

Prognostic impact of new-onset left bundle branch block after transcatheter aortic valve replacement according to preoperative diastolic dysfunction severity

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Abstract

Background and Aims

The prognostic impact of new-onset left bundle branch block (LBBB) after transcatheter aortic valve replacement (TAVR) remains unclear. We aimed to investigate whether its impact differs according to preoperative diastolic dysfunction (DD) severity.

Methods

Among 2006 patients who underwent TAVR between January 2016 and December 2021 at eight Japanese centres, 853 were classified as having grade 1–3 DD according to the American Society of Echocardiography guidelines. Patients were stratified into grade 1 DD ($n = 348$, 40.8%) and grade 2–3 DD cohorts ($n = 505$, 59.2%). The primary endpoint was 3-year all-cause death or rehospitalization for heart failure or arrhythmia.

Results

Follow-up completeness at 3 years was 78.8% (672/853). Median age was 84 years (interquartile range, 81–87), and 511 patients (59.9%) were female. New-onset LBBB was observed in 146 patients (17.1%) and was associated with the primary endpoint (adjusted hazard ratio [aHR], 1.54; 95% confidence interval [CI], 1.10–2.17; $P = .012$). In the grade 2–3 DD cohort, new-onset LBBB was associated with the primary endpoint (aHR, 1.99; 95% CI, 1.35–2.94; $P = .001$), whereas no association was observed in the grade 1 DD cohort (aHR, 0.87; 95% CI, 0.39–1.96; $P = .74$). The association differed significantly by DD grade (P for interaction = .028).

Conclusions

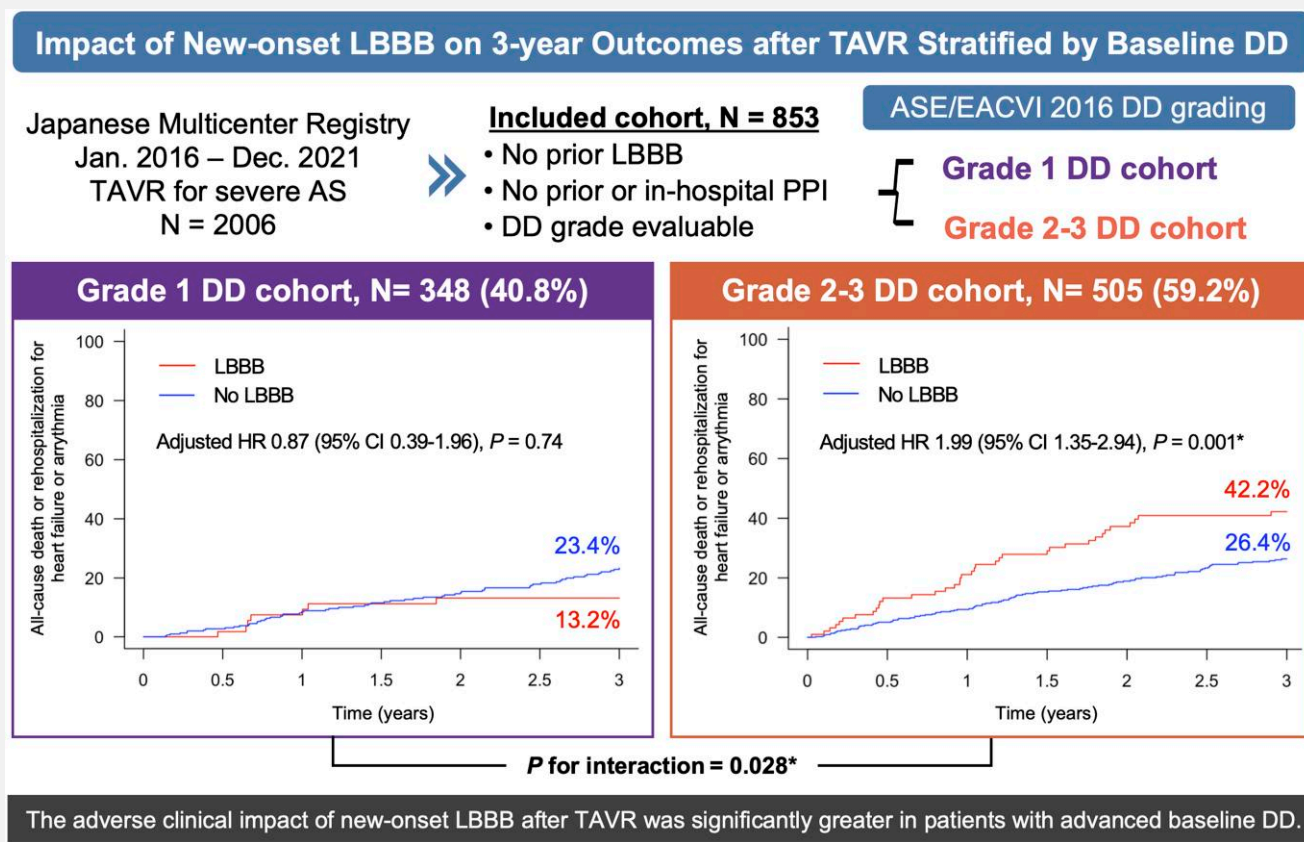
New-onset LBBB was associated with worse outcomes after TAVR, especially in grade 2–3 DD. DD grading may help identify patients more susceptible to adverse impact of new-onset LBBB.

