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Analysis of aortic root surgery with composite mechanical aortic valve conduit and valve-sparing reconstruction

Análise do tratamento cirúrgico da raiz da aorta com o tubo valvulado e com a preservação da valva aórtica

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Abstract

Objective: **Comparative analysis of early and late results of aortic root reconstruction with aortic valve sparing operations and the composite mechanical valve conduit replacement.**

Methods: **From November 2002 to September 2009, 164 consecutive patients with mean age 54 ± 15 years, 115 male, underwent the aortic root reconstruction (125 mechanical valve conduit replacements and 39 valve sparing operations). Sixteen percent of patients had Marfan syndrome and 4.3% had bicuspid aortic valve. One hundred and forty-four patients (88%) were followed for a mean period of 41.1 ± 20.8 months.**

Results: **The hospital mortality was 4.9%, 5.6% in operations with valved conduits and 2.6% in the valve sparing procedures (*P* <0.05). There was no difference neither in survival (95% CI = 86% - 96%, *P*= 0.1) nor in reoperation-free survival (95% CI = 85% - 90%, *P* = 0.29). The survival free of complications such as bleeding, thromboembolism and endocarditis were favorable to the valve sparing operations, respectively (95% CI = 70% - 95%, *P* = 0.001), (95% CI = 82% - 95% *P* = 0.03) and (95% CI = 81% - 95%, *P* = 0.03). Multivariate analysis showed that creatinine greater than 1.4 mg/dl, Cabrol operation and renal dialysis were predictors of mortality, respectively, with occurrence chance of 6 (95% CI = 1.8 - 19.5, *P* = 0.003), 12 (95% CI = 3 - 49.7, *P* = 0.0004) and 16 (95% CI = 3.6 - 71.3, *P* = 0.0002).**

Conclusions: **The aortic root reconstruction has a low early and late mortality, high survival free of complications and low need for reoperation. During the late follow-up, valve sparing aortic root reconstructions presented fewer incidences of bleeding, thromboembolic events and endocarditis.**

Descriptors: **Aorta. Aortic aneurysm, thoracic. Aortic valve insufficiency. Aortic valve.**

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Resumo

Objetivo: **Análise comparativa dos resultados imediatos e tardios da reconstrução da raiz da aorta com o tubo valvulado e com a preservação da valva aórtica.**

Métodos: **No período de novembro de 2002 a setembro de 2009, 164 pacientes com idade média de 54 ± 15 anos, sendo 115 do sexo masculino, foram submetidos ao tratamento cirúrgico da raiz da aorta. Foram 125 tubos valvulados e 39 reconstruções da raiz da aorta com preservação da valva aórtica. Dezesseis por cento dos pacientes eram portadores de síndrome de Marfan e 4,3% apresentavam valva aórtica bivalvulada. Cento e quarenta e quatro (88%) pacientes foram acompanhados durante tempo médio de seguimento de 41,1 ± 20,8 meses.**

Resultados: **A mortalidade hospitalar total foi de 4,9%; sendo 5,6% nas operações com tubo valvulado e 2,6% nas preservações da valva aórtica (*P*<0,05). Não houve diferença na sobrevida (IC 95%=86%-96%, *P*=0,1) e na sobrevida livre de reoperação (IC 95%=85%-90%, *P*=0,29). As sobrevidas livres de complicações como sangramento, tromboembolismo e endocardite foram favoráveis às operações com a preservação da valva aórtica, respectivamente (IC 95%=70%-95%, *P*=0,001), (IC 95%=82%-95%, *P*=0,03) e (IC 95%=81%-95%, *P*=0,03). A análise multivariada mostrou que a creatinina maior ou igual a 1,4 mg/dl, a operação de Cabrol e a insuficiência renal dialítica foram preditores de mortalidade, respectivamente, com chance de ocorrência (OR) de 6 (IC 95%=1,8-19,5; *P*=0,003), OR de 12 (IC 95%=3-49,7; *P*=0,0004) e OR de 16 (IC 95%=3,6-71,3; *P*=0,0002).**

