Outcomes of transcatheter aortic valve replacement in octogenarians and beyond with bicuspid *vs.* tricuspid aortic stenosis: a retrospective study

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Background: Evidence regarding transcatheter aortic valve replacement (TAVR) in octogenarians with bicuspid aortic valve (BAV) stenosis remains limited. We aimed to characterize the clinical, anatomical, and procedural features and midterm outcomes of patients aged≥80 years with BAV stenosis undergoing TAVR, using patients with tricuspid aortic valve (TAV) stenosis as a clinical reference.

Methods: This retrospective single-center study included consecutive patients aged ≥80 years who underwent TAVR for severe aortic stenosis from January 2021 to August 2024. Clinical, imaging, and procedural data were retrieved from institutional electronic medical records; valve morphology was determined using preprocedural computed tomography. The primary outcome was all-cause mortality during follow-up. Secondary outcomes included technical success, cardiovascular mortality, stroke, myocardial infarction, valve thrombosis, aortic valve reintervention, and permanent pacemaker implantation.

Results: Among 172 patients, 51 had BAV and 121 had TAV. Patients with BAV had larger aortic root dimensions, greater aortic angulation, and a greater calcification burden. They received larger transcatheter valves (25.96±2.37 *vs.* 24.98±2.54 mm; P=0.019) and underwent post-dilatation more frequently (23.5% *vs.* 9.9%; P=0.019). Technical success was similar (90.2% *vs.* 94.2%; P=0.537), as were discharge transvalvular gradients and paravalvular leak. The average follow-up duration was 33.36±14.37 months. During follow-up, all-cause death occurred in 7/51 (13.7%) and 21/121 (17.4%) patients, respectively (P=0.556), and cardiovascular death in 3/51 (5.9%) and 9/121 (7.4%; P=0.970). Survival analyses showed no significant between-group differences. No valve thrombosis or aortic valve reintervention occurred.

Conclusions: Despite greater anatomical and procedural complexity, carefully selected patients aged ≥80 years with BAV showed no statistically significant differences in early valve performance or midterm clinical outcomes compared with those with TAV. These findings may support the consideration of TAVR in this population following comprehensive Heart Team evaluation and CT-based procedural planning.

Keywords: Bicuspid aortic valve (BAV); transcatheter aortic valve replacement (TAVR); octogenarians; aortic stenosis.

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Introduction

Transcatheter aortic valve replacement (TAVR) has become a standard treatment for severe aortic stenosis. As populations age, TAVR is being performed increasingly often in older patients. Nationwide data from Denmark showed that, by 2020, TAVR accounted for 91.5% of isolated aortic valve replacement procedures in patients older than 75 years (1). Several studies have shown that even carefully selected nonagenarians derive a clear survival benefit from TAVR and that advanced age alone should not be considered a contraindication to treatment (2-4).

Bicuspid aortic valve (BAV) is the most common congenital valvular abnormality, affecting approximately 0.5% to 2.0% of the general population (5). BAV carries a substantial lifetime disease burden; population-based data suggest a cumulative morbidity of 86% by 90 years of age and a 69% lifetime risk of undergoing native aortic valve surgery (6). BAV poses distinct anatomical and procedural challenges for TAVR. Asymmetric leaflet calcification, a calcified raphe, and an elliptical annular configuration can complicate prosthesis sizing and deployment, increasing the risk of paravalvular regurgitation and aortic root injury. Although BAV accounts for approximately 10% to 15% of patients undergoing TAVR, it has been underrepresented in pivotal randomized trials, and the available evidence is derived largely from retrospective studies (7).

Previous studies have established the feasibility of TAVR in patients with BAV; however, the mean age of the enrolled populations was generally below 80 years, leaving limited evidence for patients of more advanced age (8). The proportion of BAV among patients undergoing aortic valve replacement declines markedly with age. BAV accounted for 49.5% of patients undergoing SAVR for severe aortic stenosis before 65 years of age, but only 4.5% of those aged 80 years or older (9). This pattern likely reflects the earlier clinical manifestation and treatment of BAV disease, leaving octogenarians and beyond with previously untreated BAV as a highly selected and poorly studied population. TAVR is a relatively well-established treatment for patients with TAV stenosis; therefore, patients of similar age with TAV undergoing TAVR may provide a clinical reference for characterizing the features and outcomes of patients with BAV (10,11). We therefore aimed to describe the clinical characteristics, procedural features, and midterm outcomes of octogenarians and beyond with BAV undergoing TAVR, using those with TAV as a reference. We therefore compared baseline and imaging characteristics, procedural features, and midterm clinical outcomes after TAVR between patients aged 80 years or older with BAV and those with tricuspid aortic valve (TAV), to inform clinical assessment and future research in this specific population.

