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EDITORIAL COMMENT

Pacemaker Implantation After TAVR*

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Transcatheter aortic valve replacement (TAVR) has become an established treatment option for patients with aortic stenosis who are inoperable or who are at high or intermediate risk for surgical aortic valve replacement (1). As we apply TAVR to lower-risk patients, it is imperative that the risks of TAVR are commensurate with those of surgical aortic valve replacement. One of these risks is the need for a permanent pacemaker (PPM), which may be different depending on the device used for TAVR. Although balloon-expandable valves have traditionally demonstrated lower rates of PPM implantation than self-expanding valves, the rates remain generally higher than after surgical aortic valve replacement (2). It appears that among balloon-expandable valves, the latest-generation SAPIEN 3 (third generation balloon expandable valve) (Edwards Lifesciences, Irvine, California) has a higher 30-day PPM rate (10.2% in S3i study) compared with the original SAPIEN (first generation balloon expandable valve) (3.8% in PARTNER 1A [Placement of Aortic Transcatheter Valves]) and SAPIEN XT (second generation balloon expandable valve) (8.5% in PARTNER 2A) valves (1,3,4). Conversely, the newer-generation second-generation self-expanding (CoreValve Evolut-R [Medtronic, Minneapolis, Minnesota]) valves have reported lower PPM rates (11.7%) compared with their first-generation (CoreValve Classic [Medtronic]) counterparts (19.8%) (5,6). The newest second-generation repositionable valves have 30-day new PPM rates ranging from 28.6% for the Boston Scientific (Natick, Massachusetts) Lotus valve to 9.8% for the St. Jude (St. Paul, Minnesota) Portico valve (7).

There are several questions with regard to the need for PPM in patients undergoing TAVR. What are the indications for new PPM implantation? What predicts the need for a new PPM? Does a new PPM increase the risk of death or functional deterioration on follow-up?

In this issue of *iJACC*, Maeno et al. (8) attempt to identify predictors for PPM implantation after third generation balloon expandable valve implantation. Of 240 patients undergoing TAVR with the third generation balloon expandable valve, 35 required PPM (14.6%), mostly because of complete heart block (CHB) (n = 25) or left bundle branch block (LBBB) progressing to CHB (n = 3). These investigators determined that pre-TAVR right bundle branch block (RBBB), calcification volume at the noncoronary cusp device-landing zone, and height of membranous septum (MS) were all independent predictors of PPM implantation.

CURRENT PRACTICE OF PERMANENT PACEMAKER IMPLANTATION AFTER TAVR

There are no clear guidelines for PPM implantation after TAVR. Persistent CHB is a common indication; however, the duration necessary to monitor before designating a patient with "persistent CHB" remains variable. More difficult situations arise when new LBBB, LBBB with first-degree atrioventricular block, LBBB and atrial fibrillation, or alternating LBBB and RBBB are encountered after TAVR. Lack of consensus in these situations has resulted in tremendous variability for PPM use after TAVR (9). Further, many studies report a "new" PPM rate with an entire patient population as a denominator. Because 20% to 30% of patients already have a PPM, the reported numbers underestimate the "real" need for PPM.

WHAT PREDICTS THE NEED FOR A PERMANENT PACEMAKER?

The risk factors for PPM implantation identified by Maeno et al. (8) can be explained by anatomy of the

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TABLE 1 Pre-Procedural, Intraprocedural, and Post-Procedural Risk Factors for PPM

Pre-Procedural	Intraprocedural	Post-Procedural
Bradyarrhythmia	SE valve	Mobitz II second degree heart block*
RBBB	Greater depth of implantation	Complete heart block*
First, second, or third degree AVB	Transient procedural CHB	Progressive first degree AVB *plus* LBBB*
Leaflet calcium distribution		Symptomatic bradycardia*
Membranous septum height		Need for nodal agents (AT or AF) with unstable nodal conduction* New-onset LBBB

*Typical indications for PPM implantation in current practice.

AF = atrial fibrillation; AT = atrial tachycardia; AVB = atrioventricular block; CHB = complete heart block; LBBB = left bundle branch block; PPM = permanent pacemaker; SE = self-expanding.

conduction system (10). The His bundle bifurcates into the right and left bundles at the inferior border of the MS, with the latter emerging beneath the noncoronary cusp. Therefore, valve implantation that overlaps the distal MS may affect both the right and left bundles and lead to CHB. Similarly, substantial calcification at the noncoronary cusp device-landing zone is likely to exert uneven pressure either at the level of the MS or at the left bundle that runs on the left ventricular (LV) side of the muscular septum.

