

Rehospitalization with surgical site infections after cardiac surgery

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ABSTRACT

Objectives: This study aims to investigate rehospitalization rates in patients with surgical site infections (SSIs) after cardiac surgery.

Patients and methods: This cross-sectional study included a total of 153 patients (121 males, 32 females; mean age 58.7±10.9 years; range, 18 to 80 years) who underwent open heart surgery in our cardiovascular surgery clinic and readmitted with SSI within 30 days after surgery between September 2014 and December 2014. Risk factors which were related to the patient, surgery, and hospital stay were evaluated.

Results: Of the patients, 73.8% had coronary artery bypass grafting (CABG). A total of 22 patients (14.4%) were readmitted to hospital after discharge with SSI. Half of them had saphenous infections (superficial infection n=8, deep infection n=3), while the other half had sternal infections (superficial infection n=7, deep infection n=4). Nine of these patients were rehospitalized. The mean length of hospital stay was 14.2±3.8 (range, 10 to 20) days. The risk factors for SSI development included patient, surgery, and hospitalization and hospital setting.

Conclusion: Our study results show that several risk factors may play a role in the development of SSIs and rehospitalization. Therefore, it is recommended that nurses consider that SSI is certainly a major complication after cardiac surgery and the risks should be minimized during procedure and after discharge.

Keywords: Cardiac surgery, rehospitalization, surgical site infection.

Surgical site infections (SSIs) are serious perioperative complications which accounts for about 2% of surgical procedures and they may have a devastating impact on the course of treatment.^[1-3] These infections are also associated with increased treatment intensity and prolonged length of hospital stay, and higher cumulative healthcare costs and substantial morbidity and mortality rates.^[3]

Infectious complications after cardiac surgery, which occur in 5 to 21% of cases, are well-known and difficult-to-treat problems which increase patients' suffer, healthcare cost, and postoperative mortality rates by more than five times with prolonged recovery.^[4,5]

There are three types of SSI defined by the Centers for Disease Control and Prevention (CDC). According to the CDC, SSIs are classified as either incisional or organ/space with incisional SSIs being further subcategorized as superficial (involving only skin and subcutaneous tissue) and versus deep SSIs (involving underlying soft tissue).^[3,6]

In cardiac surgery, the most common sites of infections are the respiratory tract (45.7 to 57.8%), surgical site (27.7%), and catheters or devices (20.5 to 25.2%).^[5] Surgical site infections include superficial infections of the postoperative scar and deep wound infections.^[7] Superficial sternal wound infections complicate 0.5 to 8% of cardiac surgery cases and involve the skin, subcutaneous tissue, and pectoralis fascia. Deep sternal wound infections involve the sternal bone, substernal space, and mediastinum, but are less common than superficial sternal wound infections with an incidence ranging between 0.4 and 2%.^[5]

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The contamination of the operative site may be due to the patient's endogenous flora or to the surgical team's or operating room's exogenous flora and is often perioperative. In addition, some factors promote the occurrence of SSI from this contamination such as tissue necrosis, hematoma, foreign body of a prosthesis or of an implant, and poor vascularization.^[7]

Patients may be contaminated before, during, or after surgery, and any reoperation exposes to the risk of SSIs. The risk factors are related to three factors including patient, surgery, and hospitalization. Risk factors related to the patient are age, sex, obesity, diabetes mellitus (DM), respiratory insufficiency, stroke, heart failure, atrial fibrillation, smoking, peripheral vascular disease, renal failure, cardiogenic shock, and myocardial infarction (MI). Risk factors related to surgery are type of emergency, type of surgery, operation time, prolonged perfusion time, postoperative hemorrhage, early surgical revision for bleeding, steroids, prolonged mechanical ventilation, use of intra-aortic counterpulsation devices, blood transfusion, and reoperative heart surgery (redo) surgery. Risk factors related to hospitalization and hospital setting are duration of preoperative stay and patient preparation.^[2,5,7] These predictors may result in development of SSIs after cardiac surgery through three common physiological pathways: decreased collagen synthesis, vasoconstriction, and increased immunosuppression.^[3]

In the literature, several studies have been undertaken to identify high-risk patients for infectious complications in an attempt to modify risk factors. Early recognition of an infection is of utmost importance for optimal treatment and management of the patient.^[4]

In the present study, we aimed to investigate rehospitalization rates in patients with SSIs after cardiac surgery.

