Scientific Research Publishing

Journal of Biosciences and Medicines, 2026, 14(2), 403-417
https://www.scirp.org/journal/jbm
ISSN Online: 2327-509X
ISSN Print: 2327-5081

Evaluating the Effectiveness of Closed Continuous Negative Pressure Wound Therapy in Managing Deep Sternal Wound Infections after Cardiac Surgery: A Case Series

Mahamaden Adam Kery, Hao Cao*, Yanzhong He, Yong Liu

Department of Cardiovascular Surgery, Shanghai East Hospital, School of Medicine, Tongji University, Shanghai, China
Email: *caohao@tongji.edu.cn

How to cite this paper: Kery, M.A., Cao, H., He, Y.Z. and Liu, Y. (2026) Evaluating the Effectiveness of Closed Continuous Negative Pressure Wound Therapy in Managing Deep Sternal Wound Infections after Cardiac Surgery: A Case Series. *Journal of Biosciences and Medicines*, **14**, 403-417.
https://doi.org/10.4236/jbm.2026.142030

Received: December 30, 2025
Accepted: February 10, 2026
Published: February 13, 2026

Abstract

Deep sternal wound infection (DSWI) is an uncommon yet serious postoperative complication, occurring in approximately 0.8% to 8% of patients following cardiac surgery and resulting in considerable morbidity, extended hospitalization, and increased healthcare expenditures. This study sought to examine the effectiveness of Negative Pressure Wound Therapy (NPWT) as the primary local therapeutic intervention following surgical debridement for the management of DSWI. While utilized as the central local wound management strategy, NPWT was implemented within a multimodal treatment framework that included standard systemic antimicrobial support. A retrospective case series of 15 post-cardiac surgery patients was evaluated, focusing on hospitalization duration, wound healing time, and overall recovery trajectories. Outcomes were further contextualized by comparing them with those reported in the literature for NPWT combined with complex adjunctive procedures, such as flap reconstruction or instillation therapy. The findings demonstrated an average hospital stay of 34.26 days; among the 14 patients who achieved complete wound healing, the median recovery time was approximately one month. The implications of this study are twofold. Clinically, the results suggest that NPWT, when applied as the foundational local therapy after adequate debridement, contributes to shorter hospital stays and more rapid wound recovery, potentially serving as an effective bridge to closure that minimizes the need for more invasive reconstructive surgeries. Economically, the observed reduction in hospitalization and secondary intervention rates suggests that the integration of NPWT into standard DSWI protocols may lower overall treatment-related costs. Ultimately, these findings support the inclusion of NPWT within comprehensive, multidisciplinary DSWI treatment algorithms, providing clinicians with a viable strategy to optimize patient-centered outcomes in cardiac postoperative care.

Keywords

Deep Sternal Wound Infection, Negative Pressure Wound Therapy, Debridement

1. Introduction

Deep sternal wound infections (DSWIs) are relatively uncommon but serious complications following cardiac surgery. Their reported incidence ranges from 0.8% to 5%, with some studies reporting rates as high as 8%, depending on patient risk profiles and surgical complexity [1] [2]. DSWIs are associated with high morbidity and mortality and contribute to prolonged hospitalization, frequent rehospitalizations, and increased healthcare costs [1]. Several patient- and procedure-related factors have been linked to the development of DSWI, including obesity, diabetes mellitus, prolonged mechanical ventilation, prior cardiac surgery, postoperative blood transfusions, and the use of internal mammary artery grafts [3]. These risk factors underscore the importance of effective preventive and therapeutic strategies in cardiac surgical care. Traditional management strategies for DSWIs include surgical debridement with reconstructive procedures, systemic antibiotic therapy, hyperbaric oxygen therapy, and platelet-rich plasma therapy [4] [5]. While these approaches remain essential, each has limitations related to invasiveness, resource demands, or limited effectiveness as standalone interventions.

Negative pressure wound therapy (NPWT) has gained increasing attention as a therapeutic modality for complex wounds. By applying controlled subatmospheric pressure to the wound bed, NPWT facilitates exudate removal, reduces edema, improves tissue perfusion, and promotes granulation tissue formation, thereby supporting wound healing [1]. Clinical evidence supports the use of NPWT in the management of DSWI. Retrospective and observational studies have demonstrated lower mortality rates and reduced sternal reinfection compared with conventional wound management [6] [7]. A recent systematic review and meta-analysis of 36 studies involving 3681 patients reported significant reductions in mortality and reinfection risk, along with shorter hospital and intensive care unit (ICU) stays among patients treated with NPWT [8]. In light of this evidence, the present study evaluated the role of NPWT in the prevention and treatment of DSWI in patients undergoing median sternotomy for cardiac surgery. The objectives were to assess 1) The efficacy of NPWT for infection control and wound healing; 2) Patient-reported outcomes including pain and satisfaction; 3) Cost-related outcomes associated with NPWT use in this clinical setting.

