Risks Associated with “Components Separation” for Closure of Complex Abdominal Wall Defects


St. Louis, Mo.

Learning Objectives: After studying this article, the participant should be able to: 1. Describe the pertinent surgical anatomy of the anterior abdominal wall. 2. Describe the sequential steps and technique of open “components separation” in the repair of complex midline abdominal defects. 3. Discuss the surgical risks associated with hernia takedown and abdominal reconstruction using this technique. 4. List the most common postoperative complications that occur following “components separation.”

The reconstruction of complex abdominal wall defects can often pose a significant challenge to surgeons and their patients. Complex ventral hernias may result from large tumor resections, trauma from gunshot wounds, or infections following routine abdominal surgery. “Components separation” of the abdominal musculature uses advancement of local autologous tissue, when available, to close large ventral wall defects. The authors report on a retrospective chart review of 30 patients who underwent components separation for the closure of complex abdominal defects. The study group was 50 percent female, with a mean age of 45 years, body mass index of 33.2 kg/m$^2$, and abdominal defect size of 240 cm$^2$. On average, 20 percent of patients had preoperative wound infections, 30 percent had intraoperative bowel enterotomies, and 33 percent required prosthetic mesh for closure. Total surgery time averaged 4.8 hours, with a mean postoperative stay of 12.5 days and follow-up of 9.5 months. The recurrence rate was 10 percent; postoperative complications included midline ischemia, infection, and dehiscence occurring at rates of 20, 40, and 45 percent, respectively. This study provides a comprehensive review of the risks and complications associated with the treatment of complex ventral hernias and those associated with abdominal “components separation.” (Plast. Reconstr. Surg. 111: 1276, 2003.)

Complex abdominal wall defects result from a variety of causes, including trauma,$^1,2$ previous surgery,$^3-5$ tumor resection,$^6,7$ congenital defects,$^8,9$ and infection.$^{10,11}$ The true complexity of an abdominal wall defect depends on the position, size, depth, and condition of the surrounding tissues.$^{12,13}$ Left untreated, complex abdominal defects may result in significant physical discomfort, functional restrictions, and in some cases intestinal obstruction. It is often difficult for the surgeon to balance the risk of surgical intervention with the patient’s deep desire for a clinical improvement or “cure.” This article attempts to more clearly define the risks associated with the treatment of complex midline abdominal defects using the technique of “components separation.”

ANATOMY

The abdominal wall is composed of multiple overlapping fascial and muscular layers that allow for regional advancement with complete continuity. Laterally, the muscle groups overlap one another in contrasting orientation, providing a great deal of dynamic support. The fascia of the internal oblique, external oblique, and transversus abdominis converge to form the anterolateral abdominal wall.

The blood supply to the anterior abdominal
wall is provided by a deep and a superficial vascular system.14,15 The skin, muscle, and subcutaneous tissues are supplied by direct cutaneous vessels from the superficial circumflex iliac and superficial inferior epigastric arteries. Musculocutaneous branches from the deep inferior epigastric and superior epigastric arteries also provide blood supply to the anterior abdomen. The blood supply of the lateral abdomen is provided by intercostal, subcostal, and lumbar arteries.16 Interruption of these vessels can increase the chances of midline skin necrosis, wound infection, and dehiscence.

The motor and sensory innervation to the anterior abdominal wall is provided by the intercostal, subcostal, iliohypogastric, and ilioinguinal nerves that course circumferentially from posterior to anterior. As much of the innervation as possible should be maintained to the external oblique, internal oblique, transversus abdominis, and rectus muscles to preserve dynamic support to the abdominal wall.16,17

**Components Separation**

In 1990, Ramirez et al.18 described the technique of “components separation” for the closure of midline abdominal defects. This technique allowed for the local advancement of abdominal musculature with fascial continuity and dynamic support, often without the need for regional flaps or prosthetic material. The use of “components separation” for the repair of complex abdominal wall defects has resulted in a relative decrease in recurrence rates to approximately 8 to 15 percent in most series.4,14,18,19

