Open Anterior Component Separation

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Peter Thompson and Albert Losken

Introduction

The method of anterior "components separation" was first described by Ramirez et al. in 1990 [1]. In this elegant anatomic study, the authors described a technique whereby the muscular layers of the anterior abdominal wall could be separated and then medially mobilized in order to achieve closure of large ventral defects, restoring the anatomic relationship of the rectus muscles at the midline.

Though the use of external oblique relaxing incisions was originally described as early as 1916 [2], Ramirez and colleagues are credited with important technical refinements and development of the surgery in common use today. In dissections of ten cadavers, Ramirez et al. described development of the avascular plane between the external and internal oblique muscular layers through relaxing incisions lateral to the rectus sheath. Combined with freeing the rectus from its attachments to the posterior sheath, this technique created myofascial advancement flaps with potential for significant medialization: 5 cm at the epigastrium, 10 cm at the waist, and 3 cm in the suprapubic region per side, allowing closure of defects up to 20 cm in diameter at the waist. They went on to describe a series of eleven patients with abdominal wall hernias of various etiologies including trauma, infected prostheses, and TRAM defects.

Prior to popularization of component separation and the availability of acellular dermal matrix, ventral defects which could not be closed by en bloc mobilization of the abdominal wall required placement of bridging synthetic mesh to prevent loss of abdominal domain, a technique which exposed patients to the potential of mesh infection, extrusion, fistulization, and high hernia recurrence rates [3–5]. Defects with inadequate fascial or soft tissue coverage were addressed with the inventive use of autologous tissue transfers such as the free or pedicled tensor fascia lata flap [6, 7], also with significant associated morbidity and hernia recurrence. The development of component separation therefore represented an important advance with major implications for the care of patients with this difficult surgical problem.

The goal of component separation in abdominal wall reconstruction is a tension-free re-approximation of the linea alba, thereby restoring the normal anatomic relationship of the abdominal wall muscles and off-loading the constant lateral pull of the oblique and transverse muscular system. Anterior component separation is indicated for the repair of large abdominal wall defects of any etiology; two of the most common indications include the multiply recurrent ventral hernia resulting in a hostile abdomen in which

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laparoscopic repair would be contraindicated, and abdominal trauma managed with damage control laparotomy resulting in "planned" ventral hernia. Both etiologies may be complicated by loss of abdominal domain and often occur in the setting of a contaminated field (such as infection of previously placed mesh or enterocutaneous fistula). In such situations, component separation is an indispensible tool to restore normal abdominal wall physiology and provide a durable repair.

Outcomes

Despite widespread acceptance and application of the technique, anterior component separation remains an operation plagued by high surgical morbidity. This is likely a function of both the surgery itself and the general poor state of health of many of the candidates for abdominal wall reconstruction. Common complications are the logical sequelae of large myofascial and subcutaneous flap elevation and include seroma, hematoma, infection, skin edge necrosis, wound breakdown, and hernia recurrence. Recurrence rates following anterior components separation range from 5 to 32% in major series; rates of wound complications range from 7.5 to 48%. These outcomes are summarized in Table 14.1.

Current Trends

Since the original description by Ramirez et al., various modifications of the components separation technique have been proposed in order to reduce surgical morbidity. Several of these innovations, including the type and position of mesh to be used in reinforcement of repair and the use of minimally invasive techniques for component release, continue to be topics of discussion and debate.

Minimal Dissection Technique

As originally described by Ramirez, separation of the abdominal wall components involves significant subcutaneous undermining from the midline to the level of the semilunar line in order to achieve exposure of the external oblique. The large potential space created after raising this flap predisposes to postoperative fluid collection, with rates up to 11.6% for hematoma [8] and 10% for seroma [9]. In addition, undermining of the skin and subcutaneous tissues necessitates division of lipocutaneous perforators, particularly in the periumbilical region, resulting in a relatively devascularized flap. This can increase the rate of skin necrosis and ischemia, which can complicate up to 20% of anterior component separation repairs [9]. Modifications of the traditional open anterior components separation have been suggested which provide exposure of the external oblique without the need for aggressive subcutaneous undermining. These include use of either longitudinal [10] or transverse [11] paramedian incisions to access the external oblique aponeurosis lateral to the semilunar line. Endoscopic-assisted minimally invasive release of the external oblique has also been described [12]. Despite differences in technique, the common goal of each of these modifications is preservation of the periumbilical perforators, an important blood supply to the midline abdominal skin. Periumbilical perforator-sparing techniques have been associated with decreased rates of wound healing complications, including skin necrosis and infection [13]. While minimal undermining and skin flap dissection may be preferable, there are clearly clinical scenarios in which preservation of periumbilical perforators is not possible. In very large hernias with loss of abdominal domain, retracted skin edges may tether the abdominal wall, and fascial approximation at the midline may not be possible without full release of the skin and subcutaneous tissue from the underlying layers. Also, in the setting of multiple previous abdominal operations, previous mesh onlay or previous component release, periumbilical perforators may have already been divided or no clear dissection plane may exist.

