



Vacuum-Assisted Closure for Sternal Wound Infection After Coronary Artery Bypass Surgery

Hasan Erdem¹ , Ayşe Zehra Karakoç¹ , Seda Karasakal¹ , Yeliz Karacı¹ , Arzu Antal¹ , Hasan Sunar¹

¹ Department of Cardiovascular Surgery, Kartal Kosuyolu High Specialization Training and Research Hospital, Istanbul, Turkey

ABSTRACT

Introduction: Vacuum-assisted closure of sternal infected wounds has been reported to improve morbidity and mortality, besides decreasing duration of hospitalization. The aim of this study was to evaluate early outcomes of vacuum-assisted closure of infected sternal wounds after coronary bypass surgery in our clinic.

Patients and Methods: Sixty six patients who had sternal wound infection after coronary bypass surgery in our hospital between January 2016 and December 2019 were included in the study. After surgical debridement and removal of foreign materials, vacuum-assisted closure therapy was initiated at a mean postoperative 26.56 ± 5.5 days. After wound healing and negative cultures, treatment was terminated and sternal wounds were closed with appropriate procedures.

Results: Fifty six patients (84.84%) had deep sternal infection and 10 patients (15.15%) had superficial sternal infection. Early mortality was 13.63% (nine patients), all having deep sternal infections. The most common microorganisms cultured were *Staphylococcus aureus* and *Pseudomonas aeruginosa*. Mean duration of hospitalization was 39.68 ± 2.48 days. No complications related with vacuum-assisted closure were detected. Recurrent sternal wound infection was not observed in any of the surviving patients.

Conclusion: Our results confirm that vacuum-assisted closure of wounds is a safe and effective treatment option for patients who are not candidates for primary closure or early muscle flap closure.

Key Words: Vacuum-assisted closure; sternal wound infection; coronary bypass surgery.

Koroner Baypas Cerrahisi Sonrası Sternal Yara İnfeksiyonunda Negatif Basınç Yardımlı Kapatma

ÖZ

Giriş: Vakum yardımcı kapama yönteminin morbidite ve mortaliteyi azalttığı, hastanede kalış süresini kısalttığı bildirilmiştir. Bu çalışmanın amacı, kliniğimizde koroner baypas cerrahisi sonrası gelişen sternal infeksiyonun vakum destekli kapama sistemi tedavisinin erken sonuçlarını değerlendirmektir.

Hastalar ve Yöntem: Hastanemizde Ocak 2016-Aralık 2019 tarihleri arasında, koroner baypas cerrahisi sonrası sternal yara infeksiyonu gelişen 66 hasta çalışmaya dahil edilmiştir. Hastalara cerrahi yara debridmanı ve yabancı cisimlerin uzaklaştırılmasından sonra, postoperatif ortalama 26.56 ± 5.5 günlerinde vakum yardımcı kapatma tedavisi başlanmıştır. Yara dokusunda yeterli kanlanma sağlanması, granülasyon dokusu oluşması ve negatif kültür sonuçları sağlandıktan sonra, uygun prosedür kullanılarak tedavi sonlandırılmıştır.

Bulgular: Elli altı hastada derin sternal, 10 hastada yüzeysel sternal infeksiyon tespit edilmiştir. Erken mortalite gelişen 9 (%13.63) hastanın tamamında derin sternal yara infeksiyonu mevcuttur. En sık üretilen mikroorganizmalar *Staphylococcus aureus* ve *Pseudomonas aeruginosa* olarak tespit edilmiştir. Ortalama hastanede kalış süresi 39.68 ± 2.48 gün olarak bulunmuştur. Vakum yardımcı kapatma tedavisi ile ilgili komplikasyon yaşanmamıştır. Yaşayan hastaların hiçbirisinde tekrarlayan sternal yara yeri infeksiyonu gözlenmemiştir.

Sonuç: Sonuçlarımız vakum yardımcı kapatma yönteminin, primer kapatma uygulanamayacak veya erken dönemde kas filebi ile tedavi edilemeyecek hastalarda güvenli ve etkili bir tedavi yöntemi olduğunu teyit etmiştir.