Methods

Study design and patient population

This single-center retrospective cohort study included consecutive patients who underwent TAVR at Fuwai Hospital between January 2021 and August 2024. Eligible

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patients were aged ≥80 years with severe aortic stenosis. Severe aortic stenosis was defined as a peak aortic jet velocity >4.0 m/s, a mean transvalvular gradient >40 mmHg, or an aortic valve area ≤1.0 cm^2 (12). Patients were excluded if they underwent valve-in-valve TAVR for degenerated bioprosthetic valves, received an investigational transcatheter heart valve as part of a clinical trial, or had incomplete clinical or imaging data. All TAVR procedures were reviewed and approved by the multidisciplinary Heart Team. According to preprocedural computed tomography (CT), patients were classified into the BAV or TAV group.

Data collection and follow-up

Baseline clinical characteristics, preprocedural imaging findings, and procedural data were retrospectively retrieved from the institutional electronic medical record system. Clinical outcomes were ascertained through scheduled outpatient visits, review of electronic medical records, and telephone interviews. Follow-up began on the date of TAVR. Patients were considered lost to follow-up when follow-up information could not be obtained from outpatient visits, electronic medical records, or telephone contact. The study was approved by the institutional ethics committee of Fuwai Hospital (No. 2024-2428). Written informed consent was obtained from all participants for the TAVR procedure and for the use of de-identified clinical data for research purposes. The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Study endpoints

The primary endpoint was all-cause mortality during follow-up. Secondary endpoints included technical success, cardiovascular mortality, stroke, myocardial infarction, valve thrombosis, aortic valve reintervention, and new permanent pacemaker implantation. Clinical endpoints were defined according to the Valve Academic Research Consortium-3 (VARC-3) consensus document (13). Technical success was defined as successful implantation of a single prosthetic valve in the intended anatomical position without procedural mortality or major device-related complications. Subsequent valve migration, significant regurgitation, or reintervention was evaluated separately from the technical result at procedure-room exit. Cardiovascular death included all deaths due to cardiovascular or procedure-related causes, and deaths of unknown cause were classified as cardiovascular deaths. Clinical events were identified through review of medical records and follow-up information.

Statistical analysis

Continuous variables are presented as mean ± standard deviation (SD) or median (interquartile range [IQR]), as appropriate, and categorical variables are presented as frequencies and percentages. The normality of continuous variables was assessed using the Shapiro–Wilk test. Between-group comparisons were performed using the independent-samples t test for normally distributed variables and the Mann–Whitney U test for nonnormally distributed variables. Categorical variables were compared using the x^2 test or Fisher's exact test, as appropriate. Ordinal variables were compared using

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the nonparametric rank-sum test. Clinical outcomes were summarized at discharge, 90 days, and during follow-up. Patients lost to follow-up were excluded only from the analyses of nonfatal clinical outcomes. Patients with a pre-existing permanent pacemaker were excluded from the analysis of new permanent pacemaker implantation. Overall and cardiovascular survival were estimated using the Kaplan-Meier method and compared between the BAV and TAV groups using the log-rank test. Unadjusted Cox proportional hazards regression was used to estimate hazard ratios (HRs) with corresponding 95% confidence intervals (CIs). Given the limited number of events, no multivariable Cox regression analysis was performed; therefore, only unadjusted survival estimates are reported. No imputation was performed for missing data. All statistical analyses were conducted using R version 4.5.2 (R Foundation for Statistical Computing, Vienna, Austria). A two-sided P value <0.05 was considered statistically significant.

Resuluts

Study population and baseline characteristics

Between January 2021 and August 2024, 172 consecutive patients aged ≥80 years who underwent TAVR were included in the study, comprising 51 patients with BAV and 121 patients with TAV. The average follow-up duration was 33.36±14.37 months. Baseline characteristics are summarized in *Table 1*. Overall, the two groups were well matched with respect to age, body mass index, diabetes mellitus, atrial fibrillation, previous stroke, chronic obstructive pulmonary disease, renal insufficiency, and New York Heart Association functional class (all P>0.05). Compared with patients with TAV, those with BAV were less frequently female (25.5% *vs.* 51.2%, P=0.002) and had a lower prevalence of hypertension (41.2% *vs.* 73.6%, P<0.001) and coronary artery disease (33.3% *vs.* 56.2%, P=0.006).

Imaging characteristics

Echocardiographic and CT findings are summarized in *Table 2*. Despite comparable hemodynamic severity of aortic stenosis, as reflected by similar mean transvalvular gradients and the prevalence of significant aortic and mitral regurgitation, patients with BAV exhibited mildly impaired baseline left ventricular systolic function. Specifically, left ventricular fractional shortening was significantly lower in the BAV group (29.6% ±8.3% *vs.* 34.0% ±5.9%, P=0.011), and a greater proportion of patients had reduced left ventricular ejection fraction (P=0.016). Other echocardiographic parameters, including left atrial size, left ventricular dimensions, and cardiac output, were comparable between the two groups.