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Graphical abstract



Keywords

Aortic stenosis • Aortic valve replacement • Diastolic function • Heart failure • Permanent pacemaker implantation

Introduction

Despite advances in transcatheter aortic valve replacement (TAVR) devices, new-onset left bundle branch block (LBBB) remains a common complication after TAVR for severe aortic stenosis (AS).¹ However, its clinical impact remains controversial.²⁻⁵ LBBB is well known to have a negative impact on systolic function.⁶⁻⁸ To date, studies investigating the clinical impact of new-onset LBBB after TAVR have focused predominantly on its effects on systolic function.

In contrast, recent studies have suggested that LBBB also adversely influences diastolic function, and the importance of managing patients with heart failure with diastolic dysfunction (DD) and concomitant LBBB has been increasingly recognized.⁹⁻¹¹ Patients with severe AS frequently exhibit concomitant DD, and advanced DD is associated with poor prognosis after TAVR.^{12,13} Although TAVR is a definitive treatment that relieves the afterload imposed by severe AS and improves DD, this beneficial effect may be attenuated by the development of new-onset LBBB. Based on this background, the prognostic impact of new-onset LBBB after TAVR may differ according to the severity of baseline DD. Therefore, this study aimed to evaluate the prognostic impact of new-onset LBBB after TAVR stratified by DD severity.

Methods

Study population

The ACTIVIST registry is a Japanese multicentre retrospective cohort that enrolled consecutive patients with severe AS who underwent either isolated surgical aortic valve replacement (SAVR) or TAVR between January 2016 and December 2021 at eight centres. Severe AS was defined as an aortic valve area $<1.0 \text{ cm}^2$, an aortic valve area index $<0.6 \text{ cm}^2/\text{m}^2$, an aortic valve mean gradient $\geq 40 \text{ mmHg}$, or an aortic valve peak velocity $\geq 4.0 \text{ m/s}$. The registry initially included 2811 consecutive patients with severe AS who underwent SAVR or TAVR, of whom 2006 underwent TAVR. Because new-onset LBBB was substantially less frequent after SAVR and baseline characteristics differed markedly between SAVR and TAVR patients, the present analysis was restricted to TAVR patients to avoid confounding by treatment modality. We excluded patients with missing echocardiographic data required to evaluate DD ($n = 236$), atrial fibrillation ($n = 228$), severe mitral regurgitation ($n = 41$), or mitral stenosis ($n = 34$). We further excluded those with in-hospital death ($n = 12$), missing preoperative electrocardiography (ECG) data ($n = 1$), pre-existing pacemaker before TAVR ($n = 70$), new permanent pacemaker implantation (PPI) before discharge after TAVR ($n = 122$), or preoperative LBBB ($n = 39$). A total of 1223 TAVR patients underwent DD assessment (Figure 1).

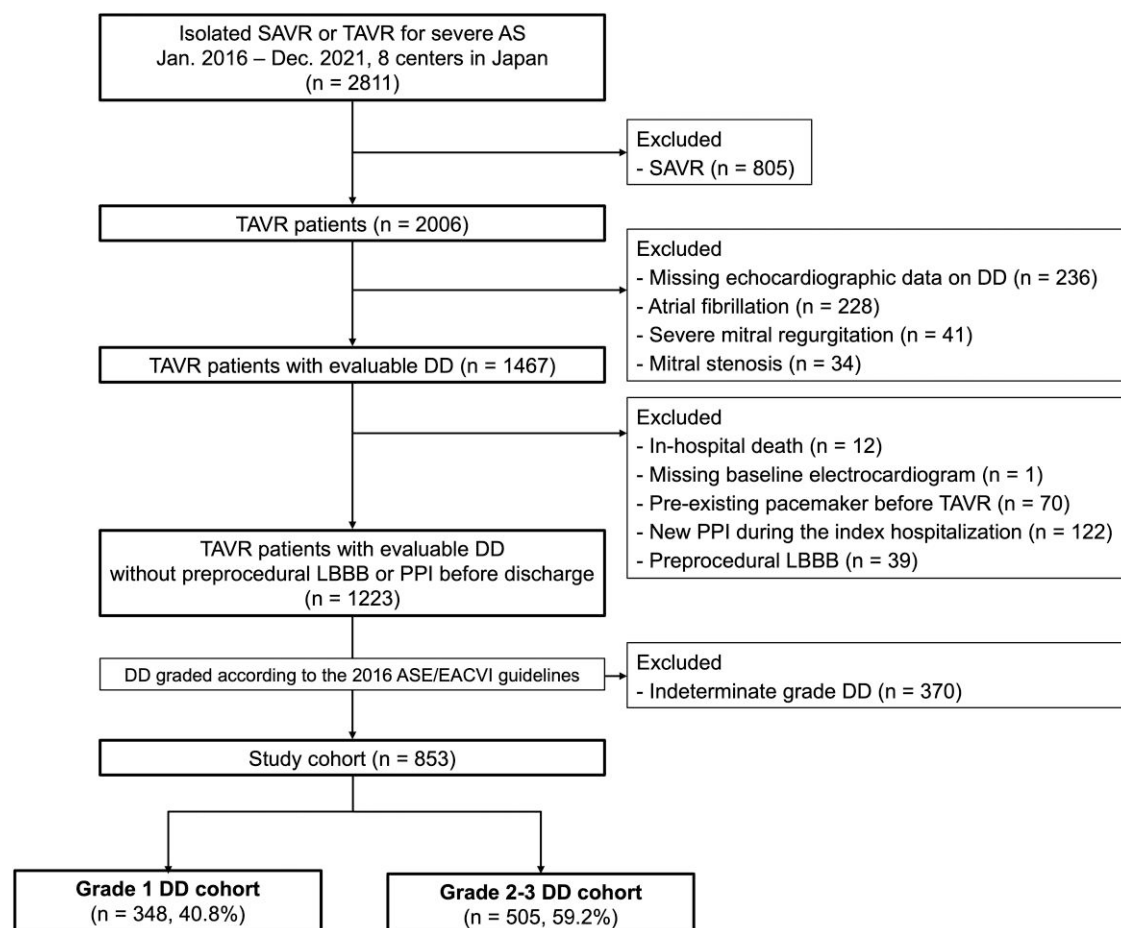


Figure 1 Flowchart of patient selection. AF, atrial fibrillation; AS, aortic stenosis; ASE/EACVI, American Society of Echocardiography/European Association of Cardiovascular Imaging; DD, diastolic dysfunction; ECG, electrocardiography; LBBB, left bundle branch block; MR, mitral regurgitation; MS, mitral stenosis; PPI, permanent pacemaker implantation; SAVR, surgical aortic valve replacement; TAVR, transcatheter aortic valve replacement