Components separation provides midline advancement of the abdominal wall by sequential incision and release of the posterior rectus sheath and external oblique muscle. Ramirez et al.18 report that bilateral partition and sequential relaxing incisions can provide approximately 10, 20, and 6 cm of advancement, in the upper, middle, and lower thirds of the abdomen, respectively. It is important to note that complete advancement is dependent on complete preservation of the anatomic structures and the quality of the local wound bed.12,20

**PATIENTS AND METHODS**

A comprehensive, retrospective chart review was performed on all patients who underwent components separation for the repair of complex abdominal wall defects at the University of Texas Health Science Center between October of 1994 and April of 1997. All patients were referred to the plastic surgery service for evaluation and repair of complicated or recurrent ventral hernias. Postoperatively, patients were followed up by the plastic surgery service and by their primary care physicians. Data were collected regarding coexisting medical diagnoses, as well as the age, sex, body mass index, size of defect, and social history of each patient. Risk factors were obtained, including obesity, steroid dependence, diabetes, and premorbid conditions. Intraoperative and postoperative data and complications associated with the procedure were obtained on all patients. A statistical analysis of the data was performed to try to detect any significant relationships among the patients’ comorbid conditions, operative data, and postoperative complications.

**Operative Technique**

All patients underwent general anesthesia through endotracheal intubation and received perioperative parenteral antibiotics and compression stockings. Each patient required take-down of a large anterior abdominal hernia with an enterolysis of adhesions. Abdominal reconstructions were performed by a board-certified plastic surgeon with an assisting surgical resident. Patients were selected for components separation if the abdominal wall defect appeared to be amenable to closure with this technique without the need for adjuvant mesh, and if the patient had a history of recurrent, large, or multiple hernias or wound contamination that precluded the use of conventional techniques (i.e., primary closure, mesh).

The components separation technique was modified in that the partition and release of the abdominal musculature was performed in a sequential manner, and only to an extent clinically necessary to close the abdominal wall defect. Using this technique, the abdominal skin is first elevated at the midline, superiorly to the level of the costal margin, and inferiorly to the symphysis pubis. The posterior rectus fascia is then released using relaxing incisions 1 to 1.5 cm lateral to the linea alba. The surgeon next attempts to approximate the fascial borders. If tension-free approximation is not possible, the surgeon proceeds with relaxing incisions to the contralateral rectus fascia (Fig. 1, above, and second from above). The release is
performed first because of the ease of exposure of this region after hernia takedown and the possible avoidance of a lateral dissection with sequential steps.

If a tension-free fascial approximation of the defect is not possible, the surgeon proceeds with exposure of the external oblique muscle and release of the fascia using relaxing incisions 2 cm lateral to the semilunar line. The external oblique is then separated from the underlying internal oblique muscle using blunt dissection. This release allows for the medial

Fig. 1. (Above) Midline ventral hernia amenable to components separation. (Second from above) Sequential release of the posterior rectus sheath following hernia takedown. (Second from below) Sequential release of the external oblique muscle lateral to the semilunar line. (Below) Complete advancement achieved following bilateral components separation.
advancement of the rectus musculature. If approximation is not possible, the contralateral external oblique is released as well, thus completing a full, bilateral components separation (Fig. 1, second from below, and below).

Once the fascial borders are approximated, tension-free skin closure is attempted by progressive subcutaneous undermining of the skin flaps. Coaptation of the skin edges is obtained by using deep dermal sutures, and drains are then placed in the subcutaneous space bilaterally. Mesh is used only when tension-free primary closure cannot be obtained after a complete release. The patient is instructed to wear an abdominal binder and to avoid heavy lifting for approximately 6 weeks.

RESULTS

A retrospective review of 30 patients undergoing components separation was performed with the collection of preoperative, intraoperative, and postoperative data, with a particular emphasis on potential risks and complications. All patients in the study had complicated abdominal wall defects resulting from trauma, abdominal operations, and multiple repairs. The study was composed of 15 men and 15 women, with a mean patient age of 45 years (range, 16 to 68); average height was 66.3 inches and average weight was 204 pounds.

