

Use of a vacuum-assisted closure system for the management of enteroatmospheric fistulae

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Abstract

Purpose The aim of this study was to analyze the management of enteroatmospheric fistulae (EAF) in an open abdomen using vacuum-assisted closure (VAC) therapy.

Methods Eighteen patients (ten male/eight female) were treated in our surgical department for the management of EAF. VAC therapy was used to manage both complex and open abdominal wounds and for effluent control in all patients except one until definitive surgery could be performed or spontaneous closure of the EAF occurred.

Results The median age of the patients was 61.1 years (range 29–84 years). Their average hospital stay was 88.89 days (range 22–129 days). The median number of VAC applications was 22.5, and the median duration of VAC applications was 43.6 days (range 14–114 days). Non-surgical spontaneous closure of the fistulae with negative pressure wound therapy could be achieved in four patients. In the other six patients, after the EAF were controlled with VAC therapy, definitive surgery was performed. Primary fascial repair was performed in two patients, and the component separation technique was synchronously performed in another two patients. Ventral hernia repair using polypropylene mesh was performed in a patient 1 year after discharge from the hospital. One patient was discharged with skin grafting plus ileostomy after the EAF was managed with VAC therapy. Eight patients (44.4 %) died due to intraabdominal infections and sepsis, which could not be controlled despite all precautions. No VAC-related complications were observed in this study.

Conclusion A VAC system can be successfully used for wound management in the control of fistula effluent in patients with an EAF in an open abdomen until spontaneous fistula closure occurs or definitive fistula surgery can be performed.

Keywords Enteroatmospheric · Fistula · Open abdomen · Abdominal complications · Peritonitis · Vacuum-assisted closure

Introduction

An open abdomen (OA) has recently been a life-saving method, used extensively worldwide, particularly in complex surgical procedures, such as those for trauma patients who initially underwent damage control surgery, patients with severe intra-abdominal infections, acute mesenteric ischemia, abdominal compartment syndrome and necrotic infections of the abdominal wall [1–3]. The management and treatment of these patients can be regarded as performance of the art of surgery. However, complications that develop due to the primary disease of the patient and the open abdomen procedure are associated with serious risks of morbidity and mortality.

The most important one of these complications is an enteroatmospheric fistula (EAF), which is a specific type of fistula seen only in patients with an open abdomen where there is an abnormal communication between the gastrointestinal tract and the skin. Unlike other types of enterocutaneous fistulae, in an EAF, the intestinal lumen is directly open to the atmosphere, without a cutaneous or a subcutaneous fistula tract or overlying skin or subcutaneous tissue, and thus, there is free flow of intestinal fluids through the fistula [2, 4, 5].

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Because the skin around the fistula is not even, isolation of the intestinal effluent with ostomy appliances is difficult. As a result, the gastrointestinal contents are constantly in contact with the exposed viscera, and the skin around the wound rapidly develops irritation, rashes, cellulitis and bacteria growth in the wound, which delays wound healing and bacteremia and/or sepsis frequently occur. Furthermore, the gastrointestinal contents directly in contact with the exposed viscera can cause new perforations by irritating the intestinal surfaces due to their lytic effects. The patient's condition can rapidly deteriorate, thus leading to septic shock.

The development of EAF in patients with an OA is reported to occur in between 1.5 and 75 % of cases [5]. Most of these patients need intensive care and have conditions that are critical and associated with various comorbidities in addition to their primary diseases. Furthermore, the enteric contents from the fistula, constant contact of the intestines with the air, existing catabolic process due to underlying disease, protein loss and infection/sepsis also increase the mortality and morbidity rates.

In this study, we review the data for our patients who underwent open abdomen management and later developed an EAF in our clinic and provide a comparison with the published literature.

Methods

A total of 33 patients underwent OA management for abdominal sepsis between 2008 and 2012 at our hospital. EAF developed in 18(54.5 %) of the 33 patients with an OA. A vacuum-assisted closure (VAC) system was used to control and manage the complex abdominal wound and fistula effluent in all but one of these patients. This study was performed with the approval of the Izmir Katip Celebi University, Ataturk Training and Research Hospital ethics committee.

