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Incidence and Outcomes of Surgical Site Infections after Adult Cardiac Surgery: A Single-Center Experience

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Abstract

Background: Surgical site infections (SSIs) remain a challenging medical problem, especially in cardiac surgery patients. There is a lack of studies evaluating the rate of and outcomes of SSIs following cardiac surgeries in Saudi Arabia. **Aims:** This study aimed to determine the incidence of SSIs after adult cardiac surgeries that were done in Madinah Cardiac Center, Saudi Arabia. Further, to identify the outcomes and risk factors contributing to death among surgical site infection patients. **Methods:** This was a 6-year, single-center, retrospective cohort study that included 93 consecutive patients who underwent adult cardiac surgery between August 2016 and August 2022. All adult patients aged 18 years or older who had clinical evidence of postoperative surgical wound infection were included. Preoperative, operative, and postoperative data (early and late) were collected from medical records. Microbiological culture reports and clinical outcomes were also recorded. **Results:** The study revealed a 9.1% (93/1021) incidence rate of SSIs. Of the 93 patients with SSIs, 60 had superficial incisional infections and 33 had deep infections with incidence rates of 5.9% and 3.2%, respectively. In-hospital mortality due to SSI was recorded in 4 out of 93 patients with an incidence rate of 4.3%. There was a significant association between the in-hospital mortality and the type of SSIs (p = 0.014). All non-survivors had deep SSIs. The type of cardiac surgery also showed a significant association with the in-hospital mortality ($p = 0.017$). Furthermore, the median duration of antibiotic administration was significantly longer in the non-survivors than in the survivors (72.5 vs 17, respectively, $p < 0.001$). **Conclusions:** In conclusion, the incidence of surgical wound infections following cardiac surgery is not low (9.1%); of which 3.2% were deep infections. The in-hospital mortality rate after treatment of SSIs was fortunately low (4.3%), and all non-survivors had deep SSIs. The non-survivors showed a significantly longer duration of antibiotics administration than survivors. Combined CABG and valve procedures showed a higher mortality rate (75%) than the isolated procedures.

Keywords

Surgical Site Infection, Cardiac Surgery, Mortality, Risk Factors, Outcomes

1. Introduction

Surgical site infections (SSIs) are postoperative wound infections that occur within 30 or 90 days of operation. They are one of the most important complications in surgical patients and remain a challenging medical problem, especially in cardiac surgery patients [1].

Sternal wound and graft harvesting site infections are the most common SSIs in cardiac surgery patients. Surgical wound infections might be superficial involving the skin, subcutaneous tissue, and the pectoralis fascia of the incision, or deep including the deep soft tissues under the fascial layer. Serious forms of deep SSIs include mediastinitis, sternal osteomyelitis, and/or retrosternal space infections [2] [3].

The cause of SSIs is primarily the microbes on the patient's skin or bacterial colonization within the genital or gastrointestinal tracts. Most previous studies revealed that *Staphylococcus aureus* is the most frequent pathogen responsible for cardiac surgical site infections [4] [5].

Several studies have identified that old age, male gender, obesity, diabetes mellitus, chronic lung disease, combined surgical procedures, long duration of operation, redo operations, use of bilateral internal mammary arteries, transesophageal echocardiography, blood transfusions, surgical re-exploration for bleeding, postoperative respiratory failure with prolonged intensive care unit stay as risk factors which increase the incidence of SSIs [6] [7] [8] [9] [10].

Surgical site infections are associated with poorer prognosis of cardiac surgery patients with increased morbidity and mortality. These infections are associated with deterioration in the postoperative quality of life, prolonged recovery, and longer hospital stays. In addition, the occurrence of SSIs poses a significant burden on resources with substantial health care costs [11] [12].

Studies that evaluated surgical site infection patients after cardiac surgery in Saudi Arabia are scarce. Moreover, none of them investigated the prognostic factors related to survival following the development of SSIs. Therefore, this study aimed to determine the incidence of SSIs after cardiac surgeries that were done in Madinah Cardiac Center (MCC), Saudi Arabia, further, to identify the outcomes and risk factors contributing to death among surgical site infection patients.

2. Methods

2.1. Study Design, Settings, and Duration

This was a 6-year, single-center, retrospective cohort study that included consecutive patients who underwent cardiac surgery at Madinah Cardiac Center, Saudi Arabia between August 2016 and August 2022.

