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Risk factors for hospital mortality in valve replacement with mechanical prosthesis

Fatores de risco para mortalidade hospitalar no implante de prótese valvar mecânica

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Abstract

Objective: **Identification of risk factors for cardiac surgery can improve surgical results. Our aim is to identify factors related to increased hospital mortality for patients who underwent mechanical cardiac prosthesis implant.**

Methods: **Prospective study with retrospective data acquirement study including 335 consecutive patients who underwent at least one implant of St. Jude Medical mechanical prosthesis between December 1994 and September 2005 at the Cardiology Institute of RS. Valve implants were 158 (47.1%) in aortic position, 146 (43.6%) in mitral and 31 (9.3%) in aortic and mitral. The following characteristics were analyzed in relation to hospital death: gender, age, body mass index, NYHA functional class, ejection fraction, type of valve lesion, hypertension, diabetes mellitus, serum creatinine, preoperative arrhythmias, prior heart surgery, CABG surgery, concomitant tricuspid valve surgery and operative priority (elective, urgent or emergent). Logistical regression was used to analyze data and odds-ratio was calculated for individual factors.**

Results: **During the follow-up there were 13 (3.88%) deaths. In-hospital mortality risk was associated with serum creatinine (*P*<0.05), ejection fraction < 30% (*P*<0.001), mitral valve lesion (*P*<0.05), concomitant CABG surgery (*P*<0.01), prior cardiac surgery (*P*<0.01) and reoperation (*P*<0.01). Increased odd-ratio were related to previous cardiac surgery (5.36; IC95% 0.94-30.56), combined revascularization (5.28; IC95% 1.51-18.36), valvar reoperation (4.69; IC95% 0.93-23.57) and concomitant tricuspid annulosplasty (3.72; IC95% 0.75-18.30).**

Conclusion: **The mortality rate is within the parameters found in the literature, identifying recognized factors which neutralization by changes in surgical indication and medical management may enable risk reduction.**

Descriptors: **Cardiac surgical procedures. Risk factors. Prostheses and implants. Heart valve prosthesis. Mortality.**

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Resumo

Introdução: **A identificação dos fatores de risco pré-operatórios na cirurgia valvar visa à melhoria do resultado cirúrgico por meio da neutralização de fatores relacionados à mortalidade aumentada. Este estudo tem por objetivo identificar fatores de risco para mortalidade hospitalar em pacientes submetidos a implante de prótese valvar mecânica.**

Métodos: **Estudo prospectivo com aquisição retrospectiva de dados com 335 pacientes consecutivamente submetidos ao implante de prótese mecânica St Jude Medical, entre dezembro de 1994 e setembro de 2005, no Instituto de Cardiologia do RS, sendo 158 aórticos, 146 mitrais e 31 mitro-aórticos. Foi analisada a relação da mortalidade hospitalar com características demográficas e operatórias dos pacientes: sexo, idade, índice de massa corporal, classe funcional (NYHA), fração de ejeção, lesão valvar, hipertensão arterial sistêmica, diabete melito, creatinina, arritmia cardíaca, cirurgia cardíaca prévia, revascularização miocárdica, plastia tricúspide concomitante e caráter da cirurgia (eletivo, de urgência ou de emergência). Utilizada regressão logística para identificar os fatores de risco e quantificada sua influência pelo cálculo de *odds-ratio*.**

Resultados: **Ocorreram 13 (3,88%) óbitos hospitalares. Características relacionadas à mortalidade aumentada foram creatinina sérica (*P*<0,05), fração de ejeção < 30% (*P*<0,001), lesão valvar mitral (*P*<0,05), revascularização miocárdica (*P*<0,01), cirurgia cardíaca prévia (*P*<0,01) e reoperação (*P*<0,01). *Odds ratio* aumentado ocorreu para cirurgia cardíaca prévia (5,36; IC 95% 0,94-30,56), revascularização combinada (5,28; IC 95% 1,51-18,36), reoperação valvar (4,69; IC 95% 0,93-23,57) e anuloplastia tricúspide associada (3,72; IC 95% 0,75-18,30).**

Conclusão: **A mortalidade observada encontra-se dentro dos parâmetros encontrados na literatura, com identificação de fatores reconhecidos cuja neutralização, mediante modificações na indicação cirúrgica e conduta médica, poderá permitir redução do risco.**

Descritores: **Procedimentos cirúrgicos cardíacos. Fatores de risco. Próteses e implantes. Prótese valvulares cardíacas. Mortalidade.**

INTRODUCTION

The valve implant surgery represents approximately 20% of all heart surgeries and because of the risk factors found in this population, accounts for 30% of the total mortality rate [1]. Mortality documented in the literature for this type of surgery varies according to the hospital, surgical technique of the surgeon and the characteristics of the population, ranging between 1% and 15%, regardless of the type of prosthesis implanted [2-5].

