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Original Article

Negative Pressure Wound Therapy versus Conventional Treatment in Post cardiac Surgery Sternal Wound Infection

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Abstract

Background: Deep sternal wound infection (DSWI) remains a severe complication after cardiac surgery, with direct association with increased morbidity and mortality. This study evaluated the efficacy and safety of negative pressure wound therapy (NPWT) compared with conventional treatment in managing DSWI.

Methods: This randomized study included 40 patients with DSWI postcardiac surgery, which were randomly divided into NPWT (n=20) and conventional treatment (n=20) groups. Patients underwent cardiac surgery between 2019 and 2023 in a single tertiary referral center. The outcomes included wound culture clearance, C-reactive protein (CRP) reduction, complications, and hospital stay.

Results: Preoperative and operative data were comparable between both groups. During treatment, NPWT significantly reduced the percentage of positive cultures to 5% compared with 30% in the conventional group (p=0.037). C-reactive protein (CRP) levels decreased significantly in the NPWT group from 210.14 ± 41.03 mg/L to 5.5 ± 6.42 mg/L (p<0.001), whereas the conventional group presented a minimal reduction from 194.28 ± 18.95 mg/L to 176.85 ± 28.19 mg/L (p=0.125). There were notably fewer complications in the NPWT group than in the conventional group, with only 5% experiencing re-infection (p=0.018). The incidence of necrosis was also lower (5% vs. 20%, p=0.151), and the need for reoperation was lower in the NPWT group (5% vs. 20%, p=0.151). The average length of hospital stay was significantly shorter in the NPWT group (20 ± 3 days) than in the conventional group (36 ± 6 days) (p<0.001).

Conclusion: Negative pressure wound therapy is more effective than conventional treatment in managing deep sternal wound infections following cardiac surgery. NPWT significantly reduces infection rates, accelerates recovery, and minimizes complications, leading to shorter hospital stays. This study supports the use of NPWT as a preferable treatment option for DSWI.

KEYWORDS
Cardiac surgery; Negative pressure wound therapy; Mediastinitis; Deep sternal wound infection

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Introduction

Deep sternal wound infection (DSWI) is a significant complication in cardiac surgery, contributing to in-hospital mortality and affecting both mid- and long-term survival rates [1]. Despite advancements in prevention and perioperative care, the incidence of DSWI remains a concern, particularly as more patients at high risk for

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infection undergo surgery [2]. The management of DSWI involves various strategies, including prophylactic antibiotic therapy, which is crucial yet controversial in terms of choice, dosage, duration, and timing [3]. Addressing patient and surgical risk factors is essential to minimize the occurrence of DSWI.

Treatment options for DSWI range from surgical interventions to advanced techniques such as negative pressure wound therapy (NPWT) [4]. While traditional methods such as surgical revision and soft tissue reconstruction are still used, NPWT has emerged as a promising approach, either as a standalone treatment or as a preparatory step for subsequent surgical closure [4]. Research indicates that NPWT may reduce the need for more invasive procedures, shorten hospital stays, and decrease complications associated with reconstruction, thus highlighting its potential benefits in managing DSWI [5].

Several factors, including the sternotomy technique, have contributed to the development of postoperative DSWI. The technique of sternotomy plays a crucial role in minimizing complications such as DSWI [6]. Performing a sternotomy correctly is vital for ensuring stability and facilitating healing, as improper techniques can lead to serious morbidity and mortality [7]. The advantages of NPWT in managing DSWI are still the subject of ongoing research [8]. This study aims to evaluate the efficacy and safety of NPWT in managing DSWI, either as a primary treatment or as a bridge to more reconstructive procedures, thereby contributing to improved outcomes in patients undergoing cardiac surgery.

Patients and Methods

Study Design and participants

This randomized controlled clinical trial was conducted between March 2019 and March 2023 at Nasr City Insurance Hospital, Egypt, and included 40 patients with DSWI postcardiac surgery. Patients had DSWI after coronary artery bypass grafting (CABG) (n= 30), CABG plus valve replacement (n= 5), aortic valve replacement (AVR) (n= 2), and mitral valve replacement (MVR) (n= 3). The study was approved by the local ethical committee, and the patients consented before participating in the study.

