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The Open Abdomen: Definitions, Management Principles, and Nutrition Support Considerations

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Abstract

The use of the "open abdomen" as a technique in the management of the complex surgical patient stems from the concept of damage control. Damage control principles underscore the importance of an abbreviated laparotomy focused on control of hemorrhage and gastrointestinal contamination in patients presenting with significant physiologic compromise. Definitive repair of injuries is postponed and the abdomen is temporarily "closed" using one of a number of different techniques. The ultimate goal is formal abdominal fascial closure within 48–72 hours of the initial laparotomy. Frequently, daily trips to the operating room are required for incremental closure of the abdominal fascia. However, in some cases, fascial closure is not possible secondary to ongoing visceral edema and loss of the peritoneal domain. In these cases, the patient is left with an "open abdomen" until skin grafting over the exposed peritoneal organs can be performed. Patients with an open abdomen have peritoneal contents exposed to the atmosphere and require a complex dressing to maintain fascial domain and provide protection to exposed organs. These patients are typically critically ill and managed in the intensive care unit early in the disease process. The open abdomen has become an important tool for the management of physiologically unstable patients requiring emergent abdominal surgical procedures. These patients present unique challenges to the critical care and nutrition support teams. Careful attention to fluid and electrolyte management, meticulous wound care, prevention of enteroatmospheric fistula, and individualized nutrition support therapy are essential to successful recovery in this patient population. (*Nutr Clin Pract.* 2012;27:492-498)

Keywords

critical care; sepsis; laparotomy; fistula; enteral nutrition; parenteral nutrition

The use of the "open abdomen" as a technique in the management of the complex surgical patient stems from the concept of damage control. Damage control principles underscore the importance of an abbreviated laparotomy focused on control of hemorrhage and gastrointestinal contamination in patients presenting with significant physiologic compromise.[1-3] Definitive repair of injuries is postponed and the abdomen is temporarily "closed" using one of a number of different techniques without formal fascial approximation at the midline. This temporary abdominal closure allows for rapid urgent reoperation and ease of planned subsequent abdominal procedures.

The abbreviated laparotomy comprises the operative phase of damage control surgery. Following the operative phase, the patient is taken to the intensive care unit (ICU), and the resuscitative phase begins. During this second phase of damage control, physiologic parameters are normalized with blood and blood product transfusions, invasive monitoring, active and passive rewarming, and metabolic and hemodynamic support. The final phase of damage control, definitive repair, occurs after the patient's physiology has normalized. During this final phase, the patient is returned to the operating room, and repair of all injuries is performed. In addition, a thorough exploration for any potential missed injuries is conducted and abdominal closure is attempted. If formal fascial closure cannot be attained, the patient is left with an "open abdomen," indicating that neither the fascia nor the skin is approximated at the midline.

Patients with an open abdomen have peritoneal contents exposed to the atmosphere (Figure 1) and require a complex dressing to maintain fascial domain and provide protection to exposed organs (Figure 2). These patients are typically critically ill and managed in the ICU early in the disease process. The ultimate goal is formal abdominal fascial closure within 48–72 hours of the initial laparotomy. Frequently, daily trips to the operating room are required for incremental closure of the abdominal fascia. However, in some cases, fascial closure is not possible secondary to ongoing visceral edema and loss of peritoneal domain. In these cases, the patient is left with an "open abdomen" until skin grafting over the exposed peritoneal organs (most commonly small and large intestine) can be performed, usually after a few weeks. These patients present a

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Figure 1. Open abdomen—fascia and skin cannot be approximated in the midline.

Figure 2. Open abdomen—suction dressing in place protecting bowel. Reproduced with permission from Tresize, F. Managing an open abdomen using Eakin cohesive: Getting the best outcome for a patient with an open abdominal wound and acute enteric fistula. http://www.eakin.eu/casestudies/46/managing_an_open_abdomen_using_eakin_cohesive.aspx.

unique challenge to the critical care team secondary to the large open wound, fluid losses due to an open peritoneal cavity, electrolyte abnormalities, high risk for gastrointestinal fistula formation, fistula management, and specialized nutrition support considerations. The purpose of this article is to review the principles of management, as well as highlight important nutrition support considerations, for patients with an "open abdomen."

