Temporary abdominal closure followed by definitive abdominal wall reconstruction of the open abdomen

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Abstract

Background: Inability to close the abdominal wall after laparotomy for trauma may occur as a result of visceral edema, retroperitoneal hematoma, use of packing, and traumatic loss of tissue. Often life-saving, decompressive laparotomy and temporary abdominal closure require later restoration of anatomic continuity of the abdominal wall.

Methods: The trauma registry, open abdomen database, and patient medical records at a level 1 university-based trauma center were reviewed from January 1988 to December 2001.

Results: During the study period, more than 15,000 trauma patients were admitted, with 88 patients (0.6%) requiring temporary abdominal closure (TAC). Patients ages ranged from 12 to 75 years with a mean injury severity score (ISS) of 28 (range 5 to 54). Forty-five patients (51%) suffered penetrating injuries, and 43 (49%) were victims of blunt trauma. Indications for TAC included visceral edema in 61 patients (70%), abdominal compartment syndrome in 10 patients (11%), traumatic tissue loss in 9 patients (10%), and wound sepsis and fascial necrosis in 8 patients (9%). Fifty-six patients (64%) underwent TAC at admission laparotomy, whereas 32 patients (36%) required TAC at reexploration. Seventy-one patients (81%) survived and 17 (19%) died. Of the survivors, 24 patients (34%) underwent same-admission direct fascial closure, and 47 patients (66%) required visceral skin grafting and readmission closure. Reconstructive procedures in the patients requiring skin graft excision included direct fascial repair (20 patients, 44%), components separation closure with or without subfascial tissue expansion (18 patients, 40%), pedicled or free-tissue flaps (4 patients, 8%), and mesh repair (4 patients, 8%). One patient refused closure. The mean follow-up was 48 months (range 6 to 144), with an overall recurrence rate of 15% (range 10% to 50%), highest in the mesh repair group.

Conclusions: Silicone sheeting TAC provides a safe and reliable temporary abdominal closure allowing for later definitive reconstruction. Direct fascial repair or components separation closure with or without tissue expansion can be utilized in the majority of patients for definitive reconstruction with low recurrence rate. © 2004 Excerpta Medica, Inc. All rights reserved.

Keywords: Temporary abdominal closure; Open abdomen; Components separation herniorrhaphy

Aggressive crystalloid and blood product resuscitation, damage control laparotomy techniques, and modern advances in critical care medicine have improved the survival of critically ill trauma patients with resultant complications including abdominal compartment syndrome (ACS) and the “unclosable” abdomen [1,2]. Often life-saving, decompressive laparotomy and temporary abdominal closure (TAC) require later restoration of anatomic continuity of the abdominal wall.

A variety of techniques of temporary abdominal closure have been described, but there are no well-designed comparative studies assessing the superiority of one technique over others [3,4]. The optimal method must contain the abdominal viscera to protect the bowel from unnecessary adhesions and desiccation, provide a homeostatic environment that aids in the resolution of visceral edema, and promote a safe and reliable fascial closure [5]. When direct fascial closure is not feasible during initial admission, split-
thickness skin grafting of visceral granulation tissue is frequently required, followed by readmission for definitive abdominal wall reconstruction [6,7].

The process of closing large, chronic abdominal wall defects can be complicated by persisting infection, enterocutaneous fistula, and “loss of domain” or abdominal wall retraction [3,8]. Techniques reported to create a tension-free repair include prosthetic mesh insertion, tissue expansion, pedicled or free-tissue flaps, vacuum-assisted wound closure, and components separation fascial release [9–16]. We present the results of a technique utilizing silicone sheeting as a temporary closure followed by direct fascial closure or visceral skin grafting and later reconstruction.

Patients and Methods

From January 1988 to December 2001, more than 15,000 trauma patients were admitted to the Medical College of Georgia level 1 trauma center. Eighty-eight patients (0.6%) required temporary abdominal closure and are the subject of this review. This study was approved by the Institutional Review Board of the Medical College of Georgia. Preliminary data on the initial 36 patients of this cohort have been previously reported [6]. Patients were identified and data was tabulated using our trauma registry, open abdomen specific database, operative logs, and patient medical records.

