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Prophylactic vacuum sealing drainage (VSD) in the prevention of postoperative surgical site infections in pediatric patients with contaminated laparotomy incisions

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Abstract

Surgical site infection (SSI) continues to be an issue in abdominal surgery, especially for contaminated (class III) and dirty-infected (class IV) wounds. Vacuum sealing drainage (VSD) was reported effective in the management of various types of wounds or skin grafts. Our goal was to investigate the efficacy of prophylactic VSD to better orient their medicosurgical care of high-risk incisions following laparotomy in a pediatric population.

A total of 331 pediatric patients with contaminated (class III) and dirty-infected (class IV) wounds following emergency laparotomy were retrospectively reviewed between January 2005 and January 2013. Among them, 111 cases were placed with prophylactic VSD when incisions were closed. Clinical outcomes, including, overall surgical site complication, device effectiveness, and mean postoperative LOS were evaluated based on VSD usage or not.

VSD was applied for an average of 5.8 days (range, 5–7 days), with 3 to 15 mL sucked fluid. The overall SSIs rate was 3% for patients with prophylactic VSD and 17% for patients with convention dressing (OR, 0.27; 95% CI, 0.10–0.71, $P=0.004$). In patients with prophylactic VSD, only 1 of 96 wound developed postoperative incision dehiscence, which is significant reduced compared with patients for conventional dressings (OR, 0.12; 95% CI, 0.01–0.95; $P=0.017$) (Table 2). It also exhibited a decreased mean postoperative LOS ($P < 0.001$) for prophylactic VSD over conventional dressings.

Our study demonstrated beneficial postoperative clinical effects of prophylactic VSD for high-risk laparotomy incisions following emergency laparotomy, such as shorter length of hospitalization, which may be attributed to the reduced overall SSIs rate.

Abbreviations: PS = propensity score, SSI = surgical site infection, VSD = vacuum sealing drainage.

Keywords: postoperative complications, surgical site infections, vacuum sealing drainage

1. Introduction

Worldwidely, surgical site infections (SSIs) are a challenging problem to surgeons and patients, particularly in heavy contamination. It is reported an incidence of 2% to 30%, or even higher, depending on the type of surgery and patient characteristics, specifically, for clean (class I), <2%; for clean-contaminated (class II), 5% to 15%; for contaminated (class III), 15% to 30%; and for dirty infected wounds (class IV), >30%.[1–3] Compared with other gastrointestinal (GI) interventions, emergency laparotomy, which are commonly contaminated surgery, have higher risk of SSIs.[4] Furthermore, intricate conditions for perforated and severe inflammation patients collectively contribute to the SSI development. Because SSIs might increase length of the postoperative hospital stays, and so pose an additional financial burden, it deserves our sufficient attention to reduce the incidence and management for the stable postoperative recovery.[5,6]

To decrease the risk of SSIs in the condition of contamination, numerous wound closure methods as the optimal therapeutic modality have been developed, like delayed primary closure, subcutaneous drain placement with or without irrigation, and loose dermal approximation with staples and wicks.[7,8] Although there was clear evidence supporting prophylactic antibiotics, the effectiveness of other preventive techniques was not confirmed, such as preoperative skin antisepsis, intraoperative glove change, suction wound drainage, and different wound closure techniques.[9,10]

Since its introduction into clinical care over a decade ago, vacuum sealing drainage (VSD) has become a prevalent treatment modality used in the management of various types of tissue injuries including acute wounds, chronic wounds, and skin grafts. A few previous studies have demonstrated that VSD treatment can facilitate complete wound drainage, speed wound healing

and resulting in a decreased wound area, and reduce incidence of infection to reduce SSIs and other wound complications.[11–13] Although VSD has been used successfully to manage many traumatic wounds and different high-risk surgical incisions including groin, median sternotomy, and complex abdominal closures with good results.[14] No studies to date have addressed prophylactic VSD in the setting of high-risk contaminated (class III) and dirty-infected (class IV) abdominal wounds, especially in pediatric patients.