1.1. Epidemiology and Risk Factors

Deep sternal wound infection, also referred to as post-sternotomy mediastinitis, remains a serious complication following cardiac surgery. Although relatively uncommon, its incidence ranges from 0.8% to 5%, with some studies reporting rates as high as 8% in high-risk patient populations [1] [2]. DSWIs are associated with high morbidity and mortality and contribute to prolonged hospitalization, frequent rehospitalizations, and increased healthcare costs [1] [3]. Mortality rates can be considerable, particularly among patients with multiple comorbidities or postoperative complications [3]. Several patient- and procedure-related factors have been linked to the development of DSWI. Patient-related risk factors include obesity, diabetes mellitus, malnutrition, and advanced age [4]. Procedure-related factors include prolonged mechanical ventilation, prior cardiac surgery, postoperative blood transfusions, and the use of internal mammary artery (IMA) grafts [4] [5]. Among these, bilateral internal mammary artery grafting has been strongly associated with increased risk due to impaired sternal perfusion and delayed healing.

1.2. Conventional Management of DSWI

Conventional management of DSWI typically involves surgical debridement combined with systemic antibiotic therapy and reconstructive procedures such as pectoralis or latissimus dorsi flap coverage [6] [7]. These approaches provide durable wound closure and restore sternal stability, particularly in patients with extensive tissue defects. However, they are invasive, require specialized surgical expertise, and are associated with prolonged recovery. Systemic antibiotic therapy remains a cornerstone of infection control but may be limited by antimicrobial resistance and adverse effects associated with long-term use. Adjunctive therapies such as hyperbaric oxygen therapy and platelet-rich plasma have also been explored, though their widespread use is constrained by resource requirements and limited supporting evidence [8].

1.3. NPWT Interventions

Negative pressure wound therapy represents a significant advancement in the management of complex wounds, including DSWI. The application of controlled subatmospheric pressure promotes exudate removal, reduces tissue edema, enhances perfusion, and supports granulation tissue formation [9]. NPWT also maintains a closed wound environment, which may reduce bacterial colonization and support wound contraction.

1.4. Clinical Evidence for NPWT

Multiple studies support the effectiveness of NPWT in managing DSWI. Retrospective cohorts and observational studies have demonstrated lower mortality rates, reduced sternal reinfection, and shorter hospital stays compared to conventional wound management strategies [10]-[12]. Meta-analytic evidence further corroborates these findings, showing significant reductions in mortality and reinfection risk across large patient populations [13] [14]. Emerging NPWT modalities, such as NPWT with instillation and dwell time, have been proposed to enhance microbial clearance and promote wound healing, though larger studies are needed to validate their effectiveness and safety [15] [16].

Despite encouraging evidence, gaps remain regarding standardized treatment protocols, long-term outcomes, cost-effectiveness, and effectiveness in high-risk populations. Addressing these gaps through future research will be essential to optimize NPWT use and improve patient outcomes in DSWI management.

2. Materials and Methods

2.1. Study Design and Setting

This study employed a retrospective case series design to evaluate the effectiveness of NPWT in the management of DSWIs among patients who had undergone cardiac surgery. The analysis focused on patient outcomes following NPWT, with particular emphasis on infection control, wound healing rates, and the cost-effectiveness of the therapy. By examining both clinical and economic endpoints, the study aimed to provide a comprehensive assessment of NPWT as a therapeutic strategy for DSWIs in a post-cardiac surgery population.

The study was conducted in the Department of Cardiovascular Surgery at Shanghai East Hospital, Tongji University School of Medicine. The study population comprised adult patients (aged 18 years and above) who had undergone cardiac surgery and subsequently received NPWT for the management of DSWIs. Patients with non-sternal wounds, those who declined NPWT, or individuals with incomplete medical records were excluded. This inclusion and exclusion framework was designed to ensure a representative sample of patients affected by DSWIs and to facilitate a focused evaluation of NPWT outcomes within a clinically relevant cardiac surgery population.

2.2. Participants and Process

Patient records were retrieved from the electronic medical records (EMR) system for the period between March 2020 and March 2024. Data collected included demographic characteristics (age, sex, and comorbidities), details of the cardiac surgery (type, duration, and any intraoperative complications), and information pertaining to DSWI diagnosis (time to diagnosis post-surgery and microbiological findings). Treatment-related variables encompassed the duration of NPWT (approximately two weeks) and the use of any adjunctive therapies. Clinical outcomes were assessed through time to wound closure, incidence of reinfection, total hospital stay, and readmission rates, while patient-reported outcomes included pain scores and satisfaction with treatment. Economic evaluation focused on the cost of NPWT relative to conventional management strategies.

