Original Article

Incidence and risk factors for sternal osteomyelitis after median sternotomy

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Background: Sternal osteomyelitis (OM) after median sternotomy is the rarest form of deep sternal wound infections (DSWIs). A retrospective study was implemented to evaluate the incidence and potential risk factors of sternal OM after median sternotomy.

Methods: We analyzed 3,410 consecutive patients who underwent cardiothoracic surgery via median sternotomy from January 2005 to December 2019 at our institution. A sternal OM and control group without any sign of wound infections after median sternotomy were selected. Comparisons of the variables between the two groups were performed using the Student's *t*-test and Fisher's exact tests. The association of potential risk factors with sternal OM was tested by logistic regression analysis.

Results: A total of 16 patients (0.47%) had sternal OM after median sternotomy. None of the variables were different between the sternal OM patients and the control group including body mass index (BMI), diabetes mellitus (DM), hypertension (HTN), left ventricle (LV) function, transfusion, operation time, cardiopulmonary bypass (CPB) time and intensive care unit and ventilator days. By univariate analysis, none of the variables were associated with an increased risk of sternal OM.

Conclusions: The incidence of sternal OM after median sternotomy in our institution was 0.47% and there was no correlation between the known risk factors of DSWI and sternal OM in our study.

Keywords: Sternal osteomyelitis (sternal OM); deep sternal wound infection (DSWI); median sternotomy; wound infection

Submitted Oct 27, 2021. Accepted for publication Feb 18, 2022.
doi: 10.21037/jtd-21-1694
View this article at: https://dx.doi.org/10.21037/jtd-21-1694

Introduction

Sternal osteomyelitis (OM) after median sternotomy is a rare and potentially fatal complication following cardiothoracic surgery (1). When sternal wound infection is classified according to the anatomic location of the infected tissue, deep sternal wound infections (DSWIs) are differentiated from superficial sternal wound infections (SSWIs). SSWIs involve only the skin and subcutaneous

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tissue (type 1) and DSWIs are categorized into four types, deep infection that extends below the fascia without involvement of the bone or retrosternal tissue (type 2A); infections involving retrosternal tissue (type 2B), bone and retrosternal tissue (type 2C); or causing frank OM (type 2D) (2,3).

The incidence of DSWIs varies between centers, countries, and the year of publication and has been reported to range from 0.2% to 8% (4,5). However, the mortality varies from 8% to 45% and DSWIs are associated with increased medical costs, prolonged hospital stays, and reoperation (6). The risk factors for DSWIs can be grouped into patient-related, intraoperative, and postoperative factors. The patient-related risk factors are older age, obesity, smoking, and the presence of comorbidities such as diabetes mellitus (DM) and chronic lung disease (4,7-9). Concomitant coronary artery bypass grafting with valve or aortic surgery, long operation time, and the bilateral use of internal mammary arteries are among the intraoperative risk factors (7,8,10). The postoperative risk factors include prolonged ventilator and inotropic support (8,11).

Sternal OM is one of the rarest forms of DSWIs and due to its rarity and even though there are known risk factors for DSWIs, the exact incidence and independent risk factors of sternal OM after median sternotomy are not well known. Sternal OM may present as purulent draining sinus tracts in patients with a closed sternal wound and these fistulas occur after the patient is discharged, usually after some weeks, months, or even years following median sternotomy (1,8,12,13). This is the reason why it is very difficult to determine the real incidence of sternal OM.

Therefore, in this study, we evaluated the incidence and tried to identify the risk factors for sternal OM after median sternotomy. We present the following article in accordance with the STROBE reporting checklist (available at https://jtd.amegroups.com/article/view/10.21037/jtd-21-1694/rc).

Methods

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by Dongguk University Ilsan Hospital institutional review board (2021-10-008) and individual consent for this retrospective analysis was waived.