The key point in our management policy is that the initial treatment must consist of an overall assessment of the patient with EAF, the nature of the fistula and the condition of the wound. Additionally, we evaluated the patients for infection and sepsis, corrected the fluid and electrolyte abnormalities and/or nutritional status, imaged the fistula and provided wound and skin care. Enteroatmospheric fistulas were first treated medically, as are other enterocutaneous fistulas, to allow for spontaneous fistula closure except in cases with conditions such as distal bowel obstruction or ongoing abdominal sepsis, or for patients with an abscess who needed urgent drainage. Once the initial stabilization of the patient and local control of the fistula output had been achieved, our efforts were focused on maintaining the stability of the patient and local control of the fistula

output, and oral feeding was started as early as possible and was continued until definitive surgery.

All of the patients in our series stayed in the intensive care unit (ICU) during most of their hospitalization. Systemic broad-spectrum antibiotics were used depending on the results of wound cultures. Microorganisms grew in the wound cultures in a significant number of these patients. Furthermore, all of the patients were given parenteral nutrition totally or peripherally by the nutrition support team at our hospital, depending on their clinical conditions, and particularly during their stay at the ICU. In patients who had a distal fistula with function of much of their small bowel and control of the surrounding wound, enteral feeding was started in gradually increasing amounts.

First, the basic wound care principles were applied in all the patients. The wounds were first irrigated with saline, and the necrotic tissues, which were a potential source of bacterial growth, were debrided. VAC applications were usually performed under general anesthesia in the operating room, depending on the clinical condition of the patients. Sometimes, the procedures were done in the ICU. Debridements were performed by or under supervision of an experienced physician until healthy and bleeding tissues were reached.

Technique

Both the isolation of the enteroatmospheric fistula opening and the prevention of the contamination of the rest of the wound by fistula effluent are important factors in the management of the abdominal wound in the patients with EAF. There are many modified methods and apparatus that can be used with a VAC system for controlling fistulae and to protect the surrounding open abdominal wound and skin. In this study, we used various techniques that were previously described in the literature for isolation of the fistula mouth [1–3, 6]. Some of these methods that were used in a significant portion of our patients are presented briefly below:

Small fistulae were first covered with a patch of hydrophilic polyvinyl alcohol foam. The entire abdominal wound was covered with polyurethane (PU) foam to seal the OA, preventing further spillage of the enteric contents. The foam was covered with an adhesive drape and continuous negative pressure was applied.

For large fistulae with protruding mucosa, the laparotomy was covered with a perforated polyethylene sheet. A hole was cut in the PU foam to match the fistula mouth, and the PU foam was placed onto the polyethylene sheet.

Ring method

This method was first described by Verhaalen et al. [2]. First, as described above, the wound debridement was completed. In the ring method, the black PU foam was cut into

a circular shape depending on the size of the opening of the fistula, then was completely covered with VAC drape to create an impermeable barrier. Therefore, the prepared ring foam apparatus was applied over the fistula opening. Adherence to the wound bed was achieved with the application of stoma paste to the bottom of the ring, then the application of a cohesive seal below the stoma paste. The rest of the granulated wound was dressed with black foam, and an occlusive drape was applied over the entire dressing area. After sealing was achieved, an ostomy bag was placed over the isolation ring to collect the effluent.

The basic difference in the ring method compared to the other VAC applications is that the fistula effluent is transferred into an ostomy bag through a hole by fixing an ostomy system over the fistula mouth. The other parts of the wound should therefore not come in contact with air after this procedure is completed. As a result, the intestinal effluent coming in contact with the other exposed intestinal parts is prevented.

The fistula opening is isolated with ostomy appliances from the open wound with the help of the VAC system. Most importantly, although we want to emphasize that the application of the VAC system was generally the same for each patient, we also used different application techniques, as mentioned above, to control the enteroatmospheric fistula in some patients. Even so, it was sometimes necessary to use two different VAC application methods to isolate the fistula mouth in the same patient. Additionally, special care should be taken to ensure that the black sponge will not touch the intestinal surface when using the ring method. We emphasize that it is necessary to use a polyethylene dressing over the exposed intestines in order to prevent the development of a new fistula using both of the above-mentioned systems. If granulation tissue formation occurs, the black foam can be directly applied on the wound. No EAF related to VAC therapy was seen in the area of the wound as a complication in the present study.