NPWT was administered using FDA-approved systems. Following surgical debridement, a sterile foam dressing was placed into the wound cavity and sealed with an adhesive film to maintain an airtight environment. A vacuum pump generated controlled negative pressure ranging from −125 mmHg to −150 mmHg (approximately −0.017 to −0.02 MPa), which was continuously applied and adjusted according to wound severity and clinical response [1] [11]. **Figure 1** below presents the general process that includes: (a) Deep sternal wound infection post debridement; (b) Applied negative Pressure Wound Therapy; (c) Post NPWT; (d) Post suture, wound healed.

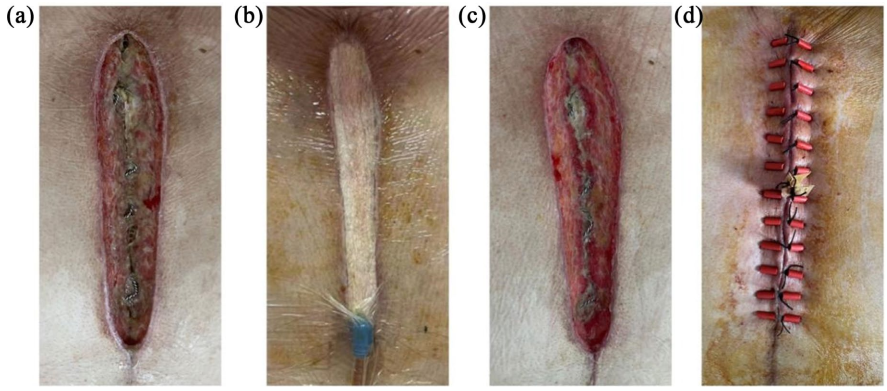

Figure 1. (a) Deep sternal wound infection post debridement. (b) Applied negative Pressure Wound Therapy. (c) Post NPWT. (d) Post suture, wound healed.

2.3. Measures

This study employed predefined primary and secondary outcome measures to systematically evaluate infection characteristics, treatment course, and hospitalization outcomes in patients with DSWI. The use of standardized, predefined metrics is essential for reducing observer bias and ensuring the reproducibility of clinical data in wound care research [17] [18]. By utilizing objective primary endpoints—such as time to wound closure and reinfection rates—this methodology allows for a rigorous quantitative assessment of therapeutic efficacy [19] [20]. Furthermore, the inclusion of secondary outcomes, specifically patient-reported pain scores and economic evaluations, provides a multidimensional view of the treatment's impact, aligning with current value-based healthcare frameworks that prioritize both clinical success and patient-centered care [21] [22]. This comprehensive approach ensures that the findings are comparable to existing literature and provide a robust basis for clinical decision-making.

Primary Outcome Measures

Microbiological Characteristics of DSWI: The primary outcome measure was the microbiological characterization of DSWI. This included the identification of causative microorganisms isolated from sternal wound cultures obtained from affected patients. Time to microbiological identification was recorded and defined as the number of days between wound culture collection and laboratory confirmation of the pathogen. Culture results were categorized as either a specific pathogen identified or no microbial growth detected. The frequency and distribution

DOI: 10.4236/jbm.2026.142030

of isolated organisms, along with their corresponding time to identification, are summarized in Table 1.

Table 1. Pathogens detected in sternum wound.

Organism	Time to Identify the Bacteria	n	%
Staphylococcus aureus	<5 days	13	86.67
Proteus mirabilis	<5days	0	0
Staphylococcus epidermidis	<5days	1	6.67
Klebsiella epidermidis	<5days	0	0
Pseudomonas aeruginosa	<5days	0	0
Mixed, with Staphylococcus aureus	<5days	0	0
No detection	<5days	1	6.67

Application of NPWT: The application of NPWT was assessed as a primary outcome measure. Utilization of NPWT, implemented through vacuum sealing drainage (VSD), was recorded as a binary variable indicating whether the therapy was used in the management of deep sternal wound infection. In addition, the duration of NPWT treatment was documented for each patient and measured in days. These measures were used to characterize the extent and intensity of NPWT application during the treatment course.

Secondary Outcome Measures

Secondary outcome measures included time to diagnosis of DSWI, length of hospital stay, post-diagnosis hospitalization duration, and cost-related outcomes. Time to diagnosis was defined as the interval, in days, between the index cardiac surgical procedure and the clinical diagnosis of DSWI. Length of hospital stay was measured from surgery to discharge. Post-diagnosis hospitalization duration captured the time from DSWI diagnosis to discharge or transition to outpatient management with negative pressure wound therapy and antibiotic treatment. Cost-related outcomes comprised direct medical costs and indirect indicators of healthcare resource utilization.

Time to Diagnosis of DSWI: Time to diagnosis of DSWI was collected as a secondary outcome measure. This variable was defined as the interval, measured in days, between the index cardiac surgical procedure and the clinical diagnosis of DSWI. Diagnosis was based on clinical findings, imaging when applicable, and microbiological evidence consistent with institutional diagnostic criteria. Recording time to diagnosis allowed assessment of the temporal onset of infection following surgery and provided insight into patterns of early versus delayed presentation of DSWI among the study population.

