

## Factors Associated with Post-Sternotomy Mediastinitis. Case-Control Study

Débora Cristine Gomes Pinto, Antônio Fernandino de Castro Bahia Neto, Flávia Lage Gonçalves, Isabel Cristina Gomes, Eduardo Back Sternick, Alessandra Maciel Almeida, Nulma Souto Jentzsch

Faculdade Ciências Médicas de Minas Gerais, Minas Gerais, MG – Brazil

### Abstract

**Background:** Mediastinitis is a severe post-median sternotomy infection with poor prognosis, even with early diagnosis and treatment.

**Objectives:** To evaluate the profile of patients submitted to sternotomy, identify the risk factors for the development of mediastinitis and evaluate the bacteriological diagnosis of patients with this infection.

**Methods:** Case-control study carried out in a large hospital in Belo Horizonte (MG, Brazil) in patients submitted to median sternotomy, from January 2015 to January 2018. The sample consisted of 65 patients, of which 13 were cases and 52, controls (1:4). For the statistical analysis, Student's t test, Mann-Whitney test and Fisher exact test were used, in addition to logistic regression, with a level of significance of 5%.

**Results:** There was a predominance of males (63.1%), and the mean age was  $58.8 \pm 10.3$  years. Evolution to death occurred in 9.2% of the patients and in 23.1% of those with mediastinitis. Myocardial revascularization was performed in 75.4% of the cases. Predominance of male gender, longer hospitalization time, post-surgical fever and death, and a greater number of risk factors were more frequent characteristics in patients who developed mediastinitis. The most common microorganism found in patients with mediastinal infection was *Staphylococcus aureus* (30.7%), in addition to a high occurrence of Gram-negative bacteria (46,2%).

**Conclusion:** The results are in accordance with the literature. Efforts should be focused on the control of risk factors prior to the procedure, in addition to improving measures that can decrease or eliminate the onset of mediastinitis, aiming at infection prevention and control. (Int J Cardiovasc Sci. 2018;31(2)163-172)

**Keywords:** Mediastinitis; Risk factors; Thoracic surgery; Surgical wound infection.

### Introduction

Mediastinitis is a severe post-median sternotomy infection, affecting the adjacent deep tissues, with clinical and/or microbiological evidence of retrosternal space involvement, which may be associated with sternal osteomyelitis, with or without instability.<sup>1,2</sup> It has an incidence of 0.4% to 5% and high mortality (14% to 47%)<sup>3</sup>. Even with early diagnosis and treatment, it does not have a good prognosis, especially in the presence of sepsis and other health problems<sup>4</sup>.

The risk factors associated with mediastinitis are pre-surgical, surgical and post-surgical ones.<sup>5</sup>

Pre-surgical factors include older age, male gender, malnutrition, obesity, smoking, Diabetes mellitus (DM) and other diseases,<sup>5,6</sup> as well as chronic renal failure (CRF) and/or creatinine serum levels  $> 1.5\text{mg/dL}$  and Left Ventricular Ejection Fraction (LVEF)  $< 40\%$ .<sup>7,8</sup>

Surgical risk factors include the type of surgery (elective or urgent), prolonged surgical time, coronary artery bypass grafting (CABG) using bilateral mammary arteries, and intra-aortic balloon insertion<sup>9,10</sup>. Routine procedures such as hair removal and the time elapsed between hair removal and the surgical incision, in addition to the sterilization of the surgical materials and the number of people in the operating

**Mailing Address:** Isabel Cristina Gomes •

Rua José Ferreira da Luz, 44. Postal Code 30750-480, Caiçaras, Belo Horizonte, MG – Brazil.

E-mail: icgomes04@yahoo.com.br, isabel.gomes@feluma.org.br

rooms, are also mentioned.<sup>10,11</sup> Other mentioned conditions are antibiotic prophylaxis, intraoperative complications,<sup>5</sup> excessive electrocautery use and previous corticosteroid therapy.<sup>12,13</sup>

Postoperative risk factors include prolonged hospital stay and length of stay in Intensive Care Units (ICU), bleeding, respiratory, nephrological and gastrointestinal complications, and the need for surgical reintervention, as well as tracheostomy and sternal instability.<sup>5,9,12,13</sup>

Many risk factors have been associated with the development of mediastinitis; however, they vary among institutions, disclosing the need for studies in different hospitals. It is also necessary to verify the bacteriological diagnosis, generally with presence of *Staphylococcus aureus* or *Staphylococcus epidermidis*, responsible for 70% to 80% of cases.<sup>14</sup>

The aim of this study was to evaluate the profile of patients submitted to sternotomy for the treatment of heart diseases and identify the risk factors for the development of mediastinitis, as well as to evaluate the bacteriological diagnosis of these cases, in a large hospital in Belo Horizonte, state of Minas Gerais (MG), Brazil.

