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Propensity score matched comparison of transcatheter aortic valve implantation versus conventional surgery in intermediate and low risk aortic stenosis patients: A hint of real-world

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Abstract

Background: *Recently, the use of transcatheter aortic valve implantation (TAVI) in intermediate-low risk patients has been evaluated in the PARTNER II randomized trial. However, in the last years, this therapy has been employed in this scenario with underreported results, as compared to surgical aortic valve replacement (SAVR).*

Methods: *We enrolled 362 consecutive patients with severe symptomatic aortic stenosis and intermediate-low surgical risk (logEuroSCORE < 20%), treated in our center with TAVI (103 patients) or single SAVR (259 patients) between 2009 and 2014. Patients were matched according to age, gender, logEuroSCORE, and use of bioprosthesis.*

Results: *Mean age of the patients was 73 ± 10.4 years, and 40.3% were women. LogEuroSCORE and Society Thoracic Surgeons score were 7.0 ± 4.4% and 4.2 ± 2.5%, respectively, with mean left ventricular ejection fraction of 52 ± 9%. There were no differences regarding other comorbidities. The length-of-hospitalization was 11 ± 5 days after TAVI vs. 17 ± 9 days after SAVR (p = 0.003). After matched comparison, no differences in terms of in-hospital mortality (5.7% after TAVI vs. 2.9% after SAVR, p = 0.687) and 1-year mortality (11.4% vs. 7.1%, p = 0.381) were found. The combined endpoint of stroke and mortality at 1-year was also similar between both groups (15.7% in TAVI patients vs. 14.4% after SAVR, p = 0.136). Multivariate analysis determined that aortic regurgitation (AR) was an independent predictor of mortality (OR = 3.623, 95% CI: 1.267–10.358, p = 0.016). Although the rate of AR was higher after TAVI, none of the patients treated with the newest generation devices (10.7%) presented more than a mild degree of AR.*

Conclusions: *TAVI is feasible and shows comparable results to surgery in terms of early, 1-year mortality, as well as cerebrovascular events in patients with severe aortic stenosis and intermediate-low operative risk. Better transvalvular gradients, yet higher rates of AR were found, however, newer devices presented comparable rate of AR.* (Cardiol J 2016; 23, 5: 541–551)

Key words: cardiac risk, aortic stenosis, TAVI, SAVR, propensity score

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Introduction

Degenerative aortic stenosis (AS) is the most common valve disease in our environment, affecting up to 7% of patients over 80 years of age [1]. For decades, the gold standard treatment was surgical aortic valve replacement (SAVR) in patients with acceptable surgical risk, but the development of transcatheter aortic valve implantation (TAVI) radically changed this scenario. Several randomized and observational studies have reported superior survival rate of symptomatic high-risk AS patients, as opposed to medical treatment [2, 3], and comparable, or even superior results in lower risk subgroups with surgery [3–5].

As a matter of fact, the enthusiastic embrace of this new therapeutic approach has led to the use of TAVI in lower risk patients in the real-world practice. Although results from larger registries seemed good with both, TAVI and SAVR, these two therapeutic alternatives had not been compared until recently through the NOTION [5] and PARTNER II studies [6], both with the former generation of TAVI devices, and the SAPIEN-3 non-randomized sub-study [7]. It is noteworthy that currently, clinical practice guidelines do not recommend TAVI for lower risk patients. Although these new studies [5–8] will shed light upon the management of a great amount of patients with such a dilemma, the high cumulative experience from the past years offers valuable information that cannot be ignored when choosing the best therapeutic alternative for our patients [9–12].

Since the beginning of our TAVI program in 2009, a heart-team based decision-making process has been used in our institution (Fig. 1), and prospective record of events for both, TAVI and SAVR patients, has been performed as the best way to audit the results. The present study aims to report our one-center experience in the treatment of intermediate and low risk TAVI patients as compared to a matched population who underwent SAVR in the same period in our institution.

