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Article

Research and Prediction of Factors Related to High Degree Atrioventricular Block after TAVI Surgery Based on Logistic Regression Model

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Abstract

Objective: Based on the logistic regression model, analyze the risk factors for high degree atrioventricular block after transcatheter aortic valve replacement (TAVI) surgery and further analyze its predictive value. **Methods**: 402 patients who underwent TAVI surgery at Henan Thoracic Hospital for "aortic stenosis" between January 2020 and January 2023 were selected as the study subjects. The study subjects were divided into A group (N = 89) and B group (N = 313) based on whether high degree atrioventricular block occurred after surgery. The age, biochemistry and other general data of patients were systematically collected through inpatient cases, and the preoperative Right bundle branch block, I degree atrioventricular block, QRS duration, and indoor block were collected through our hospital's electrocardiogram (ECG) system, Calcification integral of Aortic valve was calculated by computed tomography (CT) results. Logistic regression analysis was performed on the clinical data, and the predictive value of related factors was further analyzed through the Receiver operating characteristic. **Results**: The preoperative QRS wave duration in the A group (165.06 $\pm$ 61.25) was significantly higher than that in the B group (108.30 $\pm$ 16.30), and the difference was statistically significant ($p < 0.05$). Compared with the B group, the incidence of Right bundle branch block in the A group was significantly higher before operation. The calcification score of Aortic valve in the A group (97.58 $\pm$ 61.25) was significantly higher than that in the B group (43.59 $\pm$ 7.56), with a statistically significant difference ($p < 0.05$). Further multivariate logistic regression analysis showed that the duration of QRS wave before operation and Aortic valve calcification score were independent risk factors for high atrioventricular block after TAVI ($p < 0.05$). Through Receiver operating characteristic analysis, it was found that preoperative QRS wave duration and Aortic valve calcification score had a high predictive value for the occurrence of high atrioventricular block after TAVI. The optimal cutoff value of QRS wave duration for predicting high atrioventricular block was 152, area under curve (AUC): 0.780 (95% CI: 0.718–0.841, $p < 0.001$). The optimal cutoff value for predicting high degree atrioventricular block with aortic calcification score is 61.5, AUC: 0.997 (95% CI: 0.992–1.000, $p < 0.001$). **Conclusions**: Preoperative QRS wave duration and Aortic valve calcification score are independent risk factors for high degree atrioventricular block after TAVI, and they have high predictive value. In clinical work, risk factors should be found early and responded in time.

Keywords

aortic stenosis; transcatheter aortic valve replacement; high degree atrioventricular block

Introduction

Some studies have pointed out that aortic stenosis has become one of the common valvular heart diseases in China, and the incidence rate has gradually increased [1]. Epidemiological survey shows that the prevalence of aortic stenosis is 9.8% at the age of 80–89, while only 0.2% at the age of 50–59 [2]. At present, transcatheter aortic valve replacement (TAVI) has become an important treatment for patients with aortic stenosis [3]. However, some patients after TAVI are prone to complications such as high atrioventricular block, which further increases the incidence of heart failure, leads to further deterioration of cardiac function, and seriously affects the prognosis [4]. At present, most studies focus on the effects of the improvement of the material and structure of the valve system, surgical operation and other aspects on the conduction system after TAVI surgery. However, there are few studies on the relevant influencing factors and predictive analysis of the occurrence of high atrioventricular block events after TAVI surgery [5,6]. The purpose of this paper is to study the influencing factors of high degree atrioventricular block after TAVI operation, in order to provide clinical basis for early prediction and treatment of TAVI-related block.

Data and Methods

General Information

We collected the relevant information from 402 patients who underwent TAVI in Henan Thoracic Hospital from January 2020 to January 2023. 402 subjects were divided into study group (N = 89) and B group (N = 313) according to whether high degree atrioventricular block occurred after operation. Calcification integral of Aortic valve was calculated according to Agataston method [7], and computed tomography (CT) value >130 HU mm^2 was defined as calcification. 1 point for 131–199 HU, 2 points for 200–299 HU, 3 points for 300–399 HU, and 4 points for ≥400 HU. Calcification integral = Calcification area × Calcification coefficient. If multiple valves undergo calcification, the sum of calcification scores for each valve is the total calcification score for the patient.

The measurement method of QRS wave duration: the time limit from the earliest starting point to the latest ending point of the QRS wave.

