

CLINICAL STUDY

Wound infections after median sternotomy treated by VAC therapy, summary of results, and risk factor analysis

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ABSTRACT

INTRODUCTION: The aim of this study is to summarize results and analyze risk factors for the development of wound infection in heart surgery patients after median sternotomy.

METHOD: In this retrospective analysis with assessment of multiple risk factors, we examined 143 patients with infection after median sternotomy treated with VAC therapy from total of 4,650 patients operated in our department from 2012 to 2015.

RESULTS: Total of 143 patients developed significant SSI treated by VAC therapy following cardiac surgery. Of these, only 14 patients developed DSWI and one patient was diagnosed with suspected osteomyelitis. BMI, female gender, and use of BIMA proved to be statistically significant risk factors in our study ($p < 0.001$). The acuteness of operations did not have a statistically significant effect. However, it had a significant effect on the severity of infection ($p < 0.01$). The severity of infection proved to be a significant prognostic factor for patients' outcome ($p < 0.01$).

CONCLUSION: In our study, BMI, female gender, and use of BIMA (bilateral internal mammary artery) in patients with DM were predictors for the development of SWI. The acuteness of operation did not have a statistically significant effect. However, it had a statistically significant effect on the severity of infection (Tab. 3, Ref. 30). Text in PDF www.elis.sk.

KEY WORDS: wound infections, median sternotomy, VAC therapy, negative-pressure wound closure.

Introduction

Median sternotomy is the most common method of surgical approach in cardiac surgery (1, 2). SSI (surgical site infection) in this area remains a much-feared postoperative complication. Despite the progress in prevention, according to literature, this complication still occurs in approximately 3 % of patients (3–5). Some sources however report an incidence of up to 10 % (6, 7).

Sternal wound infections are most often divided according to the severity into superficial and deep. Superficial infection (SSWI) affects skin, subcutaneous tissue and pectoral fascia. The incidence of SSWIs ranges from 0.5 to 8 % with an associated morbidity and mortality rate from 0.5 to 9 % (8). Deep sternal infection (DSWI) affects bone, substernal space and mediastinum. This serious complication affects less than 2 % of patients (9, 10). On the other hand, in contrast to surface infections, it increases the mortality more than twice (11).

The most commonly reported risk factors for developing this infection include age, female gender, obesity, diabetes mellitus and hyperglycemia, tobacco smoking, chronic obstructive pulmonary disease, surgical technique, use of BIMA (bilateral internal

mammary artery), heart failure, renal failure, peripheral vascular disease, prolonged need for inotropic support, prolonged stay in intensive care, and emergent or urgent surgery (12–15).

There are several methods of treating sternal wound infections. The most commonly used procedures include closed suction antibiotic catheter irrigation systems, vacuum-assisted closure and various flap coverages (8). At our department we experienced the best results with VAC therapy (vacuum-assisted closure) and it is the method of choice for every sternal wound infection not responding to regular dressings. VAC therapy is accepted as a suitable method for the treatment of open infectious wounds. It reduces bacterial colonization of the wound, swelling, exudation, stimulates growth of granulation tissue, improves perfusion and creates favorable microenvironment for wound healing (16–18).

Our study attempts to summarize the results at the Clinic of Cardiac Surgery at The National Institute of Cardiovascular Diseases in Bratislava and analyze several risk factors associated with SSI.

Materials and methods*Patient selection*

The study was conducted at the Clinic of Cardiac Surgery at The National Institute of Cardiovascular Diseases in Bratislava (NÚSCH). In our retrospective study, we included patients who underwent cardiac surgery at our clinic between years 2012 and

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2015 and developed SSI in the postoperative course treated by VAC therapy. Small uncomplicated infections with ASEPSIS score (19) under 30 that were treated only by daily dressing were not included in the study. Similarly, patients with wound infections at other sites (wound infections after saphenectomy, in inguinal or deltoideopectoral region, etc.) were not included in the study. We analyzed the risk factors of 143 patients who developed SSI after median sternotomy and were treated with VAC therapy from total of 4,650 operated patients.

