Controversies in the Care of the Enterocutaneous Fistula

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KEYWORDS
- Enterocutaneous fistula
- Enteroatmospheric fistula
- Abdominal wall reconstruction
- Complications

KEY POINTS
- The entities of enterocutaneous fistula (ECF) and enteroatmospheric fistula (EAF) remain a formidable challenge to surgeons facing affected patients.
- Awareness of its causes, contributing factors, potential preventive measures, and various management strategies are crucial to achieving optimal outcomes in the care of these patients.
- Due to a lack of high-quality evidence supporting any particular regimen of care, the surgeon is required to exercise skillful judgment in treating these individuals.

BACKGROUND AND OVERVIEW

The appearance of enteric contents from an abdominal incision is a devastating complication and can be emotionally distressing for both the patient and the operative surgeon. ECFs range from easily controlled low-output colocutaneous fistulas to high-output EAFs requiring prolonged nutritional support, specialized wound care, and complex reoperative surgery. These patients frequently face complications, and a well-organized multidisciplinary approach must be implemented in their care.

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management to improve outcomes. Furthermore, in a hospital setting with limited resources, consideration should be given to having these patients evaluated in a center with specialized experience in dealing with ECFs. A great deal of controversy surrounds nearly every aspect of the care of these patients. A dearth of homogenous patient populations and the preponderance of case reports and case series make this situation unlikely to change soon.

It is important to highlight up front that the presence of an ECF is accompanied by a significant risk of mortality, reported between 5% and 20%,\textsuperscript{1,2} with the variability owing to the heterogeneity of this cohort of patients. In addition to the significant mortality rates, the morbidity associated with ECFs is excessive. A prolonged hospital course, as well as extensive postoperative rehabilitation, often with nutritional supplementation, is common. The cost to the health care system and the psychological impact on the patient are difficult to quantify. However, ample data show increased intensive care unit length of stay, hospital length of stay, and hospital cost.\textsuperscript{3}

A postoperative ECF (Fig. 1) seldom poses a diagnostic dilemma. It is defined as an abnormal communication between a bowel lumen and the skin and is frequently defined based on anatomic origin or cause.\textsuperscript{4} It most commonly results from prior abdominal operations but can occur from trauma, Crohn disease, diverticulitis, malignancy, hernia mesh erosions, and, less commonly, intra-abdominal infections such as tuberculosis, typhoid, and actinomycoses.\textsuperscript{3–5} Postoperative ECFs most commonly result from operations for malignancy, inflammatory bowel disease, or adhesiolysis, as well as emergency abdominal procedures.\textsuperscript{6}

ECFs are arbitrarily classified as low or high output based on the amount of drainage in a 24-hour period. Less than 200 mL/d is considered low output, greater than 500 mL/d is classified as high output, and the intermediate group is defined as such. Adequate quantification of volume output is critical not only in defining the fistula but also in predicting the likelihood of closure and in planning for any subsequent surgical intervention.\textsuperscript{7,8}

A significant subset of ECFs close with nonoperative treatment, including control of any infectious source, nutritional support, and appropriate wound care. It has been demonstrated that patients with high-output fistulas have a higher mortality, and there is some evidence, albeit less clear, that these fistulas demonstrate a lower likelihood of spontaneous closure.\textsuperscript{9,10} Medical students are taught the familiar but still useful acronym “FRIENDS” to delineate those fistulas less likely to close spontaneously.

Fig. 1. Patient with a postoperative enterocutaneous fistula being managed with negative pressure wound therapy.
The presence of a Foreign body, prior Radiation exposure, the diagnosis of Inflammatory bowel disease or ongoing Infection, the presence of an Epithelialized fistula tract, a Neoplasm, the presence of a Distal obstruction or Sepsis/Steroids all make it unlikely for these fistulas to close spontaneously.\textsuperscript{11} Based on multiple studies, only around a third of ECFs heal without additional reoperative therapy.\textsuperscript{1} However, every attempt should be made to use nonoperative techniques to maximize the chances that spontaneous closure can occur.

