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Transapical aortic valve implantation: results of a Brazilian prosthesis

Implante transapical de valva aórtica: resultados de uma nova prótese brasileira

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Abstract

Objective: **The aortic valve replacement is a routine procedure with acceptable risk, but in some cases, such a risk can justify contraindication. The minimally invasive transcatheter aortic valve implantation has been viable, with lower morbidity and mortality. The aim of this study was to develop a national catheter-mounted aortic bioprosthesis for the aortic position implant.**

Methods: **After animal studies, 14 patients with high EuroSCORE underwent transcatheter aortic valve implantation. Median Logistic EuroSCORE was 43.7%. Four patients presented with dysfunctional bioprosthesis, remaining ones presented calcified aortic stenosis. All patients presented symptoms. Procedures were performed in a hybrid OR under fluoroscopic and echocardiography guidance. Using a left minithoracotomy the prosthesis was implanted through the ventricular apex under ventricular pacing or hemorrhagic shock, after aortic valvoplasty. Echocardiograph and angiograph controls were performed, and the patients were referred to ICU.**

Results: **Implant was feasible in 13 cases. There were no intra-operative deaths. Median peak transvalvular aortic gradient reduced to 25.0 mmHg, and left ventricular function improved in the first seven post-operative days. Paravalvular aortic regurgitation was mild and present in 71%. No definitive pacemaker was needed. There was no peripheral vascular complication. Overall mortality was 42%.**

Conclusion: **The transapical implantation of catheter-mounted bioprosthesis was a feasible procedure. Long term follow-up is mandatory in order to access efficacy and indications.**

Descriptors: **Aortic valve stenosis. Heart catheterization. Extracorporeal circulation.**

Resumo

Objetivo: **A troca valvar aórtica é procedimento rotineiro com risco aceitável. Em alguns casos, a mortalidade é elevada, levando à contraindicação do procedimento, apesar dos sintomas. O implante minimamente invasivo transcateter de valva aórtica parece ser uma alternativa, reduzindo a morbi-mortalidade. O objetivo deste estudo foi o desenvolvimento e implante de nova prótese transcateter.**

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Métodos: **Após desenvolvimento em animais, uma prótese transcateter, balão-expansível foi utilizada em 14 casos de alto risco. O EuroSCORE médio foi de 43,7%. Quatro pacientes apresentavam disfunção de biopróteses e o restante, estenose aórtica calcificada. Todos os pacientes eram sintomáticos. Os procedimentos foram realizados em ambiente cirúrgico híbrido, sob controle ecocardiográfico e fluoroscópico. Com o uso de minitoracotomia esquerda, as próteses foram implantadas através do ápice ventricular, sob estimulação ventricular de alta frequência ou choque hemorrágico controlado, após valvoplastia aórtica. Foram realizados controles clínicos e ecocardiográficos seriados.**

Resultados: **A correta liberação da prótese foi possível em 13 casos. Uma conversão ocorreu. Não houve mortalidade operatória. O gradiente de pico médio pós-implante foi de 25 mmHg. A fração de ejeção apresentou aumento significativo após o 7º pós-operatório. Insuficiência aórtica residual não significativa esteve presente em 71% dos casos, nenhuma significativa. Não ocorreu complicação vascular periférica. Não houve necessidade de marcapasso definitivo. Um caso de acidente vascular cerebral ocorreu. A mortalidade geral foi de 42%.**

Conclusão: **O implante transapical de valva aórtica transcateter é um procedimento possível com esta nova prótese. O comportamento hemodinâmico foi satisfatório. São necessários estudos de longo prazo e com maior poder amostral, no intuito de determinar a real eficácia e indicação do procedimento alternativo.**

Descritores: **Estenose da valva aórtica. Cateterismo cardíaco. Circulação extracorpórea.**

INTRODUCTION

The degenerative aortic valve calcification related to aging is the most common cause of aortic stenosis in developed countries. It is the most common evidence for aortic valve replacement [1]. The prevalence of severe aortic stenosis increases with age and may affect up to 2% of individuals over 65 years of age [1].

There is an indication for surgery when the valve area is less than 0.7 cm^2, or the systolic gradient is higher than 50 mmHg, although the symptoms can begin earlier. Survival after the onset of symptoms is as low as 60% at 1 year and 32% in five years [2].

The standard treatment is the surgery with cardiopulmonary bypass and aortic clamping. Currently, the aortic valve replacement is a well-known procedure with consistent outcomes. The operative mortality rate is as low as around 4% [3].

Despite the well-established outcome, the risk is higher in some patients, especially the older ones. Besides the age, several comorbidities also raise the surgical risk, thus up to one third of patients have their procedure contraindicated, although the symptoms or the presence of structural cardiac impairment [4]. The existence of patent coronary grafts, extensive thoracic irradiation, or a severely atheromatous aorta, or porcelain aorta, multiple previous operations, biological fragility, and the lack of symptoms can be well documented reasons for refusal to intervene in this special group of individuals.

In searching for alternatives to high-risk patients, several groups have proposed options to conventional valve replacement.

Aortic balloon valvuloplasty was proposed in 1996 by Cribier et al. [5] as an alternative to patients considered having unacceptable risk for conventional surgical treatment. The survival rate with the technique was not satisfactory with a mortality rate of 65% at 1 year. Only 40% of patients at 1 year were free of reintervention, aortic valve replacement surgery, heart block, or death [6].

