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Original Article / Özgün Makale

Comparison of patient-prothesis mismatch after surgical aortic valve replacement and transcatheter aortic valve implantation

Cerrahi aort kapak replasmanı ve transkateter aort kapak implantasyonu sonrası hasta-protez uyumsuzluğunun karşılaştırılması

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ABSTRACT

Background: The aim of this study is to analyze the outcomes and incidence of postoperative patient-prothesis mismatch after surgical aortic valve replacement using supra-annular bioprosthesis and transcatheter aortic valve implantation.

Methods: Between January 2012 and June 2015, a total of 73 patients (37 males, 36 females; mean age 71.8±5.7 years; range, 65 to 82 years) who underwent either surgical aortic valve replacement using supra-annular bioprosthesis (n=36) or transcatheter aortic valve implantation (n=37) were included. Postoperative patient-prothesis mismatch was defined as absent, mild-to-moderate, and severe, if the indexed effective orifice area was >0.85 cm^2/m^2, >0.65 to <0.85 cm^2/m^2, and <0.65 cm^2/m^2, respectively. Both groups were compared in terms of patient-prothesis mismatch, postoperative outcomes, and mortality.

Results: The overall incidence of mild-to-moderate patient-prosthesis mismatch was 17.8% (13/73). No severe patient-prosthesis mismatch was observed. Mild-to-moderate patient-prosthesis mismatch was found in three patients (8.1%) in the transcatheter group and in 10 patients (27.8%) in the surgery group (p=0.035). Body surface area was the significant predictor of patient-prosthesis mismatch (p=0.007). Diameters of bioprosthetic valves in the surgery and transcatheter groups were 21.4±2 and 23.9±2.6 mm, respectively (p=0.002). Early mortality and pacemaker implantation rates were higher in the transcatheter group (p>0.05). Postoperative outcomes were similar between the groups. Mid-term mortality at a mean follow-up of 47.7±7.3 months was similar between the groups (p=0.158).

Conclusion: In high-risk patients with severe aortic stenosis, patient-prosthesis mismatch is mild-to-moderate after surgical aortic valve replacement and transcatheter aortic valve implantation; however, this has no effect on early mortality. Based on our study results, we suggest that the use of surgical approach for aortic valve replacement may prevent potential complications of transcatheter aortic valve implantation.

Keywords: Patient-prosthesis mismatch, aortic valve replacement, transcatheter aortic valve implantation.

ÖZ

Amaç: Bu çalışmada supra-anüler biyoprotez kapak ile cerrahi aort kapak replasmanı ve transkateter aort kapak implantasyonunun sonuçları ve işlem sonrası hasta-protez uyumsuzluğu sıklığı incelendi.

Çalışma planı: Ocak 2012 - Haziran 2015 tarihleri arasında supra-anüler biyoprotez ile cerrahi aort kapak replasmanı (n=36) veya transkateter aort kapak implantasyonu (n=37) yapılan toplam 73 hasta (37 erkek, 36 kadın; ort. yaş 71.8±5.7 yıl; dağılım, 65-82 yıl) çalışmaya alındı. İşlem sonrası hasta-protez uyumsuzluğu indekslenmiş efektif orifis alanı >0.85 cm^2/m^2 ise "yok", >0.65 ila <0.85 cm^2/m^2 ise "hafif-orta dereceli" ve <0.65 cm^2/m^2 ise "ciddi" olarak tanımlandı. Her iki grup hasta-protez uyumsuzluğu, ameliyat sonrası sonuçlar ve mortalite açısından karşılaştırıldı.