Type of Mesh: Synthetic vs. Biologic

In the original description of the components separation technique by Ramirez et al., fascial layers were reapproximated primarily in the mid-

Table 14.1 Outcomes following anterior component separation

Author (year)	Number of patients undergoing ACS	Mean follow-up (months)	Number of recurrences (%)	Number of wound complications (%)	Comments
Girotto et al. (1999) [8]	37	21	2 (6.1)	11 (30)	ACS without mesh
Saulis et al. (2002) [9]	66	12	5 (7.6)	9 (14)	ACS with or without PUP-sparing
DeVries Reilingh et al. (2003) [10]	43	15.6	12 (32)	15 (35)	ACS without mesh
Girotto et al. (2003) [11]	96	26	22 (23)	25 (26)	ACS with mesh onlay "when necessary"
Jernigan et al. (2003) [12]	73	24	4 (5.5)	–	ACS after open abdomen, most without mesh
Lowe et al. (2003) [13]	30	9.5	3 (10)	35 (?)	ACS mostly without mesh
Gonzales et al. (2005) [14]	42	16	3 (7)	14 (33)	LR vs. ACS; with and without mesh
Espinosa-de-los-Monteros et al. (2007) [15]	37	13	2 (5)	10 (26)	ACS with ADM onlay
Ko et al. (2009) [16]	200	10.3	43 (21)	38–86 (19–43)	ACS via lateral access incisions; no mesh, ADM or soft synthetic mesh as underlay
Sailes et al. (2010) [17]	545	–	100 (18)	41 (7.5)	ACS with various mesh types over 10 years
Ghazi et al. (2011) [18]	75	34	10 (13)	9 (12)	ACS with and without mesh
Krpata et al. (2012) [19]	56	9.1	8 (14)	27 (48)	PCS vs. ACS with mesh underlay

ACS anterior component separation, *PUP* periumbilical perforator, *LR* laparoscopic repair, *ADM* acellular dermal matrix, *PCS* posterior component separation

line without mesh reinforcement. This resulted in a hernia recurrence rate of up to 53% at 7 months [14]. In agreement with widely accepted principles for repair of incisional hernias [15, 16], mesh reinforcement of components separation appears to decrease hernia recurrence to as low as 5% [17]. Various types of synthetic and biologic mesh have been used as adjuncts to component separation, each with distinct advantages and disadvantages. Synthetic materials such as polypropylene have been available for use for decades. While the strength of this material may provide long-lasting protection from recurrence compared to biologic materials [11, 18], synthetic permanent mesh is often contraindicated in the contaminated field. It creates a dense inflammatory reaction that can predispose to infection, adhesion formation, and enterocutaneous fistula formation [3]. In contrast, biologic materials such as human or porcine acellular dermal matrix are generally considered safe to use in the contaminated field. These materials incorporate, revascularize, and remodel with host tissue after implantation, with minimal host inflammatory response. Biologics have been used in situations where permanent synthetic mesh is contraindicated but appears to have a tendency to stretch over time [19], resulting in recurrence rates that in some series were higher than that observed with no mesh at all [11]. The type of mesh selected for reinforcement of a components separation repair depends on numerous variables including patient comorbidities, the presence of contamination, or infection in the surgical field and the size of the hernia defect. When used correctly, the biologic mesh can provide the benefits of synthetic mesh closure through reinforcement and tension reduction, without the infection risks often associated with synthetic mesh.

Mesh Position

The position for mesh placement is also a source of debate. Investigators have described reinforcement of component separation-based abdominal wall reconstructions using mesh placed in onlay [20], underlay [11], bridging [9], or sublay (retrorectus) [21] positions. Other authors have described using a combination of these approaches for a so-called "sandwich" repair [21]. There are clearly advantages and disadvantages to each technique. For example, by placing a layer of tissue between bowel and mesh, the onlay technique theoretically decreases risk of bowel-to-mesh adhesion and enteric fistula formation. This technique also avoids the need for more extensive intraperitoneal dissection and adhesiolysis, making it a preferable option in the setting of the hostile abdomen. However, a recent review of the available literature regarding mesh position suggests that compared to the underlay position, mesh placed in the onlay position had a higher incidence of overall complications and hernia recurrence regardless of the type of mesh used [22].

Personal Algorithms and Technique

Preoperative Evaluation

Patients with large abdominal wall defects often experience significant deformity, pain, and decreased energy due to loss of normal abdominal wall mechanics, severely impacting their quality of life; however, it is important to remember that abdominal wall reconstruction is always an elective procedure, and one with potential for significant morbidity. Therefore, candidates should be chosen based on their overall likelihood of a successful repair balanced against their risk of surgical or medical complication. Patient selection for abdominal wall reconstruction with components separation begins with a thorough history and physical exam.

