Heart Surgery Forum 2024; 27(10): E1193–E1199 https://journal.hsforum.com/
doi: 10.59958/hsf.7949

Article

The Use of Subcutaneous Hemovac Drain after Open Heart Surgery with Sternotomy

Burak Bozkurt[1,*], Anil Karaagac[1], Yusuf Kagan Pocan[2], Mukan Kagan Kus[1], Mehmet Erdem Memetoglu[1], Hakki Aydogan[1], Mehmet Kaplan[1]

[1]Department of Cardiovascular Surgery, Dr. Siyami Ersek Research and Training Hospital for Thoracic and Cardiovascular Surgery, 34668 Istanbul, Turkey
[2]Department of Cardiovascular Surgery, Iskenderun State Hospital, 31240 Hatay, Turkey
*Correspondence: drburakbozkurtt@gmail.com (Burak Bozkurt)

Submitted: 31 July 2024 Revised: 15 August 2024 Accepted: 14 September 2024 Published: 21 October 2024

Abstract

Background: This study investigated the effect of subcutaneous Hemovac drain use on sternal wound complications in patients with a body mass index (BMI) ≥30 kg/m^2 undergoing open heart surgery through median sternotomy. **Methods**: This retrospective study included a total of 120 patients (74 males, 46 females) with a BMI ≥30 kg/m^2 who underwent open heart surgery through median sternotomy between January 2021 and January 2024. The mean age was 60.36 ± 11.31 years (range, 18–80 y). After median sternotomy, a Hemovac drain was placed subcutaneously in the study group (n = 60) and in controls no Hemovac drain was placed (n = 60). Durations of hospital stay, types of surgery, sternal wound complications, and preoperative, intraoperative, and postoperative data were compared between the two groups. **Results**: The duration of hospital stay ($p = 0.018$; $p < 0.05$), the rate of sternal wound complications ($p = 0.001$; $p < 0.01$), the rate of superficial sternal complications ($p = 0.001$; $p < 0.01$), and the need for antibiotics in superficial infections ($p = 0.001$; $p < 0.01$) were significantly lower in cases with a Hemovac drain compared to those without. **Conclusion**: Subcutaneous placement of a Hemovac drain after open heart surgery is a simple, easily applicable, and effective method that reduces sternal wound complications, and hospital stay in obese patients.

Keywords

Hemovac drain; median sternotomy; sternal wound complications

Introduction

Median sternotomy remains the most common incision technique in cardiac surgery. However, complications related to sternotomy significantly increase both morbidity and mortality.

The incidence of sternal wound infection (SWI) ranges between 0.9% and 20% [1]. The development of SWI is multifactorial. Patient-related risk factors include uncontrolled diabetes, age, obesity (Body Mass Index ≥30 kg/m^2), chronic obstructive pulmonary disease (COPD), hypertension (HT), malnutrition, chronic renal failure. Non-patient-related risk factors include the type of heart surgery, prolonged operation time, bilateral internal thoracic artery use, excessive use of electrocautery under the skin, the necessity for re-sternotomy, and repetitive transfusion of blood and blood products [2].

A Hemovac drain is a medical device designed to evacuate blood and fluid collections from surgical sites, particularly in closed spaces, through the principle of negative pressure. This mechanism not only facilitates efficient drainage but also creates an environment that discourages bacterial growth, thereby reducing the risk of infection. Due to these properties, the Hemovac drain is frequently employed in clinical settings to minimize hematoma formation at the incision site and to alleviate pressure on surrounding tissues caused by the accumulation of blood and fluids. By mitigating these risks, the device plays a crucial role in promoting effective wound healing.

In the context of open-heart surgery, particularly among obese patients (body mass index (BMI) ≥30 kg/m^2) who undergo procedures involving a median sternotomy incision, the risk of sternal wound complications is significantly heightened. These complications can lead to prolonged hospital stays and an increased in-hospital mortality rate. Additionally, sternal infections and sternal dehiscence are serious concerns during post-discharge follow-up in this patient population.

The primary objective of this study is to assess the efficacy of subcutaneous Hemovac drain placement in mitigating the incidence of sternal wound complications among obese patients undergoing open heart surgery. Furthermore, the study hypothesizes that this intervention will markedly decrease the incidence of sternal infections and dehiscence during the post-discharge follow-up period, thereby contributing to improved patient outcomes.