Bulgular: Genel hafif-orta hasta-protez uyumsuzluğu sıklığı %17.8 (13/73) idi. Ciddi hasta-protez uyumsuzluğu görülmedi. Hafif-orta hasta-protez uyumsuzluğu, transkateter grubunda üç hastada (%8.1) ve cerrahi grubunda 10 hastada (%27.8) görüldü (p=0.035). Vücut yüzey alanı hasta-protez uyumsuzluğu için önemli bir öngördürücü idi (p=0.007). Cerrahi ve transkateter gruplarında biyoprotez kapak çapları sırasıyla 21.4±2 mm ve 23.9±2.6 mm idi (p=0.002). Erken mortalite ve pacemaker implantasyon oranı transkateter grubunda daha yüksekti (p>0.05). Ameliyat sonrası sonuçlar gruplar arasında benzerdi. Ortalama 47.7±7.3 aylık takip süresince orta-dönem mortalite gruplar arasında benzerdi (p=0.158).

Sonuç: Ciddi aort darlığı olan yüksek riskli hastalarda, hasta-protez uyumsuzluğu cerrahi aort kapak replasmanı ve transkateter aort kapak implantasyonu sonrasında hafif-orta derecelidir; ancak bu durum erken mortaliteyi etkilememektedir. Çalışma sonuçlarımıza göre, aort kapak replasmanında cerrahi yaklaşım uygulaması transkateter aort kapak implantasyonunun muhtemel komplikasyonlarını önleyebilir.

Anahtar sözcükler: Hasta-protez uyumsuzluğu, aort kapak replasmanı, transkateter aort kapak implantasyonu.

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Patient-prothesis mismatch (PPM) is a well-known and important complication of the surgical aortic valve replacement (sAVR) and transcatheter aortic valve implantation (TAVI) procedures.[1-7] Prosthesis-patient mismatch develops, when the effective orifice area (EOA) of the inserted prosthetic valve is comparably too small in relation to body size of the patient. Its main hemodynamic consequence is a higher transvalvular gradient on the left ventricular outflow tract, which affects the long-term mortality of patients.[1-9] Several studies have reported that the incidence of postoperative PPM is higher than 20% after sAVR and the presence of PPM is associated with a 1.2- and 1.8-fold increase in the risk of all-cause mortality.[1,8,9] Literature studies have clearly demonstrated the relation of severe PPM with increased mortality due to decreased regression of the left ventricular mass after aortic valve replacement procedures.[1-9] Moreover, it has been shown in the literature that, in older patients, the presence of mild-to-moderate PPM following bioprosthetic sAVR does not influence long-term survival.[1-14] Therefore, surgical approach to aortic valve replacement may still be the first choice in high-risk patients.

Technical and technological innovations have provided new-generation valves for aortic position with improved EOA. The currently available transcatheter valves provide a better EOA, compared to surgical valves, as leaflets of these valves are mounted directly on the stents without a sewing ring.[5,10,11] On the other hand, annular calcifications are not resected during transcatheter procedures, in contrast to surgery, which may potentially affect EOA of transcatheter valves. Removal of annular calcifications during surgery and the use of a supra-annular bioprosthesis with a slim sewing ring above the aortic annulus can be associated with improved EOA after surgery. However, there is a limited number of data about the comparison of sAVR using a supra-annular bioprosthesis with TAVI in terms of PPM.[1,12] The use of surgical approach may also prevent potential complications of a TAVI procedure with unknown durability in long-term follow-up.

In the present study, we aimed to compare sAVR and TAVI in terms of development of postoperative PPM and to investigate the impact of PPM on postoperative outcome and mortality, as well as the procedure of first choice in high-risk patients.

