

Negative pressure wound therapy for children with an open abdomen

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Abstract

Purpose The utility of negative pressure wound therapy (NPWT) in the management of adults with an open abdomen has been well documented. We reviewed our experience with NPWT in the management of infants and children with this condition.

Methods The records of all children who were treated with NPWT for an open abdomen between March 2005 and September 2009 at a single children's hospital were reviewed. **Results** Twenty-five subjects were identified. They included children who developed abdominal compartment syndrome after a laparotomy ($n=12$) or in whom the abdomen could not be safely closed at the time of laparotomy ($n=13$). NPWT was accomplished with the vacuum-assisted closure (VAC®) system in all patients. The median duration for NPWT was 4.5 days. In 16 subjects, the abdomen was closed successfully after NPWT. In 14 children, the abdominal wall fascia was successfully approximated, and two children underwent a patch abdominal closure. But nine subjects died before an abdominal closure could be attempted. Only two (12.5%) children developed enterocutaneous fistulae.

Conclusions NPWT is a reliable tool for infants and children with an open abdomen. Wound management was facilitated and abdominal wall closure was ultimately achieved in all survivors. Enterocutaneous fistulae developed in two children, however, these were likely due to underlying bowel injury and would have occurred despite variations in management of the open abdomen.

Keywords VAC · Open abdomen · Abdominal compartment syndrome · Negative pressure wound therapy

Introduction

The use of negative pressure wound therapy (NPWT) for the temporary management of an open abdomen is well established in adults [1–6]. NPWT is a valuable adjunct in the care of patients with abdominal compartment syndrome (ACS), those in whom fascial closure after a laparotomy would likely result in compartment syndrome and in cases in which a staged laparotomy would be required within several days. The application of NPWT reduces intraperitoneal and abdominal wall edema, thereby permitting fascial closure, and simplifies nursing care of the abdominal wound [7].

Documented experience with NPWT in infants and children with an open abdomen is more limited [8–11]. While commercially available sponge systems are made specifically for the management of adult abdominal wounds, the institution of NPWT in the pediatric population often requires tailoring, and pressure settings norms have not been well established.

We sought to review our institutional experience with NPWT in infants and children with an open abdomen in order to establish the technique and to validate its safety and efficacy.

Material and methods

We identified children less than 14 years of age in whom abdominal NPWT had been used between March 2005 and September 2009 at the Loma Linda University Children's Hospital. This study population did not include a previously reported group of infants [12] with gastroschisis in whom

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large fascial defects were approximated with a porcine small intestinal submucosa (SIS[®]) patch and NPWT was subsequently applied.

Subjects' medical records were retrospectively reviewed and data regarding demographics, the indication for and duration of NPWT, the technique of fascial closure, and the incidence of complications were recorded.

NPWT was accomplished in larger children using the vacuum-assisted closure (VAC)[®] abdominal dressing system (KCI, San Antonio, TX). With this system, which is specifically designed for the management of an open abdomen, a thin layer of foam that is encapsulated within non-adherent, fenestrated plastic sheeting is placed over the abdominal contents. As much as possible, the sheeting was interposed between viscera and the underside of the abdominal wall, so as to prevent adhesion. A VAC[®] polyurethane foam dressing (sponge) was then trimmed to fit the wound and placed over the deeper foam layer and an adhesive drape was placed over this and the skin of the abdominal wall in order to seal the system. A pad, through which the vacuum was applied, was then secured over a small fenestration in the adhesive drape.

In infants and smaller children, the VAC[®] abdominal dressing system was too large and its design did not permit it to be trimmed. In these subjects, an improvised system was employed in which a polyethylene, Steri-Drape[®] (3 M, St. Paul, MN) was cut to size and placed over abdominal viscera and deep to the underside of the abdominal wall (Fig. 1a). A VAC[®] polyurethane foam dressing (sponge) was then trimmed to fit the wound and placed over the polyethylene drape (Fig. 1b). As above, an adhesive drape (Fig. 1c) and vacuum pad (Fig. 1d) were placed.

In all subjects, the dressing was changed every 3 days. Negative wound pressure was maintained at 75 mm Hg in infants and 125 mm Hg in children over 6 years of age. Fluid that was removed by the NPWT system was collected in a canister and its volume recorded daily.

ACS in this cohort was defined as an increase in intra-abdominal pressure associated with progressive cardiac, respiratory and/or renal dysfunction. There was no single, intra-abdominal pressure threshold used to make the diagnosis.

