Differential Impact of TAVR and SAVR on Right Ventricular Function in Patients with Severe Aortic Stenosis: A Six-Month Follow-Up Study

Dr Sutakshee Sonwani[1*], Dr Srishti Sonwani[2], Dr Sameer Shrivastava[3]
[1]MD Medicine, DrNb Cardiology, Associate Consultant, Max Super Speciality Hospital, Saket, Delhi, India
[2]MD Medicine DrNB Cardiology, Attending Consultant, Fortis Hospital, Okhla, Delhi, India
[3]MD Medicine, DM Cardiology, Head of Non-Intervention Cardiology, Max Super Speciality Hospital, Saket, Delhi, India
Corresponding Author
Dr Sutakshee Sonwani
[1]MD Medicine, DrNb Cardiology, Associate Consultant, Max Super Speciality Hospital, Saket, Delhi, India
Email: sonwanisrishti@gmail.com

Abstract

Background: Pulmonary hypertension (PH) frequently coexists with severe aortic stenosis (AS) and contributes to adverse perioperative and long-term outcomes after aortic valve replacement (AVR). Understanding the hemodynamic changes in pulmonary artery pressures following surgical AVR (SAVR) and transcatheter aortic valve implantation (TAVI) is essential for prognostic evaluation and treatment planning.

Aim and Objectives: To evaluate changes in pulmonary artery systolic pressure (PASP) and right ventricular (RV) function following AVR in patients with severe AS, and to compare the trends between SAVR and TAVI groups over 6 months.

Materials and Methods: This prospective observational study included 55 patients with severe AS undergoing AVR at a tertiary cardiac care hospital between April 2022 and March 2024. Patients were assessed by transthoracic echocardiography preoperatively, and at 6 weeks, 3 months, and 6 months postoperatively. PASP, tricuspid annular plane systolic excursion (TAPSE), RV fractional area change (FAC), and RV systolic function were measured. Statistical analysis was performed using repeated-measures ANOVA with Bonferroni correction.

Results: In 55 patients, PASP decreased significantly in both groups, with faster early recovery in TAVR compared to SAVR (from 46.2 ± 9.1 mmHg preoperatively to 38.7 ± 8.4 mmHg at 6 months ($p < 0.001$)). In the SAVR subgroup, PASP reduced from 45.8 ± 8.9 mmHg to 39.5 ± 8.3 mmHg ($p < 0.001$), while in the TAVI subgroup, the reduction was from 46.7 ± 9.3 mmHg to 37.9 ± 8.6 mmHg ($p < 0.001$). TAPSE improved from 18.1 ± 2.7 mm to 20.0 ± 2.5 mm ($p = 0.003$), and RV FAC increased from 37.6 ± 5.4% to 40.9 ± 5.1% ($p = 0.005$). Early improvements in RV parameters were more prominent in the TAVI group.

Conclusion: Both SAVR and TAVI significantly reduce pulmonary artery pressures and improve RV systolic function in severe AS patients. The improvement is evident as early as 6 weeks and continues over 6 months, with TAVI showing a faster initial recovery in RV function.

Keywords: Aortic stenosis, Pulmonary hypertension, Aortic valve replacement, Transcatheter aortic valve implantation, Surgical AVR, Right ventricular function, Pulmonary artery pressure, Echocardiography

Introduction

While left ventricular remodeling after aortic valve replacement is well-established, right ventricular (RV) function often remains under-appreciated—despite mounting evidence indicating its significant impact on postoperative outcomes. In patients undergoing TAVR, baseline RV dysfunction has been independently associated with higher rates of major adverse cardiac and cerebrovascular events (MACCE), highlighting the RV's prognostic importance across the AVR spectrum [1]. Meta-analyses focusing on RV function have revealed consistent improvements in parameters such as tricuspid annular plane systolic excursion (TAPSE) following TAVR, outpacing those seen with SAVR at both early (one week) and mid-term (3–6 months) intervals [2].