Careful attention should be paid to patients' medical comorbidities, in particular diabetes, smoking, and morbid obesity, all of which increase the risk of wound complications and hernia recurrence. The importance of preoperative counseling cannot be over-stressed, and patients should be encouraged to correct modifiable risk factors with tight blood glucose control, smoking cessation and weight loss as possible. For an elective surgery which will usually require considerable operative risk, complicated postoperative care and considerable use of hospital resources, it is reasonable to request that patients make an effort to stack the odds in their favor by losing weight and stopping smoking prior to being scheduled for surgery. Preexisting cardiac and pulmonary comorbidities necessitate preoperative consultation with the appropriate specialist in order to ensure medical optimization and fitness to undergo major surgery. Malnutrition is an equally prevalent problem in patients who may be chronically debilitated from multiple previous operations and prolonged hospital stays. Every effort should be made to optimize nutritional status as determined by trends in weight and laboratory markers such as albumin, prealbumin, and transferrin.

Likewise, a detailed knowledge of the patient's surgical history is essential for success. For patients with multiply recurrent ventral hernias, careful attention to the number and technique of previous hernia repairs, the location and type of any previously placed mesh, and the location of any scars on the anterior abdominal wall will help shape the intraoperative plan and guide technique and mesh selection (Fig. 14.1).

Preoperative imaging with CT or MRI of the abdomen can provide essential information about

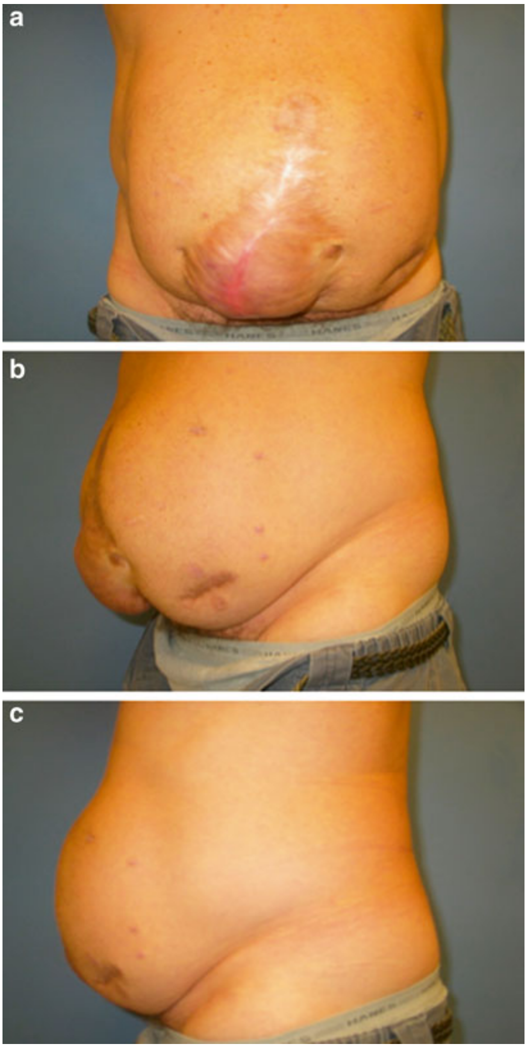

Fig. 14.1 (**a**) Anterior (**b**) oblique and (**c**) lateral preoperative photos of a patient scheduled for component separation. This middle-aged male had a history of multiple previous failed hernia repairs secondary to mesh infections, resulting in a large ventral hernia with relative loss of domain

the anatomy of the anterior abdominal musculature, position of previously placed mesh, and location of any stomas or enterocutaneous fistulas (Fig. 14.2). Most importantly for large midline defects, preoperative imaging can precisely measure the distance between the true fascial edges. In general, a full separation of anterior components can be expected to produce a unilateral rectus sheath advancement of 10–15 cm at the waistline; therefore, fascial approximation of midline defects up to 30 cm can be obtained with a full bilateral release. Less advancement is expected in the epigastric and suprapubic regions, around 5–8 cm and 3–6 cm respectively per side. The presence of a stoma, history of previous component release, or large defects in the upper or lower thirds of the abdomen may therefore preclude repair with anterior components separation alone. Preoperative imaging can help make this important determination before entering the operating room. In our practice, all patients being considered for abdominal wall reconstruction undergo some form of preoperative cross-sectional imaging. Other preoperative evaluation includes laboratory assessment of hematologic indices, serum chemistry, and nutritional markers as well as EKG and plain film chest X-ray for high-risk patients.