Length of Hospital Stay: Length of hospital stay was assessed as a secondary outcome and defined as the total duration of hospitalization following cardiac surgery. This measure was calculated in days from the date of the index surgical procedure to the date of discharge. Length of stay was used as an indicator of clinical recovery, disease severity, and healthcare resource utilization. Prolonged hospitalization was considered reflective of postoperative complications, including deep sternal wound infection, and the intensity of therapeutic interventions required during inpatient management.

Post-Diagnosis Hospitalization Duration: Post-diagnosis hospitalization duration was measured as the number of days from the confirmed diagnosis of DSWI to hospital discharge or transition to outpatient management. This outcome captured the inpatient treatment period specifically attributable to infection management. It included time required for surgical debridement, initiation and continuation of negative pressure wound therapy, antibiotic administration, and clinical stabilization. This measure was used to evaluate the burden of DSWI following diagnosis and the effectiveness of inpatient management strategies in facilitating discharge.

Cost-Related Outcomes: Cost-related outcomes were evaluated as secondary measures to assess healthcare resource utilization associated with DSWI management. Direct medical costs included expenses related to wound care materials, negative pressure wound therapy equipment, antimicrobial therapy, surgical interventions, and inpatient services. Indirect cost indicators were represented by proxy measures such as length of hospitalization and the need for prolonged inpatient care. These outcomes were used to provide an economic perspective on DSWI treatment and to contextualize clinical outcomes within resource utilization patterns.

2.4. Statistical Analysis

Descriptive analyses were performed using SPSS software (version 27, IBM Corp., Armonk, NY, USA) to characterize the demographic and clinical features of the study cohort. Continuous variables, such as age, are presented as mean ± standard deviation (SD) and range, whereas categorical variables, including sex and type of surgical intervention, are reported as frequencies and percentages. This approach provides a structured overview of baseline patient characteristics, facilitating interpretation of outcomes and enabling comparison with existing literature.

For the Demographic Characteristics, the study sample comprised 15 patients, with a mean age of 66.0 ± 14.3 years (range: 28 - 83 years). The cohort included 10 males (66.7%) and 5 females (33.3%), reflecting the sex distribution of patients undergoing complex cardiac surgeries within the study period. In terms of Clinical Characteristics, Patients presented with a range of primary diagnoses, including coronary artery disease, valvular heart disease, aortic dissection, and acute coronary syndrome. Key imaging findings corroborated these diagnoses, demonstrating stenotic coronary lesions, valvular abnormalities, and aortic pathology. Surgical interventions varied according to individual patient needs and included coronary artery bypass grafting (CABG, 4/15, 26.7%), valve replacement or repair procedures (9/15, 60%), and aortic repairs (3/15, 20%). By summarizing demographic and clinical characteristics in this manner, the study establishes a comprehensive baseline context, supporting the interpretation of therapeutic outcomes and enhancing reproducibility.

3. Results

Table 2 presents the summary of patient characteristics and surgical interventions.

Table 2. Summary of patient characteristics and surgical interventions.

Case	Age	Sex	Primary Diagnosis/Indication	Key Imaging/Findings	Surgical Intervention
1	73	F	Acute coronary syndrome	Pulmonary infiltrates; abnormal LFTs	Bioprosthetic valve replacements; temporary pacemaker
2	46	F	Post-valve replacement complications	CT/Echo abnormalities	Repeat aortic valve replacement
3	71	M	Coronary artery disease	LM 80% - 90% stenosis; LAD 95% - 99%	CABG
4	77	M	Recurrent carotid stenosis	LV wall motion abnormalities	Multiple vascular stents and repairs
5	44	M	Coronary artery disease	CT: mild findings; echo: mild MR	CABG
6	81	F	CAD with severe multi-vessel stenosis	LAD/Cx/RCA stenoses	CABG with sternal re-fixation
7	66	M	Severe aortic stenosis	Dilated aorta; valve calcification	AVR; temporary pacemaker
8	71	M	Valvular heart disease	Multi-valvular regurgitation; effusion	MVR, TVP, LAA ligation
9	66	M	CAD with atrial fibrillation	Proximal 90% - 95% stenosis	CABG + Maze procedure
10	65	F	Severe aortic stenosis	Bicuspid AV; dilated ascending aorta	AVR + ascending aorta replacement
11	28	M	Aortic dissection	CT/Echo confirmed dissection	Ascending aortic replacement
12	83	M	Mitral regurgitation	Valve stenosis	Mitral + tricuspid valve repair
13	67	M	Mitral valve stenosis	CT/Echo confirmed	Bioprosthetic valve replacement
14	78	M	Aortic dissection	CT/Echo confirmed	Descending aortic repair
15	69	M	Aortic dissection & mitral stenosis	CT/Echo confirmed	Mitral valve repair

Note: M = Male, F = Female, AVR = Aortic Valve Replacement, MVR = Mitral Valve Replacement, TVP = Tricuspid Valve Plasty, CRRT = Continuous Renal Replacement Therapy, CABG: Coronary Artery ByPass Grafting, NPWT = Negative Pressure Wound Therapy.

