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# Tricuspid regurgitation burden following transcatheter aortic valve replacement requiring early pacemaker implantation

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## ABSTRACT

**Background:** Conduction abnormality requiring the implantation of a permanent pacemaker (PPM) is a well-known and clinically important complication of transcatheter aortic valve replacement (TAVR). However, PPM implantation may result in lead-associated tricuspid valve regurgitation (TR). This study sought to determine the incidence and progression of TR following PPM implantation after TAVR.

**Methods:** This was a retrospective review of all echocardiograms of patients who underwent PPM following TAVR at the Baylor Scott & White hospitals from 2012 to 2021. The primary endpoint was TR progression at 30 days and 1 year. A subanalysis comparing the change in TR progression between small and large TAVR devices was also conducted. Secondary outcomes included all-cause death at 30 days and 1 year.

**Results:** Out of the 2744 patients who underwent TAVR between April 2012 and August 2021, 177 patients (6.5%) subsequently received a new PPM. There was a statistically significant progression of TR at 1-year follow-up (McNemar's $P$ value = 0.02). TR progression rates were comparable between the small and large valve groups at 1-year follow-up (4% vs 11%, $P = 0.09$, respectively).

**Conclusion:** In this single healthcare system study, we demonstrated a significant progression of TR in patients with PPM post TAVR at 1 year.

**KEYWORDS** Permanent pacemaker; transcatheter aortic valve replacement; tricuspid regurgitation

The number of transcatheter aortic valve replacement (TAVR) procedures for the treatment of severe symptomatic aortic stenosis has increased substantially, accompanied by a better understanding of the complications associated with TAVR. Conduction abnormality requiring the implantation of a permanent pacemaker (PPM) is a well-known and clinically important complication of TAVR.[1] However, PPM implantation may result in lead-associated tricuspid valve regurgitation (TR).[2] This study sought to determine the incidence and progression of TR following early PPM implantation after TAVR.

## METHODS

This was a retrospective review of all echocardiograms of patients who underwent de novo PPM following TAVR at

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two distinct hospitals within the Baylor Scott & White Health system from 2012 to 2021. This study was approved by our hospital's institutional review board.

Informed consent was waived given the retrospective nature of the study. Data collection was limited to patients who underwent PPM implantation within 10 days following TAVR. Patient demographics and comorbidities as well as TAVR characteristics were collected through patient electronic medical records. Most TAVR patients in our healthcare system are followed up on-site by protocol echocardiography, resulting in robust follow-up data for retrospective analysis. We retrospectively recorded echocardiographic data at baseline, 30 days, and 1 year following the implantation of PPM. Echocardiographic data points included left ventricular ejection fraction (LVEF), right ventricle systolic pressure (RVSP), estimate of right atrial pressure (estimated from the size and inspiratory collapse of the inferior vena cava), right atrial area (measured using the software on the transthoracic echocardiography machine in an apical four-chamber view), and degree of TR (graded as none/trace, mild, moderate, or severe). Progression of TR at 30 days or 1 year following the implantation of PPM was defined as an increase in the degree of TR by $\geq$2 from baseline or the presence of severe TR at follow-up.

The primary endpoint was the composite of the persistence of preexisting severe TR or progression of nonsevere TR at 30 days and 1-year post-PPM implantation; as moderate TR cannot progress beyond severe, progression was defined as a one-grade increase for moderate TR or $\geq$2 grades for lesser severities of TR. A subanalysis comparing the change in TR progression between small (<29 mm in diameter) and large ($\geq$29 mm) TAVR devices was also conducted. Secondary outcomes included all-cause death and hospital readmissions at 30 days and 1 year.

Continuous data were reported as the mean ± standard deviation or median and interquartile range (IQR; 25th, 75th percentile), and categorical data were reported as percentages. A pairwise comparison of severe TR persistence or TR progression relative to baseline was conducted using McNemar's test using each patient's individual baseline as a comparator. This testing was one-way only (e.g., persistence of severe TR or worsening of TR was compared, whereas improvement in TR grade was neither formally tested nor accommodated statistically). All analyses were performed using R statistical software, Version 4.2. Statistical significance was assessed at a significance level of 0.05.

