Early Clinical Outcomes of Surgical Management following Vacuum-Assisted Closure in Poststernotomy Mediastinitis

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Abstract

Background: Poststernotomy mediastinitis, commonly called deep sternal wound infection (DSWI), is a highly concerning complication that can occur in individuals who have undergone cardiac surgery. The optimal way for management is still not well established; antibiotics and frequent debridement followed by surgical closure are the mainstay for better outcomes.

Objectives: To assess the outcome of early surgical debridement vacuum-assisted closure (VAC) for the management of mediastinitis following cardiac surgery.

Patients and methods: This prospective study, including 32 patients with DSWI, was performed at Menoufia University Hospital between March 2021 and October 2023. All patients were managed using VAC of the wound for 5–7 days, followed by surgical closure.

Results: A total of 32 patients presented with DSWI after elective (87.5%) and emergent (12.5%) cardiac surgery. There were 18 male patients and 14 female patients, with ages ranging from 38 to 74. VAC was used for 5–7 days after surgical debridement, and then surgical closure was done directly (18.8%) or using pectoral (56.2%) or omental flap (25%).

Conclusion: Our study supported VAC therapy as a safe and effective management for DSWI. VAC decreased the mean hospital stay, wound size, and reinfection rate.

Keywords: Mediastinitis; Postcardiac mediastinitis; Sternal dehiscence; Sternal wound infection; Vacuum-assisted closure.

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Introduction

Poststernotomy mediastinitis, known as deep sternal wound infection (DSWI), is one of the most feared complications following cardiac surgery. The established definition of mediastinitis has been stated by the Centers for Disease Control and Prevention in the USA. The diagnosis of mediastinitis requires at least one of the following: an organism isolated from a culture of mediastinal tissue or fluid, evidence of mediastinitis seen during operation, or one of the following conditions, that is, chest pain, sternal instability, or fever (>38 °C), in combination with either purulent discharge from the mediastinum or an organism isolated from blood culture or culture of mediastinal drainage **(Sjögren et al.,2006; Wang et al.,2020)**.

Moreover, old age, obesity, chronic obstructive pulmonary disease (COPD), peripheral vascular disease, reoperation, long operation time, low cardiac output, prolonged ventilation time, and reexploration for bleeding are risk factors **(Defoe et al.,2011; Diez, 2007)**.

Currently, there is no consensus on the proper surgical approach to poststernotomy mediastinitis, so various wound-healing strategies have been developed during the era of modern cardiac surgery (**Kaul, 2017**).

Vacuum-assisted closure (VAC) is a novel treatment with an ingenious mechanism. This wound-healing technique is focused on applying local negative pressure to a wound. Recent publications have demonstrated encouraging clinical results; however, observations are still relatively limited and the underlying mechanisms are largely unknown **(Schiraldi et al.,2019; Kamel and Elhendawy,2021).**

This work aims to assess the early results of surgical debridement with VAC of the sternotomy wound followed by early closure for the management of postcardiac surgery mediastinitis.

Patients and methods

This prospective study, which included 32 patients with DSWI, was conducted at Menoufia University Hospital between March 2021 and October 2023. All patients included were >18 years old and diagnosed with DSWI following cardiac surgery. Patients who underwent MICS (minimally invasive cardiac surgery) or had superficial wound infections were excluded. The study was approved by the local ethics committee of the Faculty of Medicine, Menoufia University, under the number 8/2021CARS 26.

Based on a review of past literature, **(Wang et al. 2020)** found that the postoperative mortality rate was 1.9%. To avoid a 10% dropout rate, the sample size was expanded from 29 to 32 participants based on statistics and the Sample Size Pro program. The power of the study is 80%, while the confidence level is 95%.

All patients were subjected to history taking and general and local examinations.

A parenteral antibiotics regimen was used in all patients according to culture and sensitivity of the wound.

Before application of VAC dressing, complete debridement of the infected sternal wound involving removal of all sternal wires, soft tissue, and bony sequesters above and below the sternum is required. The sternal wound was debrided of foreign material and necrotic tissue until clinical improvement of the wound **(Wang et al.,2020)**.

