s fascial closure to failure. This principle must also be kept in mind during any attempt to repair a complex abdominal wall defect. It is now widely recognized that the pressure within a patient’s abdomen, due to distended viscera or edematous organs, decreases both rectus sheath blood flow and oxygen delivery to the healing fascia. This places the patient at risk for fascial dehiscence and failure. Elaborate repair of a complex abdominal wall defect that is performed under excessive tension will only lead to recurrent fascial dehiscence, potential loss of skin and subcutaneous tissues, and a more complex abdominal wall defect requiring future reconstruction (Fig 1, 2).
The avoidance of abdominal wall defects commonly begins at the time of initial laparotomy closure. Care should be taken to avoid closing the patient’s fascia under excessive tension. Whether the abdomen is closed in either a running or interrupted fashion is less important than the tension that is placed on the suture. Sutures should be placed at least 1 centimeter apart and 1 centimeter back from the fascial edge taking care to “reapproximate, but not strangulate” the fascial edges.

**Temporary abdominal closures and early abdominal wall reconstruction**
Primary fascial closure should always be the goal following any laparotomy. The carefully considered decision to abbreviate a patient’s laparotomy, leave the abdomen open, and apply a temporary abdominal closure (TAC) in the presence of critical illness, intra-abdominal catastrophe, or inability to safely perform primary fascial closure has been demonstrated to improve patient survival and decrease organ failure. The “open abdomen” and (TAC) techniques have therefore become valuable tools in the surgeon’s armamentarium as part of damage control strategies and the treatment of abdominal sepsis and elevated intra-abdominal pressure. Such techniques, while potentially life-saving, present the surgeon with the challenges of protecting the viscera and subsequent closure of the open abdomen once the patient’s critical illness has resolved. While expensive TAC dressings are available commercially, in
resource-limited settings either a plastic intravenous bag (the so-called Bógota bag, named for the Colombian surgeons who initially described its use) sewn to the skin (thus preserving the patient’s fascia unharmed for subsequent primary fascial closure) or Barker’s “vacuum-pack” dressing can serve to protect the viscera and decrease fluid losses until the patient’s abdomen can be successfully closed (Fig 3-5).

Figure 3:
A plastic intravenous bag (Bógota bag) is emptied and opened on three sides to create a strong, nonadherent prosthesis that can be sewn to the patient’s skin in an abdomen that cannot be safely closed following damage control laparotomy. This technique is inexpensive, easy to perform, and uses materials that are readily available in any hospital. Four days later, when the patient’s visceral edema had subsided, the patient was returned to the operating theatre for primary fascial closure. (Picture courtesy of Dr. Michael Cheatham, Orlando Regional Medical Center, Orlando, Florida)
Figure 4

Barker’s “vacuum-pack” temporary abdominal closure dressing: A non-adherent plastic bag or drape is “pie-crusted” to allow passage of fluids. This is placed over the viscera, tucking it under the fascial edges of the wound. This helps to prevent adherence of the viscera to the abdominal wall, thus limiting subsequent closure of the abdomen. A moist surgical towel is applied over the drape. Two large closed-suction drains are placed over the towel and the entire dressing is covered with a large adherent plastic drape. The drains are then placed on continuous suction. Fig 5 shows cross-sectional view of Barker’s dressing. (Used with the permission of KCI licensing)

Figure 5

Prolonged open abdominal decompression can result in intestinal adhesions, fascial retraction, loss of abdominal domain, enteric fistulas, and development of massive incisional hernias requiring subsequent complex abdominal wall reconstruction. Care should be taken to avoid adherence of the viscera to the abdominal wall as this will limit the success of subsequent primary fascial closure. An attempt should be made to close the patient’s abdomen every two to three days until primary fascial closure is achieved. Excessive fluid resuscitation and failure to control the source of the patient’s critical illness will only serve to prolong the need for abdominal decompression.

In some patients, continued critical illness and loss of abdominal domain will preclude successful primary fascial closure. While split thickness skin grafting of the exposed granulated viscera has traditionally been performed in such patients, this approach is associated with the highest morbidity, mortality, and economic cost. A more effective approach, especially in resource-limited settings, is early closure of the skin and subcutaneous tissue only (with or without raising skin flaps through dissection along the anterior rectus sheath) when it becomes apparent that primary fascial closure is unlikely. This approach utilizes the patient’s own tissues to protect the viscera from enteric fistula formation and facilitates earlier patient recovery and rehabilitation. The
resulting incisional hernia can be repaired 3-6 months later once the patient’s visceral edema/distention has resolved.