Timing of abdominal wall reconstruction is critical. As mentioned previously, the most common indications for components separation repair at our institution include the open abdomen after trauma with loss of abdominal domain and the multiply recurrent incisional hernia. Both of these conditions often occur in association with enterocutaneous fistulae, infected mesh, or an otherwise contaminated field. The posttraumatic open abdomen is often managed at our institution using a staged approach as previously described [23]; patients become candidates for definitive abdominal wall reconstruction 6–12 months after creation of the "planned" hernia defect by placement of split thickness skin graft on top of exposed viscera. After this period of time, inflammation and dense adhesions generally resolve and the skin graft can usually be dissected easily from the underlying bowel. A simple test to determine a patient's readiness for definitive reconstruction is the "pinch test." If the grafted skin can be easily picked up with the thumb and index finger and pinched with no intervening bowel, then surgery may safely proceed. Similarly, in the setting of recurrent ventral incisional hernias, a waiting period of at least 6 months is advisable following the most recent attempt at hernia repair; component separation or any other definitive reconstruction attempted in the setting of acute inflammation will be more likely to fail secondary to poor tissue strength.

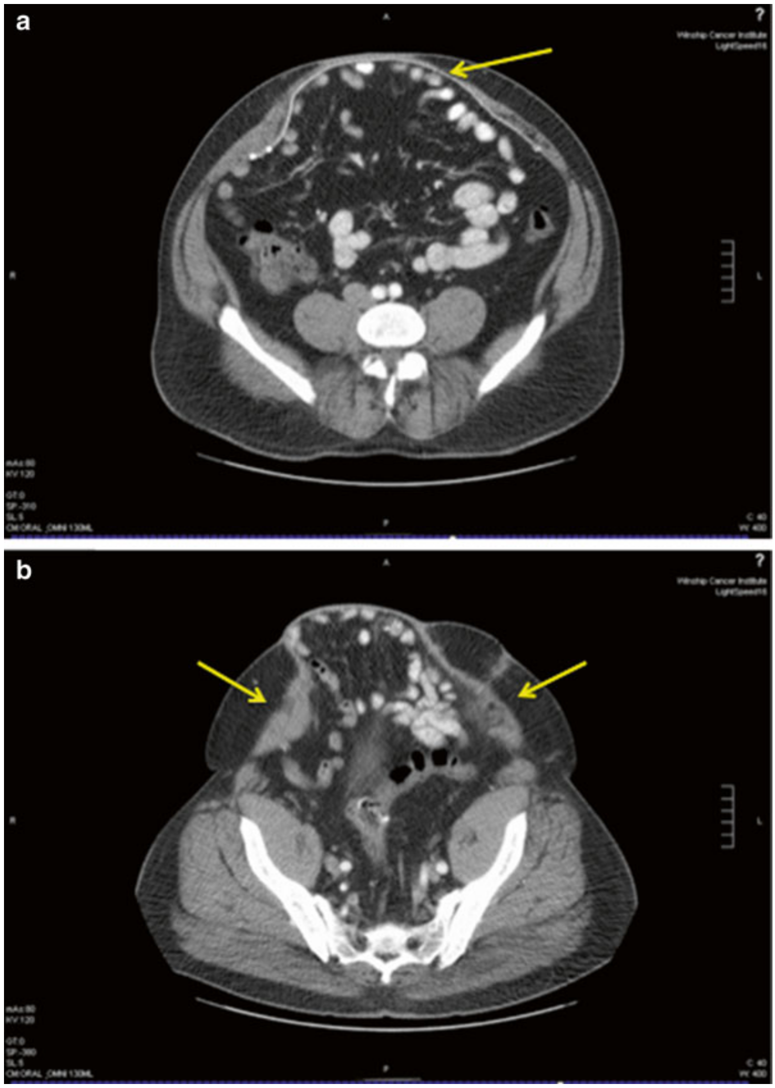

Fig. 14.2 Preoperative cross-sectional imaging with computed tomography (CT) demonstrating (**a**) thin, attenuated fascia over previously placed mesh (*yellow arrow*) and (**b**) significant rectus muscle diastasis/hernia recurrence (*yellow arrows*)

Surgical Technique

At our institution, most abdominal wall reconstructions are performed in careful coordination with a general surgery team. Patients are maintained NPO after midnight on the eve of surgery. Bowel preparation is performed at the discretion of the general surgeon. In the operative suite, patients are positioned supine with arms out. Appropriate monitoring devices are placed by the anesthesia team. Hair is removed from the operative site with clippers and the skin is prepped with chlorhexidene solution. The field is widely prepped and draped from nipples to upper thigh and to the level of the bed over each flank. Thin strips of Ioban (3M; St. Paul, MN) are often useful to secure drapes in place during these long procedures. Thromboembolic prophylaxis with sequential compression devices on the lower extremities is essential.

The operation begins usually with a full midline laparotomy followed by extensive lysis of adhesions performed by the general surgery team. The general surgery portion of the procedure also includes excision of any previously placed or infected prosthetic material, take down and repair of enterocutaneous fistulae, and bowel resections as indicated.

