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Preoperative risk factors for mediastinitis after cardiac surgery: assessment of 2768 patients

Fatores de risco pré-operatórios para mediastinite após cirurgia cardíaca: análise de 2768 pacientes

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Abstract

Background: **Longitudinal median sternotomy is the most common surgical approach for access to heart disease treatment. The deep wound infections in postoperative period of cardiovascular surgery are a serious complication requiring high costs during treatment. Different studies have indicated some risk factors for the development of mediastinitis and preoperative variables are currently under investigation.**

Objective: **The aim of this study is to identify the preoperative risk factors for postoperative development of mediastinitis in patients undergoing coronary artery bypass grafting and valve replacement.**

Methods: **This observational study represents a cohort of 2768 consecutive operated patients. The period considered for analysis was from May 2007 to May 2009 and there were no exclusion criteria. Analysis was performed by univariate and multivariate logistic regression model of 38 preoperative variables.**

Results: **Thirty-five (1.3%) patients developed mediastinitis and 19 (0.7%) associated with osteomyelitis. The patient age average was 59.9 ± 13.5 years and the EuroSCORE of 4.5 ± 3.6. Hospital mortality was 42.8%. The multivariate analysis identified three variables as independent predictors of postoperative mediastinitis: intra-aortic balloon pump (OR 5.41, 95% CI [1.83 -16.01], *P* = 0.002), hemodialysis (OR 4.87, 95% CI [1.41 to 16.86], *P* = 0.012) and extracardiac vascular intervention (OR 4.39, 95% CI [1.64 to 11.76], *P* = 0.003).**

Conclusion: **This study showed that necessity of preoperative hemodynamic support with intra-aortic balloon, hemodialysis, and extracardiac vascular intervention were risk factors for development of mediastinitis after cardiac surgery.**

Descriptors: **Mediastinitis. Postoperative complications. Surgical wound infection. Preoperative care.**

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Abbreviations, Acronyms & Symbols	
IAB	Intra-aortic balloon
IAC	Interventricular communication
DM	Diabetes mellitus
COPD	Chronic obstructive pulmonary disease
VAD	Vasoactive drugs
LVEF	Left ventricular ejection fraction
VF	Ventricular fibrillation
PH	Pulmonary hypertension
AMI	Acute myocardial infarction
CHF	Congestive Heart Failure
BMI	Body Mass Index
OI	Orotracheal intubation
PM	Pacemaker
SD	Sudden death
NYHA	New York Heart Association
CABG	Cardiopulmonary bypass grafting
VT	Ventricular tachycardia
AoV	Aortic valve
LV	Left ventricle
MiV	Mitral valve

Resumo

Introdução: **A esternotomia mediana longitudinal é a via de acesso mais utilizada no tratamento das doenças cardíacas. As infecções profundas da ferida operatória no pós-operatório das cirurgias cardiovasculares são uma complicação séria, com alto custo durante o tratamento. Diferentes estudos têm encontrado fatores de risco para o desenvolvimento de mediastinite e as variáveis pré-operatórias têm tido especial destaque.**

Objetivo: **O objetivo deste estudo é identificar fatores de risco pré-operatórios para o desenvolvimento de mediastinite em pacientes submetidos a revascularização do miocárdio e a substituição valvar.**

Métodos: **Este estudo observacional representa uma coorte de 2768 pacientes operados consecutivamente. O período considerado para análise foi de maio de 2007 a maio de 2009 e não houve critérios de exclusão. Foi realizada análise univariada e multivariada pelo modelo de regressão logística das 38 variáveis pré-operatórias eleitas.**

Resultados: **Nesta série, 35 (1,3%) pacientes evoluíram com mediastinite e 19 (0,7%) com osteomielite associada. A idade média dos pacientes foi de 59,9 ± 13,5 anos e o EuroSCORE de 4,5 ± 3,6. A mortalidade hospitalar foi de 42,8%. Na análise multivariada, foram identificadas três variáveis como preditoras independentes de mediastinite: balão intra-aórtico (OR 5,41, 95% IC [1,83 -16,01], *P*=0,002), hemodiálise (OR 4,87, 95% IC [1,41 - 16,86], *P*=0,012) e intervenção vascular extracardíaca (OR 4,39, 95% IC [1,64 - 11,76], *P*=0,003).**

Conclusão: **O presente estudo demonstrou que necessidade do suporte hemodinâmico pré-operatório com balão intra-aórtico, hemodiálise e intervenção vascular extracardíaca são fatores de risco para o desenvolvimento de mediastinite após cirurgia cardíaca.**

Descritores: **Mediastinite. Complicações pós-operatórias. Infecção da ferida operatória. Cuidados pré-operatórios.**

INTRODUCTION

Median sternotomy is a surgical approach most commonly used in the repair of heart disease. The deep surgical wound infections in cardiovascular surgeries are a serious complication due to morbidity and high costs that are required for the treatment. Its incidence varies between 0.4% and 5%, and even with existing early diagnosis and different treatment modalities, it is still a serious complication. It has high morbidity and mortality, with numbers ranging between 14% and 47% [1].

