Direct Transcatheter Heart Valve Implantation Versus Implantation With Balloon Predilatation

Insights From the Brazilian Transcatheter Aortic Valve Replacement Registry

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Background—Direct transcatheter aortic valve replacement (TAVR) is regarded as having potential advantages over TAVR with balloon aortic valve predilatation (BAVP) in reducing procedural complications, but there are few data to support this approach.

Methods and Results—Patients included in the Brazilian TAVR registry with CoreValve and Sapien-XT prosthesis were compared according to the implantation technique, with or without BAVP. Clinical and echocardiographic data were analyzed in overall population and after propensity score matching. A total of 761 consecutive patients (BAVP=372; direct-TAVR=389) were included. Direct-TAVR was possible in 99% of patients, whereas device success was similar between groups (BAVP=81.2% versus direct-TAVR=78.1%; *P*=0.3). No differences in clinical outcomes at 30 days and 1 year were observed, including all-cause mortality (7.6% versus 10%; *P*=0.25 and 18.1% versus 24.5%; *P*=0.07, respectively) and stroke (2.8% versus 3.8%; *P*=0.85 and 5.5% versus 6.8%; *P*=0.56, respectively). Nonetheless, TAVR with BAVP was associated with a higher rate of new onset persistent left bundle branch block with the CoreValve (47.7% versus 35.1%; *P*=0.01 at 1 year). Mean gradient and incidence of moderate/severe aortic regurgitation were similar in both groups at 1 year (11% versus 13.3%; *P*=0.57 and 9.8±5.5 versus 8.7±4.3; *P*=0.09, respectively). After propensity score matching analysis, all-cause mortality and stroke remained similar. By multivariable analysis, BAVP and the use of CoreValve were independent predictors of new onset persistent left bundle branch block.

Conclusions—The 2 TAVR strategies, with or without BAVP, provided similar clinical and echocardiographic outcomes over a midterm follow-up although BAVP was associated with a higher rate of new onset persistent left bundle branch block, particularly in patients receiving a CoreValve. **(*Circ Cardiovasc Interv*. 2016;9:e003605. DOI: 10.1161/CIRCINTERVENTIONS.116.003605.)**

Key Words: aortic valve stenosis ■ balloon valvuloplasty ■ left bundle branch block ■ propensity score ■ transcatheter aortic valve replacement

Transcatheter aortic valve replacement (TAVR) is a complex multistep procedure that has been established as a treatment option for patients with severe aortic stenosis, considered to be inoperable or at high surgical risk.[1] In experienced centers, there has been a trend toward a simplification of the procedure, moving from general anesthesia and surgical cutdown for the femoral access, to a more minimalistic approach with conscious sedation, local anesthesia, and a fully percutaneous approach.[2] Likewise, during the early days of TAVR, balloon aortic valve predilatation (BAVP) was considered an essential step to prepare the calcified aortic valve for the correct positioning and deployment of bulkier transcatheter heart valves (THV). Nonetheless, in line with this trend of making the procedure more straightforward, together with the greater experience of the operators and improvement of devices and technique, the need for predilatation has been questioned.

Received January 15, 2016; accepted June 23, 2016.

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The Data Supplement is available at http://circinterventions.ahajournals.org/lookup/suppl/doi:10.1161/CIRCINTERVENTIONS.116.003605/-/DC1.

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WHAT IS KNOWN

- There is a global trend toward simplification of the transcatheter aortic valve replacement (TAVR) procedures, moving to a more minimalistic approach.
- Direct-TAVR without balloon aortic valve predilatation (BAVP) has been regarded as a feasible and apparently safe technique, with theoretical advantages over the standard technique with BAVP.

WHAT THE STUDY ADDS

- Data evaluating TAVR with and without BAVP have been scarce, and the present study is the largest comparing the 2 techniques.
- This study indicates that direct-TAVR is safe and feasible, but presented no procedural, echocardiographic, or clinical advantage over the conventional technique with BAVP, whereas technical challenges were still observed in up to ≈10% of patients.
- However, TAVR with BAVP was associated with a higher rate of new-onset persistent left bundle branch block, particularly in patients receiving a CoreValve.

Direct THV implantation without BAVP has thus been contended as an attractive technique for TAVR procedures, with potential advantages of less manipulation of calcified aortic valve and left ventricular outflow tract, as well as no need for a rapid pacing run for BAVP. Collectively, these factors could finally lead to less procedural complications, with an ensuing reduction in the risk of hemodynamic compromise. These rationales for avoiding BAVP have been highlighted in previous small observational studies showing that direct TAVR without BAVP is feasible and may potentially reduce procedural complications such as stroke and conduction abnormalities.[3–5] Nonetheless, the relatively small number of patients/events, the limited follow-up and the evaluation of a single transcatheter valve system (balloon- or self-expandable) did not allow the precise determination of the real advantages of avoiding BAVP before THV implantation. The objective of the present study was, therefore, to compare the clinical, procedural, and echocardiographic outcomes of TAVR using the conventional technique with BAVP versus the direct approach, without predilatation.

Methods

Study Population

This is a substudy of the Brazilian TAVR registry, which is an ongoing national multicenter registry including 819 patients from January 2008 to January 2015. The protocol and main results of the registry have already been published elsewhere.[6] For the present study, only patients with native aortic valve stenosis treated with either the self-expandable CoreValve (Medtronic, Minneapolis, MN) or a balloon-expandable Sapien XT (Edwards LifeSciences, Irvine, CA) valve were included. A total of 58 patients (7.1%) were excluded because of valve-in-valve procedures (n=31), use of the Innovare (Braile Biomedical, Sao Paulo, Brazil) bioprostheses (n=22), or transapical approach with a Sapien XT device (n=5). Therefore, the final study population comprised 761 consecutive patients from 22 centers.