2.2. Ethical Considerations

The study was conducted following the principles of Good Clinical Practice and the Declaration of Helsinki, and its research protocol was approved by the Institutional Review Board of General Directorate of Health Affairs in Madinah, Saudi Arabia (ID: 23-037). The requirement for informed consent was waived because this was a retrospective observational study. The confidentiality of the included database was kept by giving a code number for every patient.

2.3. Eligibility Criteria

The study included all adult patients aged 18 years or older who underwent cardiac surgery and had clinical evidence of postoperative surgical wound infection before they were discharged from the hospital. The diagnosis of surgical wound infection was based on fever > 38˚C, chest pain, and purulent discharge, besides a positive bacterial culture with $\geq 10^5$ colony-forming units. Patients aged less than 18 years, did not undergo cardiac surgery or did not experience postoperative surgical wound infections were excluded. In addition, we excluded medical records with incomplete data.

2.4. Data Collection

The following data were collected from the medical records: sociodemographic and medical characteristics including age, gender, smoking, alcohol consumption, body mass index, chronic diseases, and past medical history. Operative characteristics such as type of cardiac surgery and if the operation is emergency or redo. Intraoperative factors such as duration of surgery and extra-corporeal circulation, ischemia time, and degree of hypothermia. Postoperative data including using intra-aortic balloon pump, inotropic score, duration of mechanical ventilation, re-intubation, using tracheotomy, duration of enteral and parenteral nutrition, re-operation, complications in the cardiovascular Intensive Care Unit (CVICU), readmission to the CVICU, length of stay in the CVICU, length of hospital stay. Perioperative transfusions such as the number of red blood cells, fresh frozen plasma, and platelet transfused units. Management of the SSIs including the use of antibiotics, surgical vacuum, and sternal rewiring. Microbiological culture reports, and clinical outcomes which included the in-hospital mortality or hospital discharge.

Samples for culture and sensitivity were collected through deep swabbing, tissue collection, and pus aspiration. Confirmation of retrosternal space collection was accomplished by a computed tomography scan of the chest.

Postoperative surgical wound infections were classified into either superficial, where the infection was limited to the skin and subcutaneous tissue, or deep, where the infection was associated with osteomyelitis of the sternum with or without retrosternal space infection [13] [14].

As part of standard MCC policy, all patients underwent screening nasal swabs before cardiac surgery. Positive cultures were treated with appropriate local antibiotics, then cultures were repeated to confirm complete eradication. Further, antimicrobial prophylaxis was provided to all patients from the time of intubation to a maximum of 72 hours.

2.5. Statistical Analysis

All data were tabulated and analyzed by the statistical package for the social sciences software program, IBM SPSS Statistics for Windows, version 26 (IBM Corp., Armonk, N.Y., USA). The incidence of SSIs was calculated. Continuous data that followed normal distribution were reported as mean ± standard deviation (SD) and were compared using The Student T-test, while those that were not normally distributed were represented as median with interquartile range and were compared using the Mann-Whitney U test. Categorical variables were reported as frequencies and percentages and were compared by the Chi-Square or Fisher's Exact tests as appropriate. The candidate variables that showed significant differences ($p < 0.05$) between survivors and non-survivors in the univariate analysis were included in a multivariable logistic regression analysis with a stepwise forward selection procedure. The obtained results were presented as adjusted odds ratios (AOR) to the coexistence of other predictors and their 95% confidence intervals (CI). A p-value < 0.05 was considered statistically significant.

3. Results

In this study, out of the 1021 adult patients who underwent cardiac surgery and were assessed for eligibility, 921 were excluded because they did not experience postoperative surgical site infections (SSIs). Seven patients were also excluded due to incomplete data. The study included 93 patients with confirmed SSIs with an incidence rate of 9.1% (93/1021). Of the 93 patients with SSIs, 60 had superficial incisional infections and 33 had deep infections with incidence rates of 5.9% and 3.2%, respectively (**Figure 1**). The sternum (65.6%) was the most common site of infection, followed by the lower limb (23.7%), while 10 (10.8%) patients developed both sternal and lower limb infections. Cultures were positive in all cases and the most commonly isolated pathogen was Staphylococcus (35.6%),

