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Predictors of Electrical Abnormalities Related to Mechanical Trauma during Transcatheter Aortic Valve Implantation

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ABSTRACT

Background: When it came to treating patients with severe symptomatic aortic stenosis (AS) who are at high or prohibitive surgical risk, transcatheter aortic valve implantation (TAVI) marked a paradigm change. TAVI has become a safe technique with predictable results as a result of the expanding expertise in this sector, which has also reduced the risk of problems over time and increased the use of a minimalist approach. The incidence of conduction disturbances, such as bundle branch blocks or atrioventricular blocks necessitating pacemaker implantation, has not decreased recently, in contrast to other procedural complications.

Methods: This observational study included 80 patients with symptomatic severe AS who underwent transfemoral TAVI. Patients were divided based on the development of post-TAVI conduction abnormalities into two groups. Group I (n=70) without conduction abnormalities and group II (n = 10) developed new-onset conduction abnormalities.

Results: Depth of implantation at the membranous septum (DIMS) revealed a significant AUC of 0.935 with a 95% confidence interval ranging from 0.866 to 1.000, suggesting an excellent ability to predict conduction abnormalities. The best cutoff was > 64 mm, at which sensitivity, specificity, PPV, and NPV were 90.0%, 87.14%, 50.0%, and 98.4% respectively. ΔMSID demonstrated a significant AUC of 0.936 with a 95% confidence interval ranging from 0.838 to 1.000, indicating excellent predictive ability. The best cutoff point was ≤2 mm, at which sensitivity, specificity, PPV, and NPV were 80.0%, 98.57%, 88.9%, and 97.2% respectively.

Conclusions: Conduction disturbances remain a common complication of TAVI. Presence of RBBB is a risk factor that increases patient propensity for developing such complications post TAVI. The relationship between depth of implantation and membranous septum is a strong independent procedural predictor and prospective validation of its cut-offs is needed.

Keywords: Right bundle branch block, TAVI, Severe symptomatic AS.

INTRODUCTION

The mortality rate is extremely high when severe symptomatic aortic stenosis (AS) is left untreated [1]. The TAVI results in an increase in overall survival, reverse LV remodelling, and an improvement in symptoms [2]. Currently, the era of TAVI has changed the demographic as well as clinical characteristics of AS patients towards elderly sick patients. TAVI is an alternative to surgical aortic valve replacement (SAVR) for patients with severe AS symptoms who are not surgical candidates or are believed to have a high risk of adverse procedure outcomes [3].

Except for a few years ago, TAVI was exclusively designated for patients with a high surgical risk. Nevertheless, it is currently being implemented in both low and intermediate surgical risk groups. In order to maintain safety, efficiency and patient outcomes in the face of an increasing demand for TAVI, it is imperative to optimize TAVI patient pathways and implement minimal TAVI procedures to balance the burden on healthcare systems and resources. The current organization and execution of TAVI in Egypt, as well as the integration of recommendations and guidelines into daily practice, are not currently determinable due to the absence of data. The 2023 Egypt TAVI Pathway Survey was designed to provide a thorough comprehension of the current organization of TAVI pathways and procedures, as well as to identify potential areas for improvement that could further improve the impact of healthcare [4].

As many as 34.8% of patients experience new-onset electrical conduction disturbances at the time of hospital discharge following TAVI [5]. After TAVI, left bundle branch block (LBBB) accounted for 10.5% of significant conduction disturbances [6]. The following are procedural risk factors: Post-dilatation, transcatheter heart valve (THV) oversizing and implantation depth (ID). ID is associated with the extent of the membranous portion of the interventricular septum (MS). The atrioventricular bundle of His surfaces the left ventricular outflow tract (LVOT) at MS, rendering it susceptible to pressure trauma induced by the THV. During implantation, the AV bundle and THV may be more likely to interact if a short MS is performed. AV bundle and THV may not come into contact due to a protracted MS unless the THV is deeply implanted into the LVOT [7].

This investigation aimed to ascertain the predictors of cardiac conduction disturbance and pacemaker dependency subsequent to TAVI by examining clinical, electrocardiographic, echocardiographic, radiological computed tomography (CT) and procedural variables.