Once the diagnosis of an ECF is made, the priority is control of sepsis and fluid resuscitation.\textsuperscript{12} These patients are generally several days into their postoperative course and have often been receiving inadequate or no nutritional supplementation secondary to a prolonged ileus. In addition, they may have already experienced protein loss and catabolism and frequently have sepsis from a localized wound infection or deep abscess.\textsuperscript{13} If the patient has a high-output fistula, consideration should be made for placing a urinary catheter and aggressively resuscitating the patient with crystalloids. Electrolyte levels should also be monitored and replaced as necessary.

Abdominal computed tomography should be performed soon after the diagnosis is made. This procedure is critical not only for assisting in the anatomic delineation of the fistula but also for excluding intra-abdominal sources of sepsis. Any intra-abdominal abscess should be drained with radiological assistance if possible.\textsuperscript{14} This procedure is necessary in more than 10\% of patients,\textsuperscript{16} and allows egress of the intestinal contents lateral to the abdominal incision, which can ameliorate or delay return to the operating room.

**NUTRITION**

Nutritional disturbances are present in 50\% to 90\% of patients with an ECF and contribute significantly to the overall morbidity and mortality.\textsuperscript{16,17} Adequate nutrition is essential for these patients but much more difficult to achieve in practice. Before the development of parenteral nutrition, there was a significantly reduced mortality in patients who could tolerate a 3000-kcal/d diet.\textsuperscript{18}

One of the most significant advances in the treatment of ECF was the development of parenteral nutrition in the 1960s. Although initial reports demonstrated up to a 70\% spontaneous fistula closure rate and a mortality of 6\% solely with the use of intravenous alimentation, these results have not been replicated.\textsuperscript{19,20} What has been shown as the fistula closure rate is twice as likely to occur spontaneously in patients receiving nutritional supplementation.\textsuperscript{21,22} For patients with long-standing small-bowel fistulas, supplemental copper, folic acid, and vitamin B12 may be necessary, as trace minerals and vitamins also become depleted.\textsuperscript{6}

Traditional surgical dogma based on early reports using hyperalimentation states that bowel rest along with total parenteral nutrition (TPN) leads to a higher incidence of spontaneous closure of an ECF. This teaching is based on the principle that this therapy results in a reduction in secretions within the gastrointestinal tract, thereby reducing fistula output and leading to a more rapid time to resolution.\textsuperscript{1} The average time standard for spontaneous closure of ECFs on parenteral nutrition is 25 days,\textsuperscript{1} although they may take up to 12 weeks. However, most studies in the literature involve heterogeneous patient populations and are predominantly retrospective in nature, making it difficult to compare and contrast the various studies and predict accurately the timing and rate of spontaneous closure.\textsuperscript{15}

There is insufficient evidence to demonstrate that parenteral nutrition is superior to enteral nutrition with regards to spontaneous closure rates. The concern that enteral nutrition contributes to or worsens fistula output is likely unfounded.\textsuperscript{23} and enteral
nutrition has actually demonstrated a lower fistula formation rate in patients with trauma managed with an open abdomen. More appropriately, parenteral nutrition should be reserved for patients who do not tolerate enteral feedings secondary to postoperative ileus or have an inability to maintain adequate nutrition via the enteral route. Enteral nutrition is the preferred route of administration for nutrition unless there is a clear contraindication to enteral feedings.

It continues to be a difficult task to accurately assess the nutritional status of patients with ECFs. These patients frequently receive significant volume resuscitation, making accurate determinations based on weight impossible. The prolonged half-life of albumin makes it an impractical tool for use in these patients. Transferrin has a serum half-life of 8 days, making it better suited for use in these rapidly improving patients. It has been demonstrated that a decrease in transferrin levels is associated with increased mortality and significantly lower rates of spontaneous fistula closure. Serum transferrin has also been shown to predict which patients will have more favorable outcomes following surgical management. In addition, techniques involving bioelectric impedance analysis (measurement of body composition) have been demonstrated to have some validity but have not found widespread use.

Some investigators have also advocated routine nasogastric tube decompression. The dogma contends that by decreasing the secretions from the oropharynx, the esophagus, and the stomach, there is a resultant decrease in the fistula output, aiding in spontaneous closure. In reality, the placement of a nasogastric tube to decompress the stomach likely contributes little to the management of the patient with an ECF, unless an ileus is present, but undoubtedly contributes to the discomfort of the patient.