The aortic valves used in this study were all Medtronic.

Interpretation of results of atrioventricular block: Two senior electrocardiogram experts will interpret atrioventricular block, and if the results are consistent, they will be adopted; if the results are inconsistent, it will be judged by a more qualified expert.

Inclusion criteria [8]:

① Severe aortic valve stenosis: the average transvalve pressure difference of aortic valve is ≥40 mm Hg, the trans-valve blood flow velocity is ≥4.0 m/s, and the area of aortic valve orifice is <0.8 cm^2.

② The patient has clinical symptoms: chest pain, syncope, *etc*.

③ There are contraindications or high risks in surgical operation.

Exclusion criteria:

① The anatomy of aortic root is not suitable for TAVI.

② Preoperative left bundle branch block; Complicated with severe cardiac insufficiency, liver and kidney dysfunction, active bleeding or inability to tolerate antiplatelet therapy after surgery.

③ Recently accepted coronary stent implantation, cardiac pacemaker implantation, *etc*.

④ Clinical data are incomplete.

Statistical Analysis

SPSS26.0 software (IBM Corp., Armonk, NY, USA) was used for data analysis. And the collected data were divided into counting data and measuring data. The measurement data conforming to the normal distribution is expressed by "mean ± standard deviation ($\bar{x} \pm$ u)", independent sample *t*-test is used between groups, and the counting data is expressed by absolute number (constituent ratio) χ^2 test, rank sum test is used for grade data comparison. Multivariate logistic regression analysis was used to screen the independent risk factors of atrioventricular block after TAVI. The difference was statistically significant ($p < 0.05$).

Results

Comparison of Baseline Data between Two Groups

There was no significant statistical difference between the two groups in general baseline data (Table 1).

Comparison of Preoperative Electrocardiogram (ECG) Examination Results between Two Groups of Patients

The preoperative QRS wave duration in the A group (165.06 ± 61.25) was significantly higher than that in the B group (108.30 ± 16.30), and the difference was statistically significant ($p < 0.05$). Compared with the B group, the incidence of Right bundle branch block in the A group was significantly higher before operation. There was no significant statistical difference between the two groups of patients in terms of preoperative sinus bradycardia, ventricular block, and degree I atrioventricular block (Table 2).

Comparison of Preoperative Cardiac Color Doppler Ultrasound Results between Two Groups of Patients

The calcification score of Aortic valve in the A group (97.58 ± 61.25) was significantly higher than that in the B group (43.59 ± 7.56). There was no significant statistical difference between the two groups in other indexes of cardiac color Doppler ultrasound (Table 3).

Multivariate Logistic Regression Analysis of High Atrioventricular Block after TAVI

The multivariate logistic regression analysis was carried out with the occurrence of high atrioventricular block after TAVI as the dependent variable (0 = none, 1 = yes), and the statistically significant indicators in the above table as the independent variable. The results showed that the QRS wave duration before surgery and the Aortic valve calcification score were independent risk factors for the occurrence of high atrioventricular block after TAVI ($p < 0.05$) (Table 4).

Analysis of Receiver Operating Characteristic for Predicting High Atrioventricular Block

The results of Receiver operating characteristic showed that the best cutoff value of QRS wave duration

Table 1. Comparison of baseline data between the two groups.

	A group (N = 89)	B group (N = 313)	T/χ^2	p
Age (y)	67.85 ± 5.68	68.95 ± 6.69	1.402	0.162
Male, n (%)	49 (55.1)	162 (51.8)	0.302	0.582
BMI (kg/m^2)	25.01 ± 3.65	24.90 ± 3.12	0.283	0.778
Hypertension, n (%)	42 (47.2)	143 (45.7)	0.063	0.802
Diabetes, n (%)	35 (39.3)	103 (32.9)	1.266	0.261
Smoking history, n (%)	35 (39.3)	108 (34.5)	0.703	0.402
Drinking history, n (%)	57 (64.0)	198 (63.3)	0.019	0.892
AST (U/L)	28.99 ± 4.25	29.39 ± 4.59	0.733	0.464
ALT (U/L)	31.16 ± 6.14	32.15 ± 6.05	1.367	0.173
Creatinine (ummol/L)	83.01 ± 9.58	82.36 ± 8.59	0.617	0.538
Total bilirubin (ummol/L)	19.11 ± 3.96	19.86 ± 4.54	1.424	0.155
White blood cell count (10^9/L)	8.89 ± 2.15	8.80 ± 2.25	0.336	0.737
Red blood cell count (10^{12}/L)	4.73 ± 0.59	4.89 ± 0.72	1.815	0.070
Platelet count (10^9/L)	245.36 ± 42.01	240.36 ± 44.36	0.950	0.343
Total cholesterol (mmol/L)	4.43 ± 1.30	4.36 ± 1.59	0.382	0.702
Triglyceride (mmol/L)	1.84 ± 0.73	1.83 ± 0.70	0.122	0.903
Low density lipoprotein (mmol/L)	2.26 ± 0.81	2.13 ± 0.74	1.516	0.130
High density lipoprotein(mmol/L)	1.17 ± 0.66	1.17 ± 0.65	0.001	0.999