According to Horan et al. [2], mediastinitis is defined as an infection that affects sternotomy superficially and deeper tissues, occurring within the first thirty days postoperatively and with the presence of the following criteria: (a) pain or sternal instability associated with at least one of the findings: purulent drainage through the retrosternal area, blood positive culture or drained secretion and increased in the mediastinal imaging test (b) positive culture of secretion from the mediastinum, (c) evidence of retrosternal infection during operation or histological analysis. Most deep infections occurring between one and two weeks after surgery [3]. If there is suspicion of osteomyelitis, confirmation should be performed by pathological examination of a fragment of the sternum removed during the surgical procedure of cleaning.

The most frequent clinical findings are the signs of inflammation such as redness, warmth, swelling and pain in the wound. The dehiscence and drainage of wound secretion occurring in about 70% to 80% of cases, and may or may not be related to instability of the sternum. The patient may present with fever and clinical signs of sepsis or shock, multiple organ failure, if the diagnosis is delayed.

Mediastinitis can manifest itself until the first six weeks postoperatively. After this period, its occurrence is rare, but when present, the resolution is more complex [1]. Complementary research is performed by thoracic (mediastinal widening, unilateral or bilateral pleural effusion and sternal dehiscence), complete blood count and blood cultures (leukocytosis with a shift to the left of young cells and identification of the causative agent), computed tomography (collection present in the mediastinum and may

be with or without peristernal abnormalities such as edema or blurring of soft parts, separation of the sternum and marginal bone resorption, bone sclerosis or indirect signs of osteomyelitis) and bone scintigraphy (identifies signs of inflammatory activity and process infection in the sternum).

Different studies have chosen some risk factors for the development of mediastinitis [4-7], which are listed in Chart 1.

Therapeutic options for the treatment of mediastinitis include debridement with early or late closure of the chest, debridement and closure with continuous irrigation using 0.9% saline solution, partial or total sternectomy associated to reconstruction of muscle flaps or caul, in addition to adjuvant therapies, such as the system of vacuum-assisted therapy and hyperbaric oxygenation [8-12].

The aim of this study is to identify risk factors for preoperative development of mediastinitis in patients undergoing coronary artery bypass grafting and valve replacement.

Chart 1. Risk factors associated with mediastinitis.

Preoperative risk factors
Diabetes mellitus
Peripheral vascular disease
Obesity (BMI> 30)
Congestive heart failure (NYHA III and IV)
Age> 75 years
Immunosuppression state
Chronic lung disease
Male
Intra-and postoperative risk factors
Need for mechanical circulatory support
Reoperation for bleeding
Use of both internal thoracic arteries
Cardiopulmonary bypass time> 300 minutes
Blood loss in Postoperative Recovery Unit
Sternal fracture and osteoporosis
Polytransfusion blood

NYHA - New York Heart Association; IAB - Intra-aortic Balloon, BMI - Body Mass Index

METHODS

This study represents an observational cohort. The data of 2768 consecutive patients were collected retrospectively and operations in this group are distributed as follows: 1216 (44%) valvular treatment and 1552 (56%) CABG. The period considered for the analysis was from May 2007 to May 2009 and there were no exclusion criteria.

We performed univariate and multivariate logistic regression model for the 38 preoperative variables studied and listed in Chart 2.

Statistical Analysis

For statistical analysis, we used quantitative variables (EuroSCORE, age) the Student's t test for comparison of independent groups according to the presence or absence of osteomyelitis and mediastinitis. For qualitative variables (gender, congestive heart failure, chronic obstructive pulmonary disease, diabetes mellitus, left ventricular ejection fraction, obesity, reoperation, intraaortic balloon, aortic and mitral valve replacement, coronary artery bypass grafting associated to valve replacement, cardiogenic shock, treated endocarditis, post-infarction ventricular septal defect, resectable left ventricular aneurysm, tricuspid valve replacement, ventricular tachycardia, ventricular fibrillation and sudden death, pacemaker dependency, acute myocardial infarction within 48h of evolution, asthma, preoperative intubation, pulmonary hypertension (> 25 mmHg), cirrhosis, dependence on hemodialysis, carotid artery disease, blood reactions, neurological disorders, preoperative vasoactive drug, unstable angina, emergency surgery, thoracic aortic operations, preoperative cardiac massage, MI infarction <90 days, creatinine (> 2.26 mg/dl), abuse of illicit drugs, intervention in the abdominal aorta, carotid artery or branch), we used the chi-square, and when it was not possible, by theoretical constraint, the Fisher exact test to compare groups according to the presence or absence of osteomyelitis and mediastinitis (Table 1).