Following wound debridement, VAC foam implantation is ready to be conducted. A sterile polyurethane foam dressing was trimmed to fit between the wound edges and the sternum, covering the wound's subcutaneous tissue completely (**Elawadi and Oueida, 2013**).

In the case of a DSWI with an open sternum, a second piece of sterile polyurethane foam was trimmed to fit between the sternal edges.

A rigid, noncollapsible perforated tube was inserted in the polyurethane foam dressing, and the distal end was connected to an exchangeable fluid canister that was present on the VAC device as shown in (**Fig.1**). Follow-up of the wound was done with every dressing change at 2-3-day intervals.

Fig.1. Vacuum dressing fixed to the wound after initial debridement

Follow-up of the general condition, clinically and using relevant laboratory and radiological investigation, was needed and was done regularly during admission.

Volumetric wound measurements were performed using a standard ruler, and granulation was estimated as a percentage of the surface area of the wound. Regarding the wound size, it was measured at the beginning and after 5–7 days to decide the best option for wound closure. Follow up was continued until the wound was clean and ready for closure as shown in (**Fig.2**).

Fig.2. Clean wound after vacuum dressing, wound is ready for surgical closure.

The decision to use a vascular flap was not made until after a 5-7-day interval of wound vacuum therapy. The decision to proceed to either an omental flap or a pectoralis flap; as in (**Fig.3**),was based on wound size, soft tissue defects, and the surgeon's preference (**Sjögren et al.,2005).** Weekly follow-ups were done for one month at the outpatient clinic to evaluate wound healing and any reinfection.

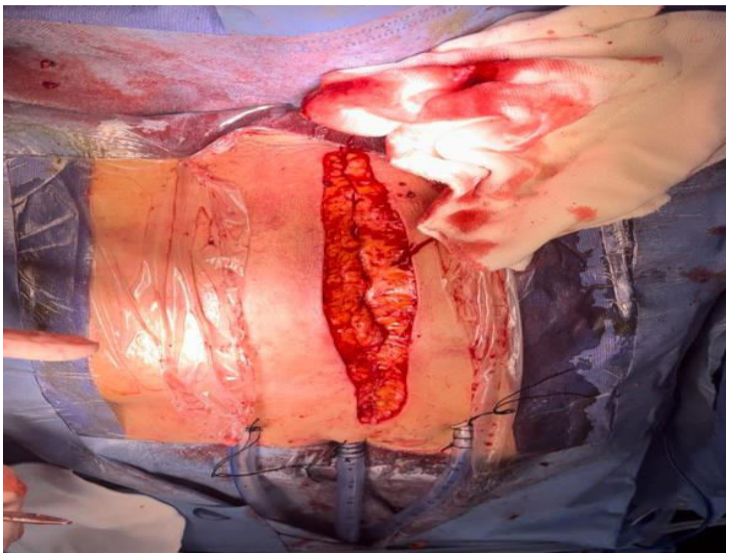

Fig.3. Wound after surgical debridement and closure of pectoral flaps.

Statistical Analysis

Shapiro-Wilk test was used for assessing the normality of data distribution. SPSS Version 22.0 was used to calculate the means and standard deviations for quantitative variables, as well as the frequencies and percentages for qualitative variables. A p-value of less than .05 was used to determine statistical significance.

Results

This group has 18 males and 14 females whose ages ranged between 38 and 70 years, with a mean of 52 ± 8.5 years. The comorbidities found were distributed, as shown in **(Table.1**).

Table 1. The basic demographic data of study subjects.

Variables	**No.**	**%**
Gender		
Male	18	56.2
Female	14	43.8
Age, years	52.3 ± 8.5 (Range, 38–70)	
Comorbidity		
HTN	14	43.8
DM	13	40.6
COPD	8	25
CKD	7	21.9
PVD	11	34.4
Steroid Therapy	2	6.3

HTN: hypertension; DM: diabetes mellitus; COPD: chronic obstructive pulmonary disease; CKD: chronic kidney disease; PVD: peripheral vascular disease.

