Original Article

Clinical Characteristics, Incidence, and Outcomes of Transcatheter Aortic Valve Implantation Stratified by New-onset Left Bundle Branch Block: A Single-center Pilot Study

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Abstract

Background: Clinical outcomes after transcatheter aortic valve implantation (TAVI) patients have not been reported in the Gulf region. **Objectives**: To define the baseline electrocardiographic (ECG), echocardiographic, and computed tomographic findings of patients undergoing TAVI and analyze the predictors of developing new-onset persistent left bundle branch block (LBBB). **Methods**: Patients with severe aortic stenosis who underwent TAVI between 2013 and 2021 at the Sabah Al-Ahmed Cardiac Centre in Al-Amiri Hospital in the state of Kuwait were included in this study. Baseline characteristics, electrocardiography (ECG), echocardiography, and preprocedural computed tomography data were extracted. The primary outcome was new-onset LBBB. **Results**: A total of 61 patients were included (65.6% females; mean age: 73.5 ± 9 years; baseline ejection fraction: 55.5% ± 9.7%). Of these, 18 developed new-onset LBBB. Those who developed LBBB tended to have lower ejection fraction (52.5 ± 9.6 vs. 56.8% ± 9.5%; $P = 0.116$). Those who developed LBBB were more likely to develop 1st degree atrioventricular block post-TAVI ($P = 0.001$). **Conclusion**: The incidence of new-onset LBBB post-TAVI was 29.5%. The new-onset LBBB group was more likely to develop conduction abnormalities requiring permanent pacemaker implantation.

Keywords: Atrioventricular block, left bundle branch block, transcatheter aortic valve implantation

Introduction

Transcatheter aortic valve implantation (TAVI) is a new procedure used as an alternative therapy for the treatment of severe symptomatic aortic stenosis for patients with intermediate and high surgical risk or inoperable patients.[1-4] Although TAVI is a safe procedure, complications can develop post- and perioperatively, mainly with the development of conduction abnormalities, including new-onset persistent left bundle branch block (LBBB), with an incidence between 30% and 50%.[1,2] This complication is explained by the proximity of the aortic valve to the conduction system, namely, the left bundle branch. During the procedure, mechanical stress is exerted from the prosthesis skirt on the interventricular septum, leading to conduction dysfunction.[1,5] In terms of outcomes, patients who develop new-onset LBBB are at higher risk of requiring permanent pacemaker implantation (PPI) because of the progression to complete

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atrioventricular (AV) heart block.[1,5,6] In addition, the left ventricle ejection fraction of the new-onset LBBB group failed to increase due to suboptimal left ventricular remodeling, ultimately leading to heart failure.[6-10] As a result, patients who develop new-onset LBBB post-TAVI have a higher risk of mortality than the TAVI group without new-onset LBBB.[1,2,8]

Therefore, the aim of our study was to analyze the incidence and predictors of new-onset persistent LBBB development after TAVI.

Methods

Study population and design

This was a retrospective study. The study included 61 severe symptomatic aortic stenosis patients who underwent TAVI in Sabah Al-Ahmed Cardiac Centre in Al-Amiri Hospital in the State of Kuwait from 2018 to 2021. Retrospectively collected data were used to define this study population using electrocardiography, echocardiography, and preprocedural computed tomography (CT) data.[11] We stratified patients into two subgroups: a group with new-onset LBBB and a group without new-onset LBBB post-TAVI. The type of TAVI prosthesis used is the balloon expandable Edwards SAPIEN valve (ESV) through the transfemoral route. The bioprosthesis sizes used in implantation were 24 mm and 25 mm valves. The study protocol was approved by the Ethical Committee at the Ministry of Health.

Electrocardiography, echocardiography, and computed tomography

Electrocardiography records from all patients were retrospectively collected and analyzed, including baseline and post-TAVI ECG. Baseline ECG was assessed for sinus rhythm and preexisting conduction abnormalities. Post-TAVI ECG was assessed for new conduction abnormalities and PPI. Transthoracic echocardiography data were collected at baseline and evaluated for ejection fraction, left ventricle hypertrophy, other valve disorders, left ventricular dysfunction, and aortic dimensions. Preprocedure CT images were collected and analyzed for aortic valve dimensions.

Statistical analysis

Continuous variables were expressed as the mean and standard deviation and were further analyzed using linear model ANOVA. Categorical variables were displayed as frequencies and percentages, and significant differences were analyzed using Pearson's Chi-square test. Statistical significance was measured as a $P < 0.05$.

