



Risk factors for surgical site infection in cardiac surgery*

Fatores de risco para infecção de sítio cirúrgico em cirurgia cardíaca

Los factores de riesgo para la infecciones del sitio quirúrgico en s a cirugía cardíaca

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ABSTRACT

Objective: To analyze the occurrence of surgical site infection (SSI) in patients undergoing cardiac surgery in the period between July 2005, and July 2010. **Methods:** A quantitative, historical cohort study that evaluated 384 patients in a public teaching hospital. The Statistical Package for the Social Sciences software was used for data analysis and for descriptive analysis, measures of association in contingency tables and logistic regression were used. **Results:** It was found that 36 (9.4%) patients developed a SSI and that mortality occurred in 14 (38.9%). *Staphylococcus aureus* was the prevalent microorganism (12, 27.3%) In the multivariate analysis, the risk factors identified as predictors of SSI were male gender, intubation for more than 24 hours, and reintubation. **Conclusion:** The risk factors predictive of the occurrence of SSI ($p < 0.05$) were: male gender, reintubation, and intubation for more than 24 hours.

Keywords: Surgical wound infection; Cardiac surgical procedures/adverse effects; Risk factors

RESUMO

Objetivo: Analisar a ocorrência de infecção de sítio cirúrgico (ISC) nos pacientes submetidos à cirurgia cardíaca no período ente julho de 2005 e julho de 2010. **Métodos:** Estudo de abordagem quantitativa, coorte histórica que avaliou 384 pacientes de um hospital público de ensino. Foi utilizado o *software Statistical Package for the Social Sciences* para a análise dos dados e para a análise descritiva, foram usadas medidas de associação em tabelas de contingência e regressão logística. **Resultados:** Verificou-se que 36 (9,4%) pacientes evoluíram com ISC e que a mortalidade foi de 14 (38,9%). O *Staphylococcus aureus* foi o micro-organismo prevalente 12 (27,3%). Na análise multivariada, os fatores de risco identificados como preditores da ISC foram gênero masculino, tempo de intubação maior que 24 horas e reintubação. **Conclusão:** Os fatores de risco preditores para ocorrência de ISC ($p < 0,05$) foram: gênero masculino, reintubação e tempo de intubação maior que 24 horas.

Descritores: Infecção de ferida operatória; Procedimentos cirúrgicos cardíacos/efeitos adversos; Fatores de risco

RESUMEN

Objetivo: Analizar la ocurrencia de infección de sitio quirúrgico (ISC) en pacientes sometidos a cirugía cardíaca en el período entre julio del 2005 y julio del 2010. **Métodos:** Estudio de abordaje cuantitativo, cohorte histórica en el que se evaluó a 384 pacientes de un hospital público de enseñanza. Fue utilizado el *software Statistical Package for the Social Sciences* para el análisis de los datos y para el análisis descriptivo, fueron usadas medidas de asociación en tablas de contingencia y regresión logística. **Resultados:** Se verificó que 36 (9,4%) pacientes evolucionaron con ISC y que la mortalidad fue de 14 (38,9%). El *Staphylococcus aureus* fue el microorganismo prevalente 12 (27,3%). En el análisis multivariado, los factores de riesgo identificados como predictores de la ISC fueron género masculino, tiempo de intubación mayor de 24 horas y reintubación. **Conclusión:** Los factores de riesgo predictores para la ocurrencia de ISC ($p < 0,05$) fueron: género masculino, reintubación y tiempo de intubación mayorior de 24 horas.

Descriptores: Infección de herida operatria; Procedimientos quirúrgicos cardíacos/efectos adversos; Factores de riesgo

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INTRODUCTION

In Brazil, the surgical site infection (SSI) is a major infection related to health care; it is ranked as third among all infections in health services and comprises 14% to 16% of infections found in hospitalized patients⁽¹⁾.

The Centers for Disease Control and Prevention (CDC) has adopted the methodology of the National Nosocomial Infection Surveillance System (NNIS), developed criteria for defining the SSI. According to the CDC, the SSI occur in the first 30 days after surgery or up to one year in case of prosthesis. Therefore, the SSI are classified into superficial incision when involves skin and subcutaneous incision; deep incision when involves soft tissue such as fascia and/or muscle and organ/cavity (in cardiac surgery called mediastinitis), when involve any organ or cavity⁽²⁻⁴⁾.