3.1. Objective Evaluation

Primary Objective: Effectiveness of NPWT in Infection Control and Wound Healing: The study looked at fifteen cases of patients with diverse cardiac problem who had surgical interventions, and had deep sternal wound infections. Negative Pressure Wound Therapy (NPWT) was a common therapeutic option for these infections. The results in the cases indicate NPWT's efficiency in infection control and wound healing, presented in Table 3.

3.2. Cases Outcomes

All 15 patients with DSWIs following cardiac surgery were treated with NPWT in conjunction with systemic antibiotics. NPWT was generally effective in promoting wound healing, controlling infection, and stabilizing patients, with most patients achieving discharge in a timely manner.

Table 3. The results of NPWT's efficiency in infection control and wound healing.

Case	Major Complications	NPWT Duration	Antibiotics/Additional Treatment	Outcome	Hospital Stay (days)
1	Pulmonary infection; poor wound healing	11 days	Meropenem + Tienam	Stable	41
2	Mediastinal infection	12 days	Vancomycin	Stable	24
3	Sternal dehiscence	14 days	Cefuroxime	Stable	18
4	Deep sternal wound infection	15 days	Standard care	Stable	112
5	Sternal dehiscence	7 days	Vacon	Stable	49
6	DSWI, sternal dehiscence	15 days	Vancomycin	Stable	40
7	Deep sternal wound infection	16 days	Vancomycin	Stable	34
8	Deep sternal wound infection	14 days	Vancomycin	Stable	35
9	Acute kidney injury (CRRT), DSWI	16 days	Vancomycin	Stable	64
10	Multi-organ dysfunction, DSWI	14 days	Vancomycin	Deceased	64
11	Deep sternal wound infection	14 days	Antibiotics	Stable	42
12	Deep sternal wound infection	14 days	—	Stable	27
13	Deep sternal wound infection	14 days	—	Stable	30
14	Deep sternal wound infection	14 days	—	Stable	23
15	Deep sternal wound infection	14 days	—	Stable	22

Time to wound healing and discharge: Among the 14 surviving patients, the mean duration of NPWT treatment until stable wound closure and discharge was 39.4 ± 22.3 days (range: 22 - 112 days).

Treatment success: 14 of 15 patients (93.3%) responded favorably to NPWT combined with standard care, achieving stable wound closure and resolution of infection.

Mortality: One patient (Case 10) died due to severe aortic stenosis and multi-organ dysfunction despite NPWT and intensive care.

3.3. Representative Cases

Case 1: A 73-year-old female with severe pulmonary infection and poor wound healing post-surgery achieved stable wound closure after 41 days of NPWT combined with antibiotics.

Case 4: A 77-year-old male with multiple vascular stents and repairs maintained stable infection control after 112 days of NPWT and standard care, highlighting variability in treatment duration depending on comorbidities and surgical complexity.

Overall, NPWT demonstrated consistent effectiveness across a range of underlying cardiac conditions and surgical interventions. The duration of therapy varied with the severity of infection and patient-specific factors, but outcomes suggest that NPWT is a reliable adjunct for managing complex DSWIs.

Secondary Objectives: Patient-Reported Outcomes

Patient-reported outcomes such as pain levels and patient satisfaction were not systematically recorded in the included cases. Clinically, the majority of patients were discharged in stable condition, with no documented readmissions related to deep sternal wound infection during the reported follow-up period. Improvement in wound condition was observed across most cases following the application of NPWT. Regarding cost-related outcomes, the study documented hospital course characteristics, including length of stay and occurrence of postoperative complications. No additional surgical interventions or prolonged hospitalizations related to wound management were reported in most patients following NPWT treatment.

4. Discussion

4.1. Effectiveness of NPWT on Infection Control and Wound Healing

The present study evaluated the effectiveness of NPWT in a case series of 15 patients who developed DSWIs following sternotomy for various cardiac surgeries. While the findings support the role of NPWT as the primary local therapeutic modality in promoting wound healing and controlling infection, it is essential to clarify that NPWT was implemented as a key component of a comprehensive, multimodal treatment strategy rather than a standalone or isolated intervention. In accordance with standard clinical protocols for DSWI, all patients in this cohort received concurrent systemic antibiotic therapy tailored to specific microbial cultures [23].

Within this integrated framework, 14 out of 15 patients demonstrated significant improvement in wound healing, with stable closure achieved within a relatively short timeframe. These results are consistent with previous studies indicating that NPWT, when used in conjunction with appropriate systemic antimicrobial support, facilitates microbial clearance, promotes granulation tissue formation, and accelerates wound closure [24] [25]. However, NPWT was not universally successful. One patient in the cohort experienced severe complications and succumbed to underlying comorbidities, highlighting that treatment outcomes are heavily influenced by the patient's baseline physiological status and the virulence of the infection. This observation aligns with findings by Sjögren *et al.*, who reported that the efficacy of NPWT, while potent as a local bridge to closure, can be compromised in patients with multiple comorbidities or critical illness [26]. Furthermore, the depth of the infection and the timing of NPWT initiation are critical determinants of final clinical success [27].

