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Research Article

Surgical Audit of Sternal Wound Infection Following Cardiac Surgery at Inkosi Albert Luthuli Hospital (IALCH), Durban, South Africa

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Abstract

Introduction: Sternal wound infection is a devastating complication following cardiac surgery. It is associated with sternal mal-union, mediastinitis and bacteremia with subsequent infective endocarditis and redo surgery. Although the incidence of sternal wound infections has decreased to 1% - 4% of all cardiac surgery procedures. Sternal wound infection continues to be associated with increased morbidity and mortality, and decrease long term life expectancy. New approaches to open heart surgery, deep and superficial wound infection has a significant impact on patients' morbidity, length of stay and cost of care. This study was to identify risk factors associated with sternal wound infection and prompt treatments measures to decrease this complication.

Methods: Between January 2016- December 2018, thirty-eight (38) adult patient above 14 years who underwent cardiac surgery developed sternal wound infection at IALCH, KwaZulu Natal Province. Retrospectively reviewed and analyzed patient's records were evaluated for demographics, risk factors, management and the outcome in relation to hospital stay and cost. The following risk factors shows significant P value<0.05.

Results: The study revealed that, of the 38 patients, 24 were female (63.2%) and 14 male (36.8%), while 26 patients (68.4%) below 60 years, 12 patients (31.6%) above 60 years. 13 patients (34.2%) developed deep sternal wound infection against 25 (65.8%) who developed superficial wound sternal wound infection. Surgical procedure was for valvular heart disease 24 (63.2%), CABG 13 (34.2%) and 1 (2.6%) concomitant CABG and valve replacement. Prolonged ICU stay 3.08 days SD=1.49 was associated with deep sternal wound infection compared to 1.79 days SD=0.723 for superficial, p=0.0001.

Conclusion: This study showed that sternal wound infection increases overall hospital stay and is associated with increased overall treatment cost therefore, it is imperative to address known risk factors by adhering to and implementing preventative programs.

Keyword: cardiac surgery; sternal wound infections; prevention; management; patients; IALCH; South Africa

Introduction

Sternal wound infection is a devastating complication following cardiac surgery. It is associated with sternal malaunion, mediastinitis and bacteremia with subsequent infective endocarditis and redo surgery. Although the incidence of sternal wound infections has decreased to 1% to 4% of all cardiac surgery procedures, they continue to be associated

with increased morbidity and mortality, and decrease long term life expectancy [1].

In spite of recent advances in coronary revascularization, new topical antibacterial agents, new approaches to open heart surgery, deep and superficial wound infection has a significant impact on patients morbidity, length of stay and cost of care [2]. Despite the significant clinical and economic consequences of sternal wound infections, there are currently no specific guidelines in cardiac surgery for the prevention and treatment of sternal wound infections [1]. Various recommendations for the prevention of wound infections during the preoperative, intraoperative, and postoperative periods, as well as principles for the most effective methods and techniques to treat sternal wound infections to obtain good outcomes are used in various hospitals. The adherence and implementations of these guidelines has never been strictly tested one by one to have a sequence of events that everyone involved with the care of cardiac patients must follow.

The cost of hospital stays and treatment of cardiac patient is enormous and it increases the budget of hospitals with a cardiac center. AT IALCH cardiac center, it has been observed that patients stay an average of 1 day to a week pre operatively and minimum of one week post-operatively depending on the type of surgery performed. The cost of patients with sternal wound complications is estimated to be twice that of patients with uncomplicated postoperative courses [3].

The treatment of superficial and deep wound infections varies, with deep sternal wound infections more costly and sometimes requiring other disciplines to be involved to manage this patients. Plastic surgery has been of paramount importance in managing deep sternal wound infection (DSWI). Plastic surgery and reconstructive materials used are costly, therefore patients who require this service on top of a cardiac procedure has significantly cost the department of health. Superficial sternal wound infection (SSWI) requires a minimum of 5 days antibiotics treatment and depending on the outcome further management may follow.

There are a number of known patient-related pre-operative, intra-operative and post-operative risk factors associated with increased risk of developing sternal wound infection (SWI) after cardiac surgery which have been studied extensively. Accordingly, major attempts have been made to decrease the incidence of SWI. It is reasonable to believe that adhering and implementing certain affordable recommendations will help reduce SWI [4].

Patients and Methods

This was a retrospective observational study done on all adult patients who developed sternal wound infection following open cardiac surgery. All adult patients, 14 years and above who underwent cardiac surgery at IALCH from January 2016 to December 2018 and developed documented sternal wound infection were included.