Patients were divided in 2 groups: the BAVP group, which represented those cases where predilatation was performed in the same procedure before the THV implantation; and the direct-TAVR group, where direct prosthesis implantation was achieved without BAVP. The decision whether to perform BAVP was left to the discretion of the operator and was based on his own experience and perception of the need to prepare the valve before THV implantation. The choice of balloon type and size was individualized according to operators' judgment, but in general the strategy to use undersized balloons for predilatation was encouraged.

TAVR Procedures and Data Collection

Indications for TAVR, device type, and approach were based on the assessment of the Heart Team at each center. Aspirin lifelong (100 mg/d) and clopidogrel (300 mg loading dose and 75 mg/d thereafter for a minimum of 1 month) were routinely prescribed, unless contraindicated. Clinical, procedural, and echocardiographic outcomes were compared between the BAVP and direct-TAVR groups not only within the overall population and according to the type of THV but also after propensity score matching.

The registry utilized a web-based case report form, and remote electronic data monitoring was performed in all cases, to actively search and correct missing and inconsistent information. On-site source documents validation was performed in randomly selected cases including one fifth of the population. Patients were clinically followed up to capture adverse events, defined in accordance with the Valve Academic Research Consortium-2 consensus.[7] An independent committee composed of 5 cardiologists and 1 neurologist adjudicated every event in the study. ECG records were obtained from all patients at baseline, immediately after the procedure, and daily until hospital discharge. ECG tracings were analyzed by a cardiologist at each center. New-onset persistent left bundle branch block (NOP-LBBB) was defined as any new LBBB occurring during the hospitalization period after the TAVR procedure that persisted at hospital discharge, including patients who died during the hospitalization period without proven resolution of the LBBB. Each institutional ethics committee approved the study, and patients gave informed consent for participation.

Statistical Analysis

Categorical variables are reported as n (%). Continuous variables are expressed as mean±SD or median (25th to 75th interquartile range) depending on variable distribution. Group comparisons were performed using the Student *t* test or Wilcoxon rank-sum test for continuous variables and χ^2 test for categorical variables. After the initial analysis, a propensity score matching, using a one-to-one matching process, was performed to adjust for the intergroup (BAVP versus direct-TAVR) differences in baseline characteristics because of the nonrandomized nature of the study. The variables in the propensity score matching included age, history of coronary artery disease, Society of Thoracic Surgeons Predicted Risk of Mortality score, mean aortic gradient on transthoracic echocardiogram, and type of bioprosthesis (CoreValve or Sapien XT). The maximum difference of propensity score for a match was established at 1%. The analyses of the propensity score–matched pairs were made taking into account the paired data. Comparisons in the propensity score–matched cohort were made with paired tests: Wilcoxon signed-rank test or the McNemar test for binary variables and paired *t* tests for continuous variables. Also, for the comparison of the time-to-event outcomes at 30 days and 1 year, logistic and the Cox regression with frailty models to matched data were used. Univariable and multivariable logistic regression analyses were used to determine the predictors of NOP-LBBB. The variables with a $P<0.05$ in the univariable analyses were included in the multivariable models that were also adjusted for baseline differences between groups (age, history of coronary artery disease, and mean aortic gradient). Also, the performance of post dilatation and the learning curve were taken into account in this analysis. The early experience was represented by patients enrolled in the registry within the first 6 months from the initial experience

at centers with >5 cases, and all patients from centers with ≤5 cases. Clinical event rates at follow-up were presented using Kaplan–Meier estimates, and comparisons between groups were performed using the log-rank test. The results were considered significant with $P<0.05$. Analyses were conducted using the Statistical Package for Social Sciences, version 15.0 (SPSS Inc, IBM, New York).

Results

Patients and Procedural Characteristics

Baseline and procedural characteristics of the 761 patients included in the study are shown in Table 1. The mean age was 81.8±7.1 years, and 51.4% of the patients were women. The mean Society of Thoracic Surgery risk score and logistic European System for Cardiac Operative Risk Evaluation were 10.2±7.9 and 20.0±14.4, respectively. Mean aortic valve area was 0.66±0.2 cm^2 with a mean transvalvular gradient of 49.9±15.7 mm Hg. Direct TAVR was performed in 389 (51.1%) patients and TAVR with BAVP in 372 (48.9%). Patients in the direct-TAVR group were younger, more likely to have coronary artery disease, and with lower mean gradient than patients in the BAVP group.

The vast majority of patients underwent TAVR via transfemoral approach (97%), with the use of a CoreValve in 577 (75.8%) and a Sapien XT in 184 (24.2%) patients. In the direct TAVR group, retrograde crossing of the aortic valve with the THV was feasible in all but in 1 (0.3%) case, requiring successful removal of a Sapien XT for predilatation. However,

Table 1. Clinical, Echocardiographic, and Procedural Characteristics of the Study Population

	Overall (n=761)	BAVP (n=372)	Direct-TAVR (n=389)	*P* Value
Clinical variables				
Age, y	81.8±7.1	82.4±7	81.2±7.2	0.02
Male sex	370 (49)	169 (45)	201 (52)	0.08
NYHA class ≥III	617 (81)	300 (81)	317 (81.5)	0.77
Diabetes mellitus	242 (32)	111 (30)	131 (34)	0.26
COPD	143 (19)	60 (16)	83 (21)	0.07
Coronary artery disease	442 (58)	196 (53)	246 (63)	0.003
Previous CABG	135 (18)	65 (17.5)	72 (18.5)	0.71
Atrial fibrillation	98 (13)	44 (12)	54 (14)	0.40
Previous pacemaker	76 (10)	32 (9)	44 (11)	0.21
Previous RBBB	75 (10)	45 (13)	30 (8)	0.08
Peripheral vascular disease	125 (16)	59 (16)	66 (17)	0.68
Pulmonary hypertension	159 (21)	76 (20)	83 (21)	0.76
Previous BAV	48 (6)	19 (5)	29 (7.5)	0.18
Logistic EuroSCORE, %	20±14.1	20.2±13.4	19.7±15.2	0.65
STS-PROM score, %	10.2±79	9.6±7.2	10.7±8.4	0.05
eGFR, mL/min	48.5±22.2	48.7±22.4	48.9±22	0.91
Echocardiographic variables				
LVEF, %	58.5±14.4	59.7±14.7	57.9±15	0.09
Mean aortic gradient, mm Hg	49.9±15.7	52.6±16.2	47.3±14.7	<0.001
Aortic valve area, cm^2	0.66±0.2	0.65±0.17	0.67±0.2	0.13
Moderate/severe aortic regurgitation	81 (13)	34 (11)	47 (15)	0.18
Procedural characteristic				
Approach				0.60
Transfemoral	738 (97)	362 (97)	376 (97)	
Nontransfemoral	23 (3)	10 (3)	13 (3)	
Postdilatation	291 (38)	136 (37)	155 (40)	0.35
Prosthesis type				0.39
CoreValve	577 (76)	277 (74.5)	300 (77)	
Sapien XT	184 (24)	95 (25.5)	89 (23)	

