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Association between fragmented QRS and postprocedural rhythm disturbances in patients who underwent transcatheter aortic valve implantation

Mustafa Duran[1]*, Murat Ziyrek[1], Yakup Alsancak[2], Hüseyin Ayhan[3]

SUMMARY

INTRODUCTION: According to recent studies, the rate of atrioventricular block requiring permanent pacing in patients following transcatheter aortic valve implantation varied between 5.7% and 42.5%. Fragmented QRS is a useful marker of myocardial scar and can predict adverse cardiac events. In this study, we examined association between fragmented QRS and postprocedural rhythm disturbances and the need for permanent pacing in patients who underwent transcatheter aortic valve implantation.

OBJECTIVE: In this study, we examined association between fragmented QRS and postprocedural rhythm disturbances and the need for permanent pacing in patients who underwent transcatheter aortic valve implantation' sentence is enough for it.

METHODS: We retrospectively analyzed standard 12-lead electrocardiographic recordings of 124 consecutive patients in whom a CoreValve prosthesis was implanted. We examined 12-lead electrocardiogram before and after procedure along with one- and six-month follow-up. We documented QRS fragmentation and postprocedural rhythm disturbances.

RESULTS: There was a significant increase in the frequency of left bundle branch block, (21.1 *versus* 0%, p<0.05) and the incidence of atrioventricular blocks requiring permanent pacing (21.1 *versus* 0%, p<0.05) following transcatheter aortic valve implantation in patients whose preprocedural electrocardiogram recordings revealed fragmented QRS compared to those without fragmented QRS. Based our collected data, the presence of QRS fragmentation in anterior derivations was the only independent factor associated with postprocedural rhythm disturbances (B-value 0.217; OR 0.805; 95%CI 0.136–4.78; p=0.004).

CONCLUSION*:* Our data showed an increased risk for the development of new-onset left bundle branch block and atrioventricular blocks following transcatheter aortic valve implantation in patients whose baseline electrocardiogram recordings demonstrated QRS fragmentation.

KEYWORDS: Aortic valve stenosis. Arrhythmias, cardiac. Transcatheter Aortic Valve Replacement.

INTRODUCTION

Transcatheter aortic valve implantation (TAVI) has emerged as a novel therapeutic option for patients who are considered to be ineligible for open surgery[1]. However, postprocedural complications including rhythm disturbances and the need for permanent pacing are common[2].

[1]Konya City Hospital, Department of Cardiology – Konya, Turkey.
[2]Necmettin Erbakan University, Medicine Faculty, Department of Cardiology – Konya, Turkey.
[3]Atilim University, Medicine Faculty, Department of Cardiology – Ankara, Turkey.
*Corresponding author: drmustafaduran44@gmail.com
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Fragmented QRS complex (fQRS) is frequently seen on routine electrocardiographic (ECG) recordings with narrow or wide QRS complexes[3]. Prognostic significance of QRS fragmentation for predicting adverse cardiac events was demonstrated in previous studies[4-6].

In this study, we aimed to investigate the predictive role of fQRS in the occurrence of rhythm disturbances and the need for permanent pacing in patients undergoing TAVI.

METHODS

We retrospectively analyzed standard 12-lead electrocardiographic recordings of 124 consecutive patients in whom a CoreValve prosthesis (Medronic Inc., Minneapolis, USA) was implanted. Patients having bundle branch block, including left bundle branch block (LBBB), incomplete or complete right bundle branch block (RBBB), or QRS duration ≥120 msec in baseline ECG, and patients with permanent pacing were excluded from the study.

Demographic and clinical characteristics of patients and procedural variables were retrospectively analyzed. Preprocedural and the first and sixth months postprocedural ECG recordings were evaluated. Patients were divided into two groups based on the presence or absence of fQRS in the preprocedural ECGs. The presence of rhythm and types of rhythm disturbances were defined according to the AHA/ACCF/HRS recommendations for the standardization and interpretation of the ECG[7]. Any of the rhythm disturbances occurring within the first 48 hours after TAVI are accepted as temporary, and those persisting more than 48 hours as permanent. ECG measurements were performed by a cardiologist who was blind to the patient data and verified by a second physician to avoid errors in measurements. Definition of fQRS was made according to previous studies[8]. Informed consent was obtained from all patients in accordance with a protocol approved by the Ethics Committee of Ankara Ataturk Training and Research Hospital (approval number: 26379996-102).