## Methods

This is a case-control study, carried out in a large hospital in the city of Belo Horizonte (MG), with data obtained from medical records of patients older than 18 years submitted to cardiac surgery from January 2015 to January 2016. The sample consisted of 65 patients, with and 52 controls paired by gender and age at a ratio of 1:4.

The case group consisted of patients diagnosed with post-sternotomy mediastinitis confirmed by the Hospital Infection Control Service and by the attending surgeon. The control group consisted of patients submitted to sternotomy during the same period, who did not develop mediastinitis.

A data collection form was created, which contained information on the patient's characteristics (gender and age), pre-surgical conditions (date of hospital admission and surgery), and pre-surgical risk factors (alcohol consumption, smoking, sedentary lifestyle, obesity, DM, dyslipidemia, hypertension, chronic obstructive pulmonary disease (COPD), CRF, class III congestive heart failure, cerebrovascular accident, coronary artery disease and previous cardiac surgery), in addition to the LVEF value. The assesses trans-surgical condition was time of Extracorporeal Circulation (ECC). In relation to

the postoperative period, the following were assessed: date of hospital admission and hospital and ICU discharges; fever ( $> 38.3^{\circ}\text{C}$ ); post-surgical creatinine and death. Prophylactic drugs and bacteriological diagnosis were also evaluated in the cases.

## Statistical analysis

Qualitative variables were described as counts and percentages, and the quantitative variables were described as mean  $\pm$  standard deviation or median  $\pm$  interquartile range, according to data normality, tested by the Shapiro-Wilks test. For the comparison of means, Student's *t*-tests and Wilcoxon Mann-Whitney tests were used for independent samples, when appropriate. The association between categorical variables was assessed using Fisher's exact test. The level of significance was established at 5%.

The combined effect of the variables on the groups was assessed using the logistic regression model. The variables with  $p < 0.20$  in the bivariate analysis were included in the multiple model, and the backward strategy was used for variable selection. The final model included the variables with  $p < 0.05$  and the variable age, maintained at the researchers' discretion. The results are shown as Odds Ratio (OR) and their respective 95% confidence intervals. (95%CI). The quality of the adjustment was assessed by the Hosmer-Lemeshow test. The analyses were performed using the free software R, version 3.1.3.

## Results

The sample consisted of 65 patients. There was a predominance of the male gender (63.1%) with a mean age of 58.8 years ( $\pm 10.3$ ). The most common type of surgery was coronary artery bypass grafting (CABG) (78.5%), followed by valve replacement (27.4%). The median number of preoperative risk factors was 4 ( $\pm 2$ ). The most commonly used prophylactic antibiotics were cefuroxime (67.7%) and vancomycin (67.7%). Regarding cefuroxime, its use was lower in patients who had a diagnosis of mediastinitis (Table 1). Regarding diabetes mellitus, 45.2% of the cases were diabetic and 33.3% were insulin-dependent, although no statistically significant differences were observed between the groups.

Previous cardiac catheterization was performed in 93.8% of the patients. A median LVEF of 60 ( $\pm 19.3\%$ ) and mean ECC time of 80  $\pm$  40.3 minutes were observed. The median time of post-surgical hospitalization was 13 days ( $\pm 15$ ), and this time was longer in patients

