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Risk factors for sternal wound infections and application of the STS score in coronary artery bypass graft surgery

Fatores de risco para infecção de ferida esternal e aplicação do escore da STS em pacientes submetidos à cirurgia de revascularização miocárdica

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Abstract

Background: **Sternal wound infection (SWI) after coronary artery bypass graft (CABG) surgery is a major complication. Identifying patients at risk of SWI is essential for the application of preventive measures.**

Objective: **To identify the pre- and intra-operative risk factors, apply the STS risk score and determine the correlation between the risk score and microorganisms isolated from surgical wounds in a Brazilian hospital.**

Methods: **This is a retrospective analysis of a database of all CABG surgeries performed in a single institution from 2006 to 2008. Chi-square analysis was used for categorical variables and Student's t-test was used for quantitative variables. Multivariate logistic regression model was used to identify independent risk factors for SWI. *P* <0.05 was considered significant.**

Results: **The infection rate was 7.2% (143/1975). The multiple regression analysis found the following risk factors: female gender (OR 2.06; 95%CI 1.40-3.03; *P*<0.001), BMI>40 kg/m² (OR 6.27, 95%CI 2.53-15.48; *P*<0.001), diabetes (OR 2.33; 95%CI 1.56-3.49; *P*<0.001), number of affected coronary arteries (OR 7.78; 95%CI 1.04-57.79; *P*<0.001) and use of bilateral internal thoracic artery (OR 3.85; 95%CI 2.10-7.07; *P*<0.001). Infected patients had a mean score of 9, whereas non-infected patients had a mean score of 7 (*P*<0.001). There was no correlation between microorganisms, scores and risk factors.**

Conclusion: **Female gender, diabetes, BMI>40 kg/m², number of affected coronary arteries and use of bilateral internal thoracic artery were associated with a higher risk of infection. The STS risk score can be successfully used and there was no correlation between microorganisms, the score and risk factors at our institution.**

Descriptors: **Infection. Risk factors. Mediastinitis. Myocardial revascularization.**

Resumo

Fundamento: **A infecção de ferida operatória esternal após cirurgia de revascularização miocárdica (CRM) é uma grave complicação. Identificar pacientes com risco elevado é fundamental para introdução de medidas de preventivas.**

Objetivo: **Identificar os fatores de risco pré e intra-operatórios, avaliar o escore de risco da STS e correlação entre o escore e os microorganismos isolados em ferida operatória em hospital brasileiro.**

Métodos: **Análise retrospectiva de um banco de dados prospectivamente coletado de todas as CRM realizadas em centro único, no período de 2006 a 2008. Teste do qui-**

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quadrado foi utilizado para variáveis categóricas e teste t-Student, para variáveis quantitativas. Modelo multivariado por regressão logística foi utilizado para identificação de fatores de risco independente para infecção de ferida esternal. *P*<0,05 foi considerado significativo.

***Resultados:* A incidência de infecção foi de 7,2% (143/1975). Na regressão múltipla, identificamos os seguintes fatores de risco: sexo feminino (OR 2,06; IC95%; 1,40-3,03; *P*<0,001), IMC>40 kg/m^2 (OR 5,38; IC95%; 2,24-12,90; *P*<0,001), diabetes (OR 2,33; IC95% 1,56-3,49; *P*<0,001), número de artérias coronárias acometidas (OR 2,06; IC95%; 1,40-3,03; *P*<0,001) e uso bilateral de artéria torácica interna (OR 3,44; IC95% 1,89-6,26; *P*<0,001). Os pacientes infectados apresentaram média de escore da STS de 9 *versus* 7 nos não infectados (*P*<0,001). Não houve correlação entre microorganismos, escore e fatores de risco.**

***Conclusão:* Sexo feminino, diabetes, IMC>40 kg/m^2, número de artérias coronárias acometidas, uso bilateral da artéria torácica interna foram associados a maior risco de infecção. O escore de risco da STS pode ser aplicado com sucesso, não havendo correlação entre microrganismos, escore e fatores de risco em nossa instituição.**

***Descritores:* Infecção. Fatores de risco. Mediastinite. Revascularização Miocárdica.**

INTRODUCTION

Sternal wound infection (SWI) is one of the most serious complications associated with coronary artery bypass graft (CABG) surgery. It is associated with an increase in the period of hospitalization, hospital costs and need for surgical re-intervention [1-5]. It is extremely important to identify patients undergoing CABG surgery who have a high risk of developing wound infection in order to provide effective preventive measures.

Several pre- and intra-operative risk factors have been associated with an increased incidence of SWI with the incidence of mediastinitis ranging from 0.4% to 5.3%, and early and in-hospital lethality varying between 10% and 47% [1,2,4-10].