After the fistula opening was isolated, an ~2–3 cm opening was made in the center of the drape to apply the suction tubing system. The initial pressure to be applied should be determined based on the experience of the responsible surgeon. Although it has been reported that the normal therapeutic level is 125 mmHg, we sometimes started with low pressures, such as 50–75 mmHg after considering the condition of the patient and the location and status of the wound, and increased the pressure progressively. In this study, although the VAC dressing was generally reapplied only every 48–72 h, the schedule for changing the wound VAC dressings varied based on the patients' status.

The enteric contents of the EAF in all but one of the patients were successfully isolated from the surrounding tissues with colostomy and/or ileostomy bags used in combination with the VAC system (Figs. 1, 2).

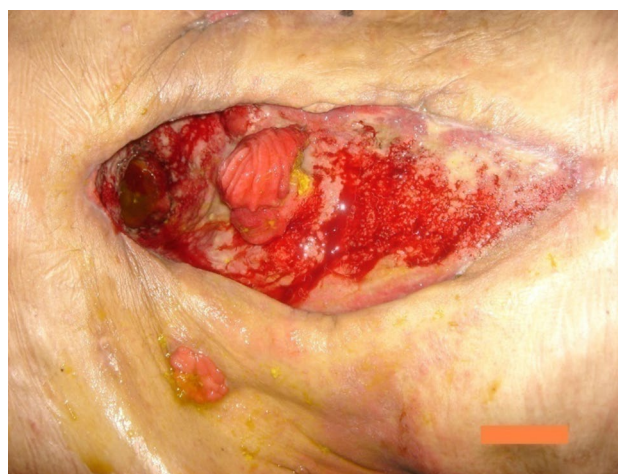


Fig. 1 An enteroatmospheric fistula after abdominal surgery

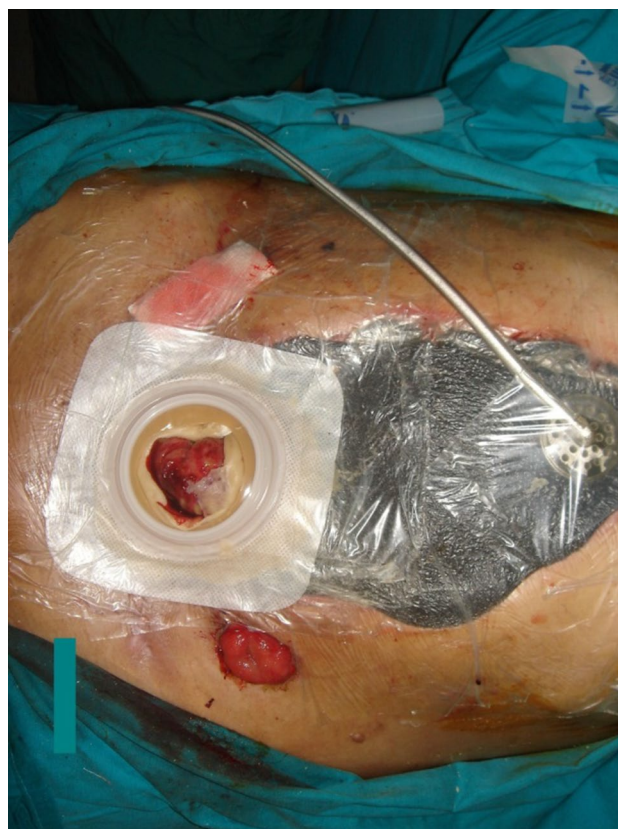


Fig. 2 The successful isolation of the fistula from the surrounding tissues with ileostomy bags used in combination with the VAC system

We also used a few different isolation techniques for controlling the enteric effluent in our patients. One of these methods was the technique defined by Layton et al. [6], who reported a simple yet effective method using a nursing bottle teat on a trauma patient on who open abdomen

procedure was performed and who developed an EAF. We used this method in only one patient in whom the routinely used methods were insufficient to isolate the ostomy stoma. However, while controlling the fistula with the nursing bottle teat, a leak occurred around the teat, so the method was given up immediately.

In the literature, it is recommended that a clinical classification is useful to determine the prognosis and to influence therapeutic decisions. Based on the amount of secretion, fistulas can be classified as low output (under 200 ml daily), moderate output (ranges between 200 and 500 ml) and high output (exceeds 500 ml per day) [7]. Of the 18 patients in the study, 11 (61.1 %) had a high-output fistula, four (22.2 %) had a low-output fistula, and three (16.6 %) patients had moderate fistula output.