BMI, body mass index; AST, aspartate aminotransferase; ALT, alanine aminotransferase.

Table 2. Comparison of preoperative ECG data between the two groups.

	A group (N = 89)	B group (N = 313)	T/χ^2	p
Right bundle branch block, n (%)	31 (34.8)	58 (18.5)	5.087	0.024
Sinus bradycardia, n (%)	19 (21.3)	78 (24.9)	0.483	0.487
Degree I atrioventricular block, n (%)	6 (6.7)	19 (6.1)	0.054	0.817
QRS wave duration (ms)	165.06 ± 61.25	108.30 ± 16.30	14.703	0.000
Ventricular conduction block, n (%)	9 (10.1)	47 (15.0)	1.390	0.239

ECG, Electrocardiogram.

Table 3. Comparison of cardiac color Doppler ultrasound results between the two groups.

	A group (N = 89)	B group (N = 313)	T/χ^2	p
LVEF (%)	52.28 ± 3.97	53.00 ± 3.72	1.586	0.114
Left ventricular end-diastolic volume (mL)	129.89 ± 12.03	131.01 ± 13.59	0.706	0.480
Left ventricular end-diastolic diameter (mm)	38.45 ± 3.11	38.29 ± 3.05	0.423	0.673
Aortic valve area (cm^2)	0.56 ± 0.21	0.55 ± 0.19	0.443	0.658
Cross-valve pressure difference of aortic valve (mm Hg)	81.09 ± 8.01	82.31 ± 9.02	1.156	0.248
Maximum cross-valve velocity of aortic valve (cm × s)	462.25 ± 10.29	461.29 ± 13.28	0.630	0.529
Aortic valve calcification score	97.58 ± 61.25	43.59 ± 7.56	39.587	0.000

LVEF, left ventricular ejection fraction.

Table 4. Multivariate logistic regression analysis of high atrioventricular block after TAVI.

	B	S.E	Wald	OR	95% CI	p
QRS wave duration	–0.083	0.034	5.994	0.920	0.861–0.984	0.014
Right bundle branch block	–2.727	2.499	1.190	0.065	0.000–8.769	0.275
Aortic valve calcification score	–0.513	0.197	8.441	0.599	0.424–0.846	0.004

TAVI, Transcatheter Aortic Valve Implantation.

for predicting high atrioventricular block was 152, area under curve (AUC): 0.780 (95% CI: 0.718–0.841, $p < 0.001$). The optimal cutoff value for predicting high degree atrioventricular block with aortic calcification score is 61.5, AUC: 0.997 (95% CI: 0.992–1.000, $p < 0.001$) (Table 5, Fig. 1).

Table 5. Receiver operating characteristic of QRS wave duration and Aortic valve calcification score before operation.

	AUC	Cut-off	*p*	95% CI	Sensitivity	Specificity
QRS wave duration	0.780	152	0.000	0.718–0.841	57.1%	97.8%
Aortic valve calcification score	0.997	61.5	0.000	0.992–1.000	97.8%	99.4%

AUC, Area Under Curve.