Preoperative risk factors are listed in Table I. The mean body mass index was 33.2 kg/m², and 83 percent of patients had an index greater than 25 kg/m². Forty-three percent of patients had a history of tobacco abuse, 23 percent were diabetic, 3 percent were steroid-dependent, and 3 percent were alcohol-dependent. In addition, 27 percent of the patients did not receive a preoperative bowel preparation. The American Society of Anesthesiologists classification system was recorded preoperatively; 37 percent of patients had a classification of greater than 2.

Each patient’s wound was classified as either clean, clean contaminated, contaminated, or dirty using the traditional wound classification system. Sixty percent of the patient’s wounds were classified as clean contaminated or worse, with 13 percent classified as contaminated and none considered dirty.

Intraoperative data are presented in Table II. The mean size of the ventral defect was 239.6 cm² (range, 16 to 988 cm²). The average duration of the entire surgery was 4.8 hours, and the average duration of the components separation was 2.8 hours. Of the patients in the study, 33.3 percent required prosthetic material, and 23.3 percent failed to have successful approximation of the fascial edges after components separation. In addition, 30 percent of hernia takedowns resulted in an enterotomy during enterolysis. The mean estimated blood loss was 293 cc, with 16.7 percent of patients requiring blood transfusions.

Postoperative data are provided in Table III. The mean total hospital stay was 18.4 days (range, 1 to 86), and the mean postoperative stay was 12.5 days (range, 1 to 87). Seventy-seven percent of the patients were extubated on the day of surgery, and the average intensive care unit stay was 2.7 days (range, 0 to 14).

TABLE II

<table>
<thead>
<tr>
<th>Selective Intraoperative Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average defect size</td>
</tr>
<tr>
<td>Average total operation duration</td>
</tr>
<tr>
<td>Average separation component duration</td>
</tr>
<tr>
<td>Average estimated blood loss</td>
</tr>
<tr>
<td>Blood transfusion</td>
</tr>
<tr>
<td>Mesh placed</td>
</tr>
<tr>
<td>Failure to approximate fascial edges</td>
</tr>
<tr>
<td>Enterotomy</td>
</tr>
</tbody>
</table>

TABLE III

<table>
<thead>
<tr>
<th>Selective Postoperative Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
</tr>
<tr>
<td>-----------------------------</td>
</tr>
<tr>
<td>Total hospital days</td>
</tr>
<tr>
<td>Day of extubation</td>
</tr>
<tr>
<td>Intensive care unit stay</td>
</tr>
<tr>
<td>Postoperative hospital stay</td>
</tr>
<tr>
<td>Return to bowel function</td>
</tr>
<tr>
<td>Follow-up (months)</td>
</tr>
</tbody>
</table>

* BMI, body mass index (kg/m²); COPD, chronic obstructive pulmonary disease; ASA, American Society of Anesthesiologists classification system.
At the time of the chart review, mean follow-up time was 9.5 months (range, 1 to 26 months).

The postoperative complications are reported in Table IV. The incidence of prolonged ileus (defined as a delay in bowel function of longer than 7 days) was 27 percent; cardiac complications (including electrocardiogram changes, tachycardia, chest pain, congestive heart failure, and blood pressure instability) were 23 percent; respiratory complications (including pneumonia, pulmonary edema, pulmonary emboli, and prolonged intubation) were 23 percent. Wound complications (including hematoma, seroma, and cellulitis) occurred at rates of 3, 10, and 17 percent, respectively. Wound ischemia, infection, and dehiscence occurred at 20, 40, and 43 percent, respectively. Of the total wound complications, 20 percent required reoperation. One patient developed an enterocutaneous fistula on postoperative day 8 that was treated conservatively. Interestingly, this patient was not among the nine patients with a reported enterotomy during the hernia takedown, but he was one of four additional patients who experienced significant areas of injury to the bowel serosa during enterolysis of intraabdominal adhesions. The hernia recurrence rate was 10 percent, and there were no deaths.