Inclusion and exclusion criteria

The study included adult patients with DSWI after elective cardiac surgery. The exclusion criteria included active bleeding wounds, untreated osteomyelitis, or exposed vessels. DSWI is defined by the Centers for Disease Control and Prevention (CDC) as an infection involving the deeper tissues of the chest, including the sternum, surrounding muscles, and the mediastinum. Diagnosis of DSWI involves isolating an organism from a culture, clinical signs and symptoms of infection and direct observation during surgery. It is important to distinguish between a Superficial Sternal Wound Infection (SSWI) and a DSWI. An SSWI only involves the skin and tissues directly beneath it, while a DSWI involves deeper structures.

Interventions and groups

All patients were placed on systemic antibiotics, and the sternal wounds were irrigated and debrided. Patients were assigned to two groups via blocked randomization generated by computer, with a block size of 2-6:

NPWT Group (n=20): Patients in this group received VAC therapy (125 mmHg) applied after debridement, which was changed every 48–72 hours until the patients were culture negative.

Conventional Group (n= 20): Patients in these groups had daily dressings, irrigation, and delayed closure.

NPWT technique

When a sternal wound infection is suspected, the patient undergoes surgical wound exploration in the operating room under general anesthesia. After confirming the infection, the viability of the sternal bone was evaluated. If signs of bone involvement or instability are present, the sternal wires are removed. The mediastinum is carefully inspected, and bacterial cultures or bone biopsies are obtained if osteomyelitis or compromised bone integrity is suspected. All necrotic or nonviable tissue is subsequently debrided, followed by meticulous hemostasis. A nonadherent foam dressing was placed to avoid direct cardiac contact. During vacuum-assisted closure (VAC) placement, sternal edges are freed

Table 1: Comparison of the baseline data between the negative pressure wound therapy (NPWT) group and the control group. Data are described as mean and standard deviation or numbers and percentages

	Control group (n= 20)	NPWT (n= 20)	P value
Age (years)	66.43 ± 6.02	65.19 ± 6.11	0.524
Male	11 (55%)	9 (45%)	0.527
Body mass index (kg/m²)	30.35 ± 3.53	30.84 ± 3.32	0.654
Diabetes mellitus	9 (45%)	12 (60%)	0.902
Hypertension	13 (65%)	10 (50%)	0.342
Smoking	6 (30%)	7 (35%)	0.337
Heart failure	2 (10%)	2 (10%)	>0.99
EuroSCORE II	1.21 ± 0.56	1.29 ± 0.66	0.662

n= count number of patients in each group; NPWT = negative pressure wound therapy
P-value > 0.05: Non-significant (NS)
P-value < 0.05: Significant (S)
P-value < 0.01: Highly significant (HS)

from adhesions to minimize friction against the right ventricle.

A VAC sponge is trimmed to fit snugly between the sternal edges, reducing shear stress on the underlying heart structures. A larger sponge is then positioned to fill the wound, which is sized generously to accommodate patient movement. In select cases, adhesive drapes are applied in strips, and dual VAC pads (proximal and distal) are connected via a Y-piece to optimize the suction distribution and thoracic stabilization.

For open sternal wounds, continuous suction was maintained at 125 mmHg. In milder cases, initial suction is set to 125 mmHg (or 100 mmHg for patients <60 kg), shifting to intermittent suction if granulation is delayed. Patients are extubated postoperatively and transferred to the ward within 2–4 hours. Ambulatory patients may resume mobility with the VAC system in place.

Table 2: Comparison of operative data between the negative pressure wound therapy (NPWT) group and the control group. Data are described as mean and standard deviation or numbers and percentages

	Control group (n= 20)	NPWT (n= 20)	P value
Operation			
CABG	16 (80%)	14 (70%)	0.881
AVR	1 (5%)	1 (5%)	
CABG+AVR	2 (10%)	3 (15%)	
MVR	1 (5%)	2 (10%)	
CPB time (min)	107.5 ± 20.36	106.5 ± 19.06	0.873
Ischemic time (min)	73.5 ± 15.48	72 ± 15.34	0.760
Mammary artery			
No	2 (10%)	3 (15%)	0.890
Bilateral mammary	2 (10%)	2 (10%)	
Unilateral	16 (80%)	15 (75%)	

n= count number of patients in each group; CABG = Coronary Artery Bypass Grafting; AVR = Aortic Valve Replacement; MVR = Mitral Valve Replacement; CPB time = Cardiopulmonary Bypass Time; NPWT = negative pressure wound therapy

P-value > 0.05: Non-significant (NS)
P-value < 0.05: Significant (S)
P-value < 0.01: Highly significant (HS)

VAC dressings are replaced every 48–72 hours under sterile operating conditions. During each change, the wound was reassessed, new cultures were collected, and residual necrotic tissue was debrided. The criteria for transitioning to definitive closure include normalization of inflammatory markers, negative cultures, and resolution of local infection signs.