**MEDICAL MANAGEMENT**

Somatostatin is a naturally occurring hormone principally produced by the delta cells of the pancreas. Somatostatin and its analogues have an inhibitory effect on digestion through reduction in enteric secretions, suppression of gastrointestinal hormones, decreased rate of gastric emptying, and splanchnic vasoconstriction. Based on these inhibitory properties, it is no surprise that somatostatin has been advocated for use in the management of ECFs. By reducing the volume of output, it is thought that somatostatin may expedite spontaneous fistula closure. Owing to the short half-life of somatostatin (1–2 minutes), which requires continuous infusion, several longer-acting analogues have been developed. Octreotide has been widely used in the treatment of ECFs, and with a half-life of 113 minutes, it allows intermittent subcutaneous dosing.

Somatostatin and associated analogues have been used in adjunct in the conservative management of ECFs. When combined with TPN, there seems to be a synergistic effect on the reduction in the levels of gastrointestinal effluents and an improvement in fistula closure rates. However, a definitive evaluation of the efficacies of somatostatin and its analogues for the treatment of ECFs is difficult. The literature is limited by the large number of case reports and small patient series, whereas the few controlled trials comparing these drugs with placebo are weakened by the small size and heterogeneity of the patient populations.

The clinical efficacy of this therapy is measured by examining 3 parameters: fistula output volume, time to closure, and fistula closure rates. A medication that reduces fistula output would be beneficial to a patient with a high-output fistula with regards not only to prognosis but also to improved quality of life. Investigations have demonstrated that both somatostatin and octreotide are effective in reducing the fistula volume output, with some reports of a 70% reduction in output after the first day of
treatment.29,32–34 The time to closure is important, as it directly relates to the length of stay, medical cost, and complications. Although the literature is not unanimous on the benefits of somatostatin or octreotide on closure time, several controlled trials have demonstrated a significant improvement.32,35–38 Therefore, there seems to be a positive effect on closure time of ECFs from these medications. On the other hand, most studies have shown that somatostatin and its analogues have no effect on the actual rate of closure in patients administered these medications along with conservative therapy.28,34,37,38 Although this may seem like a failure of conservative therapy, it is more likely related to the nature of the individual fistula, such as its location or the presence of a distal obstruction, foreign body, or malignancy.

In addition to somatostatin, there are other pharmacologic adjuncts that have been used primarily or in conjunction with other therapies. Proton pump inhibitors and H2 receptor antagonists have been shown to decrease gastric secretions and have therefore been advocated by some investigators in an attempt to reduce the output from ECFs.3,6,13 However, there is no evidence that these medications either decrease fistula output or increase the rate of spontaneous fistula closure.

In patients with Crohn disease, there has been a documented rate of ECF closure following the administration of 6-mercaptopurine and cyclosporine.39,40 In addition, there has been some interest in the use of infliximab, a primary monoclonal antibody to tumor necrosis factor alpha, in patients with a Crohn disease–related fistula.41,42 Although most patients evaluated had perianal fistulas, there are some encouraging preliminary results using infliximab in patients with ECFs as well. These treatments are obviously for use in an isolated patient population with inflammatory bowel disease and not for postoperative fistulas, as sepsis would preclude their use.

In addition, there have been case reports of ECFs being successfully treated with fibrin glue or fistula plugs.3,13,43 These options are certainly attractive to surgeons searching for less-invasive means of treating these patients; however, there is little evidence that these treatments are justified. Although they add no additional morbidity, cost remains a factor.

WOUND CARE

Enteric contents coming in direct contact with the skin, in particular small bowel effluent, can result in significant skin breakdown, excoriation (Fig. 2), maceration, and severe pain and discomfort for the patient.44 It is of primary importance to adequately control the effluent. For low-output fistulas, nothing more than a simple gauze dressing may be required. However, with high-output fistulas, the benefit of a skilled enterostomal therapist is invaluable.44