**Table 1 – Characterization of the study patients**

Variables	Total (n = 65)	Controls (n = 52)	Cases (n = 13)	p-value
<b>Gender, n (%)</b>				<b>0.526*</b>
Female	24 (36.9)	18 (34.6)	6 (46.2)	
Male	41 (63.1)	34 (65.4)	7 (53.8)	
Age, years	58.8 ± 10.3	58.1 ± 10.4	61.6 ± 9.8	0.265†
Obesity, n (%)	13 (20)	11 (21.2)	2 (15.4)	1.000*
Number of pre-surgical risk factors	4 ± 2	3 ± 3	4 ± 1	0.056‡
<b>Use of prophylactic antibiotics, n (%)</b>				
Cefuroxime	44 (67.7)	39 (75)	5 (38.5)	0.019*
Vancomycin	44 (67.7)	36 (69.2)	8 (61.5)	0.742*
Cefazolin	15 (23.1)	9 (17.3)	6 (46.2)	0.059*
Previous catheterization§	61 (93.8)	49 (94.2)	12 (92.3)	1.000*
LVEF, %	60 ± 19.3	60 ± 16	54 ± 29	0.300‡
<b>Type of surgery, n (%)</b>				
CABG	51 (78.5)	40 (76.9)	11 (84.6)	0.717*
Valve replacement	17 (27.4)	12 (24.5)	5 (38.5)	0.319*
Mitral	7 (11.3)	4 (8.2)	3 (23.1)	0.153*
Aortic	6 (9.7)	4 (8.2)	2 (15.4)	0.597*
Double replacement	4 (6.5)	4 (8.2)	-	0.571*
Valve replacement reoperation§	3 (4.8)	3 (6)	-	1.000*
Mitral	2 (3.2)	2 (4)	-	1.000*
Double replacement	1 (1.6)	1 (2)	-	1.000*
CABG + valve replacement	6 (9.7)	3 (6.1)	3 (23.1)	0.100*
Post-surgical hospitalization time, days	13 ± 15	12 ± 4.8	40 ± 21	<0.001‡
Extracorporeal circulation time§, minutes	80 ± 40.3	77.5 ± 43.5	82 ± 18.3	0.770‡
Post-surgical creatinine, mg/dL	0.86 ± 0.36	0.80 ± 0.32	1.13 ± 2.12	0.004‡
Death, n (%)	6 (9.2)	3 (5.8)	3 (23.1)	0.089*

Tests for p values: \* Fisher exact test; † Student's t test for independent samples; and ‡ Wilcoxon Mann-Whitney test; § the variable has missing data. LVEF: left ventricular ejection fraction; CABG: coronary artery bypass grafting.

diagnosed with mediastinitis. The median creatinine level observed after surgery was 0.86 mg/dL (± 0.36), and it was significantly higher in the mediastinitis group. Death occurred in 9.2% of the patients and in 23.1% of those who had post-sternotomy mediastinitis.

No differences were observed in relation to gender and age, which confirms the pairing effectiveness. A greater median number of pre-surgical risk factors were

observed among those with a diagnosis of mediastinitis, in addition to a higher proportion of patients who were submitted to CABG.

The most common microorganism found in the bacteriological diagnosis of patients with mediastinitis was *Staphylococcus aureus* (30.7%) and there was a high occurrence of Gram-negative bacteria (GNB) (46.2%) (Table 2).

Factors associated with mediastinitis that were observed in the logistic model: longer time of post-surgical hospitalization, occurrence of post-surgical fever and higher number of pre-surgical risk factors. Each increase of 1 day in post-surgical hospitalization increased the chance of developing mediastinitis by 3.2% and, with each increase of one pre-surgical risk factor, this chance increased by 57.3%. The occurrence of fever after surgery increases the chance of developing mediastinitis by more than ten-fold (Table 3).

## Discussion

This work was motivated by a case-control study carried out in the same institution from January 2005 to January 2007, with 54 patients, with a mean age of 59.7 years, submitted to sternotomy (18 with mediastinitis). Most patients were males (72.2% for the whole sample and 66.7% among those who developed mediastinitis), and 86% were submitted to CABG. Mortality was 22.2% in the sample and 33.3% among those with mediastinitis.<sup>15</sup> The results of the present study showed similar results to those of the previous study regarding age, male predominance and type of surgery (CABG), with higher proportions among those who developed mediastinitis. Regarding death, mortality was lower than that previously observed, including among patients who had mediastinitis,

but these values are still high, as shown in the literature (14% to 47%).<sup>3</sup> The median time of post-surgical hospitalization was higher in patients diagnosed with mediastinitis in both studies, showing greater severity of the cases and impact on hospital costs. The results indicate the need to investigate the factors responsible for the development of this complication, aiming at the prevention and control of health care-associated infections, aiming to improve quality of care, patient safety and to reduce costs.