In face of the unsatisfactory outcomes, several initiatives have been proposed in order to develop a way to implant a valve-based device in the aortic position capable of providing more consistent and sustained results, while allowing simultaneously the reduction of morbidity and mortality imposed by the aortic valve replacement surgery.

The first description of a catheter valve implantation was performed by Davies [7] in 1965. The idea was only resumed several decades later when Andersen et al. [8] in 1992, described the experimental implant of a metal frame on which were mounted cusps.

Only 10 years after the initial description by Andersen, Cribier et al. [9] have described the first human implant in a case of extreme severity. The immediate result was very satisfactory, leading to a significant reduction of the transvalvar gradient, improved of the ejection fraction, and the clinical status of cardiogenic shock.

Studies using prototypes in cases considered to have no conventional surgical alternative such as, I-REVIVE (Initial Registry of Endovascular Implantation of Valves in Europe) and RECAST (Registry of Endovascular Critical Aortic stenosis Treatment), were carried out in 2003 and 2004 [10]. The initial success of the procedure was as high as 75% with an increase of the valve area from 0.6 cm^2 to 1.6 cm^2, mean gradient reduction from 37 to 9 mmHg, and improvement of the ejection fraction from 45% to 53%. The 30-day mortality rate was 23% and the rate of major cardiovascular events was 26% [11].

The initial encouraging experience motivated several multicenter studies, many of them not yet published, such as the REVIVAL II (Transcatheter Endovascular

Implantation of Valves II) and REVIVE II (Registry of Endovascular Implantation of Valves in Europe II). The initial enthusiasm evoked by the results promoted the adoption of these devices by regulatory authorities, allowing the initiation of a multicenter randomized study called PARTNER (Placement of Aortic Transcatheter) [12].

In our country, there are no prosthetic valve aortic devices of transcatheter implantation available with national manufacturing and technology. Using the development of aortic stent with national technology as a model, which allowed the general population to have a larger access to these restricted techniques, the Discipline of Cardiovascular Surgery, at the Federal University of São Paulo started to develop a project of an aortic valve prosthesis for transcatheter implantation in partnership with the private sector (Braile Biomedica, São José do Rio Preto) and the FAPESP - The São Paulo State Research Support Foundation, an State Agency the aim of providing grants, funds and programs to support research, education and innovation of private and public institutions and companies in the state of São Paulo. The differential this prosthesis is based on the fact that the structure of the pericardium can be made with no need of intermediate sutures, probably increasing the resistance to wear and tear of the material.

The evaluation of clinical results of this initiative is the focus of this work.

METHODS

The clinical protocol only began after the selection phase of a suitable experimental model (Figure 1), with adequate hemodynamic performance, durability, and security.

Flow duplicators were used to test the enduringness of the device. The parameters used were the same ones used in the conventional bioprosthesis. The animal experimental phase consisted of implants in pigs during a 3-month echocardiographic and angiographic follow-up.

The prosthesis consists of an electrochemically-polished, balloon-expandable stainless steel frame-like structure. Internally, a bovine pericardial bioprosthesis was assembled, with structure and arrangement similar to the conventional bioprostheses, without splicing points between the leaflets. The diameters ranged from 20 mm to 26 mm. The mechanism for setting the valve ring is a composition of the endoprosthesis radial force and calcium interaction with the valve structure.

Between June 2008 and November 2009, 14 patients underwent transcatheter aortic valve implantation. The institutional Ethics Committee (CEP 1116/08) approved the study and protocol. Patients provided the free written informed consent.

Patients were selected by a multidisciplinary group that included cardiovascular surgeons, clinical cardiologists, hemodynamicists, and anesthesiologists. The selection of patients involved, in addition to multidisciplinary consultation and the criteria for inclusion and exclusion, the importance of aspects such as the surgical risk, expectation and quality of life.

The risk scores EuroSCORE and STS SCORE was used in order to provide a quantitative analysis on the individual risk involved in the procedure.

Patients underwent the following exams: clinical, laboratory, echocardiography, cineangiocoronariography (when the clinical condition allowed), and Doppler ultrasonography of carotid, femoral and iliac arterial systems.

Fig. 1 - Balloon-expandable device for insertion in the aortic position

Inclusion Criteria

1. Patients with exacerbated comorbidities that both teams, the cardiovascular surgery and the cardiology agreed that the mortality risk predicted for conventional intervention was higher than 15% predicted by the EuroSCORE and / or greater than 10% predicted by the STS SCORE;

2. Presence of senile degeneration of the aortic valve with severe stenosis (mean gradient > 40 mmHg, jet speed higher than 4 m/s, or valve orifice < 0.8 cm^2), or dysfunction of bioprosthetic with significant valve failure;

3. Symptomatic patients due to valve stenosis or prosthetic valve dysfunction, with functional class e" II according to the New York Heart Association (NYHA).