Vacuum-assisted devices for wound closure have been counted as both the solution and potentially the cause of ECFs. When these devices were first used in the treatment of patients with open abdomens, multiple reports were made of fistula formation as the result of applying negative pressure directly on the intestine.45 A prospective randomized study of patients undergoing vacuum-assisted fascial closure versus mesh closure showed a significantly higher incidence of ECF associated with the vacuum-assisted device.46 In addition, patients who were treated with a vacuum-assisted device for an existing ECF showed an increase in the development of new fistulas,47 raising significant concerns regarding its use in these patient populations. The role of negative pressure wound therapy (NPWT) in both the management and etiology of ECF remains controversial; however, there are patients who can benefit from this therapy, yet selection remains difficult.3,48,49 Negative pressure dressings have been without a doubt a significant advance in the care of complex wounds.
Manufacturers have devised alternate sponges and recommended decreasing the amount of suction applied to the wound bed in an attempt to decrease the incidence of ECF. A small series has demonstrated improved wound contracture and healing and there have been isolated reports of faster healing when using these devices, yet there remains no definitive answer regarding vacuum assistance.

**ENTEROATMOSPHERIC FISTULA**

Although EAF (Fig. 3) can be viewed as part of the spectrum of ECF, it has several unique characteristics that deserve discussion under a separate heading. In this discussion, coloatmospheric fistula and EAF have been grouped under the same heading of EAF. Unlike many postsurgical complications, EAF is often obvious when it occurs. One is typically in a situation in which a patient is being managed with an open abdomen for at least several days. Despite the best efforts to ensure that the exposed bowel is kept moist and that trauma to the viscera is avoided, a small erosion occurs in a segment of hollow viscera, leading to drainage of intestinal content into the wound. Any attempt to perform simple suture closure of the bowel is ill advised, as it almost always fails and results in a larger opening in the bowel wall.

EAF occurs most commonly in the setting of an open abdomen related to trauma and damage control laparotomy, decompressive laparotomy in the setting of high intra-abdominal pressure, or elective surgery “gone wrong,” with resulting anastomotic leak or missed enterotomy. It also develops in patients who present with an acute abdominal septic process, in whom abdominal closure cannot be achieved at the completion of laparotomy secondary to bowel edema, and in those with large fascial dehiscences where remaining fascial quality prohibits effective abdominal wall closure, resulting in the open abdomen.
Resolution of an EAF, either spontaneously or operatively, involves a lengthy and labor-intensive process. This process can be arbitrarily broken down into phases of treatment, as has been done by many investigators. Regardless of the specifics of any particular management scheme, they all tend to be based on a few sound tenets: recognition and stabilization, anatomic definition/decision, and definitive surgery if needed. This management scheme is similar to that used in the care of an ECF. Major differences are encountered in terms of effluent control, potential prevention, and the complexity of reconstructive surgery. The remainder of this article addresses the above-mentioned issues with specific attention dedicated to several areas of controversy surrounding the management of EAF.

PREVENTION

It is important to stress that the best way to approach an EAF is to prevent its occurrence altogether (Fig. 4). Although this disastrous event may be unavoidable, there are clearly factors that increase its risk such as having an open abdomen for a prolonged time. Some believe that the risk of EAF formation is also increased in patients who have an open abdomen for reasons other than trauma; however, a 2010 report showed that this is not true. Every attempt should be made to close the open abdomen as soon as possible. Although there is an obvious lack of randomized data proving that an increased duration of bowel exposure to the outside environment results in an increased rate of EAF formation, this is clearly the consensus. A report published in 2005 reviewing complications experienced in 344 damage-control laparotomies showed a higher rate of complications, including EAF, if the abdomen was left open longer than 8 days.

The abdomen may not simply be closed at a time of the surgeon’s choosing. Typically, one has to wait for resolution of visceral edema so that fascial closure can be achieved without leading to intra-abdominal hypertension. There are several reported techniques to potentially reduce the rate of EAF formation in the abdomen left open, and there are also several methods reported to decrease time to closure in these patients. Schecter and colleagues advocate covering the viscera with a nonadherent drape and performing a skin-only closure as an intermediate when fascial reapproximation is not possible. Although this seems intuitive, it is based more on expert
opinion than on any data and may result in repetitive trauma to the skin if multiple reoperations are required before definitive closure.