Regarding the patient profile, incidence of mediastinitis and mortality, Souza et al.<sup>4</sup> evaluated patients submitted to surgical interventions between 1991 and 2000 and found a mean age of 51.9 years, most of them submitted to CABG (also among those who developed mediastinitis) and a predominance of female patients. The incidence of post-sternotomy mediastinitis was 1.6% and the mortality rate was 21.6%. Sá et al.<sup>1</sup> evaluated patients submitted to CABG between 2007 and 2010, in whom the mean age was 62.14 years, with a predominance of males. The incidence of mediastinitis was 5.6% and the mortality rate was 32.1%. Magalhães et al.<sup>3</sup> evaluated patients submitted to cardiac surgery, from 2007 to 2009; the mean age was 60 years and most of them were males. CABG was performed in 76.2% of the patients who developed mediastinitis; only 2.3% of the patients developed post-sternotomy mediastinitis and 33% died.

**Table 2 – Microorganisms found in the bacteriological diagnosis of patients with mediastinitis**

Microorganism	n = 13 n (%)
Gram-positive	6 (46.2)
Staphylococcus aureus	4 (30.7)
Coagulase-negative Staphylococcus	1 (7.7)
Coagulase-negative Staphylococcus, Streptococcus agalactiae*	1 (7.7)
Gram-negative	6 (46.2)
Enterobacter sp	1 (7.7)
Acinetobacter baumannii	1 (7.7)
Stenotrophomonas maltophilia	1 (7.7)
Klebsiella pneumoniae, Pseudomonas aeruginosa*	1 (7.7)
Klebsiella pneumoniae	1 (7.7)
Escherichia coli, Proteus mirabilis and Klebsiella pneumoniae*	1 (7.7)
No information	1 (7.7)

\*Patients with more than one microorganism.

**Table 3 – Variables associated with the occurrence of mediastinitis**

Variables	OR (n = 65)	95% CI OR (n = 52)	p-value*
Intercept	0.008	(4.3e <sup>-5</sup> -0582)	0.042
Age	0.997	(0.918-1.086)	0.952
Post-surgical hospitalization time, days	1.032	(1.008-1.067)	0.019
<b>Fever</b>			
No	-	-	-
Yes	10.316	(2.124-61.738)	0.005
Number of risk factors	1.573	(0.978-2.640)	0.065

*The p-values refer to the significance tests of the regression coefficients. Hosmer-Lemeshow test: p = 0.620 (non-rejection of model adequacy). OR = odds ratio; 95% CI: 95% confidence interval.*

Similar results were observed in studies conducted in Brazil: Guaragna et al.<sup>8</sup> evaluated patients submitted to cardiac surgery from 1997 to 2000. Most of them were males (also in the mediastinitis group, 71.1%). The incidence of mediastinitis was 2.9% and the mortality rate was 15.8%. Moreover, a study of patients submitted to CABG from 1996 to 2007 showed an incidence of mediastinitis of 3.3% and a 6% mortality rate.<sup>6</sup> Another study carried out in patients submitted to cardiac surgery, from 2007 to 2009, had 68.5% of the sample submitted to CABG and 31.5% to valve replacement. The mean age was 59.9 years and most of them were males. The incidence of post-sternotomy mediastinitis was 1.3%, and mortality was 42.8%.<sup>16</sup>

A study carried out in the United Kingdom evaluated patients submitted to CABG from 1999 to 2009. The mean age was 67 years and 77.3% were males. The incidence of patients who developed post-sternotomy mediastinitis was 0.59%. Mortality was higher in patients who developed mediastinitis.<sup>17</sup>

Regarding the profile of the patients described in these studies,<sup>1,3,4,6,8,15-17</sup> most of them were males, mean age was around 52 to 67 years, and CABG was the most often performed surgery. Similar results were observed in both studies performed at the institution mentioned here, that is, the present study and the one by Coelho et al.<sup>15</sup>, regarding gender, mean age and type of surgery.

Male patients are more likely to develop mediastinitis and gender is even considered an independent risk factor for its development.<sup>18,19</sup> One of the probable mechanisms is related with the anatomical aspects of the

male chest (hair follicles in the region of the sternotomy), favoring bacterial growth and infection. Guaragna et al.<sup>8</sup> verified this association: most patients who developed mediastinitis were males. In the present study, it was not possible to evaluate this association, as gender was used for pairing of the controls.