Values are n (%) or mean (±SD). BAVP indicates balloon aortic valvuloplasty; CABG, coronary artery bypass graft; COPD, chronic obstructive pulmonary disease; eGFR, estimated glomerular filtration; EuroSCORE, European System for Cardiac Operative Risk Evaluation; LVEF, left ventricular ejection fraction; NYHA, New York Heart Association; RBBB, right bundle branch block; STS-PROM, Society of Thoracic Surgeons predicted risk of mortality; and TAVR, transcatheter aortic valve replacement.

in an additional 31 (8.0%) patients, other technical difficulties associated with the direct approach were encountered, including hemodynamic instability during THV positioning in severely stenosed valves in 11 patients; severe underexpansion of the CoreValve in heavily calcified aortic valves in 6 patients (1 patient with the need for removal of the entire system for predilatation, 1 patient with nose cone entrapment at the distal edge of the underexpanded prosthesis requiring parallel postdilatation for its removal, and 4 patients in which regular postdilatation was used to expand the CoreValve); major difficulty to cross the valve with a Sapien XT, requiring partial inflation of the distal portion of the delivery balloon to allow its passage in 5 cases; trapping of the Sapien XT distally inside the left ventricle, with the need for forceful pulling of the system, making accurate positioning more difficult in 5 patients; and coaxiality issues when positioning the CoreValve in severely calcified valves in 3 patients, requiring removal for predilatation in 2 cases. Therefore, in total, bailout predilatation was required in 4 (1%) cases in the direct TAVR group. None of these technical problems were reported when predilatation was performed. Postdilatation caused by paravalvular regurgitation or device underexpansion was necessary in 38.2% of the study population, with similar rates in both groups (P=0.35).

After propensity score matching, a total of 215 matched patient pairs were obtained, and the baseline and procedural characteristics were similar between TAVR with or without BAVP (Table I in the Data Supplement). The differences among patients in both groups according to valve type are shown in Table II in the Data Supplement.

Short- and Midterm Outcomes

The procedural, 30-day, and 1-year outcomes of BAVP versus direct-TAVR groups are shown in Table 2 and Table III in the Data Supplement (according to valve type). The device success rate was similar between both groups (81.2% versus 78.1%, respectively; P=0.3), as well as the other procedural outcomes, except for the mean transaortic gradient after TAVR, that was higher in the BAVP group (9.7±5.0 versus 8.7±4.3 mm Hg; P=0.007). Of note, among patients receiving a CoreValve, smaller prosthesis were implanted in the BAVP group, when compared with the direct-TAVR group (Table II in the Data Supplement). The rate of moderate/severe aortic regurgitation in the BAVP and direct-TAVR groups was similar at discharge (6.9% versus 8.4%, respectively; P=0.48; Figure 1). At 1-year follow-up, echocardiographic data were available in 285 patients (69% of the patients at risk). The rates of moderate/severe aortic regurgitation and the mean aortic gradient were similar between both groups (11% versus 13.3%; P=0.57 and 9.8±5.5 versus 8.7±4.3; P=0.09, respectively; Figure 1).

At 30 days, the incidence of all-cause death (7.6% versus 10%; P=0.25), cardiovascular death (7.3% versus 8.1%; P=0.66), all stroke or transient ischemic attack (3.1% versus 4.0%; P=0.46), and myocardial infarction (1.1% versus 1.6%; P=0.56) were similar between BAVP and the direct-TAVR groups, respectively. Likewise, at 1 year, no differences were observed in all-cause mortality (18.1% versus 24.5%; P=0.07), cardiovascular mortality (12.5% versus 16.5%; P=0.23), all stroke or transient ischemic attack (6.5% versus 7.4%; P=0.56), and myocardial infarction (1.8% versus 1.9%; P=0.75). Despite similar rates of new pacemaker implantation at 30 days (22.2% versus 20%; P=0.41) and 1 year (25.2% versus 22.2%; P=0.36), there was a higher rate of NOP-LBBB at 30 days (40.7% versus 29.7%; P=0.006) and 1 year (42.5% versus 29.7%; P=0.003) in the BAVP group. The composite end points of safety at 30 days (21.5% versus 20.8%; P=0.82) and clinical efficacy at 1 year (15.5% versus 21.7%; P=0.57) according to the Valve Academic Research Consortium-2 criteria were not different between both groups.

After propensity score matching, the procedural, 30-day, and 1-year outcomes were similar between the BAVP and direct-TAVR groups (Table 3). There was a nonstatistically significant trend toward a higher postprocedural mean gradient (9.6±5.2 versus 8.5±4.5; P=0.06) and NOP-LBBB at 30 days and 1 year (39.2% versus 30.4%; P=0.11 and 41.6% versus 30.4%; P=0.06) in the BAVP group (Table 3). Figure 2 depicts Kaplan–Meier cumulative all-cause mortality curves for groups with and without BAVP.