Exclusion Criteria

1. Evidence of acute myocardial infarction in a time interval < one month;
2. Unicuspid or bicuspid aortic valve;
3. Noncalcified aortic valve;
4. Native valve dysfunction with mixed component (stenosis and failure) with predominant regurgitation or > 3+;
5. Invasive cardiac procedures in the last 30 days (6 months after implantation of drug-eluting coronary stent);
6. Moderate to severe, or severe mitral regurgitation;
7. Nontreated significant coronary artery disease requiring surgical revascularization;
8. Obstructive hypertrophic cardiomyopathy;
9. Evidence of intracardiac mass (tumor, thrombus, or vegetation);
10. Active peptic ulcer disease;
11. Hypersensitivity or contraindication to platelet antiaggregation or in the contrast medium;
12. Aortic annulus diameter <16 mm or > 24 mm;
13. Stroke or recent transient ischemic attack (within the last 6 months);
14. Life expectancy < 12 months due to noncardiac disease or other comorbidities;
15. Presence of unstable and sessile atheromas in the ascending aorta and/or in the aortic arch found by transesophageal echocardiography, computed tomography.

Demographic characteristics and comorbidities of the patients are listed in Table 1.

A catheter-mounted aortic valve with a diameter 20% larger than the aortic valve annulus measured through

Table 1. Comorbidities and demographic characteristics.

Characteristics	n=14
Age in years (mean/interval)	75.7 / 34-88
Female gender (n/%)	6 / 42.8
Diabetes (n/%)	3 / 21.4
Glomerular filtration rate < 50 mL/min (n/%)	12 / 85.7
Dialytic renal insufficiency	0
Restrictive/obstructive pulmonar disease (n/%)	5 / 35.7
Recent Pneumonia (n/%)	3 / 21.4
Undergoing surgery while still hospitalized due to decompensation (n/%)	6/ 42.8
Undergoing surgery while still hospitalized due to decompensation – 1st half of the sample (n/%)	4/ 57.1
Undergoing surgery while still hospitalized due to decompensation – 2nd half of the sample (n/%)	2/ 28.5
Atrial fibrillation (n/%)	2 / 14.2
Functional Classe (n/%)	
II	3/21.4
III	6/42.8
IV	5/35.7
Comorbidities	
Coronary arterial disease (n/%)	4/28.5
Previous AMI (n/%)	3/21.4
Previous PTCA (n/%)	2/14.2
Previous MR prévia (n/%)	1/7.1
Peripheral arterial diseasae (n/%)	4/28.5
Previous Stroke (Previous cerebrovascular accident) (n/%)	0
Cancer (n/%)	0
Porcelain aorta (n/%)	0
Chagas (n/%)	1/7.1
Sickle cell anemia (n/%)	1/7.1
Reoperation (n/%)	6/42.8
"*Valve-in-valve*" (n/%)	5/35.7
Logistic EuroSCORE (%) (mean/interval)	43.7/12,4-74.9
Logistic EuroSCORE (%)1st half of the sample (mean/interval)	42.6/13.7-64.8
Logistic EuroSCORE (%) 2nd half of the sample (mean/interval)	44.8/12.4-79.6
STS score (%) (mean/interval)	37.4/8.3-61.1
STS score (%)1st half of the sample (mean/interval)	37.8/8.3-61.1
STS score (%) 2nd half of the sample (mean/interval)	37.1/17.1-51.8
Peak aortic gradient	79.7±4.8
Mean aortic gradiente	45.3±4.2
Left ventricle ejection fraction	47.6±3.5

PTCA - Percutaneous transluminal coronary angioplasty

transesophageal echocardiography was positioned on a catheter-balloon with a diameter compatible with its maximum aperture and compacted with the aid of a radial compressor device.

After anesthetic induction, the patient was positioned in a supine position, with a pad under the left scapula. The right inguinal region was dissected to isolate the femoral artery and vein in order to allow the secure peripheral cannulation. Previous cannulation and preparation of the cardiopulmonary bypass machine were carried out to enable greater security to the procedure with the immediate entry into perfusion in the eventuality of an accident during the procedure, besides providing controlled hypotension during the opening of the valve device in nine cases. Heparin at a dose of 4 mg/kg was administered in order to achieve an activated clotting time (ACT) above 400 seconds.

The right femoral artery was punctured using the Seldinger technique, and a 6-Fr introducer was positioned. A catheter was advanced into the aortic root with the aid of a guide wire, in order to allow the performance of control aortographies before and after prosthetic valve opening, besides identifying the aortic sinuses and coronary ostia.

The ventricular apex was identified by transthoracic echocardiography. At the marked site, an incision of approximately 5 cm in length was performed to obtain access to the ventricular apex.

The 6-Fr introducer was withdrawn, and a 24-Fr introducer was placed into position. A balloon catheter of appropriate diameter was placed on the aortic valve. Then, we carried out a controlled hypotension with the aid of venous drainage for cardiopulmonary bypass support, or a ventricular stimulation with a high-frequency pacemaker (180-200 bpm). Thereafter, the balloon was inflated to its maximum nominal pressure in order to promote aortic valvuloplasty (Figure 2).