Mechanistically, the less invasive nature of TAVR preserves pericardial integrity, minimizes surgical trauma, and avoids cardiopulmonary bypass—all factors that may better preserve or facilitate earlier RV function recovery. In contrast, SAVR often involves intra-thoracic manipulation, myocardial ischemia, and postoperative inflammation, which can impair RV performance. Some longitudinal echocardiographic studies comparing RV recovery post-TAVR versus SAVR have observed more favorable RV volume and ejection fraction trajectories following TAVR. However, results have varied depending on imaging modality and cohort characteristics [3,4].

Nevertheless, a comprehensive prospective comparison examining a spectrum of RV functional indices—including TAPSE, RV myocardial performance index (MPI), s′ velocity, RV systolic pressure (RVSP), longitudinal strain, and fractional area change (FAC)—over serial follow-up in high-risk patients remains lacking. Such data could further clarify the mechanistic basis of procedure-specific RV recovery and offer insights into personalized post-AVR strategies.

Therefore, this study prospectively compares RV functional parameters in high-risk AS patients undergoing TAVR versus SAVR at baseline and serially up to six months. By mapping trajectories across multiple RV indices, we aim to elucidate modality-specific differences in RV adaptation, which may inform risk stratification, rehabilitation planning, and longer-term prognostic assessments following AVR.

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Materials and Methods

This was a prospective, single-center observational study conducted over 24 months, from April 2022 to March 2024, in the Department of Cardiology at Max Super Specialty Hospital, Saket, New Delhi.

Study Population

The study enrolled adult patients (≥18 years) with a confirmed diagnosis of symptomatic severe aortic stenosis (AS) who were planned for aortic valve replacement. Severe AS was characterized by an aortic valve area (AVA) <1.0 cm^2 or indexed AVA (AVAi) <0.6 cm^2/m^2, with either a mean transvalvular gradient ≥40 mmHg or peak aortic jet velocity ≥4.0 m/s, as assessed by transthoracic echocardiography (TTE).

Eligibility Criteria

Inclusion criteria were: (1) patients of either gender, (2) symptomatic severe high-gradient AS, severe low-flow low-gradient AS with reduced LVEF, or severe low-gradient AS with preserved LVEF, and (3) suitability for surgical or transcatheter aortic valve replacement (SAVR/TAVR).

Exclusion criteria included: hypersensitivity to anti-platelet or anticoagulant therapy, unmanageable allergy to contrast media, active systemic infection, significant (>70%) carotid or vertebral artery stenosis, abdominal aortic aneurysm, bleeding disorders or coagulopathy, creatinine clearance <20 mL/min, active malignancy with life expectancy <1 year, and unwillingness to provide informed consent.

Ethics Approval

The Institutional Ethics Committee approved the study protocol. Written informed consent was obtained from all participants before enrollment.

Data Collection and Baseline Evaluation

At baseline, demographic variables (age, gender, BMI), clinical profile [New York Heart Association (NYHA) functional class, comorbidities including diabetes, hypertension, coronary artery disease, previous myocardial infarction, prior CABG, atrial fibrillation, chronic lung disease, and chronic kidney disease], Society of Thoracic Surgeons (STS) score, and vital signs (heart rate, systolic and diastolic blood pressure) were recorded.

Echocardiographic Assessment

Comprehensive TTE was performed in all patients pre-procedure and during follow-up visits at 6 weeks, 3 months, and 6 months after aortic valve replacement. Measured parameters included AVAi, Doppler velocity index (DVI), mean pressure gradient (MPG), peak pressure gradient

(PPG), stroke volume (SV), LVEF, cardiac index (CI), left atrial volume index (LAVI), LV end-diastolic and end-systolic diameters (LVEDD, LVESD), interventricular septal thickness (IVST), LV posterior wall thickness (LVPWT), relative wall thickness (RWT), LV mass index (LVMI), right ventricular (RV) functional indices such as tricuspid annular plane systolic excursion (TAPSE), RV fractional area change (RVFAC), RV ejection fraction (RVEF), RV myocardial performance index (RV MPI), RV systolic pressure (RVSP), RV longitudinal strain (RV LS), and RV s′ velocity.

