

Enteric Fistulas: Principles of Management

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In the past decade, surgeons have seen a quiet but dramatic shift in clinical patterns of enteric fistulas. Despite advances in nutritional care, infection control, and surgical technique, an enterocutaneous fistula (ECF) remains a source of considerable morbidity and mortality. In addition, wide adoption of damage control and the open abdomen in trauma and emergency surgery have confronted surgeons with a new and especially vicious adversary: the enteroatmospheric (or exposed) fistula (EAF). These fistulas, occurring in the midst of an open abdominal wound, are very difficult to control and present a particularly lethal challenge. Such EAFs might well be the most common type of enteric fistula facing surgeons today. Yet this shift in clinical patterns from the classic ECF to the new EAF is still totally disregarded in major surgical texts.^{1,2}

The aim of this review is to present current principles in the management of enteric fistulas. Additionally, we will demonstrate how traditional principles of managing enteric fistulas help us to better understand the physiology and natural history of EAFs and to deal effectively with this new challenge.

Enteric fistulas: historical perspective

The history of ECF must inevitably begin with Alexis St Martin, the subject of William Beaumont's experiments in gastric physiology. A gastric fistula developed after St Martin suffered a musket wound to the abdomen and chest in 1822,³ and it remained open until his death 58 years later.⁴ Lillenthal (in 1901) and von Cackovic (6 years later) reported their experience with surgical management of ECF,⁵ with fatal outcomes in all cases. Even 20 years later, the reported overall mortality remained 81%.⁶ In 1931, Bohrer and Milici⁷ advocated conservative management in acute cases and operative management of chronic cases with

"maintenance of chemical balance," capturing the key to effective management of ECF, which still remains valid today.

The introduction of antibiotics in the mid-20th century did not improve mortality from ECF. It was not until 1964 that Chapman and colleagues⁸ outlined the four cardinal principles in the initial care of patients with ECF, ie, correction of intravascular volume deficit, drainage of abscesses, control of fistula effluent, and protection of the skin.

The major breakthrough came with the introduction of total parenteral nutrition (TPN) by Dudrick and colleagues,⁹ because it directly addressed malnutrition, the leading cause of death in these patients. TPN not only reversed the patient's catabolic state, but allowed most ECFs time to heal spontaneously. Those that persisted could then be surgically closed in an infection-free, nutritionally replete patient with a good chance of success.¹⁰

Other major advances that facilitated management of ECFs were CT,¹¹ CT-guided drainage of intraabdominal abscesses,¹² and introduction of muscle and myocutaneous flaps by Mathes and Bostwick¹³ to provide soft-tissue cover for problematic fistulas that had previously challenged surgeons.

Referral of patients with ECFs to centers of excellence improves treatment outcomes. Irving demonstrated a fall in mortality rate from 42% to 20% during a 3-year period after opening an intestinal failure unit in the 1980s.¹⁴

EAF began to gain notoriety as an especially recalcitrant type of enteric fistula in the 1980s. Levy and colleagues,¹⁵ a group that pioneered open management of severe abdominal infection, reported 120 cases from their referral center in Paris in 1986 and coined the term *exposed fistula* to denote an enteroatmospheric fistula in an open (or dehiscid) abdomen. The first report in the English literature was by Schein and Decker¹⁶ from Johannesburg, who described the entity in detail and reported a 60% mortality rate, despite adherence to modern principles of fistula management.

Popularization of damage-control operations for trauma in the 1990s increased awareness of EAFs among trauma surgeons.¹⁷ In the first (and still largest) series of damage-control laparotomies, Burch and colleagues¹⁷ identified EAFs as the major complication in survivors. EAFs are

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Abbreviations and Acronyms

CD	= Crohn disease
EAF	= enteroatmospheric (or exposed) fistula
ECF	= enterocutaneous fistula
GI	= gastrointestinal
TPN	= total parenteral nutrition

both the most common and the most challenging enteric fistulas currently treated by trauma surgeons.¹⁸ There is still much confusion and lack of consensus on the best approach to control them.