Data and outcomes

The preoperative data collected for this study were age, sex, body mass index, diabetes mellitus status, hypertension status, smoking status, heart failure status, and EuroSCORE II score. Operative data included the operation performed, cardiopulmonary bypass and ischemic times, CABG conduits, and postoperative data, including mechanical ventilation time, ICU and hospital stays, massive blood transfusion, and re-exploration for bleeding. The study outcomes were wound culture results, CRP reduction, complications, and length of stay.

Statistical analysis

The data were processed, coded, and imported into IBM SPSS Statistics (Version 27, IBM Corp, Chicago, IL, USA) for analysis. Quantitative variables were summarized using means, and standard deviations, whereas qualitative variables were expressed as frequencies and percentages. For categorical data comparisons, the chi-square test was applied, with Fisher's exact test substituted when the cell count was less than 5. Independent t tests were used to compare parametric quantitative variables between two independent groups, and paired t tests were used to assess differences within paired groups for parametric data. Statistical significance was defined as a p value <0.05.

Results

Baseline Data

The study included 40 patients, with 20 in the NPWT group and 20 in the conventional treatment group. The baseline characteristics were not significantly different between the groups in terms of age, sex, body mass index, prevalence of diabetes mellitus, hypertension, smoking, heart failure, or EuroSCORE II (Table 1).

Operative Data

Operative data, including the type of surgery performed, cardiopulmonary bypass times, and ischemic times, were comparable between the groups (Table 2). The majority of patients underwent CABG, with similar rates of mammary artery utilization.

Outcomes

Positive wound cultures were present before treatment in 35% of patients in both groups. Compared with 30%, 5% NPWT significantly reduced the percentage of positive cultures in the conventional group (p=0.037).

C-reactive protein (CRP) levels decreased significantly in the NPWT group from 210.14 ± 41.03 mg/L to 5.5 ± 6.42 mg/L (p<0.001), whereas the conventional group presented a minimal reduction from 194.28 ± 18.95 mg/L to 176.85 ± 28.19 mg/L (p=0.125).

There were notably fewer complications in the NPWT group than in the conventional group, with only 5% experiencing infection (p=0.018). The incidence of necrosis was also lower (5% vs. 20%, p=0.151), and the need for reoperation was lower in the NPWT group (5% vs. 20%, p=0.151).

The average length of hospital stay was significantly shorter in the NPWT group (20 ± 3 days) than in the conventional group (36 ± 6 days) (p<0.001). Outcomes were comparable between the groups (Table 3).

Discussion

This randomized clinical study evaluated the efficacy and safety of NPWT versus conventional treatment in managing DSWIs after cardiac surgery. This study was conducted from 2019-2023, and 40 patients were divided into two groups. The results indicated that, compared with conventional methods, NPWT significantly reduced positive wound cultures, lowered C-reactive protein levels, and shortened hospital stays. Additionally, NPWT was associated with fewer complications, highlighting its effectiveness in improving patient outcomes.

Table 3: Comparison of outcomes before and after treatment between the control group and the NPWT group. Data are described as mean and standard deviation or numbers and percentages