The need for better assessment of patients undergoing heart valve surgery and its outcome led to numerous prospective and retrospective studies performed in order to estimate the in-hospital mortality, based on preoperative risk factors [6-8]. Retrospective studies with large numbers of patients are able to better identify the characteristics that might affect the surgery outcome and create models of risk stratification for different institutions [2-5].

The use of mechanical prostheses is indicated for young patients, for those with chronic atrial fibrillation requiring long time of anticoagulation and for those who wishes to minimize the need for reoperation.

The aim of this prospective study, with retrospective data acquisition, is to review the number of patients who underwent implantation of mechanical heart valve prosthesis, St Jude Medical model, in order to identify risk factors that can influence hospital mortality.

METHODS

Study Characteristics

Prospective study with retrospective data acquisition.

Population

The study included 335 patients who underwent at least one mechanical prosthesis of St. Jude Medical model, from December 1994 to September 2005, at Institute of Cardiology of Rio Grande do Sul/University Foundation of Cardiology. Of these, 181 (54%) were male and 154 (46%) were females, aged between 16 and 78 years, mean 46.8 ±

12.8 years. The functional class according to the standards of the New York Heart Association (NYHA) was: I in 24 (7.1%) patients, II in 102 (30.5%), III in 161 (48%) and IV in 48 (14.4%). 114 (34%) patients presented systemic arterial hypertension (SH), 23 (6.8%) diabetes mellitus, body mass index below 20 kg/m^2 29 (8.6%) and greater than 25 kg/m^2 142 (42.4%) patients. The left ventricular ejection fraction (LVEF), was over 50% in 253 (80%) patients, between 30 and 50% in 57 (18%) and less than 30% in six (2%). The preoperative rhythm was sinus in 237 (70.7%) patients and 98 (29.3%) presented atrial fibrillation. The mean serum creatinine was 1.15 g/dL for patients who died and 0.97 g/dL for survivors.

Valve surgery

All patients underwent surgery with cardiopulmonary bypass using a membrane oxygenator and varying levels of hemodilution and hypothermia. Myocardial preservation was performed by using hypothermic St. Thomas II cardioplegia solution. Postoperative care were previously described [9].

From a total of 335 procedures, 216 patients underwent first heart surgery, 76 had previously undergone heart surgery and 43 had undergone two or more heart surgeries. 146 (43.6%) isolated implants of mitral mechanical prostheses were performed, as well as 158 (47.1%) of the aortic model and associated implant of mitral and aortic prostheses occurred in 31 (9.3%) procedures. The valve replacement surgeries were combined with 29 (8.7%) coronary artery bypass grafting (CABG) or correction of mechanical defects secondary to myocardial ischemia and 17 (5%) tricuspid annuloplasty surgery. As the type of surgery, 329 were elective and six urgent ones, and 14 patients underwent reoperation during the hospital stay for a valve replacement surgical procedure.

Outcomes and definition of risk factors

It was considered as the primary outcome the death during surgical hospital stay for implantation of mechanical heart valve prosthesis, and the preoperative and surgical variables associated with an increased hospital mortality were considered predictors of risk factors.

The demographic characteristics assessed for mortality during hospital stay were gender, age, atrial fibrillation, ejection fraction, systemic arterial hypertension (SAH), diabetes mellitus (DM), body mass index, serum creatinine, NYHA functional class (according to the model proposed by the NYHA), type of valve lesion (aortic, mitral or mitral-aortic) and previous heart surgery. The surgical variables assessed were associated surgery (CABG and tricuspid valve surgery), valve surgery reoperation and type of surgery (elective or urgent). These characteristics are similar to the study by Ambler et al. [2] and were previously used by the authors of this study in studies with valve bioprostheses [10].

Ethical considerations

The research project for this study was submitted to the Research Unit of the Cardiology Institute of Rio Grande do Sul and approved for implementation by the Research Ethics Committee of the institution, and recorded under the protocol No. 4022/2007. During implementation of this project, norms related to patient privacy and confidentiality in the handling of medical information were followed. Postoperative history was obtained from the database of the Surgery Service and hospital records.

