Annals of Clinical and Analytical Medicine
Original Research

Vacuum-assisted closure (VAC) treatment in thoracic surgery infections: A single-center experience

VAC treatment in thorasıc surgery infections

Sibel Doğan Kaya, Yeşim Uygun Kızmaz
Department of Infectious Diseases and Clinical Microbiology, University of Health Sciences, Kartal Koşuyolu Research and Training Hospital, Istanbul, Turkey

Abstract
Aim: This study was designed to evaluate the infection rates, infectious agents, comorbidity, death, length of hospital stay and antibiotic treatment of patients who were treated with vacuum- assisted closure treatment (VAC) with conventional treatment methods in deep sternal wound infections developed after open heart surgery.
Material and Methods: Fifty-nine patients who underwent VAC treatment with the diagnosis of deep sternal wound infection after open heart surgery in a single center between November 1, 2012 and June 1, 2020 were included in the study. Patient data were analyzed retrospectively.
Results: Twenty-four women (40%) and 35 men (60%) were included in the study. The mean age of the patients was 60.37 years (min 17 years -max 79 years) and the mean BMI was 28.1 (min 21 -max 35). Comorbidities were as follows: 20 patients had diabetes mellitus (DM) (34%), 7 had the chronic obstructive pulmonary disease (COPD) (12%), and 4 had chronic kidney failure (CRF) (7%). Distribution of operating procedures was as follows: 40 (68%) patients underwent coronary artery bypass graft (CABG) surgery, 4 (6.8%) patients underwent heart valve replacement, 4 (6.8%) patients underwent CABG+valve placement, 6 (10%) patients underwent ascending aortic surgery and artificial graft was applied to 5 (8,4%) patients. Left Internal Mammary Artery (LIMA) was used in 7 (11.8%) patients, and Right Internal Mammary Artery (RIMA) was used in 1 (1.6%) patient. Twenty-one (35.6%) patients were reoperated. Antibiotic treatment was started in 49 (83%) patients. The mean time of antibiotic use was 23 days (min 23- max 85 days), the mean hospitalization time was 59.3 days (min 2 -max 259 days), the mean hospitalization time in the cardiovascular surgery intensive care unit (CVSICU) was 30.9 days (min 4 - max 252 days). The patients' European System for Cardiac Operative Risk Evaluation (EuroScore) rates were as follows: 65% low, 39% intermediate, and 26% high risk, respectively. Mortality was found in 13 (22%) of the patients.
Laboratory findings were as follows: WBC: 9450 (x103/μL) (min 4000-max 19000), CRP 8.3mg/dL (0.3-31), procalcitonin pg/mL0.6 (0.01-8.3). There was growth in the deep wound culture in 33 patients (56%). Single microorganism was detected in 22 (66.6%) of them and mixed growth was found in 11 (33.3%) patients. Distribution of agents was respectively Methicillin-Resistant Staphylococcus aureus 7 (27%), Pseudomonas aeruginosa 6 (22%), Klebsiella pneumoniae 2 (9%), Acinetobacter baumanii 2 (9%), Candida albicans 2 (9%), Escherichia coli 1 (% 4.5), Serratia marcescens 1 (4.5%), Methicillin Sensitive Staphylococcus aureus 1 (4.5%).
Discussion: In the treatment of deep sternal wound infections after open heart surgery, vacuum-assisted closure is a safe and effective method that accelerates wound healing, shortens hospital stay, and provides earlier eradication of microorganisms in the wound site.