In this context, the SSI in cardiac surgery is a complication of significant morbidity and mortality that increases costs of treatment^(5,6). The prolonged stay of patients with SSI represents an important economic factor, since they are spending almost triple the financial resources to patients with SSI than in those without infection, therefore it is clear that measures to prevent and control the SSI should be strengthened⁽⁵⁾.

The contamination of the surgical site can occur at any time during the perioperative period. Regarding transoperative period, in which there is exposure and manipulation of the tissue, during this period the entry of microorganisms is favored in the surgical site due to the existence of sources of infection, which may be endogenous (age, baseline disease) or exogenous (breaking aseptic barrier, inadequate hand hygiene)⁽⁷⁾.

According to literature, several factors may contribute to the occurrence of SSI, among them: diabetes mellitus (DM), obesity⁽⁸⁻¹⁰⁾, obstructive pulmonary disease (OPD)⁽¹¹⁻¹³⁾, age^(11,14), female gender^(8,15), sternal reexploration for bleeding^(10,16,17), blood transfusion^(17,18), duration of preoperative hospitalization^(4,14), inadequate hand hygiene^(4,7,19), among others, as the use of prophylactic antibiotic at the right time^(4,19), clinical condition of the patient, prolonged surgery time and number of professionals in the operating room⁽¹⁹⁾.

The identification of risk factors that contribute to the SSI occurrence, can provide information for planning and adoption of strategies in the prevention, control and monitoring of the infection in order to minimize their occurrence and maximize the principles of patient safety.

Although it has been observed in literature a low incidence of SSI in patients undergoing cardiac surgery, when it occurs, it is serious and may be fatal, which contributes to increased morbidity and mortality. Due to its clinical importance, this study is justified by the

need to know the local reality to support the planning of care for this population in order to reduce the incidence of SSI and ensure better quality of care for patients.

It is noteworthy that in the hospital where the study was conducted, it was implemented in 2008, the Infection Control Protocol for Preventing Infection in Cardiac Surgery. However, the implementation of this protocol in clinical practice had a low adherence by professionals. This suggests a need for greater investment in education and training for these professionals, with views to the applicability of this recommendation to ensure quality of care and reduction of SSI for this population.

Considering the importance and scarcity of studies on the local reality related to this issue, this study aimed to determine the rate of SSI; identify potential risk factors and prevalent microorganisms; verify the association of SSI and length of hospital stay in the postoperative; verify the association of SSI and mortality among patients undergoing cardiac surgery in the Heart Surgery Unit of a large public hospital.

METHODS

Quantitative approach study, historical cohort, conducted in a public and teaching hospital, with 290 beds serving patients in high complexity of clinical and surgical specialties, located in the municipality of Uberaba (MG). The Heart Surgery Unit in this hospital has only one team that performs three heart surgeries weekly.

This research is part of the project, called "Occurrence of nosocomial infection in patients undergoing cardiac surgery," which was submitted to the Ethics Research Committee of the Federal University of Triangulo Mineiro and approved under No. 1611, subject to Resolution No. 196/96 on research involving human beings.

The study population consisted of all patients who underwent cardiac surgery between July 2005 and July 2010, who met the following inclusion criteria: aged from 18 years, having undergone cardiac surgery through longitudinal median sternotomy; have undergone coronary revascularization, valve repair or exchange, corrections of congenital defects, fixes of cardiac aneurysms; thoracic aorta and excision of cardiac tumors.

In the corresponding period, there were 589 cardiac surgeries, of these, 384 patients contemplated the inclusion criteria, constituting the study population.

Data were collected from medical records of all patients undergoing cardiac surgery and from reporting cards on nosocomial infection of patients diagnosed with SSI, provided by the Commission of Hospital Infection Control of the hospital. To guide those data, we used a data collection instrument that included the

clinical and epidemiological factors related to risk factor for SSI occurrence.