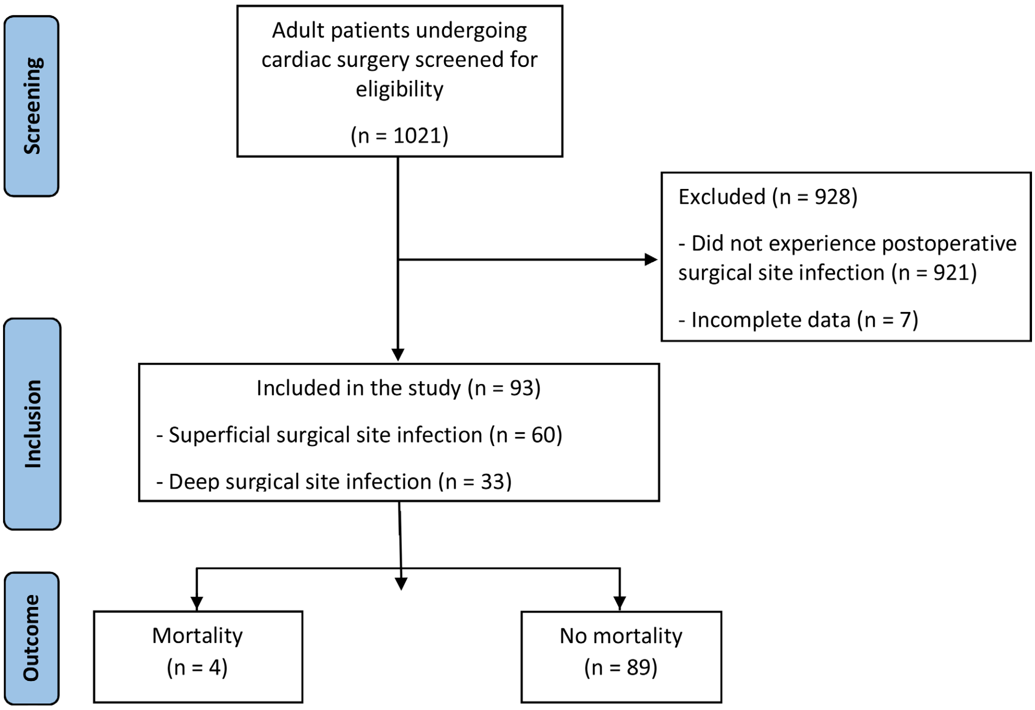

Figure 1. Patient selection flow chart.

followed by Klebsiella pneumoniae (ESBL) (16.1%) and Escherichia Coli (ESBL) (14.0%).

Patients with SSIs showed a mean age of 57.4 ± 12.0 years, with predominance of male sex (67.7%). About one-third (31.2%) of them were smokers, and one (1.1%) patient was alcoholic. Obesity was detected in 34 (36.6%) patients. The medical history of these patients revealed diabetes mellitus (76.3%), hypertension (62.4%), dyslipidemia (23.7%), unstable angina (35.5%), chronic obstructive pulmonary disease (18.3%), pulmonary hypertension (9.7%), chronic renal disease (6.5%), peripheral vascular disease (8.6%), and recent myocardial infarction (48.4%). The preoperative ejection fraction was less than 50% in 45 (48.4%) patients. The most common cardiac surgery was CABG, which was either isolated (62.4%) or combined with valve procedures (18.3%), followed by isolated valve repair or replacement surgeries (18.3%). The operation was done as an emergency in 14 (15.1%), and as a redo surgery in 2 (2.2%) patients. In CABG surgeries, the number of grafts was either one (9.3%), two (33.3%), three (41.3%), or four (16.0%). The frequency of using skeletonized mammary or endoscopic veins was comparable (23.7% and 22.4%, respectively). The mean duration in the operative room was 5.7 ± 1.4 h. During the operations, hypothermia was recorded in 61 (65.6%) patients, the median cardiopulmonary bypass time was 122.0 (IQR: 97.0 - 146.0) min, while the median cross-clamp time was 81.0 (IQR: 55.0 - 103.0) min. Transfusions of red blood cells, fresh frozen plasma, and platelets were done with median amounts of 750.0, 250.0, and 150.0 cc, respectively (Table 1).

Table 2 shows the postoperative management and outcomes of SSI patients.

Table 1. Demographic, preoperative, and operative characteristics of the studied patients (n = 93).