Gardlund et al. [11] have shown a correlation between the presence of microorganisms and risk factors for SWI.

Fowler et al. [12] published, in 2005, a wound infection risk score, using logistic regression analysis, based on data from 331,429 cases from the Society of Thoracic Surgeons National Cardiac Database (STS). A simple model with 12 variables was developed and validated for the identification of patients who are at high risk for infections after cardiac surgery.

The Instituto Dante Pazzanese de Cardiologia, located in São Paulo, is a public university hospital with a capacity of 350 beds for cardiovascular surgeries. Approximately 2,000 heart surgeries are performed annually, and about 1,000 of these are isolated CABGs. The Institution has a hospital infection control and prevention program and performs active disease surveillance, following criteria from the Center of Disease Control and Prevention (CDC) [13].

There may be population differences, and this model has not yet been applied to our population. The objectives of the present study were: to identify the pre- and intra-operative risks associated with sternal wound infection; to apply the STS risk score to patients undergoing coronary artery bypass graft surgery in a Brazilian Tertiary Hospital of Cardiology; and to analyze the correlation between etiological agents of SWI with the STS risk score and associated risk factors.

METHODS

Study design

From January 2006 to December 2008, data were prospectively collected from CABGs performed at this institution.

The STS risk score [12] was applied to the study population. The pre- and intra-operative risk factors were evaluated, and group of patients who had sternal wound infections were compared with patients without infection based on their pre- and intra-operative characteristics.

The diagnosis of sternal wound infection followed the criteria for infection set by the CDC [13]. All patients were evaluated for a period of up to 30 days after hospital discharge, and patients who had infection during this period were identified.

Details of surgical procedures for treatment of SWI

Acute wound infection treatment consisted of drainage of purulent collections, aggressive debridement of necrotic tissue and closure. Some patients required sternal rewiring or the use of pectoralis major muscle or omental flaps to increase the vascularization [14]. Although these treatments were effective in most of the patients, some did not respond and developed a wound dehiscence at different anatomical levels, sometimes even with a loss of the sternum and rib portions. In these secondary wounds plastic reconstruction was necessary.

Dehiscent wounds without loose of tissue were closed by bilateral pectoralis major fasciocutaneous flaps. For wounds with insufficient amount of bordering tissues different flaps were used according to the type of defect: advanced or rotated pectoralis major musculocutaneous flap [15], isled rectus abdominis musculocutaneous flap and omental flap followed by skin grafting. Composed breast skin flaps may be used in females [16].

Statistical analysis

The Chi-square test or Fisher's exact test, as appropriate, was used to confirm the association between qualitative variables and infection in univariate analysis. To identify differences between groups using quantitative variables, Student's t-test was used for variables with normal distribution. The Mann-Whitney test was used for variables without normal distribution. A multivariate logistic regression model was used in to identify independent risk factors for SWI. *P*-values<0.05 were considered statistically significant.

Ethical aspects

The study was approved by the Local Medical Ethics Committee.

RESULTS

During the study period, 1,975 patients underwent CABG surgery; of these, 143 (7.2%) developed wound infection, with 38 (1.9%) showing superficial wound infection, 58 (2.9%) showing deep wound infection and 47 (2.4%) showing mediastinitis.

The clinical characteristics of patients with SWI are described in Table 1.

In univariate analysis, female gender, diabetes, arterial hypertension, body mass index (BMI) greater than 40kg/m^2, number of affected coronary arteries and use of bilateral internal thoracic artery were associated with a greater risk of SWI. Multiple regression analysis identified female gender (OR 2.06; 95%CI; 1.40-3.03; *P*<0.001), diabetes (OR 2.33; 95%CI; 1.56-3.49; *P*<0.001), BMI greater than 40 kg/m^2 (OR 6.27; 95%CI 2.53-15.40; *P*<0.001), number of affected coronary arteries (OR 7.78; 95%CI 1.04-57.79; *P*<0.001) and use of bilateral internal thoracic artery (OR 3.85; 95%CI 2.10-7.07; *P*<0.001) as factors independently associated with SWI (Table 2).

The intra-aortic balloon pump was only used in 61 (3.1%) patients, and four (2.8%) of them developed wound infection.

In relation to the analysis of the wound risk score proposed by the STS, it was observed that the patients suffering from sternal infection had a higher score than non-infected patients (9 and 7, respectively; *P*<0.001).

Table 1. Clinical characteristics and risk factors evaluated.

