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Deep Sternal Wound Infection after Coronary Artery Bypass Surgery: Management and Risk Factor Analysis for Mortality

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ABSTRACT

Background: Deep sternal wound infection is a life-threatening complication after cardiac surgery. The aim of this study was to investigate the factors leading to mortality, and to explore wound management techniques on deep sternal wound infection after coronary artery bypass surgery.

Methods: Between 2008 and 2013, 58 patients with deep sternal wound infection were analyzed. Risk factors for mortality and morbidity including age, gender, body mass index, smoking status, chronic renal failure, hypertension, diabetes, and treatment choice were investigated.

Results: In this study, 19 patients (32.7%) were treated by primary surgical closure (PSC), and 39 patients (67.3%) were treated by delayed surgical closure following a vacuum-assisted closure system (VAC). Preoperative patient characteristics were similar between the groups. Fourteen patients (24.1%) died in the postoperative first month. The mortality rate and mean duration of hospitalization in the PSC group was higher than in the VAC group ($P = .026$, $P = .034$). Significant risk factors for mortality were additional operation, diabetes mellitus, and a high level of EuroSCORE.

Conclusions: Delayed surgical closure following VAC therapy may be associated with shorter hospitalization and lower mortality in patients with deep sternal wound infection. Additional operation, diabetes mellitus, and a high level of EuroSCORE were associated with mortality.

INTRODUCTION

The spectrum of sternal wound infections after cardiac surgery ranges from superficial infections to deep sternal infections known as mediastinitis. Mediastinitis occurs in 0.2-3% of patients after median sternotomy [Olbrecht 2006; Gummert 2002; El Oakley 1996]. Mediastinitis-related mortality is reported between 10-47% in the literature [Gummert 2002; El Oakley 1996]. Duration of hospital stay prolongs in patients with wound infection. Clinical burden of these patients is about three-fold greater compared to uncomplicated patients [El Oakley 1996]. Early recognition of sternal wound infection and aggressive treatment with reopening of the entire wound is essential to achieving a low recurrence rate [Fleck 2006]. The vacuum-assisted closure system (VAC) serves as a suitable environment to recovery in the wound area [Fleck 2006; Roques 1999; De Paulis 2005; Choo 2009; Vos 2012; Demaria 2003].

The objective of this study was to investigate the factors leading to mortality associated with deep sternal wound infection after open heart surgery, and to investigate wound management techniques.

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MATERIALS AND METHODS

Subjects and Study Design

Data for the patients who were operated due to deep sternal wound infection following open cardiac surgery between January 1, 2008 and December 31, 2013 in our hospital were retrospectively analyzed. The patients who had superficial infections were excluded. Patients were divided into two groups according to management strategy: primary surgical closure (PSC) or delayed surgical closure following a vacuum-assisted closure system (VAC).

Preoperative risk factors, perioperative features, ICU stay time, duration of antibiotic therapy, postoperative complications, and other clinical findings were recorded from the patient files. European system for cardiac operative risk evaluation (EuroSCORE) formula was used for assessment of preoperative risk factors [De Paulis 2005].

Surgical Procedure

Early surgical management was the treatment of choice for patients in the PSC group. Once patients in the PSC group were diagnosed with mediastinitis, they were reoperated without delay. The operational strategy was to put a 36°F chest tube and an irrigation catheter between the heart and sternum. Additional drainage tubes were inserted to the thoracic spaces if necessary. The patient's sternum was closed by stainless steel sutures and Robicsek procedure was performed in the presence of sternal fractures. Mediastinal irrigation at 100 mL/h was performed with 5% povidone-iodine irrigation solution up to 24 to 48 hours after the operation. The chest tubes were left inside until the daily drainage levels were less than 50 mL per day. The mean stay time of the drainage tubes in the PSC group was 6.2 ± 1.3 days.

Vacuum-assisted closure system was used prior to surgery in the VAC group (Figure 1). The system was installed

Figure 1. Preoperative and postoperative view of the vacuum-assisted closure system.

immediately after diagnosis of mediastinitis. The amount of drainage was followed daily, and sponges were changed every 48 hours. The sternal wound was closed surgically when the daily vacuumed drainage levels were lower than 10 mL per day. The mean time between diagnosis of mediastinitis and the operation was 16.8 days (range, 4-37). The sternum of these patients was closed with stainless steel sutures and Robicsek procedure was performed if necessary. Mediastinal drainage tubes were inserted. No patient needed insertion of a chest tube. We did not insert an irrigation catheter in patients in the VAC group.