The technique of temporary abdominal wall closure utilized silicone sheeting to increase the volume of the peritoneal cavity and provide visceral coverage. Silastic sheeting (Dow Corning Medical Products, Midland, Michigan) was used until discontinued. Since 1993, medical grade silicone sheeting (BioPlexus Corporation, Saticoy, California) reinforced with nylon mesh, and available in 12 × 18-inch pieces at 0.007 inch thickness was utilized. The cost of the reinforced sheeting was $600 per piece. The folded edge of the silicone sheeting was sutured to the fascia with a running monofilament suture. A tension-free closure was fashioned to prevent potential silicone-fascial dehiscence resulting from coughing, straining, or progressive visceral edema (Fig. 1). The large wound was covered with a saline-soaked gauze dressing that was changed several times daily to maintain the viability of the exposed abdominal wall subcutaneous tissue and fascia.

Definitive abdominal wall closure was accomplished by ventral herniorrhapsy with direct fascial closure in patients with prompt resolution of visceral edema. Patients with persistent visceral distension or significant abdominal wall tissue loss precluding direct fascial closure were managed with split-thickness skin grafting of visceral granulation tissue. The silicone sheeting was removed at bedside when it appeared that the exposed intestinal loops were adherent to each other and organized within a developing fibrinous-granulation membrane beneath the sheeting (Fig. 2). At this point, petroleum-impregnated gauze dressing changes were performed on the membrane to perpetuate a mature granulation bed, which was then covered with a split-thickness skin graft.

Reconstruction was not attempted before maturation of the abdominal skin graft, evidenced by the ability to pinch the graft from the underlying viscera. Tissue expansion was performed using a small lateral abdominal wall skin incision to identify the aponeurosis of the external oblique muscle. An elliptical-shaped expander was inserted beneath the external oblique aponeurosis for subfascial tissue expansion. Saline expansion was performed weekly per manufacturer’s recommendations (Fig. 3). The expanded fascia was utilized as a reflected overlay with direct fascial repair or as an adjunct in components separation closure. Select patients with abdominal wall tissue loss required pedicled or free-tissue tensor fascia lata flaps (Fig. 4). Free-tissue transfer involved microvascular anastomosis of the donor lateral femoral circumflex artery and vein to recipient deep inferior epigastric vasculature [13]. The components separation closure was performed as described by Ramirez et al [16]. The insertion of the external oblique muscle to the rectus sheath was incised, and the plane between external and internal oblique muscles was developed. The released muscle layers were advanced toward the midline for fascial closure (Fig. 5).

Results

Eighty-eight patients required temporary abdominal wall closure after laparotomy for trauma. There were 73 men (83%) and 15 women (17%), ranging in age from 12 to 75 years (mean 32). Forty-three patients (49%) sustained blunt injuries (33 from motor vehicle crashes, 2 from pedestrian/motor vehicle crashes, 2 from motorcycle crashes, 2 from falls, 2 from boating accidents, 2 from crush injury), and 45 patients (51%) were victims of penetrating trauma (27 from gunshot wounds, 10 from shotgun wounds, 5 from stab wounds, 2 from seat belts, 1 from impalement). The mean
ISS was 28 (range 5 to 54), and mean abdominal trauma index (ATI) was 30 (range 2 to 56).

The indications and timing for temporary closure are depicted in Table 1. Indications included massive visceral edema precluding primary fascial closure in 61 patients. Twenty-four of these patients (39%) required intraabdominal packing for hemorrhage control. Ten patients developed primary or secondary abdominal compartment syndrome (ACS) requiring decompressive laparotomy and TAC. Seven of these patients had undergone recent laparotomy with primary fascial closure, and 3 patients sustained extra-abdominal injury requiring high volume resuscitation (1 patient with thoracic vascular injury, 2 patients with extremity vascular injury). Diagnostic criteria for ACS included hypoxemia and hypercarbia associated with elevated peak airway pressure, deteriorating urinary output despite a pulmonary capillary wedge pressure greater than 18 mm Hg and no response to loop diuretics, and an intraabdominal pressure of more than 30 mm Hg measured through an indwelling urinary catheter using the technique described by Kron et al [17]. Nine patients sustained traumatic loss of abdominal wall tissue precluding primary fascial closure, 6 from close-range shotgun blast injury, 2 from seat belt avulsion injury, and 1 from an outboard motor propeller boating accident. Eight patients developed postoperative intraabdominal sepsis complicated by complex wound infections with fascial necrosis. All of these patients had either colon injury with significant fecal contamination or pancreatic injury with retroperitoneal saponification. At subsequent laparotomy, abdominal wall loss plus visceral edema precluded fascial closure.