**Simple incisional hernia repair either with or without prosthetic mesh**

Two to 10% of all laparotomies performed will result in an incisional hernia. Depending upon the size and complexity of the hernia defect, primary suture repair of the defect may be appropriate, but is associated with a recurrence rate of up to 50%. As a result, incisional hernia repair using prosthetic mesh has become common as it is associated with a recurrence rate of only 2.5%. Mesh repair can be complicated by infection, mesh extrusion, and enteric fistula formation (Fig 6). Further, mesh should not be used in a contaminated or infected field. Placing peritoneum or omentum between the mesh and bowel reduces adhesions and fistula formation, but is not always possible. Intraperitoneal placement of polypropylene mesh products should be avoided at all costs due to a high rate of enteric fistula formation and intestinal obstruction (Fig 7).

Mesh may not be available in the developing world or in resource-limited settings necessitating the use of autologous tissue. Repair of abdominal hernias with autologous tissue was first described in 1913 when surplus skin from the hernia sac was implanted dermis side facing the viscera to bridge the fascial defect. The da Silva technique, described in 1979, can be used to close small hernia defects of less than 10 centimeters in diameter: after dissecting the skin and subcutaneous tissues away from the anterior rectus sheath.
bilaterally, and the viscera from the posterior rectus sheaths, the right anterior rectus sheath is incised using electrocautery along the midline of the right rectus muscle a distance of several centimeters above and below the hernia defect. The left posterior rectus sheath is similarly incised in the midline of the left rectus muscle. These relaxing incisions allow the rectus muscles and their associated fascia to be mobilized toward the midline where a primary suture closure of the fascial edges can be performed without excessive tension.

**Components Separation Technique (CST)**
The components separation technique (CST), as originally described by Ramirez et al., is used to repair large midline abdominal hernias and wounds. It is a myofascial release that separates the components of the abdominal wall allowing their mobilization into adjacent tissue defects. Classic CST involves releasing the rectus muscle from its posterior sheath and releasing the aponeurosis of the external oblique muscle along the lateral side of the rectus, allowing the rectus muscle to slide toward the midline with its attached internal oblique and anterior rectus fascia. Fascial defects up to 10 cm wide at the upper abdomen, 20 cm at the waistline, and 6 cm at the suprapubic region may be closed using this method.

The following steps outline the classic CST procedure:

1. Through a laparotomy incision, the posterior rectus sheath is cleared bilaterally of any attachments to the viscera through careful lysis of adhesions. Care should be taken to not rush through this dissection as any resulting enterotomies may result in an enteric fistula that will cause failure of the repair.

2. The rectus muscle is loosely attached to its posterior sheath, and can be freed from the posterior sheath at this point, as Ramirez did. Other surgeons do not find this step necessary if the hernia is not very large. Freeing the rectus muscle from its’ posterior sheath allows advancement of this muscle by 3 cm in the upper third, 5 cm in the middle third, and 3 cm in the lower third.

3. Separate the skin and subcutaneous tissues from the anterior rectus sheath using electrocautery. Develop this plane until about 2 cm beyond the lateral edge of the rectus sheath (linea semilunaris). Further lateral dissection in patients with limited subcutaneous tissue may place the resulting skin flaps at risk for ischemia and failure resulting in a large soft tissue defect that will require split-thickness skin grafting.

4. Carefully incise the external oblique aponeurosis 1 to 2 cm lateral to the lateral edge of the rectus sheath (Fig 8). Extend this incision parallel to the rectus muscle, superiorly advancing at least 5 to 7 cm above the costal margin, and inferiorly down to the suprapubic region. The plane between the external and internal oblique aponeuroses is relatively avascular and should be bluntly dissected free down to the mid to posterior axillary line (Fig 9).
5. These maneuvers should allow the rectus muscle to slide toward the midline to bridge the fascial gap. The medial edges are sewn together as in a standard laparotomy closure with interrupted strong non-absorbable suture (such as #0 nylon). Drains are placed in the subcutaneous space and the skin can then be closed in the usual manner (Fig 10, 11).

Important points to improve the success of the CST are:
Avoid dissecting too deep laterally when releasing the external oblique as this can cause injury to the internal oblique and result in herniation or even rupture of the abdomen in this area.

Most hernia recurrences following CST occur in the epigastric region, so it is very important to perform adequate detachment of the lateral aspect of the rectus muscle above the costal margin, preserving the continuity of the rectus with the pectoral muscle and their contiguous fascia, so that the upper rectus can be mobilized to fill in the epigastric region.