Statistical analysis

After processing individual data, we used Fisher's exact test to determine statistical significance. We preferred Fisher's test over X²-test because some of the analyzed groups of patients were relatively small and would invalidate the X²-test. The probability randomness threshold was set at 0.01, meaning there is substantial evidence against the null hypothesis. Numerical variables were presented as mean with minimal, maximal and median values, and categorized variables were summarized by percentages. For the statistical analysis we used statistical analysis tools available at <http://www.socscistatistics.com>.

An informed consent and institutional review board permission were obtained to present these results.

Results

Incidence

In the period from 2012 to 2015, a total of 143 patients (3.08 %) developed significant SSI treated by VAC therapy following cardiac surgery. Of these, only 14 patients developed DSWI (0.3 % of total patients) and one patient was diagnosed with suspected osteomyelitis.

The study population consisted of a total of 74 men aged 38–83 years and 69 women aged 29–85 years. The mean age of men and women was 63 and 67 years, respectively. The most common primary diagnoses among SSI group were coronary heart disease (64 %) and aortic stenosis (8 %). The most common operations were CABG (69 %) and aortic valve replacement (8 %). We analyzed

Tab. 1. Infectious agents cultivated from wound swabs.

Infectious agent	Percentage of infected wounds
<i>Staphylococcus epidermidis</i>	25.17 %
<i>Enterococcus faecalis</i>	22.38 %
Unknown	17.48 %
<i>Staphylococcus aureus</i>	17.48 %
<i>Pseudomonas aureginosa</i>	7.69 %
<i>Escherichia coli</i>	6.99 %
MRSA	6.99 %
<i>Klebsiella pneumoniae</i>	5.59 %
<i>Proteus mirabilis</i>	4.9 %
<i>Klebsiella oxytoca</i>	4.2 %
<i>Staphylococcus haemolyticus</i>	3.5 %
Negative	2.8 %
<i>Staphylococcus hominis</i>	2.8 %
<i>Staphylococcus lugdunensis</i>	2.8 %
Fungi	2.8 %
Other	18.88 %

Tab. 2. Impact of acuteness of operation on the severity of SWI (p < 0.01).

Acuteness of operation	Number of patients	Superficial wounds	Deep wounds
Planned	129	121	8
Emergent	9	4	5
Urgent	5	4	1

5 risk factors in association with VAC therapy, including female gender, obesity, diabetes mellitus and hyperglycemia, use of BIMA (bilateral internal mammary artery), and emergency of surgery.

A majority of patients was suitable for secondary suture of the wound after the infection had been treated (two sterile cultivation results from wound swabs and growth of granulation tissue). Part of the patients with extensive damage however, required reconstructive surgery using tissue flaps. Of the total number of wounds, superficial were present in 85 %, deep in 10 %, complicated superficial infections in 4 % and suspected osteomyelitis in 1 % of patients. The most common pathogens isolated from wound swabs were *Staphylococcus epidermidis* (25.17 %), *Enterococcus faecalis* (22.38 %) and *Staphylococcus aureus* (17.48 %). Other relatively frequent agents were *Pseudomonas aureginosa* (7.69 %), MRSA (6.99 %) and *E. coli* (6.99 %). These data are presented in Table 1.

BMI

In the SSI group, the average BMI was higher (30.72; min: 18.8; max: 45.062; median: 30.67) compared to the average BMI of all operated patients (28.48). In the SSI group, only 13 % of patients had normal BMI; 31 % of patients were overweight, 51 % obese and 6 % morbidly obese (BMI > 40).

Gender

The SSI group had a significantly higher proportion of female patients compared to the group of all operated patients (48.25 % and 31.38 %, respectively). In our study, the female gender was confirmed to be a statistically significant factor (p < 0.01).

Diabetes mellitus and use of two arterial grafts in CABG

The use of bilateral internal mammary artery for myocardial revascularization in patients with diabetes mellitus proved to be a significant risk factor for developing SSI (p < 0.01). Patients with this combination of risk factors had a 2.5 times higher risk of developing SSI compared to total risk (7.79 % and 3.08 %, respectively).

Data summarizing risk factors, namely BMI, gender and DM + BIMA are presented in Table 2.

Severity of infection

Development of DSWI significantly worsens the prognosis of patient compared to SSWI. In the group of 14 patients with DSWI, 9 (64 %) patients died, 4 (29 %) were discharged from hospital or transferred to other departments, and 1 patient (7 %) had extensive tissue damage requiring tissue flap surgery. In the group with SSWI, 84 % patients were discharged, the mortality was 11 %, and 5 % of patients required tissue flap surgery. The severity of infection is thus a statistically significant prognostic factor (p < 0.01).