Data Analysis

We used univariate and multivariable statistical analysis using SPSS software for Windows, version 14.0, to determine prevalent and independent predictors of hospital mortality risk. For this, we used the chi-square test, Student's t test and logistic regression. In multivariate analysis, the variables were used in the form that presented a higher discriminatory power. All significant characteristics (P<0.05) in univariate analysis were considered for multivariate analysis. We considered risk characteristics those with significant association with hospital mortality for an alpha level of 0.05.

The odds ratio with confidence interval of 95% (OR, 95%) was obtained by logistic regression analysis, to estimate the relative risk of each characteristic assessed.

RESULTS

Hospital mortality

The hospital mortality was 3.88%. Of the 13 deaths, two (15.4%) were secondary to bleeding with cardiac tamponade, six (46.1%) for left ventricle failure, four cases (30.7%) for sepsis (leading to multiple organ failure) and one (7.7%) for renal failure.

Risk factors

The significant demographic characteristics related to increased mortality were ejection fraction below 30% (P<0.001), mitral valve lesion (P<0.041) and previous heart surgery (P<0.01). The serum creatinine was significantly higher in patients who died than in survivors (respectively, 1.15 and 0.97 g/dL, P=0.010).

The surgical characteristics statistically significant correlated with high hospital mortality were coronary artery bypass grafting concomitantly (P<0.01) and reoperation (P<0.05). The hospital mortality was 3.9% for aortic valve replacement, 6.8% for mitral valve replacement and 3.2% for mitral-aortic valve replacement. Table 1 shows the risk for demographic and operative characteristics. Table 2

shows the continuous variables and their respective *P* values.

Odds ratio

Odds ratio of the characteristics assessed are shown in Figure 1 and detailed in decreasing order as follows: prior surgery: OD 5.36 (95% CI 0.94-30.56); associated CABG: OD 5.28 (95% CI 1 .51 to 18.36), reoperation during hospital stay: OD 4.69 (95% CI 0.93-23.57), associated tricuspid valve repair: OD 3.72 (95% CI 0.75-18.30); mitral-aortic valve lesion: OD 3.14 (95% 0.24-41.22); DM: OD 2.60 (95% CI 0.54-12.52); SAH: OD 2.34 (CI 95% 0.76-7.14), mitral valve disease: OD

Table 1. Hospital mortality according demographic and operative characteristics

Characteristic	**Rate**	%	**Deaths**	%	***P***
Gender					
Female	154	46.0	4	2.6	0.262 n.s.
Male	181	54.0	9	5.0	
SAH					
Present	114	34.0	7	6.1	0.124 n.s.
Absent	221	66.0	6	2.7	
DM					
Diagnosed	23	9.8	2	8.7	0.215 n.s.
Absent	312	90.2	11	3.5	
(NYHA) Functional Class					
I	24	7.1	1	4.2	0.383 n.s.
II	102	30.5	3	2.9	
III	161	48.0	5	3,1	
IV	48	14.4	4	8.3	
Preoperative rithym					
Sinus	237	70.7	7	3.0	0.172 n.s.
AF	98	29.3	6	6.1	
LVEF					
>50%	253	80.0	6	2.4	**<0.001**
30-50%	57	18.0	3	5.3	
<30%	6	2.0	3	50.0	
Valvar lesion					
Aortic	158	47.1	2	3.9	**<0.05**
Mitral	146	43.6	10	6.8	
Mitral-aortic	31	9.3	1	3.2	
CABG					
Yes	29	8.7	4	13.8	**<0.01**
No	306	91.3	9	2.9	
Tricuspid valve repair					
Yes	17	5.0	2	11.8	0.084 n.s.
No	318	95.0	11	3.5	
Previous heart surgery					
No	216	64.5	4	1.9	**<0.01**
One	76	22.7	4	5.3	
≥ Two	43	12.8	5	11.6	
In-hospital reoperation					
Yes	14	4.2	2	14.3	**<0.05**
No	321	95.8	11	3.4	
Type of surgery					
Elective	329	98.2	13	4.0	0.650 n.s.
Urgent	5	1.8	0	0.0	

Table 2. Hospital mortality according demographic characteristics of continuous value

Characteristic	Mean	Standard deviation	P value
Age			
Survivors	46.64	12.8	0.123 n.s.
Death	52.23	11.9	
Body Mass Index			
Survivors	25.21	4.60	0.583 n.s.
Death	25.92	3.99	
Creatinine			
Survivors	0.97	0.27	<0.05
Death	1.15	0.21	

2.31 (95% 0.41-13.08), atrial fibrillation: OD 2.14 (95% 0.7-6.54); female: OD 1.96 (95% CI 0.59-6.5); LVEF between 30 and 50%: OD 1.61 (95% CI 0.34-7.56) and elective surgery: OD 0.96 (95% CI 0.94-0.98).