In this study, the dependent variable was the presence of SSI and independent variables related to risk factors were: gender, age, underlying disease, smoking, body mass index (BMI), clinical condition, according to the American Society of Anesthesiologists (ASA), duration of preoperative hospitalization, previous infectious site, shaving, antiseptic for skin preparation, classification of surgery, type and duration of surgery, use and duration of cardiopulmonary bypass (CPB), blood transfusion, duration of intubation, reintubation and length of postoperative hospital stay.

Data were entered into an electronic spreadsheet in Excel® program for Windows® XP and validated by double entry. Data were exported and processed in the Statistical Package for the Social Sciences (SPSS) version 11.5 for Windows XP® for processing and analysis.

Quantitative variables were analyzed as descriptive statistics, through measures of central tendency (mean and median) and variability (minimum, maximum and standard deviation – SD).

Data analysis to verify the existence of an association between SSI and categorical variables was performed using the chi-square (χ^2) test and we used the t Student test to check the mean time between SSI and the length of hospital stay after surgery. The requirements for use of parametric tests such as normality and homogeneity of variance were analyzed using the Shapiro-Wilk test and Levene.

A bivariate analysis was done in order to explore the associations between the dependent variable (SSI) and the independent variables, whose associations were expressed by relative risk (RR), odds ratios (ORs) and their respective 95% confidence interval (CI).

In multivariate analysis, the associations were studied, based on logistic regression model, the dependent variable (SSI) with the independent variables whose association with SSI in bivariate analysis with $p \leq 0.05$.

Results were considered significant at 5% ($p < 0.05$), giving to these 95% of confidence that the results were correct.

RESULTS

In this study, from the 384 patients analyzed, 36 (9.4%) were diagnosed with SSI.

In regard to sociodemographic characteristics, the majority were male 234 (60.9%), and the mean age was 54.72 years (range 18-81 years). Regarding clinical aspects, in relation to comorbidities, 319 (83.1%) patients had one or more baseline disease, and 264 (48.6%) patients had hypertension (HBP). Among other features, 108 (43.1%) were found with BMI = 25-29.9

kg/m², which shows excess weight⁽²⁰⁾ and 98 (54.1%) patients were classified as ASA index P3 ie patient with severe systemic disease⁽²¹⁾. Regarding the surgical aspects, CABG surgery is highlighted performed in 187 (48.7%) patients and the use of Polyvinyl Pyrrolidone Iodine (PPI), used in 158 (41.1%), as an antiseptic of choice for skin preparation for surgery, as the data of Table 1 presents.

Table 1. Sociodemographic characteristics, clinical and surgical patients undergoing cardiac surgery. Uberaba-MG, 2005-2010.

Variables	n (%)	Mean	SD
Coming from			
Uberaba	252 (65.6)		
Other places	132 (34.4)		
Gender			
Male	234 (60.9)	54.72	1.316
Female	150 (39.1)		
Age groups			
18-29 years	17 (4.5)		
30-39 years	35 (9.1)		
40-49 years	66 (17.2)		
50-59 years	118 (30.7)		
60-69 years	99 (25.8)		
70-79 years	47 (12.2)		
>80 years	2 (0.5)		
Comorbidities			
Hypertension	264 (48.6)		
Diabetes mellitus	82 (15.0)		
Chronic obstructive pulmonary disease	35 (6.4)		
Congestive heart failure	34 (6.2)		
Chronic renal failure	15 (2.7)		
Immunosuppressive disease	4 (0.7)		
Acute renal failure	2 (0.4)		
Other	110 (20.2)		
Smoking			
No smoking	124 (32.3)		
smoking	118 (30.7)		
Used to smoke	84 (21.9)		
Not mentioned	58 (15.1)		
Body Mass Index (BMI)*			
<18,5	7 (1.8)		
18,5-24,9	94 (24.5)		
25-29,9	108 (28.1)		
30-34,9	27 (7.0)		
35-39,9	10 (2.6)		
≥40	1 (0.3)		
Not mentioned	137 (35.7)		
Variables	n (%)	Mean	SD
Clinical status (ASA score)**			
P1	10 (2.6)		
P2	69 (18.0)		
P3	98 (25.5)		
P4	4 (1.0)		
Not mentioned	203 (52.9)		