Methods

Study population

A total of 362 patients with isolated symptomatic severe AS and intermediate-low risk who underwent TAVI or isolated SAVR between 2009 and 2014 in our institution were included in this study. The study was approved by the local bioethical committee and all patients gave their informed consent. The index population from our region included up to one million inhabitants with an average of 500 extra-corporeal surgeries per year and about 50 TAVI procedures per year. Patients' data were prospectively recorded by investigators from baseline and up to 2 years of follow-up (J.C.; J.T.; I.J.A.S.; I.M.; and C.C. participated in data collection of TAVI patients; S.D.S. and M.B. collected the data for SAVR group). Patients were considered to belong to intermediate and low surgical risk on the basis of the clinical assessment by our Heart Team considering an estimated Logistic EuroSCORE below 20%, as it was in the high risk cohort sub-analysis of PARTNER trial. Both, high risk patients according to the same score and those deemed unoperable by the Heart Team irrespective of their estimated score, were excluded from our study population. Neither patients with severe mitral valve disease, nor those with severe coronary disease who were considered candidates for multivalvular and/or revascularization surgery were included. Decision of the Heart Team to operate the patient or not was based on the guidelines [13, 14] considering not only the risk score but also the age, comorbidities, patient's preference, and frailty (Fig. 1). The last feature was assessed with Charlson index score, serum albumin (systematically recorded) and, in selected patients, 5-m walk test and 6-min walk distance tests (10% of the population, 20.6% of those aged over 80 years old). The final decision on frailty was based on all these factors together with eyeball test assessment. Other variables, such as aortic root disease or porcelain aorta were also taken into account after careful evaluation through computed tomography in borderline cases, in order to plan the procedure. If excessive risk was estimated for aorta clamping, this fact tipped the balance in favor of TAVI.

In-hospital and follow-up outcomes

Follow-up was performed through clinical visits or telephone contact at 30 days, 6 and 12 months, and annually thereafter. The follow-up was available in 100% of the study population. SAVR patients were followed by clinical visit, available for all patients at 1-month follow-up, and telephone contact. At 1-year follow-up clinical reports were available for 82.2% of patients (either from our institution or from local hospitals), and for the rest the follow-up variables were gathered through telephone contact. TAVI patients were followed in our institution at least for the first year and afterwards through telephone contact and clinical report gathered from their local institutions.

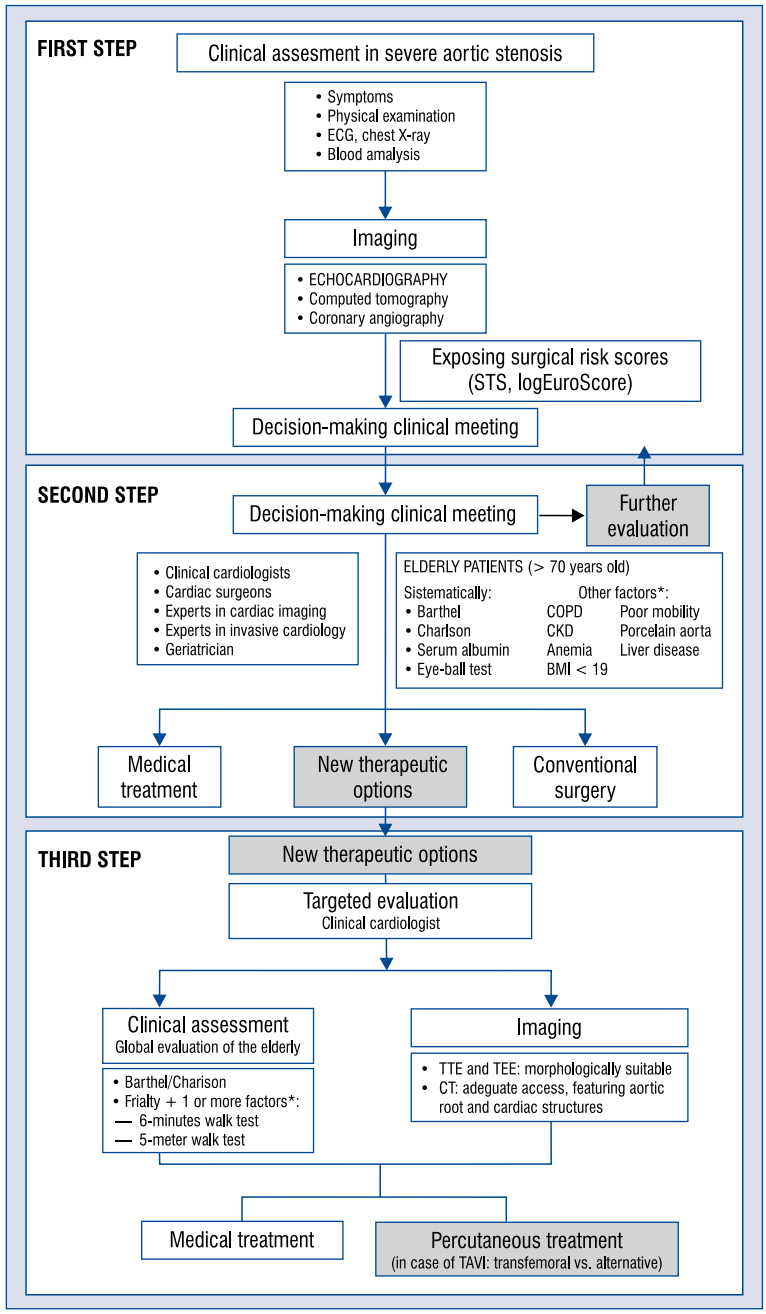

Figure 1. Algorithm followed by our Heart Team for therapeutic decision in patients suffering from severe symptomatic aortic stenosis; BMI — body mass index; COPD — chronic obstructive pulmonary disease; CKD — chronic kidney disease; CT — computed tomography; STS — Society of Thoracic Surgeons; TAVI — transcatheter aortic valve intervention; TEE — transesophageal echocardiography; TTE — transthoracic echocardiography; *Know factors that increase the operative risk.