Hypertension and Diabetes Mellitus were the commonest chronic diseases in the study group. The operative details of the first operation are listed in (**Table.2**). CABG was the most frequent procedure (43.8%), elective surgeries were 28 (87.5%) while emergency were 4 (12-5%). Eight case required re-sternotomy due to previous surgery. Wound infection timing and the causative organisms isolated are described in (**Table.3**).

Table 2. Operative data.

Variables	**No.**	**%**
Procedure		
CABG	14	43.8
VR	12	37.5
DVR	6	18.8
NCEPOD		
Elective	28	87.5
Emergent	4	12.5
Operating Time, min		
Mean ± SD	246.8 ± 40.4	
Range	157–300	
Previous Surgery		
No	24	75
Yes	8	25

CABG: coronary artery bypass grafting; VR: valve replacement; DVR: double valve replacement; NCEPOD: the National Confidential Enquiry into Patient Outcome and Death intervention classification.

Table 3. Clinical data of DSWI diagnosis (N = 32).

Variables	No.	%
Onset, days	13.4 ± 6.7 (Range, 5–25)	
1st week	7	21.9
1–2 weeks	12	37.5
More than 2 weeks	13	40.6
Organism		
Staph. aureus	17	53.1
MRSA	3	9.4
Gram-negative	9	28.1
Combined	3	9.4
Fever	32	100

DSWI: deep sternal wound infection; MRSA: methicillin-resistant *Staph. aureus*.

VAC was used for 5–7 days after surgical debridement; then, surgical closure was done directly (18.8%) or using a pectoral (56.2%) or omental flap (25%).

Upon outpatient follow-up for wound healing assessment and reinfection, only two cases (6.25%) experienced oozing after two weeks, where frequent dressing was sufficient for management. In one case (3.12%), wound dehiscence was experienced in the third week. After dressing, this case required secondary sutures for wound closure. Furthermore, complications were encountered in 9.38% of cases by the end of follow-up.

Discussion

After cardiac surgery, mediastinitis is a rare but severe complication **(Sjögren et al.,2006)**. Obesity, COPD, old age, peripheral vascular disease, reoperation, long operation time, low cardiac output, prolonged ventilation time, and reexploration for bleeding are often cited as risk factors (**Wang et al.,2020**).

Diagnosis requires at least one of the following conditions: A microorganism has been isolated from cultures of mediastinal tissue or fluid acquired during needle aspiration or surgery. During surgery, doctors discovered signs of mediastinitis or purulent discharge from the mediastinum, a fever (>38 °C), or an organism identified from blood cultures or cultures of drainage from the mediastinal region (**Defoe et al.,2011).**

Treatment for mediastinitis after a sternotomy includes antibiotics, wound incision and drainage, debridement, rewiring, closed irrigation, delayed closure, and reconstruction using an omental or myocutaneous flap **(Kaul, 2017; Diez, 2007)**.

Early in the 1990s, VAC was a technology that was eventually implemented with great success for surgical wounds. Poststernotomy mediastinitis can be treated with VAC and different strategies (**Kamel and Elhendawy,2021).**

Our findings were in line with those of (**Kamel and Elhendawy, 2021)**, who set out to compare the efficacy and clinical outcome of VAC therapy with that of standard care for the treatment of poststernotomy mediastinitis. In total, 60 individuals were used in the trial—30 were assigned to each of the two groups. There was a total of 28 female individuals (46.66%) and 32 male participants (53.34%) in their study. The male-to-female ratio was 1.14:1.

Our findings also corroborated those of (**Sjögren et al., 2005**), who sought to

evaluate the effectiveness of VAC therapy against standard care for poststernotomy mediastinitis. Then, 61 patients who had undergone VAC treatment participated in their study. The patients were divided into two groups: 44 men (72%) and 17 women (28%). The male-to-female ratio was 2.5:1.