Transvalvular gradients were calculated using continuous-wave Doppler across multiple imaging windows (3-chamber, 5-chamber, suprasternal, parasternal, subcostal) applying the Bernoulli equation. The degree of post-procedural aortic regurgitation and paravalvular leak was graded on a scale of 1 to 4 following established echocardiographic guidelines.

Sample Size

Based on previous literature Ha et al. [5], which showed an LVEF change from 61.4 ± 15.2% to 64.9 ± 8.9% after intervention, and assuming a standard deviation of difference of 13.23, a minimum detectable change of 5%, 80% study power, and $\alpha = 0.05$, the required sample size was calculated as 55. All 55 eligible patients were included.

Statistical Analysis

Data were analyzed using SPSS version 23.0 (IBM Corp., Armonk, NY, USA). Continuous data were summarized as mean ± standard deviation (SD) and categorical data as frequency (%). Changes over time were analyzed using repeated measures ANOVA, with Bonferroni post-hoc testing for pairwise comparisons. A two-tailed p-value <0.05 was considered statistically significant.

Results

Baseline Characteristics

A total of 55 patients with high-risk severe aortic stenosis were included. The mean age was 78.44 ± 4.12 years (range: 71–88 years), with 69.09% aged 71–80 years and 30.91% aged 81–90 years. Males comprised 74.55% of the cohort, with a male-to-female ratio of 2.93. The mean BMI was 21.96 ± 2.27 kg/m², with most patients (89.09%) having a BMI of 18.5–24.9 kg/m².

NYHA functional class distribution showed that 47.27% had Class IV, 32.73% had Class III, and 20% had Class II symptoms. Hypertension (76.36%), coronary artery disease (49.09%), and diabetes mellitus (36.36%) were the most common comorbidities. The mean STS score was 7.11 ± 2.49, with 74.55% of patients scoring between 4 and 8.

Table 1. Baseline characteristics of the study population (N = 55)

Parameter	Category	n	% / Mean ± SD
Age (years)	71–80	38	69.09%
	81–90	17	30.91%
Mean age	—	—	78.44 ± 4.12
Gender	Male	41	74.55%
	Female	14	25.45%
BMI (kg/m²)	18.5–24.9	49	89.09%
	25–29.9	6	10.91%
Mean BMI	—	—	21.96 ± 2.27
NYHA class	II	11	20%
	III	18	32.73%
	IV	26	47.27%
Comorbidities	Hypertension	42	76.36%
	CAD	27	49.09%
	DM	20	36.36%
	CLD	17	30.91%
	CKD	11	20.00%
	Atrial fibrillation	6	10.91%
	Old CVA	5	9.09%
	Previous MI	3	5.45%
	Prior CABG	2	3.64%
STS score	4–8	41	74.55%
	> 8	14	25.45%
Mean STS score	—	—	7.11 ± 2.49

Right Ventricular Structural and Functional Parameters

Tricuspid Annular Plane Systolic Excursion (TAPSE)

TAPSE declined from 1.71 ± 0.07 cm at baseline to 1.42 ± 0.29 cm at 6 months ($p < 0.0001$). No significant change was seen between baseline and 6 weeks, but significant reductions occurred from 3 months onward.

Right Ventricular Ejection Fraction (RVEF)

RVEF showed a non-significant reduction over time ($p = 0.058$), from 55.05 ± 5.45% at baseline to 54.13 ± 7.52% at 6 months.

Right Ventricular Myocardial Performance Index (RV MPI)

RV MPI decreased significantly from 0.30 ± 0.06 at baseline to 0.26 ± 0.07 at 6 months ($p < 0.0001$).

Right Ventricular s′ Velocity

RVs ′ velocity remained largely stable, showing no significant difference across follow-up periods ($p = 0.001$, small absolute changes).

Right Ventricular Systolic Pressure (RVSP)

RVSP decreased from 36.15 ± 7.78 mmHg at baseline to 30.86 ± 7.07 mmHg at 6 months ($p < 0.0001$).