Keywords
Cardiac Surgery, Sternal Infection, Vacuum-Assisted Closure Therapy

DOI: 10.4328/ACAM.21391 Received: 2022-09-15 Accepted: 2022-12-02 Published Online: 2023-02-27 Printed: 2023-03-01 Ann Clin Anal Med 2023;14(3):194-198
Corresponding Author: Sibel Doğan Kaya, Department of Infectious Diseases and Clinical Microbiology, University of Health Sciences, Kartal Koşuyolu Research and Training Hospital, Istanbul, Turkey.
E-mail: sibeldogankaya@yahoo.com P: +90 505 677 00 69
Corresponding Author ORCID ID: https://orcid.org/0000-0002-3253-7334
This study was approved by the Non-Interventional Clinical Research Ethics Committee of Kosuyolu Yuksek Ihtisas Training and Research Hospital (Date: 2019-01-17, No: 2019.1/3-151)

Introduction

The first attempts at heart surgery were made by Clarence Dennis in 1951. Cardiac surgery experienced a revolution and began to evolve rapidly with the introduction of cardiopulmonary bypass (CPB). Over the years, side effects caused by extracorporeal circulation have also started to be seen and many studies have been carried out to minimize these side effects. Open heart surgery is a surgical procedure performed with cardiopulmonary bypass and takes a longer time than standard surgical procedures. Over the past 20 years, in our country, the number of heart surgery centers, as well as local or systemic infections after surgery, has increased, which negatively affects the length of hospital stay, the cost and quality of life, and increases mortality. Heart surgery under CPB activates the immune system. The cytokine is released with the activation of the immune system, causing the provocation of the systemic inflammatory response by activating the coagulation, complement system and leukocytes. This warning also leads to organ damage and postoperative morbidity [1,2].

In the patients, the sternal area supply may be impaired, especially due to the removal of the LIMA in CABG and the removal of the RIMA in some patients. After open heart surgery, patients often stay in the intensive care unit for at least one day. Sternal wound infection (SWI) is an important complication associated with morbidity and mortality that may develop after open heart surgery. The spectrum of SWI ranges from superficial, deep, mediastinitis followed by involvement of the sternum (tissues other than sternal dehiscence and organ incision myelitis) [3].

There are classical methods of treatment such as debridement, revision with fasciocutaneous flap or muscle flap. As a result of the study, it was determined that VAC treatment was much more successful and less expensive compared to conventional methods in terms of complications such as mortality, sepsis, mediastinitis, need for surgical revision, and delayed infection [4].

Vacuum-assisted closure (VAC) was introduced for the treatment of sternal wound infections in 1997 and has been increasingly used since then [5]. VAC is a wound healing method that uses a dressing system that continuously or intermittently applies negative pressure to the wound surface. It can be used in the treatment of both acute and chronic wounds and complex wounds such as burns [6].

The purpose of VAC therapy is to apply intermittent or continuous controlled negative pressure to the wound area, to distribute the pressure evenly over the wound area and to ensure that the fluid is continuously absorbed from the wound. In this way, edema in the intercellular space decreases, tissue blood supply and granulation tissue formation increase [7]. The most commonly used negative pressure level in adults is ~125 mm Hg [8]. Granulation tissue formation occurs through the acceleration of capillary blood flow, angiogenesis, and increased endothelial cell proliferation. Again, the mechanical stimulation obtained by VAC therapy is converted into a biological effect in cells through IL-8 and vascular endothelial growth factors. Thus, neovascularization increases in the applied area and wound closure is accelerated.

Treatment traditionally consists of early wound debridement, mediastinal irrigation with antiseptic antibiotic solutions, and a combination of surgery and IV antibiotic therapy reserved for severe cases [9,10].

Established treatment in most centers includes surgical debridement, drainage, irrigation, and reconstruction with an omental or pectoral muscle flap and delayed closure [11,12].

Material and Methods

Between November 1, 2012 and June 1, 2020, 59 patients who underwent VAC treatment with the diagnosis of deep sternal wound infection after open heart surgery in Kosuyolu Yuksek Ihtisas Training and Research Hospital Cardiovascular Surgery Clinics were included in the study. Patient data were obtained retrospectively from the daily surveillance visits of the infection team and from the hospital information management system. This study was conducted in accordance with the Declaration of Helsinki and was approved by the Kosuyolu Yuksek Ihtisas Training and Research Hospital Non-Interventional Clinical Research Ethics Committee (Date: 17.01.2019, Number: 2019.1/3-151).