Variable	n (%)
Age, year, mean ± SD	57.4 ± 12.0
Female	30 (32.3%)
Male	63 (67.7%)
Smoking	29 (31.2%)
Alcohol	1 (1.1%)
Obesity (BMI ≥ 30 kg/m^2)	34 (36.6%)
Diabetes mellitus	71 (76.3%)
Hypertension	58 (62.4%)
Dyslipidemia	22 (23.7%)
Unstable angina	33 (35.5%)
Pulmonary hypertension	9 (9.7%)
Chronic obstructive pulmonary disease	17 (18.3%)
Chronic renal disease	6 (6.5%)
Peripheral vascular disease	8 (8.6%)
Hospital stroke	6 (6.5%)
Recent myocardial infarction	34 (36.6%)
Preoperative EF < 50%	45 (48.4%)
Preoperative EF ≥ 50%	48 (51.6%)
Isolated CABG	58 (62.4%)
Isolated valve repair or replacement	17 (18.3%)
Combined CABG and valve procedures	17 (18.3%)
Ascending Aorta replacement	1 (1.1%)
Emergency operation	14 (15.1%)
Redo Surgery	2 (2.2%)
One graft	7 (9.3%)
Two grafts	25 (33.3%)
Three grafts	31 (41.3%)
Four grafts	12 (16.0%)
Skeletonized mammary	18 (23.7%)
Endoscopic vein	17 (22.4%)
Hypothermia < 35	61 (65.6%)
Duration of operation, hour, mean ± SD	5.7 ± 1.4
CBP time, minute, median, IQR	122.0 (97.0 - 146.0)

Continued

Coss clamp time, minute, median, IQR	81.0 (55.0 - 103.0)
RBCs transfusion, cc, median, IQR	750.0 (500.0 - 1500.0)
FFP transfusion, cc, median, IQR	250.0 (200.0 - 400.0)
Platelets transfusion, cc, median, IQR	150.0 (115.0 - 240.0)

BMI: Body mass index, CABG: coronary artery bypass graft, EF: ejection fraction, RBCs: red blood cells, FFP: fresh frozen plasma, SD: standard deviation, IQR: interquartile range, CBP: cardiopulmonary bypass.

Table 2. Postoperative management and outcomes of the studied patients (n = 93).

Variable	n (%)
Low Inotropic Score	34 (36.6%)
Moderate Inotropic Score	34 (36.6%)
High Inotropic Score	25 (26.9%)
Intra-aortic balloon pump	10 (10.8%)
Mechanical ventilation, day, median (IQR)	3.0 (1.0 - 4.0)
Postoperative CPAP	24 (25.8%)
Reintubation	8 (8.6%)
Tracheostomy	10 (10.8%)
Enteral nutrition	79 (84.9%)
Parenteral nutrition	10 (10.8%)
Antibiotic duration, days, median (IQR)	17.0 (12.0 - 28.0)
Sternal rewiring	43 (46.2%)
Secondary wound closure	50 (53.8%)
Surgical vacuum (VAC)	40 (43.0%)
Fever in the first postoperative week	28 (30.1%)
Highest WBCs in the first postoperative week, $\times 10^3$, median (IQR)	13.0 (9.0 - 16.0)
Postoperative stroke	4 (4.3%)
Postoperative pleural effusion	34 (36.6%)
Reopening for bleeding	15 (16.1%)
Readmission to CVICU	16 (17.2%)
CVICU stay, day, median, IQR	6.0 (4.0 - 9.0)
Hospital stay, day, median (IQR)	23.0 (15.0 - 31.0)
In-hospital mortality	4 (4.3%)

WBCs: white blood cells, CVICU: cardiovascular intensive care unit, CPAP: continuous positive airway pressure, IQR: interquartile range.