Grading diastolic dysfunction

DD was graded *post hoc* by outcome-blinded study investigators using baseline echocardiographic data according to the American Society of Echocardiography/European Association of Cardiovascular Imaging (ASE/EACVI) recommendations.¹⁴ DD was categorized into grades 1–3, with grade 1 reflecting normal left atrial pressure and grades 2 and 3 indicating elevated left atrial pressure. Patients with severe mitral regurgitation or mitral stenosis and those with missing data required for DD classification were excluded. Grade 1 DD was defined as an E/A ratio ≤ 0.8 and E velocity ≤ 50 cm/s. Grade 2 DD was defined as an E/A ratio ≥ 2 . If the E/A ratio was ≤ 0.8 with E-velocity > 50 cm/s, or if the E/A ratio was > 0.8 but < 2 , additional parameters were assessed. The 3 variables used for further DD grading and their abnormal cut-off values were as follows: average E/e' ratio > 14 , left atrial volume index > 34 mL/m², and peak tricuspid regurgitation velocity > 2.8 m/s. When all 3 variables were available, grade 1 DD was defined if 0 or 1 variable met the cut-off value, and grade 2 DD was defined if 2 or 3 variables met the cut-off values. When only 2 of the 3 variables were available, grade 1 DD was defined if neither variable met the cut-off value, grade 2 DD was defined if both variables met the cut-off values, and DD grade was classified as indeterminate if 1 variable met the cut-off value (Supplementary Figure E1).

Among 1223 TAVR patients who underwent DD assessment, 370 with indeterminate DD grade were excluded, and the remaining 853 patients

were included in the analysis. Of these, 348 (40.8%), 458 (53.7%), and 47 (5.5%) were classified as having grade 1, 2, and 3 DD, respectively. Because of the limited number of patients with grade 3 DD, patients were stratified into grade 1 DD and grade 2–3 DD cohorts for analysis (Figure 1).

Definition of LBBB

New-onset LBBB was defined as LBBB present on the hospital discharge ECG but absent on the baseline ECG. LBBB was diagnosed according to standard criteria: QRS duration ≥ 120 ms, delayed intrinsicoid deflection in leads V5 and V6, broad monophasic R waves that were often notched in leads I, V5, and V6, and secondary ST-segment and T-wave changes in the opposite direction to the major QRS deflection.¹⁵

Study endpoints

The primary study endpoint was a composite of all-cause death or rehospitalization for heart failure or arrhythmia at 3 years. The secondary endpoints were all-cause death and rehospitalization for heart failure or arrhythmia at 3 years. Heart failure rehospitalization was defined as the first rehospitalization after the index procedure for heart failure. Rehospitalization for arrhythmia was defined as the first rehospitalization for

Table 1 Baseline patient characteristics

	No LBBB N = 707	LBBB N = 146	Missing (%)	P-value
Clinical variables				
Age, years	84.0 [81.0, 87.0]	84.0 [81.0, 87.0]	0	.93
Female sex	407 (57.6)	104 (71.2)	0	.002
Body surface area, m ²	1.4 [1.3, 1.6]	1.4 [1.3, 1.5]	0	.095
Body mass index, kg/m ²	21.6 [19.4, 24.2]	21.6 [19.9, 24.5]	0	.46
STS risk score, %	5.2 [3.8, 7.9]	5.5 [4.0, 8.0]	0	.46
NYHA class III or IV	191 (27.0)	28 (19.2)	0	.048
Hypertension	541 (76.5)	120 (82.2)	0	.14
Diabetes mellitus	195 (27.6)	42 (28.8)	0	.77
Chronic kidney disease	483 (68.3)	98 (67.1)	0	.78
Dyslipidaemia	363 (51.3)	77 (52.7)	0	.76
Stroke	88 (12.5)	16 (11.0)	0	.62
Coronary artery disease	167 (23.6)	30 (20.5)	0	.42
Chronic lung disease ≥moderate	72 (10.2)	12 (8.2)	0.5	.46
Echocardiographic variables				
Left ventricular end-diastolic diameter, cm	45.0 [41.0, 49.0]	43.0 [40.0, 46.0]	0.1	.001
Left ventricular end-systolic diameter, cm	28.0 [25.0, 33.0]	26.0 [23.0, 30.0]	0.1	.002
Intraventricular septum diameter, cm	11.0 [10.0, 12.0]	11.0 [10.0, 12.0]	0.1	.14
Posterior wall diameter, cm	11.0 [10.0, 12.0]	11.0 [10.0, 12.0]	0.2	.14
Left ventricular mass index, g/m ²	123.2 [101.7, 147.8]	112.6 [94.1, 133.9]	0.2	.001
Left ventricular ejection fraction, %	66.0 [58.0, 72.0]	67.3 [61.0, 73.0]	0	.058
Left atrial diameter, cm	43.0 [38.0, 47.0]	42.0 [38.2, 46.0]	1.1	.50
Aortic valve peak velocity, m/s	4.4 [4.1, 4.8]	4.3 [4.1, 4.9]	0.2	.58
Aortic valve mean pressure gradient, mmHg	46.0 [38.0, 56.9]	44.0 [39.0, 56.0]	0	.59
Aortic valve area, cm ²	0.7 [0.6, 0.8]	0.7 [0.6, 0.8]	0.5	.22
Aortic valve area index, cm ² /m ²	0.5 [0.4, 0.6]	0.5 [0.4, 0.5]	0.5	.70
Tricuspid regurgitation peak velocity, m/s	2.60 [2.35, 2.95]	2.55 [2.29, 2.87]	9.1	.051
Aortic regurgitation ≥moderate	91 (12.9)	16 (11.0)	0	.53
Mitral regurgitation ≥moderate	65 (9.2)	12 (8.2)	0	.71
Tricuspid regurgitation ≥moderate	37 (5.2)	8 (5.5)	0	.90
Mitral E velocity, m/s	0.7 [0.5, 0.9]	0.7 [0.6, 1.0]	0	.72
Mitral A velocity, m/s	1.0 [0.8, 1.2]	1.1 [0.9, 1.3]	0	.007
Mitral E/A ratio	0.7 [0.5, 0.9]	0.7 [0.5, 0.8]	0	.15
Average E/e' ratio	17.1 [12.8, 23.7]	18.2 [13.2, 25.5]	6.0	.25
DD grade				.48
Grade 1	294 (41.6)	54 (37.0)	0	
Grade 2	373 (52.8)	85 (58.2)	0	
Grade 3	40 (5.7)	7 (4.8)	0	