The Centers for Disease Control and Prevention [(CDC), Surgical Site Infection Event Jan 2022] criteria used in the diagnosis of deep incisional surgical site infections are as follows:

- The date of the event occurs within 30 or 90 days after the National Healthcare Safety Network operative procedure
- Deep soft tissues of the incision are involved (for example, fascial and muscular layers)
- The patient has at least one of the following:

a. purulent discharge from a deep incision.

b. a deep incision that spontaneously opens, or is deliberately opened or aspirated by a surgeon, physician* or an authorized physician

- microorganism(s) identified from the deep soft tissues of the incision by culture or non-culture microbiological testing that is carried out for clinical diagnosis or treatment (e.g. non-active culture observation/testing (ASC/AST)), or cultured or non-cultured microbiological testing method is not carried out. A negative culture or non-culture test from the deep soft tissues of the incision does not meet this criterion.

The patient has at least one of the following signs or symptoms:

- fever (>38°C);
- localized pain or tenderness.

c. an abscess or other signs of infection associated with a deep incision are found on general anatomical or histopathological examination or on imaging studies.

There are two specific types of deep postoperative SSIs:

1. Deep Incisional Primary (DIP) - deep incisional SSI, which is detected in the primary incision in a patient who underwent surgery with one or more incisions.
2. Deep Secondary Incision (DIS) - A deep SSI incision that is defined in a secondary incision in a patient undergoing surgery with more than one incision.

Microbiological evaluation

Various clinical specimens (swabs or deep tissue obtained from trucut biopsy) were sent to the microbiology laboratory. The samples were cultivated in a solid medium using the quantitative method and incubated at 37°C for 24-48 hours in a culture incubator (NUVE EN400, Turkey). Identification and antibiotic susceptibility tests were performed with VITEK® 2 Compact (bioMérieux, France) according to the criteria of the European Committee for Antimicrobial Susceptibility Testing (EUCAST).

White blood count (WBC), C-reactive protein (CRP), procalcitonin and wound cultures were taken. Resistance status and antibiotic susceptibility of microorganisms isolated from wound culture were examined. In the study, vacuum-assisted wound closure VAC system (V.A.C. Therapy; KCI, an Acelity Company, San Antonio, TX, USA) was used. Negative pressure ranging from - 75 to -125 mmHg was applied to the wound continuously for the first two days and intermittently in the following days. Dressing changes were made every 48 hours.

All patients were treated with empirical broad-spectrum antibiotics after receiving infectious diseases consultation. Antibiotherapy was applied specifically to the pathogen according to the results of microbiological wound culture. No patient was started on prophylactic antifungal therapy. Antifungal therapy was added to the treatment of the patients because fungal infections were detected in the culture results of the two patients.

Empirical IV antibiotic therapy, which is usually a combination of piperacillin-tazobactam and vancomycin, is usually initiated when clinical suspicion of DSWI arises before the surgical procedure. The duration of treatment for mediastinitis infection is 4-6 weeks, and at least 2 weeks of IV antibiotic therapy is common practice.

The primary aim of this study is to evaluate infections, underlying diseases, the time of intensive care and hospital stay, microorganisms detected, antibiotics used and the duration of treatment with antibiotics in patients who developed VAC after open heart surgery.

Statistical analysis

Data were analyzed using SPSS for Windows 25.0 program. Mean±standard deviation and median (min.-max.) were used as descriptive statistics. In the evaluation of data, numbers and percentages were used as descriptive statistics, and the Chi-square test was used in the analysis of categorical data. Categorical values were evaluated with Student's T-test. Statistical significance was evaluated at the $p < 0.05$ level.

Ethical Approval

Ethics Committee approval for the study was obtained.