4.2. Patient-Reported Outcomes

Although this study did not systematically collect patient-reported outcomes, the observation that most patients were discharged with stable, well-healed wounds suggests a potentially positive influence on pain levels, comfort, and overall treatment satisfaction. Existing literature indicates that NPWT may offer advantages in patient experience, as its continuous wound management mechanism reduces the need for frequent dressing changes, thereby decreasing pain intensity and procedural discomfort compared with conventional treatments [28]. Additionally, the ability of NPWT to promote faster wound stabilization may contribute to reduced emotional distress and improved confidence in the healing process [29] [30]. However, without formal assessment tools, such as standardized pain scales or quality-of-life questionnaires, definitive conclusions cannot be drawn. Future research should incorporate validated patient-reported outcome measures to more accurately assess subjective experiences, including pain, functional recovery, psychological well-being, and satisfaction with therapy [31].

4.3. Cost-Effectiveness of NPWT

Economic considerations play a crucial role in assessing the value of different wound management strategies, particularly in resource-intensive conditions such as DSWIs. Although this study did not include a formal cost-effectiveness analysis, the observed reductions in hospital length of stay, reinfection rates, and the need for additional surgical interventions suggest that NPWT offers meaningful economic benefits. This interpretation aligns with previous research demonstrating that NPWT can reduce overall healthcare expenditures by shortening hospitalization, decreasing dressing-change frequency, and preventing costly postoperative complications [32]. These findings suggest that NPWT provides both clinical and financial advantages in the management of DSWIs. Future studies incorporating formal cost-benefit analyses are warranted to quantify these savings more precisely and guide institutional policy decisions.

5. Limitations and Future Directions

This study has several limitations that warrant consideration. The retrospective design and small sample size limit the generalizability of the findings to broader populations. Furthermore, the absence of a comparator group precludes direct comparison with conventional wound management strategies or alternative surgical interventions. This lack of a control cohort, combined with the limited sample size, restricts the overall interpretability and statistical power of the results. Additionally, the lack of systematic patient-reported outcome data further restricts the ability to assess the subjective benefits of NPWT, such as pain intensity or quality of life. Future research should focus on larger, multi-center prospective controlled studies to validate the clinical efficacy and cost-effectiveness of NPWT within a more robust framework. Incorporating comprehensive economic analyses and structured patient feedback would provide a more holistic understanding of the benefits and limitations of this therapy in the management of DSWI.

6. Conclusion

In conclusion, NPWT demonstrates strong potential as an effective therapeutic modality for the management of deep sternal wound infections in patients undergoing cardiac surgery. The findings of this case series suggest meaningful benefits in infection control, wound stabilization, and accelerated healing, alongside possible reductions in overall treatment costs. However, the variability observed in patient outcomes highlights the importance of individualized treatment planning and careful consideration of comorbid conditions. To refine clinical application and strengthen the evidence base, future research should prioritize well-designed prospective studies with larger cohorts, standardized NPWT protocols, and comprehensive outcome measures. Such efforts will be essential for optimizing NPWT use, guiding clinical decision-making, and ultimately improving postoperative recovery and long-term outcomes for patients with DSWIs.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Review Committee of Shanghai East Hospital (Tongji University School of medicine) and its approval no.2024ys-122. All participants' data was anonymized for confidentiality and to protect their privacy.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Fleck, T. and Fleck, M. (2012) Negative Pressure Wound Therapy (NPWT) for the Treatment of Sternal Wound Infections after Cardiac Surgery. *International Wound Journal*, **9**, 19-25.

[2] Alebrahim, K. and Al-Ebrahim, E. (2020) Prevention, Classification and Management Review of Deep Sternal Wound Infection. *The Heart Surgery Forum*, **23**, E652-E657. https://doi.org/10.1532/hsf.3153

[3] Bayraktar, F.A. (2022) Results of Negative Pressure Wound Therapy for Deep Sternal Wound Infections after Cardiac Surgery. *Cardiovascular Surgery and Interventions*, **9**, 141-146. https://doi.org/10.5606/e-cvsi.2022.1383

[4] Biancari, F., Santoro, G., Provenzano, F., Savarese, L., Iorio, F., Giordano, S., *et al.* (2022) Negative-pressure Wound Therapy for Prevention of Sternal Wound Infection after Adult Cardiac Surgery: Systematic Review and Meta-analysis. *Journal of Clinical Medicine*, **11**, Article 4268. https://doi.org/10.3390/jcm11154268