Wound Management

Fascial closure in patients managed with an open abdomen remains the primary goal. Closure can be addressed in an early or delayed fashion during the primary hospitalization. Additional options include fascial bridge closure with biologic mesh material during the primary hospitalization or planned ventral hernia with delayed repair at a secondary hospitalization in 6–12 months (Table 1).[4] Early fascial closure usually requires daily visits to the operating room for incremental fasical closure over a vacuum-assisted abdominal dressing system (Figure 2). Early closure, defined as within 9 days of initial laparotomy, is associated with fewer complications and should be attainable in up to 60% of patients, particularly those requiring open abdomen after trauma.[5] Patients managed with open abdomen after intra-abdominal sepsis are less likely to have successful early closure.[6] Delayed fascial closure is defined as fascial closure at the midline occurring more than 9 days after initial damage control laparotomy.

Several devices are available to assist in achieving either early or delayed fascial closure during the primary hospitalization after damage control laparotomy. The most common of these devices are negative-pressure dressings using suction devices with sponges embedded into nonadherent plastic material placed into the peritoneal space (Figure 2). These plastic materials serve to keep the peritoneal viscera from becoming adherent to the anterior abdominal wall as incremental fascial closure is attained with multiple trips to the operating room for suture placement.[7] The negative pressure provided by these suction devices helps to reduce tissue edema and provide constant force, drawing the fascia toward the midline position.[8,9] Other devices used to aid in early or delayed fascial closure during the primary hospitalization use artificial material to temporarily bridge the fascial defect and provide constant force on the fascia toward the midline. These devices include absorbable prosthetic mesh and specialty devices such as the Wittmann Patch (HIDIH Surgical, Dőrrebach, Germany).[10] These devices are less attractive than vacuum devices because they require suturing directly to the fascial edges, which may lead to injury to these tissues as tension is applied. Successful fasical closure as far out as 4–5 weeks from the initial laparotomy has been described with the use of negative-pressure dressings.[8]

Once efforts at approximating the fascia in the midline are abandoned, usually secondary to adhesions between the peritoneal contents and the anterior abdominal wall or due to permanent loss of the peritoneal domain with

Table 1. Options for Abdominal Fascial Closure After Open Abdomen

Primary Hospitalization
Early closure
• Within 8 days of DCL
• Vacuum-assisted device with primary midline fascial closure
Delayed closure
• More than 8 days after DCL
• Vacuum-assisted device with primary midline fascial closure OR
• Bridge closure with biologic mesh
Secondary Hospitalization (6–12 Months)
Wound healing by secondary intention at primary hospitalization OR
Wound healing by skin grafting at primary hospitalization
With planned ventral hernia
Followed by
• Component separation with midline fascial closure and mesh underlay

DCL, damage control laparotomy.

retracted fascial edges, the abdomen is allowed to granulate and a skin graft is applied. Prior to granulation, an absorbable mesh material may be sutured to the edges of the retracted fascia, providing some support for the abdominal viscera. Granulation tissue will incorporate into the absorbable mesh material, and skin grafting can still be performed.

Fluid and Electrolyte Management

Patients managed with the open abdomen technique have large tissue defects (Figure 1) that can lead to increased insensible fluid losses. In addition, these wounds are open into the peritoneal cavity, adding significantly to the amount of fluid loss across the wound surface. Hydration and volume status should be meticulously monitored in this patient population.

Classic subtle signs of hypovolemia, such as tachycardia and orthostatic changes in blood pressure, are unreliable or difficult to assess in patients with an open abdomen due to prolonged recumbent positioning as well as the enhanced inflammatory states accompanying the systemic inflammatory response syndrome (SIRS) and sepsis. Instead, markers of end-organ perfusion should be used. Particularly, careful monitoring of hourly urine output and daily fluid intake/output is helpful to ensure euvolemia. Invasive monitoring of central venous pressure (CVP) is prudent in patients with any sign of renal dysfunction.

Without adequate volume replacement, loss of hypotonic fluid from the wound and peritoneal cavity can result in hypovolemic hypernatremia. Serum sodium levels should be followed until volume losses decrease with granulation and wound coverage following skin grafting. Fluid replacement should be geared toward minimizing free water losses and maintaining euvolemia. Estimation of fluid losses from the open abdomen can be difficult and challenging. Choice of replacement fluid should be based on serum sodium and circulating volume status. In the hypovolemic patient, isotonic replacement fluids should be used. Once circulating volume is restored, then replacement with hypotonic fluids is appropriate.

Protein losses across the large open abdominal wound most certainly occur and need to be considered.[11] Large amounts of protein losses across these wounds can result in changes in oncotic pressure at the capillary bed level, inducing further loss of circulating volume into the interstitial space. Fluid replacement with serum albumin may correct this loss of intravascular oncotic pressure and should be considered until the capillary leak seals following wound epithelialization and granulation tissue formation.