On multivariable analysis, variables identified as independent predictors of NOP-LBBB at 30 days after TAVR were the performance of BAVP (odds ratio, 1.78 [95% confidence interval, 1.22–2.60]; P=0.003) and the use of the self-expandable CoreValve device (odds ratio, 2.93 [95% confidence interval, 1.80–4.78; P<0.001]; Table 4).

Discussion

The present real-world registry comparing the impact of 2 different TAVR techniques, with or without BAVP, demonstrated that direct-TAVR was feasible in the vast majority of patients, yet technical difficulties were encountered in up to 8.2% of the cases. In a midterm follow-up, the 2 THV implantation strategies provided similar echocardiographic and clinical outcomes, including all-cause and cardiovascular mortality, as well as the rates of cerebrovascular events. Nonetheless, BAVP was associated with a higher rate of NOP-LBBB, particularly in patients receiving a CoreValve.

Data supporting the direct-TAVR technique during TAVR procedures have been limited, with few information on clinical and echocardiographic outcomes, and an absence of a more in-depth periprocedural analysis of the technical difficulties encountered with the direct-TAVR approach. The present investigation, including both the Sapien XT and the CoreValve THV, has shown that direct TAVR was feasible in the vast majority of patients although significant technical difficulties were still encountered during direct THV implantation in 8.2% of the cases. This included the need for bailout BAVP (1% of the cases), hemodynamic instability, as well as THV coaxiality, expansion, and positioning issues. Our results are in line with previous smaller studies where direct TAVR has been shown to be feasible in the majority of the patients although such technical difficulties have also been reported.[3–5,8] Despite these technical difficulties, device success, strictly based on the Valve Academic Research Consortium-2 criteria, was similar with both implantation approaches, and also comparable to contemporary studies using the same criteria. In addition, our study has shown that over a midterm follow-up, the echocardiographic and clinical outcomes were similar

Table 2. Procedural, 30-Day, and 1-Year Outcomes of the Study Population

	Overall (n=761)	BAVP (n=372)	Direct-TAVR (n=389)	*P* Value
Procedural outcomes				
Device success*	606 (79.6)	302 (81.2)	304 (78.1)	0.30
Implantation of 2 prosthesis	36 (4.7)	16 (4.3)	20 (5.1)	0.58
Prosthesis embolization	25 (3.3)	13 (3.5)	12 (3.1)	0.63
Prosthesis malpositioning	38 (5)	17 (4.5)	21 (5.4)	0.59
LV perforation	12 (1.6)	7 (1.9)	5 (1.3)	0.51
Coronary obstruction	3 (0.4)	2 (0.5)	1 (0.3)	0.54
Aortic rupture	2 (0.3)	0	2 (0.5)	0.17
Moderate/severe aortic regurgitation	59 (7.7)	26 (6.9)	33 (8.4)	0.48
Mean aortic gradient, mm Hg	9.2±4.7	9.7±5	8.7±4.3	0.007
Immediate procedural mortality (≤72 h)	35 (4.6)	14 (3.8)	21 (5.4)	0.282
30-d outcomes†				
All-cause death	8.8	7.6	10	0.25
Cardiovascular death	7.7	7.3	8.1	0.66
All stroke/TIA	3.6	3.1	4.0	0.46
All stroke	3.3	2.8	3.8	0.85
Disabling stroke	1.9	2.2	1.6	0.78
Major vascular complication	8.2	8.8	7.6	0.78
Life threatening/major bleeding	14.5	15.3	13.8	0.64
Acute kidney injury (stages 2 and 3)	6.8	8.8	4.9	0.06
Myocardial infarction	1.3	1.1	1.6	0.56
New pacemaker	21.1	22.2	20	0.41
New-onset persistent LBBB	35.2	40.7	29.7	0.006
Early safety*	21.2	21.5	20.8	0.82
1-y outcomes†				
All-cause death	21	18.1	24.5	0.07
Cardiovascular death	14.2	12.5	16.5	0.23
All stroke/TIA	7	6.5	7.4	0.56
All stroke	6.2	5.5	6.8	0.57
Disabling stroke	4.1	3.9	4.4	0.85
Myocardial infarction	1.9	1.8	1.9	0.75
New pacemaker	23.8	25.2	22.2	0.36
New-onset persistent LBBB	36.2	42.5	29.7	0.003
Efficacy end point (>30 d)*	18.3	15.5	21.7	0.57

Values are n (%) or mean±SD. BAVP indicates balloon aortic valvuloplasty; LBBB, left bundle branch block; LV, left ventricle; TAVR, transcatheter aortic valve replacement; and TIA, transient ischemic attack.

*According to Valve Academic Research Consortium-2 criteria.[7]

†Kaplan–Meier events probability estimates.

between TAVR with and without BAVP, even after propensity score matching, including comparable rates of stroke.

The cerebrovascular events occurring during the TAVR procedures are multifactorial; nonetheless, it has been demonstrated that up to half of the events arise within 24 hours after the procedure and instrumentation of the aortic valve apparatus plays a major role.[9,10] This is supported by a previous study evaluating high-intensity transient signals with transcranial Doppler showing that during all steps of the procedure high-intensity transient signals were detected.[10] Nonetheless, most high-intensity transient signals occurred on manipulation of the calcified aortic valve during positioning and implantation of the THV. Similarly, in another study specifically evaluating the factors associated with those acute events, both the balloon postdilatation and valve dislodgment/embolization increased in 2 to 4× such risks, respectively.[9] In our study, the need for