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PATIENTS AND METHODS

This prospective study was conducted at Nasr City Health Insurance Hospital with Cardiovascular Medicine Department, Faculty of Medicine, Menoufia University Hospital and El-Mokatam Health Insurance Hospital through the period from June, 2024 to June, 2025.

Study design and population: The study population consisted of the first 48 patients treated with Evolut R/R pro and 32 patients treated with Acurate neo2 valves.

Inclusion criteria: Severe AS defined as a mean aortic gradient exceeding 40 mmHg, a peak jet velocity more than 4.0 m/s, or an aortic valve area less than 1.0 cm², in individuals aged 72 years or older, with a logistic EuroSCORE I of 20% or higher, a New York Heart Association (NYHA) functional Class greater than II and an aortic valve annulus diameter ranging from 18 to 29 mm.

Exclusion criteria: Unicuspid or bicuspid aortic valve, extreme eccentricity of calcification, significant mitral regurgitation (>2), pre-existing prosthetic heart valve, patients with a prior pacemaker installation, a life expectancy of less than one year, active endocarditis, LV thrombosis and excessive femoral, iliac or aortic tortuosity or calcification.

Grouping: Patients were divided based on the development of post-TAVI conduction abnormalities into two groups: **Group I (n=70):** Without conduction abnormalities and **Group II (n = 10):** developed new-onset conduction abnormalities.

A comprehensive medical history was taken from each patient including details about cholesterol levels, diabetes, medications, high blood pressure, smoking and any prior or current coronary artery disease (CAD) or percutaneous coronary intervention (PCI) procedures in the family. A comprehensive physical examination was also conducted, which included evaluations of the heart and lungs, measurements for body mass index and hemodynamic (blood pressure, temperature and pulse). Blood sugar levels were checked at random, coagulation profile measures (prothrombin time, prothrombin concentration and partial thromboplastin time) were measured, liver function tests (aspartate aminotransferase and alanine transaminase) and kidney function tests were measured and a full blood count was taken.

Standard 12-lead electrocardiogram (ECG): All ECG recordings were analysed by an experienced physician blinded to treatment group.

Baseline echocardiography: Aortic dimensions (at the aortic root, Sino-tubular junction and ascending aorta levels from a dedicated parasternal long-axis view) was measured during diastole, along with interventricular septal thickness, end-diastolic diameter (LVEDd), left ventricular ejection fraction and left ventricular end-systolic diameter (LVESD). The baseline study, the stabilization of the valve, the gradient across the prosthesis, the degree of mitral regurgitation, the presence of paravalvular leaks (PVL) and the echocardiographic results were all incorporated.

Baseline multi-slice computed tomography (MSCT):

a) Aortic annulus (mean diameter, perimeter, and area): Aortic annulus analysis was done with respect to current recommendations on standardized imaging for aortovalvular sizing.

b) Height of coronary ostia (LMCA and RCA): The distance between the ostia of the coronaries and the annulus and the length of the coronaryleaflets were assessed.

c) Degree of valve calcification.

d) Basal septal calcification: It was scanned for the presence of calcification (0= no calcification, 1= presence of calcification).

e) Length of membranous septum (MS) with indexed values to BSA MSi)):Membranous septum length was defined as the distance between the aortic valve and .the crest of the muscular IVS in coronal view.

***TAVI procedure:**

The default access option for TAVI was transfemoral and valve selection was performed at the discretion of the heart team:

1. Valve type: 48 patients received Evolut R/R pro while 32 patients received accurate Neo2.
2. Valve size: patients underwent TAVI after a careful evaluation by the heart team. Size selection was based on perimeter and area measurements of the aortic annulus obtained by CT and matched with the manufacturers' recommendations.
3. Depth of Implantation (DI): To confirm orthogonality about the aortic annulus, the implant depth was measured fluoroscopically in the implantation projection, which was predetermined using CT (implanter's view). The distance between the most proximal border of the implanted valve and the native aortic annulus plane, which is located at its medial side and is associated to IVS, was defined as the depth of implantation (deepest level in the left ventricle).
4. Relationship between depth of implantation and membranous septum. This relationship was measured in2 forms:
   - Numerical difference between membranous septum and implantation depth (ΔMSID). ΔMSID is calculated as follows: ΔMSID = Membranous septum length – Implantation depth.