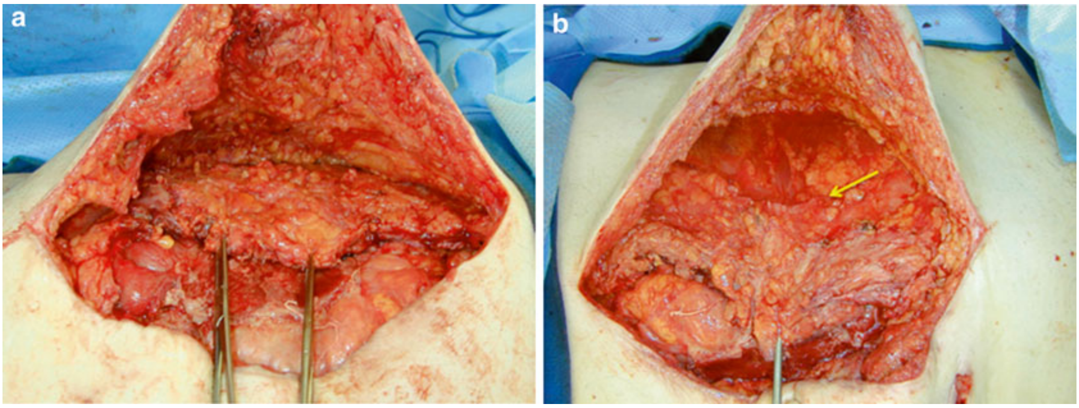

Fig. 14.3 Intraoperative photos. (**a**) After lysis of adhesions, the fascial edges are grasped with Kocher clamps and a lipocutaneous flap raised. (**b**) The external oblique aponeurosis is then incised lateral to the rectus muscle bundle. The medial cut edge of external oblique aponeurosis is designated by the *yellow arrow*

The plastic surgery team begins the reconstructive portion of the procedure with assessment of the resultant defect. The edges of the rectus sheath are grasped with Kocher clamps and pulled bilaterally toward the midline in order to determine how much advancement is necessary to recreate the linea alba (Fig. 14.3a). Identification of the true fascial edge is often difficult in the presence of dense scar, and careful dissection is often needed to locate the rectus sheath. This is an essential step as misidentification and subsequent approximation of scar tissue instead of fascia will almost certainly result in hernia recurrence.

The next step is determined by the size of the defect to be reconstructed. Often, after lysis of adhesions and freeing attachments of viscera to the overlying abdominal wall, primary approximation of fascial edges may be possible without any component release. In this instance, a mesh-reinforced primary repair is performed, with a components release added if needed to reduce midline tension. Most commonly for defects 10–30 cm in width, recreation of the linea alba will not be possible without component release. An anterior component separation is performed in the following fashion, originally described by Ramirez [1]. The fascial edge of the side to be released is grasped with a Kocher and retracted toward the midline. Counter-traction is applied by the assistant who retracts the skin edge with either a toothed forcep or handheld retractor. Dissection proceeds in a subcutaneous plane just above the rectus fascia to a point 1–2 cm lateral to the linea semilunaris, from the costal margin superiorly to the anterior superior iliac spine (ASIS) inferiorly. The external oblique aponeurosis is incised at this lateral point along the entire length of the dissection (Fig. 14.3b). Confirmation of position lateral to the linea semilunaris can be obtained by manually palpating the rectus muscle or by making a small nick in the fascia and examining the orientation of the underlying muscle fibers. Obliquely oriented fibers of the internal oblique muscle should be visible. Dissection then proceeds in the avascular plane between the internal and external oblique laterally to the mid-axillary line. Following completion of unilateral release, the bilateral fascial edges are again grasped and pulled together to check midline approximation. If a tension-free recreation of the linea alba is now possible, contralateral component release is not necessary. Avoiding contralateral dissection preserves this plane for future reconstructive procedures in the event of recurrence, and decreases the likelihood of abdominal wall necrosis, seroma formation and a lateral bulge. If tension-free approximation is not possible with unilateral external oblique release, a bilateral release is performed. If following bilateral external oblique release approximation is still inadequate, a posterior rectus sheath relaxing incision may be made as described by Ramirez

[1], however in our experience this maneuver will add only 1–2 cm of advancement at most.

