Abdominal Wall Reconstruction in Patients with Digestive Tract Fistulas

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ABSTRACT

Abdominal wall reconstruction in the digestive tract fistula patient is a complex issue. The authors review the available data and present information regarding the timing of surgery, techniques of abdominal wall reconstruction, hernia repair, and discuss pitfalls associated with the various options. A simple and basic approach to this problem is described.

KEYWORDS: Abdominal wall reconstruction, enterocutaneous fistula, hernia

Objectives: Upon completion of this article, the reader should have a global understanding of the issue of abdominal wall reconstruction in patients with digestive tract fistulas and be able to discuss the pros and cons related to various management options based on the current literature.

Surgical treatment of patients suffering with digestive tract-cutaneous fistulas can be one of the most challenging situations faced by the general and colorectal surgeon. When these fistulas do not close with nonoperative management, surgery becomes necessary for cure in those fit to undergo the procedure. Ventral / incisional hernias often coexist with fistulas in these scenarios. Many of these abdominal wall defects can be quite large and are often associated with a significant loss of abdominal domain. The responsible surgeon is faced with a multifaceted problem: when and how to approach the fistula, how to repair the associated hernia, whether or not to reconstruct a functional abdominal wall, and whether or not to perform repair of the fistula and the abdominal wall concomitantly or in a staged fashion.

These cases are typically categorized as class II–IV because the gastrointestinal (GI) tract must be violated during the procedure, and the wounds are often contaminated with bacteria or are grossly infected. Often these patients will have GI tract stomas in place (Figs. 1 and 2), which may require takedown at the time of fistula

repair, whereas others may require temporary proximal diversion to protect a high-risk anastomosis. These factors make the decision to address the abdominal wall a challenging one in terms of timing of repair, choice of prosthetic material used in reconstruction, and the decision to embark on a staged versus nonstaged approach.

The last 10 to 20 years have seen an increase in the incidence of damage control surgical techniques, as well as the management of patients with an open abdomen (laparostomy) and temporary abdominal wall closures. These unique patients are at a particularly high risk for the formation of digestive tract atmospheric fistulas (Fig. 3),^{1–3} which are notoriously difficult to control and result in fistulas associated with complex and large abdominal wall defects. One group of investigators randomized 51 patients to treatment of their laparostomies with either vacuum-assisted closure therapy or closure with polyglactin 910 mesh and showed that there were no differences in the rates of delayed primary closure or fistula formation.⁴ Fistulas

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Figure 1 Photograph depicting a patient with a laparostomy, enterocutaneous fistula, complex abdominal wall defect, and diverting loop ileostomy after a small bowel anastomotic leak post left colectomy/ anterior resection, small bowel resection, extensive lysis of adhesions, and removal of infected polypropylene mesh done to treat recurrent diverticulitis. Of note, this patient had undergone previous sigmoid resection and suffered an anastomotic leak and was left with a laparostomy after a Hartmann's procedure.

resulted in 21% of the patients managed with vacuum-assisted closure and in 5% of those treated with absorbable mesh, but these differences were not statistically significant.

The ideal situation would be to obtain control of these fistulas, provide adequate nutritional support, and wait for them to close nonoperatively. This leaves the surgeon with only the problem of abdominal wall reconstruction (AWR). Unfortunately, this is often not the scenario with which we are faced and the surgeon must address both the fistula and the abdominal wall operatively. There are several techniques at the disposal of the surgeon to address these complex problems including biologic meshes, prosthetic / alloplastic meshes, component separation techniques, and complex flap repairs. The decision as to stage the abdominal wall repair or not is a controversial one.

Any patient that is to undergo a repair of a digestive tract fistula must first be optimized nutritionally. Any fistula or abdominal wall procedure undertaken in a malnourished patient is likely to fail and may only

Figure 2 Photograph depicting a patient with a complex abdominal wall defect, open wound, and an end ileostomy after an anastomotic leak and abdominal wall necrotizing fasciitis. The patient leaked from an ileocolonic anastomosis completed after a right colectomy performed for neoplastic disease.

make matters worse. This may require a long period of dependence on parenteral nutrition and will certainly demand a great deal of patience from both the surgeon and patient.

Figure 3 Photograph depicting a patient with a large and complex abdominal wall defect and a controlled fistula after surgery to treat a ruptured abdominal aortic aneurysm.

