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Deep Sternal Wound Infection After Open-heart Cardiac Surgery and Vacuum-Assisted Closure Therapy: a Single-center Study

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ABSTRACT

Background: Despite many advances in the prevention, of sternal wound infection, especially deep ones, cardiac surgery with median sternotomy, still presents a significant postoperative complication. Numerous operative and non-operative procedures should be used in treatment, there is a prolonged hospital stay and increased hospital costs treating this postoperative complication. **Objective:** The present study was conducted aiming to determine the incidences, and risk factors, identify microbiology findings, and antibiotic therapy among patients with DSWI who underwent cardiac surgery with median sternotomy at our Clinic and VAC treatment. **Methods:** This retrospective observational study was conducted in Clinic for Cardiovascular Surgery at University Clinical Center Sarajevo from November 2015 to November 2020. The data were obtained from 15 patients with deep sternal wound infection (DSWI) following open-heart surgery. The inclusion criteria were DSWI after cardiac operation via median sternotomy, and complete results of microbiological findings obtained by sternal swab. The exclusion criteria were patients with incomplete clinical data. **Results**: We found that 9 (60%) patients were males and 6 (40%) were females. Coronary artery bypass grafting (CABG) operation had 11 (73,3%) patients, CABG with aortic valve replacement 2 (13,3%), valve replacement surgery operations (13,3%). The average age was 66 years. All patients were elective surgery patients. STS score in the Non-VAC group was 22.6, in the VAC group 16.6, and the average was 14.9. The number of patients with DSWI represents 1% of all sternotomy patients in the observed period. Two risk factors for DSWI had 37% of patients, 25% of them were diabetic, and 3 (9%) were overweight. Enterococcus faecalis was isolated predominantly in 6 (27%) patients, followed by Klebsiella pneumonia 3 (13%), Proteus mirabilis 2 (9%), and Serratia Maecenas 2 (9%). The mortality rate was 33.3% (5 of 15). **Conclusion:** The results of our study present our experience with DSWI treatment after open-heart surgery. What comes from our experience so far, is that is very important to determine patients who are at risk of developing DSWI after cardiac surgeries to lower its incidence.

Keywords: deep sternal wound infection, Cardiac surgery, risk factors, bacteriology sample.

1. BACKGROUND

The first sternotomy was performed for the excision of tuberculous mediastinal lymph nodes by Dalton et al. From the late 1990s, it became the standard for cardiac surgery procedures to approach the heart (1). But, unfortunately, patients undergoing cardiac surgical procedures using sternotomy have a significant risk of sternal wound infection (SWI).

It can be Superficial Sternal Wound Infection (SSWI), which involves the skin, subcutaneous tissue, and the pectoralis fascia without penetrating below, has an incidence of 0.5% to 8%, with an associated morbidity and mortality rate ranging from 0.5% to 9%. Superficial sternal wound infections are often completely eradicated with intravenous antibiotics and local wound care (2). But, it can be deep sternal wound infection (DSWI) also known as post-sternotomy infection of the mediastinal space (mediastinitis) and can involve the mediastinum, bone, or cartilage, and infections beneath the subcutaneous tissue (3). Despite advances in prevention, the incidence remains significant, and ranges between 0.5% and 6.8%, with in-hospital mortality rates between 7% and 47%. Some patients require further surgery, including repeated debridement and major surgical reconstruction (2).

DSWI has a significant impact on both patient prognosis and hospital budgets. Mid- and long-term survival is significantly reduced in patients that have experienced DSWI. Excess costs arise primarily from antibiotic treat-

ments and surgical procedures, as well as increased hospital length of stay (4).

Risk factors for DSWI can be broadly grouped into patient-related, intraoperative, and postoperative factors. Patient and surgical risk factors contribute to the risk of DSWI after cardiothoracic surgery.