Our experience [24] and that of others [17, 25] has demonstrated that an abdominal components separation repair reinforced with mesh has a lower rate of recurrence than a non-reinforced repair; for this reason, we consider mesh reinforcement an essential step in an anterior component separation repair. Our preference in clean and some clean-contaminated situations such as bowel resection or presence of a stoma is to use synthetic mesh such as lightweight polypropylene (Prolene®, Ethicon) or a composite mesh of polyester and non-adherent collagen film (Parietex™, Covidien) given superior strength and lower risk of recurrence of synthetics. In contaminated cases, such as removal of infected mesh or gross spillage of enteric contents, our preference is to use a porcine acellular dermal matrix. Whenever possible, mesh is placed in an intraperitoneal underlay position in order to decrease the risk of mesh contamination and seroma. It is our feeling that an underlay provides a stronger repair than mesh placed in an onlay position. The mesh is fashioned into the shape of a diamond and secured in position with transfascial U-stitches of #1 Prolene (Fig. 14.4a). The first stitches are placed at the four corners of the diamond, left untied and secured with hemostats in order to set the appropriate tension on the mesh. Additional stitches are then placed at intervals of 2–3 cm around one lateral border of the mesh (Fig. 14.4b). All sutures are controlled with hemostats and tied after all are in place, taking care that no viscera are entrapped during tying. The repair should then be probed with a finger to ensure that no gaps remain between sutures through which a loop of bowel might slip. Additional sutures are placed as needed to fill in these gaps. This process is repeated on the contralateral border of the mesh. The mesh should overlap the rectus to the external oblique for a distance of at least 4 cm and should tension the myofascial flaps in such a way as to offload the midline approximation. When the mesh is in place, the medial edges of the rectus sheath may be sutured together over the mesh using a #1 PDS in an interrupted or running fashion (Fig. 14.4c).

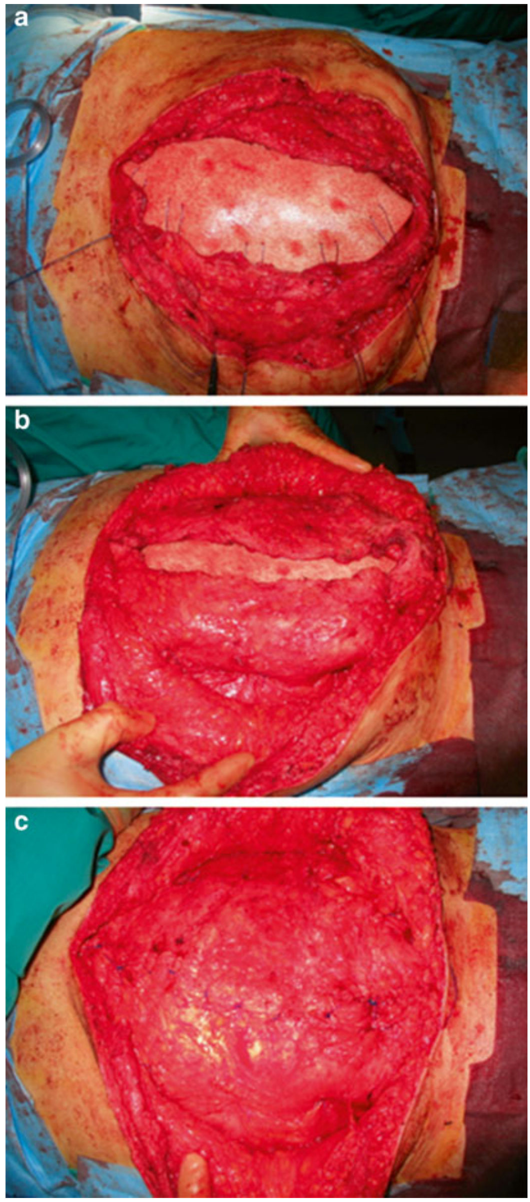

Fig. 14.4 A mesh underlay is performed with a large piece of acellular dermal matrix. (**a**) Widely spaced, interrupted #1 Prolene transfascial sutures are used to set the appropriate mesh tension. (**b**) The mesh is then secured circumferentially with additional transfascial sutures. (**c**) The overlying fascia is primarily reapproximated in the midline and sutured with interrupted or running #1 PDS suture

Subcutaneous closed suction drains are placed and brought out through the inferior skin lateral to the laparotomy incision. The skin is closed with staples.

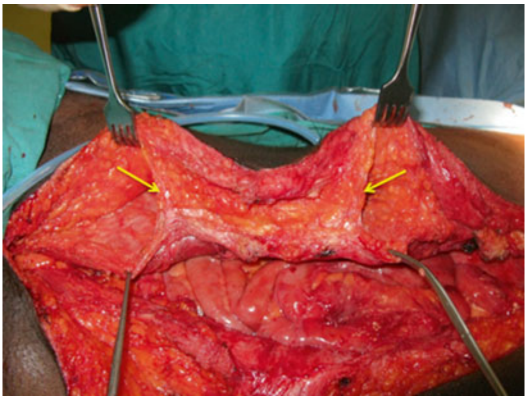

Fig. 14.5 Important perforators supplying the abdominal wall skin may be spared during anterior component separation by avoiding dissection in the periumbilical region (between *yellow arrows*). A tunnel can be created lateral to these perforators through which the external oblique relaxing incision can be made