- Percentage of depth of implantation from the membranous septum (DIMS).
- We are proposing DIMS as a predictive model for the development of post-procedural conduction disturbances DIMS was calculated as follows:

  DIMS = DI/MS x 100%. {Where DI is the implantation depth measured by fluoroscopy and MS is the membranous septum length measured by CT}.

5. The procedure was completed in the cardiac catheterization laboratory under general anesthesia or sed analgesia with echocardiography guidance
6. All patients received aspirin (75mg) and clopidogrel (≥300 mg) before the procedure and heparin during the procedure.
7. Patients continued to take aspirin indefinitely and clopidogrel for a minimum of one month post operation.
8. These data included clinical assessment findings, electrocardiogram (ECG), echocardiogram, MSCT and laboratory test results, were obtained from patient file records or during follow-up visits.

Ethical approval: Menofia Faculty of Medicine Ethics Committee authorized this study. After receiving all of the information, all participant signed their permissions. The Helsinki Declaration was followed throughout the course of the investigation.

Statistical analysis

Microsoft SPSS version 27 was employed to conduct the statistical analysis and data administration. We validated the normality of the quantitative data using direct data visualization tools and the Shapiro-Wilk test. The quantitative data were summarized using standard deviations, medians, ranges and means to ensure normality. Categorical data were summarized quantitatively and using percentages. For parametric variables, we used the independent t-test and for non-parametric ones, we used the Mann-Whitney U test to compare the groups' quantitative data.

Fisher's exact test and Chi-square test were used to compare the categorical data. In order to predict conduction issues after TAVI, we conducted ROC analysis on DIMS and ŔMSID, which represent the depth of implantation at the membrane septum. The diagnostic indices, ideal cutoff point, area under the curve and 95% confidence intervals were then determined using each ROC analysis. Researchers used univariate and multivariate logistic regression analysis to predict problems after TAVI. Results with 95% CIs and odds ratios (OR) were calculated. Together with 95% confidence intervals, a regression coefficient was calculated. Each statistical measure had two potential outcomes, when the p-value was ≤ 0.05.

RESULTS

Insignificant differences were observed between patients with and without post-TAVI conduction abnormalities regarding age, gender, BMI, BSA, creatinine clearance, smoking status, diabetes mellitus, hypertension, ischemic heart disease, history of cerebrovascular stroke and prior CABG or chronic lung disease (Table 1).

Table (1): General characteristics of the studied patients

		Total (n=80)	CHB		P value
			Yes (n = 10)	No (n = 70)	
Age (years)		76 ±4	77 ±3	76 ±4	0.522
Gender	**Males**	47 (58.8%)	7 (70%)	40 (57.1%)	0.44
	Females	33 (41.3%)	3 (30%)	30 (42.9%)	
BMI (kg/m²)		27 ±2	26 ±2	27 ±3	0.674
BSA (m²)		1.91 ±0.48	1.93 ±0.47	1.9 ±0.49	0.876
CrCl (ml/min)		57 ±11	58 ±10	56 ±12	0.728
Smoking		13 (16.3%)	2 (20%)	11 (15.7%)	0.731
DM		30 (37.5%)	4 (40%)	26 (37.1%)	0.861
HTN		48 (60%)	7 (70%)	41 (58.6%)	0.49
IHD		8 (10%)	1 (10%)	7 (10%)	1
Previous cerebrovascular stroke		9 (11.3%)	1 (10%)	8 (11.4%)	0.894
CABG		2 (2.5%)	0 (0%)	2 (2.9%)	1
Chronic lung disease		20 (25%)	1 (10%)	19 (27.1%)	0.242

Data was presented as mean ±SD or frequency (%), **SD:** standard deviation, **HTN:** hypertension, **IHD:** ischemic heart disease, **BMI:** body mass index, **BSA:** body surface area, **DM:** diabetes mellitus, **CrCl:** creatinine clearance, **CABG:** coronary artery bypass graft.