TIMING OF SURGERY

This is an area of controversy and there is no level I data that supports any particular waiting period prior to an attempt at fistula repair or abdominal wall reconstruction. Most experts would agree that a surgeon should wait at least 3 months after the initial laparotomy or fistula formation before any attempt at operative repair. This gives time for intraabdominal adhesions to soften, for the peritoneal cavity to become less hostile, and reduces the risk of iatrogenic bowel injury during the repeat procedure. These advantages apply to both fistula repair and abdominal wall reconstruction. In patients that have had split thickness skin grafts placed directly over bowel, one would typically defer definitive abdominal wall reconstruction until the graft was no longer adherent to the underlying viscera. This can be determined with a simple “pinch” test (Fig. 4) by pinching the skin graft between the index finger and thumb to see if it lifts freely from the intestine that it covers. In general, this period is longer than 3 months and can take up to a year prior to ideal conditions for proceeding with surgery.

Several retrospective studies have reported times from temporary abdominal closure to attempted definitive reconstruction that range between 2 and 929 days,^{3,5–7} with mean times to attempted reconstruction of 311 days,⁵ 184 days,⁶ and 585 days.⁷ Because of the retrospective nature of these studies, it is difficult to relate the success of a reconstructive effort with the timing of surgery, but it is clear that a waiting period of 6 months or longer is common. On the other hand,

one report suggests that waiting longer than 12 months may be associated with increased loss of domain, thereby making a tension-free repair more difficult leading to an increased recurrence.³ What is clear is that any reconstructive attempt must be well planned, and that the timing will be intimately related to resolution of inflammation, softening of the surrounding tissues, improvement in nutritional status, and overall fitness of the patient. Surgical judgment based on these multiple factors is likely the key to success.

STAGED VERSUS NONSTAGED APPROACHES

Individuals that suffer with digestive tract fistulas and abdominal wall defects often push their surgeon to achieve a quick solution to their problem. One's natural desire would be to perform all procedures necessary in a single setting to correct all the surgical problems and return the patient back to normal activity as soon as possible. Advocates of a single stage approach to this problem cite this advantage, as well as a potential decrease in overall morbidity by avoiding multiple procedures. A second school of thought is that the problems of GI tract fistulas and abdominal wall reconstruction should be handled remotely from one another at separate surgeries to improve the outcomes associated with the abdominal wall reconstruction.

There is no question that when using complex reconstructive techniques such as component separation,

Figure 4 Photograph depicting the “pinch” test prior to surgery for complex abdominal wall reconstruction, repair of an enterocutaneous fistula, and restoration of intestinal continuity.

first popularized by Ramirez and colleagues in 1990,⁸ or flaps, the first attempt will be the easiest and most likely to be successful. Given the contaminated nature of these cases in patients with fistulas or intestinal stomas, we may be able to decrease the rate of infectious complications, improve success rates, and decrease the rates of recurrent hernia by performing the abdominal wall reconstruction well after surgery to repair the fistula. Aside from the risk of infection, the nutritional status of these patients may be far superior after repair of their fistula and a waiting period.

There are no prospective studies that have randomized patients to a staged versus nonstaged approach to these problems. There are several small retrospective analyses of patients that required surgical management of both fistulas and large abdominal wall defects, some of which took a staged approach⁶ and some of which did not.^{9,10} One retrospective review of 19 patients with high-output enteroatmospheric fistulas associated with large abdominal wall defects revealed a 31.5% refistulization rate after the initial procedure performed to repair the digestive tract fistula.⁶ The investigators used a staged approach to abdominal wall reconstruction employing the use of flap procedures, but unfortunately did not report the results of the reconstruction in their manuscript. It is certainly reasonable to assume that the cases where refistulization occurred would have likely failed any abdominal wall reconstructive attempt had the procedures been performed concomitantly.

A retrospective study of 32 patients that had either intestinal stomas or enterocutaneous fistulas in the presence of large abdominal wall defects who subsequently underwent single-stage closure of the gastrointestinal tract and their abdominal wall defect using a component separation technique reported a 28% rate of wound complications, 21% recurrence of hernia, and 26% recurrence of fistulas with a median follow-up of 20 months.⁹ The authors concluded that the rates of hernia recurrence and refistulization were acceptable, but this point is certainly debatable. Because of the difficulty associated with the care of these patients, the United Kingdom has established specialized intestinal failure units to assist in, and potentially improve the care of these difficult cases.¹⁰ The standard management in one of these units is to perform repair of the fistula with concomitant abdominal wall closure/ reconstruction after optimization of the patient's overall condition focusing mainly on nutritional support and control of sepsis. Sixty-one patients underwent 63 operations to close digestive tract fistulas associated with open abdominal wounds. They used primary suture repair, with and without component separation, or suture repair in combination with absorbable or nonabsorbable prosthetic mesh to reconstruct the abdominal wall in these individuals. The observed postoperative mortality rate

was 4.8% with respiratory or surgical site infection occurring in 82.5%. Refistulization occurred in 11.1% of the group, but was more common when prosthetic mesh was used (24.1%). Porcine collagen mesh was associated with a particularly high rate of refistulization at 41.7%. These authors discourage the concomitant repair of fistulas with abdominal wall reconstruction and suggest avoiding the use of prosthetic mesh.¹⁰