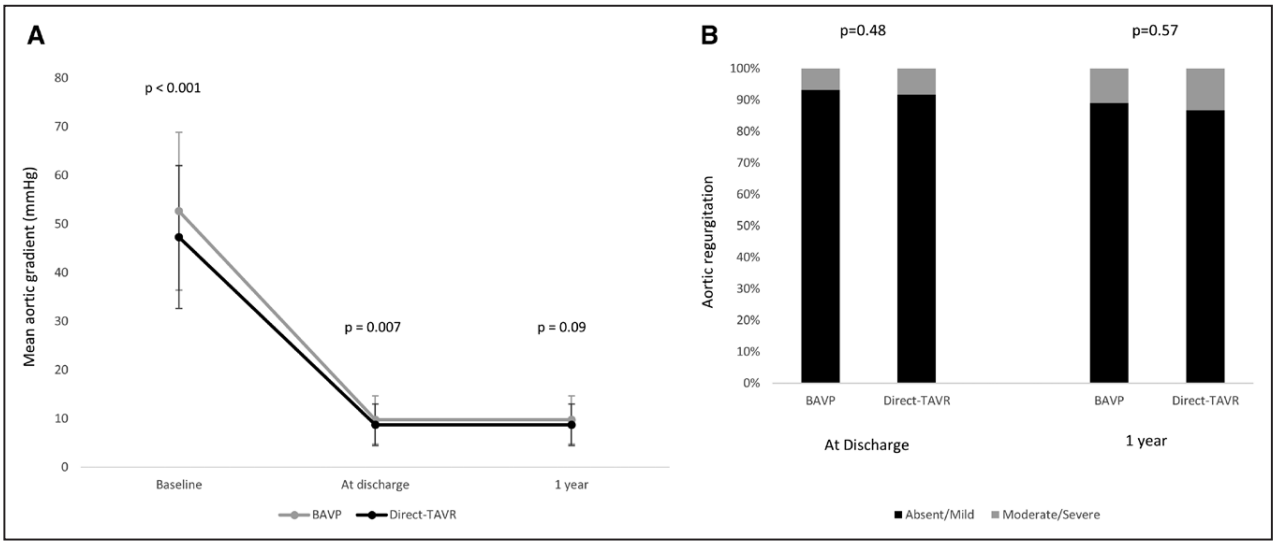

Figure 1. Changes in valve hemodynamics (mean aortic valve gradient and aortic valve area) according to the performance of balloon aortic valve predilatation (BAVP) at discharge and 1-year follow-up. Comparison of the valve hemodynamics including the mean aortic gradient (**A**) and aortic regurgitation grade (**B**) between the BAVP and direct-transcatheter aortic valve replacement (TAVR) groups at discharge and 1-year follow-up.

postdilatation did not differ in both groups with or without BAVP. Therefore, one might argue on why direct-TAVR did not ultimately reduce the risks of cerebrovascular events. The exact reasons are not completely understood, but we can speculate that the additional maneuvers needed to overcome the technical difficulties related to the direct TAVR technique might have significant adverse consequences during the procedure. In addition, BAVP may lead to a less traumatic crossing of the aortic valve by the THV, counterbalancing the risk of debris embolization attributed to the BAVP itself.[11] This is also supported by a recent study showing a higher volume of cerebral ischemic lesions by diffusion-weighted magnetic resonance imaging in patients undergoing direct-TAVR in relation to patients undergoing TAVR with BAVP.[12] Furthermore, preparing the aortic valve with BAVP, especially in those patients with a larger burden of valve calcification, may offer more room and further decrease the risks of hemodynamic instability during device delivery, facilitating the proper position of the THV, potentially leading to a more precise deployment with better outcomes.[13–15] In addition, preparation of the aortic valve could facilitate full and symmetrical expansion of the device, ultimately resulting in less paravalvular leak and minimal transaortic gradient. Finally, during balloon inflation for BAVP, there is the possibility of performing aortography that can assist in the evaluation of aortic annulus size and also assess the potential risk of coronary obstruction.[16]

With respect to the risks of conduction abnormalities after TAVR procedures, NOP-LBBB is one of the most frequent complications, occurring in ≈25% of the patients,[17,18] as in our study, where it developed in approximately one third of the patients. We have shown that avoiding BAVP seems to be a protective factor against the development of new LBBB, particularly with the self-expandable CoreValve device. We could speculate that less manipulation of the aortic valve and left ventricle outflow tract could translate into less injury to the conduction system. This is an important finding as NOP-LBBB can associate with lack of improvement in left ventricular ejection fraction, poorer functional status, and may also increase the risk of sudden death, especially in those patients with larger QRS.[18–21] Furthermore, a recent systematic review and meta-analysis including 17 studies showed that new-onset LBBB post TAVR is a marker of an increased risk of cardiac death and the need for permanent pacemaker implantation at 1-year follow-up.[21]

Of note, in a previous analysis of the Brazilian registry, with fewer patients and mostly with the CoreValve bioprosthesis, BAVP was associated with an increased need for permanent pacemaker implantation.[15] This finding, which was not replicated in our expanded series, make us think that pacemaker implantation after TAVR may be influenced by multiple factors, including liberality of indication, previous conduction disturbances, and technical factors such depth of implantation of the THV and also BAVP. Therefore, we think that avoiding any conduction disturbance should always be desired and precluding BAVP might be particularly advisable in some situations during CoreValve implants, for instance, in patients with previous right bundle branch block, to reduce the risk of advanced AV block and the need for a permanent pacemaker implantation. Likewise, some patients do not tolerate well the rapid-pacing runs such as those with reduced left ventricular ejection fraction and severe pulmonary hypertension. Therefore, in such cases, probably direct-TAVR could be preferential and this will have to be evaluated in future studies.