PATIENTS AND METHODS

This cross-sectional study was conducted at a university-affiliated hospital, located in Istanbul, Turkey between September 2014 and December 2014. A total of 153 patients (121 males, 32 females; mean age 58.7±10.9 years; range, 18 to 80 years) who underwent open heart surgery in our cardiovascular surgery clinic and readmitted with SSI within 30 days after surgery were included. *Inclusion criteria were as follows:* having open heart surgery via median sternotomy under standard cardiopulmonary bypass (CPB) including

coronary artery bypass grafting (CABG), valve repair, atrial/ventricular septal defect (ASD/VSD) repair surgery, aneurysm surgery, atrial mass excision, and redo surgery. *Exclusion criteria were as follows:* having heart transplantation and pacemaker implantation. A written informed consent was obtained from each patient. The study protocol was approved by the Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

The data were obtained with the Structured Patient Information Form which included demographic and perioperative data. The standard anesthesiology management, myocardial protection techniques, and ventilator-weaning process were performed. The perfusion temperature was allowed to decrease to 28°C during CPB and standard cold potassium cardioplegia solution was used for all patients. The patients were transferred directly from the operating room to the cardiovascular intensive care unit (CVICU). All patients were mechanically ventilated on synchronized intermittent mandatory ventilation (SIMV) with a tidal volume of 10 to 12 mL/kg, a respiratory rate of 10 to 12/min, and a fraction of inspired oxygen rate of 100%. The nurses evaluated the hemodynamic, neurological, and respiratory state of the patients. Once the patients were fully awake, the nurse made the decision to extubate the patient, if they met the extubation criteria. Education and training were also given to all patients before operation and before discharge about what they should pay attention. All patients were followed for 30 days after surgery for SSI development.

The preoperative variables were defined as the age, sex, body mass index (BMI), documented DM, renal failure, heart failure, respiratory insufficiency (chronic obstructive pulmonary disease [COPD]), peripheral vascular disease, cardiogenic shock, MI, and smoking. The intraoperative variables included type of emergency, type of surgery, duration of aortic cross-clamp and CPB, total operation time, blood transplantation, use of intra-aortic counterpulsation devices (i.e., intra-aortic balloon pump [IABP]), and redo rates. Other variables including the surgeon, anesthesiology technique, cardioplegia solution, and hypothermia were stable and they were not tested.

Statistical analysis

Statistical analysis was performed using the SPSS version 15.0 (SPSS Inc., Chicago, IL, USA). Descriptive

data were expressed in mean \pm standard deviation (SD) or number and frequency. The chi-square test, Fisher's exact test, Student's t-test, and Mann-Whitney U test were used to evaluate rehospitalization as the dependent variable and demographic and perioperative variables as the independent variables. A p value of $p < 0.05$ was considered statistically significant.

RESULTS

Of the patients, the mean BMI was 28.0 ± 4.2 kg/m². A total of 24.8% patients were smokers. The majority of the patients underwent CABG (n=113, 73.8%), followed by valve surgery (n=21, 13.7%), combined

CABG + valve surgery (n=9, 5.8%), ASD/VSD repair surgery (n=2, 1.3%), aneurysm surgery (n=2, 1.3%), atrial mass excision (n=2, 1.3%), and redo surgery (n=2, 1.3%). A total of 11 patients (7.2%) underwent an emergent surgical procedure. Baseline demographic and clinical characteristics of the patients are presented in Table 1.