Values are n (%), or median (interquartile range). Bold indicates parameters that are significantly different ($P < .05$).

DD, diastolic dysfunction; LBBB, left bundle branch block; NYHA, New York Heart Association; STS, Society of Thoracic Surgeons.

Table 2 Procedural and postoperative data

	No LBBB N = 707	LBBB N = 146	Missing (%)	P-value
Procedural variables				
Emergent procedure	9 (1.3)	2 (1.4)	0	1.0
Procedural time, min.	71.0 [59.0, 89.5]	69.0 [58.0, 91.0]	0	.49
Valve platform and model				
Balloon-expandable valve	428 (60.5)	72 (49.3)	0	.012
SAPIEN XT	23 (3.3)	3 (2.1)	0	
SAPIEN 3	405 (57.3)	69 (47.3)	0	
Self-expandable valve	275 (38.9)	73 (50.0)	0	.013
ACURATE neo	4 (0.6)	0 (0.0)	0	
CoreValve	100 (14.1)	27 (18.5)	0	
Evolut R	78 (11.0)	32 (21.9)	0	
Evolut PRO/PRO+	91 (12.9)	14 (9.6)	0	
Portico	2 (0.3)	0 (0.0)	0	
Mechanically expandable valve	4 (0.6)	1 (0.7)	0	.86
Lotus Edge	4 (0.6)	1 (0.7)	0	
Post-procedural echocardiographic variables				
Left ventricular ejection fraction, %	66.9 [61.0, 72.0]	67.0 [61.2, 71.0]	0.2	.63
Left ventricular mass index, g/m ²	117.7 [96.0, 139.7]	112.5 [93.7, 138.5]	0.2	.19
Aortic valve mean pressure gradient, mmHg	10.0 [7.0, 13.0]	9.0 [6.0, 12.0]	0.4	.11
Effective orifice area, cm ²	1.7 [1.4, 2.0]	1.7 [1.4, 2.0]	5.2	.47
Effective orifice area index, cm ² /m ²	1.1 [1.0, 1.4]	1.2 [1.0, 1.4]	5.2	.12
Prosthesis-patient mismatch ≥moderate	83 (12.4)	15 (10.9)	5.2	.62
Paravalvular leak ≥moderate	22 (3.1)	5 (3.4)	0.4	.80

Values are n (%), or median (interquartile range). Bold indicates parameters that are significantly different ($P < .05$).

any arrhythmia requiring medical intervention, such as catheter ablation or PPI.

Ethical statement

The study was conducted in accordance with the principles of the Declaration of Helsinki. The Clinical Research Ethics Committee of Osaka University Hospital approved the study protocol (Approval No. 20222 [T2]; Approval Date: 15 December 2021).

Statistical analysis

Continuous variables are presented as medians (interquartile ranges) and categorical variables as counts and percentages. Normality was assessed using the Shapiro–Wilk test. Group differences were assessed using the Wilcoxon rank-sum test, χ^2 test, or Fisher's exact test, as appropriate. Follow-up was censored at 3 years. The primary endpoint and all-cause death were analysed using the Kaplan–Meier method, whereas rehospitalization for heart failure or arrhythmia and post-discharge PPI were analysed using cumulative incidence functions with all-cause death as a competing event. Cox proportional hazards models were used for the primary endpoint and all-cause death, and Fine–Gray models for rehospitalization for heart failure or arrhythmia. Multivariable adjustment was based on clinical relevance and previous studies. The interaction between new-onset LBBB and DD cohort was assessed in multivariable models using a multiplicative interaction term. A two-sided $P < .05$ was considered statistically significant.

All analyses were performed using JMP 18.0 (SAS Institute Inc., Cary, NC, USA) or R (version 4.4.2; R Foundation for Statistical Computing, Vienna, Austria).