Closure of the abdominal cavity, especially in thin patients, can elevate the intra-abdominal pressure acutely, interfering with diaphragmatic excursion. If respiration is compromised, ensure full release such as releasing the posterior rectus sheath. Close attention should be paid to the patient’s mean airway pressure on the anesthesia machine. If mean airway pressures rise significantly, there may be too much tension on the fascial closure. Either a staged repair of the patient’s abdomen or use of mesh or autologous tissue to bridge the fascial gap may be required for safe closure.

CST allows safe closure of the abdominal wall even if patients have concurrent bowel surgery, contaminated wounds, or stomas. It offers dynamic support that increases torso strength by 40% and relieves back pain.

The most common complications following CST are wound infections and hernia recurrence in about 20 to 50% of patients. A randomized controlled trial comparing CST with prosthetic mesh repair for giant abdominal wall hernias found that wound infections in patients after CST have only minor consequences in most cases, but wound infection following prosthetic placement has major consequences such as requiring removal of the prosthetic in 39% of cases. Recurrent hernias following CST are generally small, located in the midline of the upper abdomen and relatively asymptomatic. As Harth et al. state, the repair “still could be considered successful if it addresses the contamination or fistulas and results in a smaller hernia that is easier to manage or even asymptomatic in the future”.

**Use of flaps in anterior abdominal wall reconstruction**

More complex repairs using autologous tissue include the fascia lata graft. This strong, dense fascia at the lateral side of the upper leg is separated from the underlying musculature, preserving the lateral circumflex artery, found 10 cm. below the Anterior Superior Iliac Spine (ASIS). This flap may be used as a free transplant or as a pedicled flap (the Tensor Fascia Lata Flap), which can reach infra-umbilical abdominal wall defects. The distal condensation of the iliotibial tract is not taken during the fascial harvest in order to minimize lateral knee instability. The rectus femoris muscle flap has also been used, pedicled on the lateral circumflex artery or also used as a free flap. Some tunnel this flap but this risks compression of the blood supply. Using the rectus femoris for abdominal reconstruction is associated with significant loss of muscle strength
in knee extension but this may be a trade off if the abdomen can be closed with autologous tissue. The latissimus dorsi, fed principally by the thoracodorsal artery, can similarly be used as a pedicled or free flap. The pedicled anterolateral thigh flap is excellent for the reconstruction of extensive full-thickness abdominal wall defects, including skin and fascia, with minimal donor site morbidity.

Fig 12 Fig 13 Fig 14 Fig 15
Dermatofibrosarcoma Protuberance: Abdomen reconstructed with TFL flap (Photos courtesy of Dr. Bill Rhodes)

Fig 16 Fig 17
An anterior abdominal wall defect after a failed CST. Pedicled ALT was used to reconstruct this defect successfully.

Use of pedicled and free flaps is recommended for complicated abdominal wall defects that have failed other approaches, but CST is preferred for initial management of abdominal wall hernias as it is simpler, not associated with donor site morbidity, and results in a dynamic abdominal wall repair.

**Minimally Invasive Components Separation Technique**
Division of the skin and subcutaneous tissue periumbilical perforators during exposure of the anterior rectus sheath contribute to skin necrosis
complications as well as predispose to seroma and hematoma formation due to the large exposed surface area. Prior incisions which may divide blood supply from the intercostals, superficial circumflex iliac and external pudendal arteries may further jeopardize blood supply to the skin and subcutaneous tissue flaps. Saulis et al. demonstrated that a modified CST which maintained periumbilical abdominal perforators to the abdominal skin flaps resulted in a lower rate of wound complications compared to standard CST: 2% compared to 20% respectively (p<0.05). Hematoma rates (4% and 2% respectively) and hernia recurrence (7% and 8% respectively) were similar in both groups.

Various modifications in the CST technique have subsequently been developed to minimize dissection over the anterior rectus sheaths. These include minimally invasive techniques including endoscopic and laparoscopic techniques. Butler et al. described a minimally invasive CST which does not require endoscopic or laparoscopic equipment. Following exploratory laparotomy and lysis of adhesions, 3 cm wide subcutaneous access tunnels are created bilaterally across the anterior rectus sheath at the level of the costal margin from the midline to the linea semilunaris. The plane between the external and internal obliques is opened and bluntly dissected using a suction handle not attached to suction. A 2.5 cm tunnel is then created superficial to the external oblique over the lateral release incision site using a narrow retractor and a headlight. The external oblique aponeurosis is then released 1.5 cm from the lateral edge of the rectus sheath from 12 cm superior to the costal margin to the pubis inferiorly. Butler et al. then go on to lay a bioprosthetic mesh directly against the posterior rectus sheath or muscle, preferring porcine to human acellular dermal matrix (Alloderm). Interrupted resorbable quilting sutures are placed to minimize dead space before closing the midline and resecting extra skin flaps as in a vertical panniculectomy. A review of their outcomes of 57 patients who underwent minimally invasive CST compared to 50 patients undergoing open CST showed reduced skin necrosis (11% vs 28%; p=0.011) and wound healing complications (14% vs 32%; p=0.026) in the minimally invasive group.