Statistical analysis using two-tailed Fisher’s exact tests (SAS Institute, 1989) compared 10 preoperative risk factors (Table I) by 11 postoperative complications (Table IV). Of 110 tests preformed, three demonstrated evidence of statistical significance at $p < 0.05$. The significant tests included American Society of Anesthesiologists classification of greater than 2 by prolonged ileus ($p = 0.001$), clean contaminated wound or greater by prolonged ileus ($p = 0.01$), and clean contaminated wound by open wound ($p = 0.03$). No other statistically significant relationships between patient demographics, risk factors, operative data, or complications could be identified in this study of 30 patients.

**DISCUSSION**

Complex ventral abdominal wall defects pose a significant reconstructive and clinical challenge for involved physicians. Ideally, the reconstructive surgeon should make every effort to decrease or control the operative risk before surgical intervention. If possible, patients should be required to undergo a full preoperative medical evaluation, discontinue tobacco use, increase nutrition support, receive a complete bowel preparation, and lose weight. The wound bed should be fully controlled with complete resolution of necrotic tissue, inflammation, and infection. Patients may not always be ideal surgical candidates. In such cases, conservative management with wound care and an abdominal binder may be the safest and most rational treatment option. However, because of the clinical situation and medical necessity, the reconstructive surgeon may have no other choice but to attempt to close a complex abdominal wall defect. Autologous reconstruction is the most logical option when the wound is infected or contamination is anticipated during surgery. This article attempts to assist reconstructive surgeons by describing the risks and potential complications associated with the takedown and repair of complex hernias using components separation.

A variety of predisposing factors contribute to the formation of ventral abdominal wall de-

<table>
<thead>
<tr>
<th>Complication*</th>
<th>Incidence</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prolonged ileus</td>
<td>27</td>
<td>8</td>
</tr>
<tr>
<td>Renal (oliguria)</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Cardiac (EKG changes, tachycardia, chest pain, CHF, BP instability)</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td>Respiratory (pneumonia, pulmonary edema, PE, prolonged intubation)</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td>Hematoma</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Seroma</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Ischemia</td>
<td>40</td>
<td>12</td>
</tr>
<tr>
<td>Midline wound infection</td>
<td>40</td>
<td>12</td>
</tr>
<tr>
<td>Dehiscence</td>
<td>43</td>
<td>13</td>
</tr>
<tr>
<td>Enterocutaneous fistula</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Recurrence</td>
<td>10</td>
<td>3</td>
</tr>
</tbody>
</table>

* EKG, electrocardiogram; CHF, congestive heart failure; BP, blood pressure; PE, pulmonary embolus.
ects, including obesity, pulmonary disease, wound infection, sepsis, malnutrition, anemia, and corticosteroid dependency. Left untreated, ventral wall defects may result in intestinal incarceration, strangulation, and obstruction. As many as one in 10 abdominal operations are complicated by a postoperative ventral hernia. The recurrence rate after primary repair of a complex ventral hernia is reported to be as high as 50 percent, and after secondary repair of a recurrent ventral hernia as high as 40 percent. Abdominal components separation has been shown to decrease the risk of recurrence and to provide a reliable autologous reconstructive option for complex ventral abdominal defects.

Abdominal components separation is a technique of abdominal wall reconstruction that uses local tissue to provide dynamic support to the abdominal wall and allow for a tension-free closure of the myofascial layers. Ger and Duboys reported that innervated and vascularized musculofascial flaps are superior to prosthetic materials or adynamic and devascularized autologous tissue in the repair of large hernia defects. Abrahamsom and Eldar emphasized the importance of recreating the linea alba to provide an anchor for the lateral abdominal wall anteriorly and to decrease the risk of recurrence.