Furthermore, our results agreed with those of (**De Feo et al., 2011)**, who revealed that out of 77 patients, only 17 (or 22%) were female. There are 3.3 men for every one woman. Overall, regarding gender, these results indicated that the majority of patients enrolled in VAC therapy were males. This may explain why males were more susceptible to poststernotomy mediastinitis.

Consistent with our findings, (**Kamel and Elhendawy, 2021)** discovered that the average age of participants was 48.7 ± 8.05 (35–65) years; their study was conducted at the National Heart Institute (NHI), Egypt.

Our outcomes can be supported by those of (**De Feo et al., 2011)**, who showed that the mean age was 62.6 ± 10.8 years and also revealed that the mean body mass index (BMI) was 33–44.6. We confirmed the findings of (**Sjögren et al., 2005)** that the average age was 65.8 ± 5.3 years old at the time of the study.

Consistent with our work, (**Borger et al., 1998)** identified risk variables for DSWI and reported on the effectiveness of two treatment modalities used in this study. The average BMI was 29.0 ± 4.2, according to their findings.

Our results corroborated the findings of (**Elnahas, 2018),** who reported that, according to their findings, the average age index was 65.8 ± 5.3 at the time of the study. Additional data indicated a mean BMI of 29.6 ± 5 6. Moreover, these findings demonstrated that the age of most participants ranged from 38 to 70 years, and most of them were overweight. This suggests that older age and higher BMI were identified as risk factors for poststernotomy mediastinitis.

Our results align with the findings of (**Sjögren et al., 2005)**, who found that most patients had diabetes mellitus (26, 43%) and 12 (20%) were diagnosed with chronic obstructive pulmonary disease (COPD). Regarding medical comorbidities, they found that the most common comorbidity among their participants was a history of diabetes mellitus.

In line with our findings, (**Kamel and Elhendawy, 2021)** reported that more than half of the patients had COPD, (20, 66.66%), half of the patients were diabetics (15, 50%), and 40% were hypertensive. These results revealed that the most common comorbidities among participants were a history of COPD, hypertension, and diabetes mellitus. This confirmed that COPD, HTN, and DM were frequent risk factors for poststernotomy mediastinitis.

Our findings were consistent with those of (**Elnahas. 2018)**, who followed up 17 individuals who were treated with a VAC system for poststernotomy mediastinitis following heart surgery. In 11 patients, coronary artery bypass graft (CABG) was the most performed (64.7%), followed by mitral valve replacement (17.6%), aortic valve replacement (11.7%), and a Bentall procedure (5.7%). The average operative time was 216.7 ± 45.5 minutes, with a range of 145–300 minutes. Additionally, regarding the type of procedure, these results showed that CABG surgery was the most performed operation among the patients, which may suggest that CABG increases the risk of DSWI (SWI).

(De Feo et al., 2011) discovered that 13.5% of the individuals they treated required valve replacement, but our data contradicted that because valve surgery was more common in our study.

(Rodriguez et al., 2012) sought to establish whether direct wound closure (DC)

or vacuum-assisted therapy (VAT) was more effective in treating DSWIs, depending on the presence or absence of microorganisms, which was in line with our results. According to their data, the average length of time spent in the intensive care unit was 4.08 ±5.02.

Furthermore, we found that (**Elnahas, 2018)** findings were in line with our own. According to their data, the duration of the operation was 216.7 ± 45.5 minutes. Additionally, 41% of patients experienced bleeding, and the average duration of mechanical ventilation was 15.8 ± 6.7 hours.

Regarding microbiological analysis, our study revealed that *Staph. aureus* was the etiological agent in 53.1% of cases. There were three (9.4%) cases of methicillin-resistant *Staphylococcus aureus* (MRSA) and nine (28.1%) cases of Gram-negative pathogens. Three patients (9.4%) were found to have a mixed microbial illness.

In contrast, (**Ennker et al., 2009)** reported that 35 of 45 patients (87.2%) had positive mediastinal culture results. They also demonstrated that *Staphylococcus epidermis* was the leading causative agent, being responsible for 17 infections (37.8%). In total, 10 patients (22.2%) also tested positive for *Enterococcus faecalis* and eight patients (17.8%) for *Staphylococcus aureus*.