Limitations

Although the present analysis comprises the largest cohort of TAVR-patients with and without BAVP before TAVR, the nonrandomized nature of this comparison, even after propensity matching score adjustment makes it susceptible to confounding and unmeasurable bias. Therefore, a more assertive comparison between these 2 different TAVR strategies in a properly designed randomized trial is warranted. Another important aspect of the study is that the learning curve may

Table 3. Procedural, 30-Day, and 1-Year Outcomes of the Propensity-Matched Population

	BAVP (n=215)	Direct-TAVR (n=215)	*P* Value
Procedural outcomes			
Device success*	175 (81.4)	167 (77.7)	0.40
Implantation of 2 prosthesis	9 (4.2)	12 (5.6)	0.50
Prosthesis embolization	6 (2.8)	8 (3.7)	0.59
Prosthesis malpositioning	9 (4.2)	12 (5.6)	0.50
LV perforation	4 (1.9)	2 (0.9)	0.41
Coronary obstruction	2 (0.9)	0	0.16
Aortic rupture	0	1 (0.5)	0.32
Moderate/severe aortic regurgitation	17 (7.9)	20 (9.2)	0.65
Mean aortic gradient, mm Hg	9.6±5.2	8.5±4.5	0.06
Immediate procedural mortality (≤72 h)	7 (3.3)	9 (4.2)	0.61
30-d outcomes†			
All-cause death	7.5	7.6	0.95
Cardiovascular death	7.0	6.2	0.77
All stroke/TIA	2.8	4.4	0.42
All stroke	2.4	4.0	0.45
Disabling stroke	1.9	2.5	0.25
Major vascular complication	7.5	7.5	0.88
Life threatening/major bleeding	15.5	12.3	0.38
Acute kidney injury (stages 2 and 3)	7.9	3.6	0.15
Myocardial infarction	0.9	1.4	0.65
New pacemaker	21.4	20.4	0.84
New-onset persistent LBBB	39.2	30.4	0.11
Early safety*	21.4	18.1	0.40
1-year outcomes†			
All-cause death	17.8	22	0.34
Cardiovascular death	11.1	14.9	0.37
All stroke/TIA	5.3	6.8	0.50
All stroke	4.2	6.4	0.34
Disabling stroke	2.5	4.9	0.20
Myocardial infarction	2.1	1.4	0.79
New pacemaker	26.1	21.3	0.49
New-onset persistent LBBB	41.6	30.4	0.06
Efficacy end point (>30 d)*	15.4	18.6	0.83

Values are n (%) or mean±SD. BAVP indicates balloon aortic valvuloplasty; LBBB, left bundle branch block; LV, left ventricle; TAVR, transcatheter aortic valve replacement; and TIA, transient ischemic attack.

*According to Valve Academic Research Consortium-2 criteria.[7]

†Kaplan–Meier events probability estimates.

have acted as a confounder given that less experienced Heart Teams tend to perform BAVP more frequently and implant the CoreValve deeper than the more experience ones, what could have played a role in the higher incidence of NOP-LBBB in the BAVP group. As the information on the depth of the implantation was not available in this broad national registry, the analysis was adjusted for the learning curve (Table 4) to minimize this potential limitation. We should also acknowledge that our data were not adjusted by multidetector computed tomographic variables and that echocardiographic data, although based on local experienced echocardiographers evaluation, lack a centralized core laboratory evaluation. Furthermore, the difficulties encountered with the direct-TAVR approach were self-reported, so that less severe technical difficulties may have been under-reported by the operators. Moreover, in the present study, only the Sapien XT and the

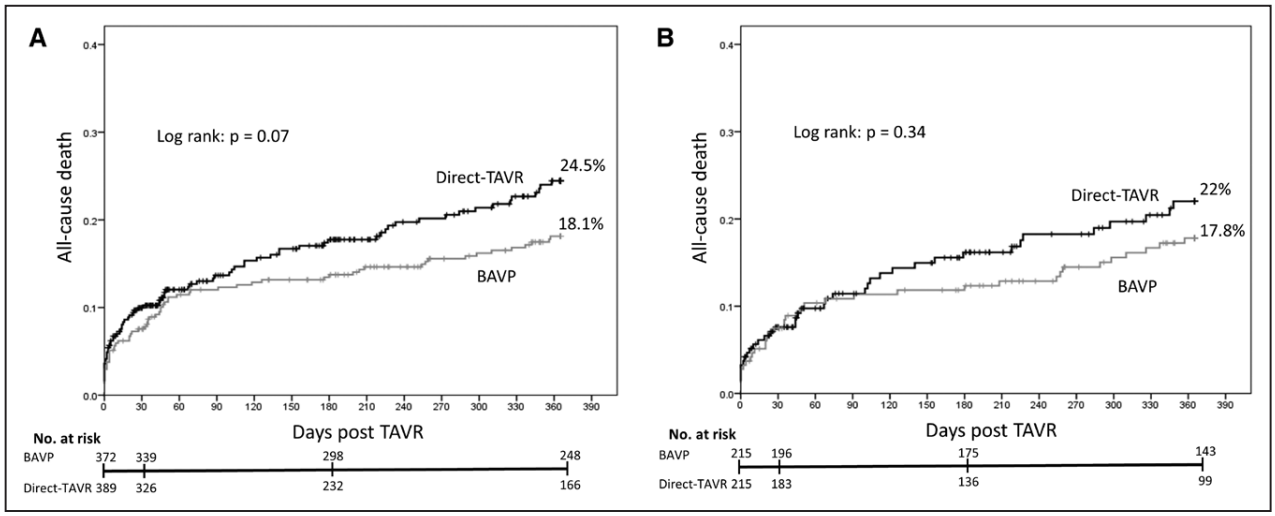

Figure 2. Kaplan–Meier mortality curves according to the performance of balloon aortic valve predilatation (BAVP). Kaplan–Meier mortality curves according to the performance of BAVP vs direct- transcatheter aortic valve replacement (TAVR) in the overall population (**A**) and after propensity score matching (**B**).

CoreValve were evaluated. Therefore, the present data may not apply for the newer generation of THV. Finally, because of the several statistical tests performed with respect to the outcomes, a type 1 error cannot be excluded, especially for significant results with $P>0.005$.