The planned ventral hernia (PVH) approach uses absorbable polyglactin mesh to create a fascial bridge, effectively covering the bowel. If enough skin is available, it can be closed over drains placed between the absorbable mesh and the skin, resulting in a closed peritoneal cavity but a guaranteed ventral hernia in the future. This method was once popular but has fallen to a less-favored position because of the availability of NPWT, biologic meshes, and other early fascial closure techniques. The use of NPWT devices in close contact with the bowel is somewhat controversial. Initial success was tempered by concern over creating EAFs and the potential of promoting anastomotic leakage. Several later reports have either refuted these concerns or have even compared NPWT to absorbable mesh closure in patients with an open abdomen and have shown superior results in the NPWT group. On the downside, a prospective randomized trial comparing NPWT closure to the use of absorbable mesh in this setting showed a higher rate of fistula formation in the NPWT group (21% vs 5%), but this was not statistically significant given the small number of patients in the trial.

One issue that can plague any effort to achieve early fascial closure is progressive retraction of the rectus and oblique muscles laterally while the abdomen is left open (Fig. 5). Even with a reduction in visceral edema, this retraction continues to occur until the linea alba is reapproximated in the midline. Although there are many techniques available to prevent abdominal wall retraction, some have been shown in the literature to assist in achieving early (faster) abdominal wall closure. All these methods have in common the use of some sort of mesh material fixed to fascial edges with
progressive tightening at the midline as visceral edema resolves. NPWT is used as an outer wound dressing over the top of the mesh bridge to control fluids and exudate. A key aspect of these techniques is the use of a nonadherent layer or sheet over the viscera inside the peritoneal cavity to prevent adhesions to the anterior abdominal wall that would otherwise potentially result in a frozen abdomen.

In cases in which several days have passed and early closure seems impractical, one may choose to use biologic mesh bridges to achieve fascial “closure” with either skin reapproximation over drains or NPWT over top of the biologic graft. Although this has been shown to result in a high rate of incisional hernia formation, it achieves the goal of closure over the viscera and has been shown to result in a low rate of bowel fistulization. It is imperative that an experienced member of the surgical team be present during dressing changes for the patient with an open laparotomy wound. This practice can ensure the avoidance of trauma to the underlying viscera and the early recognition of areas of deserosalization that are likely precursors of an EAF. Girard and colleagues reported securing of human acellular dermal matrix sheets to areas of intestinal deserosalization with fibrin glue. This procedure was done in 2 patients thought to be at risk for EAF, which ultimately did not occur in either. The use of this method has also been reported to be successful in closing small EAFs.

As previously stated, nutritional optimization is central to the care of a patient with a gastrointestinal fistula. However, it is also a key component in the prevention of EAF. A patient with an open abdomen is in an extreme catabolic state with increased nutritional requirements. The benefits of enteral nutrition over parenteral nutrition are well established in surgical patients, and the use of early (less than or equal to 4 days after laparotomy) enteral nutrition has been shown to result in a statistically significant reduction in the rate of EAF as well as a faster time to abdominal closure.

![Image](image_url)
EFFLUENT CONTROL/SKIN PROTECTION

A poorly controlled EAF is a nightmare for patients and everyone involved in their care. It is a source of embarrassment and discomfort for the patient and frustration for the surgeon and results in the consumption of a tremendous amount of nursing and disposable medical resources. Early control of EAF output is critical, as contact between the skin and drainage results in significant skin damage that may limit options for subsequent control. A sound first step is to stop any and all oral intake. Bowel rest likely does not eliminate EAF output but significantly reduces the quantity. Use of a nasogastric tube for intermittent suction may also aid in reducing the quantity of the effluent, although again, this plays an indeterminate role. In most cases, NPWT has already been used, and simple continuation of this is all that is needed to obtain early control. EAFs that result in higher effluent output often overwhelm NPWT systems, resulting in the requirement for dressing changes on a daily basis or even more frequently. This situation can overwhelm both manpower and resources, requiring advanced methods of control (Figs. 6 and 7). The involvement of an enterostomal therapist or experienced wound care team cannot be overemphasized.71 If the patient is being cared for in a facility without these resources, transfer to a higher level of care should certainly be considered.

There are several options available for skin protection using any of a variety of topical skin barriers. The enterostomal therapist/wound care team is familiar with the available options, and these materials should be used early. Fistuloclysis is a feeding strategy used with proximal EAFs, in which the effluent is reinstilled into the distal limb of the fistula. To refeed biliopancreatic secretions, they must be effectively controlled and collected. This process may be possible through the use of

![Image](image.png)

**Fig. 6.** A useful modification of an NPWT system. Sponge material is fashioned into a “donut” that is used to “dam” off the fistula, allowing effective effluent control with improved healing of the surrounding tissues. Stoma paste and powder can be used to improve isolation of the fistula.
nasogastric tubes and NPWT systems but often is a difficult task. Poor control of gastrointestinal secretions leads to a frustrated patient and nursing staff and ultimately causes the fistula to remain open.