In contrast, patients with BAV consistently exhibited larger dimensions throughout the aortic root complex, including the left ventricular outflow tract, annulus, sinus of Valsalva, sinotubular junction, and ascending aorta (all P≤0.05). In addition, BAV was associated with greater aortic angulation (P=0.044) and a higher calcification volume (547.25 [281.88, 1158.31] mm^3 *vs.* 327.25 [205.44, 532.81] mm^3, P=0.003), whereas coronary artery heights were similar between the two groups.

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Table 1 Baseline characteristics according to aortic valve morphology

Characteristics	Overall (n=172)	BAV (n=51)	TAV (n=121)	P value
Age, years	83.38±2.88	83.31±3.18	83.41±2.76	0.837
Body mass index, kg/m^2	24.37±3.45	23.60±3.34	24.70±3.46	0.057
Female sex	75 (43.60)	13 (25.49)	62 (51.24)	0.002
Hypertension	110 (63.95)	21 (41.18)	89 (73.55)	<0.001
Diabetes	45 (26.16)	11 (21.57)	34 (28.10)	0.373
Coronary artery disease	85 (49.42)	17 (33.33)	68 (56.20)	0.006
Previous myocardial infarction	14 (8.14)	3 (5.88)	11 (9.09)	0.691
Previous percutaneous coronary intervention	38 (22.09)	8 (15.69)	30 (24.79)	0.189
Previous coronary artery bypass graft	5 (2.91)	0 (0.00)	5 (4.13)	0.329
Permanent pacemaker/defibrillator	9 (5.23)	4 (7.84)	5 (4.13)	0.533
Atrial fibrillation	29 (16.86)	11 (21.57)	18 (14.88)	0.284
Previous stroke	59 (34.30)	20 (39.22)	39 (32.23)	0.378
Peripheral artery disease	78 (45.35)	21 (41.18)	57 (47.11)	0.475
Chronic obstructive pulmonary disease	7 (4.07)	1 (1.96)	6 (4.96)	0.627
Renal insufficiency	12 (6.98)	3 (5.88)	9 (7.44)	0.970
Previous mitral valve replacement	2 (1.16)	1 (1.96)	1 (0.83)	0.506
New York Heart Association class III/IV	129 (75.00)	41 (80.39)	88 (72.73)	0.289

Values are reported as mean ± standard deviation or count (%). BAV, bicuspid aortic valve; TAV, tricuspid aortic valve.

Procedural characteristics

Procedural characteristics are summarized in *Table 3*. Technical success was achieved in over 90% of patients, with no significant difference between the BAV and TAV groups (90.2% *vs.* 94.2%, P=0.537). Transfemoral access was used in over 90% of procedures and was comparable between groups (P=0.871). The distribution of implanted transcatheter heart valves was comparable between groups (P=0.753), and self-expandable valves accounted for the majority of implanted devices in both groups (88.2% *vs.* 85.1%). Consistent with the larger annular dimensions observed in patients with BAV, the implanted prosthesis size was significantly larger in the BAV group than in the TAV group (25.96±2.37 *vs.* 24.98±2.54 mm, P=0.019). Predilatation was performed in most patients without a significant between-group difference (90.2% *vs.* 79.3%, P=0.087), whereas postdilatation was required more frequently in patients with BAV than in those with TAV (23.5% *vs.* 9.9%, P=0.019). The incidence of second-valve implantation was low and comparable between the two groups (9.8% *vs.* 4.1%, P=0.273).

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Table 2 Echocardiographic and computed tomographic characteristics according to aortic valve morphology