Methods

Study Design and Population

This retrospective study included 120 patients (46 female, 74 male) with a body mass index (BMI) of $\geq$30 kg/m^2 who underwent elective open-heart surgery via median sternotomy between January 2021 and January 2024. The mean age of the cohort was 60.36 $\pm$ 11.31 years (range, 18–80 years). Patients with a history of radiotherapy or chemotherapy, those with immunodeficiency, and those who underwent emergency surgery were excluded. The study received approval from the local ethics committee and was conducted in compliance with the Declaration of Helsinki.

Definitions and Data Collection

Wound complications were classified based on the CDC's updated clinical criteria for sternal wound infections [3], which encompass Superficial Incisional Infection, Deep Incisional Infection, and Organ/Space Infection. Antibiotic use was documented according to clinical indications for suspected or confirmed infections, guided by these CDC criteria and the established postoperative care protocols in cardiac surgery.

Intervention and Comparison Groups

The routine use of Hemovac drains in all patients undergoing heart surgery was initiated on November 15, 2022. In this study, given the higher risk of sternal infection in patients with a BMI $\geq$30 kg/m^2, patients with a BMI $\geq$30 kg/m^2 who did not receive a Hemovac drain prior to November 2022 were retrospectively evaluated.

Surgical Procedure and Data Parameters

All surgeries were performed by the same surgical team. Preoperative, intraoperative, and postoperative data were meticulously recorded for all patients. The recorded data included the type of surgery, duration of hospital stay, duration of intensive care unit (ICU) stay, and types of sternal infections.

Surgical Technique

A routine median sternotomy incision was made in all patients undergoing open heart surgery. After surgical bleeding control at the end of the surgery, the sternum of all patients was united with individual steel sternal wires. Then, a 16 F Single PVC Hemovac drain was placed through an incision made below the sternal incision with a no.11 scalpel blade. The subcutaneous tissue was closed using a continuous technique with 0 polyglactin 910 suture. The skin was closed using 3-0 Polyglycolide-co-lactide, concluding the operations. Then, the Hemovac drain was activated by applying negative pressure (Fig. 1).

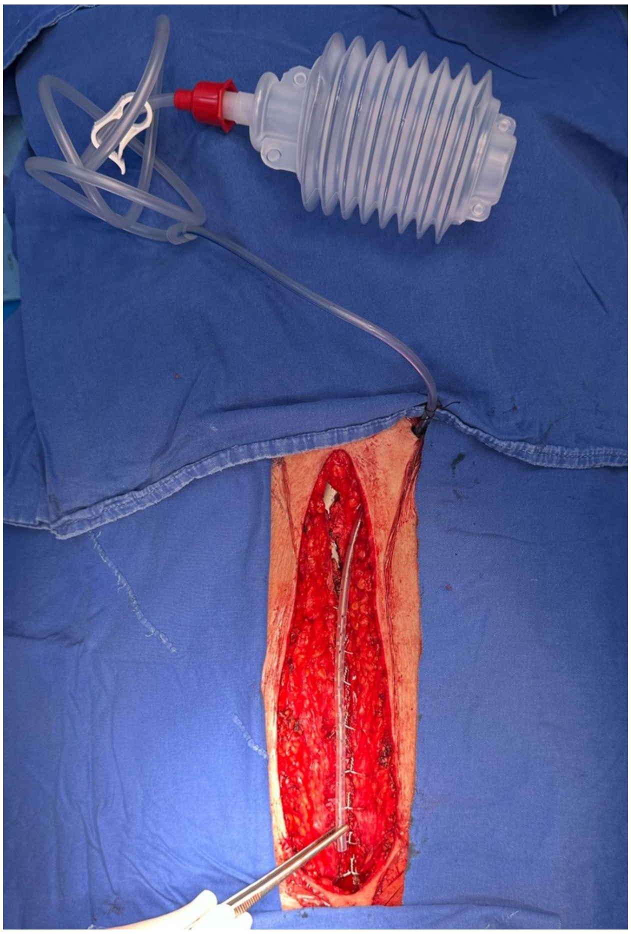

Fig. 1. Appearance of the subcutaneously placed Hemovac drain. After the sternum is closed with steel wires, a Hemovac drain is placed subcutaneously through a skin incision made with an 11-blade scalpel. The drain is then secured with 2-0 Prolene sutures. Once the skin incision is closed, the Hemovac system is activated by applying negative pressure.