PATIENTS AND METHODS

Between January 2012 and June 2015, a total of 73 patients (37 males, 36 females; mean age 71.8±5.7 years; range, 65 to 82 years) who underwent sAVR and TAVI procedure were retrospectively analyzed. The patients were divided into two groups according to the procedure applied as the sAVR group (n=36) and TAVI group (n=37). Patients with coronary artery disease, concomitant mitral or tricuspid valve disease, congenital cardiac abnormalities, previous cerebrovascular event, previous cardiothoracic procedures and deteriorated left ventricular function (ejection fraction [EF] less than 30%) were excluded. Those who underwent sAVR with the use of mechanical valves were also excluded. A written informed consent was obtained from each patient. The study protocol was approved by institutional Ethics Committee. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Decision of sAVR or TAVI were obtained by the hospital council according to the international accepted guidelines.[12] Patients' characteristics, associated comorbidities, vascular access, expected functional outcome, and length of survival after procedures were considered in the selection of sAVR or TAVI in patients with a high surgical risk. All pre-, intra-, and postoperative data were collected from our surgical records and hospital medical network, and all the surgical notes and discharge summaries were reviewed to collect supplementary information. Demographic characteristics including age, gender, body mass index, body surface area (BSA), comorbidities such as hypertension, diabetes mellitus and obstructive lung disease, EuroSCORE index, ventricular functions, and valve features were recorded.

Preoperative work-up

Preoperative detailed transthoracic and transesophageal echocardiography was performed to all patients to evaluate the native valve, calcifications, stenosis and insufficiencies, root and ascending aorta. Coronary diseases were also eliminated with preoperative angiography. Femoral artery evaluation was performed via computed tomography or angiography in patients who underwent TAVI procedure.

sAVR technique

All AVR procedures were performed with standard midline sternotomy and routine cardiopulmonary bypass (CPB) by the same surgical team. In each patient, the risk of PPM and the minimum size of the prosthetic valve was evaluated preoperatively. After resection of the aortic leaflets and decalcification if needed, the surgeon measured the orifice area carefully with an appropriate valve sizer, considered body mass index of the patient, and replaced the native valve with a suitable supra-annular bioprosthetic

valve (Sorin Biomedica Cardio Srl, Sallugia, Italy). The valves were implanted using separate 2/0 Ticron sutures with pledgets. No root enlargement was performed. All patients were weaned from CPB uneventfully. The patients were followed in the intensive care unit (ICU) postoperatively and, then, transferred to the ward.

Transcatheter aortic valve implantation technique

According to detailed evaluation of aortic annulus and iliofemoral artery, transfemoral approach was selected in TAVI procedures and the type and diameter of the bioprosthetic valves were determined. The type and number of the inserted bioprosthetic valves were registered. The procedures were performed under general anesthesia. After transfemoral access, the procedures were done using either CoreValve (Medtronic Inc., Minneapolis, MN, USA) or Edwards Sapien (Edwards Lifesciences Ltd., Irvine, CA, USA) bioprosthetic valves. Aortography and transesophageal examinations were performed immediately to exclude potential complications. Vascular access sites were repaired using a closure device (Prostar XL, Abbott Vascular, Santa Clara, CA, USA) or surgically. The patients were followed in the ICU postoperatively.

Postoperative follow-up

Postoperatively hospital and ICU stays, the detailed echocardiographic features at three months and follow-up period after surgery, early mortality (within 30 days), and complications were recorded. After discharge, the patients were followed regularly at outpatient clinic under anticoagulant treatment.

Echocardiographic examinations

To determine the presence of PPM, the EOA of each aortic valve surgically replaced were recorded from their product guides. The EOA of each TAVI valve was studied on postoperative transthoracic echocardiography. Then, effective orifice area index (EOAi) was calculated for every patient in postoperative echocardiography. The presence and level of PPM was recorded in every patient. The EOAi was found as dividing EOA to BSA of the patient. Postoperative PPM was defined as absent, mild-to-moderate, and severe, if the EOAi was >0.85 cm^2/m^2, >0.65 to <0.85 cm^2/m^2, and <0.65 cm^2/m^2, respectively.[1] Besides, the presence