A total of 22 patients (14.4%) readmitted with SSI. Eleven (50%) of them had saphenous infections (superficial infection n=8, deep infection n=3), while the remaining patients had sternal infections (superficial infection n=7, deep infection n=4). Culture examples were obtained from 14 of these patients and

Table 1
Demographic and preoperative variables of patients

	Rehospitalization (n=22)			Not rehospitalization (n=131)			Total (n=153)			<i>p</i>
	n	%	Mean \pm SD	n	%	Mean \pm SD	n	%	Mean \pm SD	
Age (year)			58.5 \pm 14.7			59.9 \pm 10.2			59.6 \pm 10.9	0.578
Sex										0.408
Female	6	27.3		26	19.8			20.9		
Male	16	72.7		105	80.2			79.1		
BMI			29.0 \pm 4.2			27.8 \pm 4.2			27.9 \pm 4.2	0.209
Life										0.331
Alone	2	9.1		7	5.3		9	5.9		
With family	20	90.1		124	94.6		144	94.1		
Smoking										0.002
Yes	12	54.5		26	19.8		38	24.8		
No	10	45.5		105	80.2		115	75.2		
Diabetes mellitus										0.374
Yes	9	40.9		41	31.3		50	32.7		
No	13	59.1		90	68.7		103	67.3		
Renal failure										0.003
Yes	3	13.6		0	0.0		3	2.0		
No	19	86.4		131	100.0		150	98.0		
Heart failure										0.217
Yes	0	0.0		13	9.9		13	8.5		
No	22	100.0		118	90.1		140	91.5		
Peripheral vascular disease										0.374
Yes	1	4.5		2	1.5		3	2.0		
No	21	95.5		129	98.5		150	98.0		
COPD										0.587
Yes	2	9.1		11	8.4		13	8.5		
No	20	90.9		120	91.6		140	91.5		
Cardiogenic shock										0.268
Yes	1	4.5		1	0.8		2	1.3		
No	21	95.5		130	99.2		151	98.7		
Preoperative myocardial infarction										0.691
Yes	8	36.4		42	32.1		50	32.7		
No	14	63.6		89	67.9		103	67.3		

SD: Standard deviation; BMI: Body mass index; COPD: Chronic obstructive pulmonary disease.

were found to be positive in eight. In total, 5.9% (n=9) and 41% (n=8) of SSI patients were rehospitalized. The mean length of hospital stay in these patients was 14.2±3.8 (range, 10 to 20) days (Figure 1).

Of a total of 22 patients who were rehospitalized, the majority was male (72.7%) with a mean age of 58.5±14.7 years and a mean BMI of 29.0±4.2 kg/m². However, there was no statistically significant difference between the patients with and without rehospitalization.

In terms of patient-related risk factors, there was no statistically significant difference between the patients with rehospitalization in terms of the living alone or with their family, DM, heart failure, peripheral vascular disease, COPD, cardiogenic shock, and MI before surgery (p>0.05). However, there was a statistically significant difference between the patients with rehospitalization in terms

of smoking and having renal failure (p<0.05) and a higher number of these patients were readmitted to hospital with SSI (Table 1).

In terms of surgery risk factors, there was a statistically significant difference only between the patients with rehospitalization with SSI in terms of the use of IABP (p<0.05). On the other hand, there was no statistically significant difference between the patients with rehospitalization with SSI in terms of the type of emergency, type of surgery, CPB, aortic cross-clamp time, operation time, and blood transfusion. In addition, there was no statistically significant difference between the patients with rehospitalization with SSI in terms of having normal or higher blood glucose level (Table 2). In terms of hospitalization and hospital setting, all patients received the same preparation to surgery and were hospitalized in the same hospital the day before surgery. After surgery,

Table 2
Intra- and postoperative data of patients

	Rehospitalization (n=22)			Not rehospitalization (n=131)			Total (n=60)			p
	n	%	Mean±SD	n	%	Mean±SD	n	%	Mean±SD	
Type of surgery										0.367
Elective	22	100.0		120	91.6		142	92.8		
Emergency	0	0.0		11	8.4		11	7.2		
Cardiopulmonary bypass time (min)			117.4±42.7			112.0±45.7			112.8±45.2	0.459
Aortic cross-clamping time (min)			78.2±38.1			74.8±35.2			75.3±35.5	0.706
Operation time (h)			4.7±0.9			4.5±1.0			4.5±1.0	0.488
Stay in CVICU (h)			32.1±18.9			36.8±25.5			36.1±24.7	0.224
IABP used										0.039
Yes	3	13.6		3	2.3		6	3.9		
No	19	86.4		128	97.7		147	96.1		
Blood Tx in CVICU										0.785
Yes	18	81.8		101	77.1		119	77.8		
No	4	18.2		30	22.9		34	22.2		
Blood Tx in Clinic										1.000
Yes	3	13.6		18	13.7		21	13.7		
No	19	86.4		113	86.3		132	86.3		
Blood glucose regulation in CVICU										0.532
Normal	9	40.9		63	48.1		72	47.1		
High	13	59.1		68	51.9		81	52.9		
Blood glucose regulation after CVICU										0.976
Normal	12	54.5		71	54.2		83	54.2		
High	10	45.5		60	45.8		70	45.8		
Length of stay in hospital (day)			8.9±4.1			7.9±3.2			8.0±3.3	0.081