Right bundle branch block was significantly more prevalent among patients with complete heart block compared to those without (30% vs. 1.4%, P = 0.005). Additionally, QRS duration was significantly longer in the complete heart block group (104 ±20 msec vs. 92 ±16 msec, P = 0.043). No significant differences were observed between the groups regarding atrial fibrillation (P = 0.567), LBBB (P = 1.000) and PR interval duration (P = 0.589). Interventricular SWT was significantly greater in patients who developed complete heart block compared to those who did not (15 ±1 mm vs. 14 ±1 mm, P = 0.035).

No significant differences were found between the groups regarding ejection fraction (P = 0.266), posterior wall thickness (P = 0.511), LVEDD (P = 0.353), LVESD (P = 0.136), mean pressure gradient (P = 0.993), aortic valve area (P = 0.359) and the presence of grade III aortic regurgitation (P = 1). No significant differences were observed between patients with and without post-TAVI complete heart block regarding computed tomography findings.

This included annulus mean diameter (P = 0.614), annulus area (P = 0.955), RCA diameter (P = 0.228), membranous septum (MS) length (P = 0.516) and the presence of aortic valve calcification grade IV (P = 0.42). Although LMCA diameter appeared numerically smaller in the conduction abnormality group, the difference was not statistically significant (P = 0.054) (Table 2).

Table (2): ECG, echocardiographic and computed tomography findings of the studied patients

	Total (n=80)	CHB		P value
		Yes (n = 10)	No (n = 70)	
ECG				
AF	13(16.3%)	1 (10%)	12 (17.1%)	0.567
LBBB	7 (8.8%)	1 (10%)	6 (8.6%)	1
RBBB	4 (5%)	3 (30%)	1 (1.4%)	**0.005***
PR interval duration (msec)	184 ±11	182 ±12	184 ±11	0.589
QRS duration (msec)	93 ±17	104 ±20	92 ±16	**0.043***
Echocardiographic findings				
EF (%)	58 ±6	56 ±6	59 ±6	0.266
SWT (mm)	14 ±1	15 ±1	14 ±1	**0.035***
PWT (mm)	14 ±1	14 ±1	14 ±1	0.511
LVEDD (mm)	50 ±7	52 ±6	50 ±7	0.353
LVESD (mm)	29 ±6	32 ±6	29 ±6	0.136
Mean pressure gradient (mmHg)	52 ±5	52 ±4	52 ±5	0.993
Aortic valve area (cm²)	0.77 ±0.13	0.8 ±0.12	0.76 ±0.13	0.359
Grade III AR	5 (6.3%)	0 (0%)	5 (7.1%)	1
Computed tomography findings				
Annulus mean diameter (mm)	23.5 ±4	23.3 ±1	23.5 ±1.4	0.614
Annulus area (cm²)	4 ±1	4 ±1	4 ±1	0.955
LMCA (mm)	13.1 ±1.4	12.3 ±1.3	13.2 ±1.4	0.054
RCA (mm)	14.2 ±1	14.5 ±1.3	14.1 ±0.9	0.228
MS (mm)	8 ±1	8 ±2	8 ±1	0.516
Aortic valve calcification grade IV	4 (5%)	1 (10%)	3 (4.3%)	0.42

Data was presented as mean ±SDor frequency (%), *:significant as P-value ≤ 0.05. LVEDD: left ventricular end-diastolic diameter, LVESD: left ventricular end-systolic diameter, mmHg: millimeters of mercury, LMCA: left main coronary artery, SWT: septal wall thickness, MCA: left main coronary artery, PWT: posterior wall thickness, RCA: right coronary artery, CT: computed tomography, MS: membranous septum. EF: ejection fraction, SD: standard deviationRCA: right coronary artery, MS: membranous septum, AR: aortic regurgitation,ECG:electrocardiogram.

Evolut R/R pro valve was used more frequently among those who developed complete heart block (90% vs. 55.7%, P = 0.038). Additionally, patients with complete heart block had a significantly larger device-implantation-to-membranous-septum distance (DIMS) (95 ±18 mm vs. 56 ±15 mm, P < 0.001), and a significantly lower ΔMSID (1 mm [0–4] vs. 4 mm [2–5], P < 0.001). Other procedural characteristics, including balloon post-dilatation (P = 0.21) and valve size > 29 mm (P = 0.691) were not significantly different (Table 3).

