VACUUM-ASSISTED CLOSURE IN THE TREATMENT OF STERNAL WOUND INFECTION AFTER CARDIAC SURGERY

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Aim: Vacuum-assisted closure (VAC) was primarily designed for the treatment of pressure ulcers or chronic, debilitating wounds. Recently, VAC has become an encouraging treatment modality for sternal wound infection after cardiac surgery, providing superior results to conventional treatment strategies.

Methods: From November 2004 to September 2006, 34 patients, undergoing VAC therapy for sternal wound infection following cardiac surgery, were prospectively evaluated. Ten patients (29 %) were treated for superficial sternal wound infection and 24 (71 %) for deep sternal wound infection. The median age was 69.9 years (range 48 to 82) and the median BMI was 33.4 kg/m² (range 28 to 41). Twenty patients (59 %) were women and 19 patients (59 %) were diabetics. Owing to sternal wound infection complications, 16 patients (47 %) were readmitted to the department. VAC was used following the previous failure of the conventional treatment strategy in 7 patients (21 %).

Results: Thirty-three patients (97 %) were treated successfully. One patient (3 %) died of multiple organ failure. The overall length of hospitalization was 34.6 days (range 9 to 62). The median number of dressing changes was 4.6 (range 3 to 10). The median VAC treatment time until surgical closure was 9.2 days (range 6 to 21 days). VAC therapy was solely used as a bridge to definite wound closure. Three patients (9 %) with chronic fistula were re-admitted 1 to 6 months after VAC therapy.

Conclusions: VAC therapy is a safe and reliable option in the treatment of sternal wound infection in cardiac surgery. VAC therapy should be considered an effective adjunct to conventional treatment modalities for the treatment of extensive and life-threatening wound infections following cardiac surgery, particularly in the presence of risk factors.

INTRODUCTION

Sternal wound infection following cardiac procedures occurs in 1 to 5 % of cases and represents a serious problem involving prolonged hospitalization, increased hospital costs, and increased morbidity and mortality^{1–4}. Conventional treatment modalities usually involve surgical debridement with open dressing or closed irrigation or delayed reconstruction^{5,6}. The vacuum-assisted closure (VAC) system was introduced into clinical practice for the treatment of pressure ulcers and chronic debilitating wounds in 1997⁷. Recent studies have reported the effectiveness of the VAC system in the treatment of sternal wound infection in cardiac surgery, with emphasis on the treatment of deep sternal wound infection^{8–11}.

Patients and methods

From November 2004 to September 2006, 34 patients, undergoing VAC therapy for sternal wound infection following cardiac surgery, were prospectively evaluated. Data

obtained from medical records included demographic characteristics are presented in Table 1. The type of cardiac procedure, time interval of wound infection presentation after the procedure, time of VAC therapy, the number of dressing changes and length of hospitalization are summarized in Table 2. Ten patients (29 %) were treated for superficial sternal wound infection (SSWI) and twenty-four (71 %) for deep sternal wound infection (DSWI).

Sternal wound infection classification and predictors of increased risk factor for sternal wound infection

Sternal wound infection was defined according to the guidelines of the Centre for Disease Control and Prevention (CDC)¹². Involvement of skin or subcuticular tissue was defined as a SSWI, involvement of deeper tissue such as a pectoral fascia, sternal bone as well as mediastinal space was classified as a DSWI. Diagnosis of sternal wound infection required at least one of the following criteria: (1) an organism was isolated from the culture or mediastinal fluid; (2) evidence of wound infection during the

Fig. 1. Deep sternal wound infection (type II)

Fig. 2. The VAC system applied into the wound.

operation and (3) one of the following conditions: chest pain, sternal instability, or fever ($>38^{\circ}\text{C}$) accompanied by either purulent discharge from the mediastinum or an organism isolated from the blood culture or culture of drainage from the mediastinal space¹¹. The simplification of the traditional Oakley-Wright classification of DSWI based on the time of presentation and the presence of risk factors was adopted by the authors¹³. A DSWI occurring within 2 weeks after the operation was classified as type I and a DSWI present 2 to 6 weeks after the operation as type II. Finally, a DSWI present for the first time more than 6 weeks after the procedure was classified as type III. Detailed wound classification types are shown in Table 3. Predictors of increased risk of DSWI included: (1) obesity, (2) pedicled bilateral internal mammary artery grafts in diabetics, prolonged operative time and (4) need for repeated blood transfusion in the early post-operative period^{3, 4}.