Variables	n (%)	Mean	SD
Previous Infection			
Yes	31 (8.1)		
No	353 (91.9)		
Hospitalization period (in days) before surgery		7.07	7.701
Shaving			
Yes	234 (60.9)		
No	150 (39.1)		
Time of shaving performed before surgery – in hours		6.09	1047.514
Antiseptic			
Polyvinyl Pyrrolidone Iodine (PPI)	158 (41.2)		
Association of PPI with other antiseptics	114 (29.7)		
Chlorhexidine	110 (28.6)		
Alcohol iodized	2 (0.5)		
Surgery Classification			
Elective	381 (99.2)		
Urgency	3 (0.8)		
Type of surgery			
Coronary Revascularization (CR)	187 (48.7)		
Mitral valve exchange (MVE)	67 (17.4)		
Aortic valve exchange (AVE)	58 (15.1)		
Interatrial communications	16 (4.2)		
MVE + AVE	12 (3.1)		
AVE + CR	9 (2.3)		
Bentall	5 (1.3)		
MVE + CR	2 (0.5)		
Interventricular communication	1 (0.3)		
Other	27 (7.0)		
Surgery duration – hours		3.755	1.0110
CPB			
Yes	374 (97.4)		
No	10 (2.6)		
CPB time-minutes		75.70	32.280
Intraoperative blood transfusion			
Yes	52 (13.5)		
No	332 (86.5)		
Duration of Intubation – hours		21.79	37.154
Reintubation			
Yes	29 (7.6)		
No	355 (92.4)		
Postoperative blood transfusion			
Yes	206 (53.6)		
No	178 (46.4)		

* World Health Organization. **American Society of Anesthesiologists

From 36 patients diagnosed with SSI, 14 types of microorganisms were identified with a prevalence of *Staphylococcus aureus* in 12 (27.3%) patients, according to the data in Table 2.

Table 2. Distribution of microorganisms isolated from patients with SSI. Uberaba-MG, 2005-2010.

Isolated microorganisms	n (%)
<i>Staphylococcus aureus</i>	12 (27,3)
<i>Klebsiella pneumoniae</i>	6 (13,7)
<i>Staphylococcus epidermidis</i>	4 (9,1)
<i>Escherichia coli</i>	4 (9,1)
<i>Staphylococcus coagulase negativa</i>	3 (6,8)
<i>Cedecia davisae</i>	3 (6,8)
<i>Enterobacter cloacae</i>	3 (6,8)
<i>Pseudomonas aeruginosa</i>	2 (4,5)
<i>Acinetobacter baumannii</i>	2 (4,5)
<i>Enterobacter aerogenes</i>	1 (2,3)
<i>Corynebacterium spp.</i>	1 (2,3)
<i>Bastonetes gram-negativos</i>	1 (2,3)
<i>Morganela morgani</i>	1 (2,3)
<i>Acinetobacter calcoaceticus</i>	1(2,3)

Regarding antimicrobial therapy for the treatment of SSI, the most used antibiotic was Cefepime Hydrochloride 25 (21.6%) Vancomycin 21 (18.1%), Imipenem+cilastatin sodium 17 (14.7%) and Oxacillin sodium nine (7.7%).

In relation to the length of ICU stay, mean length of stay of patients with SSI was 19.08 days (SD = 16.423), ranging from 4 to 70 days and patients without SSI, the mean was 4.95 (SD = 1.797), ranging from 2 to 15 days. As for the total time of hospitalization, mean length of stay of patients with SSI was 33.00 days (SD = 17.326), ranging from 6 to 76 days and patients without SSI mean was 8.24 (SD = 3.051), ranging from 3 to 29 days.

In the bivariate analysis of the data, there was statistical significance ($p < 0.05$) between gender and SSI (RR = 2.24 95% CI 1.07-5.44, $p = 0.030$), HBP (RR = 2.82 CI 95% 1.12-7.07, $p = 0.018$), DM (RR = 2.63 95% CI 1.42-4.87, $p = 0.002$), COPD (RR = 3.83 95% CI 2.02-7.28, $p < 0.001$), type of surgery (RR = 2.64 95% CI 1.16- 6.00, $p = 0.015$), duration of surgery (RR = 2.55 95% CI 1, 38- 4.73, $p = 0.002$), duration of intubation (RR = 3.92 95% CI 2.14-7.19, $p < 0.001$), reintubation (RR = 6.92 95% CI 3.93-12.17, $p < 0.001$), duration of ICU stay (mean, 19.08 days, $p < 0.001$) and total hospitalization in postoperatively stay (mean 33 days, $p < 0.001$).