	Control group (n= 20)	NPWT (n= 20)	P value
Positive culture before treatment	7 (35%)	7 (35%)	>0.99
Positive culture during treatment	6 (30%)	1 (5%)	0.037
In-group comparison	0.735	0.018	
CRP before treatment	194.28 ± 18.95	210.14 ± 41.03	0.125
CRP during treatment	176.85 ± 28.19	5.5 ± 6.42	<0.001
In-group comparison	0.012	<0.001	
Bleeding	1 (5%)	0	0.311
Necrosis	4 (20%)	1 (5%)	0.151
Infection	7 (35%)	1 (5%)	0.018
Fistula	1 (5%)	0	0.311
Reoperation	4 (20%)	1 (5%)	0.151
Secondary flaps	2 (10%)	0	0.147
Type of wound closure			
Pectoralis	14 (70%)	11 (55%)	0.061
Granulation tissue	0	6 (30%)	
Direct closure	2 (10%)	3 (15%)	
Omentum	2 (10%)	0	
Secondary closure	1 (5%)	0	
Death before closure	1 (5%)	0	
Sternum			
No fully opened	2 (10%)	12 (60%)	0.004
Refixation	13 (65%)	5 (25%)	
Left opened or removed	5 (25%)	3 (15%)	
Length of stay (days)	36 ± 6	20 ± 3	<0.001

n= count number of patients in each group; NPWT = negative pressure wound therapy; CRP = C-reactive protein

P-value > 0.05: Non-significant (NS)
P-value < 0.05: Significant (S)
P-value < 0.01: Highly significant (HS).

DSWIs are serious complications following cardiac surgery that can lead to increased mortality, prolonged hospital stays, and significant healthcare costs [9,10]. The treatment of DSWI typically involves surgical debridement, antibiotic therapy, and wound management [11,12]. Two main approaches for managing DSWI are conventional treatment and negative pressure wound therapy (NPWT). Conventional treatment methods for DSWI include surgical debridement with primary closure, continuous wound irrigation and open treatment with secondary closure. These approaches often involve removing infected tissue, irrigating the wound with antiseptic solutions, and either closing the wound primarily or leaving it open for secondary closure [13].

NPWT has gained prominence in recent years as an effective treatment for DSWI. This method involves applying controlled negative pressure to the wound bed via a specialized dressing and pump system [14,15]. Compared with conventional treatment, NPWT has been shown to be more effective at preventing recurrent infections. One study reported that NPWT had an odds ratio of 5.4 (95% CI: 1.1-27.5; p = 0.044) for preventing recurrent infection [14]. This result is consistent with our study, where we reported a

5% reinfection rate with NPWT and a 35% reinfection rate with the conventional method. Multiple studies have reported that NPWT was associated with improved survival rates in patients with DSWI [14]. A 15-year review of nearly 25,000 sternotomies revealed a significant difference in early and midterm survival, favoring NPWT [15]. In this study, we reported one case of death with conventional therapy vs no mortality in patients who underwent NPWT. Compared with conventional treatment methods, NPWT was associated with shorter hospital stays. In a meta-analysis by Liu and associates, compared with conventional methods, NPWT was associated with a reduction in mortality, reinfection, and length of hospital stay [16]. Our study demonstrated a significant reduction in the duration of hospital stay in patients who underwent NPWT compared with those who underwent conventional methods. NPWT has been shown to promote faster granulation tissue formation, decrease wound edema, and provide effective drainage of excessive and infected fluid [17]. An additional advantage of NPWT is that it allows for earlier patient mobilization by providing sternal stabilization [17]. We did not report major complications with NPWT in our series, and while NPWT is generally considered safe, it is important to note that rare complications such as right ventricular rupture and major bleeding events have been reported [16,18].

These findings suggest that NPWT should be considered a first-line treatment for DSWI in cardiac surgery patients. By reducing infection rates and hospital stays, NPWT may lead to lower healthcare costs and improved patient quality of life. This study supports the integration of advanced wound management techniques into clinical practice to enhance postoperative care in high-risk patients.

Limitations

Several limitations were present in this study. The sample size of 40 patients may limit the generalizability of the findings. The study was conducted at a single institution, which may introduce bias related to local practices and patient demographics. Additionally, the lack of long-term follow-up data on wound healing and infection recurrence limits the assessment of the lasting effects of NPWT. Future multicenter studies with larger sample sizes are needed to validate these results and explore the long-term efficacy of NPWT in diverse patient populations.

Conclusion

Negative pressure wound therapy is more effective than conventional treatment in managing deep sternal wound infections following cardiac surgery. NPWT significantly reduces infection rates, accelerates recovery, and minimizes complications, leading to shorter hospital stays. This study supports the use of NPWT as a preferable treatment option for DSWI.