Chart 2. Preoperative variables chosen for analysis

Gender	Age	LVEF	Obesity (BMI > 30)	Reoperation
Aortic valve replacement	Preoperative IAB	Mitral valve replacement	CABG + Valve	DPOC
Cardiogenic shock	Treated endocarditis	Post-infarction IVC	Resectable LV aneurysm	Tricuspid valve replacement
VT/VF/SD	PM-dependent	AMI within 48h of evolution	Asthma	Preoperative OI
DM	PH (>30 mmHg)	Cirrhosis	Hemodialysis-dependent	CHF
Drug-dependent	Carotid disease	Blood Reaction	EuroSCORE	Neurological disorders
AMI < 90 days	Preoperative VAD	unstable angina	Emergency Surgery	Thoracic aortic surgery
Creatinine (>2,26mg/dl)	Preoperative cardiac massage		intervention in the abdominal aorta, carotid artery or branch	

IAB: intra-aortic balloon; IVC: interventricular communication; VAD: vasoactive drugs; COPD: Chronic obstructive pulmonary disease, DM: Diabetes mellitus, LVEF: Left ventricular ejection fraction of the left ventricle; VF: ventricular fibrillation; HP: Pulmonary hypertension; CHF: Congestive heart failure, BMI: Body mass index, AMI: Acute myocardial infarction; TI: Tracheal intubation: SD: Sudden death; PM: Pacemaker, CABG: Coronary artery bypass grafting; VT: Ventricular tachycardia, LV: left ventricle

By univariate analysis, the variables intra-aortic balloon, hemodialysis and intervention in the abdominal aorta, carotid or arterial branch are variables associated with mediastinitis. The variables diabetes, ejection fraction of the left ventricle and creatinine showed *P* values between 5% and 10%. Thus, these variables were selected for multivariate logistic model. To obtain the final model, we used the stepwise selection process, whereby the following variables selected were: intra-aortic balloon, hemodialysis and extracardiac vascular intervention.

Table 2 presents the odds ratios and 95% CI for each variable and for the final model.

Table 1. Analyzed variables and their "*P*" values.

Variables analyzed	With Mediastinitis n =35	Without Mediastinitis n =2733	*P* values
Mean EuroSCORE	4.9 ±3.8	4.5 ±3.6	0.508
Mean age	60.6 ±13.8	59.9 ±13.4	0.768
Male	74.2%	64.7%	0.238
Female	25.8%	35.3%	
CHF	22 (62.8%)	1808 (66.2%)	0.682
COPD	2 (5.7%)	72 (2.6%)	0.240
DM	16 (45.7%)	857 (31.3%)	0.069
Mean LVEF	51.6 ±13.4	55.4 ±13.6	0.105
Obesity (BMI > 30)	6 (17.1%)	248 (9%)	0.129
Reoperation	3 (8.5%)	477 (17.4%)	0.594
Preoperative IAB	4 (11.4%)	71 (2.6%)	0.014
AoV replacement	5 (14.2%)	603 (22%)	0.269
MiV replacement	9 (25.7%)	714 (26.1%)	0.956
CABG + Valve	1 (2.8%)	183 (6.7%)	0.727
Cardiogenic shock	0	32 (1,1%)	1,000
Treated endocarditis	1 (2.8%)	111 (4%)	1.000
Post-infarction IVC	0	16 (0.6%)	1.000
LV resectable aneurysm	1 (2.8%)	88 (3.2%)	1,000
Tricuspid valve replacement	3 (8.5%)	146 (5.3%)	0.433
VT/VF/SD	2 (5.7%)	59 (2.1%)	0.179
PM-dependent	0	59 (2.1%)	1,000
AMI within 48h of evolution	2 (5.7%)	57 (2%)	0.170
Asthma	0	11 (0.4%)	1.000
Preoperative OI	1 (2.8%)	46 (1.6%)	0.453
PH (> 25 mmHg)	8 (22.8%)	655 (23.9%)	0.879
Cirrhosis	0	12 (0.4%)	1.000
Hemodialysis-dependent	3 (8.5%)	46 (1.6%)	0.023
Carotid disease	4 (11.4%)	242 (8.8%)	0.547
Blood reaction	0	28 (1%)	1.000
Neurological disorders	3 (8.5%)	193 (7%)	0.734
Preoperative VAD	3 (8.5%)	146 (5.3%)	0.433
Unstable angina	4 (11.4%)	192 (7%)	0.308
Emergency surgery	0	88 (3.2%)	0.627
Surgery of the thoracic aorta	1 (2.8%)	20 (0.7%)	0.235
Preoperative cardiac massage	0	4 (0.1%)	1.000
AMI < 90 days	9 (25.7%)	453 (16.5%)	0.150
Creatinine (> 2,26mg/dl)	4 (11.4%)	132 (4.8%)	0.090
Abuse of illicit drugs	3 (8.5%)	342 (12.5%)	0.614
Intervention in the abdominal aorta, carotid or other artery branch	5 (14.2%)	106 (3.8%)	0.012