[5] Elhassan, H., Amjad, R., Palaniappan, U., Loubani, M. and Rose, D. (2024) The Negative Pressure Wound Therapy for Prevention of Sternal Wound Infection: Can We Reduce Infection Rate after the Use of Bilateral Internal Thoracic Arteries? a Systematic Literature Review and Meta-analysis. *Journal of Cardiothoracic Surgery*, **19**, Article 87. https://doi.org/10.1186/s13019-024-02589-y

[6] Lender, O., Göbölös, L., Bajwa, G. and Bhatnagar, G. (2022) Sternal Wound Infections after Sternotomy: Risk Factors, Prevention and Management. *Journal of Wound Care*, **31**, S22-S30. https://doi.org/10.12968/jowc.2022.31.sup6.s22

[7] Sachithanandan, A. (2011) Negative Pressure Vacuum Assisted Closure Therapy Following Cardiac Surgery: Safe and Effective. *Interactive CardioVascular and Thoracic Surgery*, **12**, 120-120. https://doi.org/10.1510/icvts.2010.252668a

[8] Suelo-Calanao, R.L., Thomson, R., Read, M., Matheson, E., Isaac, E., Chaudhry, M., *et al.* (2020) The Impact of Closed Incision Negative Pressure Therapy on Prevention of Median Sternotomy Infection for High Risk Cases: A Single Centre Retrospective Study. *Journal of Cardiothoracic Surgery*, **15**, Article No. 222. https://doi.org/10.1186/s13019-020-01265-1

[9] Argenta, L.C. and Morykwas, M.J. (1997) Vacuum-assisted Closure: A New Method for Wound Control and Treatment. *Annals of Plastic Surgery*, **38**, 563-577. https://doi.org/10.1097/00000637-199706000-00002

[10] Zens, Y., Barth, M., Bucher, H.C., Dreck, K., Felsch, M., Groß, W., *et al.* (2020) Negative Pressure Wound Therapy in Patients with Wounds Healing by Secondary Intention: A Systematic Review and Meta-Analysis of Randomised Controlled Trials. *Systematic Reviews*, **9**, Article No. 238. https://doi.org/10.1186/s13643-020-01476-6

[11] Rashed, A., Csiszar, M., Beledi, A. and Gombocz, K. (2021) Impact of Incisional Negative Pressure Wound Therapy on Wound Healing after Midline Sternotomy. *International Wound Journal*, **18**, 95-102. https://doi.org/10.1111/iwj.13497

[12] Schwartzmann, E., Sy, M., Sharma, M., Mańkowski, B., Jemielity, M. and Perek, B. (2021) Negative Pressure Wound Therapy for Surgical Site Infection after Sternotomy and Its Role in Preparing the Wound for Reconstruction. *Polish Journal of Cardio-Thoracic Surgery*, **18**, 190-191. https://doi.org/10.5114/kitp.2021.109414

[13] He, S., Tang, N. and Li, S. (2025) Comparison of Negative Pressure Wound Therapy with Conventional Wound Care in the Treatment of Sternal Wound Infection after Cardiac Surgery: A Meta-Analysis with Trial Sequential Analysis. *PLOS One*, **20**, e0328771. https://doi.org/10.1371/journal.pone.0328771

[14] Porter, M.E. (2010) What Is Value in Health Care? *New England Journal of Medicine*, **363**, 2477-2481. https://doi.org/10.1056/nejmp1011024

[15] Ampatzidou, F., Sileli, M., Madesis, A., Antoniou, K., Baddur, A., Kechagioglou, G., *et al.* (2015) Predisposing Factors for Deep Sternal Wound Infection after Cardiac Surgery. *Critical Care*, **19**, Article No. P10. https://doi.org/10.1186/cc14090

[16] Al-Zaru, I.M., Ammouri, A.A., Al-Hassan, M.A. and Amr, A.A. (2010) Risk Factors for Deep Sternal Wound Infections after Cardiac Surgery in Jordan. *Journal of Clinical Nursing*, **19**, 1873-1881. https://doi.org/10.1111/j.1365-2702.2010.03193.x

[17] Gundestrup, L., Florczak, C.K. and Riber, L.P.S. (2023) Factors Associated with Deep Sternal Wound Infection after Open-Heart Surgery in a Danish Registry. *American Heart Journal Plus: Cardiology Research and Practice*, **31**, Article 100307. https://doi.org/10.1016/j.ahjo.2023.100307

[18] Kaul, P. (2017) Sternal Reconstruction after Post-Sternotomy Mediastinitis. *Journal of Cardiothoracic Surgery*, **12**, Article No. 94. https://doi.org/10.1186/s13019-017-0656-7

[19] Litwinowicz, R., Bryndza, M., Chrapusta, A., Kobielska, E., Kapelak, B. and Grudzień, G. (2016) Hyperbaric Oxygen Therapy as Additional Treatment in Deep Sternal Wound Infections—A Single Center's Experience. *Polish Journal of Cardio-Thoracic Surgery*, **3**, 198-202. https://doi.org/10.5114/kitp.2016.62604