Because VSD has shown some promise in preventing infections of various wounds, we hypothesized that prophylactic VSD device could improve therapeutic outcomes in regards to SSI development after contaminated abdominal laparotomy. The aim of this study was to evaluate this hypothesis in a heterogeneous population of pediatric patients. The study was subjected to propensity score (PS) matching analysis to eliminate the selection bias from the confounding variables.

2. Methods

2.1. Patient population

This study is a retrospective review of the pediatric patients (less than 14 years old), who undergoing an open abdominal operation, from 2007 to August 2016. Among them, 111 cases had a VSD device placed at time of the initial closure. The study protocol was approved by the Institutional Review Board of the Chongqing Medical University and performed in accordance with the ethical standards prescribed by the Helsinki Declaration. Patients were eligible for entry into the study upon meeting the following inclusion criteria: patients with a class III or IV (CDC classification) wound at the time of initial operation. Exclusion criteria included patients managed in the intensive care unit (ICU) for more than 72 hours, patients with severe chronic disease, which substantially increased the risk for operative mortality, patients with previous major intraabdominal surgery. In our institution, the decision about the placement of VSD was made according to the preference and experience of the surgical team on duty. All patients were administered broad spectrum perioperative antibiotics for a median total duration 7 days (range, 5–8). A total of 331 patients met the inclusion criteria, for each patient, the collected clinical data including demographic data, white blood cell (WBC) value upon admission, surgical procedure descriptions, postoperative hospital stay, and postoperative complications were recorded. Duration of surgery, operating time, intraoperative blood loss, transfusion rate, and necessity for reoperation were also recorded. The surgical wound was classified according to the operative notes. Before the operation and on days 1 and 5 after surgery, the following parameters were assessed in all patients: C-reactive protein, procalcitonin, and albumin tests.

2.2. Surgical technique

Our VSD technique involves placement of drainage tubes according to the size of the wound. After suture of the peritoneum and abdominal muscles, the tailored VSD drainage tubes were positioned close to the muscular layer. Subcutaneous and skin closure was used interrupted sutures approximately 1 cm apart according to conventional procedures. The drainage tubes then were subjected to subcutaneous stealth apart from the wound for the convenience of drainage tube sealing. An airtight is then seal achieved using the biooclusive transparent film (Tegaderm; 3 M, Minneapolis, MN). The VSD drainage tube is connected in the standard fashion with the vacuum flask device.

A vacuum is created by aspirating the air for continuous suction at negative 75 mm Hg for a total of 5 to 7 days. After 5 to 7 days of therapy, the dressing is removed and the wound inspected per the clinician's discretion.

2.3. Outcome evaluation

The main outcome measure was SSIs rates. Secondary outcome measures included the length of postoperative hospital stay (the number of days from the day of operation until the date of discharge). Infectious complications were confirmed with microbiological analyses and positive cultures and included pneumonia (radiographic confirmation) and abdominal, urinary, or systemic (fever [oral temperature > 38.5 °C]) infection. Wound complications consisted of wound dehiscence, swelling, and pus. In the first 5 days, more than 1 episode of nausea or vomiting was defined as early ileus.

2.4. Propensity scores and matching

Because this is a retrospective, single-center design research, and the decision to initiate prophylactic VSD was not made randomly. To limit the influence of confounding variables on selection bias in baseline characteristics on the actual effects of VSD, we performed a 1:1 PS matching analysis using SPSS 20.0 (IBM, Armonk, NY) or R 3.1.2 (The R Foundation for Statistical Computing) to generate comparable baseline clinical and demographic factors regarding VSD treatment.

A nonparsimonious multivariable logistic regression model was used which included the demographic and clinical variables, based on theoretical and empirical considerations according to the scientific literature and biological plausibility. We then match each patient with VSD to a control according to similar PS with a 0.1 caliper width and without the replacement matching algorithm. The generalized additive model was used to check linear assumption in PS model. At last, 96 patients with VSD matched to 96 patients with conventional dressing.