Jernigan and colleagues³ reviewed their experience with a three-stage approach to complex abdominal wall defects in 274 patients over 8 years. They did not specifically address individuals with fistulas, but all patients were critically ill and were managed with laparostomies. Their management scheme was as follows: stage 1—absorbable mesh insertion for temporary closure (with mesh pleating and delayed closure if edema resolved within 3–5 days), stage 2—mesh removal after 2 to 3 weeks and formation of a planned ventral hernia with placement of a split thickness skin graft over granulation tissue or a full thickness skin closure over viscera, and stage 3—definitive abdominal wall reconstruction after 6 to 12 months using the modified component separation technique. Thirty-nine percent of the patients died during stage 1 because of shock. Of the 166 patients who lived and had absorbable mesh placed, 22% underwent delayed fascial closure. In the stage 2 group there were 9 deaths from multisystem organ failure, with 96% of the remaining 120 patients having a skin graft placed over the viscera. Fourteen fistulas occurred (8% of survivors). To date, 73 of the 120 have undergone definitive abdominal wall reconstruction with no deaths and a 5% rate of recurrent hernia at a mean follow-up of 24 months. This large, but retrospective, study demonstrates nicely how a well thought out and staged reconstructive plan can result in low mortality with good long-term results.

ABDOMINAL WALL RECONSTRUCTION VERSUS PROSTHETIC CLOSURE OF A FASCIAL DEFECT

Component Separation Technique

All techniques used in abdominal wall reconstruction are associated with considerable operative risk. There is no "one best way," or simple approach to this complex problem. Component separation techniques (CSTs) and flap reconstructions tend to be technically more demanding and can be associated with an increased incidence of wound problems depending on the approach used; however, they tend to provide a functional abdominal wall reconstruction. Simple mesh underlay closure of fascial defects results in a durable hernia repair in many, but often leaves the patient with a large area of laxity on the anterior abdominal wall. The lack of a functional anterior abdominal wall may limit their physical activity

in the future, and the appearance often results in complaints related to cosmesis. It is important to consider a patient's functional status and expectations when determining which approach will be used for abdominal wall reconstruction/ hernia repair.

The CST originally popularized by Ramirez and colleagues⁸ involves separating the rectus muscle from the posterior rectus sheath and the external oblique muscle from the internal oblique thereby resulting in the ability to advance the native tissue ~5 cm at the epigastrium, 10 cm at the waistline, and 3 cm in the suprapubic region unilaterally. A bilateral CST can result in closure of defects measuring 10 cm in the epigastrium, 20 cm at the waistline, and 6 cm in the suprapubic region. This can be achieved with or without mesh reinforcement, and restores a dynamic and functional abdominal wall. There are several reports in the literature (see Table 1) on the success of CST in the management of large ventral hernias, revealing rates of hernia recurrence from 6 to 52%.^{8,11-23} One study reported on the use of intraoperative tensiometry to determine which patients could be closed primarily using CST versus which should be closed using prosthetic mesh.²³ Prosthetic mesh was required in 39% and they achieved a rate of hernia recurrence of 18% at 56 months mean follow-up. It may seem intuitive, but it is worth stating that larger hernia defects are more likely to recur and they are more likely to require mesh bridging techniques whether or not CST is used. It is ideal to obtain medial mobilization of native tissue through the use of CST and to perform a primary repair which is buttressed by a mesh underlay. Some defects are so large that bridging will still be required even after performance of component separation. One can expect higher recurrence rates in these scenarios.

A randomized comparison of CST to prosthetic mesh closure with an expanded polytetrafluoroethylene (PTFE) patch was undertaken in 39 patients.¹⁸ Wound complications were more frequent in the prosthetic group and 38% of the patients closed with mesh required its removal later because of infectious complications. Recurrent hernia was noted in 52% of those undergoing CST and in 36% of those with prosthetic repair. Although it is difficult to draw sweeping conclusions from a study of this size, the two methods appeared to be equivalent in this small group. Several minor modifications of the CST technique have been reported in the literature with varying reported success rates including inverting the skin graft overlying the bowel instead of excising it,²⁴ using a posterior components separation technique,²¹ using a so-called open-book variation,¹⁴ and the use of a subfascial absorbable mesh buttress combined with a rectus turn-over flap.¹⁵ All of these reports involved either single cases or very small groups of patients.