Results

Baseline characteristics

The majority of our study population was elderly females (65.6%), with a mean age of 73.5 ± 9 years. All patients were implanted with an ESV with a mean size of 24.8 ± 2 mm, and patients who developed new-onset LBBB post-TAVI had a slightly larger implant with a mean size of 25.3 ± 1.9 mm than the group without new-onset LBBB ($P = 0.157$).

Other patient characteristics were explored, including body mass index and cardiovascular history of hypertension, smoking, myocardial infarction, and stroke, all of which showed no association with LBBB development post-TAVI. Table 1 shows the baseline characteristics of the 61 patients included in the study. Medication records show that statin usage was common, with a prevalence of 34/61 (54.1%), mostly used by the new-onset LBBB Group 15/18 (83.3%, $P = 0.005$), suggesting that this group was more likely to have dyslipidemia. Other prevalent medications included aspirin 32/61 (52.5%) and bisoprolol 36/61 (59%). Table 2 shows a detailed list of medications taken by our study population.

Echocardiographic details and baseline electrocardiography

Table 3 illustrates the baseline ECG and echocardiography details before TAVI. Overall, baseline echocardiography showed that all patients had a mean ejection fraction of 55.5% ± 9.7%, and a slightly lower mean ejection fraction of 52.5% ± 9.6% was seen in the new-onset LBBB group than in the group without new onset LBBB (56.8% ± 9.5%, $P = 0.116$). The left ventricular hypertrophy was seen in 49/61 (80.3%) patients, with similar incidences in the groups with and without new-onset LBBB, 15/18 (83.3%) and 34/41 (79.1%), respectively ($P = 0.702$). Other valve disorders were assessed, including aortic and tricuspid regurgitation, with incidences of 27.9% and 42.6%, respectively ($P = 0.214$, $P = 0.451$). Systolic dysfunction was observed in 9/61 patients (14.8%), with a higher incidence in the new-onset LBBB group (5/18, 27.8%, $P = 0.063$). Diastolic dysfunction was seen in 42/61 patients (68.9%), occurring at a higher rate in the new-onset LBBB group (15/18, 83.3%, $P = 0.114$). The mean peak gradient, aortic velocity, and aortic valve area were 74.2 ± 17.5 mmHg, 4.3 ± 0.5 m/s, and 0.8 ± 0.2 cm^2, respectively ($P = 0.645$, $P = 0.384$, $P = 0.087$).

Baseline ECG of patients showed normal sinus rhythm in 40/61 (66.7%) higher in group without new-onset persistent LBBB 31/41 (72.1%). Atrial fibrillation was seen in 16/61 (26.7%), preexisting LBBB was seen in 3/61 (5%), and AV nodal re-entrant tachycardia was seen in a single new-onset LBBB patient. Overall, none of the abovementioned data demonstrated any association with new-onset LBBB development post-TAVI.

Computed tomography details

Table 4 illustrates the CT details and aortic valve dimensions. Overall, the mean maximum leaflet length was 17 ± 3.7 mm in all patients, and a slightly longer leaflet (mean maximum leaflet length = 17.5 ± 2 mm) was seen in new-onset LBBB patients ($P = 0.641$). The majority of patients had severe calcification (31/61, 50.8%, $P = 0.218$). The mean short axis and long axis diameters were 21.8 ± 2.5 mm and 26.8 ± 3.3 mm, respectively ($P = 0.782$, 0.495). The mean annular circumference and annular area were 76.8 ± 7.6 mm and 464.7 ± 100.3 mm^2, respectively ($P = 0.774$,

P = 0.891). The mean sinotubular junction diameter was 25.8 ± 3.5 mm (P = 0.707). The height of valsalva and area of sinus valsalva were 22 ± 4 mm and 742.2 ± 204.6 mm^2, respectively (P = 0.713, 0.239). Last, the distances to the left coronary artery and right coronary artery were 12.9 ± 2.8 mm and 15 ± 3.4 mm, respectively (P = 0.611, 0.709). All the above-mentioned data showed no association with new-onset LBBB development post-TAVI.

Posttranscatheter aortic valve implantation outcomes

Postprocedural records and ECGs were collected and are illustrated in Table 5. A total of 7/61 (11.5%) underwent PPI, 4/43 (9.3%) were without new-onset LBBB patients, and 3/18 (16.7%) were new-onset LBBB patients (P = 0.063). Single mortality occurred in a patient with new-onset LBBB (mortality rate = 1.6%, P = 0.119), where the LBBB progressed to 2:1 heart block, cardiogenic shock, and asystole.