Table 1. Preoperative demographic characteristics and echocardiographic findings

	AVR group (n=36)			TAVI group (n=37)			
Variable	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			73.8±5.5			75.4±5.6	0.23
Gender							
Female	16	44.4		20	54.1		0.48
Body surface area (m^2)			1.8±0.3			1.8±0.2	0.31
Body mass index (kg/m^2)			28±4.8			29.2±5.3	0.43
EuroSCORE (%)			7.3±7			8.9±3.8	0.23
Obesity	14	38.9		16	43.2		0.81
Hypertension	24	66.7		27	73		0.61
Diabetes mellitus	16	44.4		17	45.9		0.98
Obstructive lung disease	17	47.2		23	62.2		0.24
Smoking	20	55.6		26	70.3		0.23
Ejection fraction (%)			56.6±9.4			50.8±1	0.03
Aortic valve mean gradient (mmHg)			44.2±12			51.1±2.4	0.12
Aortic annulus diameter (mm)			20.2±2.1			19.7±2.2	0.51
Pathology							
Aortic stenosis	20	55.6		25	67.6		0.34
Aortic insufficiency	2	5.5		0	0		0.61
Mixed-type	14	38.9		12	32.4		0.46

AVR: Aortic valve replacement; TAVI: Transcatheter aortic valve implantation; SD: Standard deviation.

Table 2. Presence of patient-prothesis mismatch according to effective orifice area index values

	AVR group			TAVI group			Total		
Variable	n	%	Mean±SD	n	%	Mean±SD	n	%	*p*
PPM (+)	10	27.8		3	8.1		13	17.8	0.03
Mild-moderate	10	27.8		3	8.1		13	17.8	0.03
Severe	0	0		0	0				
PPM (-)	26	72.2		34	91.9		60	82.2	0.02
EOA (cm^2)			1.7±0.2			2.2±0.4			0.98
EOAi (cm^2/m^2)			1±0.3			1.2±0.2			0.004
Diameter of prosthesis (mm)			21.4±2			23.9±2.6			0.002

AVR: Aortic valve replacement; TAVI: Transcatheter aortic valve implantation; SD: Standard deviation; PPM: Patient-prothesis mismatch; EOA: Effective orifice area; EOAi: Effective orifice area index.

of paravalvular leak, aortic regurgitation, residual gradient, and left ventricular function were studied.

Statistical analysis

Statistical analysis was performed using the PASW for Windows version 17.0 software (SPSS Inc., Chicago, IL, USA). Descriptive data were expressed in mean ± standard deviation (SD) and number and frequency. Other specific tests were also used including variate analysis for the repetitive measurements of multiple groups, the Student's t-test for the comparison of dual groups, chi-square test for the comparison of qualitative data, and Pearson correlation test to analyze the relationship between the variables. A *p* value of less than 0.05 was considered statistically significant.

RESULTS

Of the patients, 36 underwent bioprosthetic sAVR and 37 underwent TAVI. Demographic characteristics of patients and preoperative echocardiographic findings of the sAVR and TAVI groups are shown in Table 1. The mean age of the patients in the sAVR and TAVI groups were 73.8±5.5 years and 75.4±5.6 years, respectively. The female/male ratio was similar between the groups. The BSA of the patients in the sAVR group was 1.8±0.3 cm^2, while it was 1.8±0.2 cm^2 in the TAVI group (p=0.31). There was no statistically significant difference in the ratio of hypertension, diabetes, obstructive lung disease, and obesity between the groups.

Preoperative echocardiography demonstrated that 20 patients (55.6%) had isolated and serious aortic valve stenosis and 14 patients (38.9%) had mixed-type aortic valve dysfunction in the sAVR group. Twenty-five (67.6%) of the TAVI patients had only aortic stenosis and mild aortic insufficiency accompanied with stenotic pathology in 12 patients (32.4%). Left ventricular EF in the sAVR and TAVI patients were 56.6±9.4% and 50.8±13%, respectively (p=0.031). The mean preoperative aortic valve gradients and aortic annulus diameters were similar between the groups (p=0.12 and p=0.51, respectively). The mean EuroSCORE values of the patients in the TAVI and sAVR groups were 8.9±3.8 and 7.3±7.0, respectively (p>0.05).