Regarding the type of surgery, the correlation between CABG and the development of mediastinitis is well documented in the literature. More than 80% of the cases of infection were mentioned as a surgery-associated complication.<sup>3</sup> The studies by Souza et al.<sup>4</sup>, Sá et al.<sup>1</sup> and Magalhães et al.<sup>3</sup> verified this association, as observed in this study in which CABG, besides being the most often performed surgery, showed a higher proportion of patients with mediastinitis, although it did not show statistical difference.

The incidence of mediastinitis in the evaluated studies, as described in the guideline of the American College of Cardiology / American Heart Association (ACC / AHA) in 2012,<sup>11</sup> is between 0.4 and 4.0%. In this study, it was not possible to evaluate the incidence of mediastinitis, due to the study design. However, in the cohort studies, the lowest incidence of mediastinitis was observed in the study of Ariyaratnam et al.<sup>17</sup>, carried out in the United Kingdom. Studies performed in Brazil showed an incidence varying from 1.3% to 3.3%,<sup>3,4,6,8,16</sup> except for the study by Sá et al.<sup>1</sup>, which showed an incidence of 5.6%. The authors justified the high incidence for having considered all types of cardiac surgeries including CABG, which is, according to them, associated with a greater risk of mediastinitis. Other studies<sup>1,3,4</sup> also found an association between CABG and increased risk of mediastinitis, but they showed an

incidence within the reference values indicated by the ACC/AHA guideline.<sup>11</sup> Regarding mortality, high rates have been described in the literature, with rates ranging between 14% and 47%.<sup>3</sup> In Brazilian studies of patients submitted to cardiac surgeries, mortality rates ranged from 15.8% to 42.8%.<sup>1,3,4,6,8,15</sup>. An international study showed a lower mortality rate (9.1%),<sup>17</sup> but it was higher in patients who developed mediastinitis<sup>17</sup> as observed in the present study. This variation suggests that both the incidence of mediastinitis and mortality rates may be related to the evaluated institution, and may be influenced by the routine of the institution, the use of prophylactic antimicrobials or the standardization of aseptic techniques.

Regarding the preoperative risk factors, no significant differences were observed in this study when the factors were evaluated alone, as in the previous study performed in this same institution.<sup>15</sup> However, in the logistic regression model, a greater chance of developing mediastinitis was attributed to the higher number of preoperative risk factors. Each increase of one risk factor increased the chance of having mediastinitis by 57.3%.

A literature review aimed to identify the risk factors associated to the occurrence of post-sternotomy mediastinitis in adult patients submitted to CABG. The main risk factors identified were age over 65 years, DM, obesity, COPD and surgical reintervention.<sup>20</sup>

Tiveron et al.<sup>16</sup> verified the pre-operative risk factors in patients (most submitted to CABG) and the occurrence of mediastinitis, and identified intra-aortic balloon, hemodialysis and extracardiac vascular intervention. Oliveira and Paula<sup>21</sup> found DM, hospitalization time of more than seven 7 days preoperatively, smoking and obesity as risk factors. Guaragna et al.<sup>8</sup> evaluated patients submitted to cardiac surgery, and the preoperative risk factors were: obesity, DM, COPD, previous cardiac surgery, smoking and gender – with obesity, COPD and DM being independent risk factors, even when analyzed by gender and age.

A study carried out in patients submitted to CABG showed independent preoperative risk factors related to mediastinitis, such as DM, obesity and smoking<sup>1</sup>. In a study carried out in the UK,<sup>17</sup> the following factors were listed: age, body mass index, DM and COPD.

Many risk factors have been associated with the development of mediastinitis after cardiac surgery. However, it has been observed there is no definite consensus about the most important risk factors associated with mediastinitis, nor even if each factor

can be considered an independent predictor of risk in the postoperative period. In general, the studies only describe the main risk factors associated with the disease in different health services.<sup>22</sup>

Studies carried out in different health services<sup>1,8,17,21</sup> showed similar results to those observed in the literature review,<sup>20</sup> which showed age, DM, obesity, surgical reintervention and COPD as the main risk factors related to the occurrence of mediastinitis in adult patients submitted to CABG. COPD was identified as a risk factor for mediastinitis by Ariyaratnam et al.<sup>19</sup> and Guaragna et al.,<sup>8</sup> who emphasize that patients with COPD are more susceptible to surgical wound infection due to tissue hypoxemia and the need for corticosteroid therapy in the pre- and /or postoperative period, facilitating the onset of infections.