Conclusões: **A reconstrução da raiz da aorta apresenta baixa mortalidade precoce e tardia, sobrevida livre de complicações elevada e baixa necessidade de reoperação. Durante o seguimento tardio, a reconstrução da raiz da aorta com preservação da valva aórtica apresentou menor incidência de sangramento, de fenômenos tromboembólicos e de endocardite.**

Descritores: **Aorta. Aneurisma da aorta torácica. Insuficiência da valva aórtica. Valva aórtica.**

INTRODUCTION

The surgical procedures used to reconstruct the aortic root are independent of morphological or etiopathogenic characteristics of the diseases that affect this aortic segment. The main conceptual difference of surgical techniques for aortic root lies in the use of a valved conduit or the aortic valve preservation, with their respective advantages and disadvantages. Since Bentall & De Bono [1] introduced the operation to replace the ascending aorta and the aortic valve for a valved conduit, several adaptations to this original technique have been proposed [2-5]. After mastering these operations, as an alternative, another concept for the treatment of this aortic segment arose, and it would be replaced associated with the aortic valve preservation.

Thus, it was believed that the complications related to anticoagulation could be avoided or reduced, whether they are thromboembolic or hemorrhagic, and infectious complications of patients undergoing the classic procedure. Sarsam & Yacoub [6] initially, and later, David & Feindel [7] have proposed techniques for aortic root reconstruction with the preservation of native aortic valve. In these patients, the valve leaflets do not show significant primary changes, but they may present secondary changes to the dilation of the aortic ring, in addition to abnormalities similar to those in the related aortic wall, which could limit the longevity of this procedure [8-10]. The native valve preservation, the main objective of any operation involving the heart valves, makes the procedure more laborious and time consuming, and does not ensure an early or late adequate result of the procedure (which usually occurs when using a valved conduit). Therefore, the purpose of this study is to analyze the early and late results of the aortic root reconstruction with a valved conduit, and with the aortic valve preservation.

METHODS

By reviewing the database of the Aorta Group Institute, the patients who underwent operation of aortic root reconstruction were identified, during November 2002 to September 2009. In this analysis, all patients who underwent elective or emergency procedures were included. Data were obtained by consulting the database, by reviewing medical charts and by telephone or letter, and by completing the specific questionnaire. The Institutional Ethics and Scientific Committee approved the condution of this work, with the research protocol No. 837/04.

We identified 164 patients, mean age 54 ± 15 years, 115 (70.1%) males and divided into two groups for analysis: those who underwent aortic root reconstruction with valved conduit and those who underwent radical resection of the ascending aorta with aortic valve preservation.

The epidemiological characteristics of these patients are presented in Table 1.

Table 1. Epidemiological characteristics of the patients studied.

Characteristics	Valved conduit	Aortic valve preservation	*P*
Gender			
Male	92	23	
Female	33	16	
Mean age (mean +SD)	56.4±15	46.8±13.7	0.001
Diagnostics			
Aneurysm	93	34	
Chronic dissection	24	4	
Acute dissection	8	1	
Aorta diameter (mean + SD)	64±11	55±8	
Aortic insufficiency			
Escape + discrete	31	20	
Moderate	34	8	
Serious	59	11	
Functional classification - NYHA			0.017
I	50	6	
II	40	22	
III	23	8	
IV	12	3	
Marfan Syndrome	16	11	0.024
Reoperation	28	0	<0.001
Ejection fraction (mean + SD)	57±13	65±11	
Creatinine (mean + SD) (mg/dl)	0.97±04	0.86±0.3	
COPD	13	2	
Bicuspid aortic valve	6	1	
OCI	22	0	0.005
Smoking	42	0	<0.001
Prior AMI	4	7	<0.001
Dyslipidemia	20	9	
Prior Cerebrovascular accident	7	1	

NYHA – New York Heart Association; COPD - Chronic Obstructive Pulmonary Disease; OCI - Obstructive Coronary Insufficiency, AMI - Acute Myocardial Infarction