2.5. Statistical analysis

The variables for main outcomes between the patients with VSD and controls were compared after PS matching. The statistical comparisons were performed using SPSS 20.0 (IBM, Armonk, NY). The discrete variables, expressed with frequencies (percentages), were compared by a chi-square test or Fisher exact test. Student t test was used to analyze normally distributed continuous variables, reported as means ± SDs and the Mann–Whitney U test, to compare abnormally distributed variables. The potential relative risks for postoperative variables were assessed by univariate analysis using cross-tabulation (odds ratio [OR]) with 2-tailed 95% confidence interval (CI) and a P value less than 0.05 was regarded statistically significant.

3. Results

3.1. Patient characteristics

Among the initial 331 pediatric patients eligible for analysis, who had a CDC class III or IV wound underwent gastrointestinal surgery during the study period, 106 (32.0%) received placement of VSD for closure. The baseline features of the patients according to VSD or not are summarized in Table 1. There were no significant differences before PS-matching in the demographic features of patients between the 2 groups, with the exception of

Table 1

Baseline demographics of eligible patient and preoperative variables.

VSD	Total population			Propensity matched population		
	With (106)	Without (225)	P	With (96)	Without (96)	P
Age, years	6.2±2.1	5.1±1.8	0.093	5.8±1.9	5.5±1.7	0.28
Male:female	62:44	132:93	0.54	56:40	55:41	0.50
Mean body weight, kg	13.9±6.3	11.8±5.5	0.11	12.8±4.5	12.4±4.4	0.41
Operative time, min	46.5±11.2	52.4±9.8	0.18	48.6±9.7	51.9±7.9	0.27
Operative blood loss, mL	13.4±3.8	15.3±4.3	0.35	13.9±3.6	14.6±4.1	0.46
Albumin, g/L (normal range, 35–50)	31.3±4.8	33.7±4.6	0.21	32.7±4.3	33.4±4.4	0.32
WBC, 109/L	15.3±5.1	14.6±4.3	0.22	14.9±4.6	14.7±4.1	0.37
PCT, ng/mL (normal value: 0–0.5)	7.2±2.5	6.9±2.7	0.35	7.1±2.3	7.0±2.4	0.45
CPR, mg/L (normal value: 0–10)	11.8±5.2	11.5±4.8	0.16	11.7±3.9	11.6±3.8	0.41
Causes of operation, N, %						
Appendiceal abscess	78 (72.9)	188 (76.9)	0.025	73 (74.1)	75 (73.1)	0.43
Perforation caused by trauma	13 (4.5)	19 (4.5)	0.18	11 (4.6)	10 (5.6)	0.50
Strangulative intestinal obstruction	15 (8.1)	18 (10.8)	0.063	12 (8.3)	11 (10.2)	0.50
Operation type, N, %						
Appendectomy	75 (77.5)	182 (81.3)	0.029	70 (78.7)	72 (78.7)	0.44
Small bowel anastomosis	23 (9.0)	33 (10.8)	0.077	20 (8.3)	18 (7.3)	0.43
Stomach and duodenum anastomosis	8 (4.5)	10 (3.0)	0.18	6 (4.6)	6 (5.6)	0.62
CDC classification, N, %						
III	58	170		51	54	
VI	48	55	<0.001	45	42	0.39
Closure length	6.5±1.6	5.8±1.9	0.33	6.2±1.5	5.9±1.8	0.46

CDC classification, causes of operation, and operation type, suggesting that, in this observational study, there were systematic differences in baseline characteristics between the patients with VSD and conventional dressing. There were differences in surgical approach between the 2 groups with unmatched patients (Table 1). The most common cause of surgery was appendiceal abscess (n=257, 77.6%), followed with strangulative intestinal obstruction (n=33, 10.0%) and gastrointestinal perforation caused by trauma (n=32, 9.7%). Nutritional characteristics were also similar between the 2 groups, as assessed by mean serum albumin concentrations. The operative magnitude was evaluated by the measurement of operative time, estimated blood loss, and total units of blood transfused within the 24-hour perioperative period. Under PS-matching, 96 patients with VSD were matched to 96 patients with conventional dressing. Several variables, including CDC classification, causes of operation, and operation type, became comparable after PS-matching (Table 1).