Anahtar Kelimeler: Vakum yardımcı kapama; sternal yara infeksiyonu; koroner baypas cerrahisi.

INTRODUCTION

Sternal wound infection (SWI) is a rare but life-threatening clinical condition after cardiac surgery. Incidence of sternal wound infection has decreased steadily in years but it is still related with increased morbidity, mortality, decreased survival and increased hospital costs⁽¹⁻³⁾. There

Cite this article as: Erdem H, Karakoç AZ, Karasakal S, Karacı Y, Antal A, Sunar H. Vacuum-assisted closure for sternal wound infection after coronary artery bypass surgery. Koşuyolu Heart J 2021;24(1):32-37.

Correspondence

Hasan Erdem

E-mail: herdemkvc@hotmail.com

Submitted: 17.02.2021

Accepted: 02.03.2021

Available Online Date: 01.04.2021

© Copyright 2021 by Koşuyolu Heart Journal. Available on-line at www.kosuyoluheartjournal.com

are several surgical treatment modalities for sternal infections including drainage of infective material, surgical debridement, primary sternal fixation with plates, sternal closure with muscle flaps. Vacuum-assisted closure (VAC) wound therapy was first reported as a new treatment option in 1997⁽⁴⁾. There is not still a consensus on the best treatment option for sternal infections. In 2016, recommendation guidelines for prevention and treatment of sternal wound infections was published by the American Association for Thoracic Surgery (AATS) to decrease SWI related morbidity and mortality after cardiac surgery and VAC therapy was recommended to enhance the treatment⁽⁵⁾. The aim of this study was to evaluate early outcomes of VAC therapy for SWI after coronary bypass surgery in our clinic.

PATIENTS and METHODS

Patient Population and Data Collection

Patients who underwent Coronary Bypass Grafting Surgery (CABG) in our hospital, between January 2016 and December 2019 were retrospectively reviewed. Among 4310 patients, 66 patients (1.53%) who had postoperative SWI and treated with vacuum-assisted closure (VAC) therapy were included in this study. Patients who had emergent surgical interventions and patients revascularized without use of mammarian arteries were excluded.

Patient data were collected from clinical records of the institution and laboratory results including blood and sternal wound cultures were retrieved from the electronic database of the hospital retrospectively, after approval of the study by the ethical committee of the hospital.

Definition of surgical site infection was made based on the criteria of Centers for Disease Control and Prevention^(6,7). Wound infection was defined as superficial if only subcutaneous and cutaneous layers were involved and defined as deep if the infection had reached sternal surface and/or involved the sternum. The patients with SWI were diagnosed as mediastinitis with isolation of the microorganism in sternal wound aspiration cultures or fluids and presence of symptoms as fever, angina and sternal instability besides the radiological findings of the CT scan.

Surgical Procedure and Treatment

All patients decided to be treated with VAC therapy were taken to operating room (Figure 1). Patients were covered with disposable drapes after being cleaned with chlorhexidine. General or local anesthesia was preferred depending on patient's clinical condition and the depth of surgical debridement. Surgical debridement was carried out under sterile conditions, all foreign materials, including the steel wires in patients with deep sternal infections were removed (Figure 2). Then



Figure 1. Shape of the wound at the time of initial diagnosis.



Figure 2. Surgical debridement and removal of foreign materials.

VAC treatment was started using V.A.C[®] Granufoam[™], VeraT.R.A.C.[™] Pad, V.A.C.Ultra[™] (KCI USA, San Antonio, Inc., TX) System. The size of the foam was tailored depending on the size of the wound. Applied negative pressure was set to 25-75 mmHg depending on the depth of the wound and exposure of the heart to prevent iatrogenic injury. A dressing barrier was used between the heart and sponge if necessary. VAC was usually replaced every 48-72 hours depending on the amount of drainage and the planned surgical debridement. With each replacement wound cultures were sent to the laboratory. The wound closed by using the most appropriate closure method (Figure 3).



Figure 3. Final status of the wound subsequent the surgical closure.