Definitions, classification, and natural history

A fistula is an abnormal communication between two epithelialized surfaces. An ECF is an abnormal communication between the bowel lumen and skin. It is typically associated with a triad of sepsis, fluid, and electrolyte abnormalities and malnutrition.¹⁹

ECFs are classified by their anatomy, etiology, or physiology.²⁰ Anatomically, an ECF is identified by the segment of the gut from which it originates (eg, gastrocutaneous, enterocutaneous). Etiologic classification is based on the underlying disease process (see Table 1). Approximately 20% of all ECFs result from Crohn disease (CD). The proportion is even higher after bowel resection for CD.²¹ The volume of fistula output is the basis of a physiologic classification into low-output (<200 mL/d) and high-output (>500 mL/d) fistulas. Output in the middle range (200–500 mL/d) is considered moderate.

EAFs can be classified based on the status of the surrounding abdominal wound.²² A deep EAF fistula drains intestinal content into the peritoneal cavity of an open abdomen, causing diffuse peritonitis. A superficial EAF drains atop a granulating abdominal wound, in which the peritoneal space has been obliterated or isolated by the wound-healing process. It is a completely extraperitoneal process. A deep EAF is a source of ongoing peritonitis leading to uncontrolled infection and enormous catabolism, but a superficial EAF is predominantly a wound management (or stoma control) problem.

About one-third of ECFs will close spontaneously with proper supportive care, control of sepsis, and nutritional support.¹⁸ Classic barriers to spontaneous closure include distal obstruction, mucocutaneous continuity (ie, a short or epithelialized tract), and infection or malignancy in the tract.²³ With this in mind, it is easy to appreciate the malevolent nature of EAFs: The fistula is an exposed hole in the bowel lumen without overlying skin or soft tissue. There is no tract and no realistic expectation of spontaneous healing or closure.²⁴

Table 1. Causes of Enterocutaneous Fistula

Iatrogenic
Operation
Percutaneous drainage
Trauma
Foreign body
Crohn disease
Infectious disease
Tuberculosis
Actinomycosis
Malignancy

A superficial EAF can occur suddenly after iatrogenic injury or desiccation of a loop of exposed bowel, or evolve gradually as the open abdominal wound heals around a deep fistula that has been effectively controlled, allowing the open abdomen to granulate by secondary intention. In either case, nonoperative fistula closure is a virtually impossible occurrence.

Current management of ECF**Phase 1: recognition and stabilization**

As soon as an enteric fistula is recognized, four life-threatening concerns become the focus of clinical attention, ie, fluid and electrolyte imbalance, sepsis, nutrition, and skin care.

The first hours after presentation are typically spent on aggressive volume restoration and correction of electrolyte imbalance. Hypokalemia is by far the most common electrolyte abnormality and should be corrected aggressively. Losses from high-output fistulas should be assessed and replaced every 4 hours. Fistula output from the upper gastrointestinal (GI) tract is typically replaced with normal saline solution and potassium supplementation (KCl at 10 mEq/L). Duodenal or pancreatic fistulas can require HCO₃⁻ replacement as well, and electrolyte measurement of the fistula fluid can help guide replacement.

Control of the effluent is critical not only to protect the skin from the corrosive effects of the enteric content, but also to facilitate nursing care of the patient.²⁵ The skin protection components and regimen must be tailored to the specific anatomic circumstances of each fistula.²⁶ A skilled dedicated nurse or enterostomal therapist capable of fashioning the effluent collection system to meet the unique and changing needs of each wound is critical to success.

Vacuum-assisted wound management is a recent addition to the armamentarium of fistula care.²⁷ When successful, these systems reduce the need for dressing changes and can even accelerate fistula closure by promoting wound healing.²⁸ Although there are no large studies comparing vacuum-assisted wound management with traditional

drainage bags, its use in fistula management is widespread because surgeons are familiar with the technology from its successful application to other problematic wounds. Wainstein and colleagues²⁹ recently reported their 10-year experience with a vacuum-assisted device in management of 179 fistulas in 91 patients. Forty-two patients (46%) achieved spontaneous closure within 90 days of initiating vacuum-assisted therapy. Among the others, the closure rate after operation was 84%. Overall mortality rate was 16%.