According to the calculation of the EOAi for each patient, severe PPM values (<0.65 cm^2/m^2) were not found in both either group (Table 2). However, in 17.8% (n=13) of all patients, mild-to-moderate PPM appeared. Three patients (8.1%) in the TAVI group and 10 patients (27.8%) in the sAVR group had mild-to-moderate PPM (p=0.035). The mean EOAi was 1±0.3 in the sAVR group and 1.2±0.2 in the TAVI group (p=0.004). The mean diameters of the inserted bioprosthetic valves in the sAVR and TAVI groups were 21.4±2 and 23.9±2.6, respectively (p=0.002).

The mean postoperative length of ICU and hospital stays was 2.6±3.9 and 9.3±4 days in the sAVR group and 2.9±3.8 and 7.5±5.6 days in the TAVI group (p>0.05). Early mortality was defined as death within the first 30 days after the procedure or surgery. Of all patients, nine (12.3%) died; six (16.2%) in the TAVI group and three (8.3%) in the sAVR group (p=0.479) (Table 3). In the sAVR group, one of the patients died due to cerebrovascular event, and one due to postoperative low cardiac output syndrome. The remaining patient was admitted to the hospital with hemodynamic instability 20 days after discharge. Although echocardiography was normal at the time

Table 3. Postoperative data of patients

	AVR group			TAVI group			
Variable	n	%	Mean±SD	n	%	Mean±SD	*p*
Prolonged intubation (>24 hours)	0	0		3	8.1		0.24
Pneumonia	3	8.3		4	10.8		0.98
Arrhythmia and permanent pacemaker	2	5.6		7	18.9		0.15
Paravalvular leakage	1	2.8		2	5.4		0.38
Cerebrovascular event	4	11.1		2	5.4		0.43
Acute renal failure	2	5.6		4	10.8		0.45
Hospital stay (days)			9.3±4			7.5±5.6	0.11
Intensive care unit stay (days)			2.6±3.9			2.9±3.8	0.76
Mortality	3	8.3		6	16.2		0.47

AVR: Aortic valve replacement; TAVI: Transcatheter aortic valve implantation; SD: Standard deviation.

of discharge, serious paravalvular leak was detected in the second admission. This patient was the only one in whom moderate PPM was found among non-survivors. In the TAVI group, two patients died from cerebrovascular event, two from malignant arrhythmias and hemodynamic instability after the procedure. The remaining two patients died due to low cardiac output and multiorgan failure. The remaining two patients had higher EuroSCORE values as Log score= 21.18% and 18.76%, respectively.

Table 4. Comparison of PPM (+) and PPM (-) patients in terms of demographic and echocardiographic features

	PPM + (n=13)			PPM - (n=60)			
Variable	n	%	Mean±SD	n	%	Mean±SD	*p*
Age (year)			70.8±4.5			74.3±5.9	0.07
Gender Female	7	53.8		29	48.3		0.76
Height (cm)			166.5±9.3			163.2±9.6	0.26
Body surface area (m^2)			1.97±0.2			1.77±0.2	0.007
Body mass index (kg/m^2)			31.8±7.01			27.9±4.3	0.07
Obesity	8	61.5		22	36.7		0.12
Ejection fraction (%)			58.8±5.8			52.5±12.3	0.009
Hypertension	11	84.6		40	66.7		0.32
Diabetes mellitus	7	53.8		26	43.3		0.54
Obstructive lung disease	7	53.8		33	55		0.98
Smoking	7	53.8		39	65		0.53
Aortic stenosis	6	46.2		39	65		0.22
Aortic insufficiency	1	7.7		2	3.3		0.45
Mixed aortic valve disease	6	46.2		19	31.7		0.34
EuroSCORE (%)			7.9±6.4			8.1±5.5	0.91
TAVI patients	3	8.1		34	91.9		
AVR patients	10	27.8		26	72.2		
Total number of patients	13	17.8		60	82.2		

PPM: Patient-prosthesis mismatch; SD: Standard deviation; TAVI: Transcatheter aortic valve implantation; AVR: Aortic valve replacement.