Table (3): Procedural characteristics findings between the studied groups

		Total (n=80)	CHB		P value
			Yes (n = 10)	No (n = 70)	
Valve type	**Evolut R/R pro**	48 (60%)	9 (90%)	39 (55.7%)	**0.038***
	Acurate NEO2	32 (40%)	1 (10%)	31 (44.3%)	
Balloon pre-dilatation		80(100%)	--	--	--
Balloon post-dilatation		7(8.8%)	2 (10%)	5 (7.1%)	0.21
Valve size > 29 mm		13 (16.3%)	1(10%)	12 (17.1%)	0.691
DIMS (mm)		61 ±20	95 ±18	56 ±15	**<0.001***
ΔMSID (mm)		4 (0 - 5)	1 (0 - 4)	4 (2 - 5)	**<0.001***

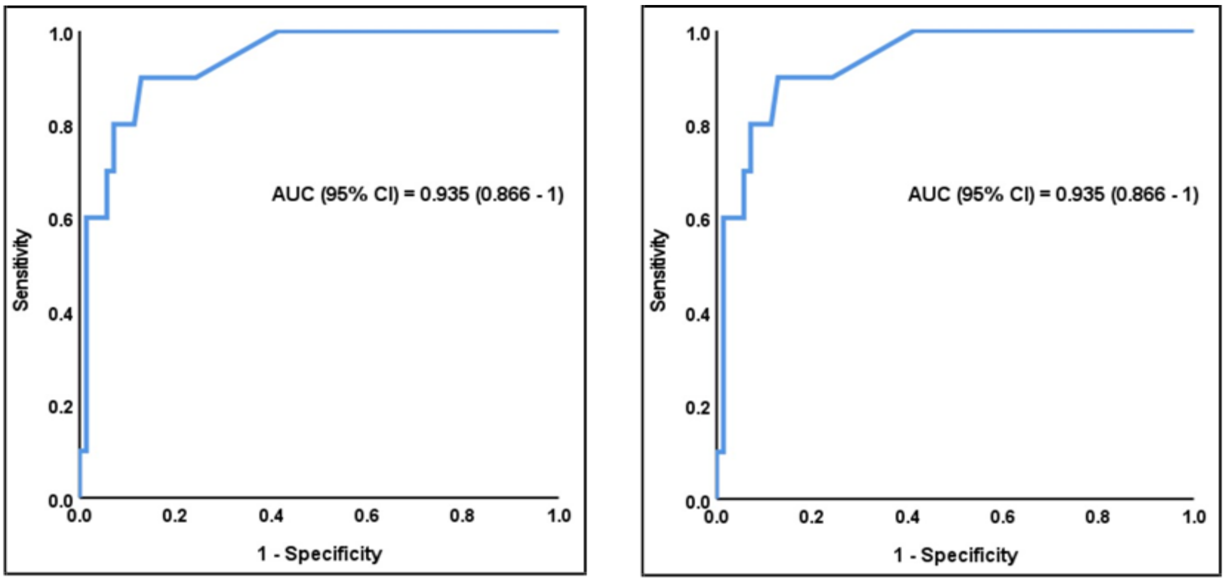
ΔMSID: membranous septum to implantation depth difference, DIMS: depth of implantation at the membranous septum, *:significant.

ROC curve analysis was performed for DIMS to predict the development of complete heart block post-TAVI. It revealed a significant AUC of 0.935 with a 95% confidence interval ranging from 0.866 to 1.000, suggesting an excellent ability to predict conduction abnormalities. The best cutoff was > 64 mm, at which sensitivity, specificity, PPV, and NPV were 90.0%, 87.14%, 50.0% and 98.4% respectively. ROC curve analysis was performed for ΔMSID to predict the development of complete heart block post TAVI. Also, it demonstrated a significant AUC of 0.936 with a 95% confidence interval ranging from 0.838 to 1.000 indicating excellent predictive ability. The best cutoff point was ≤ 2 mm at which sensitivity, specificity, PPV, and NPV were 80.0%, 98.57%, 88.9% and 97.2% respectively (Table 4 & Figure 1).