Variable	Patient with SWI	Patient without SWI	*P*-value
Age (years)	62.48	62.48	0.815
Female gender	68/143 (47.6%)	531/1832 (29%)	0.001
Diabetes mellitus	93/143 (65%)	728/1832 (39.7%)	0.001
Arterial hypertension	133/143 (93%)	1563/1832 (85.3%)	0.011
Current smoking	29/143 (20.3%)	367/1832 (20%)	0.858
Dyslipidemia	91/143(63.6%)	1148/1832(62.7%)	0.817
COPD	9/143 (6.3%)	78/1832(4.3%)	0.253
CRD	17/143 (11.9%)	180/1832 (9.8%)	0.428
Preoperative AMI	80/143 (55.9%)	940/1832 (5.1%)	0.286
Preoperative stroke	3/143 (2.1%)	67/1832 (3.6%)	0.331
PAD	35/143 (24.5%)	336/1832 (18.3%)	0.070
LVEF < 50%	57/143 (39.9%)	656/1817 (36.1%)	0.369
BMI (kg/m^2)			< 0.001
<30	83/140 (59.2%)	1410/1821 (77.4%)	
30 – 40	45/140 (32.1%)	381/1821 (20.9%)	
>40	12/140 (8.5%)	30/1821 (1.6%)	
Number of diseased coronaries			0.005
1	1/85 (1.29%)	84/85 (98.8%)	
2	16/301 (5.3%)	285/305 (94.6%)	
3	73/767 (9.5%)	694/767 (90.4%)	
Left main coronary	24/414 (5.8%)	390/414 (94.2%)	
Emergency Surgery	7/84 (8.3%)	136/1886 (7.2%)	0.698
Bilateral ITA	17/143 (11.8%)	118/1832 (6.4%)	0.001
Period of anoxia (minutes)	54.9	53.9	0.871
Period of CPB (minutes)	81.22	80.7	0.073

COPD – chronic obsrtructive pulmonary disease; CRD – chronic renal disease; AMI – acute myocardial infarction; PAD – peripheral arterial disease; LVEF – left ventricular ejection fraction; BMI – body mass index; ITA – internal thoracic artery; CPB – cardiopulmonary bypass

The isolated etiological agents of infection, with the possibility of more than a single agent affecting each patient, are described in Table 3.

The patients affected by Gram-negative bacteria had scores of 11, as compared with a score of 9 for patients affected by Gram-positive bacteria (*P*=0.063).

There was no correlation between the different etiological agents and pre-operative risk factors and mortality. There was also no difference in mortality between infected and non-infected patients (8.4% vs. 6.8%, respectively; *P*=0.309) during hospitalization.

Table 2. Multivariate logistic regression analysis.

	OR	95.0% CI		*P*-value
		Lower	Upper	
Age (by year)	0.996	0.973	1.019	0.736
Male gender	0.497	0.338	0.732	<0.001
Arterial hypertension	1.791	0.878	3.655	0.109
Diabetes	2.337	1.561	3.497	<0.001
COPD	1.862	0.852	4.068	0.119
BMI 30-40 kg/m^2	1.561	0.988	2.464	0.056
BMI >40 kg/m^2	6.270	2.539	15.485	<0.001
LVEF < 50%	1.135	0.759	1.697	0.537
PAD	1.188	0.751	1.878	0.462
3-vessel disease	7.784	1.048	57.791	0.045
Bilateral ITA	3.858	2.103	7.079	<0.001

Table 3. Microorganisms Associated with SWI.

Type of microorganisms	Nº	%
Coagulase-negative Staphylococcus	62	43.4
Staphylococcus aureus (MSRA= nº17-11.9%)	41	28.7
Klebsiella pneumoniae	18	12.6
Enterococcus faecalis	17	11.9
Enterobacter aerogenes	12	7
Enterococcus ssp	7	4.9
Pseudomonas aeruginosa	5	3.5
Acinetobacter ssp	5	3.5
Morganella morganii	3	2.1

DISCUSSION

Our institution is a public teaching hospital and has an infection control service that performs active disease surveillance, which enables the identification of wound infections after discharge. The higher rate of SWI found in the current study may be due to the post-discharge notification, which was different from what has been published in scientific journals [12,17].

According to the multivariate logistic regression analysis, female gender was associated with higher rates of SWI, which differed from results presented by Risnes et al. [18], who found males to be associated with higher rates of mediastinitis. However, in our study, there was a higher prevalence of diabetes in males.

Diabetes was associated with a higher rate of SWI, in accordance with some studies [7,10] and in contrast with others [1,4,5,19,20]. A high BMI was identified as an important risk factor for SWI, and is supported by the majority of studies on this topic [2,4,5,10]. Milano et al. [5] discuss some factors that may explain why obesity is a risk factor, such as, for example, the dose of the prophylactic antibiotic, which is not corrected on the basis of the patient body mass index, difficulty for patient skin folds to remain sterile during the procedure, and adipose tissue itself, which may function as a substrate for infection.