Table 5. Hospital and intensive care unit stays of PPM (+) and PPM (-) patients

	PPM (+)			PPM (-)			
Variable	n	%	Mean±SD	n	%	Mean±SD	*p*
Prolonged intubation (>24 hours)	0	0		3	5		0.98
Pneumonia	1	7.7		6	10		0.98
Arrhythmia and permanent pacemaker	0	0		9	15		0.34
Cerebrovascular event	2	15.4		4	6.7		0.28
Acute renal failure	1	7.7		5	8.3		0.48
Hospital stay (days)			8.9±5.6			8.3±4.8	0.71
Intensive care unit stay (days)			1.8±1.8			3.05±4.1	0.11
Mortality	1	7.7		8	13.3		0.98

PPM: Patient-prosthesis mismatch; SD: Standard deviation.

Postoperative data are presented in Table 3. There was no statistically significant difference between the groups in terms of the ratio of cerebrovascular event, pneumonia, arrhythmias and permanent pacemaker requirement, prolonged intubation, acute kidney failure, revision, and reoperation after the procedure or surgery. The mean postoperative gradients on the aortic valve were higher in the sAVR group than the TAVI groups (13.4±3.1 mmHg vs. 6.1±3.0 mmHg, p<0.05). When PPM-positive (+) and PPM-negative (-) patients were compared with each other, the BSA was found to be a significant predictor of PPM (p=0.007) (Tables 4 and 5). Mid-term mortality at a mean follow-up of 47.7±7.3 months was similar between the groups (TAVI vs. sAVR groups; 48.6% vs. 30.6%, respectively) (p=0.158) (Figure 1).

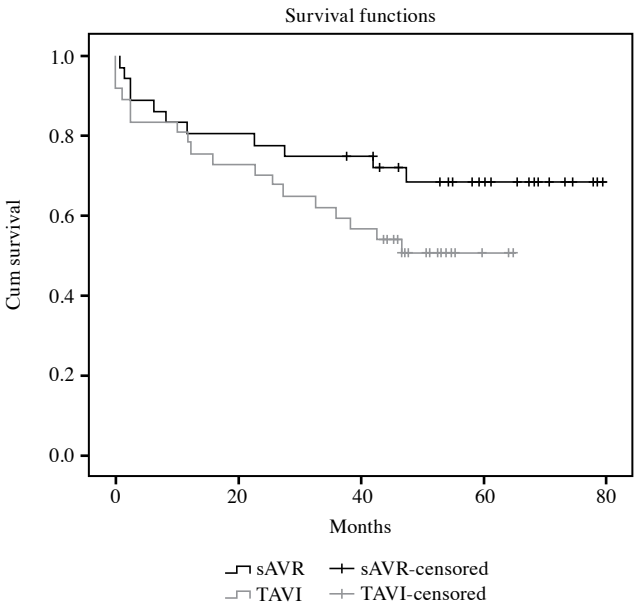

Figure 1. Survival after sAVR and TAVI.

sAVR: Surgical aortic valve replacement; TAVI: Transcatheter aortic valve implantation.

DISCUSSION

Aortic valve stenosis and aortic valve insufficiency are progressive cardiac pathologies proceeding with high mortality which cause severe left ventricular dysfunction, deterioration of hemodynamic parameters, and cardiopulmonary complications. Surgical approach is still the gold standard for the management of the aortic valve pathologies.[1-12] Bioprosthetic valves are preferred to replace the aortic valves of the patients aged above 65 years. The overall mortality of isolated aortic valve replacement is nearly 3.5% in the literature.[13] Alternatively, TAVI is another option to treat aortic valve stenosis as a less invasive approach in high-risk patients.[4-6] Transcatheter aortic valve implantation is currently an acceptable and safe alternative way to manage the symptomatic serious aortic valve stenosis, particularly in high-risk and elderly patients. The Placement of Aortic Transcatheter Valves (PARTNER) trial, which is one of the most comprehensive researches about TAVI, published the 30-days mortality of TAVI as 6.4%.[14-16] Transvalvular aortic insufficiency, paravalvular leakage, and PPM are the major functional complications which increase mortality, as well.

