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Predictors of Complete Atrioventricular Block Following Transcatheter Aortic Valve Replacement

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Abstract

Objectives: Transcatheter aortic valve replacement (TAVR) is a minimally invasive procedure used for the treatment of aortic valve disease in patients who are considered high-risk or ineligible for traditional open-heart surgery. During the TAVR procedure, various factors can affect the patient's electrical conduction system and disrupt the heart's inherent rhythm. As the frequency of procedure increases, the need for complete atrioventricular (AV) block and permanent pacemaker also increases. These factors encompass the positioning of the transcatheter valve, proximity of the valve to electrical pathways, and manipulation of the catheter within the cardiac structure. The present study aimed to evaluate the relationship between the development of complete AV block after TAVR and possible predictive parameters.

Materials and Methods: The study population consisted of 191 consecutive patients undergoing TAVR for severe aortic valve stenosis between January 2021 and June 2022. The baseline clinical characteristics and clinical information were recorded. The patients were divided into two groups according to the development of complete AV block. Multivariate logistic regression analysis was performed to identify the predictors of complete AV block.

Results: Among the participants, 13 (6.8%) developed a complete AV block. In the group with complete AV block, the prosthetic valve/aortic annulus ratio was significantly higher (p=0.015). Bradycardia and right bundle branch block (RBBB) on the pre-procedural electrocardiogram were significantly more common (p=0.001) and the AV area was lower (p=0.033) in the complete AV block group. In multivariate logistic regression analysis, preprocedural RBBB was found

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to be an independent predictor of complete AV block. Preprocedural bradycardia, aortic valve area, and prosthetic valve/aortic annulus ratio were other independent predictors.

Conclusion: Complete AV block after the TAVR procedure is a predictable complication. Larger studies are required to draw more definitive conclusions.

Keywords: Transcatheter aortic valve replacement, complete atrioventricular block, pacemaker, right bundle branch block

Introduction

Aortic stenosis is the most common valvular disease in developed countries, and its prevalence is increasing rapidly because of the aging population[1]. Surgical valve replacement is the standard treatment procedure for patients with severe symptomatic aortic stenosis. However, percutaneous aortic valve replacement has become popular in recent years, especially for elderly patients and those with comorbidities who are at high risk for surgery[2]. Transcatheter aortic valve replacement (TAVR) is a minimally invasive procedure employed for the treatment of aortic valve disease in patients who are considered high-risk or ineligible for traditional open-heart surgery[1]. TAVR involves percutaneous replacement of a bioprosthetic valve using a catheter, typically through the femoral artery or other access points. Several studies have shown that TAVR is a safe and feasible alternative for high-risk patients[3].

The incidence of patients undergoing TAVR has progressively increased, and complications related to valve replacement have become more common. Abnormalities in the conduction system of the heart may occur frequently after TAVR[4,5]. In particular, the occurrence of high-degree atrioventricular conduction disorders and subsequent need for a permanent pacemaker can be observed commonly[6]. Various studies have shown that the rate of permanent pacemaker requirement after TAVR is higher than that after the aortic valve surgery[7,8]. Previous studies have found that various risk factors increase the risk of complete AV block and thus permanent pacemaker after TAVR[9-12]. These factors include positioning of the transcatheter valve, proximity of the valve to the conduction pathways, conduction abnormalities present on the pre-procedural electrocardiogram (ECG), and manipulation of the catheter within the cardiac structure[13]. In this study, we aimed to evaluate the relationship between the development of complete AV block, termed complete heart block (CHB), after TAVR and possible predictive parameters.

Materials and Methods

This study was a single-center retrospective study. The study population consisted of 191 consecutive patients with severe aortic stenosis who underwent TAVR between January 2021 and June 2022. The implanted valves included two types of delivery systems balloon-expandable and self-expandable. Patients with acute infection, autoimmune disease, hematologic diseases, chronic liver disease, chronic kidney disease, previously implanted pacemaker, and malignancy were excluded. The study protocol was approved by the Ankara Bilkent City Hospital Clinical Research Ethics Committee No. 1 (approval no: E1-23-3921, date: 16.08.2023).

Demographic characteristics and cardiovascular risk factors were obtained from the hospital data system. ECG tracings were recorded at baseline, after the procedure, and every 24 hours until hospital discharge. The diagnosis of intraventricular conduction abnormalities is based on the recommendations of the American Heart Association[14]. CHB was defined as P waves with a constant rate with dissociated ventricular rhythm (no association between P waves and R waves) or fixed slow ventricular rhythm in the presence of atrial fibrillation. Patients with a QRS duration <120 ms were considered not having a bundle branch block, regardless of QRS morphology. The type and size of the valve implanted during the procedure were recorded from the procedure reports. ECG was performed every day after the procedure. Transthoracic echocardiography was performed before the TAVR procedure, and the left ventricular ejection fraction was calculated using the modified Simpson method.