Statistical analysis

Statistical analyses were conducted using SPSS version 20.0 (SPSS Inc., USA). Data were expressed as mean±SD for continuous variables and as counts and percentages for categorical variables. Differences were considered statistically significant at $p<0.05$. Fitness to the normal distribution was analyzed with the Kolmogorov–Smirnov test. Student's *t*-test and Mann–Whitney U tests were used for comparison of continuous variables, and chi-square and Fisher's exact tests were used for comparison of categorical variables. Binary logistic regression analysis was performed to explore independent factors associated with rhythm disturbances.

RESULTS

Of the 124 patients initially screened, 24 patients whose baseline ECG recordings demonstrated wide QRS (QRS>120 msec) were excluded, leaving 100 patients for analysis. According to our study, 71 patients whose baseline ECG demonstrated QRS fragmentation at least in one derivation formed fQRS(+) group and 29 patients whose baseline ECG did not demonstrate QRS fragmentation formed fQRS(-) group. A comparison of baseline clinical and demographic characteristics of both groups is provided in Table 1. Based on our data, male gender (52.1 *versus* 34.5%, $p<0.05$) and calculated Society of Thoracic Surgeons scores (7.3±1.7 *versus* 6.5±1.3, $p<0.05$) were significantly higher in fQRS(+) group compared with fQRS(-) group. In addition, there were significantly lower estimated left ventricular ejection fraction (45 *versus* 65%, $p<0.001$) and higher rates of the New York Heart Association (NYHA) classes (NYHA class III; 57.7 *versus* 41.4% and NYHA class IV; 26.8 *versus* 10.3%, $p<0.001$) in fQRS(+) group compared with fQRS(-) group. Although baseline ECG findings were comparable between the two groups, preprocedural heart rate was significantly lower in fQRS(+) group compared with fQRS(-) group (70.8±13.5 *versus* 77.4±13.3, $p<0.05$).

A comparison of procedural variables and postprocedural rhythm disturbances is given in Table 2. Both groups had similar procedural characteristics. Regarding rhythm disturbances, 39 of 71 patients with fQRS developed temporary rhythm disturbances during hospitalization. However, only 4 of 29 patients without fQRS developed temporary rhythm disturbances. Furthermore, 28 of 71 patients with fQRS and 1 of 29 patients without fQRS developed permanent rhythm disturbances. After implantation of the device, permanent pacing was required in 10 (10%) patients due to complete atrioventricular (AV) block.

Due to the loss of 10 patients, outcomes of 1- and 6-month follow-up were based on data of 90 patients: 62 patients in fQRS(+) and 28 patients in fQRS(-) group. The difference in permanent rhythm disturbances was also maintained in 1- month and 6-month follow-up (37.1 *versus* 0% and 38.7 *versus* 0%; $p<0.0001$). Binary logistic regression analysis provided that the presence of QRS fragmentation in anterior derivations was the only independent factor associated with postprocedural conduction abnormalities (Table 3).

Table 1. Comparison of baseline characteristics of fragmented QRS (+) and fragmented QRS (-) groups.

	fQRS (+) (n=71)	fQRS (-) (n=29)	p-value
Age (years)	76.5±8.6	79.1±5.2	0.078
Male gender, n (%)	37 (52.1)	10 (34.5)	0.045
Coronary artery disease, n (%)	47 (64.8)	15 (51.7)	0.254
Diabetes mellitus, n (%)	26 (36.6)	10 (34.4)	0.845
Hypertension, n (%)	54 (76.0)	21 (72.4)	0.758
COPD, n (%)	52 (73.2)	16 (55.2)	0.079
Atrial fibrillation, n (%)	29 (40.8)	10 (34.48)	0.495
β-Blocker therapy preoperative (n%)	44 (61.9)	17 (58.62)	0.678
Logistic EuroScore	29.9±9.6	28.5±9.7	0.509
STS score	7.3±1.7	6.5±1.3	0.035
NYHA class			
NYHA class II, n (%)	11 (15.5)	14 (48.3)	<0.001
NYHA class III, n (%)	41 (57.7)	12 (41.4)	0.046
NYHA class IV, n (%)	19 (26.8)	3 (10.3)	<0.001
Ejection fraction (%/ median, IQR)	45 (35–60)	65 (55–65)	<0.001
AVA (cm^2)	0.69±0.11	0.71±0.08	0.064
Aortic peak gradient (mm Hg)	77.4±26.8	79.9±23.5	0.658
Aortic mean gradient (mm Hg)	47.3.±14.9	49.1±16.4	0.861
Heart rate (bpm)	70.8±13.5	77.4±13.3	0.034
P wave duration (msec)	89.03±10.75	85.75±9.31	0.498
PR interval (msec)	142.06±17.86	139.03±15.56	0.297
QRS duration (msec)	106.44±3.14	103.16±5.87	0.382
corrected QT interval (msec)	398±13.55	387±10.85	0.078
AV block, n (%)	11 (15.49)	4 (13.79)	0.876