CST is likely effective because it aids in the reduction of tension allowing the reapproximation of

the patient's native tissue and also helps to reverse the loss of domain that is noted in some of these giant abdominal wall defects. Hadad and colleagues²⁵ analyzed 10 patients that had preoperative and postoperative CT scans of the abdomen and pelvis after CST repair of large abdominal wall hernias with associated loss of domain and noted significant increases in the intra-abdominal volume without any significant change in diaphragmatic height. This suggests that this technique allows for restoration of lost domain without the unfavorable result of pulmonary compromise secondary to a loss of thoracic volume.

One of the major criticisms of the CST approach is the large bilateral skin flaps that result from the dissection necessary for exposure during the procedure. These flaps are largely responsible for the reported rates of wound complications associated with this procedure. Several approaches have been devised to avoid the seroma and potential infections that are often common. Kingsworth and colleagues²² reported the use of fibrin sealant when extensive flaps were created beyond the semilunar line with a resulting seroma rate of 9.5% and a surgical site infection rate of 1.7% in 22 patients. The use of numerous "quilting" mattress sutures has been described to eliminate dead-space with the potential decrease in seroma formation, but has not been studied prospectively. Rosen et al¹⁹ described the use of a laparoscopic component separation technique in seven patients that altogether eliminates the large flaps created using the open technique. They describe the use of a balloon dissector that is traditionally used in the totally extraperitoneal endoscopic (TEPP) inguinal hernia repair technique to open the space beneath the external oblique muscle through a small incision just off the tip of the 11th rib. An additional laparoscopic port is placed in the lower lateral abdomen and the aponeurosis medial to the external oblique is released along its length laparoscopically. Release of Scarpa's fascia should also be performed, although care must be taken not to divide the linea semilunaris itself. The remainder of the reconstruction at the midline was completed using open technique and they report no recurrences after a short 4.5-month follow-up. Study of this method in a porcine model comparing it to a traditional open CST revealed that the minimally invasive technique yielded only 86% of the medial mobilization of the rectus that was achieved with the open technique.²⁶ This difference was not statistically significant. Dr. Rosen has since modified this technique where the entire procedure is performed laparoscopically with closure of the rectus muscles using interrupted figure of eight sutures placed utilizing a suture passer. Milburn and colleagues²⁷ described a technique in cadavers where the transversus abdominus fascia and posterior rectus sheath were incised laparoscopically with no skin undermining on one side, while a traditional Ramirez CST was performed on

Table 1 Current Literature on Component Separation

First Author	Year	Patients	Method	Complications (n)	Reherniation N (%)	Follow-up Mean (Range, Months)	BMI Mean (Range)
Ramirez ⁸ de Vries Reilingh ¹⁵	1990	11	CST	0	0 (0.0)	? (4–42)	Not reported
	2003	43	CST	Wound infection (6) Hematoma (5) Seroma (2) Skin necrosis (1) Fascial Dehiscence (1)	12 (30)	15.6 (12–30)	27.3
Lowe ¹⁷	2003	30	CST In 10 patients, an onlay polypropylene mesh was implanted as well//	Wound infection (12) Skin ischemia (6)	3 (10)	9.5 (1–26)	33.2
				Skin dehiscence (13) Hematoma (1) Seroma (3) ECF (1)			
Ewart ¹⁸	2003	11	CST 4 with mesh onlay 3 with tissue expansion	Wound breakdown or infection (3)	1 (9)	10 (1–60)	31 (13.8–59.2)
Ennis ²⁰	2003	10	Open-book CST 2 patients had mesh.	Cellulitis (5) Skin-edge necrosis (1) Infected mesh (2)	1 (10)	26.5 (1.25–53)	Not reported
Tobias ²¹	2003	21	CST with double-layer subfascial Vicryl buttress	ACS (2)	1 (5)	13.5 (0.5–24)	Not reported
Vargo ¹³	2004	27	CST 2 with prosthetic mesh 2 with porcine mesh	Incisional hernia (1) Skin dehiscence (4) Abscess (2) Hematoma (1)	2 (7)	? (6–27)	Weight range 48–149 kg
				Minor complications: 7 Wound infection (7) Seroma (5)	2 (11)	48 (6–144)	Not reported
Howdieshell ¹⁶	2004	46	CST in 18 patients Direct fascial closure in 20 patients TFL Flap in 4 patients Nonabsorbable mesh in 4 patients	Flap donor site infection (1)			
de Vries Reilingh ¹¹	2007	19	CST	Hematoma (1) Seroma (4) Skin necrosis (2) Wound infection (3)	10 (53)	? (5–36)	28.2 (23.9–38.7)