Patient risk factors include age, female gender, obesity, diabetes mellitus, smoking, alcoholism, malignancy, therapy with steroids, presence of comorbidities, *Staphylococcus aureus* nasal carriage, skin infection anywhere on the body, osteoporosis, chronic infections (human immunodeficiency virus, hepatitis B virus, hepatitis C virus, or bacterial infection longer than 4 weeks, or on antibiotics at surgery), and emergent/urgent surgery (4)

Intraoperative risk factors are concomitant coronary artery bypass grafting with valve or aortic surgery, long operation time, and bilateral use of internal mammary arteries. There are also postoperative risk factors such as prolonged ventilator support and inotropic support, re-exploration for bleeding, and postoperative blood transfusion.

Based on the number of risk factors and time to presentation after surgery, El Oakley and Wright classified DSWI into five classes. Such a classification can be used for comparison between different management protocols and used in research to refine the management of DSWI (3).

Vacuum-Assisted Closure (VAC) therapy is a system that promotes open wound healing through the application of negative pressure, especially in infected tissues. When applying negative pressure onto the bed of the wound, fluid material is removed, formation of granulation tissue is promoted, and wound edge approximation is helped. These mechanisms are effective in promoting the healing process which would be otherwise difficult to treat, leading not only to economic advantages but especially to noticeably improved patients' health (5). VAC therapy has been widely used for the treatment of wound infection since first described by Morykwas et al. in 1997. VAC can improve the healing of DSWI by increasing wound blood flow, reducing bacterial loads, and enhancing the formation of granulation tissue.

Currently, the treatment of DSWI has no standardized procedure, and various strategies are being used. The basic principle of operation is debridement, administration of culture-specific antibiotics, and wound closure therapy. VAC therapy has shown promising results in the treatment of DSWI (6).

Knowledge of microorganisms that can cause DSWI is important in determining the choice of antimicrobials for prophylaxis, empiric, and targeted treatment.

Systemic antimicrobial therapy should be immediately instituted after adequate sampling (cultures from tissue or wound swabs) and microbiological investigations. The empirical antibiotic therapy should be directed against the most likely causative organisms, such as coagulase-negative staphylococci, *S. aureus* (or MRSA when the MRSA prevalence in the hospital is high), and eventually Gram-negative, and anaerobic organisms. When results of microbiological cultures are available, targeted therapy should be initiated as soon as possible (3) Due to complex situations and difficulties in making the diagnosis, the management of such complications requires the involvement of a multidisciplinary team consisting of cardiothoracic surgeons, plastic surgeons, intensivists, infectious disease specialists, and clinical microbiologists.

2. OBJECTIVE

The present study was conducted aiming to determine the incidences, and risk factors, identify microbiology findings, and antibiotic therapy among patients with DSWI who underwent cardiac surgery with median sternotomy at our Clinic and VAC treatment.

3. PATIENTS AND METHODS

Over five years, from November 2015 to November 2020, out of all operated patients at Clinic for Cardiovascular Surgery, 15 patients were diagnosed with DSWI after cardiac operation. Ethical approval was obtained from the Ethical Committee of the hospital.

As the study is retrospective, the following data were collected from the medical records: demographics, comorbidities, type of admission (elective, urgent, emergency), risk factors, type and duration of surgery, microbiological culture reports, antibiotic therapy, and clinical outcomes, which included the date of death or hospital discharge.

Anesthetic and surgical procedures were standardized in all patients. Preoperative antibiotic prophylaxis was cefazolin 2 gr. iv. 30 minutes before skin incision, and 1 gr three times in following days. All patients were transferred to the intensive care unit for postoperative mechanical ventilation and were extubated following the standard indications. If needed inotropic support was introduced.

The major signs for DSWI diagnosis were unstable sternum with secretion, fever, leukocytosis, and elevation of C-reactive protein (CRP).

The wound infection was diagnosed and confirmed by positive bacterial culture results. Wound swabs were collected, beside Cafazolin, empiric antibiotic therapy with Vancomycin was indicated, until the final microbiological finding came, and then targeted antibiotic therapy was introduced. Positives cultures were treated with appropriate antibiotics with repeat cultures to confirm the eradication of colonization.

We combined two main methods of treatment for DSWI, conservative and surgical. After presternal VAC therapy and retrosternal propping, when the wound becomes clean (negative wound swab findings), it was obliterated with muscle.