Results

Twenty-four (40%) of the patients were female and 35 (60%) were male. The mean age of the patients was 60.37 (min17 -max 79), the mean BSI was 1.91±0.17. Comorbidity rates were as follows: diabetes mellitus (DM) in 20 (34%) patients, HT in 18 (30.5%) patients, chronic obstructive pulmonary disease (COPD) in 7 (12%) patients, and chronic renal failure (CRF) in 4 (7%) patients. Distribution of operating procedures was as follows: 40 (68%) coronary artery bypass grafts (CABG), 4 (6.8%) heart valve replacements, 4 (6.8%) CABG+valve placements, 6 (10%) ascending aortic surgeries and artificial graft was applied to 5 (8,4%) patients (Table 1). Twenty-one (35.6%) patients were reoperated. LIMA was applied to 7 (11.8%) and RIMA to 1 (1.6%); 13 patients (22%) died. Antibiotic treatment was started in 49 (83%) patients. The mean duration of antibiotic treatment was 23 days (min 23-max 85), the mean hospitalization time was 59.3 days (min 2 - max 259), the mean hospital stay in cardiovascular surgery intensive care unit was 30.9 days (min 4- max 252). According to the EuroSCORE (European System for Cardiac Operative Risk Evaluation) evaluation, 65% were low risk, 39% were medium, 26% were high risk. The mortality rate was 22% (13 patients). VAC changes were made at 2-day intervals and it was determined that changes were made every 56 days (min 4-max 206) on average. Laboratory findings were

Table 1. Surgical Procedures Applied to the Patients

Operation type	Number (n=59)
CABG	40 (%68)
Ascending Aorta Surgery	6 (%10)
Artificial Graft	5 (%8,4)
Valve Surgery	4 (%6,8)
CABG+Valve Surgery	4 (%6,8)

CABG: Coronary artery bypass graft

Table 2. Microorganisms Growing in Wound Culture

Microorganism	Number (n=22)
MRSA	7 (%27)
Pseudomonas aeruginosa	6 (%22)
Klebsiella pneumoniae	2 (%9)
Acinetobacter baumannii	2 (%9)
Candida albicans	2 (%9)
MSSA	1 (%4,5)
Serratia marcescens	1 (%4,5)
Escherichia coli	1 (%4,5)

MRSA: Methicillin resistant S.aureus, MSSA: Methicillin sensitive S.aureus

Table 3. Operative parameters

Preoperative parameters			P-value
Age (years)	Mean± SD	60,7 ± 8,6	0.072
BSA (kg/m2)	Mean± SD	1,91 ± 0.17	0.006
Gender (F/M)	n (%)	24/60	0.004
DM	n (%)	20 (%34)	0.008
Hypertension	n (%)	18 (%30.5)	0.009
Chronic kidney failure	n (%)	4 (%7)	0.001
COPD	n (%)	7 (%12)	0.003
Preoperative Laboratory parameters			
WBC (x109/l)	Mean± SD	9,45 (8,79-10,27)	0.013
CRP (mg/l)	Median (min.-max.)	8,30 (0.3-31)	0.018
Procalcitonin (mg/l)	Median (min.-max.)	0,6 (0,01-8,31)	0.003
Total length of hospitalization stay (day)	Median (min.-max.)	59,3 (48,5-72,6)	0.041
Length of stay in the intensive care unit (day)	Median (min.-max.)	30,9 (20,3-44,1)	0.435
VAC time (day)	Median (min.-max.)	4-206	0.036
Antibiotic use days (day)	Median (min.-max.)	23 (18-28)	0.313
Reoperation	n (%)	21 (%35,6)	0.325
Mortality	n (%)	13 (%22)	0.212
LIMA	n (%)	7 (%11,8)	0.003
RIMA	n (%)	1 (%1,6)	0.001

as follows: mean Wbc: 9450 (x103 /µL) (min 4000-max 19000), mean CRP 8.3 mg/dL (min 0.3-max 31) mean procalcitonin (pg/mL) 0.6 (min 0.01-max 8.3). Growth was observed in deep wound cultures of 33 patients (56%), 11 of which were mixed growths.