Table 1 (Continued)

First Author	Year	Patients	Method	Complications (n)	Reherniation N (%)	Follow-up Mean (Range, Months)	BMI Mean (Range)
Rosen ²³	2007	7	CST with AlloDerm underlay	Wound Infection (1) Hematoma (1)	0	4.5 (2–6)	37 (30–45)
Shabatian ¹⁴	2008	17	CST 1 reinforced with Marlex and 1 with Surgisis	Seroma (3) Abscess (2) Cellulitis (1) SBO (1)	1 (6)	21	31 (23–41)
CarboneJJ ¹⁹	2008	20	PCST w/ mesh underlay	Wound infection(3) Bowel obstruction (2)	1 (20)	10 (1–27)	31.5 (21.6–39)
Kingsnorth ²²	2008	116	Open only polypropylene with gap mesh versus tensions free repair	Seroma (11)	4 (3.4)	15.2	Weight (kg)
Dragu ¹²	2009	14	Direct suture versus component separation	Wound infection (10) Seroma (5) Secondary wound healing (2)	3 (18)	6	Mean 86, Median 85 30 (21–42)

Marlex, Chevron Phillips Chemical Co LP, The Woodlands, TX; Surgisis, Cook, Bloomington, IN; Vicryl, Ethicon, Somerville, NJ.
ACS, abdominal compartment syndrome; BMI, body mass index; CST, component separation; ECF, enterocutaneous fistula; PCST, posterior component separation; SBO, small bowel obstruction; TFL, tensor fascia lata.

the opposite side. There was no significant difference noted in the amount of medial mobilization when both techniques were compared. This method could potentially be used to perform a modified CST completely laparoscopically without a large open incision. Another minimally invasive method of achieving a lateral release has been described by creating small tunnels from the midline incision instead of large flaps.²⁸ Although this technique is approached through a large midline incision, it avoids the creation of large flaps with their attendant wound morbidity. Laparoscopic and other minimally invasive approaches to component separation are relatively new and no randomized comparisons of these techniques to traditional techniques have been undertaken.

Biologic Mesh/Sheet Prosthetics

As stated, these procedures are often considered contaminated or grossly infected when performed in patients with a digestive tract fistula or intestinal stoma. This is certainly the case when an abdominal wall reconstruction / hernia repair is performed in a single stage setting with repair of a fistula. This precludes the placement of a permanent prosthetic or alloplastic mesh to bridge a fascial defect or reinforce a primary closure secondary to risk of infection that would necessitate removal of the prosthesis. The advent of biologic prosthetic sheets has given the surgeon one more tool in the armamentarium to care for these complex patients. Although biologic meshes can still get infected in 0 to 40% of cases,^{29–47} they appear to be more suitable for placement in contaminated operative fields than do permanent synthetic prosthetics.

There are currently numerous biologic mesh products available on the market and a discussion of each is beyond the scope of this article. The majority of products are collagen based and this collagen can be either cross-linked or noncross-linked. They are all somewhat different in the way they are processed, and all products claim to support normal host fibroblast and vascular ingrowth. Each manufacturer claims that their product is either integrated into or replaced by host tissue. There is a paucity of high-quality data to support any of these claims, but what is certain is that these materials can be used safely in complicated scenarios to assist in the achievement of abdominal wall closure and visceral coverage when permanent synthetic options cannot be used. The burning question that has not been answered is, “Are they any better than placing an absorbable synthetic mesh like Vicryl (Ethicon, Somerville, NJ)?” They are certainly more expensive. The majority of data involves the use of AlloDerm (Lifecell Corp., Branchburg, NJ), a human acellular noncross-linked dermal matrix, and Surgisis (Cook Surgical, Bloomington, IN), a lyophilized, noncross-

linked porcine small intestinal submucosal collagen matrix. The majority of available data on abdominal wall reconstruction involves the use of AlloDerm and Permacol (Covidien plc, Dublin, Ireland), a cross-linked porcine dermal matrix. Cross-linked biologic prosthetics tend to be stronger and have higher bursting strengths, whereas noncross-linked biologics allow for more host cellular ingrowth and “resorb” faster *in vivo*. It is our experience that cross-linked prosthetics become encapsulated as opposed to incorporated into host tissues. This may or may not be desirable to the operating surgeon. It is important to note that a completely cross-linked prosthetic will not incorporate into host tissues at all, whereas partially cross-linked prosthetics will incorporate to some degree.