Antibiotic administration was planned by the infection committee of the hospital. Treatment with antibiotics was started with the first positive culture and then modified depending on subsequent culture results.

Statistical Analysis

Statistical analysis were performed using statistical software (SPSS, version 23.0 for Windows; SPSS, Chicago, Illinois, United States). Numerical variables were given as mean and standard deviation (SD). Continuous random variables were presented as median and range (max-min values). Kolmogorov-Smirnov test was used in the distribution analysis of the data. Homogeneously distributed data were evaluated by the Student t-test, heterogeneous data were evaluated by the Mann-Whitney U test separately. To determine independent predictors for dependent variables; subsequently to univariate analysis test results the logistic regression analysis was applied to determine the ultimate risk factors and odds ratios of the factors foreseeing the mortality after VAC application subsequent to patients undergoing CABG surgery in our clinic.

Any difference with p value <0.05 was regarded statistically significant.

RESULTS

Among 66 patients included in the study, 23 were females (33.8%) and 43 were males (63.2%). Mean age was 62.06 ± 9.37 years. The mean body mass index (BMI) of the patients was 26.5 ± 3.99 kg/m² and obesity was detected in 13 patients (19.6%). The frequency of patients with DM was 78.8% (n= 52) and 57.6% (n= 38) of patients had chronic obstructive pulmonary disease (COPD) as comorbidities. The preoperative demographics are shown in Table 1.

Table 1. Preoperative demographic data

Characteristics	Number (%) / Median
Age (years)	62.06 ± 9.37
BMI (kg/m ²)	26.5 ± 3.99
Gender	
Male	43 (63.2%)
Female	23 (33.8%)
COPD	38 (57.6%)
CVE	3 (4.5%)
PVD	1 (1.5%)
Hyperlipidemia (LDL > 150 mg/dL)	15 (22.7%)
DM (blood glucose level >140 mg/dL)	52 (78.8%)
AKI	12 (18.18%)
CKD	4 (6.06%)

BMI: Body mass index, COPD: Chronic obstructive pulmonary disease, CVE: Cerebrovascular event, PVD: Peripheral vascular disease, DM: Diabetes mellitus, AKI: Acute kidney injury, CKD: Chronic kidney disease.

Sternal dehiscence was found in 22 patients (33.3%) and the other 44 patients had only purulent flux (66.6%). Ten patients had superficial wound infections (15.2%) and 56 patients had deep sternal wound infections (DSWI) (84.8%). Twenty six patients had lesion size bigger than 10 cm (39.39%). Patients had their VAC treatment started at a mean of 26.56 days.

Prolonged intubation (more than 12 hours) was observed in 11 patients (16.66%). Postoperative mean albumin levels were 27.42 ± 5.35 g/dL and the blood albumin levels were found to be statistically significant for predicting prolonged hospital stay and mortality (p<0.05). The mean hospital stay was 39.68 ± 2.48 days. Patients postoperative data were given in Table 2.

Table 2. Postoperative data

Variable	Number (%) / Median
Sternal dehiscence	22 (33.3%)
Lesion size (> 10 cm in longitudinal axis)	26 (39.39%)
Superficial wound infection	10 (15.2%)
Deep wound infection	56 (84.8%)
VAC application (mean day)	26.56 ± 6.5
Prolonged mechanical ventilation (> 12 h)	11 (16.66%)
Length of hospital stay (days)	39.68 ± 22.48

VAC: Vacuum-assisted closure.

Most common microorganisms cultured were *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Klebsiella aerogenes* were *Escherichia coli*. The microorganisms were detailed in Table 3.

Early mortality was seen nine patients (13.63%) all having deep sternal infections. Subsequently the separate analysis the logistic regression analysis was applied to find out independent risk factors of in hospital mortality. Postoperative hypoalbuminemia, prolonged mechanical ventilation, existence of preoperative respiratory insufficiency, acute and chronic renal dysfunction were found as significant risk factors for mortality ($p < 0.05$). *Pseudomonas*, *Klebsiella* and *Morganella* microorganisms were found to be significantly related with mortality in this study (Table 4).