Statistical Analysis

A power analysis was conducted using the G*Power software (v3.1.7, Heinrich Heine University Düsseldorf, Düsseldorf, Germany) to determine the sample size. The power of the study is expressed as 1-β (where β is the probability of a Type II error), and it is generally recommended that studies achieve a power of 80%. Based on the study by Salihi and Kiziltan [4], the analysis was performed to assess the differences in sternal wound complication rates between groups. The calculation yielded an effect size of d = 0.638, and it was determined that a minimum of 32 participants per group would be required to achieve 90% power at an α level of 0.05. Considering the potential for attrition

Table 1. Preoperative data.

		Control group (n = 60)	Hemovac group (n = 60)	p
Sex	Female	25 (41.7)	21 (35.0)	^{a}0.453
	Male	35 (58.3)	39 (65.0)	
Age (years)	Mean ± SD	61.08 ± 10.79	59.63 ± 11.86	^{b}0.485
Weight (kg)	Mean ± SD	90.75 ± 12.10	92.13 ± 12.40	^{b}0.537
BMI (kg/m^2)	Mean ± SD	32.44 ± 2.27	32.51 ± 2.55	^{c}0.789
HT	Present	23 (38.3)	19 (31.7)	^{a}0.444
DM	Present	32 (53.3)	32 (53.3)	^{a}1.000
COPD	Present	0 (0.0)	1 (1.7)	^{d}1.000
Chronic renal disease	Present	9 (15.0)	1 (1.7)	^{a}0.008**
Coronary artery disease	Present	53 (88.3)	50 (83.3)	^{a}0.432
Cerebrovascular accident	Present	3 (5.0)	2 (3.3)	^{d}1.000
Preop AF	Present	0 (0.0)	60 (100.0)	^{a}0.001**
LVEF	Mean ± SD	54.08 ± 7.28	54.42 ± 8.39	^{c}0.415
Extracardiac arterial disease	Present	10 (16.7)	7 (11.7)	^{a}0.432

^{a}Pearson's chi-square test, ^{b}Student-t test, ^{c}Mann-Whitney-U test, ^{d}Fisher's exact test, **$p < 0.01$. Unless otherwise stated, data presented as number (percentage).

Abbreviations: AF, atrial fibrillation; BMI, body mass index; DM, diabetes mellitus; HT, hypertension; COPD, chronic obstructive respiratory disease; LVEF, left ventricular ejection fraction.

Table 2. Surgical interventions.

		Control group (n = 60)	Hemovac group (n = 60)	p
Procedures				
AsAo RP	Present	2 (3.3)	3 (5.0)	^{d}1.000
AVR	Present	6 (10.0)	13 (21.7)	^{a}0.080
Root enlargement	Present	2 (3.3)	5 (8.3)	^{d}0.439
MVR	Present	4 (6.7)	7 (11.7)	^{a}0.343
CABGx1	Present	1 (1.7)	3 (5.0)	^{d}0.619
CABGx2	Present	9 (15.0)	11 (18.3)	^{a}0.624
CABGx3	Present	26 (43.3)	24 (40.0)	^{a}0.711
CABGx4	Present	16 (26.7)	9 (15.0)	^{a}0.116
CABGx5	Present	1 (1.7)	2 (3.3)	^{d}1.000
Aortic root enlargement	Present	0 (0.0)	1 (1.7)	^{d}1.000
TDV	Present	1 (1.7)	1 (1.7)	^{d}1.000
Bentall	Present	1 (1.7)	3 (5.0)	^{d}0.619
PFO closure	Present	0 (0.0)	1 (1.7)	^{d}1.000
CEA	Present	1 (1.7)	0 (0.0)	^{d}1.000
Left atrial myxoma	Present	0 (0.0)	1 (1.7)	^{d}1.000

^{a}Pearson' s chi-Square test, ^{d}Fisher's exact test, $p < 0.01$. Data presented as number (percentage).