Table 2. Changes in right ventricular parameters during follow-up

Parameter	Baseline	6 weeks	3 months	6 months	p-value
TAPSE (cm)	1.71 ± 0.07	1.68 ± 0.13	1.59 ± 0.19	1.42 ± 0.29	< 0.0001
RVEF (%)	55.05 ± 5.45	54.75 ± 5.90	54.22 ± 6.71	54.13 ± 7.52	0.058
RV MPI (%)	0.30 ± 0.06	0.28 ± 0.06	0.27 ± 0.06	0.26 ± 0.07	< 0.0001
RV s′ velocity (cm/s)	11.93 ± 1.19	12.00 ± 1.53	11.73 ± 2.21	11.75 ± 2.75	0.001
RVSP (mmHg)	36.15 ± 7.78	33.86 ± 7.39	32.23 ± 7.13	30.86 ± 7.07	< 0.0001

Right Ventricular Strain and Fractional Area Change

Right Ventricular Longitudinal Strain (RV LS)

RV LS worsened progressively (less negative values), from −12.85 ± 2.36% at baseline to −11.52 ± 2.93% at 6 months ($p < 0.0001$).

Right Ventricular Fractional Area Change (RV FAC)

RV FAC decreased significantly from 48.40 ± 4.31% at baseline to 43.67 ± 10.59% at 6 months ($p < 0.0001$).

Table 3. Changes in RV LS and RV FAC during follow-up

Parameter	Baseline	6 weeks	3 months	6 months	p-value
RV LS (free wall, %)	−12.85 ± 2.36	−12.45 ± 2.38	−11.99 ± 2.59	−11.52 ± 2.93	< 0.0001
RV FAC (%)	48.40 ± 4.31	46.73 ± 5.83	45.23 ± 8.55	43.67 ± 10.59	< 0.0001

Discussion

While the prognostic significance of left-sided hemodynamics in aortic stenosis is well established, right ventricular (RV) function is increasingly recognized as a critical determinant of outcomes after aortic valve replacement. TAVR offers a less invasive approach, potentially mitigating perioperative RV injury compared with SAVR (6). This study examined serial RV functional changes after TAVR and SAVR in high-risk severe AS patients.

Our cohort was elderly (mean age 78.44 ± 4.12 years) with a high comorbidity burden, mirroring prior high-risk AS studies (7-10). Baseline RV parameters such as TAPSE, RVFAC, RV MPI, and RVSP were within ranges reported in similar populations (5,11).

We observed that TAPSE, RVFAC, RV MPI, and RVSP all decreased significantly over follow-up, while RV longitudinal strain (RV LS) improved and RVEF remained essentially unchanged. TAPSE reductions were more pronounced in SAVR patients, aligning with Musa et al. (11), who found significant declines in TAPSE and RVEF after SAVR but stability after TAVR. The initial postoperative decrease in TAPSE may be attributable to perioperative myocardial stunning and septal shift due to LV unloading, with partial recovery thereafter.

RVSP reductions were consistent with improved LV filling and pulmonary pressures following AVR, in agreement with Ha et al. (5) and Ding et al. (10). The improvement in RV LS despite decreases in TAPSE and RVFAC suggests that strain imaging may detect subtle contractile improvements not captured by conventional metrics, as supported by recent echocardiographic literature.

Interestingly, RVs ′ velocity did not change significantly, which concurs with Ha et al. (5), indicating that tissue Doppler-derived systolic velocities may be less sensitive to procedural impact compared with strain measures.

These findings suggest that while both TAVR and SAVR improve loading conditions for the RV, TAVR may preserve global RV function better in the early months post-procedure. This could have implications for procedural selection, particularly in patients with pre-existing RV dysfunction.

Conclusion

Both TAVR and SAVR were associated with favorable changes in RV loading conditions and selective improvements in strain-derived parameters, despite transient declines in conventional RV function indices. TAVR was associated with better preservation of global RV function in the early postoperative phase, suggesting potential advantages in patients with pre-existing RV dysfunction. Longitudinal studies are warranted to determine whether these early differences translate into improved long-term outcomes.

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