Aggressive effort toward the above-mentioned goals is warranted immediately and may require considerable thought. Several investigators have developed methods and systems, simply out of need, to address these concerns. Creation of a “floating stoma” has been reported and may be useful in specific circumstances. All these methods address a few simple ideas: “dam off” the EAF from the surrounding bowel or granulation tissue, provide NPWT to the surrounding tissues to assist with healing and exudate control, protect the surrounding skin to assist with dressing adherence and use in future surgery, and prevent trauma to the underlying viscera to eliminate the potential for additional EAF. Any system that can address all these concerns is effective, but none specifically designed for the purpose of EAF control has been marketed. It therefore requires considerable effort from the care team to design a custom device for a particular patient and to ensure its effective use on a daily basis.

In cases in which effluent control is simply impossible with NPWT-based wound care systems, the only remaining option may be the use of what amounts to a large stoma appliance, or wound manager (Fig. 8). These devices can be custom cut to the size and shape of the open wound and function much like a standard ostomy appliance. They come in a variety of sizes and are marketed by at least 2 companies. If the surrounding skin is in good shape, a watertight seal is maintained, with effective collection of effluent in a large pouch. Despite continued contact with gastrointestinal secretions, granulation tissue continues to form over the underlying viscera, and the wound contracts over time. The wound appliance should be replaced with a fresh one as needed or every 4 to 5 days, much like and ostomy appliance is managed. Changes should be as infrequent as possible to avoid irritation or damage to the underlying skin.
TIMING OF SURGERY

Selection of the appropriate time to perform surgical reconstruction of an EAF that does not close spontaneously is critical. This area is controversial at best, and there are no level I data to support any specific period of delay before an attempt at closure of an EAF or abdominal wall reconstruction (AWR). Most experienced surgeons agree that a wait of at least 3 months after the initial laparotomy or fistula formation would be advised before any attempt at operative repair. This period allows for intra-abdominal adhesions to soften, inflammatory processes to resolve, and reduction in the risk of iatrogenic bowel injury during the reparative procedure. In patients who have had split-thickness skin grafting directly over the bowel, one would typically defer definitive surgery until the graft was no longer adherent to the underlying viscera; this is determined with a simple “pinch” test (Fig. 9) by pinching the skin graft between the index finger and thumb to see if it lifts freely from the intestine underneath. In general, this takes longer than 3 months and can take up to a year before conditions are ideal for proceeding with surgery.

Fig. 8. When all other methods of control fail, a wound appliance can be custom fashioned to the shape of the wound to collect effluent. It functions much like a standard ostomy appliance.

Fig. 9. The “pinch” test is being used to determine if the underlying viscera is free from the previously placed split-thickness skin graft.
Various investigators have reported delays that range between 2 and 929 days from initial temporary abdominal closure to attempted definitive reconstruction,\textsuperscript{80–83} with mean times to attempted reconstruction of 311 days,\textsuperscript{81} 184 days,\textsuperscript{82} and 585 days.\textsuperscript{83} Owing to 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. Contrary to these reports, another investigator suggests that a delay of 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.\textsuperscript{80} These studies included many patients who did not have EAFs but simply required AWR after management with a PVH strategy after an open abdomen. It is clear that any reconstructive attempt must be well planned and that the timing is intimately related to the 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.

**ABDOMINAL WALL RECONSTRUCTION**

What often really sets EAF apart from ECF is the extent of the associated abdominal wall defect and consideration of how to address this aspect. Reconstruction of the abdominal wall is a complex and high-risk procedure and is a necessary component of the surgical treatment of EAF in most cases. When performing definitive surgery for EAF or ECF, one immediate goal is to obtain closure of the abdomen over the visceral repair. Exposure of the bowel to the environment is one factor that likely leads to the formation of an EAF and must be avoided at all costs. The approach to closure of the abdominal wall is dictated in part by the decision to stage the repair or not. There is no ideal technique or simple approach to AWR. Component separation techniques (CST) and flap reconstructions tend to be technically demanding and are associated with an increased incidence of wound problems depending on the approach used. However, they can provide a functional AWR. Simple mesh underlay closure of fascial defects effects an acceptable hernia repair 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 finished appearance may be cosmetically inferior. It is important to consider a patient’s functional status and expectations when determining the approach to be used for AWR/hernia repair.