3.2. VSD features and postoperative complications

The postoperative complications are summarized in Table 2. The VSD was in place for a median of 5.8 (range, 5–7 days) with no VSD-associated skin complications noted. The drained fluid from VSD was 3 to 15 mL, with the maximum at PSD3. No significant differences were identified between the groups for total postoperative complications (odds ratio [OR], 0.56; 95% confidence interval [CI], 0.29–1.09, P=0.053). The current data showed a significant benefit of VSD over conventional dressings in regard to reducing the risk of SSI. In patients with VSD, 6 of 96 wound developed a small superficial skin dehiscence without evidence of superficial or deep SSI, whereas patients with conventional dressings wound developed 11 of 96 small superficial skin dehiscence and 8 of 96 superficial SSI (OR, 0.27; 95% CI, 0.10–0.71, P=0.004) (Table 2). Complete wound healing was achieved in all 6 patients with a small superficial skin dehiscence who received VSD, 1 of whom was treated in hospital and 5 as outpatients. The average total duration of wound therapy in the outpatient clinic was 8 days (range, 3–12 days). For the patients with conventional dressings, the median duration between operation and wound therapy was 18 days (range, 5–53 days).

A reduction in postoperative incision dehiscence (OR, 0.12; 95% CI, 0.01–0.95; P=0.017) was also noted in patients receiving VSD compared with patients conventional dressings

Table 2

Postoperative complications in the matched population (chi-square test).

VSD	With (96)	Without (96)	P	Odds ratio (95% CI)
Total complications (at least 1 complication), N, %	21 (22.2)	32 (32.4)	0.053	0.56 (0.29–1.09)
Postoperative LOS, days, mean±SD	7.1±1.2	8.3±1.6	<0.001	
Total number of complications	28	41	0.035	0.55 (0.30–1.00)
Infectious complications, N, %	13 (13.9)	21 (21.3)	0.093	0.56 (0.26–1.20)
SSI, N, %	6 (8.3)	19 (13.9)	0.004	0.27 (0.10–0.71)
Pneumonia, N, %	4 (4.6)	5 (7.4)	0.50	
Sepsis, N, %	5 (0.9)	3 (2.8)	0.36	
Peritonitis or abscess, N, %	9 (5.6)	11 (12.0)	0.41	
Incision dehiscence, N, %	1 (3.7)	8 (4.6)	0.017	0.12 (0.01–0.95)
Early ileus, N, %	11	9	0.41	

(Table 2). The mean postoperative LOS was 7.1±1.2 days in patients receiving VSD, which was significantly less than the mean length of stay (8.3±1.6 days) in patients with conventional dressings (P < 0.001) (Table 2).

4. Discussion

This study compared the prophylactic VSD and conventional dressing in the management of postoperative SSIs following with emergency laparotomy interventions. To the best of our knowledge, this is the first study to evaluate the impact of the prophylactic VSD on postoperative SSIs in pediatric patients. It is in favor of the prophylactic VSD in regard of postoperative SSI in the patients with high-risk contaminated (class III) and dirty-infected (class IV) wounds, which was associated with the length of postoperative hospital stay. Therefore, prophylactic VSD might be a valuable method to help the patients with class III or IV wound abdominal wounds, at high risk of developing SSIs.