The principal investigator and supervisor have physically examined and took part in the treatment of the indexed patient. All the pre, intra, post-operative characteristics, outcome and costs were obtained from the patients charts. Treatment and management were done primarily based on institutional protocol and monitored by the operating surgeon. Treatment ranged from simple wound dressing, dressing with oral/ intravenous antibiotics, vacuum assisted dressing, wound debridement with sternal fixation and different plastic surgery procedures.

Statistical analysis

Data were collected and captured in excel and analyzed using the SPSS 25 statistical program for windows. Chi-square tests were conducted using custom tables for Pre, intra, postoperative characteristics, Type of surgery vs type of wound, In all cases, the results were analyzed and considered statistically significant when $P< 0.05$. Ethical approval was granted by the Biomedical Research Ethics Committee of the University of KwaZulu- Natal (ref. no. BREC00001554/2020)

Statistical Results

In total 38 patients were included, 24 were female (63.2%) and 14 male (36.8%). 26 patients (68.4%) aged below 60 years; 12 patients (31.6%) aged above 60 years. 13 patients (34.2%) developed deep sternal wound infection against 25 (65.8%) who developed superficial sternal wound infection. Surgical procedure performed was for valvular heart disease 24 patients (63.2%), coronary artery bypass grafting (CABG) 13 (34.2%) and 1 (2.6%) concomitant CABG and valve replacement. 14 patients (36.8%) developed infections within 7 days post-operatively, 21 (55.3%) between 7-30 days and 3 (7.9%) after 30 days.

Except clinical presentation (fever, wound erythema, drainage and sternal dehiscence) , infection was also confirmed on laboratory testing. A total of 32 (84.2%) patients had increased infective markers as compared to 6 (15.8%) patients without raised infective markers. Infective organisms were isolated in 28 (73.7%) of patients and no organism were isolated in 10 (26.3%) patients. Clinical characteristics of patients are given in table 1. Type of surgical procedure is shown in table 2. The incidence of superficial and deep sternal wound infection is shown in table 3. Risk factor analysis was divided into pre-operative, intra-operative and post-operative factors. A total of 19 factors were evaluated. 1. Age 2. Sex 3. Type of operation 4. Diabetes 5. Body mass index (BMI) 6. Chronic obstructive pulmonary disease (COPD) 7. Retro-viral disease (RVD) status 8. Pre op albumin 10. Remote infection 11. New York heart association (NYHA) 12. Duration of cardiopulmonary bypass (CPB) 13. Use of bone wax 14. Antibiotics prophylactics, re dosing and duration of use 15. Deep hypothermic arrest 16. Massive transfusion 17. Use of intra-aortic balloon pump (IABP) 18. Low cardiac output state 19. Length of ICU stay. The following factors were shown to be independent predictor of increased wound infection in this study. 1. Advanced age, 2. Obesity, 3. Smoking, 4. COPD 5. Massive transfusion, 6. Low cardiac output state (LOCS), 7. Increased length of intensive care unit (ICU) stay.

Mean Age	48.53 ± 16.196
Male/female	14/24
Obesity (BMI ≥ 30)	50%
Diabetes	39.50%
Deep/Superficial wound	34.2%/65.8%
Smoker (existing/ previous)	65.80%
COPD	36.80%
Elevated Infective markers	84.20%
Pairilero (Hospital/Community)	92.1%/7.9%

Pairilero <7 days – Hospital	36.80%
Pairilero > 7-30 days – Hospital	55.30%
Pairilero > 30 days - Community Acquired	7.90%
Albumin > 31	94.70%
Remote infection	26.30%
Heart failure	50%
HIV Positive	39.50%
Surgery: Valve	63.20%
Surgery: CABG	34.20%
Surgery: CABG & Valve	2.60%
Cardiopulmonary bypass (Mean, mins)	132.68 ± 57.649
Prophylactic antibiotics	94.70%
Massive transfusion	23.70%
LCOS	31.60%
Average length of stay in ICU (days)	2.21 ± 1.212
Average length of stay (days)	55.76 ± 41.761
Intra-aortic balloon pump	13.20%
Isolated Organism	73.70%
Treatment	57.90%
Total Cost (Mean in Rands)	118552.47 ± 88783.588
Use of Bone Wax	100%