Several unique situations deserve mention. As described previously, several authors have endorsed a periumbilical perforator-sparing approach during elevation of skin flaps [13] in order to decrease rates of seroma, skin edge necrosis, and subsequent wound healing complications. This technique is particularly useful in patients at risk for poor soft tissue perfusion such as those with peripheral vascular disease, smoking history, diabetes, and the super-obese. In our practice, we attempt to preserve perfusion of the abdominal wall in this population as much as possible through use of minimal skin flap elevation and avoidance of dissection in the periumbilical region (Fig. 14.5); however, there are two situations in which this approach is less useful. In the patient with multiple previous hernia repairs or a previous component release, the periumbilical blood supply may have already been divided. In addition, some patients (i.e., the skin-grafted trauma patient) may not have adequate skin coverage of fascia without full elevation of the skin laterally to the anterior axillary line, creating an additional sliding flap of soft tissue that can then be approximated at the midline. Other options if soft tissue coverage is inadequate include pedicled flaps such as a tensor fascia lata (TFL) or anterolateral thigh (ALT) flap, or if inadequate skin is suspected preoperatively abdominal wall tissue expanders may be used.

Postoperative Management

Postoperatively, patients are often left intubated and monitored in the ICU. Drains are placed to wall suction for anywhere from 24 hours to 5 days postoperatively depending on the extent of dissection and the surgeon's preference, and then placed to bulb suction. Perioperative antibiotics are continued for 24 hours after surgery. Some surgeons prefer continuation of antibiotics throughout the recovery period for as long as drains are in place. Postoperative imaging is often obtained at the surgeon's discretion to provide a baseline for future follow-up (Fig. 14.6).

Conclusion

Separation of abdominal components has become an essential and powerful weapon in the armamentarium of surgeons across specialties, gaining widespread popularity for the closure of abdominal wall defects resulting from trauma, infection, and previous surgery. This technique has been utilized for a variety of problems with reproducible, consistent outcomes. Further refinements by surgical innovators continue to reduce morbidity and hernia recurrence.

References

1. Ramirez OM, Ruas E, Dellon AL. "Components separation" method for closure of abdominal-wall defects: an anatomic and clinical study. Plast Reconstr Surg. 1990;86(3):519–26.
2. Gibson CL. Post-operative intestinal obstruction. Ann Surg. 1916;63(4):442–51.
3. Leber GE, Garb JL, Alexander AI, Reed WP. Long-term complications associated with prosthetic repair of incisional hernias. Arch Surg. 1998;133(4):378–82.
4. de Vries Reilingh TS, van Geldere D, Langenhorst B, de Jong D, van der Wilt GJ, van Goor H, et al. Repair of large midline incisional hernias with polypropylene mesh: comparison of three operative techniques. Hernia. 2004;8(1):56–9.
5. Lichtenstein IL, Shore JM. Repair of recurrent ventral hernias by an internal "binder". Am J Surg. 1976;132(1):121–5.
6. Williams JK, Carlson GW, deChalain T, Howell R, Coleman JJ. Role of tensor fasciae latae in abdominal wall reconstruction. Plast Reconstr Surg. 1998;101(3):713–8.

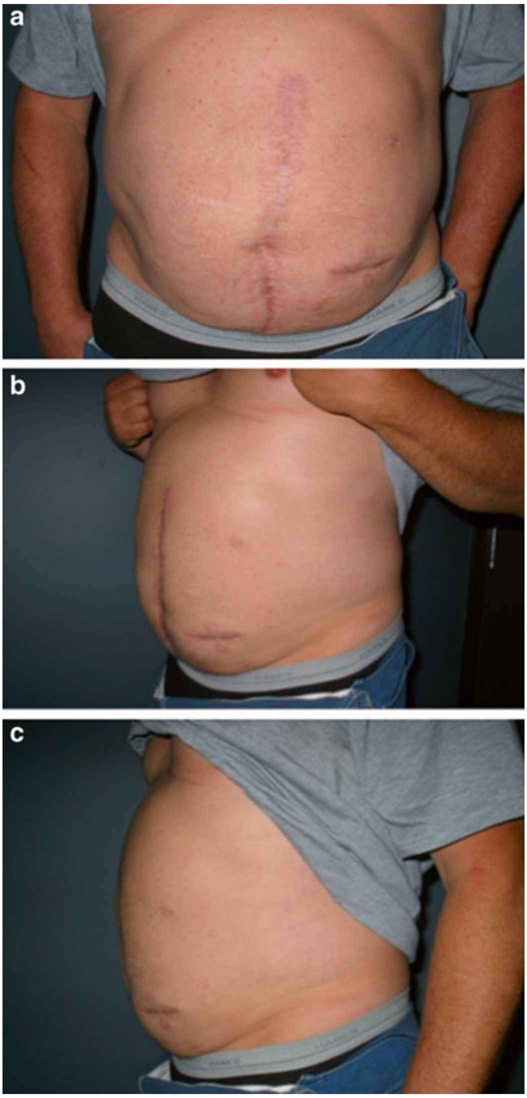

Fig. 14.6 (**a**) Anterior (**b**) oblique and (**c**) lateral postoperative photos following anterior component separation with mesh underlay