## RESULTS

Out of the 2744 patients who underwent TAVR between April 2012 and August 2021, 177 patients (6.5%) subsequently received a new PPM. The baseline demographic and procedural characteristics of the study population are presented in *Tables 1 and 2*. Of this group, 58.8% were men, with a mean age of 78.7 ± 8.4 years. Hypertension (94.9%) was the predominant comorbidity. Other common comorbidities were dyslipidemia (69.5%), diabetes mellitus (44.1%), chronic lung disease (36.2%), coronary artery disease (45.8%), prior coronary artery bypass grafting (25.4%), and prior surgical aortic valve replacement (2.3%). A total of 408 patients (14.9%) had a preexisting PPM prior to their TAVR and were not analyzed further. Mean Society of Thoracic Surgeons (STS) risk score was 5.7 ± 3.6. None of the 177 patients had a prior TAVR procedure. One hundred twenty patients (67.8%) received a balloon-expandable valve, and 57 (32.2%) received a self-expanding valve. A large valve, defined as a TAVR device $\geq$ 29 mm in diameter, was used in 54 patients (30.5%). Mean LVEF was 60 ± 5 and mean RVSP was 37 ± 6 mm Hg. The baseline echocardiographic data are presented in *Table 3*.

**Table 1. Baseline characteristics**

| Characteristic | Overall (N = 177)[a] |
|---|---|
| Mean age (years) | 78.7 ± 8.4 |
| Sex, male | 104 (58.8%) |
| Mean BMI (kg/m$^2$) | 30.1 ± 6.7 |
| Mean STS | 5.7 ± 3.7 |
| NYHA class | N = *165* |
| 0 (or not recorded) | 1 (0.6%) |
| I | 4 (2.4%) |
| II | 49 (29.7%) |
| III | 75 (45.5%) |
| IV | 36 (21.8%) |
| Diabetes mellitus | 78 (44.1%) |
| Hypertension | 168 (94.9%) |
| Dyslipidemia | 123 (69.5%) |
| Chronic lung disease | |
| None | 113 (63.8%) |
| Mild | 37 (20.9%) |
| Moderate | 16 (9.1%) |
| Severe | 11 (6.2%) |
| Dialysis | 1 (0.6%) |
| Creatinine (mg/dL) | 1.2 ± 0.7 |
| Prior CABG | 45 (25.4%) |
| Prior SAVR | 4 (2.3%) |
| Prior TAVR | 0 (0%) |
| Coronary artery disease | 81 (45.8%) |
| Peripheral artery disease | 50 (28.2%) |

[a]Continuous variables are presented as the mean ± standard deviation, or median [quartiles] if skewed, and qualitative variables are presented as the frequency (% out of nonmissing data). Missingness >5% is reported for each variable. BMI indicates body mass index; CABG, coronary artery bypass grafting; NYHA, New York Heart Association; SAVR, surgical aortic valve replacement; STS, Society of Thoracic Surgeons; TAVR, transcatheter aortic valve replacement.

Mean LVEF was 58.3 ± 11.7% at baseline. Mean RVSP was 40.3 ± 13 mm Hg at baseline.

All studied patients were alive at 1-year follow up. Twenty-eight patients (15.7%) were rehospitalized by 30 days, with 8 (4.5%) diagnosed with heart failure, and 60 patients (33.7%) were rehospitalized by 1 year, of whom 25 (14%) were diagnosed with heart failure. There was a significant improvement in the RVSP over time, decreasing from 40.3 mm Hg at baseline to 34.8 at 30-day and 33.9 at 1-year follow-up ($P < 0.01$).