125 (76.2%) reconstructions were performed with valved conduit. 123 (98.4%) mechanical and two biological valves, 47 (37.6%) Bentall and De Bono classic operations, 67 (53.6%) Bentall and De Bono modified operations (button technique) and nine (7.2%) Cabrol operations. 39 reconstructions were also carried (23.8%) with the aortic valve preservation: 26 (66.6%) remodeling operations, as proposed by Sarsam & Yacoub [6], and 13 (33.3%) replantation operations, described by David & Feindel [7] (Table 2).

The patients defined as operated with acute and Stanford type A chronic aortic dissection, respectively those who were operated on the first 14 days of the acute event and those operated after 14 days.

The late follow-up period with echocardiographic restudy was performed in 88% of patients and the mean follow-up was 41 ± 21 months.

Statistical analysis

Survival curves and event-free survivals were estimated by the Kaplan-Meier method. The associations of potential risk factors for survival were evaluated by log-rank test and the Cox proportional model (risk factors for reoperation could not be determined by low occurrence). The groups were compared using the chi-square test for categorical variables and runk-sum for continuous variables. Data were expressed as mean ± standard deviation, statistical significance was $P \leq 0.05$ and the significance for survival was evaluated with a 1-sample log-rank test.

Table 2. Operations performed for the aortic root reconstruction.

Performed procedures	nº		
Elective operations	155		
Urgent/Emergency operations	9		
Operations	164		
Classic Bentall	47		
Modified Bentall	67		
Biological Bentall	2		
Aortic root reconstruction + aortic valve preservation	39		
Reimplantation technique	13		
Remodeling technique	26		
Cabrol	9		
Associated operations	35		
Coronary Artery Bypass Graft	19		
Mitral valve replacement	2		
Mitral valvuloplasty	6		
Stent in descending aorta	8		
Arterial cannulation location	Valved conduit	Valve preservation	*P*
Brachiocephalic trunk	53	31	
Subclavian	11	0	<0.001
Aorta	61	8	
EC (min)	139±37	153±30	0.034
X Clamp (min)	109±29	130±25	<0.001
Selective cerebral perfusion (min)	23±9	17±3	<0.001

EC – Extracorporeal circulation

RESULTS

Hospital mortality was 4.9% (8 / 164), 5.6% (7 / 125) in operations with the valved conduit and 2.6% (1 / 39) in the ascending aorta reconstructions with the aortic valve preservation (P <0.05).

There were 127 aneurysms, six (4.7%) deaths, and 37 dissections with two (5.4%) deaths, 9 of them were acute and 28 were chronic.

The hospital deaths were due to septic shock in three (1.8%) patients, bleeding in two (1.2%), ventricular fibrillation in two (1.2%) and acute heart failure in one (0.6%) patient with early endocarditis of the aortic prosthesis. The immediate postoperative complications were 15 (9%), reoperations for bleeding,13 (8%) patients presented acute atrial fibrillation, 12 (7%) required permanent pacemaker, 10 (6%) initially had low cardiac output, two (1.2%), cerebrovascular accidents (CVA), two (1.2%), episodes of ventricular tachycardia, and one (0.6%), myocardial infarction.

During the study period (1233 ± 720 days), there were nine deaths, three secondary to myocardial infarction, two to cerebral infarction, one to thrombosis of the aortic prosthesis, one to pancreatic cancer and two with unknown cause. Among the followed-up patients, 98.4% were in functional class I and II (88% of the sample). The main late complications are detailed below.

The survival rate in seven years for patients undergoing aortic root reconstruction with a valved conduit was 77.6% (95% CI = 62.3% to 92.9%) and those undergoing reconstruction with aortic valve preservation was 93.5% (95% CI = 84.5% to 100%). There was no significant difference between the two forms of treatment (P = 0.1) (Figure 1).