In the multivariate analysis by logistic regression, it was found that there was statistical significance ($p < 0.05$) between SSI and gender, duration of intubation greater than 24 hours and reintubation, the reintubation variable showed the strongest association, as presented in Table 3.

Table 3. Association between SSI and independent variables analyzed by logistic regression. Uberaba-MG, 2005-2010.

Independent Variables	SSI		*OR (CI)	p-value
	YES n (%)	NO n (%)		
Gender				
Male	28 (12.0)	206 (88.0)	3.65	0.029
Female	8 (5.3)	142 (94.7)	(1.14-11.70)	
Diabetes mellitus				
Yes	15 (18.3)	67 (81.7)	1.92	0.181
No	21 (7.0)	281 (93.0)	(0.74-4.99)	
Hypertension (HBP)				
Yes	31 (11.7)	233 (88.3)	3.83	0.081
No	5 (4.2)	115 (95.8)	(0.85-17.39)	
COPD				
Yes	10 (28.6)	25 (71.4)	2.86	0.092
No	26 (7.4)	323 (92.6)	(0.81-9.73)	
Type of Surgery				
CABG	23 (11.6)	175 (88.4)	0.72	0.581
Others	7 (4.4)	152 (95.6)	(0.23-2.30)	
Duration of Surgery				
>240 minutes	19 (16.2)	98 (83.8)	2.25	0.084
<240 minutes	7 (6.4)	250 (93.6)	(0.90-5.64)	
Duration of Intubation				
>24 hours	18 (23.1)	60 (76.9)	2.73	0.041
<24 hours	18 (5.9)	288 (94.1)	(1.04-7.13)	
Reintubation				
Yes	13 (44.8)	16 (55.2)	13.26	<0.001
No	23 (6.5)	332 (93.5)	(4.12-42.69)	

HBP: hypertension, COPD: chronic obstructive pulmonary disease, SSI: surgical site infection. * OR: Odds Ratio

Regarding the patients with SSI prognostic after cardiac surgery, it was found that from the 36 patients with SSI, 14 (38.9%) died.

DISCUSSION

In this study, the incidence of SSI was higher than that identified in the literature, ranging between 0.2% and 5.6%^(8,10,16,22-25). It is important to measure the rates of SSI, because they provide data that can lead to improvement of conditions observed and prevent this serious complication in patients undergoing cardiac surgery⁽⁵⁾.

Staphylococcus aureus was the prevalent microorganism, this result was corroborated by other studies^(8,25).

Regarding the mortality rate among patients with SSI, this research was 38.9%, diverging from other studies in which the frequency ranged between 2.6% and 32.1%^(14,17,22-24). Therefore, this result indicated that the diagnosis of SSI was constituted in an aggravation of the clinical condition of the patient, which may have favored the occurrence of complications with death.

In this study, we found that variables such as male

gender, duration of intubation greater than 24 hours and reintubation were predictors of SSI in patients undergoing cardiac surgery ($p < 0.05$, multivariate analysis).

The prevalence of male gender was corroborated by other studies about patients who underwent cardiac surgery^(10,12,16,18,19,26,27). Regarding the higher incidence of SSI in male patients, this result is close to the findings of other studies^(14,28,29).

The mechanisms by which men are more prone to develop this type of infection compared to women are not yet known. One hypothesis suggests that men, because they have more hair follicles in the chest area where sternotomy is made, they may be more susceptible to bacterial growth and infection, but further studies are needed to elucidate this hypothesis⁽²⁹⁾.