[20] Tsai, Y.-J., Lee, C.-Y., Hsieh, M.-J., *et al.* (2014) Association between Post-Sternotomy Tracheostomy and Deep Sternal Wound Infection: A Retrospective Analysis. *Journal of Thoracic Disease*, **8**, 3294-3300. https://doi.org/10.21037/jtd.2016.11.70

[21] Diez, C., Koch, D., Kuss, O., Silber, R., Friedrich, I. and Boergermann, J. (2007) Risk Factors for Mediastinitis after Cardiac Surgery—A Retrospective Analysis of 1700 Patients. *Journal of Cardiothoracic Surgery*, **2**, Article No. 23. https://doi.org/10.1186/1749-8090-2-23

[22] Christodoulou, E., Vasilopoulos, G., Kalogianni, A. and Jahaj, E. (2018) Effectiveness of Negative Pressure Wound Healing Systems Applying in Sternotomy after Cardiac Surgery: A Systematic Review. *Health & Research Journal*, **4**, 204-218. https://doi.org/10.12681/healthresj.19296

[23] van Wingerden, J.J., Segers, P. and Jekel, L. (2011) Major Bleeding during Negative Pressure Wound/V.A.C.®—Therapy for Postsurgical Deep Sternal Wound Infection—A Critical Appraisal. *Journal of Cardiothoracic Surgery*, **6**, Article No. 121. https://doi.org/10.1186/1749-8090-6-121

[24] Mokhtari, A., Sjögren, J., Nilsson, J., Gustafsson, R., Malmsjö, M. and Ingemansson, R. (2008) The Cost of Vacuum-Assisted Closure Therapy in Treatment of Deep Sternal Wound Infection. *Scandinavian Cardiovascular Journal*, **42**, 85-89. https://doi.org/10.1080/14017430701744469

[25] Petzina, R., Hoffmann, J., Navasardyan, A., Malmsjö, M., Stamm, C., Unbehaun, A., *et al.* (2010) Negative Pressure Wound Therapy for Post-Sternotomy Mediastinitis Reduces Mortality Rate and Sternal Re-Infection Rate Compared to Conventional Treatment. *European Journal of Cardio-Thoracic Surgery*, **38**, 110-113. https://doi.org/10.1016/j.ejcts.2010.01.028

[26] Sjogren, J., Gustafsson, R., Nilsson, J., Lindstedt, S., Nozohoor, S. and Ingemansson, R. (2011) Negative-Pressure Wound Therapy Following Cardiac Surgery: Bleeding Complications and 30-Day Mortality in 176 Patients with Deep Sternal Wound Infection. *Interactive CardioVascular and Thoracic Surgery*, **12**, 117-120. https://doi.org/10.1510/icvts.2010.252668

[27] Grauhan, O., Navasardyan, A., Hofmann, M., Müller, P., Stein, J. and Hetzer, R. (2013) Prevention of Poststernotomy Wound Infections in Obese Patients by Negative Pressure Wound Therapy. *Journal of Thoracic and Cardiovascular Surgery*, **145**, 1387-1392. https://doi.org/10.1016/j.jtcvs.2012.09.040

[28] Segers, P. (2014) Use of Incisional Negative Pressure Wound Therapy on Closed Median Sternal Incisions after Cardiothoracic Surgery: Clinical Evidence and Consensus Recommendations. *Medical Science Monitor*, **20**, 1814-1825. https://doi.org/10.12659/msm.891169

[29] Ren, S., Liu, H. and Chang, Z. (2025) Effectiveness of Negative Pressure Wound Therapy in Treating Deep Surgical Site Infections after Spine Surgery: A Meta-Analysis of Single-Arm Studies. *Journal of Orthopaedic Surgery and Research*, **20**, Article No. 44. https://doi.org/10.1186/s13018-025-05463-2

[30] Bamba, R., Harvey, B.I., Malik, N.U., Higgins, J., Sung, C., Corvera, J.S., *et al.* (2025) A Comparative Analysis of Negative Pressure Wound Therapy Methods for Sternal Wound Infections. *Plastic and Reconstructive Surgery—Global Open*, **13**, e6579. https://doi.org/10.1097/gox.0000000000006579

[31] Bae, J., Woo, W. and Gardner, S.E. (2025) The Wound Microbiome Associated with Deep Sternal Wound Infection: A Scoping Review. *Journal of Thoracic Disease*, **17**, 5330-5346. https://doi.org/10.21037/jtd-24-1648

[32] Chaparro Mendoza, K., Cortés Salas, M.P., Alzate-Ricaurte, S., Plata-Ayala, N., Moreno, M.S., Arango Sakamoto, A., *et al*. (2025) Impact of Delayed Sternal Closure and Negative Pressure Therapy after Complex Cardiovascular Surgery. *Journal of Cardiothoracic Surgery*, **20**, Article No. 460. https://doi.org/10.1186/s13019-025-03729-8