Primary endpoints were in-hospital and 1-year mortality, stroke at 1-year, and the combined endpoint of mortality and stroke at 1-year follow-up. Assessment of cardiac mortality was performed following definitions from VARC-2 [15]. Secondary endpoints included the rate of pacemaker implantation, major bleeding (according to VARC-2 criteria) [15], in-hospital stroke, and the rate of significant aortic regurgitation (AR ≥ 2) after the procedure. Cerebrovascular events were evaluated by a neurologist. The diagnosis was assumed if there were compatible symptoms (worsening in the Modified Rankin Scale), or if compatible images of acute stroke were present in the cerebral computed tomography scan in oligosymptomatic patients. Aortic regurgitation was determined by

transthoracic echocardiography and its gradation followed the recommendations of the European guidelines [16].

Statistical analysis

Continuous variables are expressed as mean (standard deviation) or median (25^{th}–75^{th} percentile) depending on variable distribution. Group comparisons were performed using Student's t-test or the Wilcoxon test for continuous variables, and χ^2 test or Fisher's exact test for categorical variables. The univariable normality assumptions were verified with the Shapiro-Wilk test. A propensity score matching analysis was performed to adjust for intergroup (SAVR vs. TAVI) differences in baseline characteristics caused by the selection bias inherent to the non-randomized nature of the study. By using a logistic regression analysis, the probability of being assigned to high vs. intermediate-low risk was calculated from baseline and procedural characteristics. Variables exhibiting a p-value < 0.10 in the univariate analysis were included in the logistic regression analysis. Variables selected for matching, all of them prospectively collected, were age, logistic EuroSCORE, and use of bioprosthesis (all patients with mechanical prosthesis were excluded from this comparison). The reason for choosing these variables was the finding of significant differences between the two groups in the baseline analysis. In addition, inclusion of gender in the matched model was decided upon, given the known impact of this variable in outcomes of valvular interventions [17, 18]. By using these co-variables, a propensity score was calculated for each patient, and patients of the two groups (SAVR vs. TAVI) were matched using a one-to-one matching process. The maximum difference of propensity score for a match was established at 10%. Comparable patient groups including a total of 140 patients (SAVR group: 70 patients, TAVI group: 70 patients) were identified for the analysis. A Cox multivariable analysis including all variables with p value < 0.05 in the univariable analysis was used to determine the predictive factors of cumulative late mortality. Late outcomes were also assessed by Kaplan-Meier estimates and compared using the log rank test for both, the global population and population after matching. Risk-strata subanalysis in patients with intermediate risk over and under 10% was also performed. The results were considered significant with p values < 0.05. Statistical analyses were performed with the statistical package SPSS, version 18.0 (SPSS, Inc.; Chicago, Illinois, USA).

Table 1. Main reasons to refuse conventional surgery among patients with intermediate to low surgical risk.

Global TAVI population	N = 103
Cardiovascular comorbidities:	63 (61.2%)
Left ventricular severe dysfunction	36 (34.9%)
Moderate mitral regurgitation	20 (19.4%)
Porcelain aorta	4 (3.9%)*
Dilated ascending aorta	3 (2.9%)
Non-cardiovascular comorbidities:	32 (31.1%)
Respiratory disease	15 (14.6%)
Anatomical issues of the thorax	6 (5.8%)*
Liver disease	3 (2.9%)*
Other comorbidities	8 (7.7%)*
Patient's preference	8 (7.7%)

*Potentially underestimated risk according to usual operative risk scores (Σ = 20.3%); TAVI — transcatheter aortic valve implantation

Results

Main baseline characteristics of TAVI and SAVR patients

A total of 362 patients with intermediate-low surgical risk attributed to TAVI (103 patients, 28.4%) or SAVR (259 patients, 71.6%) were included in this research. Reasons that determined the preference of the Heart Team between these techniques were gathered and are schematically summarized in Table 1. Mean age of the entire intermediate-low risk study population was 73 ± ± 10 years and 40.3% of patients were women, with a mean logistic EuroSCORE of 7.0 ± 4.4%, a mean Society of Thoracic Surgeons (STS) score of 4.2 ± ± 2.5%, and left ventricular ejection fraction of 58 ± 9%. Other important characteristics have been compared between both strategies in Table 2.