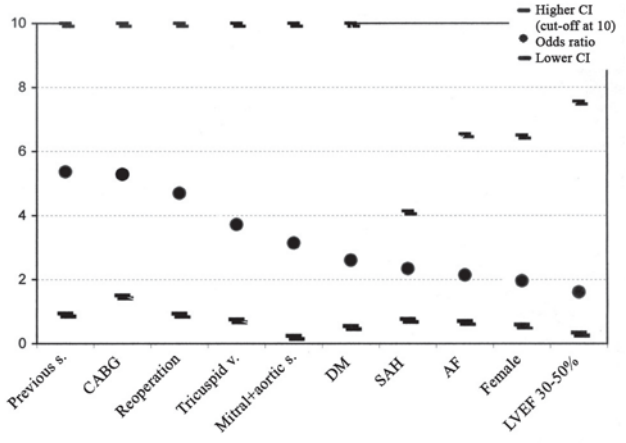

Fig. 1 – Odds ratio values (and 95% confidence interval, with cut-off in the unit 10 for higher CI) for the different characteristics studied. s. = surgery; CABG = coronary artery bypass grafting; v. = valve repair; DM = diabetes mellitus; SAH = sytemic arterial hypertension; AF = atrial fibrillation; LVEF = left ventricular ejection fraction.

DISCUSSION

The possibility to quantify the risk factors for patients undergoing valve replacement surgery is studied and known for more than 20 years [11]. However, due to advances in surgery and constant progress in noninvasive methods to diagnose this disease, the surgical risk has been decreasing [12]. Some of the characteristics of patients which in the past increased the risk of surgery, can now be safely managed. Therefore, as a result of improved perioperative management and high life expectancy, risk factors have been changed [13].

Over the years, the surgical experience has shown that factors such as age, low body mass index, renal failure, low left ventricular ejection fraction, indication for emergency surgery and valve reoperation, among others, contribute to an increased hospital mortality and greater attention from physicians involved in clinical and surgical care of the patients has been given [6-8,14].

The accomplishment of heart surgery, regardless of type, was also associated with increased surgical risk, according to Ambler et al. [2]. In their study, the authors developed a model of risk stratification for heart valve surgery taking into account characteristics associated with high hospital mortality. The following characteristics were also statistically significant: emergency surgery, age over 79 years and renal failure with need for dialysis.

For Nowicki et al. [15], in a study on independent risk factors for surgical aortic valve replacement, previous heart surgery was also confirmed as a risk factor associated with age over 70 years, small body surface, elevated creatinine, NYHA class IV, previous cardiac arrest, congestive heart failure, atrial fibrillation, emergency surgery and associated CABG. On the other hand, in mitral valve surgery, the following characteristics were statistically significant: female gender, advanced age, diabetes mellitus, CABG, prior stroke, elevated creatinine, NYHA class IV, emergency surgery and congestive heart failure.

Roques et al. [16], in the EuroSCORE study, a predictor of hospital mortality, found that heart surgery and concomitant CABG were associated with high surgical risks. Other variables significantly associated with high mortality were advanced age, creatinine, low left ventricular function, congestive heart failure, pulmonary hypertension, emergency surgery, multiple valve replacement or tricuspid procedure.

The need for reoperation was also described as a factor able to increase the surgical risk and therefore increase the in-hospital mortality. It has been identified previously by Jamieson et al. [3] and by Edwards et al. [17]. For the former, other factors also were associated with high mortality rate, such as emergency surgery, renal failure (whether or not on dialysis), low ejection fraction and functional class IV (NYHA). On the other hand, the latter identified as independent risk factors for isolated surgical valve replacement, in addition to reoperation, emergency surgery, renal failure and cardiac arrest.

Brandão et al. [18] presented a study of risk factors for a number of patients who underwent implantation of bileaflet mechanical prostheses with a mitral mortality rate of 13.5% and 7.5% aortic, justified as superior to that found in this study and dued to the inclusion of the outcome of surgeries for repair of aneurysms and dissections of the ascending aorta - known as surgeries of greatest risk. But the increased mortality observed in the group of mitral valve replacement by the authors and also observed in this sample is consistent with the results found in the literature [19,20].