Fourteen patients (14/177, 7.9%) had at least moderate TR at baseline, whereas 18 patients (18/177, 10.2%) had at least moderate TR at 1-year follow-up. There was a statistically significant difference in the pairwise comparison of the composite outcome of the persistence of severe TR or progression of nonsevere TR from baseline (McNemar's $P$ value = 0.02), with 6.2% (n = 11) of patients experiencing this outcome. However, there was not a statistically significant TR progression at 30 days following PPM implantation (McNemar's $P$ value = 1.0) (*Table 4* and *Figure 1*). At 1 year, there was no significant difference in heart failure readmission rates between patients with TR progression and the rest of the cohort (2/11, 18.2%, vs 23/166, 13.9%; $P = 0.69$).

Interestingly, 15 patients (8.4%) had TR regression of at least two grades at 1 year, and their improvement is not accounted for in this analysis. These patients had a statistically nonsignificant lower STS score than those with TR progression at 1 year (4.8 ± 2.4 vs 7.0 ± 2.9, respectively; $P = 0.08$). Both groups had comparable baseline demographics.

A subanalysis of TR progression according to TAVR valve size was performed. TR progression rates were comparable between the small and large valve groups at 30-day follow-up (2% vs 2%, $P = 1.0$) and 1-year follow-up (4% vs 11%, $P = 0.09$, respectively).

**Table 2. Procedure details**

| Procedure characteristics | Overall (N = 177)[a] |
|---|---|
| Median duration from TAVR to PPM (days) | 1 [0, 3] |
| Approach | |
| Transfemoral | 162 (91.5%) |
| Other | 15 (8.5%) |
| Valve type | |
| Balloon-expandable | 120 (67.8%) |
| Self-expandable | 57 (32.2%) |
| Mean valve size | 26.9 ± 2.9 |
| Large valve | 54 (30.5%) |
| Valve in valve fracked | 1 (0.6%) |
| Discharge location | |
| Home | 162 (91.5%) |
| Inpatient rehabilitation | 9 (5.1%) |
| Skilled nursing facility | 6 (3.4%) |
| Median length of stay (days) | 3 [2, 5] |
| Mean length of stay (days) | 3.9 ± 3.5 |

[a]Continuous variables are presented as the mean ± standard deviation, or median [quartiles] if skewed, and qualitative variables are presented as the frequency (% out of nonmissing data). Missingness >5% is reported for each variable. PPM indicates permanent pacemaker; TAVR, transcatheter aortic valve replacement.

## DISCUSSION

This was a single healthcare system study assessing the incidence, progression, and outcome of TR following PPM after TAVR. The development and progression of TR in

**Table 3. Baseline and post-TAVR echocardiographic data[a]**

| Characteristics (n = 177) | Baseline | 30-Day follow-up | 1-Year follow-up | *P* value |
|---|---|---|---|---|
| Left ventricular ejection fraction (%) | 58.3 ± 11.7 | 56.2 ± 11.2 | 57.3 ± 10.8 | 0.21 |
| RVD (cm) | 3.3 ± 0.9 | 3.2 ± 0.9 | 3.2 ± 1.1 | 0.54 |
| RVSP (mm Hg) | 40.3 ± 13 | 34.8 ± 13.3 | 33.9 ± 14.1 | <0.01 |
| Estimated RA pressure (mm Hg) | 3 [3, 8] | 3 [3, 3] | 3 [3, 8] | <0.01 |
| TR gradient | | | | 0.17 |
| None/trace | 103 (58.2) | 91 (51.4) | 79 (44.6) | |
| Mild | 61 (34.4) | 76 (42.9) | 80 (45.2) | |
| Moderate | 12 (6.8) | 7 (4.0) | 13 (7.3) | |
| Severe | 2 (0.6) | 3 (1.7) | 5 (2.8) | |
| RA area ($cm^2$) | 16.8 ± 8.1 | 16.6 ± 8.0 | 16.7 ± 9.5 | 0.98 |

[a]Continuous variables are presented as the mean ± standard deviation, or median [quartiles] if skewed, and qualitative variables are presented as the frequency (% out of nonmissing data). RA indicates right atrium; RVD, right ventricular diameter; RVSP, right ventricular systolic pressure; TR, tricuspid regurgitation.