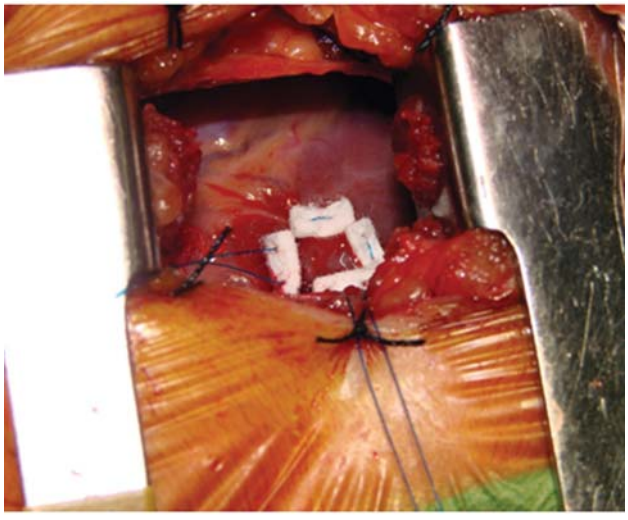

Fig. 2 - Aspect of the purse-string suture and the preparation to place the 24-Fr introducer

The balloon was deflated. The pressure restored and a control echocardiogram performed to confirm the effectiveness of valvuloplasty. The balloon was then removed and replaced over the same guide wire by the valve prosthesis mounted previously.

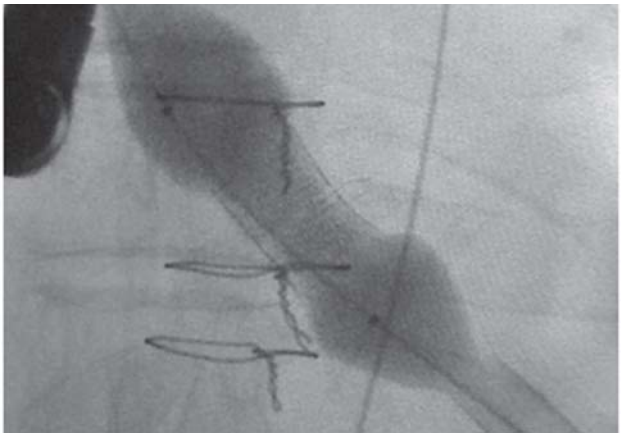

Fig. 3 - Inflation of the balloon catheter and the prosthesis opening. Fluoroscopy

A new episode of controlled hypotension was carried out and then the balloon catheter with the prosthesis mounted was inflated to its maximum nominal pressure by promoting the release of the prosthesis (Figure 3). Its rapid deflation allowed the restoration of blood pressure with the replacement of the drained volume or the suspension of ventricular stimulation. If a transesophageal echocardiogram showed leakage around the prosthesis, a new episode of balloon inflation was performed under controlled hypotension.

A control aortography documented the correct functioning of the prosthesis and a possible interference

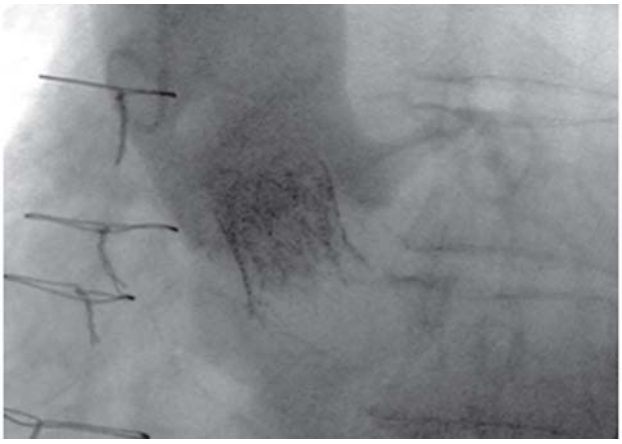

Fig. 4 - Control aortography demonstrating the patency of the coronary ostia and no significant aortic insufficiency