Characteristics	Overall (n=172)	BAV (n=51)	TAV (n=121)	P value
Echocardiography				
Aortic valve mean gradient, mmHg	53.51±15.66	54.35±16.29	53.15±15.44	0.647
Aortic regurgitation ≥3+	18 (10.47)	6 (11.76)	12 (9.92)	0.718
Left ventricular ejection fraction, %				0.016
Highly reduced (<31%)	5 (2.91)	3 (5.88)	2 (1.65)	
Moderately reduced (31%–40%)	15 (8.72)	9 (17.65)	6 (4.96)	
Mildly reduced (41%–50%)	13 (7.56)	4 (7.84)	9 (7.44)	
Preserved (>50%)	139 (80.81)	35 (68.63)	104 (85.95)	
Left atrial anteroposterior diameter, mm	43.02±6.11	42.49±6.44	43.24±5.98	0.464
Left atrial volume, mL	80.31±28.33	75.85±28.84	82.66±27.96	0.220
Interventricular septal thickness, mm	12.95±2.01	12.91±2.54	12.97±1.76	0.865
Left ventricular end-diastolic diameter, mm	49.70±6.53	51.16±6.30	49.09±6.55	0.058
Left ventricular end-systolic diameter, mm	35.04±15.00	35.98±8.74	34.63±17.06	0.626
Left ventricular posterior wall thickness, mm	11.74±2.16	11.61±1.78	11.80±2.30	0.640
Left ventricular fractional shortening, %	32.48±7.06	29.59±8.32	33.95±5.87	0.011
Left ventricular cardiac output, L/min	4.78±1.48	4.85±1.38	4.74±1.54	0.735
Mitral regurgitation ≥3+	10 (5.81)	5 (9.80)	5 (4.13)	0.273
Computed tomography				
Ascending aorta diameter, mm	36.10±4.00	38.33±3.96	35.07±3.60	<0.001
Right coronary artery Height, mm	16.43±5.72	17.06±4.56	16.17±6.14	0.398
Left coronary artery Height, mm	11.97±2.86	12.57±3.03	11.72±2.77	0.110
LVOT diameter, mm	24.76±3.59	26.93±3.61	23.85±3.18	<0.001
Annular perimeter, mm	74.85±10.80	80.53±9.31	72.44±10.52	<0.001
Annular perimeter-derived diameter, mm	23.82±3.44	25.63±2.96	23.06±3.35	<0.001
Annular area, mm^2	439.55±102.83	500.79±111.65	413.58±87.20	<0.001
Annular area-derived diameter, mm	23.50±2.73	25.10±2.82	22.82±2.40	<0.001
Left SOV diameter, mm	32.26±4.51	34.52±3.98	31.56±4.45	0.001
Right SOV diameter, mm	31.92±4.43	33.68±4.44	31.38±4.31	0.012
Non-coronary SOV diameter, mm	31.99±4.16	34.05±4.30	31.36±3.92	0.002
STJ Perimeter, mm	93.65±11.50	99.99±9.96	90.97±11.09	<0.001
STJ perimeter-derived diameter, mm	29.81±3.66	31.83±3.17	28.96±3.53	<0.001
Aortic Angulation, °	57.31±17.88	61.96±12.52	55.34±19.44	0.044
Calcification Volume (>850 HU), mm^3	361.50 (229.75, 693.50)	547.25 (281.88, 1158.31)	327.25 (205.44, 532.81)	0.003

Values are reported as mean ± SD, median (interquartile range), or count (%). BAV, bicuspid aortic valve; LVOT, left ventricular outflow tract; SOV, sinus of valsalva; STJ, sinotubular junction; TAV, tricuspid aortic valve.

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Table 3 Procedural characteristics and complications according to aortic valve morphology

Characteristics	Overall (n=172)	BAV (n=51)	TAV (n=121)	P value
Technical success	160 (93.02)	46 (90.20)	114 (94.21)	0.537
Transfemoral access	161 (93.60)	47 (92.16)	114 (94.21)	0.871
Implanted valve				0.753
Sapien 3	24 (13.95)	6 (11.76)	18 (14.88)	
Venus	98 (56.98)	31 (60.78)	67 (55.37)	
Vitaflow	20 (11.63)	4 (7.84)	16 (13.22)	
Taurus	15 (8.72)	4 (7.84)	11 (9.09)	
Evolut	14 (8.14)	6 (11.76)	8 (6.61)	
J-Valve	1 (0.58)	0 (0.00)	1 (0.83)	
Implanted valve size, mm	25.27±2.52	25.96±2.37	24.98±2.54	0.019
Implanted valve size*				0.1
Large	46 (26.74)	18 (35.29)	28 (23.14)	
Small	126 (73.26)	33 (64.71)	93 (76.86)	
Implanted valve type				0.591
Balloon-expandable	24 (13.95)	6 (11.76)	18 (14.88)	
Self-expandable	148 (86.05)	45 (88.24)	103 (85.12)	
Predilatation	142 (82.56)	46 (90.20)	96 (79.34)	0.087
Postdilatation	24 (13.95)	12 (23.53)	12 (9.92)	0.019
Implant 2 valves	10 (5.81)	5 (9.80)	5 (4.13)	0.273
Annulus rupture	0 (0)	0 (0)	0 (0)	–
Conversion to surgery	0 (0)	0 (0)	0 (0)	–
Cardiac tamponade	2 (1.16)	0 (0.00)	2 (1.65)	>0.99
Periprocedural bleeding	6 (3.49)	0 (0.00)	6 (4.96)	0.245
In-hospital death	1 (0.58)	0 (0.00)	1 (0.83)	>0.99

Values are reported as mean ± standard deviation or count (%). *, self-expandable valves were categorized as small (≤26 mm) or large (>26 mm), whereas balloon-expandable valves were categorized as small (≤23 mm) or large (≥26 mm). BAV, bicuspid aortic valve; TAV, tricuspid aortic valve.