Another risk factor related to mediastinitis is obesity, although it shows controversial results in cardiac surgeries.<sup>23</sup> Obese patients may have worse evolution when submitted to major surgeries. Obesity can impair the healing of the surgical wound, due to the rupture of the surgical sutures, facilitating bacterial invasion of the surgical site.<sup>23-25</sup> This is due to the propagation of high lateral traction forces at the edges of the skin incision in the supine position, as well as the folding of the skin in the distal third of the surgical incision in the inframammary region (area of extensive colonization of microorganisms) in the sitting position.<sup>26</sup> Since obesity is a modifiable risk factor, it is important that measures for weight reduction be adopted in the preoperative period. Additionally, it must be considered that obesity can make it difficult to adjust antibiotic doses to the body mass, consequently leading to low tissue concentrations of the antibiotic.<sup>27,28</sup> In this study, the association between obesity and mediastinitis ( $p = 1,000$ ) was not observed.

Two studies<sup>1,8</sup> demonstrated that obesity and DM were associated with the occurrence of post-sternotomy mediastinitis. A multicenter study, called the Parisian Mediastinitis Study Group,<sup>29</sup> also verified this association, in addition to showing that obesity was the only independent risk factor for mediastinitis. Regarding DM, Ledur et al.<sup>30</sup> declared that high glucose levels were associated with an increase in the inflammatory process, leading to a significant increase in infection and organ dysfunction.<sup>30</sup> Smoking, mainly associated with COPD, has also been considered one of the risk factors associated with mediastinitis.<sup>6</sup> Some authors<sup>1</sup> found smoking as an independent risk factor for the development of mediastinitis.

Considering the trans- and postoperative variables, it was also demonstrated there was no consensus on the risk factors associated with mediastinitis. The increase in the time of post-surgical hospitalization and occurrence of fever after surgery were more common in patients with mediastinitis. The mean creatinine level was also considered an independent and higher risk factor in patients with mediastinitis. Other trans-operative and post-surgical risk factors, such as the use of pediculated internal thoracic arteries and CABG with ECC, have also been mentioned in the literature<sup>1</sup>, as well as a mammary bridge when associated with obesity.<sup>8</sup> However, in this study, no difference was observed between the groups in relation to ECC ( $p = 0.770$ ).

The trans-operative period of cardiac surgery is critical because of its complexity and the procedures inherent to it, such as ECC and prolonged intraoperative time. Several factors influence the onset of surgical wound infection, such as invasive procedures and insufficient primary defense caused by surgical trauma and ECC, which, in turn, causes physiological changes in the immune system, especially due to the use of hypothermia and hemodilution, predisposing to the onset of infections.<sup>31</sup> Health professionals should be aware of them and prepared to intervene in situations of fluid volume imbalance, impaired gas exchange, protection changes due to coagulation system inhibition with systemic heparinization and sequestration of leukocytes from the circulation.<sup>32</sup>

As for the bacteriological diagnosis in this study, the most prevalent among gram-positive bacteria was *Staphylococcus aureus* (30.7%) in patients with mediastinitis. High occurrence of Gram-positive bacteria (46.2%) was also observed. Studies carried out in Brazil indicate *Staphylococcus aureus* as the predominant causal agent in mediastinitis. International studies have shown a predominance of *Staphylococcus epidermidis* and a variety of Gram-positive bacteria in 40% of cases.<sup>33</sup>

Fungal infections are infrequent.<sup>34</sup> *Staphylococcus aureus* and *Staphylococcus epidermidis* account for 70% to 80% of cases.<sup>35</sup> The presence of *Staphylococcus aureus* causes the infections to show a rapid clinical course and more aggressive characteristics; therefore, its elimination and the care required by the surgical team during the preoperative period are of utmost importance. In the study by Gib et al.<sup>36</sup>, who carried out a study in patients with postoperative mediastinitis, *Staphylococcus aureus* was also

the most prevalent microorganism (58.1%). The same was observed by Sá et al.<sup>5</sup>, who evaluated the files of patients undergoing cardiovascular surgery from 2007 to 2009. The culture of the exudate was positive in 84% of the cases of mediastinitis, with *Staphylococcus aureus* being the most often identified pathogen (28.8%).