The use of vacuum-assisted suction dressings in the management of these wounds may impart several distinct advantages in addition to wound coverage, protection of the exposed viscera, and assisting with fascial closure. First, these dressings contribute to a decrease in fluid losses across the open wound surfaces by significantly reducing evaporation.[12] Second, a closed-suction dressing draining into a dedicated canister facilitates fluid collection and allows a more accurate estimation of fluid losses from the wound and peritoneal cavity.[7] The measured fluid losses can then be more precisely replaced, and hypovolemia can be minimized or potentially avoided.

Fistula Management

A gastrointestinal fistula is the most dreaded complication associated with the use of open abdomen techniques. Because fascia and skin are not approximated at the midline, the exposed bowel is highly vulnerable to injury and fistula formation.[5,13] In addition, the longer the time lapse until fascial closure or wound coverage with skin grafting, the higher the rate of fistula formation.[4]

Technically, the term *fistula* is incorrect when referring to this complication in this patient population. A fistula is defined as the abnormal communication between 2 epithelialized surfaces. For example, an abnormal communication between the small bowel mucosa and the skin is an enterocutaneous fistula. Because the mucosa of any injured intestine in a patient with an open abdomen is open to the atmosphere, the term *enteroatmospheric fistula* has been coined to more correctly describe this complication.[14,15] Due to the complete absence of a fistulous tract, the enteroatmospheric fistula will not undergo spontaneous resolution (Figure 3).

Management of an enteroatmospheric fistula remains a significant challenge. Key components in managing this complication include prevention, control of fistula effluent, minimizing fistula output, monitoring for and correction of

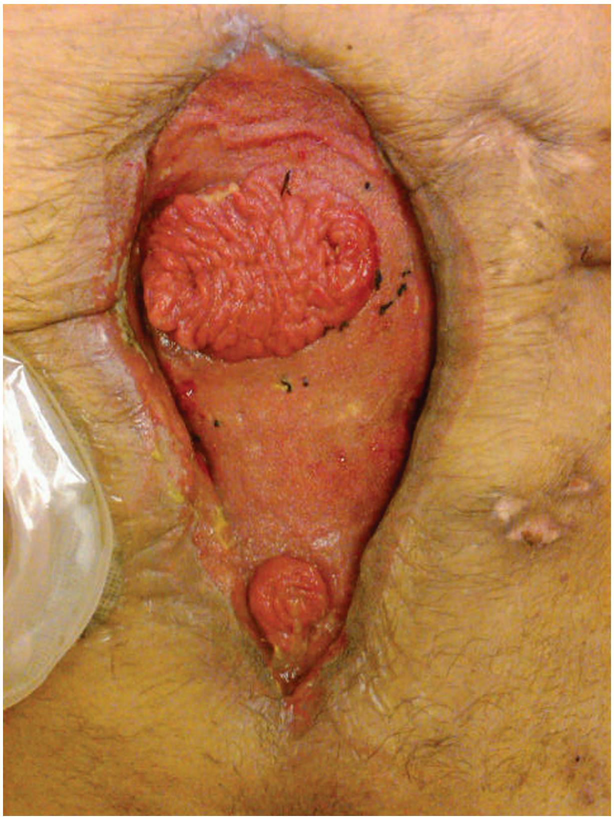

Figure 3. Two enteroatmospheric fistulae in a granulating wound.

electrolyte disturbances, nutrition support, and meticulous wound care.[4,15] The ultimate goal is surgical correction with fistula resection once the patient is ready for anterior abdominal wall reconstruction, usually 6–12 months after initial laparotomy (Table 2).[7,16]

Prevention remains the most important management principle. Whenever possible, biologic material should be placed over the exposed viscera. Greater omentum, if present, is an excellent choice. Exposed viscera must not come into direct contact with gauze dressings or standard negative-pressure sponges. Nonadherent dressings such as Vaseline-impregnated gauze, Xeroform gauze, or specialized nonadherent foam sponges should be placed directly over any exposed bowel. Last, routine wound care of the open abdomen should be performed by experienced surgeons very familiar with an individual patient's wound.[17]

Minimization of fistula output will help control wound contamination. Nasogastric drainage will divert gastric secretions from entering the proximal small bowel. However, in the absence of obstruction or prolonged ileus, long-term nasogastric drainage may not be useful in minimizing fistula output. Acid suppression with proton pump inhibitors or H_2-receptor antagonists will decrease the volume and acidity of gastric