The non-VAC group was treated conventionally, with surgical debridement, sternum fixation, and retrosternal irrigation.

VAC group treatment consisted of surgical debridement, open sternum with VAC therapy, and at the end of treatment pectoral flap with sternum refixation.

Statistical analysis was performed using Statistical Package for Social Sciences for Windows, version 20.0

Variable	Non-VAC group	VAC group	Total (n = 15)
Gender, n (%)			
Male	7	2	9 (60%)
Female	1	5	6 (40%)
Risk factors for DSWI			
Obesity	2	1	3
Diabetes mellitus	2	6	8
COPD	1	1	2
PVD	2	0	2
Miscellaneous	10	0	10
Surgical procedure			
CABG, n (%)	4	7	11
CABG + valve	2	0	2
Non CABG	2	0	2
Elective surgery, n (%)	8	7	15 (100)
STS score, n (SD)	22.6 (SD 15.2)	16.6 (SD 7.1)	14.9 (SD 9.9)

Table 1. Baseline characteristics of study groups

(IBM Corp, Armonk, NY, USA). We calculated the incidence of postoperative DSWI. Categorical variables were expressed as frequencies and proportions. Risk factors for DSWI were explored using odds ratios (ORs) plus their respective 95% confidence interval (CI) and binary logistic regression between the dependent variable and the independent variables.

4. RESULTS

For five years, at Clinic for Cardiovascular Surgery, out of all cardiac operations using the median sternotomy approach, we had 15 patients with DSWI, divided into two groups: non-VAC with 8 patients, and VAC with 7 patients. Due to the type of operations among these patients, 11 of them had coronary artery bypass grafting (CABG), 2 of them had CABG with an aortic valve, and 2 of them were valve replacement surgery. The female gender was presented with 6 (40%) patients and the male 9 (60%) patients. Some of the main risk factors such as body mass index (BMI) over 30 were presented in 3 patients, diabetes mellitus in 8 patients, chronic obstructive pulmonary disease (COPD) in 2 patients, PVD as well in 2 patients, and there were 12 patients with more than 2 risk factors for DSWI (Table 1). All 15 patients were elective surgery cases. STS score was 22.6 in the non-VAC group and 16.6 in the VAC group. The average age of patients was 66 years.

Table 2 gives us an insight into the microbiological isolates of DSWI in our patients divided into two groups. The leading isolated microorganism was Enterococcus faecalis. More than one isolated microorganism in the treated wound was present in 31% of patients.

Maxumal values of CRP in Non-VAC group was 177.6 mg/L vs. 239.6 mg/L in VAC group. At the end of treatment before the closure of the wound CRP was as needed, 65.9 in the Non-VAC group and 22.6 in the VAC group. CRP level showed a progressive decline during treatment, it was 33.4 mg/L at surgical closure of the wound.

Of the total number of treated patients, one-quarter had a positive microbiological wound finding during the hospital stay, while three quarters came for DSWI treatment after completion of postoperative treatment and discharge from the hospital.

Since no patient treated for DSWI was hemodynamically unstable did not require treatment in the intensive care unit. All patients were treated in high-dependency care.

Out of 15 treated patients, 10 (66.6%) were discharged from the hospital, and 5 (33.4%) patients died due to additional complications.

5. DISCUSSION

Although recent work shows that the incidence of DSWI is decreasing and now ranges from 1% to 4% in cardiac surgery, postoperative complications such as DSWI continue to increase morbidity and mortality and decrease life expectancy in the long term (7).

Sadanandam et al. reported a 3.6% incidence of sternal wound infection (SWI), while a few studies from the Middle East reported an incidence of 1% of DSWI which is in correlation with our findings. However, a lot of studies reported DSWI incidence rates varying from 0.4% to 2.3%. Probably this discrepancy is the result of the sample size (1).

