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Update on Open Abdomen Management: Achievements and Challenges

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Abstract The open abdomen technique is one of the greatest advances in recent times and has enormous application in the daily management of the critically ill or injured patient. It results in tremendous benefits to the initial resuscitation of these patients but also brings on many challenges beyond those that might be expected from the primary illness or injury. Recent advances in the management of the open abdomen have provided the means to overcome the challenges and reap the benefits.

Introduction

"Damage-control" surgery, with emphasis on reversing physiologic exhaustion in critically ill or injured patients, is a major advance in recent times [1]. One important component of the concept is nonclosure of abdominal fascia at an initial, abbreviated laparotomy. The benefits of the resultant open abdomen are increasingly recognized and include the following: prevention of intraabdominal hypertension (IAH) and the abdominal compartment syndrome (ACS) [1–4]; early identification of intraabdominal complications (e.g., bowel ischemia); and preservation of unviolated abdominal fascia for subsequent closure. This fascial nonclosure, although offering several benefits, creates numerous management challenges with a potential for great morbidity (enteroatmospheric fistula) and mortality (intraabdominal sepsis). There have been recent advances in managing the open abdomen that help achieve many of the benefits without incurring highly morbid complications. This review summarizes the challenges and achievements of the open abdomen technique.

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Open abdomen and postinjury multiorgan failure

The open abdomen after a traumatic or septic insult should be considered a hostile environment that is contributing to the systemic inflammatory response [5–7]. The initiating event leading to the open abdomen, whether traumatic or septic, typically leads to sequential insults of ischemia-reperfusion and a "second hit" (e.g., infection, IAH), setting the stage for multiorgan failure (MOF). In animal models of hemorrhage and IAH, several studies have documented a significant increase in tumor necrosis factor-α and interleukin-6 as well as intense pulmonary infiltration with neutrophils. This amplified response with sequential insults may explain the high incidence of postinjury MOF that is seen in patients with an open abdomen.

Open abdomen as a nursing nightmare

Uncontrolled nonsurgical bleeding and/or massive amounts of fluid resuscitation that characterize patients with an open abdomen lead to diffuse third-space fluid accumulation and weeping surfaces in the peritoneal and retroperitoneal areas. Patients can drain several liters from the open abdomen over a 24-hour period. In previous years, this was a significant nursing issue. Fortunately, this is resolved by the current practice of employing some variant of a suction system to the open abdomen dressings to keep the patient dry.

Open abdomen and protein loss

In a prospective, observational cohort study, Cheatham et al. [8] analyzed 24-hour collections of urine and abdominal fluid protein in patients with an open abdomen. Nutritional calculations that failed to account for abdominal fluid nitrogen loss significantly overestimated the actual nitrogen balance by an average of 3.5 g/24 hr. The authors suggested that an estimate of 2 g of nitrogen per liter of abdominal fluid output should be included in the nitrogen balance calculations of any patient with an open abdomen.

Open abdomen and enteral feeding

The optimal method of nutritional support for patients with an open abdomen has received scant attention until recently. In a retrospective study, Collier et al. [9] reported on 43 patients who underwent enteral nutrition that started within the first 4 days; the authors observed earlier closure of the abdomen and lower hospital charges. A recent study [10] from a multicenter prospective database evaluated clinical outcomes in adults with hemorrhagic shock after injury. In all, 32 patients were given immediate enteral nutrition (within 36 hours after completion of resuscitation), and 68 had late enteral nutrition. There was no difference in the rate of fascial closure (93.8% vs. 94.1%), multiorgan dyfunction syndrome, length of ventilator days, intensive care unit (ICU) days, hospital days, or mortality between the two groups. The rate of pneumonia was significantly different: 14 (43.8%) with immediate enteral nutrition and 49 (72.1%) with late enteral nutrition ($p = 0.008$). Immediate enteral nutrition remained independently associated with a reduction in pneumonia on stepwise regression: odds ratio, 0.32; 95% confidence interval (CI), 0.13–0.79. The authors postulated that this benefit may be related to maintenance of mucosal integrity and/or reduction of bacterial translocation.