Although, in this study, reintubation has been identified as a high risk factor (RR = 6.92) for developing SSI, there are few studies that address this issue⁽²⁸⁾. Therefore, the reasons for considering reintubation as a risk factor for SSI are still unclear, since the studies that analyzed risk factors for heart surgery, in most cases, did not mention this result, so more research is needed to address this aspect. However it can be thought that

reintubation may be linked to the seriousness of patients with infection, since this status usually triggers multiple organic alterations in the patient. .

As for the duration of intubation, this study found that when this continue for more than 24 hours, it is considered a risk factor for SSI, and this result is confirmed by other studies^(16,25,30).

In this sense, it is understood that the longer the duration of intubation, the greater the patient's stay in the ICU will be, since they will be more exposed to environmental pathogens that their defense barriers may be compromised and also the multiplicity of procedures which are performed, all these features may facilitate the development of SSI.

Regarding the length of ICU stay, patients with SSI had a mean stay of 19.08 days, this result is supported by another study in which the mean ICU stay was 17.79 days⁽³¹⁾. As for the total time of hospitalization, the mean length of stay was 33 days, which differs from other studies that showed a mean time of stay between 40 to 56 days^(8,13,24,31,32).

The prolonged hospitalization of patients with SSI represents an important economic factor, since the cost of treatment of patients with SSI is much higher than in those without infection because of the procedures such as dressings, laboratory tests, treatment, complications and use of antibiotics.

Considering the high costs of health services and the variety of options for the treatment of heart diseases, the identification of risk factors for patient's complications in postoperative may influence the decision about the appropriate course of action to be adopted for that patient⁽³²⁾, with a view to prevention and control of SSI.

Among some important aspects concerning the prevention and control of SSI researched in this study, we highlight the skin antisepsis, time of performance of shaving before the surgical incision, identification of prior site infectious and comorbidities presence.

The choice of antiseptic solution should be based on knowledge of product efficacy, cost and ease of usage⁽³³⁾. Although evidence points to the fact that chlorhexidine-based products for skin preparation for surgery have shown better results than other products for bacterial decolonization^(34,35), in this study, we observed low adherence of cardiac surgeons and health professionals who work in the surgical center to this product.

Shaving should be done only when necessary and must be done before surgery, at a time equal to or less than 2 hours⁽⁴⁾. This study showed that in most cases the mean time between the completion of shaving and

the surgical incision was over 2 hours, which differs from the CDC recommendations⁽⁴⁾.

Despite having statistical significance between SSI and infection prior to surgery, the clinical relevance should be considered in this case. Therefore, identifying and treating existing infectious site before elective surgeries is a recommendation and their rescheduling should only be done after the resolution of the problem, ie, control of infectious site⁽⁴⁾.

Although some risk factors such as DM and COPD, are widely discussed in the literature as strong predictors for SSI⁽⁸⁻¹³⁾; in this study they were not associated with the occurrence of SSI. However, we must remember that prevention and control measures are essential and are directly related to the postoperatively prognosis^(8,9,17,22,25). Thus, health care programs that address to specific aspects of the person affected by these comorbidities should be implemented not only during hospitalization of patients, since many of postoperative complications may result from these decompensating cases associated with comorbidities.

It is noteworthy that this study has limitations such as the inability to evaluate aspects mainly related to the environment of the operating room, surgical scrub and incompleteness of secondary data, as noted in those related to smoking, record on weight and height to calculate BMI, ASA score, used as sources of information for this research. However, these limitations did not affect the achievement of the objectives proposed in this study, considering the study design adopted.

Thus, this research can inform the development of other prospective studies with a view to patient safety and quality of care, due to the importance of epidemiological surveillance of this infection, highlighting the need for reflection and discussion on the implementation of institutional protocols for promoting improved quality of care for this population.

CONCLUSION

This study has highlighted that the rate of SSI in patients undergoing cardiac surgery and the mortality rate were higher than shown in the literature and the most common microorganism was *Staphylococcus aureus*.

As predictors of SSI were also identified the variables: male, duration of intubation greater than 24 hours and reintubation. Regarding the length of ICU stay, the mean was 19.08 days and the total length of hospital stay, the mean was 33 days.

It is hoped that the results of this study may provide a basis for the elaboration of programs of prevention, control and monitoring, evidence-based, in order to reduce the incidence of SSI and ensure patient safety.

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