fQRS: fragmented QRS; COPD: chronic obstructive pulmonary disease; NYHA: New York Heart Association; STS: Society of Thoracic Surgeons; AVA: aortic valve area, bpm: beats per minute; AV: atrioventricular. Bold values indicate statistical significance at p<0.05.

DISCUSSION

The main finding of this study is the presence of fQRS on surface ECG prior to the TAVI, which is a strong predictor for the development of rhythm disturbances and the need for permanent pacemaker implantation.

TAVI is a less invasive and safe therapeutic alternative in patients who are at very high surgical risk or in whom there are contraindications to surgical aortic valve replacement. On the other hand, life-threatening complications including stroke, paravalvular leak, and rhythm disturbances that require permanent pacing still persist[9]. In terms of postprocedural complications of TAVI, AV and intraventricular conduction disorders are still the most frequent adverse events[10].

Due to the importance of postprocedural rhythm disturbances, several studies were investigating the predictive risk factors for the development of rhythm disturbances in patients undergoing TAVI. According to those studies, septal wall thickness, noncoronary cusp thickness, preexisting RBBB, depth of valve implantation within the left ventricular outflow tract, postimplant prosthesis expansion, and the type of prosthesis were independent risk factors for this complication[11-14].

According to our study, there was a strong association between QRS fragmentation and postprocedural rhythm disturbances, including new-onset LBBB and complete AV block. In addition, the incidence of AV blocks requiring permanent pacing was higher in patients with fQRS than patients with non-fQRS (11 *versus* 0%, p<0.05). Furthermore, there was a strong relationship between the number of ECG leads with fQRS and the incidence of rhythm disturbances and this relation reached statistical

Table 2. Procedural characteristics and postprocedural rhythm disturbances of fragmented QRS (+) and fragmented QRS (-) groups.

		fQRS (+) (n=71)	fQRS (-) (n=29)	p-value
Single valve implantation, n (%)		66 (92.9)	28 (96.5)	0.014
Approach, n (%)	Transfemoral	67 (94.37)	27 (93.11)	0.684
	Transapical	4 (5.63)	2 (6.89)	0.698
İmplantation depth (mm)	LCC (mm)	6.37±2.54	6.32±2.53	0.601
	NCC (mm)	6.86±2.33	6.89±2.67	0.706
Predilatation, n (%)		53 (74.64)	20 (71.42)	0.804
Postdilatation, n (%)		10 (14.08)	4 (13.79)	0.901
Prosthesis size (mm)		27.30±2.66	26.85±2.46	0.181
Ratio of prosthesis size to annulus size		1.08±0.02	1.07±0.03	0.681
Intraoperative peak pressure gradient (mm Hg)		16.7±8.12	18.7±6.83	0.156
Intraoperative mean pressure gradient (mm Hg)		9.5±5.2	9.9±3.6	0.295
Postprocedural temporary rhythm disturbances				
		Total patients (n=100)	fQRS (+) group (n=71)	fQRS (-) group (n=29)
No rhythm disturbance (n)		57	32	25
Temporary RBBB (n)		4	2	2
Temporary LBBB (n)		27	25	2
Temporary first-degree AV block		17	15	2
Temporary second-degree AV block		0	0	0
Temporary third-degree AV block		12	12	0
Postprocedural permanent rhythm disturbances				
		Total patients (n=100)	fQRS (+) group (n=71)	fQRS (-) group (n=29)
No rhythm disturbance (n)		71	43	28
Permanent RBBB (n)		3	2	1
Permanent LBBB (n)		15	15	0
Permanent first-degree AV block		15	14	1
Permanent second-degree AV block		0	0	0
Permanent third-degree AV block		11	11	0
Postprocedural 1-month follow-up				
		Total patients (n=90)	fQRS (+) group (n=62)	fQRS (–) group (n=28)
No rhythm disturbance (n)		67	39	28
Permanent RBBB (n)		2	2	0
Permanent LBBB (n)		11	11	0
Permanent first-degree AV block		14	14	0
Permanent second-degree AV block		0	0	0
Permanent third-degree AV block		10	10	0

Continue...

