Hypothesis: Biological dressings can be effective tools in the management of enteric fistulas, which are the nemesis of exposed viscera.

Design: Retrospective review of medical records.

Setting: University-affiliated level I trauma center.

Patients: Patients with open abdominal cavities and coexistent intestinal fistulas who were treated between January 1, 1999, and July 1, 2006.

Interventions: Application of biological dressings to fistula sites within open abdominal cavities during serial fascial closure. Biological dressings included cadaveric skin, human acellular dermal matrix, and fibrin sealant.

Main Outcome Measures: Enteric fistula closure and healing of the abdominal wound.

Results: During the 6 years under review, there were 69 patients with open abdomens. Of these patients, 7 (10%) developed enteric fistulas and underwent application of biological dressings. In 5 patients, fistulas closed and the abdominal wound healed after application of biological dressings. One additional patient healed after fistula resection. Biological dressing treatment and fistula resection both failed in 1 patient. There was no morbidity or mortality attributable to the intervention.

Conclusions: Intestinal fistulas significantly complicate the management of patients with open abdomens. In this case series, biological dressings were effective in achieving fistula closure. A prospective multiinstitutional study is required to confirm these preliminary encouraging results.

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The open abdomen is a common iatrogenic surgical condition in the modern intensive care unit. An open peritoneal cavity promotes drainage of infection, relieves abdominal hypertension, allows repeated access to the abdomen for reevaluation and lavage, and allows damage control surgery in unstable patients requiring resuscitation and delayed anatomical reconstruction. While prospective studies have failed to demonstrate significant outcome improvement with this strategy, use is widespread because of increasing recognition of the inadequacy of other techniques. The use of open abdomen management has a number of associated complications, including wound infection, ventral hernia, and intraperitoneal abscesses. However, the nemesis of open abdomen management is a hole in the exposed bowel without overlying soft tissue, referred to as an “enteroatmospheric fistula.”

The enteroatmospheric fistula is a catastrophic complication resulting in a complex wound; electrolyte, fluid, and nutritional depletion; and infection. The physiologic consequences of this wound resemble those of a large burn. We hypothesize that treatment of an enteroatmospheric fistula with biological dressings promotes early fistula closure without resorting to more complex operations. Therefore, human acellular dermal matrix (HADM) (Alloderm; Life-Cell Corp, Branchburg, New Jersey) and cadaveric split-thickness skin were applied to enteric fistulas in patients with open abdomens.

Methods

Patients

The Trauma Registry and Department of Surgery billing records of San Francisco General Hospital were scanned and medical records were reviewed for all patients with open abdomen management between January 1, 1999, and July 1, 2006. Approval for the study was granted by the institutional review board of the University of California, San Francisco, Committee on Human Research. Patients who developed an entéric fistula in the setting of an open abdomen were selected for review. All patients with an enteroatmospheric fistula were

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treated with cadaveric split-thickness skin grafts (CSTSGs), HADM, or both. Medical records were reviewed in detail, including all admission history and physical examination results, interim summary reports, discharge summaries, pathological reports, radiographic reports, and operative reports. No exclusion criteria were applied.

INSTITUTIONAL APPROACH TO OPEN ABDOMENS

Patients were selected for open abdomen management if they had severe intra-abdominal infection requiring serial peritoneal lavage, acute mesenteric ischemia requiring second-look laparotomy, necrotizing infections of the abdominal wall requiring radical resections, damage control laparotomy for trauma, or intra-abdominal hypertension requiring decompressive laparotomy.

Once a patient has been selected for open abdomen management, a vacuum-pack dressing is generally applied at the initial operation. If delayed primary closure is not possible at the second operation, a vacuum-assisted closure device (V.A.C.; KCI, San Antonio, Texas) is used for gradual closure. A multilayered vacuum dressing is applied in the operating room 2 to 3 times a week, beginning with a fenestrated plastic drape placed over the viscera, extending to the paracolic gutters to prevent adhesion formation. A tapered wound sponge (V.A.C sponge; KCI) is placed over this drape. Overlying this, a tapered polypropylene and expanded polytetrafluoroethylene mesh (Composix; C. R. Bard, Murray Hill, New Jersey) is sutured to the fascial edges and a second sponge is placed superficially to the mesh. Finally, an occlusive dressing is placed and attached to a suction device in the usual fashion. With each return trip to the operating room, the non-absorbable mesh is further “reefed” so as to effect gradual fascial reapproximation. Mesh abdominoplasty is not the end goal—if the process is successful, the polypropylene and expanded polytetrafluoroethylene mesh is eventually removed, and delayed primary closure of the fascia is achieved.

