Junctional rhythm following transcatheter aortic valve replacement

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Introduction

Transcatheter aortic valve replacement (TAVR) has rapidly evolved as a treatment alternative to surgical aortic valve replacement for patients with symptomatic severe aortic stenosis with moderate or high surgical risk.[1,2] With the recent FDA decision to expand its indication to low-risk patients, TAVR is expected to be the primary option for aortic valve replacement in the future.[3] However, TAVR is associated with injury to the conduction system at the level of the bundle of His and the left bundle branch, leading to permanent pacemaker (PPM) implantation for complete atrioventricular (AV) block.[4] Retrospective data from a large registry of TAVR patients show that procedure-related AV block leading to PPM implantation occurs in up to 12% of patients and has been associated with longer hospital stay and a higher risk of rehospitalization.[4–8] Therefore, efforts to understand the mechanisms and to identify risk factors for post-TAVR AV block should be emphasized.

Junctional rhythm is a common electrocardiogram (ECG) finding in an early postoperative period after cardiac surgery, especially valve replacement, and has been associated with increased morbidity.[9] Accelerated junctional rhythm during ablation close to the AV junction is a harbinger of imminent complete AV block. However, the data on junctional rhythm following TAVR are scarce.[10] Our case series describes the characteristics and outcomes of 6 patients who developed junctional rhythm after TAVR at a large, urban tertiary care hospital.

KEY TEACHING POINTS

- Transcatheter aortic valve replacement (TAVR) is associated with injury to the cardiac conduction system. To our knowledge, this is the first case series to describe junctional rhythm as one of the rhythm disorders after TAVR.
- The mechanism of junctional rhythm after TAVR is not well understood. Enhanced automaticity caused by a pressure-related injury to the atrioventricular nodal region may be responsible for the development of accelerated junctional rhythm in these cases.
- Although the incidence of sustained junctional rhythm following TAVR is low, its development may be a risk factor associated with adverse outcomes, with 33% of patients in our case series requiring permanent pacemaker (PPM). Whether junctional rhythm is a predictor of patients who would potentially require PPM post TAVR remains unclear and needs further study in larger cohorts.

KEYWORDS Atrioventricular block; Junctional rhythm; Permanent pacemaker; Surgical aortic valve replacement; Transcatheter aortic valve replacement

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Case report

Identification of eligible cases

We performed a retrospective chart review of 301 consecutive patients with severe aortic stenosis who underwent TAVR at Minneapolis Veterans Affairs Medical Center from April 2015 through April 2019. Patients who developed new junctional rhythm on post-TAVR 12-lead ECG were included in the case series. The ECGs were

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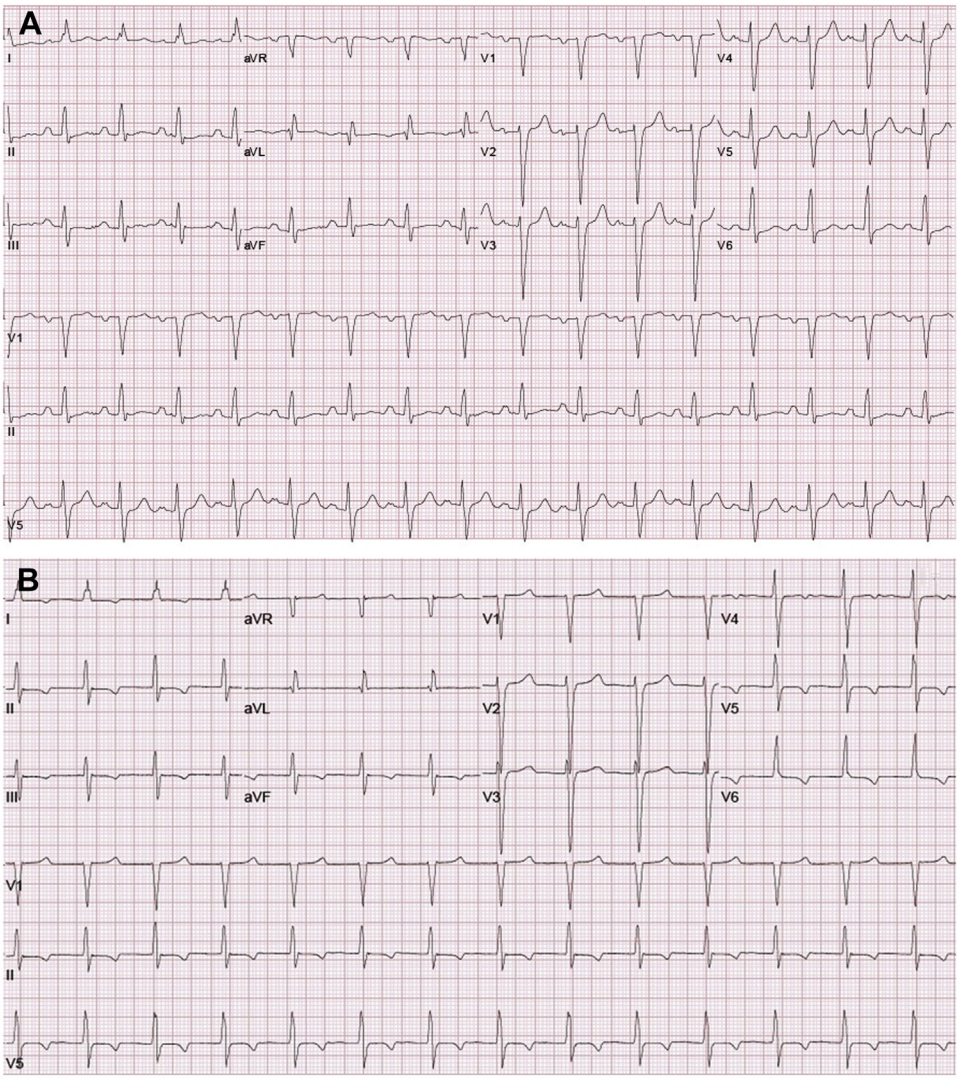