Three reoperations were performed during the follow-up period, one in those patients whose valve was preserved (remodeling operation) for important symptomatic aortic insufficiency four years after the operation, one underwent reconstruction with the valved conduit for aortic prosthetic endocarditis six years after surgery. The third valve replacement was necessary for mitral valve insufficiency in patients with typical anomalous papillary insertion from patients with Marfan syndrome, six years after the operation to preserve the aortic valve.

The reoperation-free survival in the seven-year follow up for patients undergoing the aortic root reconstruction with a valved conduit was 72.1% (95% CI = 56.1% to 88.1%) and those undergoing reconstruction with aortic valve preservation was 74.4% (95% CI = 45.5% to 100%). There was no difference between the two groups (P = 0.2916) (Figure 2).

The reoperation-free survival in the seven-year follow up for patients undergoing the aortic root reconstruction with a valved conduit was 70.7% (95% CI = 54.5% to 86.9%) and those undergoing reconstruction with aortic valve preservation was 93.5% (95% CI = 84.5% to 100%).

The hemorrhagic complications free-survival in the seven-year follow up for patients undergoing the aortic root reconstruction with a valved conduit was 59.0% (95% CI = 44.4% to 73.6%) and those undergoing reconstruction with aortic valve preservation was 93.5% (95% CI = 84.5% to 100%); significantly lower for patients receiving oral anticoagulants (P = 0.0012). Complications related to chronic use of oral anticoagulation occurred in 16 patients who had received a valved conduit. There were three major and 13 minor hemorrhages, taking into consideration that one patient died of cerebral hemorrhage (Figure 4).

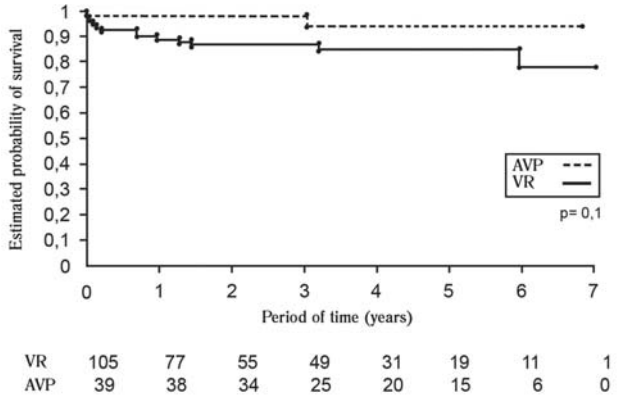

Fig. *1 - Survival curves of patients undergoing aortic root reconstruction with valved conduit (VC) and the aortic valve preservation, during a seven-year follow-up period*

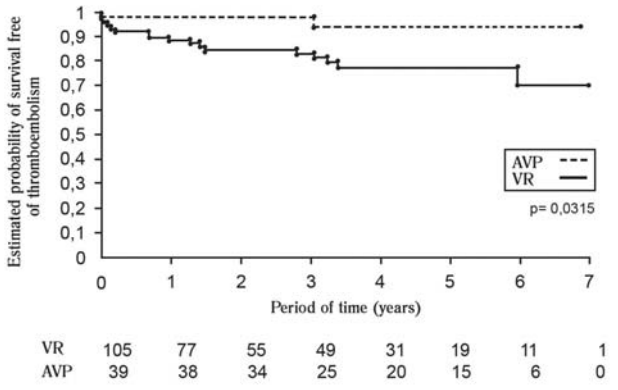

Fig. *3 - Free survival curves of thromboembolic complications in patients undergoing aortic root reconstruction with valved conduit (VC) and the aortic valve preservation, during a seven-year follow-up period*