SD: Standard deviation; CVICU: Cardiovascular intensive care unit; IABP: Intra-aortic balloon pump; Tx: Transplantation/transfusion.

Table 3
Patient data after discharge

	Rehospitalization (n=22)		Not rehospitalization (n=131)		Total (n=60)		p
	n	%	n	%	n	%	
Wound appearance before discharge							0.540
Clean	21	95.5	128	97.7	149	97.4	
Swollen	1	4.5	3	2.3	4	2.6	
Bath after discharge							0.020
Yes	20	90.9	131	100.0	151	98.7	
No	2	9.1	0	0.0	2	1.3	
Bath frequency							0.110
Everyday	1	4.5	0	0.0	1	0.7	
Every other day	6	27.3	39	29.8	45	29.4	
Once a week	14	63.6	87	66.4	101	66.0	
Two in a week	1	4.5	5	3.8	6	3.9	

the mean length of stay in hospital was 8.9 ± 4.1 days in rehospitalization patients and 7.9 ± 3.2 days in non-SSI patients. There was no statistically significant difference between the patients with rehospitalization with SSI in terms of the length of stay in hospital ($p > 0.05$) (Table 2).

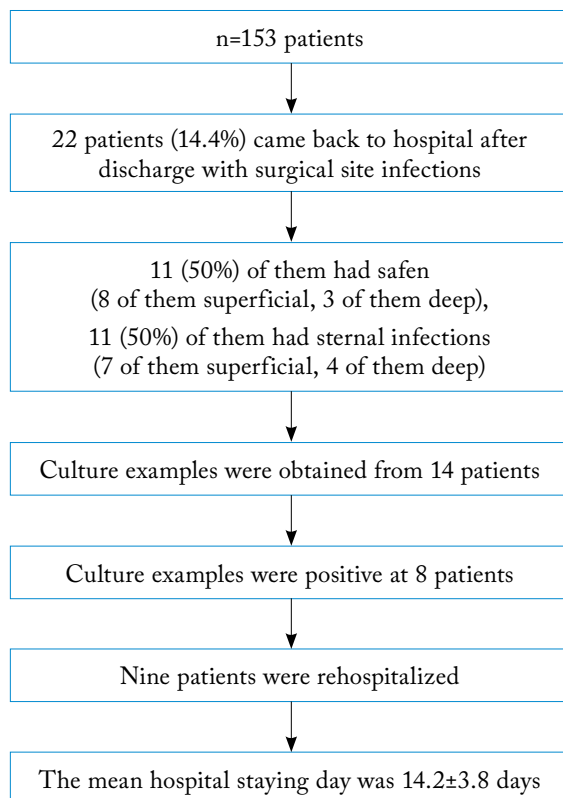


Figure 1. Flow chart of rehospitalization of patients after cardiac surgery.

On the other hand, we found a statistically significant difference between the patients with rehospitalization with SSI in terms of having bath after discharge ($p < 0.05$) and having bath was associated with decreased SSI rates (Table 3).

DISCUSSION

Surgical site infections have a negative effect on the postoperative recovery period. They are associated with increased treatment intensity, prolonged length of stay, higher costs, morbidity, and mortality.^[1,3,8-10] Major postoperative infections including bloodstream infections and SSIs occur in up to 5% of patients after cardiac surgery.^[10,11]

The reported incidence of infectious complications after cardiac surgery has ranged between 5 to 21% of cases.^[12] While superficial sternal wound infections include skin, subcutaneous tissue and pectoralis fascia, deep sternal wound infections involve the sternal bone, substernal space and the mediastinum, and occur in 0.5 to 8% and 0.4 to 2% respectively.^[5] In this study, the SSI rates were found to be similar with the literature.