Results

The 3-year follow-up rate was 78.8% (672/853). The median age was 84 years (interquartile range, 81–87 years), and 511 patients (59.9%) were female. Among 853 patients, new-onset LBBB occurred in 146 (17.1%). Baseline characteristics according to new-onset LBBB are summarized in [Table 1](#). Compared with patients without new-onset LBBB, those with new-onset LBBB were more frequently female. Procedural characteristics and post-procedural echocardiographic data are presented in [Table 2](#). The use of a self-expandable valve was more frequent in patients with new-onset LBBB.

Three-year clinical outcomes in the overall cohort

During the 3-year follow-up period, all-cause death occurred in 143 patients (16.8%), and rehospitalization for heart failure or arrhythmia in 78 patients (9.1%). New-onset LBBB was associated with a higher incidence of the primary endpoint (adjusted hazard ratio [aHR], 1.54; 95%

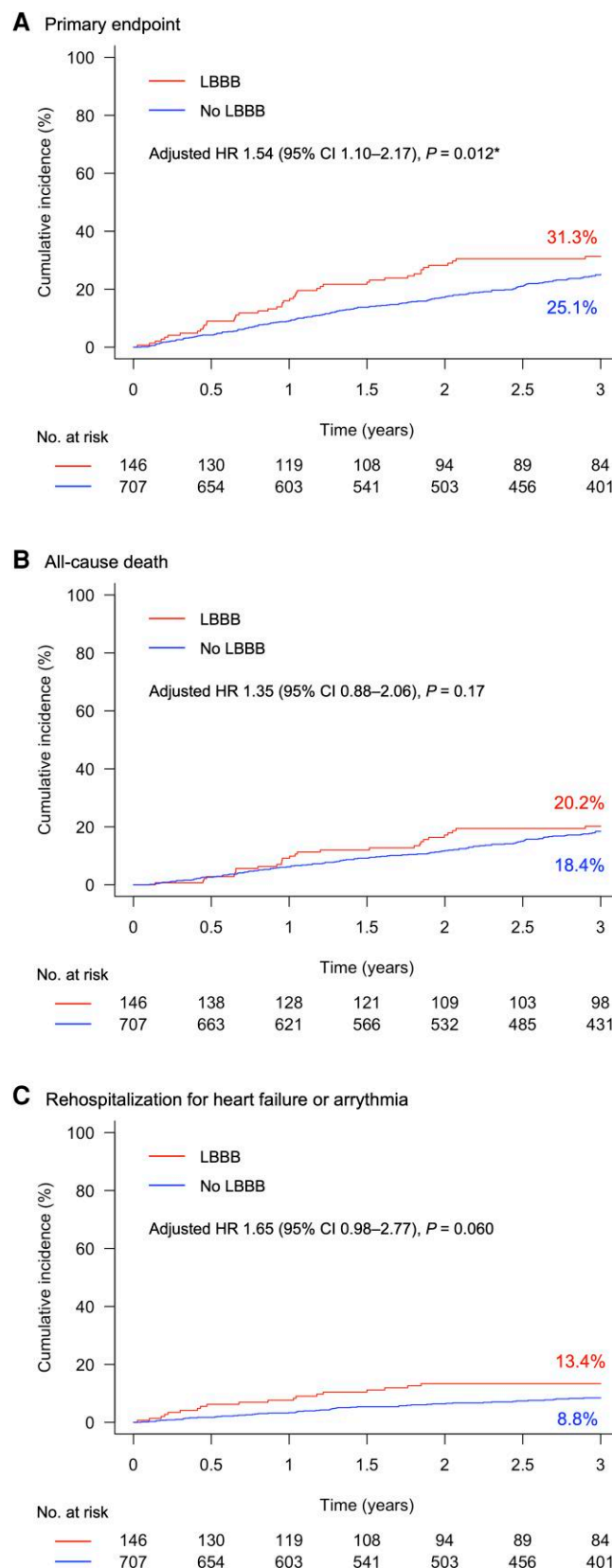


Figure 2 Three-year clinical outcomes in overall cohort. Kaplan–Meier curves are shown for all-cause death or rehospitalization for heart failure or arrhythmia (A) and all-cause death (B). The cumulative incidence function for rehospitalization for heart failure or arrhythmia is shown with all-cause death treated as a competing event (C). All curves are stratified by new-onset LBBB. CI, confidence interval; HR, hazard ratio; LBBB, left bundle branch block

Table 3 Three-year clinical events according to new-onset LBBB status

	No LBBB N = 707	LBBB N = 146
All-cause death	115 (16.3)	28 (19.2)
Rehospitalization for heart failure	50 (7.1)	12 (8.2)
Rehospitalization for arrhythmia	8 (1.1)	8 (5.5)
Permanent pacemaker implantation after discharge	5 (0.7)	6 (4.1)
Catheter ablation for tachyarrhythmia	1 (0.1)	2 (1.4)
Electrical cardioversion for tachyarrhythmia	2 (0.3)	0 (0.0)

Values are n (%). LBBB, left bundle branch block.

confidence interval [CI], 1.10–2.17; $P = .012$, Figure 2A), whereas no significant association was observed with all-cause death (aHR, 1.35; 95% CI, 0.88–2.06; $P = .17$, Figure 2B) or rehospitalization for heart failure or arrhythmia (aHR, 1.65; 95% CI, 0.98–2.77; $P = .060$, Figure 2C). Detailed 3-year clinical events are summarized in Table 3.

Three-year clinical outcomes stratified by diastolic dysfunction grade

The 3-year cumulative incidence of the primary endpoint increased stepwise according to DD grade: 21.6% in patients with grade 1 DD, 28.1% in those with grade 2 DD, and 38.3% in those with grade 3 DD (log-rank $P < .001$; Supplementary Figure E2A). Patients with indeterminate DD grade had a 3-year cumulative incidence of 24.3%, intermediate between grade 1 and grade 2 DD (Supplementary Figure E2B).