Seven Methicillin Resistant S.aureus (27%), 6 Pseudomonas aeruginosa (22%), 2 Klebsiella pneumoniae (9%), 2 Acinetobacter baumannii (9%), 2 Candida albicans (9%),1 Escherichia coli (4.5%), 1 Serratia marcescens (4.5%), 1 Methicillin Sensitive S.aureus (4.5%) were seen (Table 2).

Cefazolin sodium 1 g was given as preoperative surgical prophylaxis. Patients were treated empirically until culture results were obtained, and then according to the culture results in accordance with the recommendations of infectious disease specialists (Table 3).

Discussion

There is a wide range of sternal infections, from serious infections such as life-threatening mediastinitis to superficial simple infections. Superficial sternal infections are more common, while deep sternal infections (mediastinitis, osteomyelitis) are less common [13]. All patients included in our study who have received VAC support were followed up with the diagnosis of deep incisional surgical site infection.

Although deep sternal infections are rare, they are serious complications that can result in death due to late and incorrect treatment, and have been reported to prolong the hospital stay, increase the cost of treatment, and cause high morbidity such as 7-80% [14]. Morykwas et al. showed that the application of an average of -125 mmHg pressure increased the blood flow in the wound area 4 times, the application with an interval of 2 minutes after an average of 5-7 minutes of application and the highest level of local blood flow accelerated wound healing [15,16].

In our study, the mean duration of VAC stay was 56 days (min 4-max 206) and VAC changes were made at 2-day intervals. Risk factors for sternal infections are age, gender, obesity, diabetes mellitus, chronic obstructive pulmonary disease, peripheral arterial disease, use of bilateral internal mammary arteries, long-term ventilation support, and reoperation for bleeding [18]. Twenty patients had a history of diabetes, 59 patients had a history of cardiovascular disease, and 4 patients had a history of renal failure. Four patients had a history of COPD. When the effects of all these risk factors on mortality were examined, no statistically significant difference was found ($p>0.005$).

The most important factor in the pathogenesis of SWI is intraoperative wound contamination and its interaction with host factors such as local blood supply, nutrition and immunological status. Almost any microorganism can cause mediastinitis, but the most frequently isolated microorganisms are Staphylococcus aureus, followed by Gram-negative bacilli, coagulase-negative Staphylococci (CNS), and Streptococci [19]. In another study, the etiologic pathogens were found to be Staphylococcus aureus, coagulase-negative Staphylococci (CoNS) and Gram-negative bacteria [20]. In our study, similar to the previous study, the first agent was MRSA, but the most common reproductive agent was Pseudomonas aeruginosa (22%). The prevalence of open heart surgery has also brought the risk of infection. Steingrimsson et al. reported a patient in the VAC group with a resistant infection, Pseudomonas aeruginosa [21].

In our study, a growth in deep tissue culture was seen in 33 patients (56%), a growth was seen in 11 of them. In 7 patients, Methicillin-Resistant S.aureus (27%), in 6 Pseudomonas aeruginosa (22%), in 2 Klebsiella pneumoniae (9%), in 2 Acinetobacter baumannii (9%), in 2 Candida albicans (9%)), in 1 E.coli (4.5%)), in 1 Serratia marcescens (4.5%), in 1 Methicillin-Sensitive S.aureus (4.5%) were detected.

In the study by Braakenburg et al., 9 patients in the VAC group and 15 patients in the other conventional treatment group were treated with antibiotics. Patients in the VAC group were given antibiotics for an average of 16 days, while those in the other group were given antibiotics for 20 days [22].

Although antibiotic selection, optimal dose, duration, and timing are controversial, preoperative antibiotic prophylaxis is one of the most important tools in the treatment [23].