In conclusion, the 2 TAVR strategies, with or without BAVP, provided similar clinical and echocardiographic outcomes over a midterm follow-up although BAVP was associated with a higher rate of NOP-LBBB, particularly in patients receiving a CoreValve. Although direct-TAVR was shown to be safe in the vast majority of the patients, in ≈10% of the cases technical difficulties were encountered while crossing, implanting, and expanding the THV system. Moreover, our study did not detect any positive impact on the rates of stroke with the direct technique, which was a theoretical advantage that has stimulated operators to perform TAVR without BAVP. Therefore, we think that BAVP should still be recommended for the vast majority of the patients, especially for those with very calcified and very severe aortic stenosis, where BAVP is mandatory. BAVP should probably be performed with undersized balloons, facilitating valve positioning, deployment, and the proper THV expansion, while avoiding the risks associated with a more aggressive predilatation. Still, in those patients undergoing TAVR with a self-expandable valve, particularly in those with previous right bundle branch-block or in cases where a LBBB may have a detrimental impact on clinical outcomes, probably BAVP can be safely avoided.

Table 4. Multivariable Analysis of New Left Bundle Branch Block at 30 Days

	Univariable OR (95% CI)	*P* Value	Multivariable OR (95% CI)	*P* Value
Age, y	0.99 (0.97–1.01)	0.340	…	…
Coronary artery disease	1.29 (0.91–1.83)	0.149	…	…
Mean aortic gradient, mm Hg	1.0 (0.99–1.01)	0.591	…	…
Early experience	1.08 (0.63–1.86)	0.787	…	…
CoreValve implantation	2.98 (1.87–4.75)	<0.001	2.90 (1.78–4.72)	<0.001
Performance of BAVP	1.63 (1.15–2.30)	0.006	1.79 (1.23–2.61)	0.002
Balloon postdilatation	0.90 (0.63–1.28)	0.548	…	…

BAVP indicates balloon aortic valve predilatation; CI, confidence interval; and OR, odds ratio.

Disclosures

Dr de Brito has served as proctor for Edwards LifeSciences and Medtronic. Drs Carvalho, Sarmento-Leite, Mangione, and Lemos have served as proctor for Medtronic. Dr Ribeiro has served as proctor for Edwards LifeSciences. Dr Grube has served as proctor for Medtronic and Boston Scientific. Dr Abizaid has received research grants from Edwards Lifesciences, Medtronic and Boston Scientific. Dr Rodés-Cabau has received research grants from Edwards Lifesciences, Medtronic, and St. Jude Medical.

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Direct Transcatheter Heart Valve Implantation Versus Implantation With Balloon Predilatation: Insights From the Brazilian Transcatheter Aortic Valve Replacement Registry

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Circ Cardiovasc Interv. 2016;9:
doi: 10.1161/CIRCINTERVENTIONS.116.003605
Circulation: Cardiovascular Interventions is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 1941-7640. Online ISSN: 1941-7632

Supplemental Table 1. Clinical, echocardiographic, and procedural characteristics of the propensity-matched population.

Variable	BAVP (n=215)	Direct-TAVR (n=215)	P value
Clinical variables			
Age, years	82.2±6.7	82.2±6.5	0.98
Male	100 (47)	103 (48)	0.77
NYHA class ≥ III	178 (83)	174 (81)	0.62
Diabetes	65 (30)	64 (30)	0.92
COPD	31 (14)	45 (21)	0.08
Coronary artery disease	128 (60)	125 (58)	0.77
Previous CABG	44 (21)	27 (17)	0.39
Atrial fibrillation	25 (11)	17 (12)	0.28
Prior pacemaker	20 (9)	31 (14)	0.10
Prior RBBB	23 (11)	16 (8)	0.17
Peripheral vascular disease	38 (18)	28 (13)	0.18
Pulmonary hypertension	43 (20)	42 (20)	0.90
Previous aortic balloon valvuloplasty	15 (7)	16 (7)	0.85
Logistic EuroSCORE, %	21±14.1	19±14.8	0.15
STS-PROM score, %	10.4±7.9	10.3±8.2	0.96
eGFR, ml/min	49±22.1	46.4±20.5	0.20
Left bundle branch block	30 (15)	28 (14)	0.27
Echocardiographic variables			
LVEF, %	58.4 ± 15.3	59.2 ± 13.8	0.60
Mean aortic gradient, mmHg	49.1 ± 14.6	49 ± 15.3	0.93
Aortic valve area, cm^2	0.66 ± 0.2	0.66 ± 0.2	0.99
Moderate/severe aortic regurgitation	20 (11)	19 (11)	0.89
Procedural variables			
Approach			0.78
Transfemoral approach	209 (97)	208 (97)	
Non transfemoral approach	6 (3)	7 (3)	
Post-dilatation	72 (34)	83 (39)	0.27
Prosthesis type			
CoreValve	160 (74)	166 (77)	0.50
Sapien XT	55 (26)	49 (23)	

Values are n (%) or mean (±SD). Abbreviations as shown in Table 1.

Supplemental Table 2. Baseline and procedural characteristics of BAVP vs. direct-TAVR according to valve type