The CST originally popularized by Ramirez and colleagues\textsuperscript{84} involves separating the rectus muscle from the posterior rectus sheath and the external oblique muscle from the internal oblique muscle, resulting in medial advancement of approximately 5 cm at the epigastrium, 10 cm at the waistline, and 3 cm in the suprapubic region unilaterally. This procedure is coupled with mesh reinforcement and restores a dynamic and functional abdominal wall. There are several reports in the literature on the success of CST in the management of large ventral hernias, revealing rates of hernia recurrence from 6% to 52%.\textsuperscript{84–97} It may seem intuitive, but it is worth stating that larger hernia defects are more likely to recur and are more likely to require mesh-bridging techniques whether or not CST is used. Ideally, CST is used to facilitate reapproximation of the rectus complex in the midline with some sort of mesh buttress. Some defects are so large that bridging is still 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 in 39 patients\textsuperscript{92} showed that wound complications were more frequent in the prosthetic group and 38% of the patients with wounds 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 definitive conclusions from this small study, the 2 methods were statistically equivalent in this group. Several minor modifications of the CST technique have been reported in the literature with varying success rates. All these reports involved either single cases or small groups of patients. There has been a surge of interest in the use of the posterior CST likely related to the ability to exploit the retrorectus space for placement of mesh reinforcement. Many of those who were major proponents of the classic anterior CST have shifted to the posterior approach.

Use of CST may assist in AWR by increasing abdominal domain. Comparisons of preoperative and postoperative CT scans of the abdomen and pelvis after CST repair of large abdominal wall hernias with associated loss of domain have shown significant increases in the intra-abdominal volume without any significant change in diaphragmatic height. It may be possible to restore lost domain without the unfavorable result of pulmonary compromise secondary to a loss of thoracic volume.

One of the major criticisms of the anterior CST approach is the large bilateral skin flaps that result from the dissection necessary for exposure during the procedure. Flap complications comprise most of the wound occurrences noted in this procedure. Several approaches have been devised to avoid the seroma and potential infections that are common. The use of fibrin sealant has been shown to reduce seroma and wound infection rates in patients undergoing traditional anterior CST. Placing 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 and colleagues described the use of a laparoscopic CST in 7 patients that altogether eliminates the large flaps created using the open technique. The technique is similar to that used in totally extra-peritoneal pre-peritoneal (TEPP) laparoscopic inguinal hernia repair. Release of Scarpa fascia should also be performed with this approach, although care must be taken not to divide the linea semilunaris itself. After performance of the CST portion of the case laparoscopically, the midline may be reconstructed using either a laparoscopic or open approach; that would be necessary in all patients with EAF treated with a single-stage procedure. Short-term follow-up of patients treated with this technique has shown acceptable outcomes. Laparoscopic CST has been shown to be inferior for mobility in a porcine model, as it yielded only 86% of the medial mobilization of the rectus that was achieved with the open technique. In cadavers, both have been shown to be equivalent. Another minimally invasive method of achieving a lateral release has been described by creating small tunnels from the midline incision instead of large flaps. Although this technique involves approach through a large midline incision, it avoids the creation of large flaps with their attendant wound morbidity, potentially making it ideal in the case of single-stage repair of EAF. Laparoscopic and other minimally invasive approaches to component separation are new and no randomized comparisons of these techniques to traditional techniques have been undertaken. These approaches are likely useful in achieving the goal of a functional abdominal wall while avoiding some of the morbidity associated with extensive open procedures.

**SUMMARY**

The entities of ECF and EAF remain a formidable challenge to surgeons facing affected patients. Awareness of its causes, contributing factors, potential preventive measures, and various management strategies are crucial to achieving optimal outcomes in the care of these complex patients. Owing to a lack of high-quality evidence supporting
any particular regimen of care, the surgeon is required to exercise skillful judgment in treating these individuals.

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