Hannan et al.^[13] and Li et al.^[14] reported an all-cause readmission rate of 16.5 and 13.2%, respectively within 30 days of CABG. Both aforementioned authors concluded that postoperative infection was the most common reason for rehospitalization, consistent with our study findings.

The mortality rate of patients who develop SSI after cardiac surgery is significantly higher than those without SSI, ranging between 22 and 40%.^[3] In our study, there were no infection-related mortality.

In recent years, there are many attempts to identify predictors for the development of SSI after cardiac surgery in the field of surgery.^[3] The management of SSI is complex and prevention according to the risk factor modification offers the most effective intervention. A host of independent risk factors have been identified for SSIs.^[5] These predictors have been also examined in terms of patient, surgery, and hospitalization.

The patient-related predictors are age (>85 years), sex, obesity (BMI >30 kg/m²), concomitant diseases (i.e., COPD, respiratory failure, renal failure and hemodialysis, DM, cardiogenic shock, history of MI, and aortic calcification), the use immunosuppressive agents, and smoking. Risk factors for surgery are type of surgery (combined valve + CABG and aortic procedures), reexploration (reopening) for bleeding, blood transfusions, CPB time, and using IABP. Risk factors for hospitalization are preoperative length of stay in hospital more than three days, and preparation of the patient for surgery.^[5,15,16] In this study, the age, sex, BMI, DM, heart failure, peripheral vascular disease, COPD, cardiogenic shock, and preoperative MI did not show a significant correlation with SSIs. However, smoking and renal failure were significantly associated with SSI development.

Several studies demonstrated that age, female sex, high preoperative serum glucose levels (>200 mg/dL), DM, obesity, and smoking were statistically significantly correlated with SSI development.^[11,17,18] Bhatia et al.^[17] reported that, in patients over the age of 66 years, the changes of developing wound infections were twice as high as in patients aged between 21 and 50 years.

On the other hand, there are conflicting reports on sex as a risk factor for SSI development. Some authors have reported an increased risk, while some others have shown a decreased risk in males.^[19] There are also reports showing no significant correlation between sex and SSI development. Rogers et al.^[20] reported that women were more likely to receive allogeneic red blood cells or platelets than men. The authors found that patients who received allogeneic blood were 4.4 times more likely to develop an infection than those who did not and women had a greater risk of infection.

Kanafani et al.^[21] and Fowler et al.^[11] reported that a BMI of >40 kg/m², chronic renal failure with hemodialysis, and chronic lung disease had a higher risk of developing major infections after cardiac

surgery. In addition, Rahmanian et al.^[22] reported that a BMI value of exceeding 30 kg/m² and diabetes were the main predictors for SSI development.

Furthermore, several studies have shown that obesity has a weak correlation with SSI and having sternotomy.^[23] The possible reason for obesity being a risk factor include ineffective dose of prophylactic antibiotics, difficulty in proper skin preparation, adipose tissue providing a good substrate for infection and difficulties in vascular graft harvesting.^[17]

Diabetes, particularly uncontrolled diabetes, is a significant independent risk factor for the development of SSI in perioperative cardiac surgical patients.^[3,11,16,17,24] High perioperative blood glucose concentrations have been identified as a risk factor for SSI after cardiothoracic surgery.^[15,21,25] In patients with diabetes, postoperative hyperglycemia has been also associated with adverse outcomes such as death, MI, stroke, and septic complications before hospital discharge.^[3,21,25-27] Maintaining a serum glucose of <180 mg/dL with continuous insulin infusions in patients with and without DM reduces morbidity and mortality, lowers the incidence of sternal wound infections, shortens hospital length of stay, and improves long-term survival.^[28] Poor glycemic control prior to surgery, however, contributes to poor diabetes control after hospital discharge and increases the incidence of complications, such as poor wound healing and higher rates of SSI, and rehospitalization and increased mortality, eventually.^[29,30] It is likely that the benefits of glucose control extend to cardiac surgical patients, as most of the large-scale glucose control studies included cardiothoracic surgery patients and as poor glucose control is associated with a higher risk of SSI.^[5,31,32]

In this study, CPB time, aortic cross-clamp time, operation time, length of stay in the ICU, blood transfusion, blood glucose regulation, and type of surgery did not show a significant correlation with the SSI development. However, the use of IABP was found to be significantly associated with the SSI development.