To remark, among TAVI patients, 91 (88.3%) were treated with self-expandable system (83 Corevalve and 8 Corevalve Evolute, Medtronic Inc., MN, USA) and 12 (11.6%) underwent balloon-expandable prosthesis (9 Edwards-SAPIEN XT and 3 Edwards-SAPIEN-3, Edwards Lifesciences Inc., CA, USA). The approach was transfemoral in 89.3% of them. In the SAVR group, the prosthesis was mechanical in 42.5% of patients (110 patients) and in 149 (57.5%), the chosen device was a bioprosthesis. Mean hospital stay was 15.6 ± 15.4 days with a mean stay in the intensive care unit of 3.5 ± 5.5 days (TAVI patients: 3.1 ± 4.7 vs. SAVR patients: 9 ± 10.1 days, p = 0.006).

Significant differences between both groups were found in terms of logistic EuroSCORE (TAVI

Table 2. Baseline characteristics according to the use of transcatheter aortic valve implantation (TAVI) or surgical aortic valve replacement (SAVR) in the global study population and 1:1 matched study population.

Variables	Global data			Matched data*		
	TAVI (n = 103)	SAVR (n = 259)	P	TAVI (n = 70)	SAVR (n = 70)	P
Baseline characteristics						
Age [years]	81 ± 6.9	70 ± 9.9	0.001	79 ± 7.7	78 ± 5.6	0.381
Gender (female)	41 (39.8%)	105 (40.5%)	0.898	34 (48.6%)	36 (51.4%)	0.136
LogEuroSCORE [%]	10.8 ± 4.1	5.6 ± 3.6	0.001	9.4 ± 3.8	9.3 ± 3.9	0.735
STS score [%]	5.3 ± 2.4	4.1 ± 2.6	0.001	4.6 ± 2.1	4.3 ± 2.4	0.326
Diabetes mellitus	34 (33%)	60 (23.2%)	0.054	26 (37.1%)	18 (25.7%)	0.185
Arterial hypertension	71 (68.9%)	165 (63.7%)	0.346	45 (64.3%)	51 (72.9%)	0.362
CKD	14 (13.6%)	13 (5%)	0.005	11 (15.7%)	6 (8.6%)	0.302
COPD	29 (28.2%)	43 (16.6%)	0.013	21 (30%)	11 (15.7%)	0.064
NYHA III–IV	56 (54.4%)	126 (48.6%)	0.326	37 (52.9%)	40 (57.1%)	0.749
Previous AF	16 (15.7%)	45 (17.4%)	0.700	9 (13%)	14 (20%)	0.405
Previous pacemaker	5 (4.9%)	5 (1.9%)	0.153	2 (2.9%)	1 (1.4%)	0.999
Previous LBBB	4 (3.9%)	8 (3.1%)	0.746	0 (0%)	2 (2.9%)	0.496
Baseline echocardiogram						
Left ventricular ejection fraction [%]	59 ± 12.9	57.7 ± 3.6	0.126	58.2 ± 13.6	57.9 ± 4.5	0.159
Aortic regurgitation ≥ 2	29 (28.4%)	64 (24.7%)	0.493	20 (28.6%)	20 (28.6%)	0.999
Aortic valve area [cm^2]	0.62 ± 0.15	0.64 ± 0.22	0.650	0.62 ± 0.16	0.67 ± 0.23	0.266
Maximum gradient [mm Hg]	80.2 ± 21.3	80.6 ± 25.8	0.897	79.4 ± 19.2	77.5 ± 29.6	0.869
Medium gradient [mm Hg]	51.3 ± 13.8	50.8 ± 17.9	0.819	50.2 ± 12.7	49.7 ± 19.9	0.921
Severe PHT [mm Hg]	11.7%	10 (3.9%)	0.005	7 (10%)	7 (10%)	0.999

*Matched for LogEuroSCORE, use of bioprosthesis, age, and gender.
Data are expressed as absolute frequency and percentages for qualitative variables and as mean and standard deviation for quantitative variables. A comparison between groups was performed using Student's t-test or U Mann-Whitney test depending on the distribution, and by Fisher exact test for categorical variables; AF — atrial fibrillation; CKD — chronic kidney disease (clearance with MDMR < 60 mL/min); COPD — chronic obstructive pulmonary disease; LBBB — left bundle branch block; NYHA — New York Heart Association; PHT — pulmonary hypertension; STS — Society of Thoracic Surgeons

10.8 ± 4.1% vs. SAVR 5.6 ± 3.6%; p = 0.001) and relevant comorbidities, such as chronic kidney disease (CKD) (TAVI 13.6% vs. SAVR 5%; p = 0.005) and chronic obstructive pulmonary disease (COPD) (TAVI 28.2% vs. SAVR 16.6%; p = 0.013). Also, patients in the TAVI group were older with mean age of 81 ± 6.9 vs. 70 ± 9.9 years in the SAVR group, p = 0.001. In particular, among TAVI patients, 62% of them were above 80 years as compared to 9.3% in the SAVR cohort (p < 0.001). In order to reduce the impact of these baseline differences in the comparison of both techniques (TAVI and SAVR), a propensity score analysis was performed after a 1:1 matching process including the main baseline variables presenting the differences. Moreover, gender was included in the matching process. Given that COPD and CKD are included in the logistic EuroSCORE, only the latter was selected for matching.