**Table 4. Pairwise comparisons of TR progression from baseline at 30 days and 1 year**

| Comparison | Persistence of severe TR or progression of nonsevere TR[a] | McNemar pairwise *P* value |
|---|---|---|
| 30 days vs baseline | 3/177 (1.7%) | 1.0 |
| 1 year vs baseline | 11/177 (6.2%) | 0.02 |

[a]Composite outcome of persistence of severe tricuspid valve regurgitation (TR), worsening by 1 grade of moderate TR or ≥2 grades for lesser severities of TR.

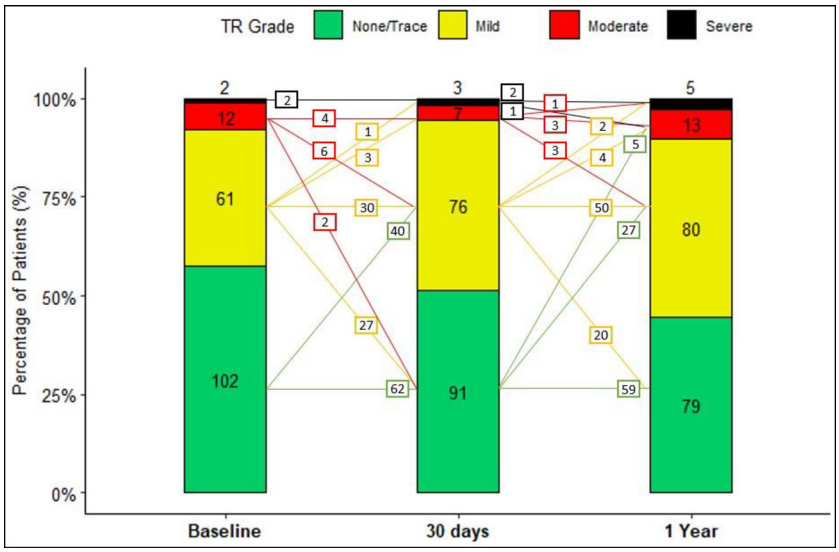



**Figure 1.** Tricuspid regurgitation at baseline, 30 days, and 1 year.

such a setting could be the result of TAVR device implantation, PPM implantation, a comorbid medical condition (e.g., atrial fibrillation), or a combination of all.

TAVR procedures have been reported to impact TR by inducing conformational changes in the right ventricular geometry and the tricuspid valve. In a recent study by Nona et al, large TAVR valves were more likely to be associated with the development of TR.[3] Several mechanisms have been proposed to explain this association, such as tricuspid annular deformation and mechanical interference of the TAVR device with the leaflets resulting in a malcoaptation of the tricuspid valve. In the current study, TR progression rates were comparable between the valve size groups at 30-day and 1-year follow-up, suggesting that valve size was not a factor in this series.

PPM implantation across the tricuspid valve may cause various adverse events.[4] TR is a well-known and clinically important complication with poor outcomes.[5] The overall incidence of substantial TR following PPM implantation varies widely between studies (ranging from 10% to 38%)[6,7] due to different study populations and different grading scales used to define TR. Several hypotheses have been proposed to explain lead-associated TR, divided into mechanical and electrical factors. Mechanical factors include leaflet perforation, adhesion of the lead to the valve leaflets resulting in abnormal coaptation, lead impingement on the leaflets, and lead entanglement. Electrical factors include right ventricular dyssynchrony or a delay in activation within the right ventricle.

Preexisting significant TR has been identified as a predictor of TR progression after TAVR.[8] In the current study, 163 patients (92.1%) had mild or trace/no TR at baseline, of whom 9 (5.5%) presented with worsening TR at 1 year. On the other hand, 14 patients (7.9%) had moderate or severe TR at baseline, of whom 2 (14.3%) had persistence of their preexisting severe TR or progression of their nonsevere TR. Moreover, several underlying diseases have been identified to worsen TR after TAVR, notably atrial fibrillation,[9] although this was not assessed in the current analysis.