The number of affected coronary arteries, found in our study, was associated with higher rates of SWI, which was in agreement with the study presented by Risnes et al. [18].

The use of bilateral internal thoracic arteries was strongly related with higher rates of SWI. Walkes et al. [21] found a 4.4% incidence of mediastinitis when using bilateral internal mammary artery grafts, as compared with 2.2% when using single mammary artery grafts (*P*=0.06). A meta-analysis [22] places the use of bilateral internal thoracic artery grafts as an important risk factor for greater wound infection, but there is no consensus in the literature [23]. This fact may be explained by lower sternal and operative wound irrigation after bilateral use.

Studies that have focused on the use of skeletonized internal thoracic arteries [22-24] have not found an increase in SWI associated with the use of bilateral internal thoracic artery grafts. In a study by Milani et al. [24], in 70 diabetes patients, the use of the skeletonized bilateral internal thoracic artery significantly reduced the incidence of mediastinitis (*P*=0.044). Some recently published studies have emphasized the importance of the skeletonized ITA harvesting [25-27]. This technique was rarely used in patients in our institution and therefore, it was not analyzed.

Recent studies [17,28,29] have found some different risk factors for SWI, identifying age, COPD and reoperation as markers. These differences may be attributed to population differences. In our sample, age was not a statistically significant factor, and neither was COPD and reoperation.

There was also no increase in mortality in our population relative to those not affected by SWI. This finding is in agreement with a recent study presented by Risnes et al. [18]. The early identification of SWI, in association with broad-spectrum antibiotic therapy and adequate surgical intervention can explain this finding.

In our study population, a higher STS risk score was found in patients with SWI than in non-infected patients (9 vs. 7, *P*<0.001). Despite the differences between the populations from the STS database and a Brazilian public teaching hospital, the STS score was validated and showed similar results; thus, it can be applied to other populations.

The correlation between microorganism presence and the depth and severity of wound infections has not been well studied. Gardlung et al. [11] have shown that there is a relationship between high BMI and SWI caused by *coagulase-negative Staphylococcus*. In our population, the correlation between microorganisms that cause SWI and the risk score proposed by Fowler was evaluated; however, there was no significant difference between Gram-negative and Gram-positive bacteria (11 vs. 9, P=0.063). These data are unique given that most studies do not evaluate the risk of infection according to the etiological agent. This may suggest that the sample did not have enough statistical power for an association with risk factors for SWI, or it may also indicate that all patients are susceptible to SWI regardless of the microorganism causing it.

The patients referred for CABG with high risk scores require preventative measures that will reduce the development of SWI. Given the risk factors found in this study, intervention would not be effective at reducing the rate of wound infections because a high BMI, female gender and the number of arterial lesions are not amenable to intervention. The intervention possibilities are limited to surgical procedure, and the use of bilateral internal thoracic artery grafts in women with a high BMI and three vessel injuries are not recommended. Adequate glycemic control in diabetic patients is mandatory. New strategies have been developed to improve the sternal hemostasis, and possibly in the future will result in a lower incidence of SWI [30]. The actions to prevent hospital infection and good practices in general must be practiced in patients with higher risk factors to avoid this problem that is associated with an increase in the period of hospitalization, hospital costs and need for surgical re-intervention [31].

Study limitations

A limitation of this study is that only one public hospital in São Paulo was evaluated, such that the sample may not represent the general Brazilian population.

Only pre- and intra-operative risk factors were analyzed. The use of the intra-aortic balloon pump and skeletonized internal thoracic artery grafts were not analyzed both because they were not used very much in during this study. Some other known risk factors for SWI (for example, blood transfusions [32]), were not analyzed.

In our sample, there were high risk patients with scores higher than 9 who did not develop an infection, and low risk patients with scores lower than 7 who developed wound infection, which is similar to what was shown by Fowler et al. [12].

Further studies are necessary to better understand this phenomenon, as high scores do not necessarily mean wound infection but is associated with a higher risk of developing wound infection. Similarly, low scores do not guarantee that the patient is safe from developing an infection and only indicates that they are at lower risk.

CONCLUSIONS

Female gender, diabetes, BMI > 40 kg/m^2, number of affected coronary arteries and the use of bilateral internal thoracic artery grafts were associated with a higher risk of SWI. The STS risk score can be successfully used in a study population in a Brazilian Tertiary Hospital of Cardiology for patients undergoing revascularization surgery.

In this study, no correlation was found between the etiological agents isolated in SWI and risk score.

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