No specific duration or number of VAC applications can be stipulated, because each case is different in terms of the patient's status and depending on the condition of the wound. The VAC applications were ended based on the decision of the responsible specialist and depended on improvements in wound healing.

Results

An open abdomen was used for the 33 patients in these series because of an intraabdominal infection and/or sepsis, which had developed either due to the primary diseases of the patients or as a result of complications of surgery. The enteroatmospheric fistula developed during the first 1–2 weeks of OA in 18 of the 33 patients who underwent open abdomen management. These included ten males and eight females (mean age 61.1 years, range 29–84). The mean body mass index (BMI) of our patients was 32.1 (19.8–46.7); so the patients were mostly overweight or obese. In total, fourteen patients had comorbidities (cardiovascular disease in six, diabetes mellitus in three, morbid obesity in three, a history of cancer in three, an immunologic disorder in one, a history of cerebrovascular accident in one, abdominal tuberculosis in one and chronic renal failure in one patients). The demographics and some clinical characteristics of our patients are shown in Table 1.

As shown in Table 1, the average hospital stay was 88.8 days (range 22–190 days). The mean ICU stay was 15.5 days (range 1–40 days). The average duration of VAC applications in our series was 43.6 days (range 14–114 days), and the average number of applications was 22.5 (5–59). The EAF was successfully isolated in all but one of the patients. This patient died due to uncontrollable sepsis despite the fact that the VAC system was applied at the early stage and definitive surgery was performed at the later stage.

Nine of the patients with EAF (50 %) had undergone surgery for locally advanced stage or metastatic disease,

Table 1 The details of the patients in this study

| Criteria | N (range or %) |
|--|-------------------|
| 1. Number of patients | 18 |
| 2. Female/male | 8/10 |
| 3. Age (years) | 61.1 (29–84) |
| 4. BMI (kg/m ²) | 32.13 (19.8–46.7) |
| 5. Comorbid factors | 16 |
| (a) Cardiovascular disease (CVD) ^a | 6 |
| (b) Diabetes mellitus ^a | 3 |
| (c) Morbid obesity ^b | 3 |
| (d) History of cancer | 2 |
| (e) History of cerebrovascular accident (CVA) ^a | 1 |
| (f) Immunological disorder | 1 |
| 6. Average hospital stay (days) | 88.89 (22–190) |
| 7. Average ICU stay (days) | 15.5 (1–40) |
| 8. Average duration of VAC dressing (days) | 43.61 (14–114) |
| 9. Average number of VAC dressings | 22.5 (5–59) |
| 10. Mortality | 8/18 (44.4 %) |

^a CVD associated with CVA in one patient

^b Diabetes mellitus associated with morbid obesity in two patients

and three patients (16.6 %) had undergone incisional hernia repairs with prosthesis implantation, and had a small intestine perforation, which had developed due to graft migration. One patient who had small intestine perforation due to graft migration had undergone two surgeries for malignant gastrointestinal stromal tumors (GISTs) and had received a graft implant due to the development of an incisional hernia after her last operation. The other two patients had incisional hernia, but they both also had type 2 diabetes mellitus with morbid obesity. In the first of these patients, dual polyester mesh was used to repair her incisional hernia, and the mesh was placed opened with an inlay technique. Open onlay polypropylene mesh repair for the incisional hernia was used in the two other patients. The primary diseases or causes of the need for OA in the other patients with an EAF in our series are shown on Table 2.

The enteroatmospheric fistulae and abdominal wounds in four patients (22.2 %) were spontaneously closed following the conservative medical treatment and VAC application. They had low-output fistulas with only one fistula opening, and enteral feeding was started early in the course of treatment. Two of the patients were relatively young compared to the others, and they had no comorbidities or coexisting illnesses. Two patients did not want to undergo ventral hernia repairs after discharge, and they are being followed up on an outpatient basis. One patient had undergone total gastrectomy due to gastric cancer, and although this patient's fistula closed spontaneously, he died 4 months later because of metastatic liver disease. The last patient successfully underwent ventral hernia repair

Table 2 The primary causes in the patients with enteroatmospheric fistulae

| Primary causes | Number of patients |
|--|--------------------|
| I-Malignancies | |
| GIS malignancies (5 colorectal cancer, 2 gastric cancer) | 7 |
| Metastatic ovarian cancer | 1 |
| Locally advanced bladder cancer | 1 |
| II-Small intestine perforation | |
| Prolene mesh migration into the small intestine | 3 |
| Peritoneal dialysis, catheter erosion into the bowel | 1 |
| Iatrogenic (Tbc peritonitis) | 1 |
| Unknown primary cause | 1 |
| Strangulated inguinal hernia | 1 |
| III-Primary suture leakage following duodenal ulcer perforation | |
| IV-Colonic fistula following acute necrotizing pancreatitis | 1 |
| Total | 18 |

with polypropylene mesh 1.5 years after the first surgery (Table 3).