Intravenous empiric antibiotic therapy was initiated just after diagnosis of mediastinitis and therapy was altered to the appropriate antibiotics after antibiogram results were obtained from the wound culture. The average duration of antibiotic therapy was 28.7 days in PSC group compared to 24 days in the VAC group (Table 2).

Statistical Analysis

Statistical analyses were performed with SPSS 16 for Windows (SPSS Inc, Chicago, IL, USA). Normality of the distribution of the data was determined using Kolmogorov-Smirnov test. Data were expressed as numbers and percentages for categorical variables and mean ± standard deviation or median and range for continuous variables according to distribution of the data. Categorical data were compared with χ^2 test or Fisher's exact tests. Normally distributed data were compared using Student's *t* test, while data with skewed distribution were compared with Mann-Whitney *U* test. Differences were accepted as significant when *P* was <.05.

RESULTS

During the 5 years period, a total of 4,350 patients underwent median sternotomy for open cardiac surgery. Of these patients, 58 (1.3%) had deep sternal wound infection and were enrolled in this study. All of these patients underwent operation for debridement and sternum reconstruction.

Table 1. Clinical Characteristics of Patients*

	PSC Group	VAC Group	Total	*P*
Male sex/female sex, n	6/13	22/17	28/30	.078
Age, y	61.8 ± 8.2	60.3 ± 5.9	60.8 ± 6.7	.417
Diabetes mellitus, n (%)	11 (58)	19 (49)	30 (52)	.520
Hypertension, n (%)	18 (94)	31 (79)	49 (84)	.137
Smoking, n (%)	5 (26)	7 (18)	12 (20)	.469
BMI, kg/m^2	28.3 ± 3.7	30.6 ± 5.3	29.8 ± 4.9	.109
Renal failure, n (%)	3 (16)	4 (10)	7 (12)	.522
COPD, n (%)	8 (42)	13 (33.3)	21 (36.1)	.523
EuroSCORE	4.07 ± 3.0	3.88 ± 2.0	3.9 ± 2.4	.596
Additional operation, n (%)	3 (21)	5 (12.8)	6 (10.3)	.351

*Data are presented as the mean ± SD where indicated. PSC indicates primary surgical closure; VAC vacuum-assisted closure; BMI, body mass index; COPD, chronic obstructive pulmonary disease.

Table 2. Clinical Course

	PSC Group	VAC Group	*P*
VAC time, d	0	16.8	–
Duration of antibiotic use, d	28.7	24	.097
Duration of treatment, d	38.2	31.1	.034
Mortality, n (%)	8 (42.1)	6 (15.3)	.026

PSC indicates primary surgical closure; VAC, vacuum-assisted closure.

Nineteen patients (32.7%) underwent PSC, whereas VAC before surgical closure was used in 39 patients (67.3%). Twenty-eight patients were female (48%) and 30 were male (52%). Fifty of these patients had undergone coronary artery bypass grafting (CABG) surgery and 8 had undergone other surgical procedures in addition to CABG. Mean EuroSCORE of patients who underwent additional surgical procedures was found to be higher than in patients who underwent isolated CABG procedure (6.5 ± 1.3; range, 5-9 versus 3.56 ± 1.1; range, 1-4, respectively; *P* = .043). Left internal thoracic artery (LITA) was used for the left anterior descending artery (LAD) anastomoses in all patients. Right internal thoracic artery (RITA) was not harvested in any of the patients. The coronary arteries besides LAD were grafted with saphenous veins. None of the patients had undergone isolated heart valve surgery.

Mean body mass index (BMI) of the patients was calculated as 29.8 ± 4.9 kg/m^2 (range 21.1-44.3). Mean EuroSCORE was 3.9 ± 2.4. There was no statistically significant difference between the two groups in terms of BMI value and EuroSCORE value (Table 1). Median hospital stay time

Table 3. Isolated Microorganisms in the Deep Mediastinal Wound Culture

	Surviving Group n = 44	Mortality Group n =14	Total
Microorganism			
Proteus mirabilis, n	4	0	4
Staphylococcus aureus, n	16	6	22
CN staphylococcus, n	2	0	2
Enterococcus spp, n	1	2	3
Acinetobacter, n	8	4	12
Escherichia coli, n	3	1	4
Enterobacter cloacae, n	6	1	7
Klebsiella pneumonia, n	2	0	2
D group streptococcus, n	2	0	2
Total	44	14	58

CN indicates coagulase negative.