Tab. 3. Risk factors.

Risk factor	All patients	SWI group	p
Average BMI [kg.m ²]	28.48	30.72	< 0.01
Proportion of female patients	31.38 %	48.25 %	< 0.01
Diabetes mellitus + use of BIMA	3.08 %	8 %	< 0.01

Acuteness of the operation

The acuteness of operations did not have a statistically significant effect on the development of SSI. However, it had a statistically significant effect on the severity of infection ($p < 0.01$). In the group of electively operated patients with SSI, only 6.2 % developed DSWI. In contrast, patients in urgent group developed DSWI in 20 % while in emergent group in as much as 56 %. These data are presented in Table 3.

Discussion

In the period between 2012 and 2015, 3.08 % of patients developed SSI after median sternotomy. The incidence is slightly lower than the actual incidence since we included only patients treated with VAC therapy. The common practice at our department is to use VAC therapy for every infection not manageable by standard dressing. These results still compare to the incidence spectrum of SSI most commonly reported in literature, which is approximately 3 % of patients (3–4). Some sources however report the incidence of up to 10 % (6, 7).

The incidence of DSWI in our study was 0.3 % and every patient with DSWI was treated by deep VAC therapy. Compared to other studies, this incidence is on the lower end of the spectrum (9, 10, 20). The mortality associated with DSWI in our study was however significantly higher (64 %) compared to the results of other studies which range from 10 up to 40 % (18). These results may be biased due to the small number of patients in the DSWI group (14 patients over the period of 4 years) but require a further investigation nonetheless.

BMI is a widely acknowledged risk factor for the development of SSI (12–15). According to a study from Brazil (21), the odds ratio for developing SWI in patients with BMI > 30 is 1.56 while in patients with BMI > 40, it is 6.27. The average BMI in the SSI group in our study was 30.72. Only 13 % of patients had normal BMI; 31 % of patients were overweight, 51 % obese and 6 % morbidly obese (BMI > 40).

The infectious agents associated with SSI were most commonly skin commensals (*Staphylococcus epidermidis*; 25.17 %) and microorganisms originating in the digestive tract (*Enterococcus faecalis*; 22.38 %). These results correlate with the previous study by Lamaignen et al (22).

In our study, the female gender was confirmed to be a statistically significant factor ($p < 0.01$). The SSI group had a significantly higher proportion of female patients compared to the group of all operated patients (48.25 % and 31.38 %, respectively). A study from Tehran Heart Center reported results very comparable to ours (52.3 % compared to 25.5 %) (23). This study interestingly also states that female gender is not viewed as a significant risk factor by other related investigations.

In our experience, one of the most feared combinations of risk factors is diabetes mellitus and the use of two arterial grafts in CABG. Arterial grafts are superior to venous ones in terms of patency (24). Use of two arterial grafts (BIMA, bilateral use of IMA – left and right internal mammary artery) for myocardial revascularization is therefore a favorable alternative compared with the use of one arterial graft and one venous graft (24, 25). Although there are still no conclusive data, the use of BIMA improves survival and reduces the need for redo surgery (26). This procedure however carries an increased risk of developing SSI due to the disruption of blood supply to this area. In our study, patients with this combination of risk factors had a 2.5 times higher risk of developing SSI compared to total risk (7.79 % and 3.08 %, respectively). In contrast, a more recent study (27) states that the use of BIMA was not associated with a significantly higher morbidity.

The acuteness of operations in our study did not have a statistically significant effect on the development of SSI. However, it had a statistically significant effect on the severity of infection. Other studies (28, 29) also report higher risk of developing DSWI in emergent or urgent operations. But according to an older study (30), the emergency of operation affects the incidence of SSI in general, and not only the severity of infection as we observed.

There are several limitations to our study. It is a single-center retrospective study. The investigation of patients was limited to the hospital admission and did not include long-term follow-up after discharge. The fact that the number of patients in DSWI group was relatively small could cause a bias.

In conclusion VAC therapy is an effective treatment for the management of SWI. Our results are comparable with the results reported in literature. BMI, female gender, and use of BIMA are predictors for the development of SWI in our study.

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