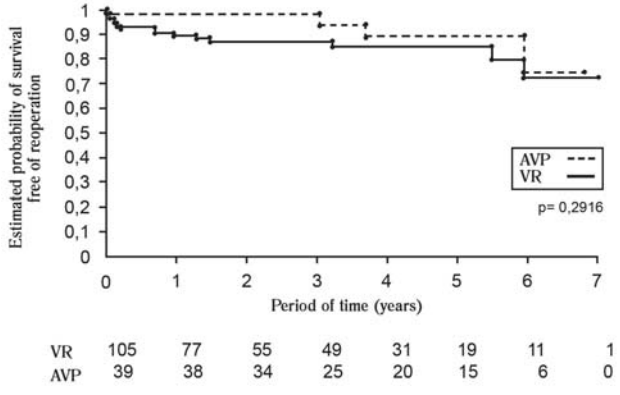

Fig. *2 - Free survival curves of reoperation in patients undergoing aortic root reconstruction with valved conduit (TV) and the aortic valve preservation, during a seven-year follow-up period*

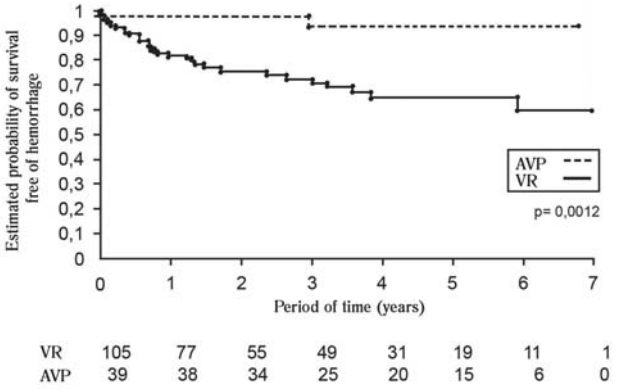

Fig. *4 - Free survival curves of bleeding complications in patients undergoing aortic root reconstruction with valved conduit (VC) and the aortic valve preservation, during a seven-year follow-up period*

Table 3. Predictors of hospital mortality and late mortality in surgical patients.

	Univariate (*P*)	Multivariate (*P*)	Risk ratio
Pre- and intraoperative variables			
Previous surgery	0.007		
CHF	0.007		
Chest pain	0.001		
Creatinine	0.0001	0.0004	10.3 (2.8 – 37.2)
EC period	0.03		
Postoperative variables			
Ventricular tachycardia	0.0001		
Reoperation due to bleeding	0.02		
Low debit	0.0002		
Pacemaker dependent	0.007		
Perioperative CVA	0.3		
Bronchopneumonia	0.007		
Acute renal failure requiring dialysis	0.0001	0.0001	18.4 (4 – 78)
Ventricular arrhythmia	0.008		
Cabrol operation	0.007	0.0001	18.4 (4.2 – 80)
Associated mitral valve plasty	0.004		
Hospitalization period	0.03		

(Values in parentheses with a 95% confidence interval) CHF - Congestive heart failure; EC- Extracorporeal circulation; CVA - Cerebrovascular accident

The endocartitis free-survival in the seven-year follow up for patients undergoing the aortic root reconstruction with a valved conduit was 71.2% (95% CI = 55.2% to 87.2%) and those undergoing reconstruction with aortic valve preservation was 93.5% (95% CI = 84.5% to 100%); significantly lower for patients receiving the valvular prosthesis (*P* = 0.0028). Five patients with prosthetic valve endocarditis presented the resolution of the infectious condition only with drug treatment (Figure 5).

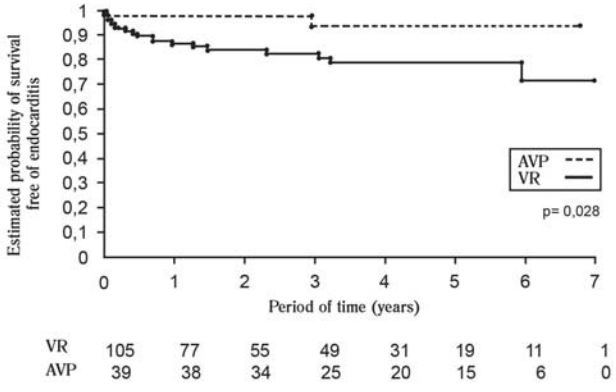

Fig. *5 - Free survival curves of endocarditis patients undergoing aortic root reconstruction with valved conduit (TV) and the aortic valve preservation, during a seven-year follow-up period*