Postprocedural ECG records were assessed for new-onset conduction abnormalities. The incidence of the right bundle branch block was 4/61 (6.6%), and the majority occurred in the group without new-onset LBBB 3/43 (7%, P = 0.838). The incidence of 1st degree AV block was 4/61 (6.6%), exclusively in the new-onset LBBB patients (P = 0.001). In addition, the total incidence of complete heart block was 5/61 (8.2%), 4/43 (9.3%) in the group without new-onset LBBB and 1/18 (5.6%) in the new-onset LBBB group (P = 0.627). Furthermore, 2nd degree AV block and bifasicular block had a single case each (1.6%). The incidence of atrial fibrillation was 4/61 (6.6%) in the majority of patients in the group without new-onset LBBB (3/43, 7%).

Discussion

In our study, the incidence of new-onset LBBB post-TAVI was 18/61 (29.5%). Possible predictors of this complication were explored by analyzing the following: First, patient characteristics, including age, sex, and cardiovascular history; second, echocardiography, baseline, and post-TAVI ECG, and CT of aortic valve dimensions were assessed and showed no association with new-onset LBBB development. In terms of hospital outcomes, the total incidence of PPI was 9/61 (14.8%), and the incidence was higher in the new-onset

Table 1: Baseline characteristics

Baseline characteristics	*n* (%) unless specified otherwise			*P*
	Total (*n*=61)	With LBBB (*n*=18)	Without LBBB (*n*=43)	
Age (years), mean±SD	73.5±9.0	70.4±8.8	74.7±8.9	0.088
Female gender	40 (65.6)	13 (72.2)	27 (62.8)	0.48
BMI (kg/m^2), mean±SD	32.6±8.1	32.3±6.7	32.7±8.9	0.872
Cardiovascular history				
Hypertension	52 (85.2)	14 (77.8)	38.0 (88.4)	0.287
Diabetes	41 (67.2)	12 (66.7)	29 (67.4)	0.953
Dyslipidemia	28 (45.9)	11 (61.1)	17 (39.5)	0.123
Smoking	4 (6.6)	1 (5.6)	3 (7)	0.838
Coronary artery disease	35 (57.4)	13 (72.2)	22 (51.2)	0.129
Past history of myocardial infarctions	13 (21.3)	6 (33.3)	7 (16.3)	0.138
PCI	25 (41)	8 (44.4)	17 (39.5)	0.722
CABG	4 (6.6)	1 (5.6)	3 (7)	0.838
Stroke	6 (9.8)	1 (5.6)	5 (11.6)	0.468
Pulmonary hypertension	9 (14.8)	3 (16.7)	6 (14)	0.785
Chronic kidney disease	17 (27.9)	5 (27.8)	12 (27.9)	0.992
NYHA				
Class 1	46 (76.7)	14 (77.8)	32 (76.2)	0.89
Class 2	7 (11.7)	2 (11.1)	5 (11.9)	
Class 3	5 (8.3)	1 (5.6)	4 (9.5)	
Class 4	2 (3.3)	1 (5.6)	1 (2.4)	
Etiology: Degenerative	52 (85.2)	15 (83.3)	37 (86)	0.785
EuroScore, mean±SD	5.8±5.4	5.8±1.8	5.8±6.7	0.994
Symptoms				
Syncope	2 (3.3)	1 (5.6)	1 (2.3)	0.518
Dyspnea	19 (31.1)	8 (44.4)	11 (25.6)	0.147
Angina	9 (14.8)	5 (27.8)	4 (9.3)	0.063
TAVI characteristics				
Bioprosthesis size, mean±SD	24.8±2	25.3±1.9	24.5±2	0.157

SD: Standard deviation, LBBB: Left bundle branch block, BMI: Body mass index, PCI: Percutaneous coronary intervention, CABG: Coronary artery bypass surgery, NYHA: New York Heart Association, TAVI: Transcatheter aortic valve implantation, EuroScore: European system for cardiac operative risk evaluation