As is shown in Table 4, patients with EAF are able to undergo successful definitive surgery. Although definitive surgery was actually performed in eight patients, definitive surgery was successful in only six patients, while two patients died because of early postoperative complications. Definitive surgical treatment was generally delayed 2–4 months (59–127 days) to allow for the stabilization of the patients' general status and for preoperative planning. The common characteristics of the six patients who underwent successful definitive surgery included good source control and the elimination of the infection and/or sepsis, maintaining an optimal nutritional status and successful management of both the wound and fistula output. On the other hand, the two patients who died had some negative factors, such as comorbidities, the prolonged use of TPN, previous laparotomies, hypoalbuminemia and a high-output proximal small intestinal fistula.

Definitive surgery was performed in two patients at a relatively earlier postoperative period than in the other patients, because it was very difficult to regulate their fluid and electrolyte balance. Abdominal exploration was performed directly on the granulated median wound, and the fistulized small bowel segment was resected and a primary anastomosis was performed in these patients. Furthermore, primary fascial repair was performed in two patients, and the component separation technique was synchronously performed in another two patients. One patient who underwent primary fascial repair was discharged from the hospital with a diverting ileostomy. Ventral hernia repair using

Table 3 The clinical features of the patients with spontaneous closure of the fistula ($N = 4$)

| Primary disease | Age | Injury | Comorbidity | Fistula volume | Time to spontaneous closure (days) | Ventral hernia repair |
|--------------------------------|-----|--|------------------------------------|----------------|------------------------------------|--|
| Recurrent ventral hernia | 62 | Infected mesh eroded into the bowel causing the initial fistula. After mesh removal and primary repair of the small bowel perforation, a new fistula developed | Diabetes mellitus + morbid obesity | Low | 91 | No (refused) |
| Acute necrotizing pancreatitis | 57 | Colonic fistula | No | Low | 42 | No (refused) |
| Gastric cancer | 68 | Esophagojejunal anastomosis leakage after total gastrectomy for gastric cancer | CVD | Low | 22 | No (died from metastatic liver disease 4 months after the first operation) |
| Duodenal ulcer perforation | 53 | Leak after repair of a duodenal perforation | No | Low | 76 | Repair with propylene mesh |

Table 4 The clinical features of the patients who underwent successful definitive fistula surgery

| Primary disease (surgery) | Age | Injury | Comorbidity | Fistula volume | Definitive fistula surgery | Time to definitive fistula surgery (days) | Delayed ventral hernia repair |
|--|-----|---|---|----------------|---|---|--|
| Sigmoid cancer (sigmoid colon resection) | 29 | Fistula from anastomotic leakage | No | Moderate | Successful fistula resection | 75 | (repaired with PPM) ^a 1 year after discharge from the hospital |
| Gastric cancer (total gastrectomy) | 68 | Wound evisceration and small bowel necrosis after total gastrectomy | CVD associated with CVA | High | Successful fistula resection and primary fascial repair | 83 | – |
| Strangulated inguinal hernia (partial small bowel resection) | 65 | Bowel resection, ileostomy, wound dehiscence, fistula from anastomosis. Primary anastomotic leakage | CVD | High | Successful fistula resection and primary fascial repair | 62 | – |
| Right colon cancer (right hemicolectomy) | 54 | Right hemicolectomy, fistula from anastomosis | CVD | High | Successful fistula resection and component separation technique | 127 | – |
| Rectal cancer (abdominoperineal resection) | 72 | Wound evisceration and small bowel necrosis after abdominoperineal resection | CVD | High | Successful fistula resection and component separation technique | 99 | – |
| Small bowel obstruction and perforation due to peritonitis carcinomatosa (primary repair of perforation) | 52 | Failure of primary sutures and generalized peritonitis | She underwent an operation for ovarian cancer and peritonitis carcinomatosa 2 years earlier | High | Repair wound with split thickness skin graft | 59 | No |