Figure 1 Junctional rhythm following transcatheter aortic valve replacement. **A:** A baseline 12-lead electrocardiogram of case 2 was recorded before transcatheter aortic valve replacement (TAVR), demonstrating normal sinus rhythm. **B:** On post-TAVR day 0, a repeat 12-lead electrocardiogram of case 2 was obtained, which demonstrated accelerated junctional rhythm with a ventricular rate of 83 beats per minute and nonspecific T-wave inversions in the inferolateral leads.

independently reviewed by 2 investigators (N.A. and B.A.). The diagnosis of junctional rhythm was established on the basis of ECG finding of regular QRS complexes, not preceded by a P wave. Relevant prespecified characteristics and outcomes of each patient were abstracted from the electronic medical records. This study was approved by the Minneapolis Veterans Affairs Medical Center Institutional Review Board and the individual consent requirement was waived.

Case description

Among 301 consecutive patients who underwent TAVR, 6 patients (2%) had junctional rhythm on post-TAVR 12-lead ECG (Figure 1). The patients had a mean age of 70.2 ± 5.8 years and 83.3% were men. All 6 patients had sinus rhythm at baseline. Pre-existing right bundle branch block (RBBB) was present in 1 patient. No patient had a baseline PR interval >200 ms.

All 6 patients developed junctional rhythm on post-TAVR day 0. In 3 patients (cases 2, 3, and 6), junctional rhythm continued into days 1 and 2. The mean ventricular rate during junctional rhythm was 68.2 ± 12.1 beats per minute. Of the 6 patients, 4 (67%) had accelerated junctional rhythm (ventricular rate >60 beats/min). Five patients (83.3%) had TAVR with a SAPIEN 3 balloon-expandable valve while 1 (16.7%) had an Evolut R self-expandable valve.

In 2 patients (cases 2 and 5), junctional rhythm was accompanied by nonspecific ST-segment or T-wave abnormalities without change in QRS complex morphology. However, neither had chest discomfort or diagnostic regional wall motion abnormality on transthoracic echocardiogram post TAVR. From preprocedural coronary angiogram, case 2

Table 1 Characteristics and outcomes of patients who developed post–transcatheter aortic valve replacement (junctional rhythm)

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Type of valve	SAPIEN 3	SAPIEN 3	SAPIEN 3	Evolut R	SAPIEN 3	SAPIEN 3
Valve size	26 mm	26 mm	29 mm	34 mm	26 mm	29 mm
Route of access	TAo	TF	TF	TF	TF	TF
Baseline characteristics						
Age (years)	67	62	71	68	81	72
Sex	F	M	M	M	M	M
Aortic valve area (cm^2)	0.85	0.8	0.59	0.93	0.52	0.99
Mean aortic gradient (mm Hg)	52	26	50	39	37.5	40
LVEF (%)	50	20–25	60–65	55	55–65	55
CAD	Yes	Yes	Yes	Yes	Yes	Yes
Prior CABG	No	No	Yes	Yes	No	No
Beta-blocker use	No	Yes	No	Yes	Yes	No
Serum sodium (mEq/L)	139	139	144	133	141	141
Serum potassium (mEq/L)	3.0	4.0	4.4	3.9	4.3	4.7
Serum magnesium (mEq/L)	2.1	2.0	2.4	2.5	2.3	2.2
Baseline ECG rhythm	Sinus	Sinus	Sinus	Sinus	Sinus	Sinus
Baseline PR interval (ms)	200	200	158	160	158	192
Baseline QRS interval (ms)	90	126	106	82	84	166
Baseline bundle branch block	No	No	No	No	No	Yes (RBBB)
Postprocedural ECG						
Rate of junctional rhythm (beats/min)	84	83	70	52	58	62
Postprocedural day of detection	Day 0	Day 0	Day 0	Day 0	Day 0	Day 0
Presence of bundle branch block	No	No	Yes (RBBB)	Yes (LBBB)	No	Yes (RBBB)
QRS interval (ms)	88	118	152	152	108	164
Outcomes						
Mortality	Died 11 days after TAVR	Died 34 months after TAVR	Alive	Alive	Alive	Alive
Postprocedural PPM	No	No	Yes (5 days after TAVR)	No	No	Yes (1 day after TAVR)

CABG = coronary artery bypass grafting; CAD = coronary artery disease; ECG = electrocardiography; LBBB = left bundle branch block; LVEF = left ventricular ejection fraction; PPM = permanent pacemaker; RBBB = right bundle branch block; Tao = transaortic; TAVR = transcatheter aortic valve replacement; TF = transfemoral.

had known chronic total occlusion of the right coronary artery, while case 5 had nonobstructive coronary artery disease.