Abbreviations: AsAo Rp, replacement of ascending aorta; AVR, aortic valve replacement; CABG, coronary artery bypass grafting; CEA, carotid endarterectomy; TDV, tricuspid de vega; MVR, mitral valve replacement; PFO, patent foramen ovale.

"CABGx1, 2, 3, 4, 5" refers to the number of coronary arteries that have been bypassed during coronary artery bypass grafting (CABG) surgery. The number following "CABGx" indicates how many vessels were bypassed, with CABGx1 indicating a single vessel bypass, CABGx2 indicating two vessels, and so on up to CABGx5, which indicates that five coronary arteries were bypassed.

during the study, it is advisable to include more participants than the calculated minimum. SPSS Statistics 27.0 software (27.0 IBM New York / United Stated) was used for the analysis of data. Data were expressed in mean (standard deviation), median (range), and frequency (percentage), where appropriate. The Shapiro-Wilk test and Box Plot graphs were used to assess the normality of data distribution. For the comparison of continuous data, student t-test or Mann-Whitney U was used, depending on the distribution of data. For the comparison of qualitative data, Pearson's chi-square

Table 3. Perioperative and postoperative data.

		Control group (n = 60)	Hemovac group (n = 60)	p
Reoperation	Present	10.00 (16.7)	7.00 (11.7)	^{a}0.432
BITA	Present	20.00 (33.3)	9.00 (15.0)	^{a}0.019*
CPB time	Mean ± SD	151.23 ± 49.71	154.87 ± 64.96	^{c}0.799
CC time	Mean ± SD	111.72 ± 34.27	117.08 ± 51.94	^{c}0.904
IABP	Present	0.00 (0.0)	2.00 (3.3)	^{d}0.496
ICU stay (days)	Mean ± SD	2.82 ± 7.22	1.37 ± 1.19	^{c}0.152
Hospital stay (days)	Mean ± SD	16.15 ± 17.97	9.87 ± 6.68	^{c}0.018*
Mortality	Alive	57.00 (95.0)	60.00 (100.0)	^{d}0.244
	Dead	3.00 (5.0)	0.00 (0.0)	
Hemovac removal (day)	Mean ± SD	-	5.67 ± 1.68	-
Hemovac drainage (cc)	Mean ± SD	-	169.50 ± 84.28	-
LCOS		2.00 (3.3)	2.00 (3.3)	^{d}1.000
Post-op renal failure		2.00 (3.3)	2.00 (3.3)	^{d}1.000
Inotropic support >24 hours		6.00 (10.0)	5.00 (8.3)	^{a}0.752
Re-hospitalization		7.00 (11.7)	8.00 (13.3)	^{a}0.783

^{a}Pearson's chi-Square test, ^{c}Mann-Whitney-U test, ^{d}Fisher's exact test, *$p < 0.05$. Unless otherwise stated, data presented as number (percentage).

Abbreviations: BITA, bilateral internal thoracic artery; CC time, cross-clamp time; CPB time, cardiopulmonary bypass time; IABP, intra-aortic balloon pump; ICU, intensive care unit; LCOS, low cardiac output syndrome.

Table 4. Sternal infections.

		Control group (n = 60)	Hemovac group (n = 60)	p
Sternal wound complication	Present	23 (38.3)	7 (11.7)	^{a}0.001**
Superficial sternal complication	Present	18 (30.0)	4 (6.7)	^{a}0.001**
No treatment	Present	0 (0.0)	2 (3.3)	^{d}0.496
Antibiotic treatment	Present	20 (33.3)	2 (3.3)	^{a}0.001**
Deep sternal complication	Present	5 (8.3)	1 (1.7)	^{d}0.207
Antibiotic treatment	Present	5 (8.3)	1 (1.7)	^{d}0.207
Surgical treatment	Present	5 (8.3)	1 (1.7)	^{d}0.207
VAC treatment	Present	1 (1.7)	0 (0.0)	^{d}1.000

^{a}Pearson's chi-square test, ^{d}Fisher's exact test, **$p < 0.01$. Data presented as number (percentage).

Abbreviation: VAC, vacuum assisted closure.

test or Fisher's exact test was used. Statistical significance was evaluated using p values ($p < 0.05$) and 95% confidence intervals.