Meaningful, untreated TR is associated with a poor prognosis. In a study by Nath et al, patients with moderate or severe TR had worse outcomes than patients with mild or less TR.[10] In the current study, longer follow-up is needed, especially for patients who presented with the composite of TR progression or persistence of severe TR, to extrapolate long-term clinical outcome conclusions for this patient population.

A key limitation of this study is that no comparison group was included for TR progression in post-TAVR patients for whom a new PPM was not required. Future analyses comparing TR progression between the two populations are planned. While statistically significant by McNemar testing for the composite of persistence of severe TR or progression of TR from baseline to 1 year, we did not

account for those patients that demonstrated improvement in TR. Moreover, whereas the persistence of severe TR or progression of nonsevere TR fulfills statistical significance, it is of a modest magnitude on the 1-year time scale and of unclear clinical scope without formal testing for the improvement of TR in other patients.


1. Dowling C, Firoozi S, Panoulas V, et al. Initial experience of a self-expanding transcatheter aortic valve with an outer pericardial wrap: the United Kingdom and Ireland Implanters' registry. *Catheter Cardiovasc Interv*. 2020;95(7):1340–1346. doi:10.1002/ccd.28512.
2. Al-Bawardy R, Krishnaswamy A, Bhargava M, et al. Tricuspid regurgitation in patients with pacemakers and implantable cardiac defibrillators: a comprehensive review. *Clin Cardiol*. 2013;36(5):249–254. doi:10.1002/clc.22104.
3. Nona P, Coriasso N, Khan A, et al. Pacemaker following transcatheter aortic valve replacement and tricuspid regurgitation: a single-center experience. *J Card Surg*. 2022;37(9):2937–2942. doi:10.1111/jocs.15363.
4. Marijon E, Trinquart L, Otmani A, et al. Predictors for short-term progressive heart failure death in New York Heart Association II patients implanted with a cardioverter defibrillator–the EVADEF study. *Am Heart J*. 2010;159(4):659–664.e1. doi:10.1016/j.ahj.2010.01.011.
5. Cheng Y, Gao H, Tang L, Li J, Yao L. Clinical utility of three-dimensional echocardiography in the evaluation of tricuspid regurgitation induced by implantable device leads. *Echocardiography*. 2016;33(11):1689–1696. doi:10.1111/echo.13314.
6. Lee RC, Friedman SE, Kono AT, Greenberg ML, Palac RT. Tricuspid regurgitation following implantation of endocardial leads: incidence and predictors. *Pacing Clin Electrophysiol*. 2015;38(11):1267–1274. doi:10.1111/pace.12701.
7. Höke U, Auger D, Thijssen J, et al. Significant lead-induced tricuspid regurgitation is associated with poor prognosis at long-term follow-up. *Heart*. 2014;100(12):960–968. doi:10.1136/heartjnl-2013-304673.
8. Schewel D, Schewel J, Schlüter M, et al. Correlation of tricuspid regurgitation and new pacemaker implantation in patients undergoing transcatheter aortic valve implantation. *Int J Cardiol*. 2018;261:37–41. doi:10.1016/j.ijcard.2018.03.030.
9. Cremer PC, Wang TKM, Rodriguez LL, et al. Incidence and clinical significance of worsening tricuspid regurgitation following surgical or transcatheter aortic valve replacement: analysis from the PARTNER IIA trial. *Circ Cardiovasc Interv*. 2021;14(11):e010437. doi:10.1161/CIRCINTERVENTIONS.120.010437.
10. Nath J, Foster E, Heidenreich PA. Impact of tricuspid regurgitation on long-term survival. *J Am Coll Cardiol*. 2004;43(3):405–409. doi:10.1016/j.jacc.2003.09.036.