There are a variety of retrospective reports in the literature on the use of AlloDerm in hernia repair and abdominal wall reconstruction.^{29–47} These studies included between 10 and 144 patients revealing hernia recurrence rates between 0 and 100% with variable follow-up (see Table 2). There is unfortunately a fair amount of heterogeneity in the approach to reconstruction within each study, making it difficult to draw definitive conclusion from the data. The use of Permacol has also been investigated in reports including between 1 and 28 patients with hernia recurrence rates of 0 to 15% with a variable length of follow-up.^{29–32} Several studies on the use of Surgisis to repair both ventral and inguinal hernia defects in contaminated environments have been published.^{33–35} These studies have included between 20 and 53 patients with mean follow-up periods of 14 to 19 months, and showed hernia recurrence rates of 0 to 30%. All ventral repairs completed in these studies were performed using a fascial bridging technique. One study of the use of a noncross-linked porcine dermal scaffold in the abdominal wall reconstruction of 16 patients reported a 7% hernia recurrence rate after 16.5 months of follow-up.⁴⁷ Importantly, the majority of these patients underwent CST and they achieved complete apposition and closure of the rectus muscles in 88%. The porcine matrix was used as a reinforcing underlay in the majority of these patients, but was used as a bridge graft in those where rectus apposition could not be achieved. The only recurrence was noted in a patient who was “bridged” (Fig. 5).

There is some controversy as to whether or not bridging a fascial defect with a biologic prosthetic is an adequate hernia repair. Blatnik and colleagues⁴⁰ retrospectively reviewed their experience with 11 patients that had large complex hernias bridged with human acellular dermal matrix and found that they had an 80% hernia recurrence rate at a mean follow-up of 24 months at a cost of \$5,100 per patient. They comment in the title of their manuscript that bridging with a biologic may just result in an expensive hernia sac. Another study showed that a biologic mesh-reinforced primary repair (involving CST

Table 2 Current Literature Regarding Biologic Mesh in Ventral Hernia Repair and Abdominal Wall Reconstruction

First Author	Year	Patients	Method	Material	Complications (n)	Reherniation n (%)	Follow-up Mean (Range, Months)	BMI Mean (Range)
Liyanage ²⁹	2006	1	Underlay	Permacol	Seroma and superficial wound dehiscence	0	12	Not reported
Parker ³⁰	2006	9	Underlay	Permacol	Wall abscess (1) Skin dehiscence (1)	1/9	18.2	Obesity in 5 patients
Shaikh ³¹	2007	20	Underlay	Permacol	Death (1) [MOF] Seroma (2) Minor wound infection (2) Hematoma (1) Skin-edge necrosis (1) Superficial wound dehiscence (1) Wound sinus (1) Superficial wound dehiscence (1)	3 (15)	18 (6–36)	Median weight 72 kg (62–110)
Hsu ³²	2009	28	Underlay	Permacol	Superficial wound dehiscence (1) Cellulitis (1) Fluid collection (4) Wound infection/ECF (1) Wound infection (8) Seroma (2) Death (1) [CHF POD #30] Partial dehiscence (13) Reactions to mesh (6)	3 (10.7)	16	34 (19.1–61.4)
Franklin ³³	2004	53	Laparoscopic Underlay	Surgisis		0	19 (1–30)	Not reported
Ueno ³⁴	2004	20	Onlay 3 Underlay 17	Surgisis		6 (30)	15.7	Not reported
Helton ³⁵	2005	53	Laparoscopic 13 CST 3 with interpositional in 2 Onlay 3 Underlay 40	Surgisis		9 (17)	14 (2–29)	32
Jin ³⁶	2007	37	Onlay 3	AlloDerm	Infection (13) Hematoma (1) Death (2) [MSOF] Death (1) [POD 20, DIC preexisting]	12 (35) (Interpositional 8)	22.2 (15–37)	Bridge 34.8 Reinforcement 29
Espinosa de los Monteras ³⁷	2007	39	Interpositional 11 Underlay 1 Sandwich 22 82% primary closure with overlay 18% underlay mesh with overlay HAD	AlloDerm	DVT (3) Partial dehiscence (6) Seroma (3) Hematoma (1)	5%	15	34 (22–62)

Table 2 (Continued)