Association of new-onset LBBB with outcomes according to diastolic dysfunction severity

In the grade 1 DD cohort, new-onset LBBB was not associated with the primary endpoint, all-cause death, or rehospitalization for heart failure or arrhythmia (aHR, 0.87; 95% CI, 0.39–1.96; $P = .74$ for the primary endpoint; aHR, 1.14; 95% CI, 0.47–2.76; $P = .77$ for all-cause death; and aHR, 0.33; 95% CI, 0.05–2.28; $P = .26$ for rehospitalization for heart failure or arrhythmia; Figs. 3A–C).

In the grade 2–3 DD cohort, new-onset LBBB was associated with a higher incidence of the primary endpoint, all-cause death, and rehospitalization for heart failure or arrhythmia (aHR, 1.99; 95% CI, 1.35–2.94; $P = .001$ for the primary endpoint; aHR, 1.66; 95% CI, 1.01–2.73; $P = .047$ for all-cause death; and aHR, 2.06; 95% CI, 1.16–3.67; $P = .014$ for rehospitalization for heart failure or arrhythmia; Figs. 3A–C). The association between new-onset LBBB and the primary endpoint differed according to DD grade (P for interaction = .028, Table 4).

Post-discharge permanent pacemaker implantation

Eleven patients (1.3%) required PPI after discharge. The 3-year cumulative incidence of post-discharge PPI was highest in patients with new-onset LBBB in the grade 2–3 DD cohort, followed by those without new-onset LBBB in the same cohort, whereas no events occurred in either group in the grade 1 DD cohort (6.8%, 1.3%, 0%, and 0%, respectively; Gray's $P < .001$; Figure 4).

Discussion

The main findings of this study were as follows: (1) 17.1% of patients had new-onset LBBB at discharge after TAVR; (2) new-onset LBBB was associated with the primary endpoint in the grade 2–3 DD cohort, but not in the grade 1 DD cohort; and (3) a significant interaction was observed between new-onset LBBB and DD grade for the primary endpoint.

Incidence and pathophysiological impact of new-onset LBBB after TAVR

New-onset LBBB occurs more frequently after TAVR than after SAVR. The incidence after SAVR has been reported to be 4.0%–7.8%,^{16–18} whereas after TAVR it is substantially higher, ranging from 18% to 65% with self-expandable valves and 4%–30% with balloon-expandable valves.¹⁹ In the present cohort including both self-expandable and balloon-expandable valves, the incidence of new-onset LBBB was 17.1%, consistent with previous reports, as was the higher prevalence of self-expandable valves in the new-onset LBBB group.

LBBB induces intraventricular dyssynchrony, characterized by early septal contraction and delayed activation of the lateral wall. This mechanical discoordination reduces contractile efficiency, impairs left ventricular relaxation and filling, and promotes adverse left ventricular remodelling. Contractile dyssynchrony prolongs isovolumic contraction and relaxation, thereby shortening diastolic filling time and increasing left ventricular filling pressure, particularly during tachycardia.^{20–22} Over time, these alterations may increase diastolic stiffness and further exacerbate DD.^{10,11} In a cardiovascular magnetic resonance study of patients undergoing TAVR, Dobson et al. showed that TAVR-induced LBBB was associated with significant inter- and intraventricular dyssynchrony at 6 months and less favourable left ventricular reverse remodelling.²³

Prognostic impact of new-onset LBBB according to baseline DD

Previous studies of new-onset LBBB after TAVR have primarily focused on systolic function. Although several reports have shown that patients who develop new-onset LBBB experience a decrease in left ventricular ejection fraction (LVEF), the reduction is relatively small, ranging only from 1.4% to 3.7%.^{2,4,5} In patients with reduced LVEF, impaired recovery of systolic function caused by new-onset LBBB may account for worse outcomes after TAVR.^{4,5,24} In contrast, in patients with preserved LVEF, who constitute the majority of patients with severe AS, such minimal reductions are unlikely to fully explain the increased risk of adverse cardiac events.

Heart failure with preserved ejection fraction, characterized primarily by DD, is common in severe AS, affecting approximately 40–55% of patients.^{25–27} In our cohort, advanced DD (ASE/EACVI DD grade ≥ 2) was present in almost 60% of patients. Pre-procedural DD is an established predictor of outcomes after TAVR,^{12,13} and limited improvement in DD after TAVR has been associated with worse prognosis.¹² In this study, new-onset LBBB after TAVR was associated with an approximately twofold higher risk of all-cause death or rehospitalization for heart failure or arrhythmia among patients with advanced DD, whereas no clear association was observed among those with grade 1 DD. These findings suggest that baseline DD severity may modify the association between new-onset LBBB and post-TAVR outcomes. Although the underlying mechanisms remain uncertain, the inability of the left ventricle to recover diastolic function in the presence of LBBB may partly account for this differential risk. However, because postoperative DD grade was not assessed in this study and standardized echocardiographic criteria for DD grading in patients with LBBB are lacking,¹⁴ the impact of new-onset LBBB on diastolic