Standard 12-lead ECG (filter 40 Hz, 25 mm/s, 10 mm/mV) was recorded in all patients before and after the procedure. Patients with fasting blood glucose >126 mg/dL, those with a documented diagnosis of diabetes mellitus, or those on insulin or oral antidiabetics at admission were considered diabetic. Hypertension was defined as current antihypertensive use or a systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg.

Statistical Analysis

SPSS statistical software (SPSS 22.0 for Windows, Inc., Chicago, IL, USA) was used for statistical analysis. Categorical variables are presented as numbers and percentages, and quantitative data are presented as mean ± standard deviation or median and interquartile range according to the distribution pattern. The Kolmogorov-Smirnov test was used to test the distribution of the quantitative data. Student's t-test or Mann-Whitney U test was used to compare continuous variables. Chi-square test or Fisher's exact test was used to identify statistically significant differences for categorical variables. Logistic regression analysis was used to examine the association between CHB and other variables. Variables with a p-value of <0.2 in the univariate logistic regression analysis were included in the multivariate logistic regression model. A 2-tailed p<0.05 was considered significant.

Results

A total of 191 patients were included in the study. Patients were divided into two groups as with and without CHB. The mean age of the patients was 76.76±8.0 and 85 (44.5%) of them were males. Thirteen (8.5%) of the patients had CHB during follow-up period. Baseline demographics and clinical, ECG, and echocardiography parameters are shown in Table 1. There was no significant difference in terms of gender and age between the two groups. Diabetes mellitus, hypertension, and known coronary artery disease were also similar in both groups. Chronic kidney disease and atrial fibrillation were more common in patients with CHB. The prosthetic valve size/aortic annulus diameter ratio was significantly higher in patients with CHB (2.61±5.15 vs. 6.64±10.36; p=0.015). There was no significant difference in the frequency of CHB according to valve type. Electrocardiographic conduction parameters of all patients at baseline and cardiac conduction parameters at follow-up after the procedure are shown in Table 1. Preprocedural bradycardia and RBBB frequency were higher in patients with CHB (p<0.001). The aortic valve area was significantly lower in the CHB group (0.70±0.15 vs. 0.63±0.08 cm^2; p=0.033). Mitral annular calcification frequency was significantly higher in the CHB group (p=0.001). In multivariate logistic regression analysis, preprocedural RBBB was found to be an independent predictor of CHB (odds ratio 3.985, 95% confidence interval 2.654-9.184; p<0.001). Preprocedural bradycardia, aortic valve area, and prosthetic valve size/aortic annulus diameter ratio were other independent predictors of CHB (Table 2).

Discussion

This study investigated the predictive factors for developing postprocedural CHB in patients undergoing TAVR for severe aortic stenosis. This study demonstrated that preprocedural bradycardia, preprocedural RBBB, aortic valve area, and prosthesis/aortic valve annulus ratio were independently associated with the development of CHB.

A study by Leon et al.[15] was one of the first studies to demonstrate the mortality benefit of TAVR in patients who were not candidates for surgical aortic valve replacement (SAVR) because of the Society of Thoracic Surgeons risk score and comorbidities. Subsequent studies have shown

Table 1. Baseline characteristics of study patients

Variables	CHB (-) (n=178)	CHB (+) (n=13)	p-value
Age	76.83±7.99	75.76±8.06	0.643
Male gender, n (%)	79 (44.4)	6 (46.1)	0.794
Diabetes mellitus, n (%)	76 (42.7)	7 (53.8)	0.568
Hypertension, n (%)	146 (82.0)	11 (84.6)	0.653
Coronary artery disease, n (%)	112 (62.9)	6 (46.2)	0.282
Chronic kidney disease, n (%)	53 (29.8)	6 (46.2)	**0.045**
Atrial fibrillation, n (%)	36 (20.2)	6 (46.2)	**0.035**
Body mass index	29.25±6.24	27.96±3.27	0.451
STS score (%)	4.61±2.99	4.23±2.48	0.823
CT aort valve calcium score	2857.27±3264.00	1574.63±1965.17	0.398
Prosthetic valve size/aortic annulus diameter	2.61±5.15	6.64±10.36	**0.015**
Prosthetic type			
Self-expandable, n (%)	117 (65.7)	8 (61.5)	0.593
Balloon-expandable, n (%)	46 (34.3)	5 (38.5)	
Pre-procedural electrocardiogram			
Bradycardia, n (%)	10 (5.6)	5 (38.5)	**0.001**
PR interval (ms)	163.59±30.72	167.29±29.41	0.756
Left bundle branch block, n (%)	21 (11.8)	2 (15.3)	0.436
Right bundle branch block, n (%)	34 (19.1)	6 (46.1)	**0.001**
Echocardiography finding			
Aortic valve area (cm^2)	0.70±0.15	0.63±0.08	**0.033**
Aortic mean gradient (mmHg)	48.41±11.07	50.77±15.66	0.474
Mitral annular calcification, n (%)	114 (64.0)	9 (69.2)	**0.001**
LVEF (%)	51.54±12.81	49.46±8.77	0.440
Systolic PAP (mmHg)	41.81±13.24	38.27±12.67	0.390