Seventy-one patients (81%) survived, and 17 patients (19%) died. The causes of death included exsanguination in 6 patients (35%), lethal head injury in 4 patients (23%), multiple organ failure in 4 patients (23%), myocardial infarction in 2 patients (12%), and pulmonary embolism in 1 patient (7%). The mean length of hospital stay for survivors was 45 days (range 11 to 142). The length of stay for patients undergoing direct fascial closure was 33 days (range 11 to 83), compared with 57 days (range 20 to 142) for patients requiring visceral skin grafting. The mean length of survival for patients who died was 10 days (range 1 to 66), longest among patients in whom multiple organ failure developed. No patient had an enterocutaneous fistula, wound infection, or fascial necrosis as a result of this TAC technique. Four patients (5%) required revision or replacement of the silicone sheeting due to progressive visceral edema and recurrent ACS (2 patients) or fascial-sheeting dehiscence (2 patients).

Of the 71 survivors, 24 patients (34%) underwent direct fascial closure and 47 patients (66%) required split-thickness skin grafting of visceral granulation tissue (Table 2). Direct fascial closure was performed on or before postoperative day 5 in all applicable patients. There was no difference in the mean ISS or ATI between patients who underwent direct fascial closure compared with those who required visceral skin grafting. Factors precluding early fascial closure included persistent visceral edema, intraabdominal infection requiring open or percutaneous drainage, ileus resulting in enteral nutrition intolerance, sustained intracranial hypertension, hypoxemia secondary to adult respiratory distress syndrome (ARDS), and additional surgical procedures such as spine stabilization and orthopedic fracture fixation with associated blood loss and requirement for further volume resuscitation. Time to split-thickness skin grafting, dependant on development of mature visceral granulation tissue, varied from 12 to 50 days (mean 20) after TAC. The skin grafted surface area ranged from 150 to 1,500 cm² (mean 250 cm²), the largest wounds resulting from traumatic tissue loss or postinfection debridement. The skin graft take rate varied from 80% to 100% (mean 95%), and no patient required regrafting.

Definitive abdominal wall reconstruction at subsequent hospitalization was performed in 46 patients (Table 2). One patient refused skin graft excision and definitive closure. Reconstruction was not attempted until the abdominal skin graft became pliable and separable by palpation from the visceral edema.
underlying viscera, ranging from 4 months to 1.5 years (mean 10 months) after grafting. After graft excision, definitive closure was accomplished by direct fascial repair in 20 patients (44%). As a result of abdominal wall retraction ("loss of domain") or tissue loss, 56% of patients required either fascial release, transfer, or replacement by prosthetic mesh to complete closure. Eighteen patients underwent components separation fascial release of the external oblique musculature. Six of these patients had undergone subfascial tissue expansion to compensate for traumatic or infectious fascial loss. Two patients required pedicled tensor fascia lata flaps for infraumbilical muscle and fascia loss, and 2 patients required free-tissue tensor fascia lata flaps for supraumbilical and infraumbilical skin, muscle, and fascia loss. Four patients, all early in the series, underwent polypropylene mesh interposition or onlay repair.

Follow-up information was available for patients with direct fascial closure at initial hospitalization and reconstruction at subsequent hospitalization for an average of 48 months (range 6 to 144). In the index admission direct fascial closure group of 24 patients, wound infections occurred in 3 patients (13%), and 5 patients developed ventral hernias for a recurrence rate of 21%. Complications noted in the readmission closure group of 46 patients included wound infections in 7 patients (15%), 5 of these 7 patients underwent simultaneous stomal closure; wound seroma requiring percutaneous drainage in 5 patients (11%); and flap donor site infection in 1 patient (2%). Seven patients developed ventral hernias for a recurrence rate of 15% in the later reconstruction group. Recurrent hernias developed in 2 of 20 patients (10%) after direct fascial repair, 2 of 18 patients (11%) after components separation closure, and 2 of 4 patients (50%) after mesh repair.