Inotropes were used with an inotropic score of low, moderate, or high (36.6%, 36.6%, and 26.9%, respectively). Ten (10.8%) patients required an intra-aortic balloon pump. All patients were mechanically ventilated with a median duration of 3.0 (IQR: 1.0 - 4.0) days, and postoperative continuous positive airway pressure was used in 24 (25.8%) patients. The frequency of reintubation and tracheostomy was 8.6% and 10.8%. Seventy-nine (84.9%) patients were on enteral nutrition, while 10 (10.8%) needed parenteral nutrition. Antibiotics were used with a median duration of 17.0 (12.0 - 28.0) days. A surgical vacuum was applied in 40 (43.0%) patients. Sternal rewiring was performed in 43 (46.2%), whereas in 50 (53.8%) patients, the wound closure was by secondary intention. The incidence rates of postoperative stroke, pleural effusion, reopening for bleeding, and readmission to the cardiovascular intensive care unit (CVICU) were 4.3%, 36.6%, 16.15, and 17.2%, respectively. The median length of stay in the CVICU and the hospital were 6.0 (IQR: 4.0 - 9.0) and 23.0 (IQR: 15.0 - 31.0) days, respectively. In-hospital mortality due to SSI was recorded in 4 out of 93 patients with an incidence rate of 4.3%.

We found a significant association between the in-hospital mortality and the type of SSIs ($p = 0.014$). All (100.0%) non-survivors had deep SSIs. The type of cardiac surgery also showed a significant association with the in-hospital mortality ($p = 0.017$). Three out of the four (75%) non-survivors underwent combined CABG and valve procedures. Furthermore, the median duration of antibiotic administration was significantly longer in the non-survivors than in the survivors (72.5 vs 17, respectively, $p < 0.001$). Alternatively, none of the potential risk factors including age, gender, obesity, diabetes mellitus, isolated pathogen whether Staph or not, site of infection whether sternal or in the lower limb, emergency operation, redo surgery, the use of surgical vacuum, sternal rewiring versus secondary wound closure showed significant association with in-hospital mortality of SSIs patients (**Table 3**).

A multivariable forward stepwise logistic regression analysis revealed that the duration of the antibiotic administration (related to the continuous positive wound culture and high inflammatory markers) was the only significant predictor of in-hospital mortality ($p = 0.004$). Patients who showed prolonged antibiotic administration were 1.070 times more likely to die (AOR: 1.070, 95% CI: 1.022 - 1.120). Other candidate variables including the types of cardiac surgery and the type of surgical wound infection whether superficial or deep were not significant independent predictors of death (**Table 4**).

4. Discussion

Surgical site infections represent a considerable burden for healthcare systems and have a great effect on postoperative outcomes. There is a lack of studies evaluating the rate of and outcomes of SSIs following cardiac surgeries in Saudi Arabia. Thus, this retrospective cohort study was conducted to explore more about the incidence and outcomes of cardiac surgery patients with SSIs and the risk factors contributing to death. This will provide a benchmark for comparing national and international data.

The current study revealed that the incidence of SSIs following cardiac surgery

Table 3. Factors associated with in-hospital mortality among patients having surgical site infections after cardiac surgeries.

		Surgical site infections (n = 93)				
		Survivors (n = 89)		Non-survivors (n = 4)		p-value
		n	%	n	%	
Age, year	Mean ± SD	57.2 ± 11.9		62.3 ± 16.2		0.413
Gender	Female	29	32.6%	1	25.0%	1.000
	Male	60	67.4%	3	75.0%	
Type of SSIs	Deep	29	32.6%	4	100.0%	0.014*
	Superficial	60	67.4%	0	0.0%	
Isolated pathogen	Staphylococcus	30	33.7%	3	75.0%	0.126
	Non-Staphylococcus	59	66.3%	1	25.0%	
Site of SSIs	Sternal	58	65.2%	3	75.0%	0.267
	Lower limb	22	24.7%	0	0.0%	
	Both	9	10.1%	1	25.0%	
Obesity	No	57	64.0%	2	50.0%	0.621
	Yes	32	36.0%	2	50.0%	
Diabetes mellitus	No	20	22.5%	2	50.0%	0.237
	Yes	69	77.5%	2	50.0%	
Type of cardiac surgery	Isolated CABG	58	65.2%	0	0.0%	0.017*
	Isolated valve procedures	16	18.0%	1	25.0%	
	Combined CABG and valve procedures	14	15.7%	3	75.0%	
	Ascending Aorta replacement	1	1.1%	0	0.0%	
Emergency operation	No	76	85.4%	3	75.0%	0.485
	Yes	13	14.6%	1	25.0%	
Redo Surgery	No	87	97.8%	4	100.0%	1.000
	Yes	2	2.2%	0	0.0%	
Inotropic Score	Low	32	36.0%	2	50.0%	1.000
	Moderate	33	37.1%	1	25.0%	
	High	24	27.0%	1	25.0%	
Surgical VAC	No	51	57.3%	2	50.0%	1.000
	Yes	38	42.7%	2	50.0%	
Wound closure	Secondary wound closure	48	53.9%	2	50.0%	1.000
	Sternal rewiring	41	46.1%	2	50.0%	
Duration of antibiotic, day	Median (IQR)	17 (11 - 26)		72.5 (65 - 99)		<0.001*

SD: standard deviation, SSI: surgical site infection, CABG: coronary artery bypass graft, * Significant at $p < 0.05$.