Results

The demographic data and risk factors of the patients are shown in Table 1. Subgroup analyses were conducted to assess the effect of the Hemovac drain across different patient demographics, including age groups, sex, and the presence of comorbid conditions like diabetes and hypertension. No statistically significant difference was found between the groups in terms of gender, age, weight, body mass index, and frequencies of hypertension, diabetes, chronic obstructive pulmonary disease, and coronary artery disease ($p > 0.05$). The preoperative chronic kidney disease rate (creatinine >1.2 mg/dL) was significantly lower in the Hemovac drain group (p = 0.008; $p < 0.01$). The preoperative atrial fibrillation (AF) rate in the Hemovac drain group was significantly higher when compared to controls (p = 0.001; $p < 0.01$). However, the groups were similar in terms of left ventricular ejection fraction (LVEF), extracardiac arteriopathy, and surgical procedures ($p > 0.05$). Surgical procedures performed are listed in Table 2.

Table 3 shows perioperative and postoperative data. The cardiopulmonary bypass time (CPB time), cross-clamp time (CC time), intra-aortic balloon pump (IABP) usage, and intensive care stay duration (ICU stay, days) did not show a statistically significant difference based on the presence of a Hemovac drain ($p > 0.05$). However, duration of hospital stay was significantly shorter in the Hemovac drain group (p = 0.018; $p < 0.05$). No statistically significant difference was found between the groups in terms of mortality, low cardiac output syndrome (LCOS), inotropic support >24 hours, and reoperation due to bleeding ($p > 0.05$).

Postoperative sternal wound complications are shown in Table 4. The logistic regression analysis showed that: Hemovac: OR = 0.20 (95% CI: 0.20–0.53, p = 0.001), Age (years): OR = 0.98 (95% CI: 0.95–1.02, p = 0.410), BMI x: OR = 1.00 (95% CI: 0.85–1.21, p = 0.979).

The use of Hemovac has a statistically significant effect in reducing the risk of sternal wound complications (OR = 0.20, p = 0.001). This indicates that Hemovac drain usage is an important factor in reducing sternal complications.

The variables Age and BMI do not have a significant impact on the risk of complications (p-values are greater than 0.05). The rate of sternal wound complication (SWC) development in cases with a Hemovac drain was significantly lower than those without (p = 0.001; $p < 0.01$). Only seven patients (11.7%) in the Hemovac group developed SWC, while this number was 23 (38.3%) in the group without a Hemovac. The rate of superficial sternal complications in the Hemovac group was significantly lower. Four patients in the Hemovac group developed a superficial infection, while this number was 18 in the control group (p = 0.001; $p < 0.01$). The rate of antibiotic use for superficial infections in cases with a Hemovac drain was significantly lower. Only two patients (3.3%) in the Hemovac group received antibiotics postoperatively, while this number was 20 (33.3%) in the control group (p = 0.001; $p < 0.01$).

Potential confounding variables, such as the presence of diabetes and the use of bilateral internal thoracic artery grafts, were controlled by matching patients on these variables during the analysis. However, residual confounding cannot be entirely excluded, particularly in the retrospective nature of the study.

Discussion

Complications at the sternal wound site increase morbidity and mortality following open heart surgery and elevate healthcare costs [5]. The development of sternal wound site infection is multifactorial, and its causes can be categorized as follows: patient-related causes (diabetes, hypertension, obesity, chronic obstructive pulmonary disease, coronary artery disease, malnutrition, chronic renal failure, and immunodeficiency), operative causes (prolonged operation time, and prolonged cross-clamp time, *etc.*), and postoperative causes (prolonged ICU care, and prolonged mechanical ventilation, *etc.*) [2]. Previous studies identified obesity as an independent risk factor for sternal wound site complications among all reasons [2,6–8]. In obese patients undergoing heart surgery, the closure of the median sternotomy incision holds special importance. There are publications indicating that the use of Jackson Pratt drains in obese patients with a BMI >30 kg/m^2 reduces the development of superficial sternal complications [4]. Although Hemovac drains are used in post-sternotomy mediastinitis, our literature search did not find any publication on their routine use following open heart surgery [9]. Hemovac drains are also used in orthopedic, abdominal, and gynecological surgical interventions to accelerate wound healing and prevent the development of infections.