Table 3. Microorganisms in mediastinal cultures

Microorganisms	Number (%)
<i>Staphylococcus aureus</i>	15 (n= 15, 22.7%)
<i>Pseudomonas aeruginosa</i>	14 (n= 14, 21.2%)
<i>Klebsiella</i>	10 (n= 10, 15.2%)
<i>Escherichia coli</i>	6 (n= 6, 9.1%)
<i>Enterobacter</i>	6 (n= 6, 9.1%)
<i>Morganella morgagni</i>	4 (n= 4, 6.06%)
<i>Serratia</i>	4 (n= 4, 6.06%)
<i>Acinetobacter aerogenes</i>	2 (n= 2, 3.03%)
<i>Proteus mirabilis</i>	2 (n= 2, 3.03%)

Table 4. Predictors of in-hospital mortality

	OR	95% CI Lower	UPPER	p value
Prolonged mechanical ventilation	13	2.61	64.607	0.003
Respiratory insufficiency	4.26	0.957	19.030	0.045
AKI	4.90	1.08	22.23	0.028
CKD	0.081	0.035	0.187	0.000
Postoperative hypoalbuminemia	0.804	0.668	0.968	0.019
<i>Pseudomonas</i> in cultures	6.80	1.42	32.47	0.008
<i>Morganella</i> in cultures	7.85	0.951	64.930	0.029
<i>Klebsiella</i> in cultures	7.85	0.951	64.930	0.029

OR: Odds ratio, AKI: Acute kidney injury, CKD: Chronic kidney disease.
 $p < 0.05$ is statistically significant.

DISCUSSION

Deep sternal wound infections (DSWI) is a serious complication of cardiac surgery, increasing morbidity and mortality. It results in prolonged hospitalization, re-operations and increased costs^(3,8). In case of deep sternal infection, first step treatment principles are almost standard, including surgical debridement of all necrotic and infected tissues, removing foreign materials, drainage of purulent material under suitable antibiotic treatment. Techniques for closure of sternum vary; it can be closed immediately or delayed.

There are several therapeutic options for treatment of DSWI, including surgical revision with open or closed irrigation, surgical debridement followed by delayed closure with Robicsek technique, sternal plating, nitinol clips and muscle flap closure and VAC therapy but there is not still an exact consensus on the optimal approach for DSWI⁽⁹⁻¹¹⁾.

Durgun et al., reported sufficient results with rectus and pectoral muscle flaps for deep sternal infections⁽¹²⁾. Similarly a recent study by Pan et al., stated better short and long-term outcomes and unimpaired respiratory function with bilateral pectoralis muscle flaps compared with VAC therapy in a total of 132 post cardiac surgery patients⁽¹³⁾.

On the contrary, Dohmen et al., in their consensus statement recommended prophylactic use of negative pressure wound therapy (NPWT) in patients with major risk factors (BMI < 15 or > 40 kg/m²), insulin dependent diabetes mellitus, dialysis for chronic renal failure to prevent DSWI after cardiothoracic surgery⁽¹⁴⁾. VAC therapy helps to improve local blood flow, remove excessive effluent, protect superinfection with contamination and keep the edges of wound together⁽¹⁵⁻¹⁷⁾. Deniz and colleagues reported their comparative results of patients treated with conventional therapy and negative pressure

therapy and stated that NPWT provided better survival and low failure rate compared to conventional techniques⁽¹⁸⁾.

Fuchs et al., reported that the VAC system helped to have negative wound cultures in a shorter time that resulted in reduced hospitalization period⁽¹⁹⁾. Similarly Raja and colleagues reported that VAC treatment reduces the time period between surgical debridement and sternal closure⁽²⁰⁾. Negative pressure wound therapy is proposed in AATS guidelines as a class IIa recommendation in patients with deep sternal wound infections as a bridge for delayed sternal closure⁽⁵⁾. A recent study by Martino and colleagues, showed that VAC therapy had significantly improved outcomes of both deep and superficial wound infections with complete healing and without recurrence⁽²¹⁾.