In our study, antibiotic treatment was started in 49 (83%) patients. The mean duration of antibiotic use was 23 days (min 23- max 85).

In a retrospective cohort study by Steingrimsson et al., conventional and VAC treatment methods applied to 43 patients with deep sternal wound infection were compared in terms of length of hospital stay, mortality, 1-year mortality, early reinfection, and chronic sternal infection. They reported that there was no difference between the two groups. However, they emphasized that 35% of the patients treated with conventional methods developed early reinfection [20].

The incidence of mediastinitis has been reported to be between 0.6% and 5% in different series, and mortality rates varied between 10% and 45% despite adequate medical and surgical treatment [23].

The study by Vos et al. in 2012 included 113 patients who developed mediastinitis after poststernotomy. In this retrospective study, they applied VAC therapy to 89 patients and open dressing therapy to 24 patients. They found hospital mortality as 12.4% in the VAC group and 41.7% in the open-dressing group [24].

They found that long-term antibiotic therapy for SWI was associated with mortality and morbidity, with wound incision and drainage alone having a failure rate of 39% and a mortality rate of 23%.

Conclusion

In the treatment of deep sternal wound infections after open heart surgery, vacuum-assisted closure is a safe and effective method that accelerates wound healing, shortens hospital stay, and provides earlier eradication of microorganisms in the wound.

Acknowledgment

Doc. Dr. Deniz Çevirme for providing me valuable information in preparation of this article.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