Mesh as an adjunct to the Components Separation Technique
The use of mesh as an adjunct to CST has become more prevalent in the literature. Risk of complications was increased by the presence of contamination (p=0.04), enteric fistulas (p=0.02), diabetes (p=0.04), and body mass index over 25 (p=0.01). A retrospective study by Espinosa-de-llos-Monteros et al. however found a lower recurrence rate when component separation was reinforced with human cadaveric acellular dermis (AlloDerm) (0% with n=32) than when there was no reinforcement (13% n=29) (p=0.006). The largest study to date is Sailes et al.’s 10 year review of synthetic and biological mesh in component separation. 545 patients received CST, of which
225 had no mesh placement, 100 had biological (human cadaveric acellular dermis) mesh placement, and 220 had synthetic mesh placement. There were 42 (19%) recurrences in the CST group without any mesh supplementation, 20 (20%) recurrences in the CST group reinforced with biological mesh, and 38 (17%) recurrences in the CST group reinforced with synthetic mesh, demonstrating no statistically significant difference in recurrence rates with type of mesh used. Overall recurrence rate following CST is 18.3%.

**Enteric fistulas**

Perhaps the most dreaded aspect of repairing abdominal wall defects is the management and repair of enteric fistulas (Fig 19, 20). Such connections between the intestine and skin are associated with significant morbidity and mortality, especially in resource-limited settings where ostomy supplies are limited to non-existent and resources for treating electrolyte and nutritional deficiencies from high-output fistulas are poor. As a result of the devastating impact of enteric fistulas on both patient and hospital alike, a surgeon should do everything possible to avoid such complications following initial abdominal closure. All intestinal anastomoses should be buried within the adjacent viscera and covered by omentum, if possible.
Fig 19: Enteric fistula due to anastomotic dehiscence. Note visible silk sutures. Fig 20: Complex abdominal wall defect with multiple enteric fistulas. This dreaded complication presents a formidable challenge to any surgeon and greatly complicates patient care and nutrition. (Pictures courtesy of Dr. Michael Cheatham, Orlando Regional Medical Center, Orlando, Florida.)

Although the novice surgeon may be tempted to try, attempts to perform simple suture closure of enteric fistulas are doomed to failure and often result in a larger fistula than what was there to begin with. The optimal treatment for an entero-cutaneous fistula is en bloc resection of the intestine and involved skin with primary reanastomosis. This is commonly easier said than done as a result of extensive adhesions and chronic inflammation due to the fistulous tract.

Fig 21: The non-healing wound and anastomotic dehiscence depicted in Figure 19 has been excised en bloc and the underlying intestinal loops dissected free. Fig 22: The enteric fistula and skin are excised and resection with primary repair is performed. The anastomosis should be covered with omentum, if possible. The abdominal wall is then closed in layers to cover the anastomosis. (Pictures courtesy of Dr. Michael Cheatham, Orlando Regional Medical Center, Orlando, Florida.)
Recommendations from the Ventral Hernia Working Group

As the treatment for ventral hernia repair is evolving, a Ventral Hernia Working Group (VHWG) consisting of four general surgeons and four plastic surgeons, all experts in this field, met in 2008 for a two day summit to propose a grading system and evidence-based recommendations to guide the selection of surgical techniques in repairing incisional hernias. Principles outlined are:

1. Optimize the patient’s condition including nutritional status, smoking cessation, diabetes management, and setting patient expectations
2. Prepare the wound by reducing bioburden prior to surgery via management of abscesses and skin irritation from fistulas, as well as by thorough debridement of devitalized tissues at the time of surgery and using a staged approach if necessary, as wound infection has been associated with higher recurrence rates.
3. Perform a CST to centralize the rectus muscles as far as possible, thereby providing a functional innervated abdominal wall.
4. Reinforce the closure with appropriate material although no prospective data is available yet on comparing CST alone with reinforcement with mesh.

Based on studies comparing suture repair alone to mesh repair, the VHWG recommended the use of prosthetic mesh to reinforce the repair, placed as an underlay because of the theoretical advantages of this technique, except in contaminated or frankly infected wounds. Biological mesh may be a good option in contaminated wounds, but frankly infected wounds should not have any mesh repair material used and surgeons should consider a delayed repair.

Editor’s Note: A special thanks to Dr. Rick Miller at Vanderbilt for his significant contributions including illustrations, text preparation and extensive references which are found in a section at the end of the book under “References.”