Echocardiographic outcomes at discharge

Postprocedural echocardiographic findings at discharge are summarized in *Table 4*. Mean transvalvular gradients were comparable between the BAV and TAV groups (11.0 [7.0–15.0] *vs.* 10.0 [8.0–13.0] mmHg; P=0.795). Although patients with BAV had a lower mean left ventricular ejection fraction (57.3±9.7% *vs.* 60.6±8.3%, P=0.023), the proportion of patients with preserved left ventricular ejection fraction (>50%) was similar between groups (P=0.094). In addition, changes in left ventricular ejection fraction, left ventricular dimensions, left atrial anteroposterior diameter, and the severity of paravalvular leak did not differ significantly between groups (all P>0.05).

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Table 4 Echocardiographic outcomes at discharge according to aortic valve morphology

Characteristics	Overall (n=171)	BAV (n=51)	TAV (n=120)	P value
Mean transvalvular gradient, mmHg	10.50 (8.00, 14.00)	11.00 (7.00, 15.00)	10.00 (8.00, 13.00)	0.795
LVEF, %	59.62±8.81	57.27±9.66	60.60±8.27	0.023
LVEF >50%	146 (85.38)	40 (78.43)	106 (88.33)	0.094
ΔLVEF, %	1.00 (–4.00, 6.00)	1.00 (–3.50, 8.00)	0.50 (–4.00, 5.00)	0.24
LAAD, mm	41.62±5.86	40.84±6.49	41.95±5.56	0.259
LVEDD, mm	48.09±6.27	49.61±6.97	47.45±5.86	0.055
ΔLVEDD, mm	–1.00 (–5.00, 1.00)	–2.00 (–4.50, 0.50)	–1.00 (–5.00, 2.00)	0.737
LVESD, mm	32.95±7.23	34.84±8.41	31.99±6.38	0.035
ΔLVESD, mm	–1.00 (–4.00, 2.50)	–1.00 (–5.00, 2.50)	–1.00 (–3.25, 2.25)	0.392
Paravalvular leak				0.135
None	98 (57.31)	24 (47.06)	74 (61.67)	
Mild	72 (42.11)	27 (52.94)	45 (37.50)	
Moderate	1 (0.58)	0 (0.00)	1 (0.83)	

Values are reported as mean ± standard deviation, median (interquartile range), or count (%). BAV, bicuspid aortic valve; LVEF, left ventricular ejection fraction; LAAD, left atrial anteroposterior diameter; LVEDD, left ventricular end-diastolic diameter; LVESD, left ventricular end-systolic diameter; TAV, tricuspid aortic valve.

Clinical outcomes

Clinical outcomes are summarized in *Table 5*. No significant between-group differences were observed in the primary endpoint or any secondary endpoints at discharge or 90 days (all P>0.05). During the 3-year follow-up, all-cause mortality (13.7% *vs.* 17.4%, P=0.556), cardiovascular mortality (5.9% *vs.* 7.4%, P=0.970), stroke (4.4% *vs.* 1.8%, P=0.722), myocardial infarction (0% *vs.* 1.8%, P=1.000), and new permanent pacemaker implantation (7.1% *vs.* 13.2%, P=0.449) remained comparable between the BAV and TAV groups. No cases of valve thrombosis or aortic valve reintervention occurred during follow-up.

Kaplan-Meier analysis (*Figure 1*) demonstrated no significant differences in either overall survival (log-rank P=0.828) or cardiovascular survival (log-rank P=0.839). The estimated 1-, 2-, and 3-year overall survival rates were 97.4%, 89.4%, and 82.9% in the TAV group and 95.9%, 85.6%, and 81.9% in the BAV group, respectively. Corresponding cardiovascular survival rates were 98.3%, 96.3%, and 90.9% in the TAV group and 97.8%, 95.3%, and 91.1% in the BAV group. Consistent with these findings, univariable Cox proportional hazards analysis showed no significant association between BAV morphology and either all-cause mortality (HR 0.91, 95% CI 0.39–2.14; P=0.828) or cardiovascular mortality (HR 0.88, 95% CI 0.24–3.23; P=0.839).