	CoreValve			Sapien XT		
	BAVP (n = 277)	**Direct-TAVR (n = 300)**	**P value**	**BAVP (n = 95)**	**Direct-TAVR (n = 89)**	**P value**
Clinical variables						
Age, years	82.5 ± 6.9	80.8 ± 7.4	0.006	82 ± 7.3	82.3 ± 6.5	0.77
Male sex	131 (47)	169 (56)	0.03	38 (40)	32 (36)	0.57
NYHA class ≥ III	231 (83)	256 (85)	0.52	69 (73)	61 (68.5)	0.54
Diabetes	84 (30)	107 (36)	0.17	27 (28)	24 (27)	0.82
COPD	45 (16)	72 (24)	0.02	15 (16)	11 (12)	0.50
Coronary artery disease	143 (52)	199 (66)	<0.001	53 (56)	47 (53)	0.68
Previous CABG	50 (18)	55 (18)	0.93	15 (16)	17 (19)	0.55
Atrial fibrillation	34 (13.5)	34 (15)	0.82	7 (7)	9 (10)	0.11
Prior pacemaker	35 (12)	28 (10)	0.55	9 (10)	4 (4)	0.12
Prior RBBB	32 (12)	25 (9)	0.18	13 (15)	5 (6)	0.09
Peripheral vascular disease	48 (17)	53 (18)	0.91	11 (12)	13 (15)	0.54
Pulmonary hypertension	61 (22)	76 (25)	0.35	15 (16)	7 (8)	0.1
Previous BAV	14 (5)	27 (9)	0.07	5 (5)	2 (2)	0.45
Logistic Euroscore, %	20.6 ± 13	20.5 ± 16	0.92	18.9 ± 13.6	17 ± 12.1	0.34
STS-PROM score, %	9.4 ± 7	10.7 ± 8.5	0.03	10.2 ± 8	10.5 ± 8.4	0.81
eGFR, ml/min	48.4 ± 21	48.1 ± 22	0.88	49.8 ± 26	51.6 ± 22	0.62
Echocardiographic variables						
LVEF, %	59.6 ± 15	57 ± 15.3	0.04	60 ± 14	61 ± 14	0.65
Mean aortic gradient, mmHg	51.8 ±16.4	47.4 ± 15	0.001	54.7 ± 15	46.8 ± 14	<0.001
Aortic valve area, cm^2	0.66 ± 0.2	0.65 ± 0.2	0.26	0.65 ± 0.2	0.68 ± 0.2	0.24
Aortic annulus, mm^2	22.4 ± 2.4	23.9 ± 3.4	<0.001	22.3 ± 2.6	23.2 ± 3.1	0.10
Moderate/severe aortic regurgitation	26 (12)	37 (15)	0.30	8 (9)	10 (13.5)	0.4
Procedural variables						
Transfemoral approach	267 (96)	287 (96)	0.66	95 (100)	89 (100)	>0.99
Post-dilatation	105 (38)	123 (41)	0.45	31 (33)	32 (36)	0.63
Prosthesis type/size			<0.001			
Corevalve 26 mm	122 (44)	28.7				
Corevalve 29 mm	140 (50.5)	51.3				
Corevalve 31 mm	15 (5.5)	20.0				
Sapien XT 23 mm				38 (40)	40 (45)	0.75
Sapien XT 26 mm				54 (57)	45 (52)	
Sapien XT 29 mm				3 (3)	3 (3)	

Values are n (%) or mean (±SD). Abbreviations as shown in Table 1.

Supplemental Table 3. Procedural, 30-day and 1-year outcomes of BAVP vs. direct-TAVR according to valve type

	CoreValve			Sapien XT		
	BAVP (n = 277)	Direct-TAVR (n = 300)	P value	BAVP (n = 95)	Direct-TAVR (n = 89)	P value
Procedural variables						
Procedure success *	221 (79.8)	231 (77.3)	0.47	81 (85.3)	72 (80.9)	0.43
Implantation of two prosthesis	14 (5.1)	17 (5.7)	0.74	2 (2.1)	3 (3.4)	0.60
Prosthesis embolization	11 (4.0)	12 (4.0)	0.99	1 (1.1)	0	0.33
Prosthesis malpositioning	15 (5.4)	19 (6.3)	0.64	2 (2.1)	2 (2.2)	0.95
LV perforation	6 (2.2)	3 (1.0)	0.26	1 (1.1)	2 (2.2)	0.52
Coronary obstruction	0	1 (0.3)	0.34	2 (2.1)	0	0.17
Aortic rupture	0	1 (0.3)	0.34	0	1 (1.1)	0.30
Moderate/severe aortic regurgitation	25 (8.9)	30 (10.1)	0.63	1 (1.2)	2 (2.5)	0.61
Mean aortic gradient, mmHg	9.7 ± 5	8.8 ± 4.5	0.04	9.8 ± 4.7	8.3 ± 3.7	0.05
Immediate procedural mortality (≤ 72 h)	12 (4.2)	9 (3.1)	0.60	4 (4.1)	3 (3.6)	0.90
30-day outcomes †						
All-cause death	7.2	9.1	0.41	8.5	12.8	0.36
Cardiovascular death	7.2	7.7	0.80	7.5	9.5	0.65
All stroke/TIA	2.6	3.8	0.57	3.3	4.8	0.62
All Stroke	2.6	3.5	0.65	3.3	4.8	0.72
Disabling stroke	1.9	1.4	0.69	3.3	2.3	0.42
Major vascular complication	9.9	5.8	0.13	15.4	13.7	0.12
Life threatening/Major bleeding	17.2	12.8	0.15	9.5	17.2	0.1
Acute kidney injury						
Myocardial infarction	0.4	2.1	0.07	3.2	0	0.09
New Pacemaker	26.5	22.7	0.26	10.4	10.9	0.93
New persistent LBBB	46	35.1	0.02	24	13.7	0.14
1-year outcomes †						
All-cause death	18.8	24.3	0.15	16.1	25.4	0.28
Cardiovascular death	12.6	16.9	0.23	12.1	15.4	0.86
All stroke/TIA	5.7	7.2	0.43	8.8	9.5	0.97
All Stroke	4.4	6.5	0.47	8.8	9.5	0.97
Disabling Stroke	2.8	4.1	0.52	7.4	7.2	0.59
Myocardial infarction	1.3	2.4	0.21	3.2	0	0.09
New Pacemaker	29.5	25.4	0.26	13.4	10.9	0.82
New persistent LBBB	47.7	35.1	0.01	25.9	13.7	0.11

Values are n (%) or mean ± SD.

* According to VARC-2 criteria (11)

† Kaplan-Meier events probability estimates.

Abbreviations as shown in Tables 1 and 3.