Table 2. Continuation.

Postprocedural 6-month follow-up			
	Total patients (n=90)	fQRS (+) group (n=62)	fQRS (–) group (n=28)
No rhythm disturbance (n)	66	38	28
Permanent RBBB (n)	3	3	0
Permanent LBBB (n)	11	11	0
Permanent firs-degree AV block	11	11	0
Permanent second-degree AV block	0	0	0
Permanent third-degree AV block	10	10	0

fQRS: fragmented QRS; LCC: left coronary cusp; NCC: noncoronary cusp; RBBB: right bundle branch block; LBBB: left bundle branch block; AV: atrioventricular.

Table 3. Data of binary regression analysis.

	Beta value	Odds ratio	95%CI	p-value
Age	0.561	0.398	0.871–2.156	0.065
Male gender	0.231	0.167	0.451–1.542	0.483
STS Score	0.698	0.781	0.653–2.156	0.078
Preprocedural ejection fraction	0.327	0.349	0.642–2.256	0.087
AVA	0.611	0.472	0.486–1.459	0.118
Baseline heart rate	0.134	0.371	0.380–1.014	0.569
Baseline PR interval	0.498	0.287	0.135–1.816	0.603
Fragmentation in anterior leads on baseline ECG	0.217	0.805	1.036–4.78	0.004
Baseline QT_c interval	0.531	0.269	0.690–2.698	0.517
Baseline QRS interval	0.719	0.491	0.997–3.175	0.071
Prosthesis size	0.598	0.370	0.792–2.784	0.089

STS: Society of Thoracic Surgeons; AVA: aortic valve area. Bold values indicate statistical significance at p<0.05.

significance in anterior leads compared with inferior leads (84.1 *versus* 50%, p<0.05).

Although the exact mechanisms that cause the formation of fQRS are not fully understood, altered homogeneity of myocardial electrical activity as a result of myocardial fibrosis and/or ischemia is generally accepted as the underlying mechanism[15,16]. Recent studies also revealed the strong relationship between the presence of fQRS and severe aortic stenosis. According to a study conducted by Agac et al.[17], the incidence of fQRS was found to be 46% in patients with severe aortic stenosis. In our study, there was a higher rate of fQRS in patients with severe aortic stenosis compared with their study (71 *versus* 46%). The most plausible explanation was higher rates of comorbid conditions and lower rates of calculated ejection fraction in our study compared with their cohort.

In another study conducted by Ay et al.[18], there was a strong association between fQRS and long-term survival in patients undergoing TAVI. Although outcomes of our study were comparable with their study, our study group consisted of higher rates of patients with fQRS than their study (71 *versus* 30.7%). Due to exclusion of patients with a prior history of myocardial infarction, coronary bypass surgery, severe coronary lesions, and those with an ejection fraction ≤30% from their study, this difference was observed. They also investigated the relationship between the need for permanent pacing following TAVI and the existence of fQRS. According to their study, the need for permanent pacing in the long term was higher in patients with fQRS compared with patients without fQRS (8.3 *versus* 3.7%, p=0.29). Compared with our study, the rate of permanent pacing was lower (0.5 *versus* 10%) in their study and the most plausible explanation was the difference in types of devices used for the procedure. In our study, all patients (100%) underwent TAVI with the CoreValve prosthesis. However, only 26 (22.2%) of 117 patients underwent TAVI with CoreValve prosthesis in their study.

CONCLUSIONS

In conclusion, our data showed an increased risk for the development of new-onset LBBB and AV blocks in patients whose baseline ECG recordings demonstrated QRS fragmentation.

AUTHORS' CONTRIBUTIONS

MD: Conceptualization, Data curation, Formal analysis, Writing – original draft. **MZ:** Data curation, Formal analysis, Writing – review & editing. **YA:** Conceptualization, Writing – review & editing. **HA:** Conceptualization, Data curation, Formal analysis, Writing – review & editing.

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