Table (4): ROC analysis of DIMS and ΔMSID to predict conduction abnormalities

	AUC	95% CI	Best cutoff point	Sensitivity	Specificity	PPV	NPV	P
DIMS	0.935	0.866 - 1.000	>64	90.00%	87.14%	50.00%	98.40%	**<0.001***
ΔMSID	0.936	0.838 - 1.00	≤2	80.00%	98.57%	88.90%	97.20%	**<0.001***

ΔMSID: membranous septum to implantation depth difference, AUC: area under the curve, DIMS: depth of implantation at the membranous septum, NPV: negative predictive value, PPV: positive predictive value, CI: confidence interval, *:significant**.**



(A) **(B)**

Figure (1): (A) ROC analysis of DIMS to predict conduction abnormalities, (B) ROC analysis of ΔMSID to predict conduction abnormalities.

Pre-TAVI, 13 patients had atrial fibrillation (AF), 7 had LBBB, and 4 had RBBB. Among the 13 patients with AF, 7.7% developed complete heart block (CHB) following TAVI. Of the 7 patients with LBBB, 14.3% developed post-TAVI CHB. Among the 4 patients with RBBB, 75% developed post-TAVI CHB (Table 5).

Table (5): Pre-TAVI conduction disturbance and its relation to post TAVI complete heart block

		Post TAVI CHB	
Pre TAVI conduction disturbance	**Total**	**Yes**	**No**
AF	13	1 (7.7)	12 (92.3%)
LBBB	7	1 (14.3)	6 (85.7%)
RBBB	4	3 (75)	1 (25%)

RBBB: Right bundle branch block, LBBB: Left bundle branch block. AF:atrial fibrillation.

All variables that showed significant associations with post-TAVI complete heart block were included in univariate and multivariate logistic regression analyses. Multivariate logistic regression revealed that several independent predictors were significantly associated with the development of post-TAVI complete heart block. Presence of RBBB increased the risk by more than 34-fold (OR = 34.213, 95% CI: 2.573–454.912, P = 0.007). Each 1 msec increase in QRS duration was associated with a 4.1% increase in risk (OR = 1.041, 95% CI: 1.003–1.080, P = 0.034), while each 1 mm increase in SWT nearly doubled the risk (OR = 2.332, 95% CI: 1.044–5.208, P = 0.039). Use of the Evolut R/R pro valve was associated with a 12-fold increase in risk (OR = 12.071, 95% CI: 1.094–133.140, P = 0.042). Additionally, each 1 mm increase in device-implantation-to-septal-margin distance (DIMS) raised the risk by 11.6% (OR = 1.116, 95% CI: 1.052–1.184, P < 0.001). Conversely, for each 1 mm increase in the change in MSID (ΔMSID), the risk decreased by 98% (OR = 0.02, 95% CI: 0.001–0.385, P = 0.01), controlling for age, gender, BMI, smoking, DM, hypertension, and ischemic heart disease (Table 6).

Table (6): Univariate and multivariate logistic regression analyses to predict conduction abnormalities

	Univariate		Multivariate	
	OR (95% CI)	**P-value**	**OR (95% CI)†**	**P-value**
RBBB	29.571 (2.702 - 323.694)	**0.006***	34.213 (2.573 - 454.912)	**0.007***
QRS duration (msec)	1.031 (0.999 - 1.064)	0.058	1.041 (1.003 - 1.080)	**0.034***
SWT (mm)	2.002 (1.013 - 3.957)	**0.046***	2.332 (1.044 - 5.208)	**0.039***
Evolut R/R pro	8.5 (1.022 - 70.707)	**0.048***	12.071 (1.094 - 133.140)	**0.042***
DIMS (mm)	1.093 (1.048 - 1.139)	**<0.001***	1.116 (1.052 - 1.184)	**<0.001***
ΔMSID (mm)	0.087 (0.020 - 0.382)	**0.001***	0.02 (0.001 - 0.385)	**0.01***

*:significant, OR: odds ratio, CI: confidence interval, RBBB: right bundle branch block, QRS: QRS complex duration, SWT: septal wall thickness, DIMS: depth of implantation at the membranous septum, ΔMSID: membranous septum to implantation depth difference, †: adjusted for age, gender, BMI, smoking, DM, hypertension, and ischemic heart disease.