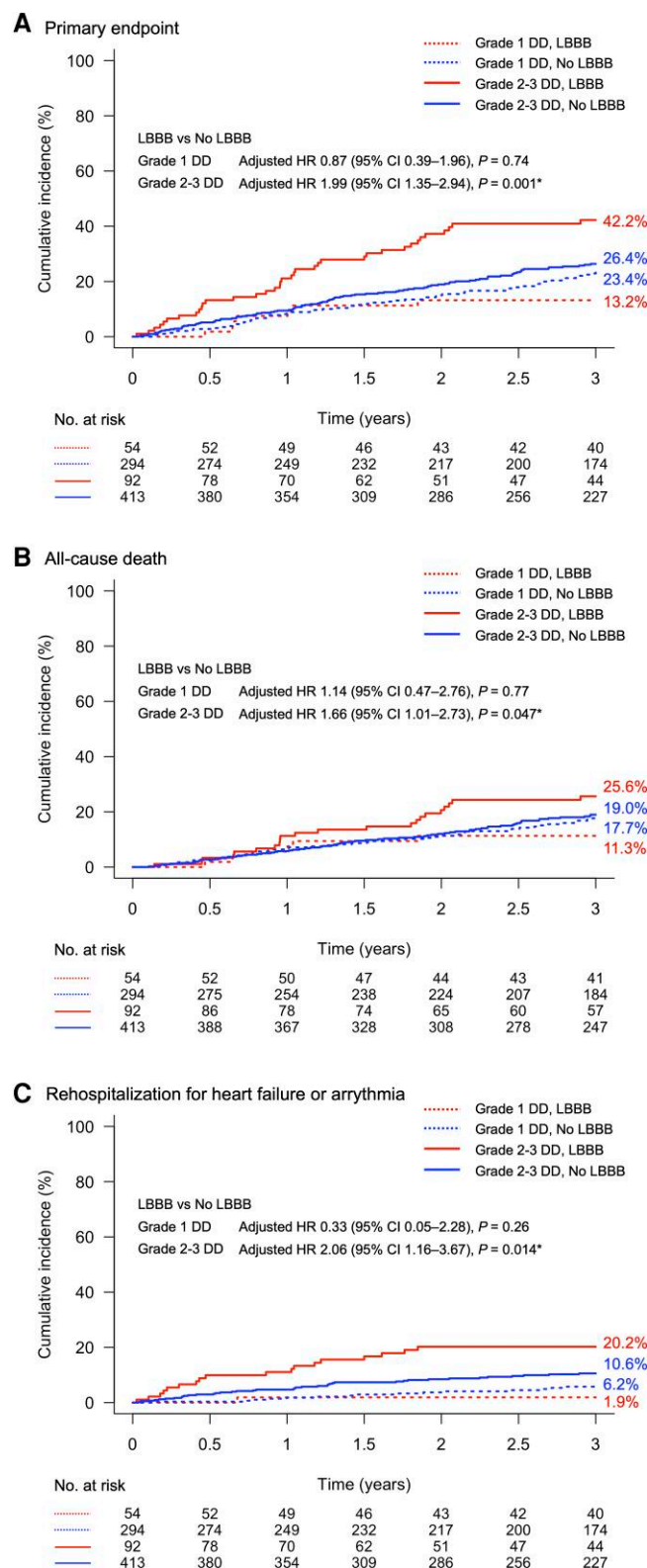


Figure 3 Three-year clinical outcomes stratified by diastolic dysfunction grade. Kaplan–Meier curves are shown for all-cause death or rehospitalization for heart failure or arrhythmia (A) and all-cause death (B). The cumulative incidence function for rehospitalization for heart failure or arrhythmia is shown with all-cause death treated as a competing event (C). All curves are stratified by DD grade and new-onset LBBB. CI, confidence interval; DD, diastolic dysfunction; HR, hazard ratio; LBBB, left bundle branch block

Table 4 Impact of new-onset LBBB on three-year clinical outcomes

3-Year follow-up	HR (95% CI)	P value	Adjusted HR (95% CI)	P value	P value for interaction
All-cause death or rehospitalization for heart failure or arrhythmia					
Overall cohort	1.39 (1.00–1.94)	.052	1.54 (1.10–2.17)	.012	.028
Grade 1 DD vs Grade 2–3 DD cohort					
Grade 1 DD cohort	0.57 (0.26–1.26)	.16	0.87 (0.39–1.96)	.74	
Grade 2–3 DD cohort	1.90 (1.30–2.77)	<.001	1.99 (1.35–2.94)	.001	
All-cause death					
Overall cohort	1.16 (0.76–1.75)	.49	1.35 (0.88–2.06)	.17	.31
Grade 1 DD vs Grade 2–3 DD cohort					
Grade 1 DD cohort	0.66 (0.28–1.54)	.34	1.14 (0.47–2.76)	.77	
Grade 2–3 DD cohort	1.45 (0.90–2.35)	.13	1.66 (1.01–2.73)	.047	
Rehospitalization for heart failure or arrhythmia					
Overall cohort	1.65 (0.98–2.79)	.061	1.65 (0.98–2.77)	.060	.093
Grade 1 DD vs Grade 2–3 DD cohort					
Grade 1 DD cohort	0.32 (0.04–2.42)	.30	0.33 (0.05–2.28)	.26	
Grade 2–3 DD cohort	2.12 (1.21–3.70)	.009	2.06 (1.16–3.67)	.014	

Cox proportional hazards models were used for the primary endpoint and all-cause death, whereas rehospitalization for heart failure or arrhythmia was analysed using a Fine–Gray subdistribution hazards model, with all-cause death treated as a competing event. The multivariable models included age, sex, body mass index, diabetes mellitus, dyslipidaemia, chronic kidney disease, hypertension, NYHA class III or IV, coronary artery disease, left ventricular ejection fraction, aortic valve mean pressure gradient, and use of a self-expandable valve; in the overall cohort, grade 2–3 DD was further included. Bold indicates parameters that are significantly different ($P < .05$). CI, confidence interval; DD, diastolic dysfunction; HR, hazard ratio; LBBB, left bundle branch block.

improvement after TAVR remains unclear. Further studies using imaging modalities other than echocardiography, such as cardiac magnetic resonance imaging, are warranted to elucidate the pathophysiologic mechanisms by which LBBB affects diastolic properties.²³