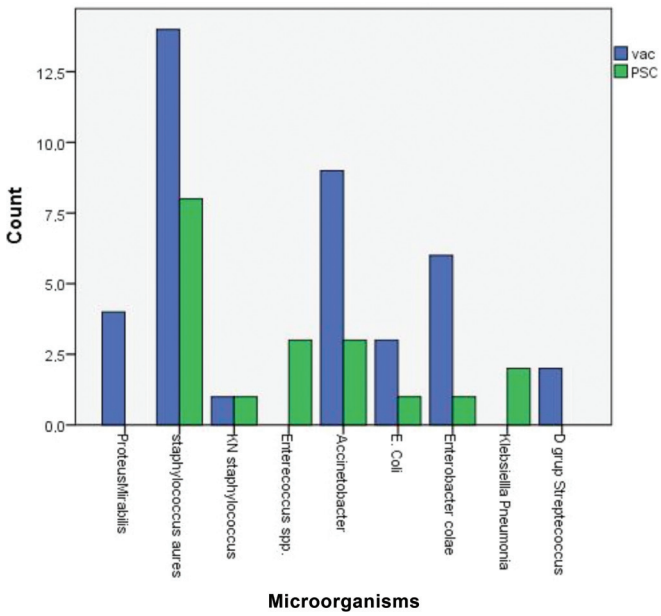

Figure 2. Bacteriological findings according to the closure technique.

tended to be longer in the PSC group, whereas mean duration of antibiotic treatment was similar in both the PSC and VAC groups (Table 2).

Bacteriological Findings

Nine different types of microorganisms were isolated on wound culture. The most common were *Staphylococcus aureus* (n = 22, 37.9%) and *Acinetobacter* (n = 11, 18.9%). All bacteria species isolated on wound cultures are presented in Table 3. The type of microorganism isolated on wound culture did not seem to be associated with clinical outcomes. Bacteriological findings tended to be different between the two groups, but a statistically significant difference was not found (Figure 2) (P = .057).

Table 4. Factors Predicting Mortality*

	Mortality Group n =14	Surviving Group n = 44	*P*
Hypertension, n (%)	12 (85)	37 (84)	.886
Additional operation, n (%)	6 (42)	2 (4.5)	.01
Renal failure, n (%)	1 (7)	6 (13)	.524
COPD, n (%)	8 (57)	13 (29)	.063
Diabetes mellitus, n (%)	11 (79)	19 (43)	.022
Female, n (%)	8 (57)	20 (45)	.455
BMI, kg/m^2	29.6 ± 3.7	30.1 ± 5.2	.492
Age, y	62.3 ± 1.8	60.3 ± 1	.341
EuroSCORE	5.1 ± 0.4	3.6 ± 0.3	.004
Duration of treatment, d	33.4 ± 3.6	34 ± 2	.848
Duration of antibiotic use, d	25.5 ± 2.3	25.6 ± 1.8	.975
VAC versus PSC group, n	6/8	33/11	.026

*Data are presented as the mean ± SD where indicated. COPD indicates chronic obstructive pulmonary disease; BMI, body mass index; VAC, vacuum–assisted closure; PSC, primary surgical closure.

Mortality

A total number of 14 patients (24.1%, 6 patients in PSC group and 8 patients in VAC group) died due to prolonged intubation, heart failure, sepsis, and multi-organ failure. Comparison of non-survivors and survivors are presented in Table 4. Mortality rate was higher among patients with an additional cardiac surgical procedure (62.5% versus 18%, P = .015), suffering from diabetes mellitus (36.7% versus 10.7%, P = .031), and in the primary surgical closure group (42.1% versus 15.3%, P = .026). Median EuroSCORE was 3 (range, 0-10) in survivors and 5 (range, 1-7) in the deceased group (P = .009). The type of microorganism isolated on wound culture did not seem to affect mortality. Chronic obstructive pulmonary disease patients and obese patients had a higher rate of mortality but this increase did not reached a statistically significant level (Figure 3) (P = .061, P = .053 respectively).

Complication Associated with VAC

One patient had bleeding from the wound side. The VAC therapy was terminated and bleeding was taken under control.