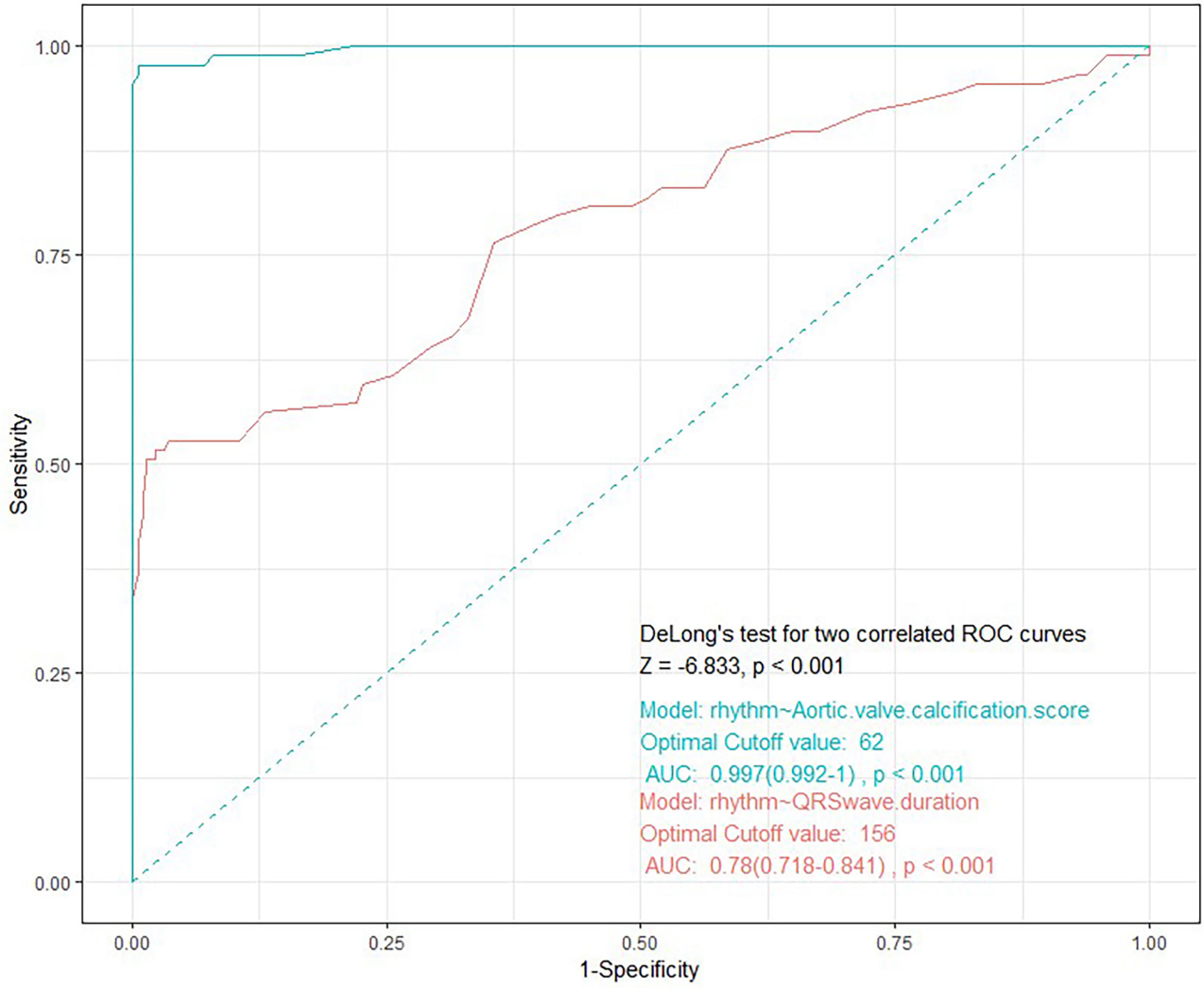

Fig. 1. ROC curve of high degree atrioventricular block.

Disscussion

High degree atrioventricular block refers to Mohs type II atrioventricular block and third degree atrioventricular block [9]. At present, most studies [10–12] believe that the possible mechanism of high degree atrioventricular block after TAVI is the anatomical relationship between aortic valves and the conduction system, and the operation results in conduction system inflammation, ischemia, edema, *etc*. His bundle is close to the Aortic valve when walking, and the left bundle branch is close to the bottom of the fiber triangle between the non-coronal valve and the right coronal valve. The anatomical close relationship between the Aortic valve and the heart conduction system is the anatomical basis for the easy occurrence of conduction block after TAVI. Siontis *et al*. [13] and other meta-analysis involving 8020 subjects showed that compared with surgical Aortic valve replacement, TAVI had lower all-cause mortality and stroke incidence. However, in terms of long-term effects, the latest study [14] shows that the 7-year mortality rate after TAVI surgery is approximately 75%. It is of great clinical significance to actively prevent and intervene as early as possible the high-risk factors of high atrioventricular block after TAVI surgery.