Patients with less severe valve diseases have been accepted due to the tendency to recommend surgery in earlier states of the disease, which can determine a lower prevalence of risk factors and result in lower mortality [21]. Possibly, this population - which has younger patients - performs implant of mechanical prostheses, and the inclusion of patients with severe cardiac or systemic involvement is reduced, resulting in hospital mortality supposedly lower than that observed in the population for the implantation of bioprosthesis [22].

To determine the factors that contributed to hospital mortality, some of the risk predictors identified in the studies already cited in the literature [2-5,14] were considered, focusing on those presented by Amber et al. [2]. This attitude is justified by the ready availability of medical information considered by these authors, whose record is part of the hospital routine. We should consider that this approach excludes some known risk factors such as pulmonary arterial hypertension, chronic obstructive pulmonary disease and peripheral vascular disease [3], because such factors are not found in the records of most patients assessed.

The use of odds ratios as a resource for statistical analysis made it possible to estimate the surgical risk separately determined by one of the characteristics assessed without interference from the others [23]. The predictors of higher risk in this study were: previous heart surgery (OR 5.36), associated CABG (OR 5.28), the patient required reoperation during the same hospital stay after another valve surgery (OR4, 69), associated tricuspid valve repair (OR 3.72), combined mitral and aortic valve replacement (OR 3.14), diabetes mellitus (OR 2.6), hypertension (OR 2.34), atrial fibrillation (OR 2.14), females (OR 1.96) and LVEF between 30 and 50% (OR 1.61). Of the characteristics mentioned above, the OR was increased in study by Hellgren et al. [21] for atrial fibrillation in procedures for combined aortic or mitral valve replacement (OR 4.1). However, other factors mentioned by the authors, such as valve replacement over the age of 70 years (OR 2.1) and NYHA functional class IV (OR 2.2) were not identified in our study, possibly due to differences in the populations approached, especially with regard to age.

In a study performed in this institution [10], with patients who had undergone implant of bioprosthesis, increased odds ratio was observed for associated tricuspid surgery (OR 3.71), combined mitral and aortic surgery (OR 2.86) and females (OR 2.43). Other characteristics with higher OR, such as emergency surgery, dialysis, age over 80 years and two or more previous surgeries were not highlighted in this study. Also, it is possible that the difference in age of patients included in the two studies has influenced in the findings. A study comparing results with implantation of bioprostheses and mechanical prostheses in the same institution may be useful in clarifying the differences in mortality and risk factors associated with different valve replacement implants.

CONCLUSION

It is expected that operative risk factors identified in the study, which were ejection fraction, mitral valve disease, high serum creatinine, previous heart surgery and surgery during hospital stay for heart valve surgery - also identified by other authors and already emphasized in this discussion [2-5], have their role minimized in the risk, either by changing the criteria of indication (as higher precocity), better clinical compensation or change in operative routines.

REFERENCES

1. Birkmeyer JD, Siewers AE, Finlayson EV, Stukel TA, Lucas FL, Batista I, et al. Hospital volume and surgical mortality in the United States. N Engl J Med. 2002;346(15):1128-37.

2. Ambler G, Omar RZ, Royston P, Kinsman R, Keogh BE, Taylor KM. Generic, simple risk stratification model for heart valve surgery. Circulation. 2005;112(2):224-31.

3. Jamieson WR, Edwards FH, Schwartz M, Bero JW, Clark RE, Grover FL. Risk stratification for cardiac valve replacement. National Cardiac Surgery Database. Database Committee of The Society of Thoracic Surgeons. Ann Thorac Surg. 1999;67(4):943-51.

4. Jin R, Grunkemeier GL, Starr A; Providence Health System Cardiovascular Study Group. Validation and refinement of mortality risk models for heart valve surgery. Ann Thorac Surg. 2005;80(2):471-9.

5. Kuduvalli M, Grayson AD, Au J, Grotte G, Bridgewater B, Fabri BM; North West Quality Improvement Programme in Cardiac Interventions. A multi-centre additive and logistic risk model for in-hospital mortality following aortic valve replacement. Eur J Cardiothorac Surg. 2007;31(4):607-13.

6. Mistiaen W, Van Cauwelaert P, Muylaert P, Wuyts F, Harrisson F, Bortier H. Risk factors and survival after aortic valve replacement in octogenarians. J Heart Valve Dis. 2004;13(4):538-44.