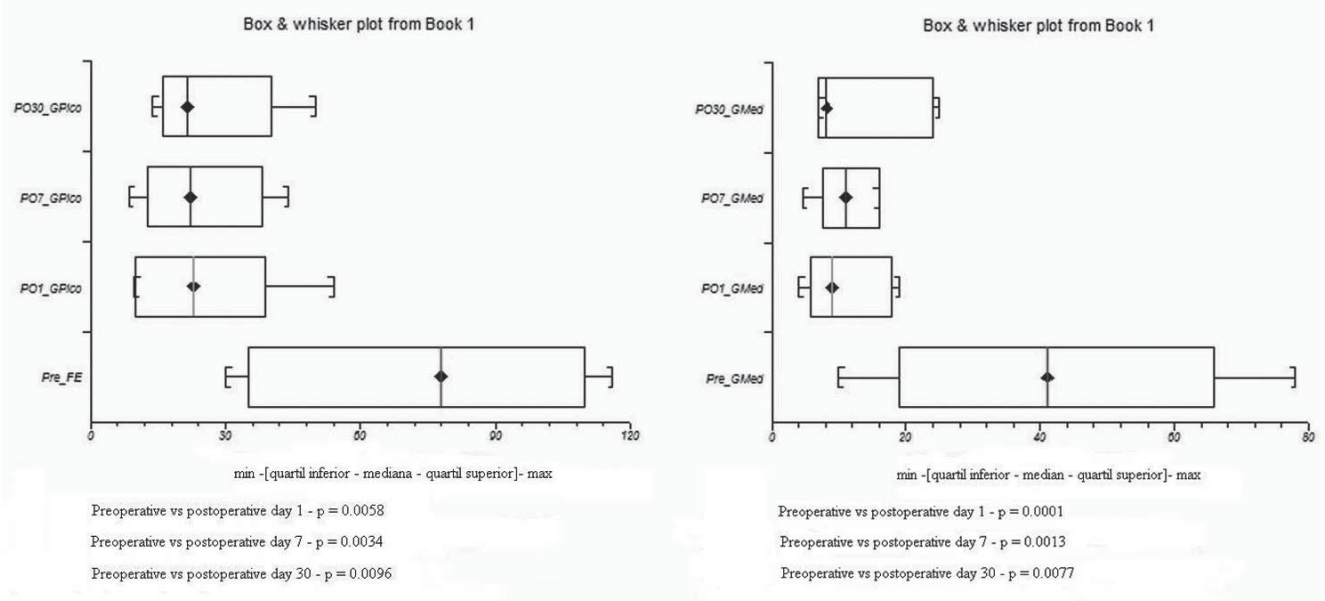

Fig. 5 - A. Aortic transvalvular peak gradients preoperatively;on postoperative day 1, postoperative day 7, and postoperative day 30. B. Mean aortic transvalvular gradients on the preoperative period, on postoperative day 1, postoperative day 7, and postoperative day 30

with the coronary filling, in cases of doubt with the use of echocardiogram (Figure 4).

The introducer was removed and the ventricular apex occluded using the purse-string suture. The patient was awakened from anesthesia when the clinical conditions were favorable and referred to the intensive care unit.

The procedure success was defined as a correct implant, satisfactory hemodynamic profile, no valve or perivalvular significant leaks, and immediate lack of major complications.

Statistical analysis was performed using SPSS version 11. The confidence level of 0.05 was used as significant. The comparison between the means used the Friedman test, after verifying the normal distribution of values. The mean and standard error were used to express the analysis, unless specified otherwise. The analysis of hemodynamic data excluded the following cases: patient 2 who undergone conversion to the conventional procedure; patient 9 died before 30 days of follow-up; and patients 12, 13, 14 because they do not complete 30 days of follow up at the moment of completion of this study.

RESULTS

All cases were performed at the Federal University of São Paulo - Paulista School of Medicine in a hybrid operating room. The successful valve implantation was possible in 13 cases. There was only one immediate conversion to prosthesis migration. No intraoperative deaths occurred.

We used the following sizes of devices: 3 (20 mm), 6 (22 mm), 2 (24 mm), and 2 (26 mm). The cases of valve-in-valve used two prostheses of 20 mm and three of 22 mm, respectively.

All patients survived the procedure, and the overall mortality rate was 42.8%. There was one death within the first 30 days of follow up due to a related complication (stroke). There were five in-hospital deaths (before discharge). These were resulting from clinical complications not directly related, including bronchopneumonia (three cases) and tracheoesophageal fistula (one case). Only one of the individuals who were discharged from the hospital died during follow-up due to Influenza A H1N1. The mortality of the second half of the sample was 14.2%.

The result hemodynamic assessed by echocardiography was satisfactory, with a significant reduction of the peak gradient from 79.7 ± 9.9 to 25.0 ± 5.2 mmHg on the first postoperative day (P = 0.0058). The outcome showed that the reduction of the gradient was maintained in subsequent examinations, with no statistically significant difference between the gradient obtained after implantation in the immediate postoperative period. The gradient also showed a significant reduction from 40.1 ± 7.3 mmHg to 10.7 ± 2.0 mmHg on the first postoperative day (P = 0.0001). The development also demonstrated the maintenance of this reduction (Figure 5).

Periprosthetic aortic regurgitation has occurred in most cases. Four patients showed no reflux (all valve-in-valve); six, mild insufficiency; and four mild to moderate insufficiency.

The ventricular function measured through the left ventricle ejection fraction using Simpson's method showed statistically significant improvement from 44.46 ± 3.4 to 56.8 ± 3.3, on the seventh day after surgery (P = 0 , 0001), sustained on the follow-up period (Figure 6).

Table 2. Operatory variables.

Variable	n=14
Successful procedure (n/%)	13/92.8
Conversion to conventional replacement (n/%)	1/7.1
Ressuscitation	0
Defibrillation (n/%)	2/14.2
Entry on cradiopulmonary bypasss support	2/14.2
Contrast (mL)	80±9.4
Fluoroscopy time (min)	16.5±1.9
Procedute time (min)	217.7±26.6

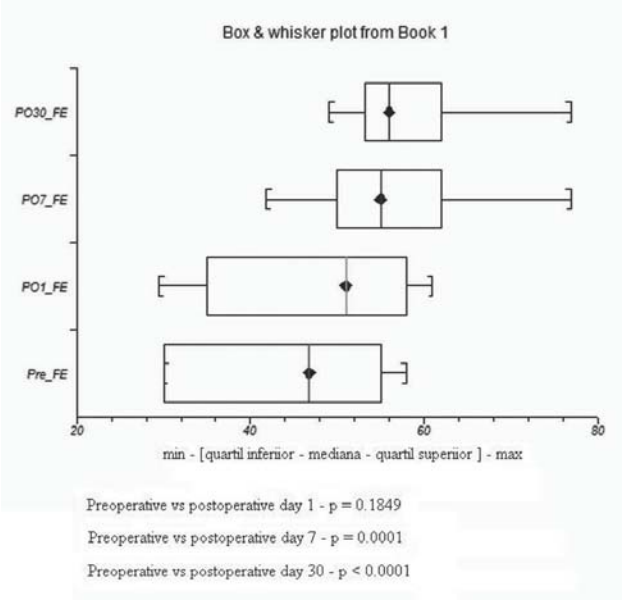

Fig. 6 - Ejection fraction of left ventricle preoperatively, on postoperative day 1, postoperative day ,7 and postoperative day 30

No patient had a complete atrioventricular block or need a permanent pacemaker implantation.