Table 2. Management of the Enteroatmospheric Fistula

Prevention
Protect exposed viscera
Suction dressing
Wound accessed by experienced providers only
Minimize fistula output
Octreotide
Proton pump inhibitors/H_2 blockers
Control fistula effluent
Proximal intestinal diversion
Convert EAF into ECF
Minimize contamination with suction dressing
Floating stoma
Fluid and electrolyte management
Nutrition support
Enteral feeding
Refeed across fistula
Resect chronic fistula (6–12 months)

EAF, enteroatmospheric fistula; ECF, enterocutaneous fistula.

secretions, decreasing fistula output. Octreotide is a somatostatin analogue that can be administered subcutaneously. Its actions include inhibition of the secretion of many gastrointestinal hormones, including gastrin, cholecystokinin, secretin, insulin, glucagon, and vasoactive intestinal peptide. In addition, it has been shown to inhibit gastric acid secretion, pancreatic exocrine secretion, and intestinal and gallbladder contractility. Through these actions, the administration of octreotide may decrease fistula output, making control of fistula effluent more manageable.[18,19]

Controlling fistula effluent is an important part of minimizing further wound contamination and limiting wound sepsis. Enteroatmospheric fistulae deep within the open wound may result in spillage of intestinal contents within recesses of the wound and contribute to ongoing sepsis. Surgical intestinal diversion proximal to a distal fistula is essential in the management of a deep enteroatmospheric fistula.[17] Careful ostomy placement through the skin and fascia lateral to the open wound is mandatory. If proximal diversion is not possible, then converting the enteroatmospheric fistula to an enterocutaneous fistula should be considered. This is accomplished by first mobilizing the subcutaneous tissues near the fistula. A catheter is then placed into the mucosal opening and tunneled laterally through the previously mobilized subcutaneous tissues and brought out the skin. This should divert the fistula effluent and allow a fistulous tract to develop.[20] Finally, if none of the prior options is possible, controlling fistula effluent with strategic placement of suction drains under a vacuum-assisted dressing and isolation of the enteroatmospheric fistula as a "floating stoma" should be performed (Figure 4).

The continued loss of intestinal fluids rich in electrolytes and protein through an enteroatmospheric fistula contributes to

Figure 4. Open abdomen with enteroatmospheric fistula. Fistula effluent is managed with closed-suction drains placed in dependent areas. Vacuum-assisted dressing will be placed over the drains to establish suction and evacuation of effluent. Reproduced with permission from openabdomen.org. Trauma. http://www.openabdomen.org/diseases/trauma.cfm.

Table 3. Tonicity of Gastrointestinal Secretions

Foregut secretions		½ Normal saline
Salivary		¼ Normal saline
Esophageal	Hypotonic	½ Normal acetate
Gastric		¼ Normal acetate
Midgut secretions		
Duodenal		
Pancreatic		Normal saline
Biliary	Isotonic	Normal acetate
Jejunal		Lactated Ringers
Ileal		Plasmalyte
Hindgut secretions		½ Normal saline
Colon		¼ Normal saline
Rectum	Hypotonic	½ Normal acetate
		¼ Normal acetate

hypovolemia, electrolyte disturbances, and malnutrition. Fistula output should be carefully estimated and replaced with the appropriate balanced salt solution. Replacement fluid selection should be based on the electrolyte composition and tonicity of the intestinal fluid losses. Intestinal fluid tonicity is easily approximated by determining the location of the fistula. Foregut fistulae from the oral cavity (salivary fistula), esophagus, or stomach are hypotonic and should be replaced with hypotonic solutions. Midgut fistulae from the duodenum, biliary tree, pancreas, and small bowel are isotonic and require isotonic fluid replacement. Hindgut fistulae from the colon and rectum are again hypotonic and should be replaced with hypotonic replacement fluids (Table 3).

Nutrition Support Considerations

Early administration of goal-directed enteral nutrition (EN) improves wound healing, reduces hospital and ICU lengths of stay, decreases infection rates, and may improve survival after critical illness and injury.[21-24] Based on these findings, the recommendations for nutrition support in the patient with an open abdomen always include early EN when feasible. Enteral access distal to the ligament of Treitz is preferred. However, proximal enteral access in the duodenum or stomach is acceptable.