Extensive and/or massively discharging SSWI requiring frequent dressing changes was primarily managed by the VAC system. In the treatment of the DSWI, the VAC system was initially employed as a treatment modality for failed conventional treatments involving one-step wound debridement, sternal rewiring and application of closed drainage. Later, when the technique was well mastered, the VAC system was routinely used as a first-line treatment for DSWI as well. The identical therapeutic algorithm was adopted for all sternal wound infections. Necrotic tissue

and foreign materials were debrided under aseptic conditions and the wound bed was massively irrigated with normal saline solution (Figure 1). Sterile polyurethane foam dressing, with a defined pore structure of 400 to 600 μm (Granufoam®, KCI, Vienna, Austria), was trimmed to fit between the wound edges. In the case of DSWI, a layer of non-adhesive dressing was applied to the anterior aspect of the heart to protect the free wall of the right ventricle and/or conduits. Subsequently, foam was placed in two layers, on the one placed under the sternal edges the second was superimposed to fill up the whole wound cavity. Tubing was applied to the foam dressing (TRACpad®, KCI, Vienna, Austria) and the wound was sealed with a transparent adhesive drape (Figure 2). The drainage tube was connected to a purpose-built vacuum source (VAC ATS® pump unit; KCI, Vienna, Austria). The VAC device is able to generate continuous or intermittent negative pressure variations from 50 to 250 mm Hg. The target subatmospheric pressure is monitored and maintained at the wound site, even during the patient's movement and breathing. Exudates from the wound were collected into a canister embedded into the pump unit. Initially, 50 mm Hg of negative pressure was applied to the adjunct of the foam to the wound geometry. The therapy was subsequently targeted to 125 mm Hg continuous negative pressure. The polyurethane foam dressing was changed every 48 to 72 hours. The wound was repeatedly, gently debrided, irrigated with a saline solution and covered in

Fig. 3. The result of the VAC therapy. Prepared wound bed prior to the reconstruction.

the same fashion. At least two bacteriological culture samples from the wound were obtained during each dressing change. In case of the DSWI, the wound bed preparation and foam placement were carried out under a short period of general anaesthesia. The patients were extubated immediately after the procedure, if their general condition allowed it. Meticulous nutritional support as well as tight intravenous insulin management was ensured. The antibiotic treatment was given according to the sensitivity of the bacteriological strains and the clinical response of the patient. All patients received a prolonged course of culture-dependent intravenous antibiotics during the VAC treatment. Antibiotics were discontinued when the healing process and parameters of inflammation had diminished except from DSWI when oral antibiotics were continued for 4 weeks after the wound closure. Wound culture characteristics are summarized in Table 4. The wound was considered to be free of any infection according to advanced local signs of the healing process including the formation of well-vascularised granulation tissue together with negative bacteriological cultures (Figure 3). Further, the decline in serological inflammatory parameters, particularly the C-reactive protein level less than 50 mg/l was required for termination of the VAC therapy. Since excessive residual defects remained, all patients were subsequently indicated for the reconstructive procedure.

RESULTS

Complete healing was achieved in 33 patients (97 %). One patient suffering from DSWI died (3 %) of multiple organ failure on the 24th postoperative day, despite achieving negative bacteriological cultures during the therapy. The hospital stay ranged from 9 to 62 days (median 34.6 days). Median of the SSI presentation after cardiac procedure was 16 days (range 4 to 52 day). Sixteen (47 %) patients were re-admitted to our department due to sternal infection despite uneventful wound healing at the time of discharge. The median VAC treatment time until surgical closure was 9.2 days (range 6 to 21 days). The wound defects after VAC therapy were managed either by direct wound closure or by local fasciocutaneous and/or myocutaneous advancement flaps based on the size of the residual defect to ensure tension-free closure. In the SSWI group, one partial superficial wound dehiscence after the direct closure was recorded. In addition, one patient was re-admitted for sinus tract formation 6 months after the VAC therapy. Both patients were successfully healed by debridement and major pectoral myocutaneous flap transfer. In the DSWI group, seven patients (29 %) were switched to VAC therapy after failure of the conventional treatment strategy. Afterwards, based on increasing experience, 17 patients with DSWI (71 %) were scheduled for the VAC system application as a first-line procedure. In an effort to preserve chest stability, the subsequent reconstructive procedure in this group involved either complete or partial sternum rewiring, depending on the sternal mass loss during debridement. Simultaneously, any residual soft tissue defect was covered by bilateral major pectoral myocutaneous advancement flap in all cases of DSWI. One partial wound dehiscence was noted in the distal part of sternotomy and managed by a delayed direct wound closure. In addition, 2 patients (6 %) were re-admitted 1 to 6 months after wound closure due to wire-associated chronic sinus tract formation. One or more independent risk factors for the sternal wound infection development were presented in all patients (Table 1). *Staphylococcus aureus* and coagulase-negative staphylococcus dominated in the spectrum of organisms cultivated from wounds (Table 3), but, no methicilline-resistant staphylococcal strains were cultivated. There was no significant difference in outcome based on etiological causative agent. The continuous VAC therapy reaching subatmospheric pressure up to 125 mm Hg caused no patient discomfort. No VAC device-related complications were noted.