Table 2: Medication history of study population

Medications	*n* (%) unless specified otherwise			*P*
	Total (*n*=61)	With LBBB (*n*=18)	Without LBBB (*n*=43)	
Statins	34 (55.7)	15 (83.3)	19 (44.2)	0.005
Aspirin	32 (52.5)	10 (55.6)	22 (51.2)	0.754
Clopidogrel	32 (54.1)	8 (44.4)	25 (58.1)	0.328
Rosuvastatin	12 (19.7)	5 (27.8)	7 (16.3)	0.303
Lisinopril + hydrochlorothiazide	1 (1.6)	1 (5.6)	0	0.119
Metformin	7 (11.5)	4 (22.2)	3 (7)	0.088
Lantus	16 (26.2)	9 (50)	7 (16.3)	0.006
Novorapid	4 (6.6)	3 (16.7)	1 (2.3)	0.039
Warfarin	4 (6.6)	2 (11.1)	2 (4.7)	0.353
Bisoprolol	36 (59)	10 (55.6)	26 (60.5)	0.722
Methyldopa	1 (1.6)	0	1 (2.3)	0.514
Amlodipine	5 (8.2)	0	5 (11.6)	0.131
Furosemide	15 (24.6)	2 (11.1)	13 (30.2)	0.114
Apixaban	6 (9.8)	2 (11.1)	4 (9.3)	0.829
Glyceryl trinitrate	5 (8.2)	2 (11.1)	3 (7)	0.591
Dabigatran	2 (3.3)	0	2 (4.7)	0.352
Rivaroxaban	2 (3.3)	2 (11.1)	0	0.026

All numbers shown are *n* (%).LBBB: Left bundle branch block

Table 3: Echocardiographic and baseline electrocardiographic detail

ECG characteristics	*n* (%) unless specified otherwise			*P*
	Total (*n*=61)	With LBBB (*n*=18)	Without LBBB (*n*=43)	
Ejection fraction, mean±SD	55.5±9.7	52.5±9.6	56.8±9.5	0.116
Left ventricular hypertrophy	49 (80.3)	15 (83.3)	34 (79.1)	0.702
Tricuspid regurgitation	26 (42.6)	9 (50)	17 (39.5)	0.451
Aortic regurgitation	17 (27.9)	7 (38.9)	10 (23.3)	0.214
Systolic dysfunction	9 (14.8)	5 (27.8)	4 (9.3)	0.063
Diastolic dysfunction	42 (68.9)	15 (83.3)	27 (62.8)	0.114
Peak gradient (mmHg), mean±SD	74.2±17.5	76±14.6	73.4±18.8	0.645
Peak aortic velocity (m/s), mean±SD	4.3±0.5	4.2±0.5	4.4±0.5	0.384
Aortic valve area (mm^2), mean±SD	0.8±0.2	0.7±0.2	0.8±0.2	0.087
Mean gradient (mmHg), mean±SD	44.5±11.6	43.4±8.4	45±12.7	0.642
Baseline ECG				
AF	16 (26.7)	6 (35.3)	10 (23.3)	0.273
AVNRT	1 (1.7)	1 (5.9)	0	
LBBB	3 (5)	1 (5.9)	2 (4.7)	
SR	40 (66.7)	9 (52.9)	31 (72.1)	

SD: Standard deviation, LBBB: Left bundle branch block, ECG: Electrocardiographic, AF: Atrial fibrillation, AVNRT: Atrioventricular nodal re-entrant tachycardia, SR: Sinus rhythm

LBBB group (5/18, 27.8%) than in the group without new-onset LBBB (4/43, 9.3%) (P = 0.063). In addition, the incidence of complete AV block was higher in the group without new-onset LBBB 4/43 (9.3%, P = 0.627), explaining the need for PPI in this group. Furthermore, 1st degree AV block was seen exclusively in the new-onset LBBB group (4/18, 22.2%, P = 0.001), indicating that LBBB is likely to progress to 1st degree AV block. A single mortality was recorded in the new-onset LBBB group, and records showed that this patient progressed further into a 2:1 heart block and developed new ST-T changes followed by cardiogenic shock leading to asystole.

Conduction dysfunction is the most common complication following TAVI, and the incidence usually ranges between 30% and 50%.[1,2,12,13] This can be explained by the proximity of the aortic valve to the conduction system and the superficial position of the left bundle branch in the interventricular septum.[14,15] During the procedure, injury occurs due to stress applied to the interventricular septum by prosthesis skirt during valve expansion, balloon predilation, or guidewire insertion.[15,16] In terms of outcomes, patients who develop new-onset LBBB are more likely to receive PPI, the main indication being the development of a complete AV block.[1,6,16,17] In addition, the mortality rate is generally higher in the new-onset LBBB group