Predictors of hospital and late mortality determined by univariate analysis are detailed in Table 3. The multivariate analysis showed that creatinine greater than or equal to 1.4 mg / dl showed an OR of 6 (95% CI = 1.8 to 19.5, P <0.003), the Cabrol operation showed an OR of 12 (95% CI = 3-50, *P* <0.0004) and renal dialysis showed an OR of 16 (95% CI = 3.6 to 71, *P* <0.0002) (Table 3). Both in univariate and multivariate analysis predictors of the need for reoperation were not identifid, during the follow-up period.

DISCUSSION

The operations for the aortic root reconstructions have already been widely used, as their immediate and late results are known, as well as a greater technical difficulty of carrying out the to preserve the aortic valve.

In this study, we observed a low mortality of these operations. The difference in results observed between the operations with the valved conduit and the aortic valve preservation do not allow us to state that, one type of operation overlaps the other, because the groups are not similar and the aortic valve preservation is not a operation for all patients. In any manner, the complications related to the chronic use of oral anticoagulation (thromboembolic and / or hemorrhagic phenomena) and prosthetic valve infection should be taken into consideration when choosing an operation against another.

Wannamathee et al. [11] also observed that the elective aortic root reconstruction has reduced mortality, especially when compared to urgent or emergency interventions. In a multicenter study, 675 patients with Marfan syndrome who underwent reconstruction with a valved conduit showed hospital mortality of 1.5% in elective cases, 2.6% for urgent cases and 11.7% in the emergency rooms. In multivariate analysis, the Cabrol operation was significant to decrease the late survival. In our study, this change was mainly due to the fact that we used this surgical technique in cases of reoperation, and "per se" should justify the worst result. Other variables, such as reduced ejection fraction, aortic regurgitation severity and increased left ventricular cavity were not predictors of late mortality.

Apart from the low occurrence, we observed no difference in the reoperation of our patients, regardless of operation carried out for the aortic root reconstruction, differently from what other authors has presented. The probable reason due to the strict selection of patients for the aortic root reconstruction with valve preservation, the low number of procedures in the aortic leaflets, external fixation of the commissural pillars when using the remodeling technique and the follow-up time relatively short for the study patients [12].

Ergin et al. [13] reported significant reduction in reoperation rate and increased survival in patients undergoing operation with a valved conduit when used the technique proposed by Kouchoukos Button et al. [5]. Svensson et al. [14] did not need to reoperate any patient in his sample. Savunen & Aho [15] performed angiography in 53 of the 60 patients studied, three years after the operation with a valved conduit, and faced no problem in coronary ostial anastomoses. Niederhäuser et al. [16], with seven reoperations in 181 patients operated with a valved conduit, did not identify predictors for the need of reoperation. On the other hand, Zehr et al. [17] in a series of 203 surgical patients observed that Marfan syndrome, root reconstruction with the aortic valve preservation and the need of associated valvular procedure were significant predictors for necessity of reoperation.

Yacoub et al. [18] observed 11% of reoperation in a ten-year follow-up with series of 158 patients who underwent remodeling technique, especially due to secondary aortic insufficiency to late dilation of the aortic ring. David et al. [19] showed that in 151 patients who underwent aortic root reconstruction with the aortic valve preservation, the reoperation-free survival of the aortic valve was 99.1% for reimplantation technique and 97, 2% for the remodeling technique in an eight-year follow up period. Nevertheless, the severe aortic insufficiency-free survival during the study period was different when compared to both techniques, with 90.3% for the reimplantation technique and 55.6% for the remodeling technique.

The fixation of the aortic ring was considered as the main reason for the lowest incidence of reoperation in patients who underwent reimplantation technique when compared to remodeling technique [12,18-22]. Several other technical changes were suggested for the reconstruction process of the aortic root with valve preservation and were summarized by Miller [23] in the editorial referred above.