Prosthesis-patient mismatch is a well-described event in patients undergoing aortic valve replacement procedures.[4,7,9-11] Age, gender, comorbidities, emergency of the operation, aortic root pathologies, infections, left ventricular EF, and selection of true size of prosthetic valve are the major factors that have close relation with mortality and PPM.[4-7,9] The concept of PPM was first introduced by Rahimtoola in 1978, as the effective prosthetic valve area, after insertion into the patient, is less than that of a normal human

valve.[4-7] The main hemodynamic consequence of PPM is a high transvalvular pressure gradient through a normally functioning prosthetic valve after procedure. Therefore, the presence of PPM leads to reduced left ventricular mass regression in long-term and mortality.

Previous studies showed that postoperative PPM might have a significant impact on cardiac events and mortality in both sAVR and TAVI procedures.[4-11] However, in our study, we found no statistically significant difference between the PPM (+) and PPM (-) groups including early mortality and complications. In addition, no severe PPM was found in any patients, which could be considered an acceptable outcome of both sAVR and TAVI procedures. This finding indicates that open surgery is still the superior approach in high-risk patients, despite higher EOA and EOAi of TAVI valves. Although mild-to-moderate PPM was higher in the sAVR patients, postoperative outcomes and morbidities were similar between the groups. However, the incidence of pacemaker implantation and early mortality was higher in the TAVI group. Despite relatively short follow-up period, we may conclude that the presence of PPM has no impact on the early postoperative events.

There is a limited number of studies comparing sAVR and TAVI in terms of postoperative outcomes, mortality, and PPM. Cohort A section of the PARTNER trial showed 30-day mortality rates for AVR and TAVI as 6.5% and 3.4% respectively. However, one-year mortality rates were found to be 26.8% for sAVR and 24.3% for TAVI.[1,14,17,18] On the other hand, postoperative complications, cerebrovascular events, paravalvular leakage, and functional aortic valve insufficiency were found to be more frequent for TAVI in the aforementioned trial. In our study, however, we found no statistically significant difference in the TAVI and sAVR groups in terms of early mortality and postoperative complications. Moreover, regarding postoperative PPM, the PARTNER trial showed that the incidence of PPM was 60.0% (severe: 28.1%) in the sAVR-randomized control trial cohort versus 46.4% (severe: 19.7%) in the transcatheter aortic valve replacement (TAVR)-randomized control trial cohort ($p<0.001$) and 43.8% (severe: 13.6%) in the TAVR-non-randomized control trial cohort.[1] This study is the latest and the only report regarding the comparison of surgery and TAVI for PPM. The authors concluded that, in patients with severe aortic stenosis and high surgical risk, mild-to-moderate PPM was more frequent after sAVR than TAVI. Of note, the absence of severe PPM should be considered an advantage of supra-annular bioprosthetic aortic valves.

Several risk factors including female gender, obesity, age >65 years, and New York Heart Association (NYHA) Class III/IV heart failure have been reported to be the major predictors of clinically significant PPM.[4-9] Patients with aortic stenosis tend to have a smaller aortic annulus, which not only allows for a smaller valve to be placed, but also decreases the postoperative EOA; this, in turn, increases the risk of postoperative PPM. In the PARTNER trial, the results showed that, in patients with an aortic annulus diameter <20 mm, severe PPM developed in 33.7% undergoing sAVR compared to 19.0% undergoing TAVR ($p<0.002$).[1] The authors concluded that TAVI might be preferable to sAVR in patients with small aortic annulus. In our study, PPM (+) and PPM (-) patients were also compared with each other and showed similarity regarding preoperative demographic features, postoperative mortality, and ICU and hospital stay. However, we observed that the only predictor of PPM was low BSA, which was another risk for PPM, even if the sizes of implanted valve were similar.