Discussion

This is the first study specifically comparing TAVR outcomes between octogenarians and beyond with BAV and those with TAV. First, octogenarians with BAV retained the typical anatomical features of bicuspid disease, including a larger aortic root

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complex, greater calcification burden (547 *vs.* 327 mm³; P=0.003), and more pronounced aortic angulation. Second, these anatomical differences were associated with greater procedural demands, as reflected by the use of larger transcatheter valves (25.96 *vs.* 24.98 mm; P=0.019) and more frequent postdilatation (23.5% *vs.* 9.9%; P=0.019). Third, despite this greater complexity, technical success remained similar (90.2% *vs.* 94.2%; P=0.537), with no significant between-group differences in 3-year all-cause mortality (13.7% *vs.* 17.4%; P=0.556).

Table 5 Clinical outcomes at discharge, 90 days, and during follow-up according to aortic valve morphology

	Overall (n=172)	BAV (n=51)	TAV (n=121)	P value
At discharge (n=172)				
All-cause death	1 (0.58)	0 (0)	1 (0.83)	>0.99
Cardiovascular death	1 (0.58)	0 (0)	1 (0.83)	>0.99
Stroke	1 (0.58)	1 (1.96)	0 (0)	0.297
Myocardial infarction	0 (0)	0 (0)	0 (0)	–
Aortic valve reintervention	0 (0)	0 (0)	0 (0)	–
Valve thrombosis	0 (0)	0 (0)	0 (0)	–
New permanent pacemaker (n=163)*	11 (6.75)	3 (6.38)	8 (6.90)	>0.99
At 90 days				
All-cause death	3 (1.74)	1 (1.96)	2 (1.65)	>0.99
Cardiovascular death	2 (1.16)	0 (0)	2 (1.65)	>0.99
Stroke	2 (1.16)	1 (1.96)	1 (0.83)	0.506
Myocardial infarction	0 (0)	0 (0)	0 (0)	–
Aortic valve reintervention	0 (0)	0 (0)	0 (0)	–
Valve thrombosis	0 (0)	0 (0)	0 (0)	–
New permanent pacemaker (n=163)*	14 (8.59)	3 (6.38)	11 (9.48)	0.74
At 3 years†	n=156	n=46	n=110	
All-cause death	28 (16.28)	7 (13.73)	21 (17.36)	0.556
Cardiovascular death	12 (6.98)	3 (5.88)	9 (7.44)	0.97
Stroke	4 (2.56)	2 (4.35)	2 (1.82)	0.722
Myocardial infarction	2 (1.28)	0 (0)	2 (1.82)	>0.99
Aortic valve reintervention	0 (0)	0 (0)	0 (0)	–
Valve thrombosis	0 (0)	0 (0)	0 (0)	–
New permanent pacemaker (n=148)*	17 (11.49)	3 (7.14)	14 (13.21)	0.449

Values are reported as mean ± standard deviation or count (%). †, patients lost to follow-up (n=16) were excluded only from the analyses of nonfatal clinical outcomes. *, patients with a pre-existing permanent pacemaker (n=9) were excluded from the analysis of new permanent pacemaker implantation. BAV, bicuspid aortic valve; TAV, tricuspid aortic valve.