It has been shown that surgical manipulation of one or more aortic leaflets aiming to a better coaptation is related to the increased need for valve reoperation in the late follow-up of these patients [24]. In our study, only six (15%) patients required valve procedure associated with the manipulation of the aortic valve, with good results until this moment of the follow-up period.

The valve preservation in patients with Marfan syndrome is another point of contention. Although the aortic valve leaflets are often functionally normal, they are structurally compromised. Missirlis et al. [8] observed that the length of the aortic valves leaflets in Marfan syndrome is greater than the normal ones. It was also demonstrated that the abnormal fibrillin metabolism affects the valvar tissue in these patients. Fleischer et al. [10] also showed that the aortic and mitral valve leaflets are equally affected by the fragmentation of fibrillin-1, as well as the aortic wall, and these changes are more intense when patients are older than 20 years. In this report, 11 patients with Marfan syndrome underwent aortic root reconstruction with valve preservation, without the need for reoperation. Oliveira et al. [22] reported that 61 patients with Marfan syndrome underwent reconstruction with the aortic valve preservation and present 100% survival free of reoperation in 10 years. However, 25% already present from moderate to severe aortic valve insufficiency.

As patients with Marfan syndrome, patients with bicuspid aortic valve, despite the morphological changes of the leaflets, had good results, similar to those obtained in trivalvular patients [25].

Oliveira et al. [22] also observed that the aortic valve leaflets, in general, appeared to be normal when the aneurysm was shorter than 5 cm and only 50% of them appeared to be normal when the aneurysm had between 5 and 6 cm. On the other hand, in patients with aneurysms larger than 6 cm, most of the leaflets was abnormal, being more recommended the replacement of the root for the valved conduit.

The ring size also seems relevant when choosing the operative technique. Aortic rings larger than 25 mm before the root reconstruction were significant predictor for the need of reoperation [23]. Casselman et al. [26] reported that a 27 mm ring or larger can be a predictor of recurrent aortic insufficiency in bicuspid aortic valve repair.

Due to what we observed and the difficult access of the brazilian population to adequate health care in the long-

term period, it seems a problem to the aortic root reconstruction with a valved conduit, especially by the continued use of oral anticoagulants. Six (4.8%) of our patients had thromboembolic events during the follow-up period and one of them resulted in death. Kouchoukos et al. [5], dealing with patients whose medical care is considered superior to the reality of third world countries as Brazil, also observed a significant incidence of problems related to inadequate anticoagulation. There were thromboembolic complications in 18% of patients in the twelve-year follow up. Hemorrhagic complications are also a reality for patients using oral anticoagulants. Sixteen (12.8%) of our patients had hemorrhagic complications, with one death of cerebral hemorrhage.

The infectious complications are more frequent when the native valve is not preserved. In our sample, the presence of six (4.8%) patients with valve infection could have resulted in greater need for reoperation, if the therapeutic success with drug treatment of prosthetic valve endocarditis had not been so high.

The late mortality of these patients is low, similar to the life expectancy of the general population, as demonstrated previously [17]. Renal failure, being dialytic or not, it is a factor that is invariably associated with higher mortality, either early or late. In this study, the Cabrol operation was also presented as a predictor of mortality, although it is important to mention not because of the operation itself, but due to the fact that it is performed in patients at higher operative risk (reoperations).

Despite the indisputable results of operation for the aortic root reconstructions with a valved conduit, complications from the use of mechanical valve prosthesis are not negligible, especially for the reality in our public health system. The entire procedure can be done with similar results to those obtained with the valved conduit preserving the native valve and it should be stimulated, even if it is not a procedure either for all surgeons or all patients. [27,28].

In conclusion, we can state that the aortic root reconstruction has a low early and late mortality, a high survival free of complications and little need for reoperation. During the late follow-up, the aortic root reconstruction with preservation of the aortic valve showed a lower incidence of bleeding, thromboembolic events and endocarditis.

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