Souza et al.<sup>4</sup> who evaluated the files of patients submitted to cardiac surgeries between 1991 and 2000, verified that *Staphylococcus aureus* was the most frequently isolated microorganism from the surgical wound (46.0%), followed by *Pseudomonas aeruginosa* (21.6%) and *Staphylococcus epidermidis* (8.1%). The cases with *Staphylococcus epidermidis* isolation developed chronic mediastinitis.

Charbonneau et al.<sup>37</sup> carried out a study in patients with cardiac mediastinitis admitted to the ICU from 2000 to 2008 in two hospitals in France, and found that 309 patients developed post-sternotomy mediastinitis, of which 29.4% had Gram-positive bacteria. The presence of Gram-positive bacteria was associated with drainage failure, secondary infection, need for prolonged mechanical ventilation and/or use of vasopressor agents.

There are several possibilities regarding the entry points for pathogens in patients submitted to thoracic or cardiac surgery, such as the sternal irrigation impairment using internal thoracic arteries during myocardial revascularization, use of prostheses in contact with the bloodstream, organic weakness and, in some cases, poor hemodynamic status in the patients' postoperative period, causing low immunological deficits, especially in diabetic, and elderly patients and/or those with severe myocardial dysfunction.<sup>10,38</sup>

Thus, preventive measures<sup>39</sup> are crucial to avoid patient colonization by microorganisms, such as reducing hospitalization time, especially before surgery, avoiding colonization by microorganisms selected from the hospital environment; performing stringent patient asepsis; using the electrocautery as little as possible in the diuresis; handling tissues carefully; avoiding surgical trauma to the sternum as much as possible; performing rigorous hemostasis; periodically guiding the team and evaluating the equipment used in the surgical center or in the ICU; in addition to adequately handling drains, catheters and operative dressings.

This study had as limitations the short period of evaluation of an infection with low prevalence, which resulted in the recording of few cases. The use of

data obtained from paper medical records can show weaknesses such as missing data and inaccurate information. Additionally, the study was performed with data from a single hospital, and is not a representative sample of the state of Minas Gerais.

## Conclusion

Many risk factors have been associated with the development of mediastinitis after cardiac surgery. However, it has been observed there is no definite consensus about the most important risk factors associated with mediastinitis and whether each factor can be considered an independent risk predictor for mediastinitis in the postoperative period.

This study showed a male predominance, mean age of 58.8 years, and coronary artery bypass grafting (CABG) as the most common type of surgery, in agreement with the literature findings. The characteristics of the patients who had a diagnosis of mediastinitis comprised a higher proportion of males, a higher number of myocardial revascularization surgeries, and a higher death rate. Regarding the risk factors, the following were observed: a higher mean number of preoperative risk factors, longer time of hospital stay and greater occurrence of postoperative fever. The microorganism most frequently found in patients with mediastinitis was *Staphylococcus aureus*, and the presence of Gram-positive bacteria was elevated.

The results indicate the need to investigate the factors responsible for the onset of this complication, aiming at the prevention and control of healthcare-associated infections to improve patient quality of care and safety. Efforts should focus on risk factor control prior to the procedure, as well as the improvement of measures that may reduce or eliminate the complication onset, aiming at the prevention and control of healthcare-associated infections. Therefore, it is

necessary to train the health teams to control the risk factors associated with mediastinitis, as well as reinforcing preventive measures, to avoid patient colonization by microorganisms.

## Author contributions

Conception and design of the research: Pinto DCG, Jentsch NS. Acquisition of data: Pinto DCG, Gonçalves FL, Jentsch NS. Analysis and interpretation of the data: Pinto DCG, Bahia Neto AFC, Gomes IC, Sternick EB, Almeida AM, Jentsch NS. Statistical analysis: Gomes IC, Almeida AM. Writing of the manuscript: Pinto DCG, Bahia Neto AFC, Almeida AM. Critical revision of the manuscript for intellectual content: Pinto DCG, Bahia Neto AFC, Gomes IC, Sternick EB, Almeida AM, Jentsch NS. Supervision / as the major investigator: Almeida AM.

## Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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## Ethics approval and consent to participate

The study was approved by the Research Ethics Committee of Hospital Universitário São José/ Faculdade de Ciências Médicas, in Belo Horizonte (MG), under CAAE number 36416014.1.0000.5134.

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