Our findings contradicted those of (**Meszaros et al., 2016)**, who aimed to determine whether risk variables for sternal wound infections differ with the kind of surgical procedure in cardiac surgeries. The most common bacterium to be isolated was coagulase-negative *Staphylococcus* (54%), followed by MRSA (13%) and *Enterobacteriaceae* (11%). Two patients had extended-range b-lactamase-producing *Escherichia coli*, and 1.9% of the patients had a polymicrobial illness.

Corroborating the findings of (**Erdem et al., 2021)**, who sought to compare the efficacy and clinical outcome of VAC therapy with that of standard care for poststernotomy mediastinitis. Sixty people participated in their study. Their results demonstrated that the duration of VAC therapy was 7.42 ± 2.23 days.

(Erdem et al., 2021) reported that the average wound size reduction after VAC treatment was 31.7%, which was consistent with our findings. Approximately 59% of granulation tissue was formed on average and 22 (92%) of the patients were cured.

Furthermore, **(Cowan et al., 2005)** found that VAC therapy resulted in a significant reduction in wound size (54% ± 23% by day 14) and a final reduction of 80% ± 21% at the end of the treatment. Additionally, VAC was associated with a reduced need for secondary surgical intervention using regional flap coverage for wound closure in 14 patients (64%). Of these, eight patients (36%) received direct surgical wound closure (tertiary intention), and six patients (28%) were allowed to completely granulate.

(Cowan et al., 2005) also reported that eight patients (36%) who did not achieve remarkable improvements in VAC underwent further debridement and surgical reconstruction using a regional flap, most often pectoralis major, with or without sternectomy.

Our findings corroborated those of (**Elawadi and Oueida, 2013)**, who found that the median time for VAC was 6.51± 1.85 days (range: 3–9). In total, 34 people were treated, with 21 undergoing direct surgical wound closure and 13 undergoing rewiring. Inpatient care required a mean of 11.28 ± 2.09 days (range: 6–16 days).

In line with our findings, (**Erdem et al., 2021)** revealed that at one week, 87% (SE, 0.06) of patients in the study group had no signs of a recurrence; at two weeks, 81%

(SE, 0.07); at three weeks, 75% (SE, 0.08); and at four weeks, 72% (SE, 0.08).

Furthermore, our results were consistent with (**Kamel and Elhendawy, 2021),** which showed that the mean hospital stay after VAC therapy was 12.18 ± 1.92 days. In their study, complete healing could be achieved in eight of the 30 patients (26.66%) who were diagnosed with DSWI and were managed only with the VAC device until the wound became clean. In their research, the mortality rate was 3.33% in patients with VAC therapy, while it was 13.33% in those treated with conventional treatment. Furthermore, a 6.67% reinfection rate after VAC treatment was demonstrated, which was statistically significant.

Conclusion

Our study supported the idea that VAC therapy was safe and effective. VAC decreased the mean hospital stay, the mean reduction in wound size, and the reinfection rate. We recommend early surgical closure of the wound using a local flap as needed after a short period of vacuum application.

We also recommend adherence to infection control instructions, meticulous tissue handling without excessive destruction or diathermy use and good hemostasis to decrease the operative risk for infection. Control of perioperative risk factors is also a corner stone in minimizing the wound infection e.g. glycemic control, blood products transfusion and obesity.

Declarations

Ethics approval and consent to participate

The study was approved by the local ethics committee of the Faculty of Medicine, Menoufia University under the number: 8/2021CARS 26. Informed consent to participate was signed before starting the study.

Consent for publication

Consent to publish was obtained from patients involved.

Availability of data and material

All data generated and analyzed during this study are included in this published article.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions: RS shared in study design, scientific writing, surgical management and patient follow-up**; HS** shared in data collection, analysis of the collected data and scientific writing; **SA** shared in study design, collect data, surgical management and patient follow-up; **IK** shared in analysis of the collected data, surgical management and scientific writing.

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