Early EN support may not be possible in most patients managed with the open abdomen technique due to the concomitant physiologic compromise associated with the initial pathophysiologic insult. In these patients, early focus is on control of infection, reversal of shock, and repair of injuries at a planned reexploration. Assessing the patient's nutrition status is an important first step. Parenteral nutrition (PN) may be required initially until physiologic status is normalized in patients presenting with overt signs of malnutrition.[25] Well-nourished patients should tolerate a period of 7–10 days without nutrition support. During this initial period, enteral access must be addressed. Surgically placed jejunostomy may complicate the management of patients in whom midline fascial closure cannot be attained. However, surgical jejunostomy is an excellent option for those patients in whom early fascial closure is possible. Other options include endoscopic feeding tube placement, specialty devices that aid in passing a feeding tube through the pylorus, or frictional feeding tubes that pass through the pylorus by peristalsis. Last, gastric feeding may be attempted, but once intolerance is demonstrated, more distal access should be obtained. In the nutritionally replete patient, if full enteral support cannot be attained by 7–10 days, then PN or a combination of enteral support supplemented with PN should be used. For the malnourished patient, PN should be initiated at day 1 and stopped once enteral support is at goal (Figure 5).

Assessment of nutrition requirements should be performed on all patients managed with an open abdomen. These patients have large open wounds and will require increased protein and caloric support. Estimation of nutrition requirements can be done using one of many predictive equations for estimating basal energy expenditure. Several of these equations (Swinamer, Ireton-Jones, Brandi, Faisy, and Penn State equations) were designed specifically for critically ill patients.[26] Alternatively, indirect calorimetry with a metabolic cart can be used for individualized measurement of energy requirements. Standard measures, including prealbumin, serum albumin, and C-reactive protein, should be followed. In general, most patients with an open abdomen will require 25–35 kcal/kg/d of nonprotein calories and 1.5–2.5 g of protein/kg/d. I have found the single most reliable indicator of appropriate nutrition support to be timely and adequate wound granulation.

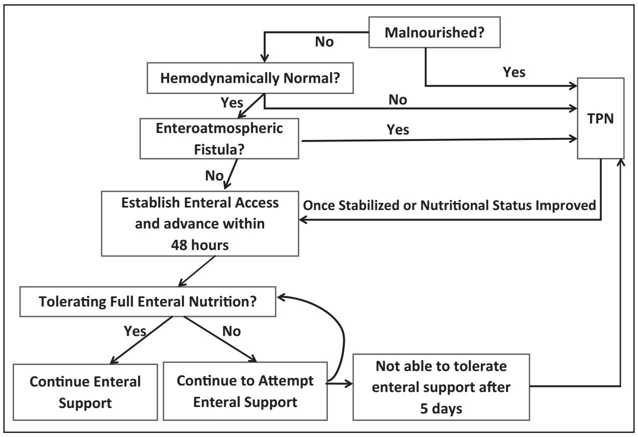

Figure 5. Nutrition support in patients with an open abdomen.

It is important to recognize that standard measures of anabolic metabolism, such as calculation of positive nitrogen balance, will frequently be erroneous for patients with an open abdomen due to unmeasured protein losses across the large open wound.[11] Protein losses from these large open wounds will be dependent on daily volume of exudate. Protein content can be estimated as approximately 2.9 g protein/dL of exudate.[27]

A 24-hour urine urea nitrogen level should be followed at least weekly and nutrition support therapy modified based on these measurements. Nitrogen balance should be calculated with the adjustment of 1 g of protein loss per 500 mL of fistula output.[25] Failure to account for these unmeasured protein losses will lead to underfeeding and inadequate nutrition support. In addition, protein supplementation should be given even in the presence of renal dysfunction. Protein requirements should not be truncated for fear of inducing the need for hemodialysis. I favor a transient period of hemodialysis over protein malnutrition in this patient population.

Patients with enteroatmospheric fistulae present a unique challenge to the nutrition support team. In addition to the above recommendations, one must meticulously account for and replace fluid and electrolytes lost through the gastrointestinal fistula as well as develop individualized nutrition support plans designed to deliver adequate calories and protein to these challenging patients. The surgeon should make a concerted effort to measure and document the location of each fistula, the total length of bowel remaining, and the presence or absence of a functional ileocecal valve. This information is important in determining the likelihood of enteral feed intolerance due to short gut syndrome. In addition, individualized attempts at designing distal feeding or refeeding regimens through the enteroatmospheric fistula should be made. Refeeding fistulous output will help to reduce fluid and electrolyte disturbances as well as increase caloric delivery. Refeeding regimens can be difficult to maintain. Collaboration with an experienced enterostomal nursing specialist is essential for success.

Summary

In summary, the open abdomen has become an important tool for the management of physiologically unstable patients requiring emergent abdominal surgical procedures. These patients present unique challenges to the critical care and nutrition support teams. Careful attention to fluid and electrolyte management, meticulous wound care, prevention of enteroatmospheric fistula, and individualized nutrition support therapy are essential to successful recovery in this patient population.

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