In our study, the mean duration of surgery was 4.5±1.0 (min: 2-max: 8) hours. Duration of surgery may be also a risk factor. Operations lasting for more than two hours are known to be associated with increased infection rates.^[17] Fowler et al.^[11] reported that infections were associated with perfusion time (200 to 300 min), placement of IABP, and the presence of three or more distal anastomoses.

In recent studies, blood transfusion has been identified as an independent risk factor. Blood transfusion is associated with impaired immunocompetence.^[17] Although transfusion may be necessary to prevent or treat tissue hypoxia, the immunomodulatory effects of allogeneic blood transfusion have been recognized for decades. Transfusion-related immunomodulation has been also shown to result in an increased risk of nosocomial infections and mortality in many patient cohorts.^[3] Rogers et al.^[20] reported that patients who received allogenic blood transfusion were four times more likely to develop infection after cardiac surgery. However, in our study, there was no statistically significant correlation between the use of blood transfusion and rehospitalization.

Postoperative SSI increased the length of hospital stay and cost in proportion to the severity of infection. The cost increased by 3.8%, 14.7%, and 29.4% in mild, moderate, and severe infections, respectively.^[17] In a study, the length of hospital stay was found to be 5.9 and 15 days, respectively.^[17] Fowler et al.^[11] showed that 47% of cardiac surgery patients with SSI required more than 14 days in the hospital. In another study, the presence of SSI prolonged the length of stay by about 9.7 (range, 6 to 14) days.^[3] This increase in the length of stay is also consistent with our study findings.

Skin preparation for surgery is one of the key elements to prevent postoperative infections. Investigating skin preparation modalities, such as hair removal and preoperative antiseptic showering, would build further evidence for best nursing practice and help nurse managers to develop and implement a protocol for appropriate preoperative skin preparation.^[2,3]

Although postoperative wound care and dressing is well-investigated in the literature, there is a limited number of data regarding the timing for the first dressing as the predictor for SSIs. Timing of the first postoperative dressing affects the inflammatory phase of wound healing.^[33] The duration of the inflammatory phase of wound healing is about two to three days. Investigating whether to cover the wound for two to three days affects the wound infection rate would be helpful to develop and implement a protocol for the wound care postoperatively.^[3]

In their study, Dal et al.^[34] reported that, after discharge, 24.5% of patients experienced a problem related to caring at home, 60.4% had surgery wound

infections, and 63.5% patients were readmitted to hospital. Good discharge planning and home-based care services would improve patient recovery following surgery and prevent complications. Postoperative bathing and showering may also remove the dead skin cells, dirt, microorganisms, and sweat that have collected around the wound edges. It may also reduce contamination of the surgical site, help to prevent infection, and promote wound healing.^[35,36] However, in a study, Toon et al.^[36] reported no statistically significant difference in the rate of SSI development between the patients having early versus late postoperative bathing. In another study, Ucar^[37] also reported that the postoperative rate of infectious complications was similar in patients having early versus late postoperative bathing.

This study has some limitations. First, all of the patients studied were from a single academic medical center, and our results may not represent patients developing SSI in other institutions. Second, this study does not take into account the socioeconomic status that may lead to infection development while addressing some factors affecting the development of infection.

In conclusion, infectious complications can be reduced with many simple measures, starting with risk factor modification at the first anesthetic preoperative screening visit thorough to postoperative risk factor vigilance in the intensive care unit and after discharge. Nurse-led reminder systems, care bundles, admission order sets, and discharge protocols appear to be particularly effective at meeting the quality targets in the management of Surgical site infections.^[3,38] Of note, Surgical site infections are certainly major complications of cardiovascular surgery. It should be, therefore, kept in mind that risk factors should be minimized during the procedure to employ more effective preventive measures for postoperative wound infections.

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