The Egyptian Journal of Hospital Medicine (October 2022) Vol. 89, Page 4617- 4621

Vacuum Assisted Therapy in Management of Deep Sternal Wound Infections in Pediatric Cardiac Surgery

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ABSTRACT

Background: In adult and pediatric cardiac surgery, median sternotomy is considered the usual access to gain variable cardiac operations. Although the rarity of this complication in pediatrics, it is serious and carry a high risk of morbidity and mortality. Vacuum assisted closure (VAC) system is increasingly used for treating deep sternal wound infection (DSWI), VAC therapy becomes a widely accepted method for treating DSWI and mediastinitis in adults. In spite of this, there is no wide experience of using the VAC system in pediatric cardiac surgery.

Objective: The aim of the current work was to investigate the safety and efficacy of vacuum-assisted therapy in management of deep sternal wound infections in pediatric cardiac surgery.

Subjects and Methods: Between May 2012 to April 2022, we treat 44 infant and child complicated with postoperative DSWI and mediastinitis. This prospective analytical study was conducted at Abo Elrish Hospitals, Cairo University. The main primary end point of our study was complete resolution of sternal wound and patient survival.

Results: Since 2012 to 2022 about 44 patients treated from DSWI and/or mediastinitis post pediatric cardiac surgery using VAC system. Age of the patients ranging from 3 months to 9 years with mean 2.5 years. There was one case of mortality not related to VAC therapy in our study group due to severe chest infection in spite of dramatic improvement of the local wound condition within one week of starting treatment. No complications were encountered during the period of VAC treatment. Most importantly, there was no VAC device related complications experienced in all patients. The VAC was used as a destination therapy in 42 cases with wound closure by secondary sutures. There was only one case needed a sternal rewiring with good results.

Conclusion: It could be concluded that VAC therapy is a safe and effective treatment modality for either infant and children and provide a good alternative to the conventional methods of treatment in settings of mediastinitis and deep sternal wound infections with excellent results.

Keywords: DSWI – VAC Therapy– Pediatric Cardiac Surgery.

INTRODUCTION

In adult and pediatric cardiac surgery, median sternotomy is considered the usual access to gain variable cardiac operations. In spite of the huge number of procedures done annually, the incidence of deep sternal wound infection (DSWI) and mediastinitis in pediatric patients is low [(1,2)]. The incidence of DSWI is about 0.2% to 5% among postoperative pediatric cardiac populations which is less than incidence in adult age group [(2,3)]. Although the rarity of this complication in pediatrics, it is serious and carry a high risk of morbidity and mortality [(4)]. DSWI postoperatively causes prolonged intensive care unit duration and hospital stay with additive cost to the patients and health systems [(5)]. Many treatment methods had evolved in management of DSWI including early aggressive surgical debridement with repeated dressing, closed irrigation, muscle and omental flaps, but results still not satisfactory with mortality rates ranging from 5% to 47% [(6,7)]. Vacuum assisted closure (VAC) system was first introduced by Obdeijn et al in 1997 as a new technique for treating DSWI [(8)]. Since then, VAC therapy becomes a widely accepted method for treating DSWI and mediastinitis in adults. Despite this, there is no wide experience of using the VAC system in pediatric cardiac Surgery [(9,10)].

The VAC system allows a uniform negative pressure all over the wound surface which promotes wound healing by increasing vascular and lymphatic flow, removing localized edema, increasing granulation tissue formation and angiogenesis [(6,7)].

The aim of the current work was to investigate the safety and efficacy of vacuum-assisted therapy in management of deep sternal wound infections in pediatric cardiac surgery. We report our 10 years' experience of using the VAC system as a safe and effective technique in management of DSWI and mediastinitis in infants and children till complete sternal wound healing.

PATIENTS AND METHODS

This prospective analytical study included a total of 44 infant and child complicated with postoperative DSWI and mediastinitis, treated at Abo Elrish Hospitals, Cairo university. This study was conducted between May 2012 to April 2022.

The diagnosis of the DSWI and mediastinitis based on the United States Centre for Disease Control and Prevention guidelines[(8)]. All patients subjected to full history analysis including:

- Demographic characteristics.
- Echocardiographic diagnosis.
- Type of surgical operation.
- Full laboratory investigations: renal function tests, liver function tests, bleeding profile, complete blood count (CBC), and blood & wound culture.
- Chest X-ray and/ or chest Computed Tomography (CT) scan.

Received: 18/5/2022
Accepted: 25/7/2022

- Sternal wound characteristics.
- VAC settings.

The duration of VAC therapy was defined as the time from application till removal. The main primary end point of our study is complete resolution of sternal wound and patient survival.

Surgical technique

Once deep sternal infection (with or without bony involvement) was confirmed, all patients subjected to wound reopening in operative theatre or in pediatric post cardiac intensive care unit. Sometimes mild sedation needed with midazolam (0.05 to 0.1 mg/kg/hour) to improve patient tolerance and comfort. All necrotic tissues and infected sutures are removed with meticulous hemostasis. After that, the removed material and necrotic tissues sent to bacteriological culture and sensitivity. Washing of the wound by diluted bovidone iodine 10% and topical antibiotic (amikacin). A sterile open pore polyurethane foam was trimmed fitting to geometry of the wound and no extension beyond wound edges (Figure 1).