Prompt postoperative recovery serves as the main focus of all surgical specialties. Among all the recovery measures, SSIs is a common and costly problem after surgery, especially with contaminated cohort. CDC class III or IV wounds often resulting from emergent intervention, which are often beyond the surgeon's control.[15,16] VSD technique has demonstrated benefit intreatment of soft tissue infection, skin defects, and complicated wounds, on the basis of drains out seepage, pus, and necrotic tissues through negative-pressure[17]; however, no studies have evaluated its utility in the setting of a high-risk abdominal wound closures in contaminated cohort. In our research, there were no significant differences of system infection between the 2 patient groups, for routine perioperative antibiotics, like pneumonia, peritonitis or abscess, sepsis, and we found that the placement of a VSD resulted in a statistically significantly lower incidence of overall wound infection. The overall infection rate for type III and IV incisions was 13.2%, whereas for the patients with a subcutaneous closure VSD, the infection rate was 5.7%. The most striking results occurred in patients with the highest degree of contamination. An infection developed in only 3 of the 53 patients with type IV wounds who had a VSD (Table 2). Of the 98 infections that occurred during hospitalization, 77 (79%) were superficial and only 21 (21%) were deep. Therefore, in our practice, almost 94% of type IV wounds can be closed primarily with the presumption of primary healing. Wound infections would be expected in a significant number of patients, but none were identified. These data suggest, but do not prove, that the use of a subcutaneous VSD in patients with type IV incisions results in a decrease in the rate of wound infection, so support the application of the closure technique reported herein. Most authors recommend that type IV wounds be managed by delayed primary closure. In truly significant contamination, a period of dressing changes could be followed by delayed primary closure, and now their wounds could be closed primarily at the time of operation, resulting in decreasing time to function and normal life.

The essential of this technique described herein consist in the holding incision edges together, isolating the incision from external air, and removing the infectious materials accumulation,[18] which has been seen in open wounds and has recently been applied to closed surgical wounds thought to be at high risk for infection. Removing even a small amount of proinflammatory fluid and decreasing wound edema maybe beneficial.[19] Patients were noted to have 0 to 10 mL of fluid in the tubing and canister

at the time of removal. Most of the incisions (71%) in the VSD patients had 3 to 15 mL of collectable fluid sucked out within the first 3 days. Furthermore, although there are other negative pressure wound management systems currently in use. The VSD device used in these patients were functioning properly. The adhering dressing allowed reliable delivery of negative pressure and fluid removal, and the antiinflammatory gauze protects the skin from contact with the pad pasting directly. In our patients cohort, there were only 3 patients with tube blocking. Absence of fluid in the tubing or canister may be due to tight wound closure. The optimal time of catheter removal was not addressed here and all catheters were removed on the morning of the 5 to 7 postoperative day, because of absence of fluid in the last days. In addition, not only does pad pasting decrease lateral tension on the wound and acts as a dressing to provide a sterile environment for wound healing, but also the negative pressure may decrease lymphocele formation (as lymphatics are often transected during this type of incision), which prevents skin edges from becoming macerated, promoting epithelialization. It is also believed that the negative pressure fosters improved wound base perfusion and oxygenation, which may decrease SSI risk. Furthermore, it is suggested in the experimental setting that early postoperative period would enhance host defense mechanisms. The fluids in wounds have a progressive reduction in the opsonic activity of bacteria for phagocytosis and killing by neutrophils.[20] They reported a wound infection rate of 3% in 100 patients who underwent bilateral nephrectomy, splenectomy, and renal transplantation and in whom closed suction drainage for the evacuation of fluid was used.[21]

Although our study is the largest reported series of pediatric patient undergone emergency laparotomy interventions, there are several limitations to our study. First, this is a retrospective, single-center case series being compared with historical controls, in which we collected the data with inherent risk of selection bias, for the decision to initiate VSD was not made randomly. The study also takes place over a long period and outcomes from many patients may not reflect outcomes from current treatment algorithms, there have likely been many practice changes, including postoperative care, length of antibiotic therapy, and supplemental oxygen use, leading to different care practices between study patients. Potential confounding by indication is an important consideration. Practitioners are likely to initiate VSD in more severe patients. We intended to select the patients with potential contamination. However, we could not completely avoid variables that may affect this comparison. These unmeasured variables may have affected our results as residual confounders. Therefore, our results need to be carefully interpreted.

In summary, clinical evidence from the present study suggest that VSD can be successfully applied to the closure of high-risk (CDC class IV) midline laparotomy incisions, thus offering a recent insight into the optimizing of our surgical and therapeutic approach. We acknowledge that these results are based on a homogenous group of patients. It will be necessary to be followed up with a prospective randomized study to best utilize the limited therapies available, including a true cost analysis, inherent to this study design.

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