IAB: intra-aortic balloon; IVC: interventricular communication; VAD: vasoactive drugs; COPD: Chronic obstructive pulmonary disease, DM: Diabetes mellitus, LVEF: Left ventricular ejection fraction of the left ventricle; VF: ventricular fibrillation; HP: Pulmonary hypertension; CHF: Congestive heart failure, BMI: Body mass index, AMI: Acute myocardial infarction; TI: Tracheal intubation: SD: Sudden death; PM: Pacemaker, CABG: Coronary artery bypass grafting; VT: Ventricular tachycardia, LV: left ventricle

Table 2. Univariate and multivariate models for analysis of selected variables.

	Univariate Model				Multivariate Model			
		95% CI				95% CI		
Variable	Odds ratio	LL	UL	*P*	Adjusted Odds ratio	LL	UL	*P*
DM	1.84	0.94	3.60	0.074				
EF	0.98	0.96	1.00	0.108				
IAB	4.83	1.66	14.07	0.004				
Hemodialysis	5.48	1.62	18.53	0.006	5.41	1.83	16.01	0.002
Creatinine > 2.26mg/dl	2.54	0.89	7.31	0.083	4.87	1.41	16.86	0.012
Extracardiac Vascular Intervention	4.13	1.57	10.86	0.004	4.39	1.64	11.76	0.003

IAB: Intra-aortic Balloon DM: Diabetes Mellitus EF: Ejection Fraction CI - Confidence Interval LL – UL: Lower Limit - Upper Limit

RESULTS

Of the 2768 patients who underwent surgery, 35 (1.3%) patients developed mediastinitis and 19 (0.7%) with osteomyelitis. Most patients were male (72.4%). Of the 35 patients with mediastinitis, 24 (68.5%) had undergone CABG and 11 (31.5%), valve replacement. Among the 18 patients with osteomyelitis, 13 (72.2%) underwent CABG and five (27.7%), valve replacement. The mean age of patients was 59.9 ± 13.5 years and EuroSCORE of 4.5 ± 3.6. Hospital mortality was 42.8%. The univariate analysis identified the following risk factors: diabetes mellitus (OR 1.84-95% CI [0.94 to 3.6], *P* = 0.074), left ventricular ejection fraction (OR 0.98 - 95% CI [0.96 to 1.00], *P* = 0.108), intra-aortic balloon (OR 4.83-95% CI [1.66 to 14.07], *P* = 0.004), dialysis (OR, 5.48-95% CI [1.62 to 18.53], P = 0.006), creatinine> 2.26 mg / dl (OR 2.54-95% CI [0.89 to 7.31], *P* = 0.083) and extracardiac vascular intervention (OR 4.13 - 95% CI [1.57 to 10.86], *P* = 0.04). After multivariate analysis, we selected: intra-aortic balloon (OR 5.41-95% CI [1.83 16.01], *P* = 0.002), dialysis (OR 4.87-95% CI [1.41 - 16.86], *P* = 0.012) and extracardiac vascular intervention (OR 4.39-95% CI [1.64 to 11.76], *P* = 0.003).

DISCUSSION

Access to the structures of the anterior mediastinum by longitudinal median sternotomy and its synthesis with wires were first described by Milton in 1897, and gained widespread since the advent of cardiopulmonary bypass, and currently is one of the most commonly used surgical incisions in the world [13 , 14]. While providing an excellent approach to the heart and great vessels, it is difficult to immobilize this opening safely, due to the constant movement and effort to breathe and cough.