In this series, we reported our early experience with patients who had delayed closure and had VAC therapy before closure. Our patients had persistent infection even after debridement and we needed to drain mediastinal spaces due to purulent effluent with the VAC system. Our results confirmed effectiveness of VAC, with acceptable mortality rate and absence of recurrence in all cases.

Early mortality was found to be 13.6% in our series which is similar with the previous studies⁽²²⁾. Risk factors for mortality were found to be respiratory insufficiency, prolonged ventilation, acute and chronic renal insufficiency and postoperative hypoalbuminemia in our study. Risk factors for deep sternal infections have been reported as obesity, advanced age, chronic obstructive lung disease, diabetes mellitus and use of mammarian arteries as conduits after CABG operations^(15,23). Patients in our series were high risk patients by means of these risk factors for infection, therefore the mortality observed was probably related with the preoperative comorbidities.

Duration of the VAC treatment seemed to affect the length of hospitalization (mean 39.6 days) but in fact these patients were our first group of patients and the decision making process for utilization of VAC system was prolonged. That is the probable reason for prolonged hospitalization. Depending on our early experience, we believe that early use of VAC with the onset of infection signs and symptoms, will contribute us for better results.

LIMITATIONS

Major limitation of the study is its retrospective design and relatively small number of patients. We did not have a control group treated with conventional methods to compare the effect of VAC treatment on morbidity and mortality in patients with mediastinitis, which we need to evaluate in a further study.

CONCLUSION

Despite adherence to all precautions to prevent sternal infections, postoperative superficial and deep infections may occur. Treatment options should be individualized, depending on patients clinical condition, risk factors, depth of the infection and microorganisms cultured. VAC of wounds is a safe and reliable treatment option for patients who are not candidates for primary closure or early muscle flap closure.

Ethics Committee Approval: The study was approved by the Non-Invasive Clinical Research Ethics Committee of Health Sciences University Kartal Koşuyolu High Specialization Training and Research Hospital (Date: 23.05.2019; Number: 2019.4/19-196).

Informed Consent: Due to the design of the study, consent to volunteer could not be obtained from the patients.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept/Design - HE, AA; Analysis/Interpretation - AK; Data Collection - SK, YK; Writing - AA, AK, HE; Critical Revision - AA, AK, HS; Final Approval - HS; Statistical Analysis - AK; Overall Responsibility - HE, AK, SK, YK, AA, HS.

Conflict of Interest: The authors have no conflicts of interest to declare

Financial Disclosure: The authors declared that this study has received no financial support.

REFERENCES

1. Braxton JH, Marrin CA, McGrath PD, Ross CS, Morton J R, Norostky M, et al. Mediastinitis and long-term survival after coronary artery bypass graft surgery. *Ann Thorac Surg* 2000;70:2004-7. [[Crossref](#)]
2. Milano CA, Kesler K, Archibald N, Sexton N, Jones RH. Mediastinitis after coronary artery bypass graft surgery. Risk factors and long-term survival. *Circulation* 1995;92:2245-51. [[Crossref](#)]
3. Graf K, Ott E, Vonberg RP, Kuehn C, Haverich A, Chaberny IF. Economic aspects of deep sternal wound infections. *Eur J Cardiothorac Surg* 2010;37:893-6. [[Crossref](#)]
4. Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment: clinical experience. *Ann Plast Surg* 1997;38:563-76. [[Crossref](#)]
5. Lazar HL, Salm VT, Engelman R, Orgill D, Gordon S. Prevention and management of sternal wound infections. *J Thorac Cardiovasc Surg* 2016;152:962-72. [[Crossref](#)]
6. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control* 2008;36:309-32. [[Crossref](#)]
7. Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG. CDC definitions of nosocomial surgical site infections, 1992: a modification of CDC definitions of surgical wound infections. *Infect Control Hosp Epidemiol* 1992;13:606-8. [[Crossref](#)]