We initially hypothesized that the use of Hemovac drains in patients with a BMI >30 kg/m^2 undergoing open heart surgery would reduce sternal wound site complication rates, durations of hospitalization, and preventing bacterial colonization, thereby accelerating wound healing. For this purpose, we placed Hemovac drains subcutaneously in 60 patients with a BMI >30 kg/m^2 who underwent open heart surgery through a median sternotomy. Sternal wound complications (SWC) developed in only seven patients (11.7%), while one patient (1.7%) developed a deep sternal complication. The SWC rate in Hemovac group was statistically significantly lower than controls (p = 0.001; $p < 0.01$).

Despite studies indicating that the use of a closed negative pressure drainage system in the surgical field reduces surgical site infection (SSI) [10–13], a randomized controlled trial with patients undergoing abdominal surgery with and without a drainage system use found that the use of a closed negative pressure drain system was not effective in preventing surgical site infections. However, a subgroup analysis showed that surgical site infections were significantly less common in association with drainage use among patients undergoing colorectal malignancy surgery and lower abdominal incisions [14]. A multicenter randomized controlled trial involving 280 obese women concluded that placing a subcutaneous drain after cesarean section was not effective in preventing wound complications [15]. Despite these negative results in different surgeries, in our study, SWC, superficial sternal infections, and antibiotic use due to infection were significantly lower in the Hemovac group ($p < 0.05$).

Sternal wound site infection can lead to the development of deep infection because of the bacterial infection spreading to deep tissues. Patients may exhibit clinical presentations ranging from sternal osteomyelitis and mediastinitis to septicemia. In such cases, hospital stays may be prolonged due to infection. Recent studies have explored the efficacy of various types of drains in cardiac surgery. For example, a study comparing traditional large-bore drains with smaller siliastic drains found none of the three chest tubes was superior to drain postoperative bleeding or considering pain at removal. Local clinical routines and cost aspects should be the guide in choosing drainage system for open cardiac operations [16]. A comparative study examining the use of Jackson Pratt drains found no significant difference in durations of hospital stay between the two groups, whereas in our study, the median duration of hospital stay in the Hemovac group was 7.5 days compared to 11 days in the controls [8]. The duration of hospital stay for cases with Hemovac was statistically significantly lower than for those without (p = 0.018; $p < 0.05$), suggesting that the use of Hemovac drains may reduce hospital stays following open heart surgery.

Limitations

The main limitation of the present study is its retrospective design. Future research should focus on prospective randomized trials to confirm the findings of this study and explore the long-term impact of Hemovac drains on patient outcomes. Additionally, cost-benefit analyses of routine drain use in various patient populations would be valuable. While this study did not conduct a detailed cost analysis, future studies should explore the economic impact of Hemovac drain use, considering both direct costs (e.g., hospitalization, antibiotics) and indirect costs (e.g., readmissions, extended follow-ups). However, these results obtained in the group at highest risk for sternal wound development (BMI >30 kg/m^2) indicate that better and more beneficial outcomes could be achieved through studies with different designs and a larger number of patients.

Conclusion

Findings of the present study suggest that placing subcutaneous Hemovac drain appears effective in reducing wound complications and hospital stay in obese patients, these findings should be confirmed by larger, prospective studies to validate the generalizability of the results.

Availability of Data and Materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions

BB, MK and MKK designed the research study. BB and MKK performed the research. AK and YKP contributed to the analysis and interpretation of the data for the study. MEM and HA analyzed the data. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

The study was approved by the local ethic committee (Ethics Committee of Haydarpasa Numune Hospital, Istanbul, Turkey; date, 03.07.2023; no, 2023/KK/53). All study procedures were conducted in accordance with the Declaration of Helsinki. A written informed consent was obtained from the parents and/or legal guardians of the patients.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest. Mehmet Kaplan serves as editorial board member of this journal. Mehmet Kaplan declares that he was not involved in the processing of this article and has no access to information regarding its processing.

References

[1] Ulicny KS, Jr, Hiratzka LF. The risk factors of median sternotomy infection: a current review. Journal of Cardiac Surgery. 1991; 6: 338–351.