Challenge of enteroatmospheric fistula(s) with an open abdomen

An enterocutaneous fistula, or communication, between the gastrointestinal tract and the skin in the middle of an open abdomen is called an enteroatmospheric fistula. This is a highly complex problem to treat and is best prevented. Strategies for preventing the fistula are to cover all exposed bowel with omentum, avoid hyperresuscitation and the resulting bowel edema, and minimize serosal injury to the exposed bowel. The most important strategy, however, is to obtain closure of the fascia or, at least, the skin of the abdomen.

This is an area where there have been many recent accomplishments, and a variety of techniques are now available to obtain fascial closure. They include the Vacuum Pac method, commercial V.A.C. systems, "artificial burr," dynamic retention sutures, "silo," zipper, and absorbable mesh. If fascial closure is not possible, early midline closure of skin mobilized from either side of the abdomen can be accomplished to cover the bowel. These various methods are well summarized in a recent review with a critical analysis of their effectiveness [11]. The highest closure rates were seen with the artificial burr (90%), dynamic retention sutures (85%), and V.A.C. (60%). The closure rates, if only prospective studies are considered, were 71% for V.A.C., 90% for the Vacuum Pac, and 75% for the artificial burr. The authors also pooled the percentages of fistulas and abscesses, weighted for study size (1/variance). The weighted fistula rate ranged from 2.0 to 5.7, greatly reduced by these modern systems, compared with earlier series with zipper, mesh, or loose packing techniques. One recent prospective, randomized trial compared polyglactin mesh with V.A.C. [12]. Among 51 randomized patients, there were no differences between delayed primary fascial closure rates in the V.A.C. (31%) and MESH (26%) groups. The fistula rate in the VAC group was 21%, which was not statistically different from the 5% rate for the MESH group.

It appears that the fistula rate can be reduced with careful attention to detail and early closure of the abdomen. It is important to avoid closing the fascia under tension. This can be determined intraoperatively by monitoring peak inspiratory pressure or bladder pressure. Several series also established that the closure rate was best with posttraumatic abdomens, and the inability to achieve primary abdominal fascial closure was associated with infectious complications such as pneumonia, blood or soft tissue infections, and large transfusion requirements [13, 14].

Certain points about treating the enteroatmospheric fistula must be taken into consideration [15–19]. Attempts to close a fistula in the middle of an open abdomen with exposed bowel loops are usually unsuccessful but may be worth a try in selected patients. Fibrin glue and acellular dermal matrix can occasionally seal a small enteroatmospheric fistula. If the fistula occurs in an open abdomen that has not yet granulated into a "frozen" visceral block, continued contamination will occur and predispose to sepsis. In these patients, the goal should be to protect the rest of the open abdomen by attempting to isolate the fistula and treat it as a stoma. Wound care consultants have many techniques and ideas and are a real asset. It is important to keep the rest of the peritoneal cavity clean and free of abscesses. Occasionally, suturing the edges of the fistula to the plastic silo used for temporary coverage can create a

controlled stoma over which a stoma bag can be applied. The goal is to allow the rest of the open abdomen around the fistula to granulate. Once this is accomplished, the open abdominal wound is essentially a carpet of granulation tissue and is ready for skin grafting. The grafts usually take well and sometimes may grow over and close the fistula, if small.

Recently, a number of reports have described successful use of vacuum-assisted wound management in the control of fistula effluent with eventual healing of the fistula. In other instances, an open abdomen and fistula can be managed by soft tissue cover with fascia or even skin as previously discussed, combined with fistula intubation to create a drainage tract. The fistula can then heal because it is covered by well perfused soft tissue so long as intraabdominal abscesses and/or distal obstruction are not present.

The combination of an open abdomen and a fistula is extremely catabolic, and the patients must be supported by aggressive nutrition. Enteral nutrition may be allowed by well placed feeding tubes placed orally or by cannulating the fistula. If enteral nutrition is unsuccessful, intravenous nutrition should be used judiciously.