7. Albeyoglu SC, Filizcan U, Sargin M, Cakmak M, Goksel O, Bayserke O, et al. Determinants of hospital mortality after repeat mitral valve surgery for rheumatic mitral valve disease. Thorac Cardiovasc Surg. 2006;54(4):244-9.

8. Litmathe J, Boeken U, Kurt M, Feindt P, Gams E. Predictive risk factors in double-valve replacement (AVR and MVR) compared to isolated aortic valve replacement. Thorac Cardiovasc Surg. 2006;54(7):459-63.

9. Pereira E, Costa AR, Santos MF, Davidt NS, Lara RFA. Avaliação pré-operatória. In: Nesralla I, ed. Cardiologia cirúrgica: perspectivas para o ano 2000. São Paulo:BYK;1994. p.93-100.

10. De Bacco G, De Bacco MW, Sant'Anna JRM, Santos MF, Sant'Anna RT, Prates PR, et al. Aplicabilidade do escore de risco de Ambler para pacientes com substituição valvar por bioprótese de pericárdio bovino. Rev Bras Cir Cardiovasc 2008; 23(3):336-43.

11. Scott WC, Miller DC, Haverich A, Dawkins K, Mitchell RS, Jamieson SW, et al. Determinants of operative mortality for patients undergoing aortic valve replacement. Discriminant analysis of 1,479 operations. J Thorac Cardiovasc Surg. 1985;89(3):400-13.

12. Florath I, Rosendahl UP, Mortasawi A, Bauer SF, Dalladaku F, Ennker IC, et al. Current determinants of operative mortality in 1400 patients requiring aortic valve replacement. Ann Thorac Surg. 2003;76(1):75-83.

13. Hokken RB, Steyerberg EW, Verbaan N, van Herwerden LA, van Domburg R, Bos E. 25 years of aortic valve replacement using mechanical valves. Risk factors for early and late mortality. Eur Heart J. 1997;18(7):1157-65.

14. Duncan AI, Lin J, Koch CG, Gillinov AM, Xu M, Starr NJ. The impact of gender on in-hospital mortality and morbidity after isolated aortic valve replacement. Anesth Analg. 2006;103(4):800-8.

15. Nowicki ER, Birkmeyer NJ, Weintraub RW, Leavitt BJ, Sanders JH, Dacey LJ, et al; Northern New England Cardiovascular Disease Study Group and the Center for Evaluative Clinical Sciences, Dartmouth Medical School. Multivariable prediction of in-hospital mortality associated with aortic and mitral valve surgery in Northern New England. Ann Thorac Surg. 2004;77(6):1966-77.

16. Roques F, Nashef SA, Michel P; EuroSCORE study group. Risk factors for early mortality after valve surgery in Europe in the 1990s: lessons from the EuroSCORE pilot program. J Heart Valve Dis. 2001;10(5):572-7.

17. Edwards FH, Peterson ED, Coombs LP, DeLong ER, Jamieson WR, Shroyer ALW, et al. Prediction of operative mortality after valve replacement surgery. J Am Coll Cardiol. 2001;37(3):885-92.

18. Brandão CMA, Pomerantzeff PMA, Cunha CR, Morales JIE, Puig LB, Grinberg M, et al. Substituição valvar com próteses mecânicas de duplo folheto. Rev Bras Cir Cardiovasc. 2000;15(3):227-33.

19. Baudet EM, Puel V, McBride JT, Grimaud JP, Roques F, Clerc F, et al. Long-term results of valve replacement with the St. Jude Medical prosthesis. J Thorac Cardiovasc Surg. 1995;109(5):858-70.

20. Fernandez J, Laub GW, Adkins MS, Anderson WA, Chen C, Bailey BM, et al. Early and late-phase events after valve replacement with the St. Jude Medical prosthesis in 1200 patients. J Thorac Cardiovasc Surg. 1994;107(2):394-7.

21. Hellgren L, Kvidal P, Stahle E. Improved early results after heart valve surgery over the last decade. Eur J Cardiothorac Surg. 2002;22(6):904-11.

22. De Bacco MW, Sant'Anna JRM, De Bacco G, Sant'Anna RT, Santos MF, Pereira E, et al. Fatores de risco hospitalar para implante de bioprótese valvar de pericárdio bovino. Arq Bras Cardiol. 2007;89(2):125-30.

23. Hamilton MA. Choosing the parameter for 2 x 2 table or 2 x 2 x 2 table analysis. Am J Epidemiol. 1979;109(3):362-75.