Although fistula output can be reduced with somatostatin and octreotide,³⁰ clinical use of these pharmacological adjuncts has neither been studied in a prospective randomized fashion nor become the standard of care. Somatostatin has a dramatic effect on reducing fistula output, but its clinical use is limited by a very short half-life (ie, 1 to 3 minutes). Its synthetic analogue octreotide, with a half-life of 2 hours, reduces GI secretions, prolongs transit times, and facilitates absorption of water and electrolytes. Studies demonstrated a 40% to 93% reduction in fistula output after 48 hours of octreotide,³¹ and a striking shortening of the time to fistula closure from a mean of 50 days to 5 to 10 days.³² No evidence exists that pharmacological manipulation improves fistula closure rates.³³ Octreotide has the potential to adversely affect immune function as a result of growth hormone inhibition.³⁴⁻³⁶ There are no clinical data to confirm or exclude this possibility. It is also important to keep in mind that if the patient has one of the conditions that prohibit spontaneous closure, such as distal obstruction, use of octreotide is futile in promoting spontaneous fistula closure and can become merely a very expensive way to reduce fistula output while actually delaying the surgical procedure ultimately required for definitive closure.

Intraabdominal infection associated with ECF presents either as an abscess (contained infection) or peritonitis (uncontained). The former is identified by a CT scan and is then usually drained percutaneously under CT guidance. The latter is a surgical emergency that requires urgent laparotomy to achieve source control, typically by exteriorization of the leak or proximal diversion. Rarely, a very early fistula can be resected or closed surgically on presentation.

Effective nutritional support is the next priority. Dudrick and colleagues³⁷ have reviewed enteral and parenteral nutritional support in fistula patients. Baseline nutritional requirements are 20 kcal/kg/d carbohydrate and fat and 0.8 g/kg/d protein. Caloric and protein requirements can increase to 30 kcal/kg/d and 1.5 to 2.5 g/kg/d, respectively, in patients with high output fistulas.³⁰

Relative merits of enteral versus parenteral feeding in patients with enteric fistulas are actively debated, but there is no Level I evidence to favor either route.³⁸ Enteral feed-

ing, if feasible, preserves the intestinal mucosal barrier as well as immunologic and hormonal gut function. It is often not possible to use effectively because of feeding intolerance, inability to access the GI tract, or high fistula output.

Addition of fish oil or omega-3 fatty acids to an enteral diet can have a salutary effect on immune function,³⁹ perhaps because of increased blood flow to the lymphoid tissue in the ileum.⁴⁰ Randomized control trials have demonstrated lower infection rates in patients in the ICU⁴¹ after abdominal operations⁴² and after severe injury.⁴³ A recent meta-analysis suggests that enteral diets with fish oil and omega-3 fatty acids improve survival.⁴⁴ Other studies conclude that there are no clear advantages to fish oil supplementation.⁴⁵⁻⁴⁷ There are no randomized control trials investigating the use of fish oil and omega-3 fatty acid supplements in the treatment of ECFs.

TPN has been shown to improve the spontaneous closure rates of enteric fistulas.^{31,38} Nutritional support must be initiated with prudence, patience, and caution in severely malnourished patients because of the risk of inducing refeeding syndrome.⁴⁸ This risk can be reduced by correcting fluid, electrolyte, and vitamin abnormalities before initiation of conservative levels of nutritional support, and by gradually advancing to goal feeding for several days as the patient demonstrates increasing tolerance of the feeding regimen.

Phase 2: anatomical definition and decision

The next phase entails delineation of the fistula anatomy. The aim is to develop enough imaging information to assess the likelihood of spontaneous closure. A fistulogram rarely identifies the specific origin of the tract, but can be useful when the diagnosis is in doubt. Fistulograms have been largely replaced by abdominal CT scans, which demonstrate not only the anatomy of the tract and its origin, but also the presence of intraabdominal abscesses or associated pathology. If the anatomical detail provided by the CT scan is insufficient, a contrast study of the relevant part of the GI tract will help define the anatomy.

Spontaneous fistula closure rates vary from 15% to 71%.^{8,15,49-57} Martinez and colleagues²⁶ and Wainstein and colleagues²⁹ reported spontaneous closure rates of 37% and 46.2%, respectively, in two recently published studies. Visschers and colleagues²⁴ reported spontaneous closure in only 16% of cases in another recent series of 135 patients; but mean time from fistula onset to reconstructive operation was only 53 days. As a general principle, reconstructive operations should be delayed if fistula output is gradually decreasing and the wound (or tract) shows signs of healing.²⁹ Although the timing of the definitive operation to close the fistula is a matter of judgment, there is no debate that the patient should be free of infection, be nutritionally

replete, and have supple soft tissue in the area of the fistula opening, tract, or wound.