^a Polypropylene mesh

Table 5 A summary of the features of patients who died

| Primary disease | Age | Injury | Comorbidity | Fistula volume | Definitive fistula surgery | Length of hospital stay (ICU stay), days | Cause of death |
|---|----------|---|---|----------------|---|--|--|
| Recurrent ventral hernia | 67 (ES) | Infected mesh eroded into bowel, causing initial fistula. After mesh removal and primary repair of the iatrogenic small bowel perforation, leakage of primary sutures | Two operations for malignant GIST (3 and 5 years earlier) | High | Definitive surgery could not be performed | 55 (27) | Uncontrolled intraabdominal sepsis, general status deterioration |
| Bladder cancer (locally advanced) | 84 (ES) | Leaking small bowel anastomosis (after surgery for mechanical small bowel obstruction) | CVD+Bladder cancer (recurrent and locally advanced) | High | Definitive surgery could not be performed | 42 (4) | Uncontrolled intraabdominal sepsis, general status deterioration |
| Peritoneal dialysis catheter erosion into small bowel | 50 (ES) | Leakage of primary sutures (also abdominal cocoon secondary to chronic ambulatory peritoneal dialysis) | CRF | Moderate | Definitive surgery could not be performed | 37 (12) | Uncontrolled intraabdominal sepsis |
| Recurrent ventral hernia | 76 (ES) | Infected mesh eroded into bowel causing initial fistula. After mesh removal and primary repair of the small bowel perforation, a new fistula developed | Morbid obesity+type 2 D. mellitus | High | Definitive surgery could not be performed | 42 (36) | Uncontrolled intraabdominal sepsis |
| Small intestine perforation, unknown primary cause | 72 (ES) | Anastomotic leakage (abdominal cocoon secondary to chronic infection) | No | High | Definitive surgery could not be performed | 112 (12) | Uncontrolled intraabdominal sepsis |
| Abdominal cocoon secondary to tuberculosis | 51 (ES) | Iatrogenic small intestine perforation at laparotomy and leakage of primary suture | Abdominal Tbc | Moderate | Definitive surgery could not be performed | 35 (5) | Uncontrolled intraabdominal sepsis |
| Rectal cancer | 57 (ELS) | Anastomotic leakage and generalized peritonitis | Immunological disorder | High | Definitive surgery (after 4 months) | 138 (23) | Uncontrolled intraabdominal sepsis |
| Sigmoid colon cancer | 54 (ELS) | Colonic anastomotic leakage+multiple iatrogenic small bowel lacerations | Type 2 diabetes mellitus+morbid obesity | High | Definitive surgery (after 3 months) | 180 (02) | Uncontrolled intraabdominal sepsis |

CRF chronic renal failure, ES emergency surgery, ELS elective surgery

polypropylene mesh was performed in one patient 1 year after discharge from the hospital. These patients survived without any new problems after definitive surgery. One patient underwent skin grafting only after their EAF was controlled with VAC. This patient was discharged from the hospital with an ileostomy.

Eight patients (44.4 %) died due to intra-abdominal infections and sepsis, which could not be controlled despite all efforts. Some clinical data on these patients who died in our study are summarized in Table 5. Five patients died during conservative treatment due to uncontrolled intra-abdominal sepsis. Another patient was not able to undergo surgery even in the late postoperative period due to an abdominal cocoon secondary to a long-standing postoperative infection, and subsequently died. Two patients died due to intraabdominal sepsis, in spite of definitive surgery. The reasons for mortality in these patients were sepsis 3 days after definitive surgery, and an unknown cause 4 days after definitive surgery.

No EAF related to VAC therapy was seen in the area of the wound as a complication in any of these patients.

Discussion

Enteroatmospheric fistulae are a serious clinical problem. Unfortunately, there is no standardized method, which can be used on every patient [6]. Although surgical techniques, anesthesia and intensive care facilities are improving, the mortality rate due to EAFs is still high and was reported to be 36–64 % in the literature [4, 7]. This rate was 44.4 % in our series, which is consistent with the previous findings.