Patients with enteroatmospheric fistulas are so ill, and the abdomen so hostile, that definitive resection of the involved bowel segment must be delayed for many months (often a year or more), when the wound has matured and the patient's nutritional status is in a positive balance. Fistula resection, when planned appropriately, is often surprisingly easy to accomplish. It is not uncommon to find that the intrabdominal adhesions are flimsy, and the bowel loops are easy to dissect. In rare instances, abdominal wall reconstruction may require fascial prosthesis or myocutaneous flaps in close collaboration with a plastic surgery team.

In summary, skin or fascial closure over exposed viscera, when possible, is the best temporary dressing and prevents enteroatmospheric fistulas. Once established, the fistulas are best managed by meticulous wound care and nutritional support, but they demand attention to detail, innovative care, and patience on the part of the surgical team.

Open abdomen and its effect on intraabdominal hypertension

An open abdomen with nonclosure of fascia is an important prophylactic measure used to avoid the development of IAH in high risk patient groups [1–4]. The ultimate goal is to prevent the development of ACS. Considering the frequency of the development of IAH in the these patient populations and the consequent morbidity and mortality from IAH and ACS, the open abdomen technique contributes enormously to combating them.

The goal of leaving the abdomen open and using temporary closure is to have tension-free closure without elevating the intraabdominal pressure (IAP). Frequent monitoring of IAP is essential, as IAH can still occur even with the abdomen open. An increasing IAP $>$ 15 mmHg with the onset of a new organ failure is an indication for abdominal decompression. This can be done at the bedside or in the operating room. After decompression, the open abdomen management is continued with temporary closure.

The World Society of Abdominal Compartment Syndrome (WSACS) is refining the concepts of IAH and ACS by consensus opinion and is working toward establishing multicenter, multidisciplinary studies to determine the critical levels of IAH and the optimal methods of treating it—important concepts that help prevent postinjury MOF. The pathophysiology of IAH and ACS (primary, secondary, tertiary) and IAP monitoring are discussed elsewhere in this issue and are beyond the scope of this review. The reader is also referred to a recent editorial and monograph on ACS published by members of the WSACS [3, 4].

Open abdomen and its long-term impact

Cheatham and Safcsak [20] performed a prospective cohort study of patients who required abdominal decompression for more than 48 hours to determine the long-term psychological effects of open abdomen and chronic ventral hernias. The patients were asked to complete the SF-36v2 health survey at regular intervals for 2 years after the decompression. Patients discharged with a chronic incisional hernia (44 patients) were compared with those discharged with primary fascial closure (14 patients) as well as with the general population. Quality-adjusted life years (QALYs) and successful return to employment were determined. At 6 months after decompression, physical and social functioning were significantly decreased among the hernia patients compared with the general population. By 18 months, these patients demonstrated normal physical and mental health perception. The two groups exhibited decreased, but identical, QALYs (mean $\pm$ SD: 1.20 $\pm$ 0.11 vs. 1.23 $\pm$ 0.25; $p = 0.39$) and similar ability to resume employment (41% vs. 55%; $p = 0.49$). The authors concluded that decompression of an open abdomen does not have a negative impact on long-term physical or mental health perception.

Summary and conclusions

The open abdomen technique is one of the greatest advances in recent times and has enormous application in

the daily management of the critically ill or injured patient. It results in huge benefits to the initial resuscitation of these patients by avoiding all the problems of closure under tension, facilitating damage-control procedures, reducing IAH, and contributing to the early recognition of intraabdominal catastrophes. Patients with an open abdomen appear to have fewer intraabdominal adhesions, and the adhesions that do form are often flimsy. The open abdomen, however, brings on many challenges beyond those that might be expected from the primary illness or injury. With experience and careful management, these challenges can be easily met and turned to achievements. It is the responsibility of the clinician to apply management principles judiciously to obtain the most benefit from the open abdomen.

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