Results

NPWT was utilized in the management of an open abdomen in 25 children. The demographics and treatment course of these subjects is summarized in Table 1.

The median age of subjects was 15 months and the population included several premature neonates. There were 21 children with primary intra-abdominal pathology, including four with blunt trauma, five with intestinal obstruction, and three with necrotizing enterocolitis. The remainder had systemic illnesses.

In 12 subjects, a decompressive laparotomy was performed in an effort to alleviate ACS and NPWT was instituted at that time. In the other 13, NPWT was initiated after a laparotomy when it was believed that primary fascial closure would place the patient at high risk for the development of ACS.

The median duration of NPWT was 4.5 days (range 1–30 days). Fascial approximation was achieved in 14 days and a patch closure was used in 2 days. The remaining nine

Fig. 1 Application of a modified abdominal wound VAC system in a neonate following a laparotomy for ischemia–reperfusion injury: **a** Insertion of a Steri-Drape[®] between the abdominal wall and viscera and **b** placement of a VAC[®] polyurethane foam dressing over that. **c** Fenestration of the adhesive drape that secures the foam dressing and attachment of a vacuum pad with the application of 75 mm Hg negative pressure

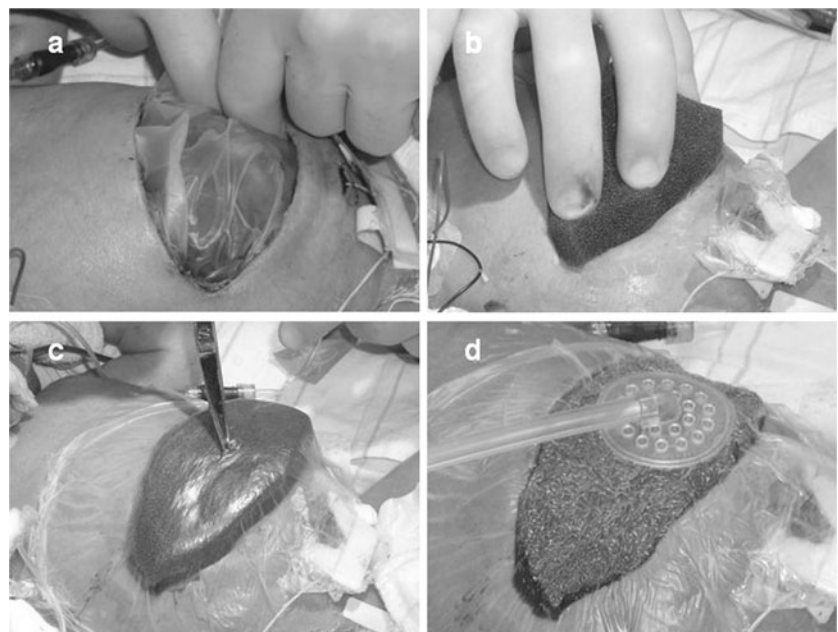


Table 1 Subject demographics and clinical course

Case	Age	Diagnosis	Abdominal compartment syndrome	Duration of NPWT (days)	Abdominal closure	Complications	Cause of death
Primary intraperitoneal pathology							
1	2 months	Hirschsprung's disease, s/p colectomy	Yes	1	None	Death	Sepsis
2	3 years	Strangulated intestinal obstruction	No	15	Fascial approximation	ECF	
3	7 years	Strangulated intestinal obstruction	No	3	Fascial approximation		
4	9 months	Strangulated intestinal obstruction	Yes	6	Fascial approximation		
5	14 months	Leukemia, post splenectomy	Yes	15	Fascial approximation		
6	13 years	Strangulated intestinal obstruction	No	16	None	Death	Sepsis, withdrawal of care
7	10 years	Lymphoma, gastric perforation	No	1	None	Death	Sepsis
8	6 years	Gastric necrosis post-fundoplication	No	2	Fascial approximation		
9	12 days	Gram-negative sepsis, intestinal ischemia	No	10	Fascial approximation	Intestinal necrosis/perforation	
10	17 months	Bladder injury post hernia repair	No	2	Fascial approximation		
11	6 months	Gastroschisis, intestinal atresia	Yes	5	SIS Patch		
12	11 days	Necrotizing enterocolitis	No	4	Fascial approximation		
13	10 days	Necrotizing enterocolitis	No	1	None	Death	Sepsis, pulmonary hemorrhage
14	5 months	Necrotizing enterocolitis, postresection	Yes	6	Fascial approximation		
15	17 months	Tuberculous peritonitis, intestinal perforation	No	5	Fascial approximation		
16	7 months	Intestinal obstruction	No	5	Fascial approximation		
17	17 days	Gastroschisis, intestinal ischemia/perforation	No	4	Fascial approximation with drain		
Abdominal trauma							
1	13 years	Jejunal perforation	Yes	30	SIS patch	ECF	
2	7 years	Splenic/liver laceration, head injury	Yes	1	None	Death	Head trauma, withdrawal of care
3	4 years	Renal hematoma	Yes	7	Fascial approximation		
4	2 years	Cecal perforation, head injury	No	1	None	Death	Cardiac arrest
Systemic disease							
1	14 years	Lower extremity necrotizing fasciitis	Yes	1	None	Death	Sepsis
2	4 weeks	Congenital heart disease, s/p cardiac arrest	Yes	24	None	Death	Cardiac arrest
3	15 months	Gram negative sepsis, h/o biliary atresia	Yes	7	Fascial approximation		
4	3 months	Sepsis post esophageal atresia repair	Yes	5	None	Death	Sepsis