A total of 140 patients (70 TAVI patients and 70 SAVR patients) underwent matched comparison. Baseline characteristics of the selected patients are summarized in Table 2.

In-hospital and follow-up outcomes

All patients were followed for at least 1 year. In-hospital and follow-up outcomes have been summarized in Table 3.

The global population did not present differences in terms of major bleeding (TAVI 11.7% vs. SAVR 15.4%; p = 0.353) or in-hospital stroke (TAVI 1.9% vs. SAVR 5.4%; p = 0.119). On the contrary, the rates of permanent pacemaker implantation (20.4% vs. 6.6%; p < 0.001) and aortic regurgitation

Table 3. In-hospital and follow-up outcomes according to the use of transcatheter aortic valve implantation (TAVI) or surgical aortic valve replacement (SAVR) in the global study population and 1:1 matched study population.

Variables	Global data			Matched data*		
	TAVI (n = 103)	SAVR (n = 259)	P	TAVI (n = 70)	SAVR (n = 70)	P
Periprocedural outcomes						
Transfemoral	92 (89.3%)	–	–	65 (92.8%)	–	–
Self-expandable	91 (88.4%)	–	–	68 (97.1%)	–	–
Biological prosthesis	103 (100%)	149 (57.5%)	< 0.001	70 (100%)	70 (100%)	0.999
Left ventricular ejection fraction [%]	58.7 ± 11.5	56.7 ± 3.6	0.132	58.3 ± 12.1	58.4 ± 5.1	0.167
Aortic regurgitation ≥ 2	29 (28.2%)	8 (3.0%)	0.001	21 (30%)	2 (2.9%)	0.001
Aortic valve area [cm^2]	1.48 ± 0.34	1.26 ± 0.15	0.001	1.47 ± 0.32	1.24 ± 0.16	0.001
Maximum gradient [mm Hg]	19.1 ± 14.9	30.7 ± 16.9	0.001	20.6 ± 16,9	30.8 ± 15.7	0.001
Medium gradient [mm Hg]	10.8 ± 10	17.9 ± 10.8	0.001	11.8 ± 11.1	18 ± 9.1	0.001
Major bleeding**	12 (11.7%)	40 (15.4%)	0.353	4 (5.7%)	8 (11.4%)	0.183
Permanent pacemaker	21 (20.4%)	17 (6.6%)	< 0.001	12 (17.1%)	8 (11.4%)	0.334
In-hospital stroke	2 (1.9%)	14 (5.4%)	0.119	0 (0%)	3 (4.3%)	0.122
In-hospital mortality	7 (6.8%)	9 (3.5%)	0.168	4 (5.7%)	2 (2.9%)	0.687
Follow-up outcomes						
Mortality (1 year)	13 (12.6%)	12 (4.6%)	0.007	8 (11.4%)	5 (7.1%)	0.381
Cardiovascular mortality (1 year)***	5 (38%)	10 (83%)	0.008	4 (50%)	3 (60%)	0.999
Stroke (1 year)	3 (2.9%)	37 (14.3%)	0.021	3 (4.2%)	5 (7.1%)	0.392
Mortality/stroke (1 year)	16 (15.5%)	49 (18.9%)	0.678	11 (15.7%)	10 (14.4%)	0.136

*Matched for LogEuroSCORE, use of bioprosthesis, age, and gender
**Bleeding according to VARC-2 criteria including bleeding due to vascular complications.
***Mortality due to cardiovascular cause (% upon the global death) defined as death from cardiac causes, non-coronary vascular cause, periprocedural death, valvular causes, sudden death and death of unknown cause (VARC-2 criteria).
Data are expressed as absolute frequency and percentages for qualitative variables and as mean and standard deviation for quantitative variables. A comparison between groups was performed using Student's t-test or U Mann-Whitney test depending on the distribution, and by Fisher exact test for categorical variables.

(AR ≥ 2) (TAVI 28.2% vs. SAVR 2.9%, p = 0.001) were higher after TAVI. Echocardiographic results demonstrated lower gradients and larger aortic valve area after TAVI with no differences in left ventricular ejection fraction.

Of note, in-hospital stay was shorter after TAVI (11 ± 5 days) than in SAVR patients (17 ± ± 9 days, p = 0.003). However, in-hospital mortality rate after TAVI (6.8%) was higher than after SAVR (3.5%), p = 0.168, reaching statistical significance at 1-year follow-up with 12.6% in the TAVI group and 4.6% after surgery (p = 0.007). In deeper detail, death was mainly of cardiac etiology in 37% of the TAVI patients who died within the first year, as opposed to 80% of those treated surgically (p = 0.008).