If a patient with an open abdomen has a fixed visceral block and develops a small enteroatmospheric fistula, an attempt is made to close the fistula with the application of HADM and fibrin glue. Meshed cadaver skin is applied to the surrounding bowel to prevent desiccation and contact with dressings, and to protect against the adverse effects of exposure to enteric succus emanating from the fistula. If the fistula fails to seal (as is usually the case), meshed cadaver split-thickness skin is reapplied as necessary to protect the adjacent bowel. A petroleum jelly–impregnated gauze is placed over the CSTSG, followed by a fenestrated plastic drape and the wound dressing previously described. We do not intubate the fistula. Intubation will not control an enteroatmospheric fistula but will enlarge the fistula and risk erosion into an adjacent loop of bowel (Figure).

If a large fistula is present, it is generally impossible to achieve delayed primary fascial closure. The fistula will not heal without well-vascularized tissue placed over the fistula. We use a variety of methods depending on the nature of the specific wound. The options include (1) rotation or advancement skin flaps placed over a fistula intubated with a soft rubber tube, (2) muscular fascial rotation or advancement skin flaps, and (3) free flaps. We often will serially place fibrin glue between the fistula and the flap in an attempt to seal the fistula and permit the vascularized flap to stick to the adjacent bowel to achieve definitive closure.

If these methods fail, conservative management is necessary for many months before a major operation to explore the abdomen, dissect the entire gastrointestinal tract, and resect the fistula. At the end of such an operation, the problem of achieving visceral coverage remains. Careful thought must be given to bowel coverage before the operation. Sometimes a simple solution (eg, rotation of a large previously delayed skin flap) is preferable to a theoretically ideal solution (eg, free muscle or myocutaneous flap) in an elderly patient with limited physiologic reserve who has already undergone a 6- to 8-hour intestinal procedure before the abdominal wall reconstruction.

RESULTS

Sixty-nine patients underwent open abdominal management during the study period. Of these patients, 7 (10%) developed 1 or more enteroatmospheric fistulas and received biological dressings. The age range was 20 to 65 years (mean±SD, 47±16 years). Five patients were men and 2 were women. The indication for initial laparotomy was gunshot wound (2 patients), pancreatitis (2 patients), and blunt trauma, gastric variceal hemorrhage, and duodenal ulcer perforation (1 patient each). The mean±SD time to development of the fistula was 24±15 days from the index operation.

Three patients (43%) achieved fistula closure solely with the application of biological dressings. One patient healed with CSTSG only, 1 with HADM only, and 1 with a combination of CSTSG and HADM. Fistulas in 2 other patients (29%) healed with a combination of CSTSG and pedicled flaps (1 fasciocutaneous and 1 muscle rotation). In these patients, CSTSG was used to protect the bowel that was adjacent to the fistulas, and soft tissue flaps were closed over the viscera without removing the CSTSG from the bowel. In all, 5 patients (71%) had enteric fistulas successfully treated with biological dressings, each requiring between 1 and 6 serial applications to achieve definitive fistula closure (Table).

Biological dressings failed in 2 patients (29%). One of these patients subsequently underwent successful fistula resection. In the other patient, treatment with biological dressings and multiple attempts at fistula resection with fasciocutaneous flap coverage failed.
Only 1 patient developed sepsis because of intraabdominal infection after application of the dressings. The dressing material did not seem to contribute to the infection in this patient. None of the patients died as a complication of enteroatmospheric fistula treatment. One patient died 2 years after fistula closure of unrelated urosepsis. There were no complications attributable to the use of biological dressings.

COMMENT

The open abdomen is a common entity in surgical intensive care units because of advances in the management of trauma, peritonitis, and other diseases requiring massive fluid resuscitation. An enteroatmospheric fistula occurring in the midst of an open abdomen is a disaster. If the fistula develops before consolidation of the visceral block, contamination of the peritoneal cavity will occur and it may precipitate the systemic inflammatory response syndrome. If the fistula develops after consolidation of the visceral block, as is usually the case, peritoneal contamination is unlikely. However, such a fistula occurring in the midst of a granulating abdomen results in a major wound management problem, requiring control and replacement of the fistula effluent.

This retrospective clinical review addresses our initial experience with application of biological dressings as an adjunct in the management of an established enteroatmospheric fistula. All of the patients survived, and 5 of the 7 achieved fistula closure with use of biological dressings. Furthermore, there were no adverse effects attributable to the biological dressings. Clearly, we are evaluating a few patients without a control group for comparison. The limited frequency of this problem would require a multicenter study to determine the optimal method of treatment. However, our encouraging results suggest that the early application of biological dressings is efficacious and safe.