Components separation can be used to reconstruct complex ventral abdominal defects with innervated and vascularized tissue, without necessitating distant tissue transfer. The procedure recreates the linea alba, successfully providing a midline anchor. Using components separation, Ramirez et al. reported a recurrence rate of 8 percent, DiBello and Moore a rate of 8.5 percent, Lowe et al. a rate of 14 percent, and Thomas et al. reported no recurrences.

Components separation is associated with a significant decrease in recurrence rates. This technique provides a local autologous reconstruction option for complex and contaminated wounds. However, components separation is not without significant risk, a full understanding of which is important before surgery. The procedure itself must be analyzed in the context of the patient’s preoperative medical condition, complexity of the defect, and complications related to both hernia take-down and reconstruction. In our series of 30 patients, correction of midline defects was achieved with a comparable recurrence rate of 10 percent.

In this study each of the cases complicated by a recurrence had several notable preoperative risk factors (Table V). One of the postoperative recurrences followed a full-thickness fascial injury, noted during release of the external oblique fascia, in the left upper quadrant along the costal margin. This was the only known technical error that occurred during components separation, and it was repaired immediately with interrupted sutures. However, a computed tomographic scan performed on postoperative day 4 demonstrated that this error resulted in the formation of a new hernia lateral to the midline in the exact area of the fascial injury. A technical error resulting in a fascial injury during components separation can be quite serious, because it results in loss of fascial continuity and dynamic support in a wound often closed under tension and associated with a significant loss of intraabdominal domain.

On the basis of their preoperative profiles, wounds, and American Society of Anesthesiologists classifications, the patient population in this study was high-risk; not surprisingly, there were a variety of surgical complications, notably wound infection, ischemia, and dehiscence. Of the 12 patients who had postoperative midline wound infections, 10 had contaminated or clean contaminated wounds preoperatively. We also found a correlation between ischemia and dehiscence in that those outcomes complicated by ischemia inevitably evolved into dehiscence (six of six). In addition, each case of dehiscence was preceded either by ischemic changes (six of 13) or by midline wound infection (10 of 13). It follows that infection and ischemia are predictors of dehiscence and that
these changes are ominous indications of wound outcome.

A two-tailed Fisher’s exact test was used to determine whether a relationship existed between the most common surgical risk factors and postoperative complications. A statistically significant relationship seemed to exist between American Society of Anesthesiologists classification greater than 2 and occurrence of an ileus ($p = 0.001$), wounds that were not clean and occurrence of an ileus ($p = 0.01$), and wounds that were not clean and occurrence of an open wound ($p = 0.03$). The relationship between wound contamination and wound dehiscence, and wound contamination and prolonged ileus, is both clinically understandable and believable. However, it is somewhat difficult to understand clinically why a patient’s American Society of Anesthesiologists classification would be related to the presence of a prolonged ileus. Therefore, it should be noted that because of the limited number of patients in the study and the large number of variables examined, it would not be unexpected to see several significant results simply by chance when the null hypothesis is true.

The goal of components separation is to re-establish fascial continuity for dynamic support of the abdominal wall and to avoid prosthetic material in contaminated wounds. In this study, it is notable that 33.3 percent of patients had mesh placed in the defect during the procedure. Mesh was often used for support when closing wounds under tension, and it did not necessarily reflect a treatment failure in every case. It is the authors’ opinion that treatment failure is most closely tied to the clinical recurrence rate. However, it is also our opinion that procedural failure of components separation is reflected by the failure to re-approximate the fascial edges. In this study, we failed to approximate the fascial edges in 23.3 percent of patients because of a combination of factors: failure to fully anticipate the fascial advancement, significant intraabdominal distention, and an underestimation of defect size in relationship to reliable tissue availability.

In this study, the intraoperative and postoperative data reflect the complexity and risk of the surgery. The total length of the components separation averaged 4.8 hours, 16.7 percent required blood transfusion, 30 percent had enterotomies, and 33 percent needed mesh. The time required to take down the ventral hernia often resulted in significant bowel distention, blood loss, and an inability to close the defect without mesh, even in light of a contaminated wound. The postoperative data demonstrated an average surgical intensive care stay of 2.7 days as a result of pulmonary and renal compromise often due to loss of intraabdominal domain. The mean postoperative hospital stay was 12.5 days, due to delayed return of bowel function and concerns related to the midline wound.