After a matched comparison, differences in mortality diminished, leading to an in-hospital mortality rate of 5.7% after TAVI vs. 2.9% after SAVR (p = 0.687), and mortality at 1-year of 11.4% and 7.1% after TAVI and SAVR, respectively (p = 0.381). The combined endpoint of stroke and mortality at 1-year was also similar between both groups, with 15.7% in TAVI patients and 14.4% after SAVR (p = 0.136).

Univariate analysis revealed that the use of TAVI and the presence of residual significant AR were the main determinants of cumulative mortality in the global population. However, multivariate analysis in the matched population indicated only AR as an independent predictor of mortality with odds ratio (OR) = 3.623 (95% confidence interval [CI] 1.267–10.358, p = 0.016). What is worth mentioning is that none of the patients treated with the newest generation devices presented more than a mild degree of AR. Apart from that, in the subgroup with lower estimated surgical risk (logistic EuroSCORE < 10%), also AR ≥ 2 resulted as an independent predictor of mortality at 1 year (OR = 3.66, 95% CI 1.92–14.56, p = 0.006). Survival

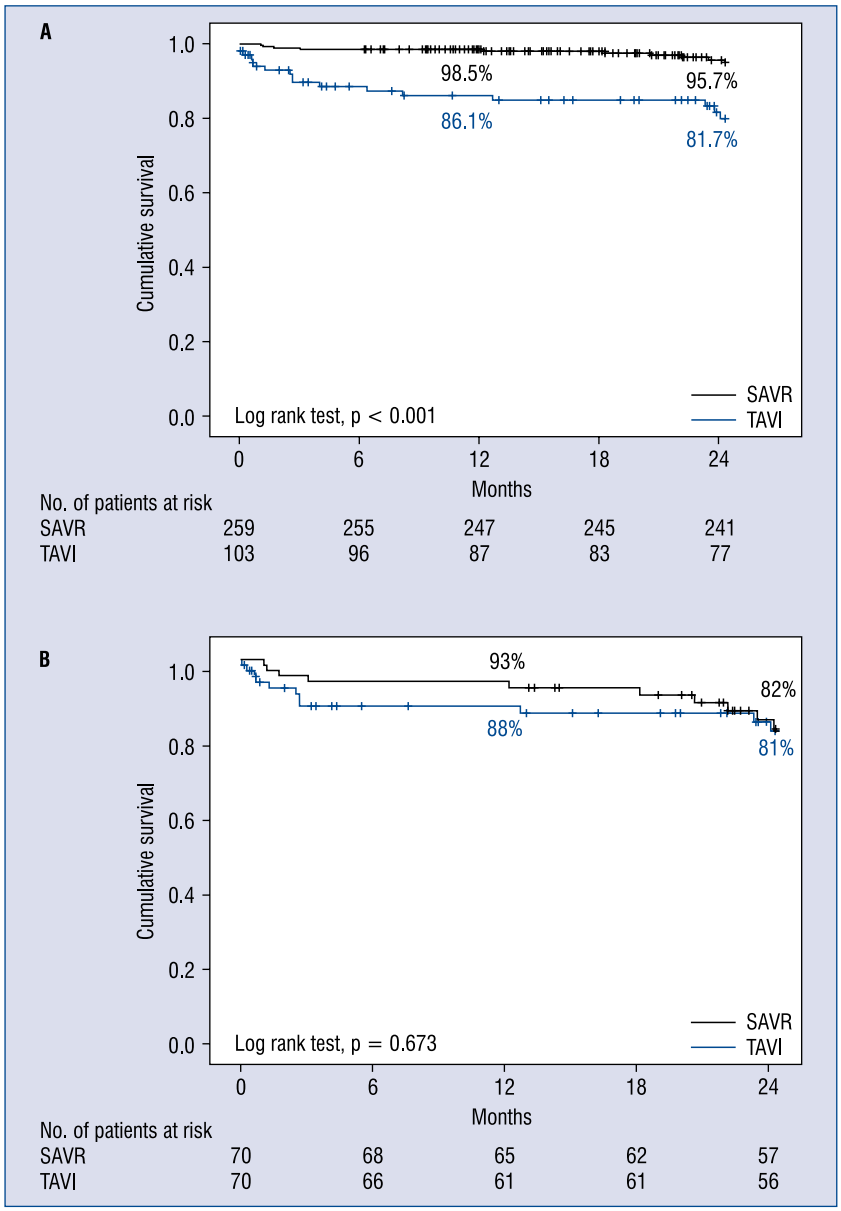

Figure 2. Survival curves according to the use of transcatheter aortic valve implantation (TAVI) or surgical aortic valve replacement (SAVR) in intermediate to low risk patients; Global population (**A**) and the matched population according to age, gender (**B**), logistic EuroSCORE, and use of bioprosthesis.

curves according to the use of TAVI or SAVR have been depicted in Figure 2.