Patient selection

This retrospective study was performed at the Department of cardiothoracic surgery at the Dongguk University Ilsan Hospital. Consecutive patients who underwent cardiothoracic surgery via median sternotomy from January 1, 2005, to December 31, 2019, were included. The patients were diagnosed with sternal OM by an attending physician and an infection control physician during their hospital stay and readmission period based on the clinical, laboratory, and computed tomography (CT) findings (14). To confirm the diagnosis of sternal OM, we reviewed the database and collected relevant information regarding the patients, including their clinical records, laboratory examination results, and CT findings. CT findings of cortical destruction, sequestrum, involucrum, sinus tract formation, demineralization, and an abscess (15) are needed for the final confirmation of sternal OM. The control patients were selected among eligible patients without any evidence of DSWIs or superficial wound infections.

Operation procedure and treatment of sternal OM

Antibiotic prophylaxis was used in all patients. Cefuroxime was most commonly used, starting 30 minutes before the operation until 72 hours after surgery. An interlocking figure-of-eight wire closure technique and single transsternal configuration were generally used in patients who underwent cardiothoracic surgery through a median sternotomy. The establishment of cardiopulmonary bypass (CPB) involved the vena cava and aorta or vena cava, axillary artery, and femoral artery. In coronary artery bypass graft surgeries (CABG), we used bypass graft of left internal thoracic artery, right internal thoracic artery and great saphenous vein. All surgeries were performed by three experienced surgeons at the institution with standardized technique at the time and cardiac or aortic surgeries were performed 45 and 3 cases of thoracic surgeries were performed with median sternotomy.

The treatment of sternal OM included antibiotics, sternal debridement, and flap reconstruction. Cefuroxime was the most commonly used antibiotic. The omental flap was used as material for flap reconstruction.

Statistical analysis

Comparisons of the variables were performed using the Student's *t*-test and Fisher's exact tests. The association of potential risk factors with sternal OM was tested by logistic regression analysis. Variables with a P value of less than 0.2 in the univariate analysis were included in the

Table 1 The demographics and operative variables of the eligible patients

Variables	Sternal OM (n=16)	Control (n=32)	P value
Age (years)	61.3±12.6	61.3±11.9	0.98
Male/female	7/9	14/18	0.99
BMI (kg/m^2)	24.9±5.4	25.6±3.8	0.62
DM	5	9	0.99
HTN	7	21	0.22
Smoking	3	14	0.12
LV function (%)	51.9	54.3	0.22
Transfusion	12	28	0.41
Operation type			0.41
CABG	7	18	
Cardiac or aorta surgery	6	12	
Non-cardiovascular surgery	3	2	
CPB time	229.7±131.5	205.3±72.1	0.61
ICU (days)	5.5±12.7	3.5±4.3	0.43
Ventilator (days)	3.0±9.2	1.6±4.2	0.48

OM, osteomyelitis; BMI, body mass index; DM, diabetes mellitus; HTN, hypertension; LV, left ventricle; CABG, coronary artery bypass graft; CPB, cardiopulmonary bypass; ICU, intensive care unit.

multivariate analysis. P values and 95% confidence interval were corrected using Bonferroni's method in multiple comparisons. Statistical analyses were executed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA).

Results

Clinical characteristics and risk factors

A total of 3,410 consecutive patients who underwent median sternotomy were included in the study between January 2005 and December 2019. Among 3,410 patients, 16 patients met the criteria of sternal OM by the clinical, laboratory, and CT findings. Therefore in our study, the incidence of sternal OM after median sternotomy was 0.47%. We then carefully selected a control group with exact matching method to choose patients negative for sternal OM with demographic variables (i.e., age and sex) similar to those of the patients with sternal OM. Because the number of patients without any signs of wound infections after median sternotomy was rather small, we could only apply 1:2 ratio matching.