The basic principles for the treatment of EAF are the same as those for the treatment of other gastrointestinal fistulae [7–10]. The treatment of enteroatmospheric fistulae requires a stepwise multidisciplinary approach, and the essential principles of the management of enteroatmospheric fistula include the following components: (1) restoration of the blood volume and correction of fluid/electrolyte and acid–base imbalances, (2) early recognition and treatment of infections and sepsis with appropriate antibiotics, (3) evaluation and drainage of abscesses, preferably percutaneously, (4) initiation of a regimen of alimentary tract rest, (5) beginning and maintaining optimal nutrition by total parenteral nutrition and/or enteral nutrition as soon as possible and (6) controlling the fistula opening by separation/suction of the intestinal effluent [7, 8, 10].

The wound management goals were to isolate the intestinal fistula output of an EAF from the surrounding OA surface, because this is considered to be a source of major morbidity, because it contains abdominal exudates, and to protect the integrity of the peri-wound skin from maceration. On the other hand, the main aim of the fistula

management was to provide stabilization in preparation and support of patients undergoing a definitive fistula takedown procedure or to ensure spontaneous closure of the EAF if possible. Generally, the treatment of EAFs is more complex and difficult than the treatment of other enterocutaneous fistulae, and usually requires a few months. Almost all of the affected patients are critically ill, and the fistula is usually seen in the early stages of their ICU courses. They are also frequently affected by malnutrition and local sepsis. Additionally, because of the adhesion of the bowels firmly on the abdominal wall, edema of the tissues and organs, particularly the bowels, the skin and the subcutaneous tended to move laterally, and the fact that the bowel serosa are injured even during the smallest dissections, surgical intervention for closing the fistula, and particularly for diversion of the proximal part, are usually unsuccessful [8–11].

On the other hand, any intervention for intubation of the intestinal fistulae may also enlarge the fistula stoma. Covering the fistula with a well blood-fed tissue is the most effective approach and allows the spillage from the fistula to be controlled; however, even this approach does not guarantee that the fistula will close [12]. Various materials and methods, such as fibrin adhesives, drainage catheters, local repair and reinforcement, traditional ostomy apparatus, multilayer wound dressings and vacuum-assisted wound closure systems with various techniques for controlling gastrointestinal effluent have been used for the management of EAF in the past 10 years [5, 8–10, 13, 14].

Currently, vacuum-assisted closure systems are widely used to control enteric effluent in patients with EAF. This can make it possible to avoid bowel content spillage into the organs and tissues surrounding the fistula, preventing continued sepsis. It has been reported that VAC also increases the rate of tissue granulation and augments wound contracture. VAC may not only provide control of the complex abdominal wound, but also contributes to increased wound granulation and healing [9, 10, 15]. Kubiak et al. [16] demonstrated that peritoneal negative pressure therapy prevented multiple organ injury in a chronic porcine sepsis and I/R model, and they concluded that peritoneal negative pressure therapy also reduces the systemic inflammation and organ damage. Jacobs et al. [17] reported that a VAC device accelerated wound healing by increasing the pro-angiogenic growth factor production, and improved collagen deposition in small animal VAC wound model. Cheatham et al. [18] compared VAC and Barker's vacuum packing technique in a prospective study, and they concluded that the VAC system is associated with significantly higher 30-day primary fascial closure rates and lower 30-day all-cause mortality among patients who required an open abdomen for at least 48 h during the treatment of a critical illness.

VAC wound systems reduce the nurse and physician care, especially in patients with excessive discharge from the abdomen. Moreover, since the VAC system is replaced only every 48–72 h, it facilitates wound care. The elimination of odors arising from necrotic tissues and the fact that it provides a closed system gives significant comfort to both the patients and the team responsible for patient care. The use of a VAC system can also facilitate patient mobilization in some cases.

The cost of the system is the most important disadvantage, and presents a serious problem in patients requiring long-term VAC application. In our series, in one patient who died in spite of VAC application and all of the medical treatments, the cost of just the VAC amounted to ~US\$ 20,000. However, the advantages and disadvantages of the VAC system should be evaluated without considering these costs, because there is currently no effective alternative treatment for these patients.

We want to emphasize that every patient in our series could be a separate case report in terms of both the characteristics of their diseases and the isolation method used for the EAF. This is because, although the application method used for the VAC system in every patient is generally the same, some patient-specific modifications were done for some of our patients, and the duration of the applications varied from patient to patient. In the recent literature, surgeons have begun to use various techniques involving negative pressure wound management systems, such as fistula VAC, floating stoma, nipple VAC and ring and silo VAC in the patients with EAF for isolating the enteric effluent [1–3, 19–21]. As a result, there is no single “best” isolation method that can be used with a VAC system to control fistula effluent in every patient with an EAF. VAC may be used with various modifications to control any gastrointestinal contents, depending on the condition of the fistula and the experience of the surgeon. The most important point in the decision regarding the management of the wound in patients with EAF is not which method is used, but whether the isolation method can control the fistula by providing complete isolation of the intestinal contents.