[2] Ridderstolpe L, Gill H, Granfeldt H, Ahlfeldt H, Rutberg H. Superficial and deep sternal wound complications: incidence, risk factors and mortality. European Journal of Cardio-thoracic Surgery: Official Journal of the European Association for Cardio-thoracic Surgery. 2001; 20: 1168–1175.

[3] Berríos-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, *et al*. Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017. JAMA Surgery. 2017; 152: 784–791.

[4] Salihi S, Kızıltan HT. Does using Jackson-Pratt drain affect the incidence of sternal wound complications after open cardiac surgery? Turk Gogus Kalp Damar Cerrahisi Dergisi. 2019; 27: 15–22.

[5] Graf K, Ott E, Vonberg RP, Kuehn C, Haverich A, Chaberny IF. Economic aspects of deep sternal wound infections. European Journal of Cardio-thoracic Surgery: Official Journal of the European Association for Cardio-thoracic Surgery. 2010; 37: 893–896.

[6] Sá MPBDO, Soares EF, Santos CA, Figueiredo OJ, Lima ROA, Escobar RR, *et al*. Risk factors for mediastinitis after coronary artery bypass grafting surgery. Revista Brasileira De Cirurgia Cardiovascular: Orgao Oficial Da Sociedade Brasileira De Cirurgia Cardiovascular. 2011; 26: 27–35.

[7] Molina JE, Lew RSL, Hyland KJ. Postoperative sternal dehiscence in obese patients: incidence and prevention. The Annals of Thoracic Surgery. 2004; 78: 912–912–7; discussion 912–7.

[8] Risnes I, Abdelnoor M, Almdahl SM, Svennevig JL. Mediastinitis after coronary artery bypass grafting risk factors and long-term survival. The Annals of Thoracic Surgery. 2010; 89: 1502–1509.
[9] Rashed A, Frenyo M, Gombocz K, Szabados S, Alotti N. Incisional negative pressure wound therapy in reconstructive surgery of poststernotomy mediastinitis. International Wound Journal. 2017; 14: 180–183.
[10] Krishnamoorthy B, Al-Fagih OS, Madi MI, Najam O, Waterworth PD, Fildes JE, *et al*. Closed suction drainage improves clinical outcome in patients undergoing endoscopic vein harvesting for coronary artery bypass grafting. The Annals of Thoracic Surgery. 2012; 93: 1201–1205.
[11] Tsujita E, Yamashita YI, Takeishi K, Matsuyama A, Tsutsui SI, Matsuda H, *et al*. Subcuticular absorbable suture with subcutaneous drainage system prevents incisional SSI after hepatectomy for hepatocellular carcinoma. World Journal of Surgery. 2012; 36: 1651–1656.
[12] Fujii M, Bessho R, Miyagi Y, Nitta T. Negative-pressure sternal wound closure with interrupted subcuticular suturing and a subcutaneous drain tube reduces the incidence of poststernotomy wound infection after coronary artery bypass grafting surgery. Surgery Today. 2020; 50: 475–483.
[13] Harish R, Kazi FN, Sharma JVP. Efficacy of Subcutaneous Closed Suction Drain in Reduction of Postoperative Surgical Site Infection. Surgery Journal (New York, N.Y.). 2021; 7: e275–e280.
[14] Kaya E, Paksoy E, Ozturk E, Sigirli D, Bilgel H. Subcutaneous closed-suction drainage does not affect surgical site infection rate following elective abdominal operations: a prospective randomized clinical trial. Acta Chirurgica Belgica. 2010; 110: 457–462.
[15] Ramsey PS, White AM, Guinn DA, Lu GC, Ramin SM, Davies JK, *et al*. Subcutaneous tissue reapproximation, alone or in combination with drain, in obese women undergoing cesarean delivery. Obstetrics and Gynecology. 2005; 105: 967–973.
[16] Bjessmo S, Hylander S, Vedin J, Mohlkert D, Ivert T. Comparison of three different chest drainages after coronary artery bypass surgery–a randomised trial in 150 patients. European Journal of Cardio-thoracic Surgery: Official Journal of the European Association for Cardio-thoracic Surgery. 2007; 31: 372–375.