Table 1 shows the patient characteristics and operation data for our final study population. None of the variables were different between the sternal OM patients and the control group including body mass index (BMI), DM, hypertension (HTN), left ventricle (LV) function, transfusion, operation time, CPB time, and ICU and ventilator days. By means of univariate analysis, none of the variables were associated with an increased risk of sternal OM (*Table 2*). Variables with a P value of less than 0.2 in the univariate analysis (smoking and HTN) were included in the multivariable analysis. However, these variables were also not statistically significant (*Table 3*). For checking the nutritional status of patients, preoperative serum albumin and hemoglobin level were statistically not different between two groups.

For the follow up, 3 patients in the control group were follow up loss, and follow up range was between 5 to 84 months with mean of 38 months of the two groups.

In our study group, patients with prolonged ICU stay (more than 10 days) were 3 patients, which were 17, 18 and 51 days respectively. Two of 32 patients (6.3%) of control group had prolonged ICU stay and one of 16 patients (63%) of sternal OM group had prolonged ICU stay (51 days). In the sternal OM group, reoperation for postoperative wound rate was 10/16 (63%) and only one patient had omental flap

Table 2 Univariate risk factor analysis of sternal OM and control groups

Variable	OR	95% CI	P value
Age	0.999	0.950–1.051	0.98
Sex	1.000	0.298–3.353	0.99
BMI	0.963	0.833–1.113	0.61
DM	1.162	0.314–4.297	0.82
HTN	0.407	0.119–1.391	0.15
Smoking	0.297	0.071–1.248	0.09
LV function	1.040	0.976–1.110	0.23
Transfusion	0.429	0.092–2.003	0.28
Operation type			
CABG	Reference	–	0.41
Cardiac or aorta surgery	1.286	0.287–5.768	0.99
Non-cardiovascular surgery	3.857	0.396–37.586	0.37
CPB time	1.003	0.994–1.011	0.53
ICU (days)	1.672	1.342–1.705	0.43
Ventilator (days)	1.677	1.401–1.697	0.48

OM, osteomyelitis; OR, odds ratio; BMI, body mass index; DM, diabetes mellitus; HTN, hypertension; LV, left ventricle; CABG, coronary artery bypass graft; CPB, cardiopulmonary bypass; ICU, intensive care unit.

Table 3 Multivariate risk factor analysis of sternal OM and control groups

Variables	OR	95% CI	P value
Smoking	0.283	0.065–1.231	0.09
HTN	0.386	0.108–1.382	0.14

OM, osteomyelitis; OR, odds ratio; HTN, hypertension.

coverage, whereas 9 patients received surgical debridement.

Overall morbidity rate was 7/16 (44%) from sternal OM group and 8/32 (25%) for control group. Mortality rate was 5/32 (16%) from the control group, however no case of mortality was found on the sternal OM group.

CT findings and pathogens of sternal OM

All of the 16 patients with confirmed sternal OM after median sternotomy had cortical destruction of the midline of the sternum on chest CT (*Figure 1*). The earliest sternal OM manifested 1 month after surgery and the latest complication occurred 11 months after surgery. All 16 patients with sternal OM had symptoms of wound infections and 10 patients had positive wound cultures. The most common pathogens isolated from the wounds were *Staphylococcus aureus* (n=4, 40%), *Aspergillus* (n=2, 20%), and *Streptococcus* species, *Bacillus cereus*, *Pseudomonas aeruginosa*, and *Corynebacterium* at one each.

Discussion

The aim of this study was to identify the incidence and risk factors of sternal OM after median sternotomy. Since sternal OM is a subgroup of DSWIs and is the rarest form of DSWIs (2,3), the exact incidence and risk factors have not been studied yet. There are many reports of the incidence of DSWIs after cardiac surgery. According to the literature, the incidence of DSWIs after cardiac surgery has been reported to be between 0.2% and 8.0% (4,5).

Figure 1 A 61-year-old female who underwent median sternotomy 4 months earlier presented with chest pain and redness at the surgical site. The coronal chest CT shows an osteolytic lesion at the sternotomy site at the manubrium. The sternal area biopsy showed *Aspergillus* species. CT, computed tomography.