DISCUSSION

TAVI is a well-established treatment option for individuals with severe aortic stenosis who face an intermediate to high surgical risk. Recent clinical trials demonstrate that TAVI is non-inferior or even superior in short- to mid-term results in low-risk patients compared to SAVR [9].

Based on our study, right bundle branch block (RBBB) was significantly more prevalent among patients with conduction abnormalities compared to those without (30% vs. 1.4%, P = 0.005). Additionally, QRS duration was significantly longer in the conduction abnormality group (104 ±20 msec vs. 92 ±16 msec, P = 0.043). Regarding our study also, among the 4 patients with RBBB, 75% developed post-TAVI CHB which ensures that RBBB is the strongest predictor on conduction abnormalities after TAVI. Multivariate logistic regression revealed that several independent predictors were significantly associated with the development of post-TAVI complete heart block. Presence of RBBB increased the risk by more than 34-fold (OR = 34.213, 95% CI: 2.573–454.912, P = 0.007). Each 1 msec increase in QRS duration was associated with a 4.1% increase in risk (OR = 1.041, 95% CI: 1.003–1.080, P = 0.034). This is consistent with **Nazif *et al.*** [10] who demonstrated that regardless of the device (CoreValve vs. SAPIEN valve), baseline RBBB consistently predicts PPI.

One year following TAVI, baseline RBBB, PR interval duration before and after TAVI, PR interval change (>28 ms) within three days of TAVI and porcelain aorta have been identified as independent predictors of pacemaker reliance, while there was no significant differences between the groups' baseline LBBB or AF [11], which is partially consistent with our study as regarding our study there was no significant differences observed between the groups regarding PR interval duration, atrial fibrillation or LBBB. This might be explained by the fact that we did not undertake invasive electrophysiological tests in this study making it impossible to determine whether AV nodal injury or infra-hisian damage was the cause of our patients' prolonged atrioventricular conduction time. However, it is conceivable that this was owing to infra-hisian injury in our sample as well, where PR interval lengthening was frequently accompanied with new onset LBBB. Finally, our results regarding PR interval as a predictor of conduction abnormalities after TAVI was concordant with **Boonyakiatwattana *et al.*** [12] who demonstrated no statistically significant differences between patients develop conduction disturbance or not regarding PR interval with p value > 0.05.

Our study showed that no significant differences were found between the groups regarding ejection fraction (P = 0.266), posterior wall thickness (P = 0.511), LVEDd (P = 0.353), LVESD (P = 0.136), mean pressure gradient (P = 0.993), aortic valve area (P = 0.359), and the presence of grade III aortic regurgitation (P = 1), which is consistent with other results [11, 13].

Regarding pre-operative CT findings, no significant differences were observed between patients with and without post-TAVI conduction abnormalities. This included annulus mean diameter (P = 0.614), annulus area (P = 0.955), right coronary artery (RCA) diameter (P = 0.228) and membranous septum (MS) length (P = 0.516). Although left main coronary artery (LMCA) diameter appeared numerically smaller in the conduction abnormality group, the difference was not statistically significant. This is consistent with **Baraka *et al.*** [14] who demonstrated non significance of height of LM and height of RCA between 2 groups with p value > 0.05.

Our results showed that there was no significant differences between the two groups regarding the presence of aortic valve calcification grade IV, which is discordant with **Baraka *et al.*** [14] and **Tretter *et al.*** [15], which may be contributed to the exclusive use of Evolut Pro and Acurate NEO2, which weren't used in the two previously mentioned studies. Also, the valves we used were self-expandable valves, while **Baraka *et al.*** [14] used the balloon expandable Sapien XT valve and **Tretter *et al.*** [15] used the balloon-expanding valve (SapienXT or Sapien3, Edwards Lifesciences, Irvine,CA,USA). According to our study, incidence of conduction abnormalities was significantly higher with Evolut R/R pro. Multivariate logistic regression revealed that use of the Evolut R/R pro valve was associated with a 12-fold increase in risk (OR = 12.071, 95% CI: 1.094–133.140, P = 0.042). This is concordant with the results of **Kalogeras *et al.***[16]**,** which showed that self-expanding THVs with a bottom-up deployment mechanism (Evolut system 12–18%; Portico/Navitor with FlexNav [Abbott] 9–19%) had the highest frequency of PPI, whereas self-expanding THVs with a top-down deployment mechanism (ACURATE neo2 system 7%) and the balloon-expandable SAPIEN 3 Ultra (5–10%) had the lowest rates.