The intraoperative variables are listed in Table 2.

It was required the cardiopulmonary bypass support in a case with conversion to a conventional procedure and in one case without conversion.

Three patients required readmission after discharge. One patient showed a lobar pneumonia. Another had a hemothorax on the left, probably secondary to apical ventricular bleeding requiring chest tube drainage without the need for surgical re-exploration, and the third one also had pleural effusion on the left, requiring thoracentesis.

DISCUSSION

The aortic valve replacement is the procedure of choice in patients with aortic valve stenosis or dysfunction of bioprostheses symptomatic with high gradient. This procedure is well established in the literature and their results favorable and consistent, even in higher age groups and patients with multiple comorbidities [13-15].

Although meeting the well-defined criteria for the indication of the procedure, approximately 30-60% of patients may have a surgical indication denied because they are considered to be at high risk [2,16].

There are many reasons for the contraindication to the conventional procedure, including the following: the presence of extensive calcified or porcelain aortas, the presence of patent coronary grafts, thoracic radiotherapy, or the existence of multiple comorbidities. The assessment of these patients' operative risk is based on several scores, which seek to predict mortality for a given patient undergoing a surgical procedure, besides, of course, the personal perception of the care team.

There are several limitations of the risk scores, among them the non-inclusion of some features considered as risk for intervention, such as mediastinal irradiation, porcelain aorta, liver dysfunction, abnormalities of the chest wall, and previous mediastinitis. It should be taken into account that the individuals which served as the basis to compose the scores were actually undergoing the surgery, limiting the inference in groups that were not originally considered candidates for interventional procedure [17].

Important part of the cases consisted of reoperated patients, which is known to increase the risk of a new intervention. Despite this, reports demonstrated the safety and efficacy of transcatheter intervention in this group of patients who have not only valve reinterventions, but aortic and coronary artery reinterventions as well [18]. Thus, this particular group is especially benefited by the new alternative.

Unlike the literature, our patients had comorbidities as yet not described, such as Chagas disease and sickle cell anemia and therefore not compared to the international risk scores, demonstrating the need to individualize the risk stratification and adapt it to our environment. Another very much younger patient than those reported in previous cases in the literature presented extremely high-risk score, multiple comorbidities, four cardiovascular reoperations, and sickle cell anemia polysensitised by blood products, highlighting the fact that younger patients with high-risk of

reintervention may benefit technique. From then on, a new group can be formed in which this procedure will serve as a bridge to partial recovery, clinical improvement and provision of more satisfactory conditions for definitive conventional therapy.

The occlusion of the left ventricular apex after manipulation with large caliber introducers is another challenge. The non-use of cardiopulmonary bypass support may cause difficulty in apical hemostasis with consequent blood loss. Perhaps the two cases of hemothorax in the study may have been the result of a slow apical bleeding with spontaneous resolution.

Although the atrioventricular block is a relatively common complication, a permanent pacemaker implantation was not required. The Balloon-expandable prosthesis, such as the Edwards Sapien THV (Edwards Lifesciences, Irvine, CA) had need indexes of permanent cardiac stimulation of 7% [12]. The auto-expandable prostheses such as the CoreValve (CoreValve, Irvine, California) presented complete atrioventricular block rate relative higher reaching as much as 24% [12].

The conversion needs to median sternotomy, total cardiopulmonary bypass support, and conventional valve replacement has been described as around 1.2% [12]. This study presented only one case of conversion; however, the small number of patients in our study may have not permitted adequate statistical comparisons. The cause of conversion was directly related to the learning curve.

Several groups have demonstrated the persistence of various degrees of aortic insufficiency after the procedure, mainly from perivalvar origin, usually ranging from mild to moderate degree [19]. The prevalence of failure is higher than expected to conventional substitutions [20,21]. Given the irregularity of the circumference of the aortic valve annulus after balloon valvuloplasty, the presence of failure is not surprising due to the difficulty encountered by the prosthetic device to perform a perfect coaptation with the valve annulus calcification. On the other hand, the presence of extensive calcification of the annulus appears to be a decisive factor in the adequate support of the prosthesis, thus helping to prevent further migration of the device.

Data from the International Registry of Edwards Sapien showed a 45% failure of 1+, 32% of 2+, and 7.5% of 3+ for prostheses with a 23 mm-diameter. With the use of 26 mm-diameter prosthesis, there were no failures of 3+, but 50.8% and 36.1% showed failure of 1+ e 2+, respectively [12]. In this series, the aortic insufficiency was comparable to the results of the record cited using 26 mm-diameter prostheses. Probably, the availability of a greater number of prosthetic diameters may have allowed more precise selection of a suitable model capable of better coaptation in relation to the native valve annulus. Patients undergoing valve-in-valve implant showed no aortic insufficiency perivalvar by coaptation, naturally more regular between the two prostheses.