However, a recent study by Robinson *et al.* (16) reported a 1.2% incidence of DSWIs and Pan *et al.* (17) reported that the incidence of DSWI was 1.33% after cardiac surgery.

Improvements in aseptic techniques and prophylactic antibiotic use may have contributed to the reduction in the incidence of DSWIs after cardiac surgery (17). Some studies have reported that antibiotic prophylaxis was beneficial for reducing the incidence of DSWIs after surgery (18-21). In this study, the incidence of sternal OM was 0.47% and we believe that this study was the first to report the incidence of sternal OM alone after median sternotomy in a single institution. However, considering that there some patients were lost to follow and not readmitted to the institution and that sternal OM may present even years following median sternotomy, the occurrence of DSWIs may have been underestimated.

Large retrospective and prospective outcome studies have identified risk factors associated with DSWIs. The risk factors for DSWIs are older age, obesity, smoking, DM, chronic lung disease, concomitant coronary artery bypass grafting with valve or aortic surgery, long operation time, the bilateral use of internal mammary arteries, and postoperative prolonged ventilator and inotropic support (4,7-11). In this study, none of these risk factors were associated with sternal OM after median sternotomy. In our results, HTN and smoking had a trend of difference between the two groups. However, we believe that these results were due to an imbalance in the population of patients with HTN and smoking data between the two groups. The sentinel event for the pathogenesis of sternal OM after median sternotomy remains a matter of debate. The proposed causes include the direct spread of pathogens associated with a local infection versus hematogenous dissemination (15,22). Regardless of the inciting event, pathogens invade the metaphyseal arterioles and cause microabscesses, which eventually coalesce into larger macroabscesses, resulting in pressure erosion on the surrounding bone, which leads to OM (15). The abovementioned known risk factors associated with DSWIs may be associated with delayed wound healing and these factors might have resulted from the direct spread of a wound infection (23,24). Since sternal OM can occur due to the direct spread of local infection or by the hematogenous dissemination of pathogens, the hematogenous dissemination of infection may act through a different mechanism than the direct spread of local infection and these DSWI risk factors may not be involved in the context of sternal OM.

In our study, CT scans were performed in all patients to rule out the possibility of DSWIs. A CT showing the presence of OM between the edges of the sternum with cortical destruction and osteolytic changes helped the diagnosis of sternal OM after median sternotomy. Since CT offers superior bony resolution compared to other imaging modalities, the reported sensitivity for detecting OM ranged from 92.8% to 93.5% and the specificity ranged from 85.1% to 96% (25).

The most common pathogen isolated from wound cultures in our study was *Staphylococcus aureus*, consistent with previous studies (4,17).

Our study had some potential limitations. First, this was a retrospective study, which cannot account for the effect of unknown variables. Second, the number of patients in our study was small since sternal OM after median sternotomy is very rare. To exclude potential bias, the sample size of the control group was also limited by excluding patients with any signs of wound infections after median sternotomy. Third, since the numbers of sternal OM cases were very small, there was a limit to demonstrating statistical significance.

Conclusions

In conclusion, the incidence of sternal OM after median

sternotomy in our institution was 0.47% and there was no correlation of the known risk factors for DSWIs with sternal OM in our study.

Acknowledgments

Funding: None.

Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jtd.amegroups.com/article/view/10.21037/jtd-21-1694/rc

Data Sharing Statement: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-21-1694/dss

Peer Review File: Available at https://jtd.amegroups.com/article/view/10.21037/jtd-21-1694/prf

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jtd.amegroups.com/article/view/10.21037/jtd-21-1694/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are 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. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This study was approved by Dongguk University Ilsan Hospital institutional review board (2021-10-008). The requirement for written consent was waived because of the retrospective nature of the study.

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Cite this article as: Cha YK, Choi MS, Bak SH, Kim JS, Kim CH, Chung MJ. Incidence and risk factors for sternal osteomyelitis after median sternotomy. J Thorac Dis 2022;14(4):962-968. doi: 10.21037/jtd-21-1694