The pathophysiology of mediastinitis is complex and multifactorial. The excessive handling of inpatient, as prolonged use of central venous catheters and hemodialysis, venous and arterial punctures for collection of repeated examinations in immunocompromised patients or in a poor state of nutrition, favors the entry and action of pathogens. Cardiac transplantation is presented as additional risk factor for the development of mediastinitis, by the presence of immunosuppression [15,16]. Furthermore, the involvement of sternal irrigation after dissection of left internal thoracic artery, right or both, in patients with low tissue perfusion consequent to a state of low cardiac output, also facilitate the action of bacteria [17].

Recent studies indicate that the male patient is more prone to develop mediastinitis and is an independent risk factor for its development [18-20]. In the present study, as well as that published by Sá et al. [21], there was a higher incidence of mediastinitis in male patients. One of the probable mechanisms relates to the anatomy of man. Recent studies have shown that females exhibit greater collateral circulation, which gives greater protection to women, and hair follicles in the sternotomy region present in greater numbers in men favor the growth and bacterial infection [22,23]. Furthermore, the male presents higher rates of diabetes mellitus [24,25]. The presence of diabetes impairs wound healing and cellular and humoral immunity, which leads to increased risk of infections, especially in patients who take insulin to control blood glucose [26].

In the present study, were identified as risk factors in the univariate analysis, diabetes mellitus, ejection fraction, intra-aortic balloon, hemodialysis, creatinine greater than 2.26 mg/dl and extracardiac vascular intervention. After multivariate analysis, there was a statistically significant incidence of sternal complications in patients using preoperative intra-aortic balloon, hemodialysis and those who underwent extracardiac vascular interventions. It is believed that the first two risk factors are associated with invasive manipulation in the preoperative period through vascular punctures and the prolonged period between

admission and surgery, beyond the state of tissue hypoperfusion caused by cardiogenic shock which led to insertion the intra-aortic balloon [27]. Regarding the third risk factor, the presence of peripheral artery disease associated with extracardiac vascular disease requiring surgical intervention relates to the state of tissue hypoperfusion that affected also the sternum. Rahmanian et al. [28] demonstrated a higher hospital mortality in patients with chronic renal deep sternal infection who were dependent on dialysis.

Other studies confirm the relationship between increased mortality and renal failure alone or associated with other complications, which may vary between 30% and 80% [29,30]. Different studies were designed to establish risk scores for mediastinitis and, thus, act preemptively, decreasing morbidity and mortality, in addition to hospital costs resulting from prolonged hospitalization [31-34].

Magedanz et al. [35] assessing 2809 patients, identified five risk factors for mediastinitis in patients undergoing coronary artery bypass grafting, which include chronic obstructive pulmonary disease, obesity, multiple blood transfusions in the postoperative, surgical intervention and angina class IV. The need for surgical intervention was a risk factor for mediastinitis most important in this group of patients. From these data, the authors formulated a risk score for postoperative mediastinitis in myocardial revascularization, which was later validated by Sá et al. [20].

Another recently published study examined 107 patients who developed mediastinitis in a cohort of 18,532 patients who underwent CABG and with a mean follow up of 10.3 years [36]. The authors identified as independent risk factors for developing mediastinitis: COPD, age, male gender, stenosis of the left main coronary artery, diabetes mellitus and obesity (BMI> 30 kg/m2). These last two were also identified as risk factors for mediastinitis after coronary artery bypass surgery by Sá et al. [37], and they reinforced also in other publications [38.39], the importance of obtaining the internal thoracic artery grafting with skeletonized dissection technique in high-risk groups, in order to reduce the incidence of this complication.

Limitations of the Study

The study was limited to the analysis of preoperative risk factors, not including intraoperative or postoperative variables, without identifying other risk factors for developing mediastinitis. Despite being performed in a hospital of national reference, it only involves a single center, where routine of preoperative care is the same for all patients. It is an observational study and presents some limitations of the drawing itself, and therefore, further studies with larger samples are needed.

CONCLUSION

The need for the use of preoperative intra-aortic balloon, hemodialysis and extracardiac vascular surgery present as statistically significant risk factors for the occurrence of postoperative mediastinitis in CABG and valvular treatment. Based on the analysis of the results obtained in the present study, we observed that patients using preoperative intra-aortic balloon present chance of occurrence of mediastinitis 5.4 times higher than patients without intra-aortic balloon.

Patients undergoing hemodialysis and preoperative extracardiac vascular intervention also present increased odds of mediastinitis with rates of approximately 4.9 times and 4.4 times greater than the other, respectively.

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