A permanent dual-chamber pacemaker was implanted in 2 (33%) patients (cases 3 and 6) for complete AV block on post-TAVR days 5 and 1, respectively. This rate is higher than the overall incidence of PPM implantation in our cohort of 301 patients, which is 22.0%, although this does not yield statistical significance owing to the low number of patients in the junctional cohort. At 1 year follow-up, these 2 patients had 8% and 87.5% ventricular pacing, respectively.

In case 3, junctional rhythm spontaneously converted to sinus rhythm before the patient was discharged on post-TAVR day 1. RBBB and normal PR interval were observed. The patient was subsequently rehospitalized for complete AV block with left bundle branch block requiring PPM implantation on post-TAVR day 5. On the other hand, in case 6, junctional rhythm did not return to sinus rhythm. Baseline RBBB and left anterior fascicular block were observed on postprocedural ECG. Ultimately, PPM was implanted on post-TAVR day 1. Neither patient required temporary pacing owing to hemodynamic stability during junctional rhythm.

Two (33%) patients (cases 1 and 2), died during follow-up, 11 days and 34 months post TAVR,

respectively. In patients without junctional rhythm following TAVR in our entire cohort, the 1-month and 1-year mortality rates were 2.4%, and 15.3%, respectively. The cause of death in case 1 was pulseless electrical activity, which occurred 11 days post TAVR; an autopsy was performed but the cause remained unrevealed. The cardiac rhythm was sinus before death. The cause of death in case 2 was unknown.

Characteristics and outcomes of patients with post-TAVR junctional rhythm are summarized in Table 1.

Discussion

Among 301 patients undergoing TAVR at our institution, we found 6 (2%) who developed sustained junctional rhythm on 12-lead ECG following TAVR. Of these, 2 (33%) developed complete AV block requiring PPM implantation, and another 2 (33%) died. These are novel observations of a new rhythm disorder after TAVR.

Several mechanical and electrophysiological risk factors for post-TAVR complete AV block have been identified thus far. Low depth of implantation of the valve into the left ventricular outflow tract, greater prosthesis–to–left ventricular outflow tract ratio, pre-existing RBBB or AV block, and postprocedural development of left bundle branch block are some of these risk factors.[6,10,11] Our observations in this case series suggest that post-TAVR junctional rhythm may also be a risk factor associated with adverse outcomes.

Whether post-TAVR accelerated junctional rhythm requires any treatment beyond supportive care is largely unknown. In our case series, all patients were hemodynamically stable during junctional rhythm. PPM was ultimately implanted in 33% of patients. The clinical course of cases 3 and 6 suggests that post-TAVR junctional rhythm might be related to the development of AV block.

In these cases, the junctional rhythm, captured on 12-lead ECG, was sustained. However, some patients may develop transient junctional rhythm during the inflation of the valve. The prevalence of transient junctional rhythm during TAVR is unknown, and it may be challenging to identify these transient arrhythmias during the procedure. Further, the clinical implications of transient junctional rhythm are unknown and require further study.

The mechanism of junctional rhythm after TAVR is not clearly understood. Lessons from pediatric literature suggest that procedures that involve either manipulation of the AV node, such as ventricular septal defect repair, or pressure on that area, such as from cardiopulmonary bypass cannulation, can lead to enhanced cardiac automaticity and subsequent junctional tachycardia.[12] As of this moment, the mechanism of accelerated junctional rhythm after TAVR is unknown. However, it is possible to speculate that mechanical pressure applied by the valve on the AV node may be responsible for the development of accelerated junctional rhythm. Coexisting sinus node dysfunction in this older population may also play a role. More investigation is needed to uncover the mechanisms behind our observations.

Although cardiac surgery has been associated with the development of complications including AV block and need of PPM implantation, remarkably, the rate of PPM after TAVR is twice as high as that following surgical aortic valve replacement (12% vs 6%).[4,13–15] As TAVR is expected to be the predominant treatment modality for aortic valve replacement, it becomes increasingly important to identify patients at risk for PPM implantation. Whether accelerated junctional rhythm should be regarded as an early sign of conduction system injury, a predictor of subsequent AV block, or an indication for PPM in high-risk patients remains unclear and needs further study in larger cohorts. The optimal management strategy in patients with sustained junctional rhythm following TAVR is an important clinical question. Larger observational studies are urgently required to determine the clinical significance of this arrhythmia following TAVR.

Conclusions

Cardiac conduction system disturbances remain among the most frequent complications of TAVR. To our knowledge, this is the first case series to describe post-TAVR junctional rhythm. Post-TAVR junctional rhythm may help clue us in on an earlier diagnosis of high-degree AV block. The mechanisms and implications of this newly described arrhythmia after TAVR need further study.

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