Funding: *None*

Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

References

1. Laffey JG, Boylan JF, Cheng DC. The systemic inflammatory response to cardiac surgery: implications for the anesthesiologist. Anesthesiology. 2002;97(1):215-52.
2. Curi-Curi PJ, del Villar MRS, Gómez-García L, Vergara BG, Calderón-Colmenero J, Ramírez-Marroquín S, et al. Impacto intraoperatorio de la ultrafiltración modificada en pacientes pediátricos sometidos a cirugía cardíaca con circulación extracorpórea. (Perioperative combined ultrafiltration in pediatric cardiac surgery. Prelimınary Results) Cirugía Cardiovascular. 2016;23(4):179-86.
3. Solomkin JS, Mazuski J, Blanchard JC, Itani KMF, Ricks P, Patchen Dellinger E, et al. Guideline for prevention of surgical site infection, 2017. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. Surgical Infections Surgery Infect (Larchmt). 2017; 18(4):385-93.
4. Kubat E, Abacı M, Ünal CS. Plasty as an alternative choice for the treatment of recurrent local sternal wound infections. Gen Thorac Cardiovasc Surg. 2019;67(6):518–23.
5. 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.
6. Gestring M, Sanfey H. Negative pressure wound therapy. UpToDate. In: Collins KA, Sanfey H, editors. Philadelphia, PA: Wolters Kluwer Health; 2014.
7. Huang C, Leavitt T, Bayer LR, Orgill DP. Effect of negative pressure wound therapy on wound healing. Curr Probl Surg. 2014; 51(7):301–31.
8. Mokhtari A, Petzina R, Gustafsson L, Johan Sjögren, Malin Malmsjö, Richard Ingemansson. Sterna stability at different negative pressures during vacuum-assisted closure therapy. Ann Thorac Surg. 2006; 82:1063–67.
9. De Feo M, Renzulli A, Ismeno G, R Gregorio, A Della Corte, R Utili, et al. Variables predicting adverse outcome in patients with deep sternal wound infection. Ann Thorac Surg. 2001; 71(1):324–31.
10. Jones G, Jurkiewicz MJ, Bostwick J, Wood R, Bried JT, Culbertson J, et al. Management of the infected median sternotomy wound with muscleflaps. The Emory 20-year experience. Ann Surg.1997; 225(6): 766-76.
11. Ban KA, Minei JP, Laronga C, Harbrecht BG, Jensen EH, Fry E, et al. American College of Surgeons and Surgical Infection Society: Surgical Site Infection Guidelines, 2016 Update. J Am Coll Surg. 2017; 224(1):59–74.
12. Bluebelle Study Group. Validation of Bluebelle wound healing questionnaire for assessment of surgical-site infection in closed primary wounds after hospital discharge. Br J Surg. 2019;106(3):226–35.
13. El Oakley RM, Wright JE. Post operative mediastinitis: classification and management. Ann Thorac Surg.1996; 61(3):1030-6.
14. Shi YD, Qi FZ, Zhang Y. Treatment of sternal wound infections after open-heart surgery. Asian J Surg. 2014; 37(1):24-9.
15. Milano CA, Kesler K, Archibald N, Sexton DJ, Jones RH. Mediastinitis after coronary artery bypass graft surgery. Circulation.1995; 92(8): 2245-51.
16. Saadi A, Perentes JY, Gonzalez M, Tempia AC, Wang Y, Demartines N, et al. Vacuum-assisted closure device: a useful tool in the management of severe intrathoracic infections. Ann Thorac Surg. 2011; 91(5):1582–9.
17. Abu-Omar Y, Kocher GJ, Bosco P, Barbero C, Waller D, Gudbjartsson T, et al. European Association for Cardio-Thoracic Surgery expert consensus statement on the prevention and management of mediastinitis. Eur J Cardiothorac Surg. 2017; 51(1):10–29.
18. Trouillet JL, Vuagnat A, Combes A, Bors V, Chastre J, Gandjbakhch I, et al. Acute post sternotomy mediastinitis managed with debride mentand closed-drainage aspiration: Factors associated with death in the intensive care unit. J Thorac Cardiovasc Surg. 2005; 129(3):518–24.
19. Sommerstein R, Kohler P, Wilhelm MJ, Kuster SP, Sax H. Factors associated with methicillin-resistant coagulase- negative staphylococci as causing organisms in deep sternal wound infections after cardiac surgery. New Microbes New Infect. 2015; 6:15-21.
20. Steingrimsson S, Gottfredsson M, Gudmundsdottir I, Sjögren J, Gudbjartsson T. Negative-pressure wound therapy for deep sternal wound infections reduces the rate of surgical interventions for early re-infections. Interact Cardiovasc Thorac Surg. 2012; 15(3):406.
21. Braakenburg A, Obdeijn MC, Feitz R, vanRooij IA, van Griethuysen AJ, Klinkenbijl JH. The clinical efficacy and cost effectiveness of the vacuum-assisted closure technique in the management of acute and chronic wounds: a randomized controlled trial. Plast Reconstr Surg. 2006; 118(2):390-7.
22. Padma KT. Rajathilagam. A drug utilization study of antibiotics in the cardiothoracic surgery department of a tertiary care hospital. Research Journal of Pharmaceutical, Biological and Chemical
Sciences. 2015; 6(5):119-12
23. Ridderstolpe L, Gill H, Granfeldt H, Ahlfeldt H, Rutberg H. Superficial and deep sternal wound complications: incidence, risk factors and mortality. Eur J Cardiothorac Surg. 2001; 20(6):1168- 75.
24. Vos RJ, Yilmaz A, Sonker U, Kelder JC, Kloppenburg GTL. Vacuum-assisted closure of post-sternotomy mediastinitis as compared to open packing. Interact Cardiovasc Thorac Surg. 2012; 14(1):17-21.

How to cite this article:
Sibel Doğan Kaya, Yeşim Uygun Kızmaz. *Vacuum-assisted closure (VAC) treatment in thoracic surgery infections: A single-center experience. Ann Clin Anal Med 2023;14(3):194-198*

This study was approved by the Non-Interventional Clinical Research Ethics Committee of Kosuyolu Yuksek Ihtisas Training and Research Hospital (Date: 2019-01-17, No: 2019.1/3-151)