Auffret *et al*. [15] and other studies involving 3527 patients with TAVI showed that the 30-day permanent pacemaker implantation rate (40.1% *vs* 13.5%) and mortality

rate (10.2% *vs* 6.9%) significantly increased when there was Right bundle branch block before surgery. In this study, the incidence of preoperative Right bundle branch block in the A group was significantly higher than that in the B group (34.8% *vs* 18.5%), which was consistent with the previous study [14]. The possible mechanism is that the left bundle branch is dissected near the Aortic valve, and mechanical operation during the operation is easy to cause inflammation and edema of the left bundle branch, thus causing abnormal conduction of the left bundle branch. If there is Right bundle branch block before the operation, the risk of causing high atrioventricular block is greatly increased. This study excluded left bundle branch block during enrollment, so there are few studies on baseline left bundle branch block and postoperative new left bundle branch block. The next step should continue to deepen this study. A retrospective study [15] on the occurrence of conduction block after TAVI surgery found that preoperative QRS wave broadening is closely related to the occurrence of high degree atrioventricular block. A study of 494 subjects [16] also found that patients who underwent pacemaker implantation due to high atrioventricular block after TAVI had significantly longer QRS wave duration compared to the B group. In this study, the QRS duration in the A group was significantly higher than that in the B group, with a statistically significant difference. Further Logistic regression analysis showed that the QRS duration was an independent risk factor for high atrioventricular block after TAVI. The Receiver operating characteristic showed that the best cutoff value of QRS wave duration for predicting high atrioventricular block was 152, AUC: 0.780 (95% CI: 0.718–0.841, $p <$ 0.001). The possible mechanism is that when the electrical impulse generated by the Sinoatrial node is transmitted to the left and right bundle branches, the QRS wave duration is widened due to conduction block, so the QRS wave broadening also reflects bundle branch block in essence [17]. Pollari and others [18] used enhanced CT to scan the Aortic valve of 581 patients undergoing TAVI, and found that Aortic valve calcification was a risk factor for complications and reduced survival rate after TAVI. In this study, the Aortic valve calcification score in the A group was significantly higher than that in the B group. Multifactor logistic regression analysis showed that Aortic valve calcification score was an independent risk factor for high atrioventricular block after TAVI. The Receiver operating characteristic showed that the best cutoff value of aortic calcification integral for predicting high atrioventricular block was 61.5, AUC: 0.997 (95% CI: 0.992–1.000, $p < 0.001$). The possible mechanism is that when Aortic valve calcification is serious, the more times balloon pre dilation is required during operation, the greater the probability of mechanical stimulation damaging the left bundle branch, and the greater the risk of conduction block. A study [19] suggests that the depth of valve implantation is also one of the factors affecting conduction block. An excessively high implantation position increases the risk of valve leakage or valve embolism [20]. When the implantation is too deep, the risk of valve reflux and conduction block will increase [21]. There are research reports [22] that for every 1mm increase in valve implantation depth, the risk of postoperative left bundle branch block increases by 15%–40%. This study did not further explore the relationship between valve implantation location and atrioventricular block, which is a limitation of this study and should be further deepened in the next step.

Conclusions

Preoperative QRS wave duration, Right bundle branch block and Aortic valve calcification are independent risk factors for high atrioventricular block after TAVI. The optimal cutoff value for predicting the duration of preoperative QRS wave for postoperative high atrioventricular block in TAVI is 152, AUC: 0.780 (95% CI: 0.718–0.841, $p <$ 0.001). Early detection and timely response to the risk factors of high degree atrioventricular block after TAVI surgery in clinical work are expected to greatly improve patient prognosis.

Availability of Data and Materials

All clinical data comes from the hospital case system.

Author Contributions

PH and ZW conceptualized and designed the article; Implementation and feasibility analysis of research conducted by ZW; PH collects data and writes a paper; PH and NL conducted data organization, analyzed and explained the results; PH conducted statistical processing; PH revised their paper; PH and ZW are responsible for the quality control and proofreading of the article; ZW is responsible for the overall management and supervision of the article. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This study has been exempted the ethics by the institution.

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Conflict of Interest

The authors declare no conflict of interest.

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