It is generally accepted that occurrence of an ECF is associated with obliterative peritonitis⁵⁸ inside the abdomen. This severe intraabdominal inflammatory response leads to dense vascular adhesions that preclude surgical intervention. Any attempt to enter the abdomen during this period is doomed to fail and can prove fatal. This obliterative peritonitis is thought to abate after about 6 weeks in a closed abdomen, but requires 6 to 12 months to resolve with an open abdominal wound.

Phase 3: definitive operation

Resecting an ECF and reestablishing continuity of the GI tract is a complex operation that requires careful planning, precision, and patience. It is usually not advisable to schedule other major elective operations on the same day because these demanding procedures are often "all-day cases." During a typical operation, the peritoneal cavity is entered through a carefully planned incision that takes into consideration the potential need for complex abdominal wall reconstruction with well-vascularized soft tissue. This is followed by adhesiolysis to free the abdominal wall circumferentially from adherent bowel. To identify the fistula and approach it safely, the surgeon must be prepared to spend hours performing painstaking meticulous adhesiolysis and mobilizing the entire length of the GI tract from the ligament of Treitz to the rectum, if necessary. Any inadvertent enterotomies or large serosal defects must be carefully repaired. Once the fistula has been clearly defined, the aim is to resect the segment of bowel that is the origin of the fistula and to reestablish GI continuity. This is followed by definitive reconstruction of the abdominal wall defect, as we will describe here. Intestinal failure because of extensive bowel resection is a risk. The emerging field of small bowel transplantation offers an alternative to lifelong parenteral nutrition in carefully selected patients with this devastating complication.⁵⁹

ECF from CD

Management of ECF from CD presents special challenges because of the enigmatic disease process, frequent use of immunosuppressive drugs, and associated malnutrition. Some 20% to 30% of all ECFs are a result of CD.⁶⁰ These fistulas can arise spontaneously or occur after intestinal operation. CD fistulas are classified as those with no evidence of active disease (type 1) or as more complex fistulas associated with intraabdominal abscesses (type 2). This classification is important because conservative management is likely to attain spontaneous closure with a type 1 but not a type 2 fistula.⁵⁴ Neither infliximib⁶¹ nor oct-

reotide^{33,57} substantially reduces the need for operation in patients with CD fistulas.

If an operation is required, the surgeon should mark intended stoma sites preoperatively and strongly consider placing ureteral stents if the need for colon mobilization is anticipated. Complete resection of the ECF as well as the diseased bowel is necessary to prevent recurrence.⁶² Wedge resections or oversewing the fistula are suboptimal procedures that should be reserved for patients with only short bowel syndrome and who cannot afford to lose more functioning gut.

Current management of enteroatmospheric fistula

EAF is very often a preventable complication.⁶³ In patients with an open abdomen, simple precautions can reduce the likelihood of an exposed fistula. The greater omentum (if available) should be used to cover the bowel and minimize the area of exposed gut. If the omentum cannot be used, early application of a biological dressing (such as cadaver skin) can contain and protect the bowel and prevent desiccation and fistula formation. If the open abdomen is then left to granulate and heal by secondary intention, there is no requirement for nonabsorbable mesh. Neither negative-pressure dressings nor gauze dressings should be applied directly to the exposed bowel. This is all the more relevant if there are one or more unprotected suture lines in the gut. Access to the wound should be limited to one or two highly experienced surgical care providers, and not delegated to junior members of the surgical team, to reduce risk of accidental bowel injury.

Approach to deep EAF

When a deep EAF is identified in an open abdomen, the first priority is control of ongoing peritonitis. These patients are typically critically ill, and the fistula usually presents in the early stages of their surgical ICU courses. After rapid resuscitation (if required), the patient should undergo emergency operation. The surgeon must be fully aware that most deep EAFs do not have an early definitive surgical solution. The goal at this stage is source control. This will be the first step in a management strategy designed to stabilize the patient and allow the abdominal wound to granulate and heal around the fistula, in anticipation of definitive closure many months later.