The current data do not allow conclusions about the impact on survival or the ventricle performance, as well as the occasional need for reintervention caused by the presence of residual aortic insufficiency. It can be assumed that the behavior should resemble to light native insufficiencies, unless it causes hemolysis, and it requires the need for conventional intervention and the replacement of the transcatheter prosthesis by a conventional bioprosthesis [20,21]. Accepting the presence of an aortic insufficiency as a natural consequence and part of the procedure, rather than seeing it as a complication, is part of the paradigm changing that involves the transcatheter aortic valve treatment.

All the transvalvular gradients after implantation were low, demonstrating a favorable hemodynamic profile of the new device. It is possible that the gradients of these new devices are even lower than those expected to the conventional bioprostheses and these devices might have larger effective valve orifices probably due to their prostheses constructive features. These features can contribute positively to a better hemodynamic performance during follow-up, and they can be translated into the possibility to increase survival rates [22].

The improvement in ventricular function is compatible with that expected after stenosis removal and the reduction of the ventricular ejection gradient in patients with the presence of functional reserve. The study could suggest a regression of ventricular dysfunction, just as had been shown in a short time [11.23]. This improvement is faster, but comparable in final absolute terms to the conventional replacements [22]. The rapid improvement may explain, in part, the differences in the mortality rate observed between transcatheter and conventional procedures. The possible causes of this difference do not include the use of cardiopulmonary bypass support and aortic clamping under cardioplegic protection, and the presence of a lower afterload generated by transcatheter prostheses [22].

The in-hospital mortality rate of the procedure is inconstant, but lower than predicted by the risk scores, ranging between 23% [10] and 6.3% [12]. Indeed, the mortality rate in our series is high, which may be caused by a small number of individuals, as well as the selection of severe patients, which becomes evident in the analysis of the mean EuroSCORE and STS SCORE of the study population.

The stratification of our mortality rate after half of the experience makes it clear that there is a definite learning curve in the patient selection and in the performance of the procedure. The severity of the individuals remained high in both halves with no significant difference between them. It is also worth mentioning that the first half of the sample

was composed mostly of individuals admitted with decompensated heart failure, contrary to what has happened in the second half of the sample where 28% of the subjects were already hospitalized before the procedure.

The causes of death were not directly related to the heart or to the intervention itself (except in one patient), showing that the challenge of handling a treatment like this one does not end at the time of intervention. The target population consists of patients with decreased functional reserve, which makes it susceptible to medical complications due to the aggressiveness of the intervention [24].

The mortality rate of transcatheter procedure is also dependent on a learning curve and on an improvement of the profile of the devices. Data yet unpublished gathered from the SOURCE registry show that the 30-day survival rate related to the procedure was initially around 70%, progressing to the current 94% [12].

Some authors have questioned the superiority of the result of alternative procedure over the conventional intervention. They are using the literature review of large series of high-risk patients undergoing aortic valve replacement with cardiopulmonary bypass support as a baseline, which shows a risk around 7.8% [25]. Of course, it is difficult to compare these populations, given that individuals referred for transcatheter procedure are elderly, they have more comorbidities and present highest risk scores. The large series of mortality and morbidity of the classical intervention, for the most part, represents statistical services of great surgical activity, surgical referral centers, and exceptional personal experiences, and it may not represent the reality of a global universe of patients in different centers of distinctive complexities, thus creating bias in the comparison. Likewise, the alternative procedure is also performed in referral centers, making it more difficult to compare the results of both methods.

Data of the Edwards Sapien registry implants show that the expected survival at six months is around 80% and around 75% at 1 year [12]. Those rates are good compared to those expected in the natural history of symptomatic aortic valve stenosis. In coming years, an increasing number of high-risk patients will have undergone transcatheter intervention and more consistent data on performance, and results will be available, contributing to the refinement of the inclusion and exclusion criteria.

The study has limitations inherent to the initial experience. Besides the small number of patients, there is a sharp learning curve. The improvement of outcomes after the initial intervention is clear in the literature [23,24].

It is evident that the new technique shows promising results, which are capable of promoting a documented symptomatic relief and improvement in ventricular function with an acceptable morbidity and mortality rate. The present result is a short-term one. A pressing need for further investigation with randomized long-term studies is fully justified.

In the current scenario, the transcatheter treatment of aortic stenosis and dysfunction of bioprostheses in an aortic position should be restricted to cases with expected high operative risk. The uncontrolled spread of this therapy caused by the attractiveness of the procedure over the conventional intervention should be opposed. Possibly, soon the advance of the devices allows the expansion of the procedure indication.

CONCLUSIONS

The clinical implant proved to be technically feasible and with satisfactory hemodynamic profile. Long-term studies are needed using a greater sample in order to determine the true efficacy and the indication of the alternative procedure.

REFERENCES

1. Otto CM, Lind BK, Kitzman DW, Gersh BJ, Siscovick DS. Association of aortic-valve sclerosis with cardiovascular mortality and morbidity in the elderly. N Engl J Med. 1999;341(3):142-7.