If there is sternal gaping, we avoid direct contact between the heart or great vessels with the foam. So, a Vaseline gauze can be used as a layer between the heart and the polyurethane foam. Moreover, a non-collapsible evacuation tube was embedded to the fashioned foam and then covered with a sterile transparent adhesive drape. Making sure that the drape is totally covering the wound with tight sealing to the skin at a distance 2-3 cm beyond wound edges in all directions.

This evacuation tube was connected to the VAC device which was adjusted to intermittent mode with initiation of a negative pressure between 50 to 100 mmHg. Intermittent mode allowed cycling with 5 minutes on and 2 minutes off. Sometimes continuous mode being used if there is copious wound drainage for one dressing only.

The VAC dressing usually changed every 2-4 days with average 3 days. The porous polyurethane foam allowing an equal distribution of the sub atmospheric pressure to whole wound surface with progressive reduction of the wound size and progressive formation of granulation tissue with time.

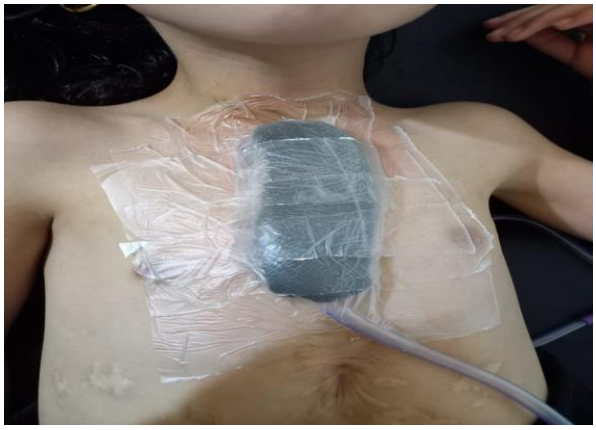

Figure (1): Showing polyurethane foam trimmed according to wound geometry and connected to evacuation tube to VAC device.

Termination of the VAC therapy depends on decline in inflammatory serologic parameters, negative wound bacteriological cultures for at least 2 successive cultures and clinical resolution of the local signs of wound infection.

Antibiotic protocol:

After the first debridement, broad spectrum Antibiotics were given empirically then selection was done according to the result of culture and sensitivity.

Culture swabs were obtained every other dressing with changing the antibiotic strategy according to it. Antibiotics were continued until there was no bacterial growth in two consecutive swabs at least.

Ethical consent:

An approval of the study was obtained from Cairo University Academic and Ethical Committee. Written informed consent of all the participants' parents was obtained after being informed about the aims and process of the study as well as applicable objectives. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical Methods

Data were statistically described in terms of mean, frequencies (number of cases) and percentages when appropriate. Comparison of numerical variables between the study groups was done using Student *t* test for independent samples. All statistical calculations were done using computer programs SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows.

RESULTS

During the period 2012 to 2022, 44 patients were treated from DSWI and/or mediastinitis post pediatric cardiac surgery using VAC system. Age of the patients ranging from 3 months to 9 years with mean 2.5 years. 28 Patients were males (63.6 %) and 16 were females (36.4%) (Table 1).

Table (1): Demographic data and timing of VAC application

Age	3 months – 9 years, mean (2.5 years)
Sex	Male n=28 (63.6%) Female n=16 (36.4%)
Time (from operation till vacuum application)	6 – 13 days, mean (8.2 days)

The primary diagnosis was ventricular septal defects(VSD) in 14 cases (31.8%) treated by patch closure (9 patients) or pulmonary artery banding (PAB) (5 patients), Fallot tetralogy in 11 case (25%) treated by total repair(7 patients) or modified Blalock-Taussing shunt (4 patients), atrial septal defect (ASD) in 5 patients(11.36%) who treated by patch closure, Transposition of the great arteries (TGA) in three patients (6.8%) who underwent arterial switch operation(1 patient) or atrial switch, Senning operation (2 patients) and remaining 11 cases were of different pathologies (Table 2).

Table (2): Primary echocardiographic diagnosis and treatment.

Primary Diagnosis	Treatment	Number	Percentage
VSD	Primary closure or PAP	14	31.82%
F4	Total Repair or MBT shunt	11	25%
ASD	Patch closure	5	11.36%
TGA	Arterial switch or atrial switch	3	6.82%
TAPVD	Total repair	3	6.82%
DORV	Rastelli	1	2.27%
ASD + PS	Patch closure + pulmonary valvotomy	3	6.82%
Supra valvular AS	One or two patch technique	2	4.55%
ALCAPA	Redirection	1	2.27%
SAM	Resection + myectomy	1	2.27%

VSD, ventricular septal defect. F4, fallot tetrology. ASD, atrial septal defect. TGA, transposition of great arteries. TAPVD, total anomalous pulmonary venous drainage. DORV, double outlet right ventricle. PS, pulmonary stenosis. AS, aortic stenosis. ALCAPA, anomalous left coronary artery from pulmonary artery. SAM, subaortic membrane. MBT, modified blalock-taussing.