CHB: Complete heart block, CT: Computed tomography, LVEF: Left ventricular ejection fraction, PAB: Pulmoner artery pressure, STS: Society of thoracic surgeons score

Table 2. Univariate and multivariate logistic regression analysis for prediction of CHB

Factor	Univariable		Multivariable	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Chronic kidney disease	1.435 (0.784-5.008)	0.180	1.324 (0.654-5.958)	0.222
Atrial fibrillation	1.284 (0.041-40.087)	0.88	-	-
Pre-procedural bradycardia	5.80 (2.433-8.124)	0.035	6.22 (3.234-8.565)	**0.010**
Pre-procedural RBBB	4.415 (2.145-15.045)	0.001	3.985 (2.654-9.184)	**0.001**
Aortic valve area	1.012 (0.999-3.052)	0.069	1.015 (1.001-3.014)	**0.050**
CT aort valve calcium score	1.000 (0.999-1.001)	0.844	-	-
Mitral annular calcification	1.013 (0.892-1.324)	0.491	-	-
Prosthetic valve size/aortic annulus diameter	1.263 (1.017-1.569)	0.035	1.288 (1.024-1.456)	**0.030**

CHB: Complete heart block, CT: Computed tomography, RBBB: Right bundle branch block, OR: Odds ratio, CI: Confidence interval that TAVR may be superior to SAVR in patients with low and intermediate surgical risk[6,16]. With the expansion of the indication for TAVR, there has been an increasing trend in the number of procedures performed and their associated complications.

Electrical conduction disturbances, particularly CHB, are one of the most important complications of this procedure. One of the main causes of conduction abnormalities after TAVR is known to be the pressure of the prosthetic valve on the direct conduction system in the left ventricular outflow tract[17]. Recently, despite significant improvements in the success of TAVR, the incidence of conduction disturbances has not significantly decreased[18]. The cause of conduction abnormalities after TAVR has been associated with many factors, including preprocedural conduction abnormalities, anatomical proximity of the cardiac conduction system to the aortic valve annulus, and technical reasons[19]. Furthermore, the development of CHB has been associated with increased postprocedure hospitalization, in-hospital mortality, and increased use of health resources[17].

Several studies have investigated electrocardiographic, procedural, or anatomical factors as precursors of CHB[20]. Some studies have shown that older age is a precursor of CHB[18,20]. In our study, no significant relationship was found between age and AVB. In the literature, CHB is a frequently associated electrocardiographic finding in patients with RBBB[21,22]. In our study, RBBB predicted CHB, confirming other studies. In most studies, the risk of CHB was compared with the transapical and endovascular approach, and there was no statistically significant difference in the risk of CHB according to the type of intervention[10,23,24]. In our study, the TAVR procedure was performed using only the endovascular approach. In previous studies, the development of CHB was more frequent in self-expandable valves than in balloon-expandable valves[20]. In our study, no significant difference was found between the valve type and CHB. However, more patients are needed to clearly assess the effect of valve type on the development of AV block.

With the increasing number of TAVR procedures, the need for CHB and pacemaker implantation is also increasing. In addition to the increased risk of mortality and morbidity, the development of CHB has a negative impact on the duration of hospitalization and hospitalization cost. Some studies have identified predictive factors for developing CHB[19,21,22]. Al-Ogaili et al.[18] study emphasized risk factors known to be associated with the development of CHB, such as comorbidities and underlying conduction disorders. Specifically, RBBB increased the risk of CHB almost five-fold, and it was emphasized that this finding should be considered carefully before the procedure[18]. Similar to these studies, our study also showed that RBBB was a strong predictive factor. Preprocedural bradycardia, aortic valve area, and prosthesis/aortic valve annulus ratio were other independent predictors of CHB.

Advancements in TAVR technology have facilitated the development of valve designs specifically tailored to minimize interference with the electrical conduction system. These designs reduce CHB after the procedure, thus reducing the need for pacemaker implantation and preventing patient worsening. Therefore, it is crucial to investigate the predictive factors that determine the necessity of pacemaker implantation in patients undergoing TAVR.

Study Limitations

This study has several limitations. First, the study has a retrospective and single-center design, which may limit the generalizability of its results. Second, the study has a relatively small sample size. In addition, our study did not include any information on transcatheter valve positioning.

Conclusion

Complete atrioventricular block in the TAVR procedure is associated with preprocedural bradycardia, preprocedural RBBB, aortic valve area, and prosthesis/aortic valve annulus ratio. Early identification of these parameters and preventive management against the risk of CHB may reduce mortality and morbidity.

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