In the operating room, the surgeon often discovers that achieving source control is much easier said than done. Exteriorization or proximal diversion, as mentioned here for ECFs, is often impossible because of massive edema of both the viscera and abdominal wall, as well as mesenteric thickening and foreshortening. More importantly, dense vascular adhesions begin to form in the open abdominal wound after approximately 1 week of exposure. This is the

open abdominal equivalent of the obliterative peritonitis we described here, resulting in complete fusion of the bowel loops at 10 to 14 days from initial operation, and creation of an impenetrable visceral block.⁶⁴

On rare occasions, it might be possible to seal a small hole in the bowel with an acellular human dermal matrix graft fixed in place with fibrin glue⁶⁵ or an autogenous split-thickness skin graft.⁶⁶ Although the probability of success in either case is small, the cost of failure is minimal. These local applications are more likely to succeed in a superficial exposed fistula surrounded by granulation tissue, as we will describe here. More often than not, the surgeon is faced with continuous intestinal spillage and no conventional effective means to address it directly. The patient's only hope rests with the surgeon finding a way to somehow separate the open peritoneal cavity from the uncontrolled spillage.⁶⁷

Tube drainage of the deep, open-mouthed fistula is not practical or useful. Because there is no tract (the hole in the gut is exposed), intubation only serves to enlarge the hole as intestinal content leaks around the tube. One improvised technique to achieve source control is the floating stoma.⁶⁷ This entails suturing the edges of the hole in the gut to a similar-sized hole tailored in a plastic sheet that serves as a temporary abdominal closure device and separates the intestinal effluent from the open peritoneum. An ostomy bag is applied to the plastic sheet around the improvised stoma, allowing the protected peritoneal cavity to heal. In other words, the deep EAF is gradually converted into a superficial one during several weeks.

In recent years, vacuum-assisted wound management has simplified management of deep exposed EAFs.⁶⁸ Continuous suction of the fistula output minimizes contact time between intestinal fluid and exposed peritoneum, thus achieving *de facto* source control. This negative-pressure dressing also simplifies nursing care, eliminates the need for frequent dressing changes, and protects the surrounding skin. When the fistula has a high output or there are several holes in the gut, a useful technique is to intubate the holes and bring the tubes out perpendicularly through the sponge of the vacuum-assisted dressing.²² With this technique, the majority of intestinal effluent is collected in the tubes, as the sponge serves as a stable rig that anchors the tubes, prevents dislodgement, and collects any residual fluid that might leak around the tubes.

Several recent reports of fistula formation associated with vacuum-assisted wound management⁶⁹ have led to a call for caution in its use directly over exposed bowel,⁷⁰ especially if fresh suture or staple lines in the bowel are exposed. Although Level I data are lacking, it is an essential precaution to avoid direct contact between the vacuum

sponge and exposed bowel with the use of a plastic sheet to prevent adherence and potential fistula formation. If the risk of fistulization is substantial, additional protection can be provided by placing cadaver split-thickness skin as a biologic dressing between the bowel and the negative-pressure sponge.⁷¹

A central feature of a deep exposed fistula is the tremendous catabolism that it generates. The uncontrolled ongoing peritonitis, large open abdominal wound (metabolic equivalent of a large full-thickness burn), and protein losses from the GI tract combine to create added accelerated catabolism in an already critically ill patient. Although it is difficult to measure nitrogen balance with all these multifocal losses, it is becoming clear that conventional nutritional support, as outlined here for ECF, often does not suffice because protein and caloric requirements exceed those that can be delivered by either route alone. A combination of parenteral and enteral nutrition might be needed to minimize or reverse the lethal catabolic meltdown.

Approach to superficial EAF

A superficial EAF, although not often a life-threatening emergency, presents a major wound and stoma management problem. The surgeon faced with a fistula spilling intestinal content onto a large carpet of granulation tissue (representing the granulated visceral block of the open abdomen) has to buy time until definitive closure of the fistula can be undertaken, typically 6 to 12 months from the index operation and in conjunction with definitive abdominal closure. The two realistic options are to either attempt direct local closure of the fistula opening extraperitoneally or convert the fistula into a controlled stoma.