**Comments**

This review describes a technique for temporary abdominal wall closure and the procedures required to restore abdominal wall continuity. Visceral edema, primary or secondary abdominal compartment syndrome, and abdominal wall loss due to trauma or infection precluded primary fascial closure. Silicone sheeting was used as a temporary abdominal wall closure. It is impermeable, allows nearly watertight closure, and is pliable and reinforced for added durability. It provides a smooth and inert surface with minimal to no irritation of bowel serosa, hence, the lack of intestinal fistula or fascial necrosis in our series. The sheeting is transparent, permitting evaluation of underlying viscera and recognition of intraperitoneal bleeding, enteric contamination, or infection. Silicone promotes the development of a fibrinous membrane over omentum and intestinal

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**Table 1**

<table>
<thead>
<tr>
<th>Indication</th>
<th>No. of patients (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visceral edema</td>
<td>61 (70%)</td>
</tr>
<tr>
<td>Abdominal compartment syndrome</td>
<td>10 (11%)</td>
</tr>
<tr>
<td>Traumatic tissue loss</td>
<td>9 (10%)</td>
</tr>
<tr>
<td>Wound sepsis, fascial necrosis</td>
<td>8 (9%)</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td></td>
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<tr>
<td>Admission laparotomy</td>
<td>56 (64%)</td>
</tr>
<tr>
<td>Reexploration</td>
<td>32 (36%)</td>
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</tbody>
</table>
serosa. Once granulated, the wound can be skin grafted with excellent success to provide closure when early fascial approximation is not feasible.

One third of the patients underwent same-admission direct fascial closure within 5 days of TAC. If direct fascial closure was not accomplished on or before postoperative day 5, visceral skin grafting was required. Factors prohibiting early fascial closure included persistent visceral edema resulting from continued hemorrhage, development of sepsis, or postoperative renal insufficiency; intraabdominal or retroperitoneal abscess requiring open or percutaneous drainage; ileus resulting in enteral nutrition intolerance and consequent delay in granulation tissue formation; sustained intracranial hypertension resulting from head injury or hypoxemia secondary to ARDS prohibiting general anesthesia; and additional neurosurgical and orthopedic operative procedures requiring further resuscitation.

Complication and overall recurrent hernia rates were similar between initial and subsequent hospitalization closure groups. Recurrent herniation was actually less likely to occur after direct fascial repair (10%) or components separation technique (11%) at subsequent hospitalization as compared with direct fascial repair (21%) at index admission, despite 30% of later reconstruction patients undergoing simultaneous stomal closure.

A technique reported in the literature to achieve early fascial closure is vacuum-assisted wound closure. Important components include the use of a nonstick visceral sheeting and a polyurethane sponge. The polyethylene sheet prevents visceral-abdominal wall adhesion, and the thick sponge, when under suction, provides traction on the abdominal wall and prevents fascial retraction over time. Early fascial closure rates of 65% to 85% have been reported utilizing this technique [14,15].

Creating a tension-free repair with prosthetic mesh does not provide dynamic contractile support [18]. Nonabsorbable mesh is associated with a relatively high risk of infection, skin and bowel erosion, and enteric fistula formation. In a recent series of 200 prosthetic mesh repairs with follow up ranging from 2 to 10 years, Leber et al [10] described an early and late complication rate of 18% and 27%, respectively, with an enterocutaneous fistula rate approaching 16%. With increasing experience and interest in biologic fascial substitutes such as Alloderm Acellular Tissue Matrix (Lifecell, Branchburg, New Jersey) and Surgisis Hernia Repair Graft (Cook Surgical, Bloomington, Indiana), utilization of nonabsorbable mesh may decline [19,20].

The use of released, local myoaponeurotic abdominal wall flaps for herniorraphy reduces the morbidity associated with the use of nonabsorbable synthetic materials, and the additional donor-defect problems of complex tissue transfer. In 1990, Ramirez et al [16] described the “components separation” method of repair of challenging abdominal wall defects. This method involves dissecting the abdominal components, including the rectus abdominis and internal oblique muscles. The released muscle layers are advanced toward the midline and sutured together to close the defect. If the internal oblique fascia is left intact, Spigelian hernia is prevented, and the nerves to the rectus abdominis muscles are preserved. Numerous series reveal a remarkably low recurrence rate and very good functional results with unilateral, bilateral, and variants of layer separation [16,18,21,22].

The reluctance of many surgeons to leave the abdomen open after laparotomy for trauma may in part be related to the significant challenge of abdominal wall reconstruction in patients in whom early definitive fascial closure is not possible. Silicone sheeting temporary abdominal closure provides a safe and reliable initial closure technique allowing for later reconstruction. Direct fascial repair or components separation closure with or without tissue expansion can be utilized in the majority of patients for definitive reconstruction with low recurrence rate.

References