2. Varadarajan P, Kapoor N, Bansal RC, Pai RG. Clinical profile and natural history of 453 nonsurgically managed patients with severe aortic stenosis. Ann Thorac Surg. 2006;82(6):2111-5.

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

4. Iung B, Cachier A, Baron G, Messika-Zeitoun D, Delahaye F, Tornos P, et al. Decision-making in elderly patients with severe aortic stenosis: why are so many denied surgery? Eur Heart J. 2005;26(24):2714-20.

5. Cribier A, Savin T, Saoudi N, Rocha P, Berland J, Letac B. Percutaneous transluminal valvuloplasty of acquired aortic stenosis in elderly patients: an alternative to valve replacement? Lancet. 1986;1(8472):63-7.

6. Davidson CJ, Harrison JK, Leithe ME, Kisslo KB, Bashore TM. Failure of balloon aortic valvuloplasty to result in sustained clinical improvement in patients with depressed left ventricular function. Am J Cardiol. 1990;65(1):72-7.

7. Davies H. Catheter mounted valve for temporary relief of aortic insufficiency. Lancet. 1965;1:250.

8. Andersen HR, Knudsen LL, Hasenkam JM. Transluminal implantation of artificial heart valves. Description of a new expandable aortic valve and initial results with implantation by catheter technique in closed chest pigs. Eur Heart J. 1992;13(5):704-8.

9. Cribier A, Eltchaninoff H, Bash A, Borenstein N, Tron C, Bauer F, et al. Percutaneous transcatheter implantation of an aortic valve prosthesis for calcific aortic stenosis: first human case description. Circulation. 2002;106(24):3006-8.

10. Cribier A, Eltchaninoff H, Tron C, Bauer F, Agatiello C, Sebagh L, et al. Early experience with percutaneous transcatheter implantation of heart valve prosthesis for the treatment of end-stage inoperable patients with calcific aortic stenosis. J Am Coll Cardiol. 2004;43(4):698-703.

11. Cribier A, Eltchaninoff H, Tron C, Bauer F, Agatiello C, Nercolini D, et al. Treatment of calcific aortic stenosis with the percutaneous heart valve: mid-term follow-up from the initial feasibility studies: the French experience. J Am Coll Cardiol. 2006;47(6):1214-23.

12. It´s Over: Compiled data from source registry. 09 Dec 9; Heart Valve Summit 2009: American Association for Thoracic Surgery, 2009.

13. Kolh P, Kerzmann A, Honore C, Comte L, Limet R. Aortic valve surgery in octogenarians: predictive factors for operative and long-term results. Eur J Cardiothorac Surg. 2007;31(4):600-6.

14. Edwards MB, Taylor KM. Outcomes in nonagenarians after heart valve replacement operation. Ann Thorac Surg. 2003;75(3):830-4.

15. 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.

16. Iung B, Baron G, Butchart EG, Delahaye F, Gohlke-Bärwolf C, Levang OW, et al. A prospective survey of patients with valvular heart disease in Europe: The Euro Heart Survey on Valvular Heart Disease. Eur Heart J. 2003;24(13):1231-43.

17. Zajarias A, Cribier AG. Outcomes and safety of percutaneous aortic valve replacement. J Am Coll Cardiol. 2009;53(20):1829-36.

18. Walther T, Falk V, Borger MA, Kempfert J, Ender J, Linke A, et al. Transapical aortic valve implantation in patients requiring redo surgery. Eur J Cardiothorac Surg. 2009;36(2):231-4.

19. Al-Attar N, Himbert D, Descoutures F, Iung B, Raffoul R, Messika-Zeitoun D, et al. Transcatheter aortic valve implantation: selection strategy is crucial for outcome. Ann Thorac Surg. 2009;87(6):1757-62.

20. O'Rourke DJ, Palac RT, Malenka DJ, Marrin CA, Arbuckle BE, Plehn JF. Outcome of mild periprosthetic regurgitation detected by intraoperative transesophageal echocardiography. J Am Coll Cardiol. 2001;38(1):163-6.

21. Rallidis LS, Moyssakis IE, Ikonomidis I, Nihoyannopoulos P. Natural history of early aortic paraprosthetic regurgitation: a five-year follow-up. Am Heart J. 1999;138(2 Pt 1):351-7.

22. Clavel MA, Webb JG, Pibarot P, Altwegg L, Dumont E, Thompson C, et al. Comparison of the hemodynamic performance of percutaneous and surgical bioprostheses for the treatment of severe aortic stenosis. J Am Coll Cardiol. 2009;53(20):1883-91.

23. Webb JG, Pasupati S, Humphries K, Thompson C, Altwegg L, Moss R, et al. Percutaneous transarterial aortic valve replacement in selected high-risk patients with aortic stenosis. Circulation. 2007;116(7):755-63.

24. Walther T, Falk V, Kempfert J, Borger MA, Fassl J, Chu MW, et al. Transapical minimally invasive aortic valve implantation; the initial 50 patients. Eur J Cardiothorac Surg. 2008;33(6):983-8.

25. Grossi EA, Schwartz CF, Yu PJ, Jorde UP, Crooke GA, Grau JB, et al. High-risk aortic valve replacement: are the outcomes as bad as predicted? Ann Thorac Surg. 2008;85(1):102-6.