Discussion

Our results illustrate how challenging can be the selection of the best therapeutic strategy in patients with severe symptomatic AS and intermediate-low surgical risk due to the wide range of concomitant factors that condition the actual risk. This may explain the variable results reported to date. In our experience, after initiation of the TAVI program, less than one third of patients estimated at lower risk were treated with percutaneous prosthesis. Main determinants were cardiovascular concomitant findings that underscore open surgery procedures, however, in a low and intriguing proportion of candidates TAVI was selected due to patients' preference.

Intermediate and low risk patients treated with TAVI appeared to be a less healthy population, older, and with higher surgical estimated risk

Table 4. In-hospital and follow-up outcomes according to therapeutic strategy (SAVR vs. TAVI) in different cohorts according to age (cutoff: 80 years old).

Variables	≤ 80 years old (275 patients)			> 80 years old (87 patients)		
	TAVI (n = 40)	SAVR (n = 235)	P	TAVI (n = 63)	SAVR (n = 24)	P
In-hospital mortality	2 (5%)	9 (3.8%)	0.665	5 (7.9%)	0	0.316
In-hospital stroke	2 (5%)	18 (7.7%)	0.748	3 (4.8%)	1 (4.2%)	0.999
Mortality (1 year)	4 (10%)	11 (4.7%)	0.247	9 (14.3%)	1 (4.2%)	0.272
Mortality/stroke (1 year)	6 (15%)	28 (11.9%)	0.604	12 (19%)	2 (8.3%)	0.332

SAVR — surgical aortic valve replacement; TAVI — transcatheter aortic valve implantation

than those deemed operable. Accordingly, they presented higher 1-year mortality. However, after reduction of these baseline differences through a propensity score matched process, a comparable mortality rate was found. On the contrary, the rate of significant AR after the intervention was higher after TAVI albeit, our initial experience with newer TAVI devices suggests that this issue may have been adequately addressed. The clear impact of AR on mortality in agreement with previous research, even in the group with lower surgical risk (logistic EuroSCORE < 10%), highlights the great potential impact of last-generation devices [19]. Indeed, our findings strongly suggest that we may be close to the surgery being overtaken by TAVI in terms of clinical outcomes in this lower risk group of patients, making device durability the last boundary.

Baseline profile of the study population

Intermediate and low risk patients selection is complex. Most scores in use in clinical practice have been developed to assess surgical risk but do not address the specific risks of percutaneous procedures [20]. Although STS score has been demonstrated to be more accurate in TAVI patients [21] and some specific tools have been developed to characterize the risk in this subset [22], we decided to use logistic EuroSCORE for risk stratification of the patients due to its prospective calculation in our sample and the fact that our Heart Team made decisions on the basis of this value, which confers to this score an exceptional validity in our scenario. In fact, it has been reported to be accurate in the past [23], although its cutoff value for high risk has not been clearly established and varies from 15% to 20%.

The proportion of patients with severe AS and intermediate or low risk who are deemed for TAVI has not been reported in main registries, probably because of its wide variation among different regions. In our experience, almost one third of lower risk patients were treated with TAVI. However, as described in Table 1, the actual risk may have been underestimated in one out of five patients due to several comorbidities affecting 20.6% of the population. This is in agreement with the intermediate risk cohort of patients in PARTNER-II study, which in fact were considered to belong to the higher one fifth of patients with higher risk. On the other hand, 7.7% of these patients were acceptable surgical candidates (mean logistic EuroSCORE of 4.7 ± ± 3.9% and all of them aged over 80 years) but refused this therapy. Interestingly, all of them were alive at 1-year of follow-up with only two remarkable events: the need for pacemaker implantation in 1 patient due to a complete atrioventricular block 4 days after the implantation, and a vascular (successful) intervention due to a failed femoral closure. In fact, age alone was probably one of the main factors that determined the use of TAVI in lower risk population despite the lack of evidence supporting this management [24]. Regarding this point, we conducted a sub-analysis between groups below and above 80 years old (Table 4), with no significant differences in the 1-year mortality rate between them.