Bacteriological cultures of debridement specimens were Staphylococcus aureus in 15 patient, pseudomonas in 8 cases, Staphylococcus epidermidis in 4, Methicillin resistant staph. Aureus (MRSA) in 4, enterobacter faecalis in 2 cases, candida in 2 cases and mixed organisms in 11 cases.

Table (3): Type of organism

Type of Organism	Number	Percentage
Staph. Aureus	15	34.1%
Pseudomonas	8	18.2%
Staph. epidermidis	4	9.1%
MRSA	4	9.1%
Enterobacter-faecalis	2	4.55%
Candida	2	4.55%
Mixed	11	25%

Infection was confirmed between 6 to 13 days postoperatively (mean 8.2) at which VAC system applied to the wound. The median time of the VAC therapy was 18.2 days (range from 13 to 43 days). All Dressing changes had performed in pediatric ICU every two to four days with mean three days. Intermittent mode was used in all case with a negative pressure 50 mmHg in small infants while in elder cases adjusted between 75 to 100 mmHg. Continuous mode was applied in early dressings if there is large amount of discharge which changed again to intermittent mode after decrease in amount of discharge.

The VAC therapy was well tolerated by infants and children as there is no change in heart rate, blood pressure or respiratory pattern observed, which considered the pain indicators in such age group.

Regarding to treatment outcomes, no bleeding or secondary hemorrhage occurred during VAC application or even initial debridement. Moreover, there is excellent results related to clinical wound improvement in the form of a healthy granulation tissue formation besides declining in the inflammatory parameters (Figure 2).

A

B

C

Figure (2): Shows (A) Before VAC application, (B) After 1 week of VAC application, and (C) After 2 week of VAC application.

There was one case of mortality not related to VAC therapy in our study group due to severe chest infection in spite of dramatic improvement of the local wound condition within one week of starting treatment. No complications were encountered during the period of VAC treatment. And most importantly, there was no VAC device related complications experienced in all patients.

The VAC was used as a destination therapy in 42 cases with wound closure by secondary sutures. There is only one case needed a sternal rewiring with good results.

DISCUSSION

Poststernotomy wound infection and mediastinitis is considered a fatal complication following cardiac surgery that increase mortality, prolong the duration of hospital and ICU stay and increase the cost of care [1,2,9,10]. Although there is several reports evaluating the VAC therapy as a model treatment for DSWI and mediastinitis in adult population, there is a limited studies dedicated to describe VAC system use in the pediatric patients [3,11]. Infants and children with DSWI are considered a unique population because of weak and immature immune system. The incidence of DSWI and mediastinitis in pediatrics is much less than adults [1]. **Caniano *et al.*** [12] reported an encouraging results of using the VAC system of several wound infections in a pediatric patients. **Ohye and colleagues** [13] published their experience with pediatric poststernotomy mediastinitis, they performed wound debridement with immediate or delayed primary closure to overcome the need for reconstructive and plastic surgery. Although the acceptable results, prolonged management of open wounds is so physically and psychologically demanding in pediatric population.

The VAC therapy was emerged as alternative to other conventional techniques which improves results and decreases recurrence. In treatment of DSWI the VAC device allow continuous elimination of putrid exudates, toxins and pathogenic organisms which have inhibitory effect on wound healing. It also decreases tissue edema and removes the excessive fluids which decreases bacterial colonization. With continuous suction, a new healthy granulation tissues start to appear on wound surface with gradual decreasing of the wound size [10]. Pored polyurethane foam allows a uniform negative pressure to the whole wound surface which enhances microcirculation and causing arteriolar dilatation [11].

Sternal bone is important for chest wall integrity and respiratory mechanics, so the aim of any treatment is to preserve sternum to allow acceptable growth and chest wall stability in infants and children [13]. Adjustment of the VAC device to a negative pressure between 50 to 100 mmHg was tolerated by all patients and not affecting the hemodynamics. On the other hand, VAC therapy significantly improved respiratory mechanics by splinting of the sternum and diminishing paradoxical movement. In our study, there were excellent results in all patients regarding to clinical wound improvement and declining in inflammatory parameters. Only one patient needed sternal rewiring in the operative room under complete general anesthesia but forty two patients needed wound closure by secondary intension sutures most of them performed in the pediatric surgical ICU. There is no complications and no secondary hemorrhage detected in our study group. There is only one mortality case not related to VAC therapy but due to severe respiratory tract infection.

CONCLUSION

It could be concluded that VAC therapy is a safe and effective treatment modality for either infant and children and provide a good alternative to the conventional methods of treatment in settings of mediastinitis and deep sternal wound infections with excellent results.

Conflict of interest: The authors declare no conflict of interest.
Sources of funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
Author contribution: Authors contributed equally in the study.

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