Our patient population was not unique, in that components separation was often undertaken as an operation of “last resort,” after other corrective attempts failed or easier procedures were deemed contraindicated. In our experience, components separation provided a highly reliable and successful reconstructive option for patients with complex abdominal wall defects, and a local autologous reconstructive option for high-risk wounds. The procedure was associated with some significant morbidity that should not be understated or ignored. This morbidity, in many cases, was more closely related to the hernia takedown than to the abdominal reconstruction. Nevertheless, reconstructive surgeons must familiarize themselves with these risks and fully inform their patients of the potential risk of morbidity. We strongly believe that fully preparing for the intraoperative and postoperative occurrences and complications in these very challenging clinical situations will provide the best opportunity for a safe and successful outcome.

James B. Lowe, III, M.D.
Washington University School of Medicine
Suite 17424 East Pavilion
Campus Box 8283
One Barnes-Jewish Hospital Plaza
St. Louis, Mo. 63110
lowej@msonotes.wustl.edu

REFERENCES
5. George, C. D., and Ellis, H. The results of incisional


Risks Associated with “Components Separation” for Closure of Complex Abdominal Wall Defects

1. WHAT IS THE REPORTED RECURRENCE RATE FOR MIDLINE ABDOMINAL DEFECTS FOLLOWING “COMPONENTS SEPARATION”?
   A) 0
   B) Less than 5 percent
   C) Less than 20 percent
   D) Less than 30 percent
   E) Greater than 30 percent

2. BILATERAL PARTITION AND SEQUENTIAL RELAXATION OF THE POSTERIOR RECTUS FASCIA AND THE EXTERNAL OBLIQUE CAN ACHIEVE APPROXIMATELY HOW MANY CENTIMETERS OF ADVANCEMENT IN THE MIDDLE ABDOMEN?
   A) 6 cm
   B) 10 cm
   C) 15 cm
   D) 20 cm

3. WHAT IS THE APPROXIMATE ENTEROTOMY RATE FOR PATIENTS UNDERGOING A TAKEDOWN OF COMPLEX MIDLINE ABDOMINAL WALL DEFECT?
   A) 0
   B) 5 percent
   C) 10 percent
   D) 20 percent
   E) 30 percent

4. WHAT IS THE MOST COMMON POSTOPERATIVE COMPLICATION FOLLOWING OPEN COMPONENTS SEPARATION?
   A) Enterocutaneous fistula
   B) Hematoma
   C) Recurrence
   D) Wound dehiscence
   E) Serum

5. FOLLOWING ABDOMINAL TRAUMA, WHAT IS THE INCIDENCE OF VENTRAL HERNIA?
   A) 1 percent
   B) 5 percent
   C) 10 percent
   D) 20 percent
   E) 30 percent

6. FOLLOWING REPAIR OF VENTRAL HERNIA WITH THE COMPONENTS SEPARATION TECHNIQUE, WHICH IS THE MOST FREQUENT COMPLICATION?
   A) Cardiac abnormalities
   B) Prolonged ileus
   C) Pneumonia
   D) Pulmonary embolus
   E) Need for prolonged ventilatory support
7. WHICH OF THE FOLLOWING PREOPERATIVE CONDITIONS HAS BEEN SHOWN TO HAVE A STATISTICAL SIGNIFICANT EFFECT ON THE INCIDENCE OF POSTOPERATIVE COMPLICATIONS FOLLOWING HERNIA REPAIR WITH THE COMPONENTS SEPARATION TECHNIQUE?

A) Obesity
B) Smoking history
C) Size of abdominal defect
D) American Society of Anesthesiologists' ranking of 3 or greater
E) Age greater than 40 years