DISCUSSION

Risk factors of mediastinitis are multifactorial and include prolonged cardiopulmonary bypass time, thoracic and mediastinal drainage tubes, CABG surgery, chronic obstructive

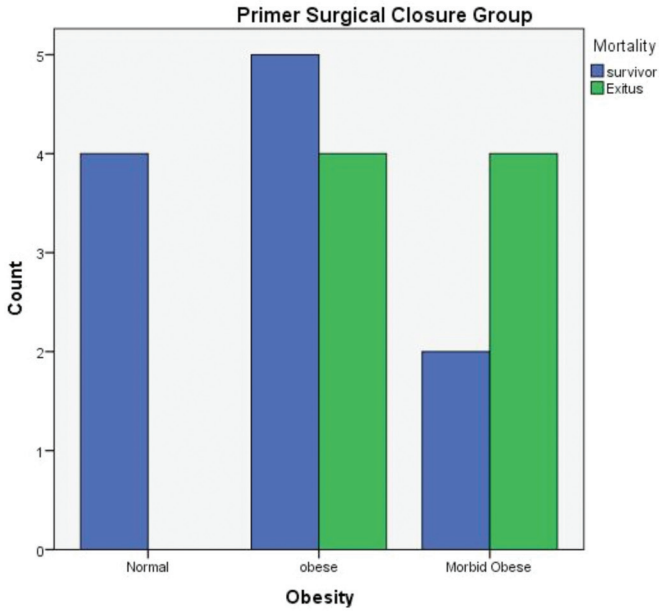

Figure 3. Mortality rate increased with obesity in the primary surgical closure group.

pulmonary diseases, diabetes, thoracic deformity, obesity, advanced age, steroid therapy, and male sex [Gummert 2002; El Oakley 1996]. In patients with mediastinitis, mortality risk factors were determined as obesity, renal failure, chronic obstructive pulmonary diseases, and advance age [Gummert 2002; El Oakley 1996; Roques 1999]. In the present study, chronic obstructive pulmonary disease patients are more prone to death than other patients. But this finding hasn't reached statistical significance. Additional operation, diabetes mellitus, and high level of EuroSCORE were found as the independent risk factors for mortality. Microbiological results and other perioperative variables were not predictive effects on mortality. De Paulis et al suggested that bilateral pedicled harvesting of the internal thoracic arteries may carry a higher risk of sternal wound infection [De Paulis 2005], whereas Choo et al did not find a relation between bilateral internal thoracic artery harvesting and the risk of mediastinitis [Choo 2009]. In the current study, pedicled left internal thoracic artery was used in all of the patients and bilateral internal thoracic artery harvesting was not performed in any of the patients. Accordingly, we did not evaluate the effects of internal thoracic artery harvesting.

Vacuum-assisted closure provides a sterile environment and maintains a simple and effective wound care [Demaria 2003; Raja 2007]. VAC prepares an appropriate environment for wound healing while accelerating the elimination of bacteria and toxins in the wound [Demaria 2003; Raja 2007]. It also accelerates wound healing by increasing blood flow and granulation formation on the wound surface [Bovill 2008; Farinas 1995; Song 2003]. VAC was shown to be beneficial for respiratory and hemodynamic functions [Raja 2007; Conquest 2003].

In this study, mortality rate of patients in the VAC group was lower than in the PSC group. Nevertheless, the total mortality rate was higher from the previous suppurative mediastinitis series [Bovill 2008; Farinas 1995; Song 2003]. Six patients in the PSC group and 8 patients in the VAC group died due to prolonged intubation, heart failure, sepsis, and multiorgan failure. In addition, the number of diabetic patients, additional cardiac surgery patients, and patients with high EuroSCORE values was higher in the deceased group. However, increased age, chronic renal failure, chronic obstructive pulmonary disease, and hypertension were not found as the risk factors of mortality.

Although duration of VAC was planned as 10 days in our clinical practice, as in previous studies, in some of the cases it was longer due to continuation of suppurative drainage. Mean duration of VAC until surgical closure was 16.8 (range, 4-37) days. The bacteriologic spectrum, identified in wound cultures, was found to be similar to the other studies with a majority of *staphylococcus aures* infection [Bovill 2008; Farinas 1995; Song 2003].

Fuchs et al reported that duration of hospital stay, intensive care unit stay, and mortality rates were higher in patients with VAC used prior to surgical closure when compared to the patients who underwent PSC [Fuchs 2005]. According to the review by Baillot et al, sternal stability and survival rates were found to be better in patients who underwent surgical closure after receiving VAC therapy [Baillot 2010]. In our experience, while duration of antibiotic therapy was similar in PSC and VAC groups, duration of treatment and mortality rate were higher in the PSC group.

The limitations of our study include the possibility of selection bias, the relatively small number of patients with a highly prevalent disease, lack of data for other adverse outcomes during the follow-up period, and the possibility of missing medical records to assess the survival status.

CONCLUSION

This study implicates that VAC prior to surgical closure may lead to lower mortality. Diabetes and additional heart operation were independent risk factors for mortality in the patients with post sternotomy suppurative mediastinitis. We believe that further prospective controlled studies with larger numbers of patients may require investigating additional risk factors.

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