In the present study, we detected 13 (17.8%) mild-moderate PPM (+) patients. No severe PPM was observed in all patients. Two groups were compared with each other regarding PPM and PPM was found more frequent (n=10) in sAVR group significantly ($p=0.035$). Patients had similar demographic features and EuroSCORE values in two groups. Although studies are limited in the literature comparing TAVI with sAVR in terms of PPM, TAVI has often better results in recent studies.[1,10,11] In the PARTNER trial, the mean gradient ratio and EOA ratio were found better in the TAVI.[14] Therefore, it is necessary to evaluate the increased rates of PPM in surgery. A more detailed evaluation of patients using preoperative echocardiographic measurements and excluding patients with small aortic root and orifice may lead to better results with surgical intervention. Some technical options such as aortic root enlargement, selection of true size of valve, selection of supra-annular valves, or stentless bioprosthesis and management of difficulties during implantation of the bioprosthesis may prevent PPM after surgery.

In our study, mortality of patients in the TAVI group was higher than patients in the sAVR group; however, we found no statistically significant difference between the groups. The results of the PARTNER 1 trial showed that, at five years, the risk of death was 67.8% in the TAVR group compared to 62.4% in the sAVR group ($p=0.76$).[19] In addition, PPM, particularly in the elderly group,

does not increase the mortality in many of the studies. Thus, we may conclude that reducing the PPM may be non-significant in this elderly population. Similarly, the presence of mild-to-moderate PPM following bioprosthetic sAVR does not influence long-term survival.[12,14] With the unknown durability of TAVI valves, the increased need for permanent pacemakers in these valves which has been shown to be associated with decreased survival, and the lack of follow-up data, we may not conclude that TAVI may be the initial choice of treatment in patients with an increased BSA and small aortic annulus, who are at risk of PPM. The use of sAVR may prevent potential complications of a TAVI procedure and implantation of a TAVI valve with the unknown durability in long-term.

Although prostheses have the same number and geometric orifice areas, functional EOA can be different depending on the BSA, model of the prothesis and gender of the patient. Different pressure gradients develop in different patients, since determinative phenomenon of the cardiac output at rest is BSA. The EOAi depending on the BSA of the patient has 80% specificity and 74% sensitivity to estimate the presence of PPM.[4] After all, it has been noted that PPM can be largely avoided using the correct preventive strategy at the time of operation both for sAVR and TAVI.[1-18] In surgery, the incidence of PPM can be reduced by choosing the correct size of bioprosthesis, using stentless bioprosthesis, supra-annular implantation of the valve, aortic root manipulations or extensions, considering the left ventricular EF, BSA, age, and gender of the patient during operation. Recent studies have also demonstrated that allografts, homografts, and stentless bioprostheses have less gradient differences inversely greater EOA. In the coming days, these grafts can be used more frequently both in surgery and TAVI.[1-3,19,20]

Nonetheless, there are some limitations to this study. Small sample size in both groups and relatively short follow-up period to examine long-term effects of PPM on cardiac events are the main limitations. Retrospective design of the study is also another limitation. In addition, the lack of the aortic root enlargement procedures during operations can be considered a limitation in the surgical patient group. Additionally, the mean EF of patients with PPM was 58.8±5.8% which was statistically significant. This might have brought about a bias which is that the PPM might be due to high EF. As EF may lead to miscalculation of the transvalvular gradients, this bias is a limitation of the study.

In conclusion, in high-risk patients with severe aortic stenosis, patient-prosthesis mismatch is mild-to-moderate after surgical aortic valve replacement and transcatheter aortic valve implantation; however, this has no effect on early mortality. With the unknown durability of transcatheter aortic valve implantation valves, the increased need for permanent pacemakers in these valves, which has been associated with decreased survival, and the lack of long-term follow-up data, we conclude that the use of surgical aortic valve replacement may prevent the potential complications of transcatheter aortic valve implantation. Nevertheless, surgeons should perform aortic valve replacement with root enlargement techniques to decrease the rate of postoperative patient-prosthesis mismatch.

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