	Non-VAC group		VAC group		Total (n = 15)	
Initial pathogenic bacteria	No	%	No	%	No	%
Enterococcus faecalis	4	66%	2	33%	6	27%
Stenotrophomonas maltophilia	1	100%	0	0%	1	4.5%
Pseudomonas species	1	100%	0	0%	1	4.5%
Staphylococcus epidermidis	1	100%	0	0%	1	4.5%
MRSA	2	100%	0	0%	2	9%
Serratia marecens	1	50%	1	50%	2	9%
E. coli	1	100%	0	0%	1	4.5%
Proteus mirabilis	0	0%	2	100%	2	9%
Citrobacter freundi ESBL	0	0%	1	100%	1	4.5%
Acinetobacter baumanii	0	0%	1	100%	1	4.5%
Klebsiella pneumonie ESBL	0	0%	3	100%	3	13%
Pseudomonas aerouginosa	1	100%	0	0%	1	4.5%
Staphylococcus aureus MSSA	0	0%	0	0%	0	0%
Total	12	54%	10	46%	22	100%
No isolates > than 1	4	57%	3	43%	7	47%

Table 2. Microbiological characteristics of DSWI

	Non-VAC group	VAC group
Number of revision procedures	1.22 (1-2)	1.86 (1-3)
Time between operation and the first revision	10.67 (0-30)	20 (12-30)
Hospital stay (days)	23.50 (SD 13.15)	38.17 (SD 28.65)

Table 3. Number of revision, revision time, and hospital days

There are varying results regarding the impact of gender on DSWI after surgery. Some studies showed higher incidence in male patients, but some studies confirm higher incidence in female patients. In our sample of patients, 60% were males and 40% were females (8, 9).

We confirm in our study that obesity and diabetes mellitus were risk factors for DSWI, as many published studies confirmed (10, 11).

Staphylococcus aureus and S. epidermidis are reported as the most common pathogens that cause DSWI following cardiac surgery. Al-Majid et al. found in their study that MSSA is likely to be isolated in male, a diabetic patients who underwent CABG operation. Other implicated organisms include E. coli, Enterobacter spp, Pseudomonas aeruginosa, β-hemolytic streptococci, and S. Aureus (1, 11).

In our study, the most common isolate from wound swab was Enterococcus faecalis in 6 patients (27%). Other frequent isolates were Proteus mirabilis (9%), Klebsiella pneumonia (13%), MRSA (9%), and Serratia machines (9%). Out of a total number of patients, 7 patients (47%) had more than one copy of isolated bacteria in the wound swab. As 4 of the treated patients (26%) got deep sternal wound infection (DSWI) during their treatment in hospital, and 11 patients (74%) were hospitalized for DSWI treatment from their homes, we presumed that patients should be educated for posthospital care of their wound. According to our protocol, we were using cephalosporins as antimicrobial prophylaxis, before surgery and until patients were discharged. In the case of symptoms of DSWI, we kept the antibiotic the patient was receiving, Cefazolin 1 gram three times a day, and we added Vancomycin 1 gram twice a day. According to the obtained microbiological isolates and antibiogram, two antibiotics were usually included, Vancomycin and Imipenem, ie Meropenem.

Out of 15 patients in our study with DSWI, 7 patients were with VAC therapy. In the Non-VAC group 3 patients died, and in the VAC group 2 patients died. Patients with lethal outcomes were patients with several comorbidities present, ie with a higher number of risk factors for the development of DSWI predominantly in the VAC group. Our mortality rate was 33.4% while Gwely et al. had a 25% mortality rate and Filsoufi et al.12 14%. It is important to note that all patients who had lethal outcomes were patients who came from their homes, on average 15 days after discharge from the hospital.

6. CONCLUSION

DSWI is one of the serious postoperative complications after median sternotomy in cardiac surgery operations. Unfortunately, despite preventive procedures and treatment of DSWI, there is still a high incidence and high mortality rate. This represents a heavy burden on patients and the health system due to high treatment costs. Our experience showed good results with using VAC therapy in DSWI, but our study has a small number of patients and we should follow up further patients with DSWI and their VAC treatment.

- **Authors contribution**: WL, KH, YL, and SS designed research concept, prepared, and drafted a manuscript. W.L. also analyzed the data and designed a proposed mechanism. Final proofreading was made by the first author.
- **Conflict of interest**: None declared.
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