First Author	Year	Patients	Method	Material	Complications (n)	Reherniation n (%)	Follow-up Mean (Range, Months)	BMI Mean (Range)
Patton ³⁸	2007	67	Onlay 5 Interpositional 28 Underlay 34	AlloDerm	Seroma (3) Recurrent Fistula (3) Superficial wound infection (8) Deep wound infection (3) Dehiscence (6) Intraabdominal bleed (2) Evisceration (1) Death (1) [MOF]	12 (17.9)	10.6 (0–38)	Not reported
Bellows ³⁹	2007	20	Underlay	AlloDerm	Dehiscence (6) Intraabdominal bleed (2) Evisceration (1) Death (1) [MOF]	6 (30) Laxity in 10%	9.3 (2–16)	32
Blatnik ⁴⁰	2008	11	Interpositional	AlloDerm	None reported	8 (80)	24 (18–37)	40 (16–73)
de Moya ⁴¹	2008	10	Underlay	AlloDerm	Hematoma (1) Infected mesh (1) Abscess (1) Dehiscence (1) Death (1) [MOF]	1 (10) Laxity in 60%	? (1–12)	Not reported
Misra ⁴²	2008	70	Onlay 10 Interpositional 1 Underlay 59 CST with onlay	AlloDerm	Rejection (1) Infection (2)	14 (20)	? (1–12)	Not reported
Bluebond-Langner ⁴³	2008	27	AlloDerm 18 CST with interpositional 9 CST with AlloDerm (+) Prolene onlay 2 Underlay	AlloDerm	Intraabdominal abscess (1) Wound infection (6)	0 Laxity in 26%	(~13)	31.6 (23–43)
Taner ⁴⁴	2009	11	Underlay	AlloDerm	Seroma (3) Superficial wound infection (2) ECF (1)	0	(~12)	Not reported
Maurice ⁴⁵	2009	63	Onlay 4 Interpositional 18 Underlay 41	AlloDerm	Seroma (17) Hematoma (1) ECF (2) Sinus (5) Skin breakdown (13) Dehiscence (4)	26 (68)	7.3 (0.29–26.5)	38 (19–70)
Lin ⁴⁶	2009	144	Onlay 3 Interpositional 34 Underlay 103 Unknown 4	AlloDerm	Infection (39) Seroma (14) Fistula (11) SBO (1)	39 (27.1) Laxity in 7.6%	5.75 (0–25)	35.2 (17.97–67.81)

Table 2 (Continued)

First Author	Year	Patients	Method	Material	Complications (n)	Reherniation n (%)	Follow-up Mean (Range, Months)	BMI Mean (Range)
Pomahac ⁴⁷	2009	16	CST and Underlay 7 Underlay 9	Xen-Matrix	Seroma (3) Superficial wound dehiscence (1) Infection (1) Death (2)	1 (17)	16.5	27.5 (22.5–3.2)

AlloDerm, LifeCell, Branchburg, NJ; Surgisis, Cook, Bloomington, IN; Permacol, Covidien plc, Dublin, Ireland; XenMatrix, Brennen Medical LLC, St. Paul, MN; Prolene, Ethicon, Somerville, NJ. BMI, body mass index; CHF, congestive heart failure; CST, component separation; DVT, deep vein thrombosis; DIC, disseminated intravascular coagulation; ECF, enterocutaneous fistula; HAD, human acellular dermis; IBD, inflammatory bowel disease; MOF, multi-organ failure; MSOF, multi-system organ failure; POD, post-operative day; SBO, small bowel obstruction; SSI, surgical site infection.

in most) had only a 20% recurrence whereas 80% of patients who were bridged with the same biologic had hernia recurrence.³⁶ Somewhat confusing the situation, the hernias that were bridged in this study were significantly larger than those that were not. Additional investigators sought to compare their results with biologic onlay reinforcement of CST abdominal wall reconstructions to a group of historical controls where onlay reinforcement was not used.³⁷ They found that decreased recurrence rates were seen only in medium-sized hernias (those that did not have to be bridged) as opposed to larger defects. There have been other reports that surgical site infection is more common with larger biologic implants,⁴⁵ and that hernia recurrence in those treated with biologic implants are more common in women, increased body mass index, prior failed repair,⁴⁶ and with use of the ultra-thick form of human acellular dermal matrix as opposed to the thick variety.⁴²