Table 4. A multivariable forward stepwise logistic regression model for identifying risk factors of in-hospital mortality among patients having surgical site infections after cardiac surgeries.

Parameters	Beta coefficient	p-value	AOR	95% CI of AOR		Accuracy	p-value
				Lower	Upper		
Antibiotic duration, days	0.068	0.004*	1.070	1.022	1.120	96.8%	<0.001*
Constant	−6.418	<0.001*					

AOR: adjusted odds ratio, CI: confidence interval, *Significant at $p < 0.05$.

was 9.1%, with superficial (skin and subcutaneous tissue) and deep infections (osteomyelitis with/without retrosternal space collection) rates of 5.9% and 3.2%, respectively. These figures reflect the rate of SSIs developed at the sternum, lower limb, or both among a composite of patients who underwent isolated or combined cardiac procedures with various severity of cardiac conditions. A previous study in Saudi Arabia at King Khalid University Hospital, Riyadh revealed a lower incidence (3.5%) of SSIs of which 2.5% were superficial and 0.7% were deep [14]. Another Saudi study at King Fahad Armed Force Hospital, Jeddah reported a 6.4% incidence of SSIs at 30 days after discharge; out of which 4.5% were superficial and 1.9% were deep wound infections [15]. A study in Dubai, United Arab Emirates reported a 3.6% incidence of SSIs in patients who underwent CABG surgery [16]. On the other hand, a study from Egypt reported a high (18.36%) incidence of sternal wound infections but 15.3% of these infections were superficial [17]. Recent studies from Switzerland [18], France [8], Australia [19], and the United Kingdom reported an incidence of sternal wound infections of 0.5% to 7.8%. Further, Lemaignen *et al.* [8] and Lazar *et al.* [2] reported that superficial SSIs range from 0.5% to 8%, while the incidence of deep infections differed between 0.5% and 5.6% [9] [10]. More wider range of sternal wound infections ranging from 0.9% up to 20% has been reported by earlier studies from various geographic regions [20] [21] [22].

It seems that SSIs remain a major challenge despite proper precautions, and the observed discrepancy in their incidence rates after cardiac surgery are attributed to differences in patients' profile, the adopted SSI definition and classification, and the type of cardiac operation [1]. However, the quality of the institution's local epidemiological surveillance and care have an important role in controlling the incidence of infection. Following SSI prevention policies such as appropriate hand hygiene and antibiotic prophylaxis practices and strict monitoring by the institution's infection control department can help control the rates of postoperative infections [23]. Moreover, the use of the surgical safety checklist and targeted perioperative intervention strategies are essential to minimize the rates of this challenging complication [24].

Regarding the cause of SSIs, the most commonly isolated pathogen in this study was Staphylococcus (35.6%), followed by *Klebsiella pneumoniae* (ESBL) (16.1%) and *Escherichia coli* (ESBL) (14.0%). A corresponding study at King

Khaled, Riyadh, Saudi Arabia reported a predominance of *Staph aureus* (57.5%) [14]. Another study at a cardiac center in the Eastern region of Saudi Arabia reported a common isolation of *S. epidermidis* from superficial wound infections [25]. Other studies also indicated that *Staphylococcus aureus* and *S. epidermidis* are the most common pathogens that cause infections following cardiac surgery [26] [27].

Infections at the surgical wound remain a major cause of concern after cardiac surgery. They have a negative impact on the patient's outcomes. The occurrence of SSIs leads to increased duration of hospital stay and increased morbidity and hospital costs. The estimated costs for patients with sternal wound infections were 2.8 times that for patients with uncomplicated postoperative courses. Surgical site infections are also associated with an increased incidence of death after cardiac surgery [1] [3] [28].