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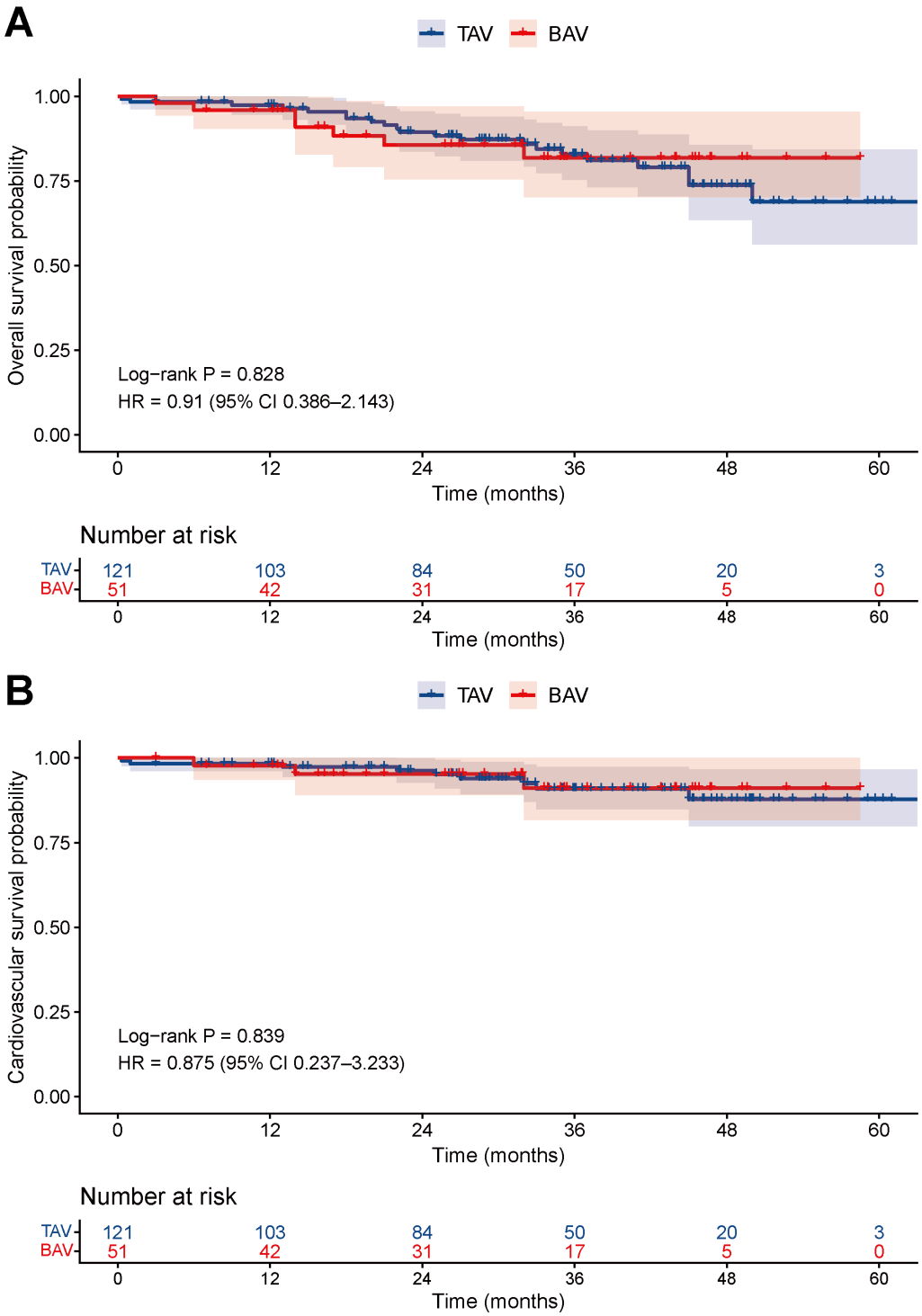


Figure 1 Kaplan-Meier curves for overall survival (A) and cardiovascular survival (B) after TAVR. Patients with BAV and TAV had comparable all-cause mortality (log-rank P=0.828; HR 0.91, 95% CI 0.386–2.143) and cardiovascular mortality (log-rank P=0.839; HR 0.88, 95% CI 0.237–3.233). Shaded areas indicate 95% confidence intervals.BAV, bicuspid aortic valve; CI, confidence interval; HR, hazard ratio; TAV, tricuspid aortic valve; TAVR, transcatheter aortic valve replacement.

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ctogenarians and beyond with BAV represent a uniquely selected population that warrants separate consideration. BAV is associated with earlier onset of valvular disease and a lifetime risk of requiring intervention exceeding two-thirds (6), yet the proportion of BAV among patients undergoing aortic valve replacement declines markedly with age—from approximately 50% before 65 years to less than 5% at 80 years or older (9). This pattern suggests that many BAV patients undergo intervention earlier in life, leaving those who reach octogenarian age with native BAV as a highly selected population. In our cohort, patients with BAV also had lower prevalences of hypertension (41.2% *vs.* 73.6%; P<0.001) and coronary artery disease (33.3% *vs.* 56.2%; P=0.006) than those with TAV, which may partly reflect this selection process, although intrinsic differences in cardiovascular risk profiles between BAV and TAV cannot be excluded. Accordingly, octogenarians and beyond presenting for TAVR with untreated native BAV may represent patients with slower disease progression, no prior indication for surgery related to significant aortopathy, or anatomy considered suitable for transcatheter treatment. These explanations remain inferential, but they highlight why outcomes from younger BAV cohorts should not be directly extrapolated to octogenarians.

Despite this selection, octogenarians with BAV in our cohort retained the characteristic anatomical complexity of bicuspid disease, including larger aortic root dimensions, greater calcification burden, and more pronounced aortic angulation than their TAV counterparts. OThese features can impair valve expansion and sealing and complicate valve sizing, underscoring the importance of detailed preprocedural CT assessment of both the annulus and the supra-annular structures that may constrain the transcatheter valve (14,15). In our cohort, larger transcatheter valves were therefore used in the BAV group (25.96 *vs.* 24.98 mm; P=0.019), consistent with their larger annular dimensions, and postdilatation was performed more frequently (23.5% *vs.* 9.9%; P=0.019), likely to optimize frame expansion and sealing. Despite the greater anatomical complexity of BAV, technical success was comparable between the 2 groups (90.2% *vs.* 94.2%; P=0.537). Detailed computer tomography (CT)-based planning, appropriate valve sizing, and more frequent postdilatation may have contributed to this result by improving valve expansion and sealing. Contemporary studies have similarly reported improved procedural outcomes in BAV with newer-generation devices (16), although technical success remains slightly lower than in TAV in some registry studies (17). The predominance of self-expanding valves in our cohort might also have facilitated adaptation to irregular BAV anatomy through sustained radial force, a hypothesis supported by the BIVOLUTX registry study (18) showing favorable hemodynamic performance of self-expanding platforms in bicuspid morphology.