Other important group of factors that determined the use of TAVI included disease of the aorta (dilation, or complex atheroma) and the presence of concomitant mitral regurgitation. In these two scenarios, the use of TAVI represents a partial solution to a complex problem with much higher risk if operated [25–27]. On the one hand, clamping a dilated and/or diseased aorta may damage this structure leading to the need of Bentall intervention which increases the risk of comorbidities related to the intervention [28]. From another point of view, the medical management of moderate mitral regurgitation during aortic surgery has been associated to worse outcomes [25], while in

TAVI patients up to 60% may improve the degree of mitral regurgitation after the procedure [29, 30]. Therefore, not only baseline characteristics but also procedural differences play a role in the estimation of outcomes with each technique. Regarding this point, several discussions may come about around alternative accesses for TAVI. In our series, 11 procedures were decided to be transapical, with longer rates of in-hospital stay (average of 17 days) and worse outcomes: 2 in-hospital deaths, 3 complete left bundle branch block, 1 in-hospital re-intervention and 3 deaths in the first 6 months. For this reason, alternative approaches such as transaxillary access have been adopted in our institution, with promising results.

Procedural features and in-hospital outcomes

Technical differences between TAVI and SAVR (transfemoral and with sedoanalgesia in about 90% of the TAVI patients and with general anesthesia, sternotomy, and aorta clamping in all SAVR) can explain a majority of the differences in acute outcomes. Although at the beginning of TAVI procedures there was great concern about the risk of stroke (over 5% at that time) [31], the reduction in the profile of the devices and the simplification of the procedure may explain the lower rates of this problem after TAVI than after SAVR in our series. This is in agreement with recent research suggesting a higher rate of subclinical stroke after SAVR than what had been previously thought [32]. Nevertheless, the incidence of a significant cognitive impact seems to be similar between the two techniques [33]. Moreover, the higher stroke rate after SAVR before the matched analysis can also be explained by the relatively high use of mechanical prosthesis in the SAVR group (42.5%, 110 patients). The median age for the surgical group was 69 ± 9.9 years old and the rate of previous atrial fibrillation was 17.5%. These two reasons, together with patients' preference, had a crucial role in the decision of implanting a mechanical prosthesis but the potential risk of hemorrhagic stroke cannot be overlooked. Indeed, the impact on prognosis of mechanical prosthesis is an object of controversy, and this is the reason why these patients were excluded in the matched analysis. Several studies suggest a potential benefit compared with biological prostheses across a broad range of age groups up to 70 years. Accordingly, the high use of this kind of prosthesis by surgeons in our institution (in agreement with alternative large series [34, 35] was performed mostly in patients below 70 years of age (n = 106, 96%) after a careful information concerning the risks of anticoagulation, valve thrombosis, and rate of re-intervention according to the selected valve. In general, our policy was to implant biological valves (surgical or TAVI) in all patients older than 75 years old.

What is more, the rate of new permanent pacemaker implantation did not present significant differences between the matched groups, although it remained over 15% in the TAVI group. The clinical experience and the development of devices that can be more accurately deployed and potentially repositioned had clearly contributed to the decrease of the rate of permanent pacemaker implementation, far from the initial rate close to 40% [36, 37].

In terms of valve hemodynamics, TAVI patients presented better aortic valve area and lower gradients. However, a higher degree of AR was detected. The high-rate of self-expandable prosthesis may partially explain both facts. The supravalvular position of the leaflets in this device has been related to better transvalvular gradients when compared to conventional surgery and to balloon-expandable prosthesis [37, 38]. What is more, the use of this prosthesis has been associated to higher rate of paravalvular leak, which indeed was related to higher mortality [39, 40]. The fact that patients were not matched according to anatomical factors as the degree and distribution of calcium in the native valve may have conditioned our findings, but this limitation was present as well in main TAVI trials.

Follow-up outcomes

Although AR degree remained higher after TAVI, our experience with newer devices suggests similar results to that of surgical prosthesis (7% of moderate-severe AR according to recent research) [41]. Concerning the 1-year mortality rate, both global and cardiac mortality presented comparable results in the matched cohort irrespective of the therapeutic strategy. Concomitant cardiac disease had been excluded from the inclusion criteria of main trials [3, 4]. In the light of our results, the impact of these factors in real-world practice seems to be acceptable, but further investigation is needed.

Limitations of the study

The main limitation of this study was its retrospective and non-randomized nature that has been partially attenuated by the matching process. Moreover, the predominant use of self-expandable percutaneous valves may have conditioned the

results limiting its external validity for balloon-expandable systems. Finally, the threshold used for selecting lower risk patients (logistic EuroSCORE < 20%) was in accordance with PARTNER trial, however, a stricter criterion may better reflect the group of lower risk patients. This fact could affect the sample size and power, thus it was discarded from the analysis.

Conclusions

In conclusion, TAVI is feasible and shows comparable results to surgery in terms of early, 1-year mortality, as well as cerebrovascular events in patients with severe AS and intermediate to low operative risk. Better transvalvular gradients, yet higher rates of AR were found, however, newer devices showed comparable rates of AR. This is a heterogeneous group of patients requiring a more accurate assessment of surgical risk in order to improve validity of future research and improve their outcomes.

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