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References

1. Phoon PHY, Hwang NC. Deep Sternal Wound Infection: Diagnosis, Treatment and Prevention. J Cardiothorac Vasc Anesth. 2020; 34(6): 1602–13.
2. Perezgrovas-Olaria R, Audisio K, Cancelli G, et al. Deep Sternal Wound Infection and Mortality in Cardiac Surgery: A Meta-analysis. Ann Thorac Surg. 2023;115(1):272–80.
3. Hever P, Singh P, Eiben I, Eiben P, Nikkhah D. The management of deep sternal wound infection: Literature review and reconstructive algorithm. JPRAS Open. 2021; 28:77–89.
4. Biancari F, Santoro G, Provenzano F, et al. Negative-Pressure Wound Therapy for Prevention of Sternal Wound Infection after Adult Cardiac Surgery: Systematic Review and Meta-Analysis. J Clin Med. 2022;11 (15): 4268.
5. Myllykangas HM, Berg LT, Husso A, Halonen J. Negative pressure wound therapy in the treatment of deep sternal wound infections – a critical appraisal. Scandinavian Cardiovascular Journal. 2021;55(6):327–32.
6. Shaikhrezai K, Robertson FL, Anderson SE, Slight RD, Brackenbury ET. Does the number of wires used to close a sternotomy have an impact on deep sternal wound infection? Interact Cardiovasc Thorac Surg. 2012; 15(2): 219–22.

7. Sakamoto H, Fukuda I, Oosaka M, Nakata H. Risk factors and treatment of deep sternal wound infection after cardiac operation. Ann Thorac Cardiovasc Surg. 2003;9 (4):226–32.
8. Banjanović B, Karabdic IH, traus S, Berberovic BH, Djedovic M, Granov N. Deep Sternal Wound Infection After Open-heart Cardiac Surgery and Vacuum-Assisted Closure Therapy: a Single-center Study. Medical Archives. 2022; 76: 273–7.
9. Ali U, Bibo L, Pierre M, et al. Deep Sternal Wound Infections After Cardiac Surgery: A New Australian Tertiary Centre Experience. Heart Lung Circ. 2020;29(10):1571–8.
10. Lee GS, Bisleri G, Tam DY. Deep Sternal Wound Infections: One Bad Cut, a Lifetime of Trouble. Ann Thorac Surg. 2023;115(1):280–1.
11. De Feo M, Gregorio R, Della Corte A, et al. Deep sternal wound infection: the role of early debridement surgery. European Journal of Cardio-Thoracic Surgery. 2001;19(6):811–6.
12. Kuonqui K, Janhofer DE, Takayama H, Ascherman JA. A Review of 559 Sternal Wound Reconstructions at a Single Institution: Indications and Outcomes for Combining an Omental Flap With Bilateral Pectoralis Major Flaps in a Subset of 17 Patients With Infections Extending Into the Deep Mediastinum. Ann Plast Surg. 2023;90(6S): S521 – S525.
13. Schimmer C, Sommer SP, Bensch M, Leyh R. Primary treatment of deep sternal wound infection after cardiac surgery: a survey of German heart surgery centers. Interact Cardiovasc Thorac Surg. 2007;6(6):708–11.
14. Gegouskov V, Manchev G, Goranovska V, Stoykov D. Negative Pressure Wound Therapy Becomes the Treatment of Choice of Deep Sternal Wound Infection. Heart Surg Forum. 2022;25(4):E601–7.
15. Singh Erica; Harper J. Garrett KA. Overview and Management of Sternal Wound Infection. Semin Plast Surg. 2011;25(01):25–33.
16. Liu YT, Lin SH, Peng C, et al. Effectiveness and safety of negative pressure wound therapy in patients with deep sternal wound infection: a systematic review and meta-analysis. International Journal of Surgery. 2024; 110 (12): 8107 - 8125.
17. Bayraktar FA, Özhan A, Baştopçu M, Özhan HK, Mete EMT. Results of negative pressure wound therapy for deep sternal wound infections after cardiac surgery. Cardiovascular Surgery and Interventions. 2022; 9 (3): 141 – 146.
18. Bota O, Taqatqeh F, Bönke F, et al. The role of negative pressure wound therapy with instillation and dwell time in the treatment of deep sternal wound infections—A retrospective cohort study. Health Sci Rep. 2023;6(7):e1430.