Patients who underwent NPWT for abdominal compartment syndrome are identified

subjects died before the abdomen could be closed. The majority of deaths were secondary to overwhelming sepsis.

An enterocutaneous fistula (ECF) developed in two subjects. One was a 13-year-old boy who underwent a 30-day course of NPWT after repair of a jejunal perforation due to blunt trauma. An ECF developed 1 week after abdominal closure with an SIS[®] patch. The fistula was operatively closed 4 months later. The other was a newborn with gastroschisis and ischemic intestine that was contained in a silo for 2 weeks until a necrotic segment of ileum was resected and NPWT was instituted for 15 days. The fascia was then approximated, but an ECF appeared 4 days later. The fistula closed spontaneously.

One neonate with sepsis and diffuse, intestinal ischemia–reperfusion injury was found to have a segment of necrotic small bowel with a perforation that developed 4 days after NPWT was instituted. Four days after a segmental resection, a staged anastomosis and fascial closure was accomplished.

Discussion

Infants and children may have an open abdomen after a decompressive laparotomy for ACS [13] or when fascial closure is unsafe or impossible after an operation for other intra-abdominal pathology. The successful management of these patients must include protection of the abdominal viscera, simplification of wound care, and facilitation of eventual fascial closure.

To our knowledge, this retrospective review represents the largest reported series of infants and children with an open abdomen managed with NPWT. It confirms the efficacy of NPWT as a tool for wound control in these complicated patients. The dressing system greatly simplified nursing care as dressing changes were necessary only every 3 days and fluid was prevented from leaking onto surrounding skin or into the bed. Fascial approximation was ultimately achieved in 87.5% of survivors, and the remainder underwent patch closures, all of which remain intact.

An ECF developed in two subjects (12.5% of survivors) after the completion of NPWT. In both of these cases there were compromised segments of intestine with suture lines as well as long durations of NPWT. This is consistent with the findings of a collective review of patients who underwent damage-control laparotomies in which there was a 2–25% incidence of ECF [14]. In a third subject in whom ischemia–reperfusion injury progressed to full-thickness necrosis under observation during NPWT a segmental resection was performed before a fistula could develop. It is likely that all of these intestinal leaks would have developed in these complex cases no matter what technique of abdominal dressing had been used.

Others have reported success with “Vac-pac” systems in adults [15] and children [16, 17], in which a towel or gauze is packed in an open abdomen and suction is applied through tubing placed under an adhesive dressing. While these dressings adequately control fluid drainage, they may apply negative pressure unevenly and inconsistently, as compared to VAC[®] systems. This might lead to less efficient edema clearance and predispose to visceral complications related to transiently high pressures.

Staged abdominal closure using sutures [18], patch abdominoplasty [3, 19, 20], and silos [21] have also been utilized in the setting of an open abdomen. However, these methods lack the capability to actively evacuate edema fluid and repeated suturing may compromise the fragile fascia of a neonate.

Conclusion

In summary, we have found NPWT to be a valuable tool for the management of an open abdomen in infants and children. Although there are no trials that directly compare it to other treatment modalities in this setting, the theoretical advantages of a controlled application of negative pressure, particularly, in neonates, suggest that NPWT may be the treatment of choice in these complicated patients.

Conflicts of interest None.

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