Table 4: Computed tomography findings preprocedure

CT characteristics	*n* (%) unless specified otherwise			*P*
	Total (*n*=61)	With LBBB (*n*=18)	Without LBBB (*n*=43)	
Maximum leaflet length (mm), mean±SD	17±3.7	17.5±2	16.7±4.3	0.641
Degree of calcifications				
Mild	6 (9.8)	0	6 (14)	0.218
Moderate	24 (39.3)	7 (38.9)	17 (39.5)	
Severe	31 (50.8)	11 (61.1)	20 (46.5)	
Short axis diameter (mm), mean±SD	21.8±2.5	21.9±2.2	21.8±2.6	0.782
Long axis diameter (mm), mean±SD	26.8±3.3	26.3±3.8	27±3.1	0.495
Annular circumference (mm), mean±SD	76.8±7.6	77.2±6.3	76.6±8.3	0.774
Annular area (mm^2), mean±SD	464.7±100.3	467.4±81.4	463.4±109.1	0.891
Sinotubular junction diameter (mm), mean±SD	25.8±3.5	26.1±3.9	25.6±3.4	0.707
Height of valsalva (mm), mean±SD	22±4	22.3±2.8	21.9±4.4	0.713
Area of sinus valsalva (mm), mean±SD	742.2±204.6	809.4±194.3	710.4±206.5	0.239
Distance to left coronary artery (mm), mean±SD	12.9±2.8	12.7±19.1	13.1±3	0.611
Distance to right coronary artery (mm), mean±SD	15±3.4	14.8±2.5	15.2±3.8	0.709

SD: Standard deviation, LBBB: Left bundle branch block, CT: Computed tomography

Table 5: Posttranscatheter aortic valve implantation outcomes and posttranscatheter aortic valve implantation electrocardiographic data

Outcomes	*n* (%) unless specified otherwise			*P*
	Total (*n*=61)	With LBBB (*n*=18)	Without LBBB (*n*=43)	
Post-TAVI outcomes				
Permanent pacemaker implantation	7 (11.5)	3 (16.7)	4 (9.3)	0.410
Death	1 (1.6)	1 (5.6)	0	0.119
Post-TAVI ECG				
RBBB	4 (6.6)	1 (5.6)	3 (7)	0.838
1st degree AV block	4 (6.6)	4 (22.2)	0	0.001
2nd degree AV block	1 (1.6)	1 (5.6)	0	0.119
Complete heart block	5 (8.2)	1 (5.6)	4 (9.3)	0.627
Bifasicular block	1 (1.6)	0	1 (2.3)	0.514
AF	4 (6.6)	1 (5.6)	3 (7)	0.838

LBBB: Left bundle branch block, TAVI: Transcatheter aortic valve implantation, ECG: Electrocardiographic, RBBB: right bundle branch block, AV: Atrioventricular, AF: Atrial fibrillation

because the LBBB interferes with left ventricular function improvement and leads to ventricular dysynchrony and heart failure.[14,15]

Other studies have established possible predictors of new-onset LBBB development post-TAVI, divided into procedure-related and patient-related predictors. The most important procedure-related predictor is the type of device used in implantation. Irene *et al*. established that LBBB development was more frequent in the Medtronic CoreValve Revalving System than in the Edward SAPIEN system, with incidences of 50% and 13.5%, respectively, because of the longer bioprosthesis frame of MCRS.[13,18,19] In addition, Irene *et al*. and Urena *et al*. both found that lower ventricular positioning or deeper implantation of bioprosthesis is associated with a higher risk of LBBB.[18-21] Furthermore, Gutierrez *et al*. found that a greater oversizing of the balloon during valve implantation was associated with a higher risk of LBBB development.[12] Conversely, patient-related predictors such as a longer QRS duration pre-TAVI were found to increase susceptibility for conduction dysfunction according to Urena *et al*.[19,20] Last, the extent of calcification in the aortic valve was found to increase the risk for LBBB development post-TAVI according to Thomas *et al*.[22]

The limitations of our study are as follows. First, as it is a pilot study, the cohort chosen was limited. Second, only a single type of TAVI system was used, which is the ESV system; thus, we were not able to compare the incidence of LBBB post-TAVI in other systems. Last, there were no intraoperative data regarding details of the procedure in the database, such as the depth of implantation; thus, we were not able to explore intra-procedural predictors of LBBB development.

Conclusion

In severe symptomatic aortic stenosis patients, who underwent TAVI, 29.5% developed new-onset persistent LBBB. Many

parameters have been explored in our study to assess the predictors of such complications; however, none showed any association with new-onset LBBB development. In terms of outcomes, the new-onset LBBB group had a higher incidence of PPI (27.8%), with the main indication being progression to complete heart block.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Ethics approval statement

This study was approved by the Ethics Committee and Ministry of Health Kuwait.

Patient consent statement

Patient consented was not mandated for this retrospective observational study. Permission to reproduce material from other sources: No material from other sources is included in this study.

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Conflicts of interest

There are no conflicts of interest.

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