DISCUSSION

The VAC system was initially designed to treat chronic or debilitating wounds⁷. Since the first use of VAC therapy in 1989, this treatment modality has rapidly evolved into a widely accepted treatment for chronic and acute wounds, contaminated wounds, burns, and wound complications from unsuccessful operations⁸. The system combines the benefits of both closed and open wound

Table 1. Preoperative characteristics (n = 34)

Variable	value	%
Age (y)	69.9 (48–82)	
BMI (kg/m ²)	33.4 (28–41)	
M/F ration	15/17	44/56
Diabetes mellitus	20	59
COPD	6	18
CHRF	6	18
Immunosuppressive therapy	3	9

BMI – body mass index

M/F – male/female

COPD – chronic obstructive pulmonary disease

CHRF – chronic renal failure

Table 2. Cardiac procedures and wound care characteristics (n = 34)

Variable	value	%
CABG	25	74
CABG+AE/MAZE	5	14
CABG (BIMA)	2	6
Valve replacement	2	6
Time to presentation of infection (d)	16 (3–52)	
No. of wound dressings	4.6 (3–10)	
Length of VAC therapy (d)	9.2 (6–20)	
Overall length of hospitalization (d)	34.6 (9–62)	

CABG – coronary artery bypass grafting

AE – aneurysmectomy

MAZE – atrial fibrillation treatment

BIMA – bilateral internal mammary artery harvest

treatment. On one hand, the controlled application of subatmospheric pressure to the wound approximates the wound edges and provides a mass filling effect. On the other hand, it has a positive effect in several wound healing processes. It produces arteriolar dilatation, improves microcirculatory flow, reduces wound oedema and bacterial colonization^{7, 8, 14, 15}. Generally, it leads to significant acceleration of granulation tissue formation^{7, 8, 15}.

Sternal wound infections remain some of the most feared complications in cardiac surgery. Growing experience with VAC treatment in the field of cardiac surgery is showing its over the conventional treatment of sternal infections including either one-step surgical debridement, sternal rewiring and closed mediastinal drainage or repeated debridement, open packing and subsequent sternal reconstruction^{8–11, 16, 17}. In the VAC group, freedom from mediastinal microbiological cultures was achieved earlier, C-reactive protein level declined more rapidly, in-hospital

Table 3. Wound sternal infection classification (n = 34)

Variable	n	%
SSWI	10	29
DSWI	24	71
Type I	9	37
Type II	10	43
Type III	5	20

SSWI – superficial sternal wound infection

DSWI – deep sternal wound infection

Table 4. Wound culture characteristics (n = 34)

Variable	n	%
Staphylococcus aureus	20	58
CoNS	9	27
Escherichia coli	1	3
Pseudomonas aeruginosa	3	9
Klebsiella oxytoca	1	3
MRSA	0	0

CoNS – coagulase negative staphylococcus

MRSA – methiciline-resistant staphylococcus

stay was shorter, sternal closure was achieved earlier and long-term survival tended to be higher^{17–20}. VAC therapy markedly reduced required surgical intervention and re-operations for persistent infections, even in the group of high-risk patients¹⁹. Beyond the positive effect of the VAC on the local wound healing process, the foam becomes firm through application of subatmospheric pressure and acts as a splint for the sternum^{10, 11}. This enables mobilization of the patients and allows them either to breathe spontaneously or to be weaned from artificial ventilation during the inherent therapy^{8, 11}. Further, the stabilisation of the remaining sternal edges may be helpful in preventing right ventricular or conduit injury^{8–10}. VAC therapy was primarily used as a bridge to allow cleaning and preparation of the wound bed for further reconstruction^{8, 10, 11}. Use of the VAC therapy as a definitive closure strategy has been recently reported^{8, 21}. This approach seems to be mostly beneficial in high-risk patients, where it reduces dependence on regional flap and incidence of flap-related morbidity, or in cases of SSWI. Nevertheless, this approach is associated with time extension for the VAC treatment as well as increased cost²¹. Traditionally, timing of the following surgical closure is based on the appearance of the wound, negativity of wound cultures and general patient condition. However, the VAC therapy,

guided by C-reactive protein level, facilitates timing of wound closure, decreased morbidity and increased cost-effectiveness of the procedure²². Decline in C-reactive protein levels below 50 mg/l can be considered a safe trigger for wound closure timing within the institutional algorithm²³.

The authors present their first experience with VAC treatment for sternal wound infections following cardiac surgery. Despite the limited patient cohort, inhomogeneous group of patients and nonrandomized design, VAC therapy was effective and suitable, particularly in the presence of risk factors such as obesity, diabetes, bilateral internal mammary artery grafting and immunosuppressive therapy. The positive effect of subatmospheric pressure on the local wound healing process, active wound drainage and approximation of the wound edges was advantageous. In the case of DSWI, the VAC system allow us to perform wound debridement repeatedly under brief general anaesthesia and subsequently enabled, due to the stabilizing effect on the sternal halves, spontaneous ventilation and early mobilization of patients. VAC therapy was used as a bridge to definitive surgical closure in all cases. Regarding the extent of tissue loss, the tension-free closure technique was widely accepted with the use of local advancement flaps to cover residual soft tissue defects if needed²⁴. However, the sternum-sparing approach, including sternum rewiring for preservation of chest stability, may be associated with later risk of wire-related, chronic sinus tract formation²⁵.

CONCLUSION

The VAC system is a safe and reliable option in the treatment of extensive wound sternal infection in cardiac surgery, mainly promising as the first-line treatment for DSWI, with excellent survival and low failure rate.

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