8. Sachithanandan A, Nanjiah P, Nightingale P, Wilson IC, Graham TR, Rooney SJ, et al. Deep sternal wound infection requiring revision surgery: impact on mid-term survival following cardiac surgery. *Eur J Cardiothorac Surg* 2008;33:673-8. [[Crossref](#)]
9. Schimmer C, Sommer SP, Bensch M, Bohrer T, Aleksic I, Leyh R. Sternal closure techniques and postoperative sternal wound complications in elderly patients. *Eur J Cardiothorac Surg* 2008;34:132-8. [[Crossref](#)]
10. Song DH, Lohman RF, Renucci JD, Jeevanandam V, Raman J. Primary sternal plating in high-risk patients prevents mediastinitis. *Eur J Cardiothorac Surg* 2004;26:367-72. [[Crossref](#)]
11. Reiss N, Schuett U, Kemper M, Bairaktaris A, Koerfer R. New method for sternal closure after vacuum-assisted therapy in deep sternal infections after cardiac surgery. *Ann Thorac Surg* 2007;83:2246-7. [[Crossref](#)]
12. Durgun M, Durgun SO, Ozakpınar HR, Eryılmaz AT, Oktem HF, Inozu E, et al. Approach to of infected sternotomy wounds in the management of mediastinitis. *Turk Gogus Kalp Dama* 2012;20:820-5. [[Crossref](#)]
13. Pan T, Li K, Fan FD, Gao YS, Wang DJ. Vacuum-assisted closure vs. bilateral pectoralis major muscle flaps for deep sternal wounds infection. *J Thorac Dis* 2020;12:866-75. [[Crossref](#)]
14. Pascal MD, Markou T, Ingemansson R, Rotering H, Hartman JM, Valen RV, et al. Use of incisional negative pressure wound therapy on closed median sternal incisions after cardiothoracic surgery: clinical evidence and consensus recommendations. *Med Sci Monit* 2014;20:1814-25. [[Crossref](#)]
15. Colli A, Camara ML. First experience with a new negative pressure incision management system on surgical incisions after cardiac surgery in high risk patients. *J Cardiothorac Surg* 2011;6:160. [[Crossref](#)]
16. Fleck TM, Fleck M, Moidl R, Czerny M, Koller R, Giovanoli P, et al. The vacuum-assisted closure system for the treatment of deep sternal wound infections after cardiac surgery. *Ann Thorac Surg* 2002;74:1596-600. [[Crossref](#)]
17. Morykwas MJ, Argenta LC, Shelton-Brown EI, McGuirt W. Vacuum assisted closure: a new method for wound control and treatment: animal studies and basic foundation. *Ann Plast Surg* 1997;38:553-62. [[Crossref](#)]
18. Deniz H, Gokaslan G, Arslanoglu Y, Ozcaliskan O, Guzel G, Yasim A. Treatment outcomes of postoperative mediastinitis in cardiac surgery; negative pressure wound therapy versus conventional treatment. *J Cardiothorac Surg* 2012;7:67-74. [[Crossref](#)]
19. Fuchs U, Zittermann A, Stuetgen B, Groening A, Minami K, Koerfer R. Clinical outcome of patients with deep sternal wound infection managed by vacuum-assisted closure compared to conventional therapy with open packing: a retrospective analysis. *Ann Thorac Surg* 2005;79:516-21. [[Crossref](#)]
20. Raja SG, Berg GA. Should vacuum-assisted closure therapy be routinely used for management of deep sternal wound infection after cardiac surgery. *Interact Cardiovasc Thorac Surg* 2007;6:523-6. [[Crossref](#)]
21. Martino AD, Del Re F, Falcette G, Morganti R, Ravenni G, Bortolotti U. Sternal wound complications: results of routine use of negative pressure wound therapy. *Braz J Cardiovasc Surg* 2020;35:50-7. [[Crossref](#)]
22. Joseph L, Jeanmonod RK. Delayed presentation of deep sternal wound infection. *West J Emerg Med* 2014;15:134-6. [[Crossref](#)]
23. Loop FD, Lytle BW, Cosgrove DM, Mahfood S, McHenry MC, Goormastic M, et al. Sternal wound complications after isolated coronary artery bypass grafting: early and late mortality, morbidity, and cost of care. *Ann Thorac Surg* 1990;49:179-86. [[Crossref](#)]