Direct closure of superficial "bud" fistulas was first described by Sarfeh and Jakowatz.⁶⁶ The procedure entails very limited dissection to define the edges of the fistula opening, followed by extraperitoneal suture repair of the hole in the bowel on the surface of the granulating abdominal wound. The key principle is to cover the suture line with a biological dressing (autogenous or cadaver skin graft or acellular dermal matrix), with or without a tissue adhesive. Sarfeh and Jakowatz⁶⁶ reported a success rate of 50%, but the important point here is that these are local, low-risk procedures that can be repeated easily. Jamshidi and Schechter⁷¹ reported successful local closure of five of seven EAFs, but the mean number of attempts per patient was four.

If local closure fails or is not feasible, another option is to accept the fistula and approach it as a stoma. Onlay split-thickness coverage of the granulating wound surrounding the fistula is often necessary to achieve stable wound coverage. A negative-pressure sponge dressing with a hole fashioned to allow collection of the enteric contents can be



Figure 1. Enterocutaneous fistula surrounded by skin grafts covered by negative-pressure sponge.

applied to the skin graft. (see Fig. 1) After wound healing, there are many creative stoma management solutions, using a variety of stoma bases, wound dressings, and creams to protect the surrounding skin. A skilled, dedicated, and talented stomal therapist and nursing staff are the essential prerequisites to successful outcomes.

Delayed reconstruction of the abdominal wall

All patients with an EAF have an open abdomen that cannot be closed primarily, and all of those who survive the efforts to control the fistula as described here will eventually need delayed abdominal reconstruction. The clinical maxim: “it is impossible to reconstruct EAF patients too late—only too early” is provocative but sound advice. If the bowel is covered by a skin graft, the reconstruction should be delayed until the skin graft can be gently pinched off the bowel between thumb and forefinger, the so-called “pinch test.”⁷² This signifies that there is a tissue plane between the skin graft and the gut, facilitating one of the most vexing steps of the reconstruction, ie, dissection of the skin graft off the bowel.

The goal of operation, besides closing the fistula, is to reconstruct the abdominal wall with durable well-vascularized coverage. In realistic terms, this often entails complex technical approaches that will benefit from timely involvement of a plastic surgeon in planning and executing the procedure. A two-team approach has the advantage of providing a well-rested plastic surgeon focused on reconstruction after a long and tedious visceral dissection by the general surgery team. Preoperative assessment of the abdominal wall defect is important to determine which tissue components are missing or inadequate and which can be used for reconstruction. Autogenous tissue is obviously an ideal choice for repairing tissue defects in a procedure that

entails resection and reconstruction of bowel because it reduces the risk of prosthetic infection.

The components separation technique⁷³ is the workhorse of abdominal wall reconstruction when the rectus abdominis muscle is intact. It allows medial advancement of the rectus myofascial unit on both sides to bridge the fascial gap. Primary closure of defects up to 10 cm in the upper abdomen, 20 cm in the mid abdomen, and 6 to 8 cm in the lower abdomen can be achieved with this technique.⁷³

Depending on the specific nature of the defect, the presence of comorbidities, and degree of obesity, technical options such as random, pedicle, or free flaps with microvascular reconstruction might be feasible, efficacious alternatives. Use of tissue expanders to increase the surface area of skin flaps before definitive reconstruction should also be considered. Biologic materials, such as acellular human⁷⁴ or porcine⁷⁵ dermal matrix or porcine submucosa,⁷⁶ can be used for visceral overlay protection or abdominal wall reconstruction. Unfortunately, recent reports of very high rates of hernia formation and abdominal wall laxity^{77,78} are curbing the early enthusiasm for use of these new biological materials.

Other muscle flaps that are useful in abdominal wall reconstruction can be based on the tensor fascia lata,⁷⁹ rectus femoris,⁸⁰ and latissimus dorsi.⁸¹ Use of microvascular techniques increases the versatility of these muscle flaps. The options for abdominal wall reconstruction are limited only by the missing tissue components and the imagination and skill of the reconstructive surgeon. Finally, referral to a center capable of providing optimal comprehensive care is prudent in these complex, labor-intensive patients.¹⁶

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