Table 1. *Clinical characteristics of the 38 patients.*

	Frequency	Percent	Valid Percent	Cumulative Percent
1 Valve	24	63.2	63.2	63.2
2 CABG + Valve	1	2.6	2.6	65.8
3 CABG	13	34.2	34.2	100.0
Total	38	100.0	100.0	

Table 2. *Shows the type of surgical procedure performed.*

	Frequency	Percent	Valid Percent	Cumulative Percent
1 Deep	13	34.2	34.2	34.2
2 Superficial	25	65.8	65.8	100.0
Total	38	100.0	100.0	

Table 3. *The incidence of superficial and deep sternal wound infection.*

Advanced age over 60 years is a predictor of increased deep sternal wound infection, n-12, 7 patient developed deep sternal wound infection as compared to 5 who developed superficial wound infection with a p=0.04. There was also a significant association between LCOS and deep sternal wound infection with a p=0.007. In this study we found out that the use of IABP intra operatively is a major risk factor for sternal wound infection with all the patient n=5 where IABP was used developed sternal wound infection. Most diabetic patient n=15 developed sternal wound infection. There were 8 deep and 7 superficial wound infections. This shows a significant association between diabetes mellitus and wound type, p=0.049 as indicated in table 4.

		1 Deep	2 Superficial	Total
Pre op diabetes	1 Yes	8	7	15
	2 No	5	18	23
Total		13	25	38

Table 4. *Association between diabetes and wound type.*

Although duration of CPB is shown to increase SWI especially beyond 150 min in most studies, there was no significant association between the duration of CPB and SWI in this study as shown in table 5.

		CPB min (Binned)		Total
		1 < 150	2 150+	
WOUND TYPE	1 Deep	6	7	13
	2Superficial	15	10	25
Total		21	17	38

Table 5. *Shows the relationship between wound type and the duration of CPB (min).*

This study showed (table 6) an average ICU stay of 3.08 days SD=1.49 for deep sternal wound infection compared to 1.79 days SD=0.723 for superficial, p=0.0001. Average days in hospital was 92.31 SD=46.9 for deep and 36.76 days SD=22.17 for superficial wound infection, p=0.0001. Cost of treatment was significantly higher for deep sternal wound infection when compared to superficial p<0.0001.

Wound type		N	Mean	Std. Deviation	Std. Error Mean
POSTOP ICU day	1 Deep	13	3.08	1.498	0.415
	2 Superficial	25	1.76	0.723	0.145
Days in Hospital	1 Deep	13	92.31	46.855	12.995
	2 Superficial	25	36.76	22.167	4.433
Total cost	1 Deep	13	196246.15	99613.875	27627.918
	2 Superficial	25	78151.76	47126.120	9425.224

Table 5: *Wound type vs length of stay and cost*

Discussion

The current study shows that SWI is associated with prolonged hospital stay and increased hospital cost. This is in keeping with other studies that indicates that patients with sternal wound complications accumulate an average of 20 additional hospital days and incur an estimated 2.8 times the cost of that for patients with uncomplicated postoperative courses[5]. Average days in hospital was 92.31 SD=46.9 for deep and 36.76 days SD=22.17 for superficial wound infection, p=0.0001. Cost of treatment was significantly higher for deep sternal wound infection when compared to superficial p<0.0001. The mean total cost for DSW was R196246.15 as compared to R78151.76 for SWI.

The Pairolero classification of infected median sternotomies divides wounds into three types based on duration and clinical findings [6, 7]. The majority of cases are type II infections, which occur during the second to fourth weeks after Costochondritis is rare, but osteomyelitis is frequent. This study also indicated that most wounds occur between 7-30 days n-21 (55.3%).

It is important to distinguish DSWIs from superficial sternal wound infections (SSWIs). SSWI involves the skin, subcutaneous tissue, and pectoralis fascia only. The incidence of SSWIs is 0.5 to 8% with an associated morbidity and mortality rate ranging from 0.5 to 9%[8]. The diagnosis may be made clinically by the presence of erythema, drainage, fever, and sternal instability but is often occult with a low-grade fever as its only presentation. SSWIs are often completely eradicated with intravenous antibiotics and local wound care if necessary without long-term sequelae[9]. The main presentation in our study was fever, erythema and wound drainage.