Post-discharge pacemaker implantation

In addition, this study examined the incidence of PPI according to new-onset LBBB status. Patients with new-onset LBBB remain at increased risk of PPI not only in the early postoperative period but also after hospital discharge.^{2,4,5} A prospective study of patients with new-onset LBBB treated with the Evolut R/PRO valve demonstrated bradyarrhythmic events in 37.5% of cases and a 12.5% rate of PPI within 2 years.²⁸ These findings underscore the importance of long-term rhythm surveillance in patients with new-onset LBBB after TAVR. In the present study, post-discharge PPI occurred only in patients with advanced DD and was more frequent in those with new-onset LBBB. Therefore, new-onset LBBB after TAVR may warrant closer post-discharge rhythm monitoring, particularly in patients with advanced DD.

Clinical implications

The findings of the present study suggest that the assessment of preoperative DD may help better understand the prognostic implications of new-onset LBBB after TAVR. Preoperative identification of patients with advanced DD may identify those who are particularly susceptible to the adverse effects of new-onset LBBB and who may therefore require closer post-procedural surveillance. In addition, prevention of new-onset LBBB may be especially important in this population. Given the association between self-expandable valves and new-onset LBBB observed in the present cohort, careful valve selection, including the use of balloon-expandable valves when anatomically and clinically

appropriate, as well as implantation depth optimization and avoidance of excessive prosthesis oversizing, may represent potential preventive strategies. However, advanced DD alone should not be considered an indication for a specific valve platform, and valve selection should remain individualized. Further studies are warranted to determine whether such LBBB-prevention strategies can improve outcomes in patients with advanced DD.

Limitations

This study had several limitations. First, because it had a retrospective design, it was subject to selection bias and unmeasured confounding factors. Second, the QRS duration in patients with LBBB was unavailable, limiting our ability to account for the severity of electrical dyssynchrony, which may have influenced the outcomes. Third, myocardial mechanics data, including global longitudinal strain and dyssynchrony indices, were not systematically available. Therefore, we could not determine whether myocardial mechanics changes after new-onset LBBB contributed to clinical outcomes. Fourth, information regarding the use of cardiac resynchronization therapy was not collected despite its potential impact on clinical outcomes. Fifth, approximately 30% of patients who underwent DD assessment were classified as having indeterminate DD grade and were excluded from the analysis because definitive DD grading was not possible. This exclusion may have introduced selection bias and limited the generalizability of our findings. In addition, the proportion of patients classified as having grade 3 DD was lower than expected.¹² Although this may partly reflect the multicentre retrospective design based on routine echocardiographic data rather than standardized core laboratory assessment, the exact reason could not be determined from the present registry. Sixth, because arrhythmic events were defined as rehospitalization for arrhythmia, asymptomatic or minimally symptomatic arrhythmias that did not lead to hospitalization may have been under-ascertained. Thus, our

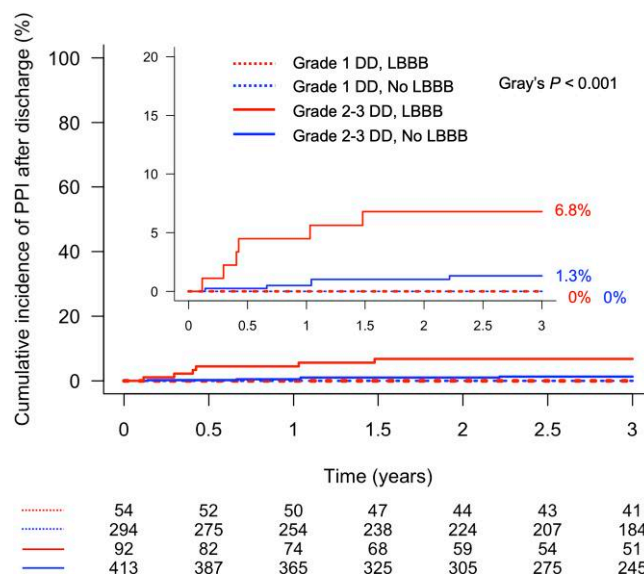


Figure 4 Post-discharge permanent pacemaker implantation. The cumulative incidence function for post-discharge PPI is shown for the 4 groups according to DD cohort and new-onset LBBB status, with all-cause death treated as a competing event. DD, diastolic dysfunction; LBBB, left bundle branch block; PPI, permanent pacemaker implantation

findings reflect clinically apparent arrhythmia-related rehospitalizations rather than the overall burden of post-TAVR arrhythmias. Finally, post-operative DD grade could not be assessed because DD grading is challenging in patients with LBBB. Mechanical dyssynchrony can alter mitral annular velocities and may lead to an apparent increase in E/e', potentially resulting in overestimation of LV filling pressure. Therefore, the impact of new-onset LBBB on diastolic improvement after TAVR remains unclear.

Conclusions

In this multicentre retrospective registry study, new-onset LBBB after TAVR was associated with poorer prognosis in patients with baseline grade 2–3 DD, whereas this adverse impact was not evident in patients with grade 1 DD. Further research is required to elucidate the mechanisms underlying the detrimental effects of new-onset LBBB in TAVR patients with advanced DD.

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Author Contributions

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Supplementary Data

Supplementary data are available at *European Heart Journal – Valvular and Structural Heart Disease* online.

Declarations

Data Availability

The data underlying this article are not publicly available due to ethical restrictions and patient privacy concerns. De-identified data may be available from the corresponding author upon reasonable request and with appropriate institutional approval.

Disclosure of Interest

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Ethical Approval

Ethical Approval was not required.

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