An enteroatmospheric fistula is inherently problematic because it lacks a formal fistula tract and overlying well-vascularized soft tissue; therefore, there is no chance that the fistula will close spontaneously, even in the absence of distal obstruction or malnutrition. The usual basic principles of fistula management apply: drainage of associated fluid collections, delineation of fistula anatomical features, relief of any distal obstruction, treatment of systemic infection, and nutritional support. When dealing with the special problem of enteroatmospheric fistulas, several other principles should be stressed. The first principle is prevention. Exposed viscera should be meticulously protected from tissue trauma. If prolonged exposure of the viscera is anticipated, we favor prophylactic application of meshed cadaver split-thickness skin to protect the viscera from injury and desiccation. This dressing also has the potential to reduce the metabolic cost of the wound—as it does in a burn wound—although we have no data to support this assertion. Adherent HADM or CSTSG should not be removed because of the risk of bowel injury. We have successfully closed the abdomen with these grafts in place without adverse consequences.

The second principle is attempt to seal the fistula. We favor use of fibrin glue and HADM for closure of small fistulas. Alternatively, split-thickness skin coverage of enterocutaneous “bud” fistulas may be successful. In a recent series, 5 of 9 of these fistulas treated with split-thickness skin autografts closed. The chance of success may be small but, if unsuccessful, nothing is lost. In our series, 3 of the 7 patients achieved fistula closure with the use of biological dressings alone.

We prefer skin allograft as the initial biological dressing in most cases for several reasons. (1) The use of skin allograft as a protective dressing for the viscera preserves the option of delayed primary fascial closure. (2) Temporary coverage of large wounds with skin allograft in unstable patients avoids a large donor site. (3) If the allograft takes, there is a high likelihood that the subsequent autograft will be successful.

The third principle is control of fistula effluent. Exteriorization of the fistula is best, but usually impossible in the midst of an open abdomen with a fixed visceral block. The “floating stoma” is an interesting option, but we have no experience with its use in our center. The vacuum-assisted wound management system is often effective in controlling fistula effluent. Alternatively, a variety of wound management systems relying on plastic wound bags may be used. As a general rule, intubation of the fistula in an open abdomen makes the hole bigger, risks erosion into adjacent loops of bowel, and adds nothing to effluent control. Skilled and committed nursing care is required for effective management of these effluent control systems.

Table. Review of Biological Dressings Used in 7 Patients With a Fistula

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Biological Dressing Type</th>
<th>Outcome</th>
<th>No. of Dressing Applications</th>
<th>Abdominal Sepsis After Dressing</th>
<th>Total No. of Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CSTSG and HADM</td>
<td>Success</td>
<td>6</td>
<td>No</td>
<td>28</td>
</tr>
<tr>
<td>2</td>
<td>CSTSG</td>
<td>Success</td>
<td>2</td>
<td>No</td>
<td>16</td>
</tr>
<tr>
<td>3</td>
<td>CSTSG</td>
<td>Success</td>
<td>2</td>
<td>No</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>CSTSG</td>
<td>Success (flap combined with dressing)</td>
<td>1</td>
<td>No</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>CSTSG</td>
<td>Success (flap combined with dressing)</td>
<td>3</td>
<td>No</td>
<td>21</td>
</tr>
<tr>
<td>6</td>
<td>CSTSG</td>
<td>Failure (closed with fistula resection)</td>
<td>2</td>
<td>No</td>
<td>14</td>
</tr>
<tr>
<td>7</td>
<td>CSTSG and HADM</td>
<td>Failure (failed fistula resection)</td>
<td>12</td>
<td>Yes</td>
<td>38</td>
</tr>
</tbody>
</table>

Abbreviations: CSTSG, cadaveric split-thickness skin graft; HADM, human acellular dermal matrix.
The fourth principle is coverage of the fistula with well-vascularized soft tissue. This maneuver is not always possible, but significantly improves the likelihood of fistula closure. In our series, 1 patient was successfully treated with a fasciocutaneous flap placed over the CSTSG. The CSTSG failed in another patient who successfully healed after reapplication in combination with a rectus abdominus muscle transposition flap.

The fifth principle is resection of established fistulas unresponsive to conservative measures. Fistula resection should be pursued only when the patient is well nourished and free of infection, which may require a delay of many months (sometimes ≥1 year).

The sixth principle is daily attendance by a senior surgeon to maintain continuity. An enteroatmospheric fistula is a devastating emotional burden for the patient and the family. A mature clinician providing accurate information and encouragement is necessary to promote psychological stability.

In conclusion, we report a limited initial experience with the use of meshed cadaver split-thickness skin and HADM as biological dressings to assist with the treatment of enteric fistulas in open abdomens (enteroatmospheric fistulas). Of the 7 patients, 5 achieved fistula closure with biological dressings. These adjuncts seem to work best in combination with delayed primary abdominal closure or rotation/advancement flaps. The promising initial results described herein warrant further investigation of the technique with a multi-institutional prospective study.

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