As defined by the Centers for Disease Control and Prevention, DSWIs require the presence of one of the following criteria: (1) an organism isolated from culture of mediastinal tissue or fluid; (2) evidence of mediastinitis seen during operation; or (3) presence of either chest pain, sternal instability, or fever (> 38°C), and either purulent drainage from the mediastinum, isolation of an organism present in a blood culture, or culture of the mediastinal area[2]. These patients require a much more aggressive treatment regimen consisting of early surgical debridement with subsequent autologous tissue coverage and long-term intravenous antibiotics. Treatment and management of our patients was done primarily based on institutional protocol and monitored by the operating surgeon. SWI treatment ranged from simple wound dressing, dressing with oral/ intravenous antibiotics while DSW was treated with vacuum assisted dressing, wound debridement with delayed sternal fixation and other different plastic surgical procedures.

Risk factor stratification and patients characteristics was done in correlation with the new guideline for the prevention and management of sternal wound infections presented by Harold L. Lazar in the European journal of Thoracic and cardiovascular surgery in 2016- Expert Consensus Review. A total of 19 factors were evaluated. 1. Age 2. Sex 3. Type of operation 4. Diabetes 5.BMI 6. COPD 7. RVD status 8. Pre op albumin 10. Remote infection 11. NYHA 12. Duration of CPB 13. Use of bone wax 14. Antibiotics prophylactics, re dosing and duration of use 15. Deep hypothermic arrest 16. Massive transfusion 17. Use of IABP 18. Low cardiac output state 19. Length of ICU stay. The following factors were shown to be independent predictor of increased wound infection in this study. 1. Advanced age, 2. Obesity, 3. Smoking, 4. COPD 5. Massive transfusion, 6. LOCS, 7. Increased length of ICU stay.

Most studies have identified the following as key contributors to the development of sternal wound infections. 1. Nasal staphylococcus carries, incorrect pre surgical preparation, poor nutritional status, remote infections, poorly controlled glycemic, smoking till surgery, incorrect use and dosage of antibiotics, use of bone wax, type of surgery, technique, duration , ICU stay and blood transfusion[1]. Additionally, to the above-described well-known risk factors to augment the risk of SWI after cardiac surgery, deep hypothermia and usage of synthetic graft may worsen the result of SWI related to aortic surgery [10]

As per Expert Consensus Review 2016 the use of bone wax is shown to increase sternal SWI. In this study all 38 patients had bone wax applied to the sternotomy wound, no nasal mupirocin was used. Antibiotics prophylaxis was administered in all patient accept those already on treatment however timing, re dosing and duration of use was not accurate or probably not properly recorded. Electrocautery was also used in all of

our patients. This indicates on areas that we think we need institutional protocol review to pare with Expert Consensus Review.

Patients with DSWI die at a rate that is twice that of those without. The associated mortality rate in the literature ranges from 10 to 47%. Risk factors for the development of DSWIs after median sternotomy include diabetes, obesity, chronic obstructive pulmonary disease, osteoporosis, tobacco use, reoperation, prolonged intensive care unit stays, and use of assist devices. Treatment begins with exploration and debridement of all necrotic tissues with removal of all foreign materials and exposed cartilage[11]. A study by Daya. M et al in 2009 at IALCH concluded that the use of VAC dressing and definitive wound closure using sternal plating is an effective method for managing sternotomy wound dehiscence. Most of our patients with DSWI underwent a similar treatment and had favorable outcome.

Due to budget constraint and necessity of state cardiac service particularly KNZ province that is densely populated and this service also caters for other provinces especially eastern cape, I believe adherence and implementing basic evidence based recommendation is of paramount importance to save cost and continue with state cardiac service. The aim of this audit was not merely to identify risk factors as this is already done extensively in other studies but mainly to pin point certain critical area we believe are not part of our institutional protocol.

The strength of this audit is that it is the first in our department about sternotomy infection and hopefully would sensitize surgeons, nurses and all members responsible for the patients on the current consensus on preventing SWI. The limitations are its retrospective nature, short duration and few patients, not reporting on mortality. A large similar study is required to validate the findings.

Conclusion

This study shows that sternal wound infection increases overall hospital stay and is associated with increased overall treatment cost. In addition to pre-operative optimization of patient related factors and procedure related factors. The research team recommend nasal mupirocin prophylaxis to be implemented, discontinue the universal use of bone wax, minimize unnecessary use of diathermy, standardize and monitor pre-operative skin preparation, adhere to appropriate antibiotic prophylactic timing and duration of use.

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Conflict of interest

The authors declare that they all have no conflict of interest.

Author contribution

IA: Study conception and design, Developed the initial draft, Data acquisition, analysis, interpretation, and manuscript. KM: Reviewed every draft and assisted with writing and editing.

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