7. Williams JK, Carlson GW, Howell RL, Wagner JD, Nahai F, Coleman JJ. The tensor fascia lata free flap in abdominal-wall reconstruction. J Reconstr Microsurg. 1997;13(2):83–90. discussion 90-81.
8. de Vries Reilingh TS, van Goor H, Rosman C, Bemelmans MH, de Jong D, van Nieuwenhoven EJ, et al. "Components separation technique" for the repair of large abdominal wall hernias. J Am Coll Surg. 2003;196(1):32–7.
9. Lowe III JB, Lowe JB, Baty JD, Garza JR. Risks associated with "components separation" for closure of complex abdominal wall defects. Plast Reconstr Surg. 2003;111(3):1276–83. quiz 1284-1275; discussion 1286-1278.
10. Maas SM, van Engeland M, Leeksma NG, Bleichrodt RP. A modification of the "components separation" technique for closure of abdominal wall defects in the presence of an enterostomy. J Am Coll Surg. 1999;189(1):138–40.
11. Ko JH, Wang EC, Salvay DM, Paul BC, Dumanian GA. Abdominal wall reconstruction: lessons learned from 200 "components separation" procedures. Arch Surg. 2009;144(11):1047–55.
12. Lowe JB, Garza JR, Bowman JL, Rohrich RJ, Strodel WE. Endoscopically assisted "components separation" for closure of abdominal wall defects. Plast Reconstr Surg. 2000;105(2):720–9. quiz 730.
13. Saulis AS, Dumanian GA. Periumbilical rectus abdominis perforator preservation significantly reduces superficial wound complications in "separation of parts" hernia repairs. Plast Reconstr Surg. 2002;109(7):2275–80. discussion 2281-2272.
14. de Vries Reilingh TS, van Goor H, Charbon JA, Rosman C, Hesselink EJ, van der Wilt GJ, et al. Repair of giant midline abdominal wall hernias: "components separation technique" versus prosthetic repair: interim analysis of a randomized controlled trial. World J Surg. 2007;31(4):756–63.
15. Burger JW, Luijendijk RW, Hop WC, Halm JA, Verdaasdonk EG, Jeekel J. Long-term follow-up of a randomized controlled trial of suture versus mesh repair of incisional hernia. Ann Surg. 2004;240(4):578–83. discussion 583-575.
16. den Hartog D, Dur AH, Tuinebreijer WE, Kreis RW. Open surgical procedures for incisional hernias. Cochrane Database Syst Rev. 2008(3):CD006438.
17. Espinosa-de-los-Monteros A, de la Torre JI, Marrero I, Andrades P, Davis MR, Vasconez LO. Utilization of human cadaveric acellular dermis for abdominal hernia reconstruction. Ann Plast Surg. 2007; 58(3):264–7.
18. Ko JH, Salvay DM, Paul BC, Wang EC, Dumanian GA. Soft polypropylene mesh, but not cadaveric dermis, significantly improves outcomes in midline hernia repairs using the components separation technique. Plast Reconstr Surg. 2009;124(3):836–47.
19. Schuster R, Singh J, Safadi BY, Wren SM. The use of acellular dermal matrix for contaminated abdominal wall defects: wound status predicts success. Am J Surg. 2006;192(5):594–7.
20. Sailes FC, Walls J, Guelig D, Mirzabeigi M, Long WD, Crawford A, et al. Synthetic and biological mesh in component separation: a 10-year single institution review. Ann Plast Surg. 2010;64(5):696–8.
21. Pauli EM, Rosen MJ. Open ventral hernia repair with component separation. Surg Clin North Am. 2013;93(5):1111–33.
22. Albino FP, Patel KM, Nahabedian MY, Sosin M, Attinger CE, Bhanot P. Does mesh location matter in abdominal wall reconstruction? A systematic review of the literature and a summary of recommendations. Plast Reconstr Surg. 2013;132(5):1295–304.
23. Jernigan TW, Fabian TC, Croce MA, Moore N, Pritchard FE, Minard G, et al. Staged management of giant abdominal wall defects: acute and long-term

results. Ann Surg. 2003;238(3):349–55. discussion 355-347.
24. Ghazi B, Deigni O, Yezhelyev M, Losken A. Current options in the management of complex abdominal wall defects. Ann Plast Surg. 2011;66(5):488–92.
25. Holton III LH, Kim D, Silverman RP, Rodriguez ED, Singh N, Goldberg NH. Human acellular dermal matrix for repair of abdominal wall defects: review of clinical experience and experimental data. J Long Term Eff Med Implants. 2005;15(5):547–58.