Another expected distinctive characteristic of our series is the prolonged duration of the hospital stays due to their primary diseases and/or wound complications. The average hospital stay in our series was 88.9 days (range 22–190 days). The majority of these patients were old patients with other serious systemic diseases, and they spent most of their hospital stays in the ICU.

If the fistula output is high, life-threatening severe metabolic disturbances often occur, and the rate of spontaneous closure of the fistula is lower in these cases [3]. Moreover, it has been reported that high-output fistulae continue to have a mortality rate of ~35 % in patients with enterocutaneous fistulae [22]. In this study, the fistula closed

spontaneously with conservative treatment in only four patients (22.2 %), and all of these patients had low-output fistulae. On the other hand, six (54.5 %) of the 11 patients with a high-output fistula died.

An EAF may close spontaneously or may be closed surgically [23]. There are many factors that affect both of the spontaneous closure of the fistula and the mortality rates in patients with EAFs, and successful wound management is only one of these factors. If the fistula is controlled with the VAC when it is applied together with other conservative measures, surgery should be avoided if possible during the first weeks when there is intensive inflammation.

If an exploratory laparotomy is performed in the early postoperative period, it will most likely result in disappointing results due to dense adhesions, small bowel serosal lacerations and mesenteric tears. Llyod et al. [24] concluded that if a fistula does not close spontaneously, the surgical intervention to be performed to close the fistula should be postponed for at least 3 months in patients with enterocutaneous fistulae. Demetriades reported that a definitive surgical repair is ideally performed 4–6 months after treatment in patients with an EAF [25].

In the present study we were able to perform definitive surgery in two patients 2 months after treatment without any problems such as heavy adhesions, bowel laceration or dissection difficulties due to inflammation. Although we agree that fewer difficulties will be encountered if definitive surgical repair is delayed, we think that the definitive surgery can be successfully performed 2 months after the initial operation depending on both the nature of the primary disease and general condition of the patient with the EAF. We believe that both the duration of conservative treatment and timing of definitive surgery should be individualized according to the patient characteristics and clinical status. For example, if the fistula output progressively decreases or is locally controlled, the patient's condition is stable; there is no intra-abdominal sepsis that necessitates intervention, the nutritional status of the patient is good, and conservative treatment may be continued. The patient should be treated conservatively as soon as possible after the diagnosis of an EAF, and definitive surgery should be delayed until the patient's condition is suitable, often at 4–6 months after the development of the EAF.

Marinis et al. [9] suggested that a lateral surgical approach via the circumference of the open abdomen is the method of choice to avoid further damage to the exposed viscera and to facilitate resection of the involved bowel loop. In our series, the lateral surgical approach was preferred in all of the patients on whom definitive surgery was performed. It was seen that when the skin forming the edge of the defect and the granulated tissue adhering to the skin were dissected very precisely and carefully, both the dissection and the exposure could be easily provided.

When infection control, meticulous and rigorous wound care and adequate fluid electrolyte and nutritional support have been achieved, the healing process and anabolic phase occur in the patients with an OA. Once this process has started in the patients with EAF, then extra problems will be more easily resolved. In this study, our experience has shown that if the EAF can be controlled and the patient is not septic and when oral feeding started as early as possible, the prognosis will be better. We emphasize that providing nutritional support (whether via oral feeding or TPN), successful management of the EAF and controlling sepsis are the three most important factors for spontaneous fistula closure.

As a result, a multidisciplinary approach should be employed, particularly in the ICU, in a manner consistent with the basic approaches used for the treatment of other enterocutaneous fistulae, particularly nutritional support, infection treatment and wound care. Fistula control is one of the most important stages of the treatment, and the management and treatment of each and every case should be done as per basic principles. We would like to emphasize the fact that wound management and treatment are specific to patients who develop EAF after their open abdomen procedures. Of course, VAC is not a method that can be successfully used in each and every case; however, it is an important tool that can be used by the surgeon in selected cases for controlling and managing the wound in the patients with EAF.

Conflict of interest The authors declare that they have no conflicts of interest.

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