In the present study, 4 out of 93 patients with SSIs have died with an incidence rate of 4.3%. Furthermore, there was a significant association between in-hospital mortality and the type of surgical wound infection, whereas all (100.0%) non-survivors had deep SSIs. In this context, the reported mortality rate for patients with deep sternal infections was high and ranged from 3% to 24.7% in different studies [1] [29]. A recent meta-analysis of patients with a deep sternal wound infection after cardiac surgical procedures concluded an increased risk of the overall death rate among these patients [28].

Two previous studies suggested that some of the established risk factors for deep sternal wound infections including higher age, diabetes mellitus, and an increased preoperative risk of death appear to be also predictors of a poor outcome after the treatment of this infection [30] [31]. It has been also reported that the female sex, a longer ICU stay, a prolonged duration of the primary operation and the use of the internal thoracic artery negatively impact the survival rate in patients with deep sternal wound infections [32]. However, Hämäläinen and coworkers [33] recently concluded that the quality of surgical treatment of deep sternal wound infections as well as accurate postoperative care are the most important factors that decrease 1-year mortality.

In our study, we investigated various potential risk factors for death among patients with SSIs, but most of these variables did not show significant relationship in the univariate or multiple logistic regression analysis. The type of cardiac surgery showed a significant association with in-hospital mortality in the univariate analysis but not in a multivariable analysis. Three out of the four (75%) non-survivors underwent combined CABG and valve procedures.

In the present study, antibiotics were used for the management of SSIs with a median duration of 17 days, besides the implementation of surgical vacuum (43.0%) and sternal rewiring (46.2%). The non-survivors showed a significantly longer duration of antibiotics administration than survivors which is attributed to the continuously positive repeated wound cultures and high inflammatory markers. The regression analysis revealed that Patients who showed prolonged antibiotic administration were 1.07 times more likely to die (AOR: 1.070, 95%

CI: 1.022 - 1.120).

The standard of care for SSIs in cardiac surgery patients involves antibiotic therapy and surgical treatment [34]. The extent of the infection, the clinical condition of the patient, and microbiological results guide the management. In case of superficial infections, incision and drainage at the surgical site are sufficient while deep infections require a proper surgical treatment that is adjusted to the patient's condition. This involves the removal of necrotic tissues, draining infected spaces, and sternum closure. Also, negative pressure wound therapy is an adjuvant therapy that may be useful in accelerating the healing process and reducing daily wound handling. Plastic surgery techniques are often needed for the reconstruction of the sternum [35]. Besides surgical intervention, treatment success considerably depends on the appropriate use of antibiotics. However, the increased use of antibiotics increases the emergence of antibiotic-resistant pathogens, which is a challenging global issue [36].

5. Limitations

This single-center study limits the generalization of the results. Thus, there was a lack of follow-up data after discharge due to the retrospective nature of the study. Concerns should also be raised about the inherent bias related to the use of administrative hospital databases. We also did not compare the outcomes of surgical site infection patients with control patients who did not experience the infections as this was limited by our data sources.

6. Conclusion

Based on these findings, the incidence of surgical wound infections following cardiac surgery is not low (9.1%), of which 3.2% were deep infections. The in-hospital mortality rate after treatment of SSIs was fortunately low (4.3%), and all non-survivors had deep SSIs. Combined CABG and valve procedures showed a higher mortality rate (75%) than the isolated procedures. The non-survivors showed a significantly longer duration of antibiotics administration than survivors, with 1.07 times increased likelihood of death. The antibiotic administration was based on the positive results of the repeated wound cultures and high inflammatory markers.

Author Contributions

Ayman R. Abdelrehim, Mohamed Azmi, Ibraheem H. Alharbi and Hasan I. Sandogji contributed to conception, design of the study. Nouf lami, thikra alkhalaf and shily contributed to analysis and interpretation of data. Ayman R. Abdelrehim, Bilal Rahmani, Khalis Elseyd and Ahmed M. Shabaan wrote the initial draft of the article. All authors agreed to the final version of the manuscript to be published also they have agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Ethics Approval and Consent to Participate

The study was approved by the Research Ethics Committee of the General Directorate of Health Affairs in Madinah National Registration Number (ID: IRB23-037), confidentiality of the participants' data was ensured by keeping the data sheets anonymous after assigning a code number specific to each patient, which is known only by the investigators.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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