Another controversy that exists regarding the use of biologics in abdominal wall reconstruction is the issue of what defines a recurrent hernia versus simple abdominal wall laxity. Unfortunately, the difference between these two, if one exists, is often not addressed in manuscripts that discuss hernia recurrence rates. In one of the few studies that do, Bleubond-Langner and colleagues⁴³ comment in their manuscript that bridging was performed in 9 of the 27 patients in their study group who underwent repair of large abdominal hernias using AlloDerm as an underlay in combination with CST. Two of the 9 patients also had a polypropylene mesh onlay constructed over the biologic. Laxity was seen at 1-year follow-up in 7 of the 9 that did not have a polypropylene mesh onlay performed. Another small retrospective study of 10 trauma patients that had large abdominal wall defects bridged with AlloDerm showed that laxity occurred in all (follow-up completed in only 60%) at the 1-year follow-up visit.⁴¹ AlloDerm in particular has been associated with abdominal wall laxity with long-term follow-up, and this is believed to be related to the elastin content in the graft. The manufacturer suggests pre-stretching the graft and placing it under some tension to minimize this complication.

In the situation of a staged abdominal wall reconstruction in a patient that has previously undergone fistula repair, and the latter stage is considered clean, a synthetic prosthetic mesh may be appropriate to use. The issue of bridging versus complete myofascial reapproximation is, however, pertinent in the select patient population with complex abdominal wall defects. Although the idea of tension-free hernia repair has made its way from use in the inguinal region to use in ventral hernia repair; it may be that this concept is fundamentally flawed for these patients. It is obvious that bringing a patient's fascia together in the midline under extreme tension is at risk of failure in many cases; however, a certain amount of tension on a repair is

Figure 5 Photograph depicting a “bridge” type hernia repair using a biologic mesh in a patient undergoing abdominal wall reconstruction and takedown of an end ileostomy.

desired. When surgeons place a piece of prosthetic mesh as an underlay to bridge a fascial defect, a degree of tension is intentionally placed upon the underlay mesh to fascia interface. A prosthetic placed with no tension at all results in a palpable bulge or soft spot at the location of the fascial defect. This is undesirable to many patients both physically and cosmetically. Mesh should likely either be placed under some tension to flatten abdominal contour, or a component separation should be performed to achieve complete myofascial approximation and a functional abdominal wall reconstruction. This issue is controversial and is not strongly supported by data; however, a 2005 review of 188 patients with large abdominal hernias showed a recurrence rate of 31% in patients treated with a fascial-bridging synthetic prosthetic versus 9% in those that had complete restoration of myofascial continuity of the abdominal wall.⁴⁸ It is our recommendation that primary fascial closure be performed whenever possible while using a prosthetic underlay to reduce hernia recurrence. This applies to both synthetics and biologics, but is certainly more important when using a biologic with the intention of performing a durable hernia repair.

RECOMMENDATIONS

The issue of abdominal wall reconstruction in a patient with a digestive tract fistula is a complex problem. These patients are seen infrequently outside of major specialized centers because of the difficulty associated with their

treatment. There are only a limited number of studies that address this problem and all are retrospective with relatively small numbers of subjects. This leaves us to use our best judgment and the available data to make treatment decisions that will have a lifetime of impact. One must first consider the ultimate goal of treatment, and then determine the patient's comorbidities and functional status, as well as the patient's expectations.

Often ridding an elderly or obese patient of a fistula and taking a “patch the tire” approach to hernia repair may be all that is required or possible. However, when faced with a young and active patient with an average build who developed a fistula after sustaining a posttraumatic open abdomen, the approach toward complete abdominal wall reconstruction through total myofascial reapproximation is quite justified and will likely impart the best outcome. Given the complexity of these two processes, a staged approach to abdominal wall reconstruction is to be advised. Repair the fistula first, obtain temporary abdominal wall closure or a planned ventral hernia, and come back 6 months later to reconstruct the abdominal wall definitively. This approach to timing can also be taken if the goal is simply to bridge a fascial defect. One can expect improved success if the fistula repair and hernia repair are performed remote from one another. Bridging large fascial defects with the currently available biologic meshes cannot be considered a durable hernia repair based on the available evidence. Although this may suffice as a bailout procedure in many situations, it is probably little more effective than simply

placing an absorbable synthetic mesh instead. Given the cost associated with the available biologics, their use in this particular situation is ill-advised. Biologics certainly seem to be useful as buttresses to repairs in which the fascia can be closed primarily, and are a better choice in a contaminated procedure. Though not discussed within this article, there are several techniques for abdominal wall reconstruction that employ the use of free and rotational flaps as well as the use of tissue expanders. These methods may be required in the most complex of cases and should be undertaken with the assistance of an experienced plastic surgeon.

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