Additionally, patients with conduction abnormalities had a significantly larger DIMS (95 ±18 mm vs. 56 ±15 mm, P < 0.001), and a significantly lower ΔMSID (1 mm [0–4] vs. 4 mm [2–5], P < 0.001). Other procedural characteristics, including balloon post-dilatation (P = 0.21) and valve size >29 mm (P = 0.691), were not significantly different. Multivariate logistic regression also revealed that each 1 mm increase in device-implantation-to-septal-margin distance (DIMS) raised the risk by 11.6% (OR = 1.116, 95% CI: 1.052–1.184, P < 0.001). Conversely, for each 1 mm increase in the change in MSID (ΔMSID), the risk decreased by 98% (OR = 0.02, 95% CI: 0.001–0.385, P = 0.01), controlling for age, gender, BMI, smoking, DM, HTN and IHD. This is consistent with **Jilaihawi *et al.***[7] who reported that depth of implantation and numerical difference between ΔMSID was statistically significant in patients needed PPI (4.5 ± 1.9 vs. 3.2 ± 1.8) and (-1.6 ± 2.4 vs. 0.9 ± 3.0) respectively with p value 0.002 and < 0.001 respectively. And no statistically significant differences between patients needed PPI or not regarding predilatation and post-dilatation or valve oversizing with p value > 0.05. Also concordant with **Boonyakiatwattana *et al.*** [12] who demonstrated that depth of implantation, numerical difference between ΔMSID and percentage of DIMS with p-value <0.001 for all of them. Also, revealed no statistically significant differences between patients develop conduction disturbance or not regarding pre-dilatation and post-dilatation with p value > 0.05.

In our study, ROC curve analysis was performed for DIMS to predict the development of complete heart block post-TAVI. It revealed a significant AUC of 0.935 with a 95% confidence interval ranging from 0.866 to 1.000, suggesting an excellent ability to predict conduction abnormalities. The best cutoff was > 64 %, at which sensitivity, specificity, PPV and NPV were 90.0%, 87.14%, 50.0% and 98.4% respectively. This meets the results of **Hamdan *et al.*** [17] which showed that the best cutoff criteria for PPM implantation prediction were MS length of 7.4 and ΔMSID of 0.4 mm and the corresponding negative predictive values were 86% and 89%. High-degree AV block was more likely to occur in patients in the lowest quartiles of MS length (≤ 6.8 mm) and ΔMSID (≤ −1 mm). The OR was 11.3 (95% CI: 2.9 to 43.8) for the ΔMSID and 4.7 (95% CI: 1.3 to 16.4) for MS duration. The best cutoff thresholds for predicting high-degree AV block were determined using sensitivity/specificity decision plots to be an MS length of 7.8 mm and a ΔMSID of 0.4 mm, respectively, with negative predictive values > 95% and almost 97% [17]. This is also consistent with the results of **Baraka *et al.*** [18] who showed that depth of THV implantation has an important role in the development of post-TAVI conduction problems. In a model that combines all pre- and post-procedural parameters, a percentage ratio of depth of implantation assessed from the NCC in CT to the entire length of the MS more than 70.42% was found to be the most important predictor of conduction problems.

LIMITATIONS

The relatively small sample size may be contributed to some insignificant results. It was a center- center study so there was a difference between individuals.

CONCLUSIONS

The current study concluded that presence of RBBB increased the risk for conduction abnormalities by more than 34-fold. Each 1 msec increase in QRS duration was associated with a 4.1% raise in risk, while each 1 mm increase in SWT nearly doubled the risk. Use of the Evolut R/R pro valve was associated with a 12-fold increase in risk. Additionally, each 1 mm increase in DIMS raised the risk by 11.6%. Therefore, we recommend that further studies with larger sample size and multicenter studies should be carried out.

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