The mean transvalvular gradients at discharge were similar between the BAV and TAV groups (11.0 *vs.* 10.0 mm Hg; P=0.795). Moderate or severe paravalvular leak was uncommon in both groups, and the overall distribution of leak severity did not differ significantly, although mild leak was numerically more frequent in patients with BAV. Similar findings were reported in the SWEDEHEART registry, which included 7,095 contemporary TAVR procedures and found no significant differences between BAV and TAV in postprocedural gradients or paravalvular leakage (19). Some CT-based studies further suggest that the greater geometric distortion of transcatheter valves in BAV may not necessarily impair early hemodynamic performance. In a CT registry of 175 patients with BAV treated with Evolut valves, Xiong *et al.* found that frame underexpansion and ellipticity were not associated with impaired short-term hemodynamics or leaflet

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thickening (20). Similarly, Iskandar *et al.* found deployment asymmetry to be more common in BAV than in TAV (OR, 1.88), without a corresponding adverse effect on short-term hemodynamic or procedural outcomes (21). These observations provide a possible explanation for the comparable early valve performance observed in our cohort despite the greater anatomical complexity of BAV. Discharge LVEF was lower in the BAV group (57.3% ±9.7% *vs.* 60.6% ±8.3%; P=0.023); however, baseline systolic function was also less favorable, and the change in LVEF was similar between groups. The lower postprocedural LVEF therefore likely reflects baseline ventricular differences rather than an inferior response to TAVR.

Midterm clinical outcomes were comparable between the 2 groups. At 3 years, all-cause mortality was 13.7% in the BAV group and 17.4% in the TAV group (P=0.556), while cardiovascular mortality was 5.9% and 7.4%, respectively (P=0.970). Incidence of stroke, myocardial infarction, and permanent pacemaker implantation were also similar, and no valve thrombosis or aortic valve reintervention occurred during follow-up. Kaplan-Meier analyses showed no differences in overall or cardiovascular survival, and BAV morphology was not associated with mortality in univariable Cox analysis. These results are in line with contemporary comparative studies. Makkar *et al.* reported comparable 1-year mortality and stroke after propensity matching, although early stroke and pacemaker implantation were more frequent in BAV (22). Forrest *et al.* likewise observed no difference in 1-year mortality or stroke among patients treated with contemporary self-expanding valves (23). Among patients with severe valve calcification, Sun *et al.* also found similar 1-year mortality and stroke, although pacemaker implantation remained more common in BAV (24). Longer-term data from Li *et al.* further demonstrated comparable rates of structural valve deterioration and bioprosthetic valve failure between BAV and TAV (25). Most previous cohorts, however, included patients with mean or median ages below 80 years. By focusing exclusively on patients aged 80 years or older, our study minimizes confounding related to the younger age profile typically seen in BAV populations and supports comparable midterm outcomes after TAVR in carefully selected elderly patients with BAV and TAV.

This study has several limitations. Firstly, the single-center, retrospective design is inherently subject to selection bias and unmeasured confounding. Patients aged ≥80 years with BAV who underwent TAVR may also have undergone more stringent anatomical and clinical selection than those with TAV. Secondly, the modest sample size, including only 51 patients with BAV, and the limited number of deaths, strokes, and permanent pacemaker implantations reduced statistical power. Multivariable Cox regression was therefore not performed, and residual confounding cannot be excluded. Thirdly, baseline differences between the TAV and BAV groups may have influenced survival outcomes. Finally, the study predominantly involved self-expanding valve platforms, limiting the generalizability of the findings to patients treated with balloon-expandable valves.

Conclusion

In carefully selected octogenarians and beyond undergoing TAVR, BAV was associated with greater anatomical and procedural complexity. Nevertheless, technical success, early valve hemodynamics, and 3-year clinical outcomes were comparable to those observed in patients with TAV. These findings support the consideration of TAVR

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in selected octogenarians with BAV after comprehensive Heart Team evaluation and detailed CT-based procedural planning.

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Footnote

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Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: This retrospective study was approved by the ethics committee of Fuwai Hospital, Chinese Academy of Medical Sciences (No. 2024-2428).

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