How do the data from the current analysis dovetail with those of previous studies? In an analysis from the PARTNER 1 trial, there was significant early hazard for PPM, with 86% of devices implanted within 1 week of TAVR, mostly as a result of high-grade atrioventricular block (11). Importantly, there was a continued risk of PPM among patients with new-onset LBBB, up to 10% at 30 days and 12.9% at 12 months (12). Further, 58% of new LBBB cases were noted at 1-year follow-up. Interestingly, among patients with new LBBB, almost one-half received a PPM for sick sinus syndrome, which is unrelated to TAVR procedures. Demonstrating the importance of understanding pre-TAVR conduction, Holter monitoring prior to TAVR among 435 patients revealed that 16% of all patients and 31% of patients eventually receiving a PPM displayed some evidence of previously unknown conduction disease (13).

It is evident that although an understanding of a patient's potential predisposing factors for PPM is important, these features are uncontrollable. However, the presence of these factors may inform the need for continued observation for conduction deficit (Table 1). Ultimately, the only variable that can be controlled at the time of the procedure is the depth of implantation, and the current analysis demonstrates that MS height helps to define the degree of "freedom" for this depth.

NEW PERMANENT PACEMAKERS AND THE RISK OF MORTALITY OR MORBIDITY

The impact of PPM implantation on mortality and morbidity after TAVR remains controversial. In the general population, patients with a high burden of right ventricular pacing demonstrate an increased risk of LV dysfunction development and also of worse survival, perhaps resulting from the abnormal electrical and mechanical activation pattern (14). Among TAVR-treated patients, however, the impact on survival of PPM implantation is controversial, although the development of LV dysfunction has been demonstrated (12,15,16). Similarly, patients with LBBB after balloon-expandable TAVR demonstrate a higher risk of PPM implantation and failure of improvement in LV ejection fraction after TAVR. Whether all patients with LBBB and/or a need for long-term pacing after TAVR should automatically receive a biventricular pacemaker remains unknown.

The need for PPM implantation after TAVR is a complication that may result in new-onset or worsening LV dysfunction and may be associated with overall worse survival. These implications may be especially germane as TAVR is offered to lower-risk patients. Studies such as the one by Maeno et al. (8) are important in furthering our understanding of preprocedural and procedural factors that may allow us to provide TAVR to our patients even more safely.

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REFERENCES

1. Thourani VH, Kodali S, Makkar RR, et al. Transcatheter aortic valve replacement versus surgical valve replacement in intermediate-risk patients: a propensity score analysis. Lancet 2016;387:2218–25.

2. Robich MP, Schiltz NK, Johnston DR, et al. Risk factors and outcomes of patients requiring a permanent pacemaker after aortic valve replacement in the united states. J Card Surg 2016;31:476–85.

3. Makkar RR, Fontana GP, Jilaihawi H, et al. Transcatheter aortic-valve replacement for inoperable severe aortic stenosis. N Engl J Med 2012; 366:1696–704.

4. Leon MB, Smith CR, Mack MJ, et al., PARTNER 2 Investigators. Transcatheter or surgical aortic-valve replacement in intermediate-risk patients. N Engl J Med 2016;374:1609–20.

5. Manoharan G, Walton AS, Brecker SJ, et al. Treatment of symptomatic severe aortic stenosis

with a novel resheathable supra-annular self-expanding transcatheter aortic valve system. J Am Coll Cardiol Intv 2015;8:1359–67.

6. Adams DH, Popma JJ, Reardon MJ, et al. Transcatheter aortic-valve replacement with a self-expanding prosthesis. N Engl J Med 2014;370:1790–8.

7. Tuzcu EM, Kapadia SR. Next generation valves: what are we looking for? J Am Coll Cardiol Intv 2016;9:76–8.

8. Maeno Y, Abramowitz Y, Kawamori H, et al. A highly predictive risk model for new permanent pacemaker implantation after SAPIEN 3 transcatheter aortic valve replacement. J Am Coll Cardiol Img 2017;10:xx–x.

9. Bjerre Thygesen J, Loh PH, Cholteesupachai J, Franzen O, Sondergaard L. Reevaluation of the indications for permanent pacemaker implantation after transcatheter aortic valve implantation. J Invasive Cardiol 2014;26:94–9.

10. Syed FF, Hai JJ, Lachman N, DeSimone CV, Asirvatham SJ. The infrahisian conduction system and endocavitary cardiac structures: relevance for the invasive electrophysiologist. J Interv Card Electrophysiol 2014;39:45–56.

11. Nazif TM, Dizon JM, Hahn RT, et al., PARTNER Publications Office. Predictors and clinical outcomes of permanent pacemaker implantation after transcatheter aortic valve replacement: The PARTNER (Placement of Aortic Transcatheter Valves) trial and registry. J Am Coll Cardiol Intv 2015;8:60–9.

12. Nazif TM, Williams MR, Hahn RT, et al. Clinical implications of new-onset left bundle branch block after transcatheter aortic valve replacement: analysis of the partner experience. Eur Heart J 2014;35:1599–607.

13. Urena M, Hayek S, Cheema AN, et al. Arrhythmia burden in elderly patients with severe aortic stenosis as determined by continuous electrocardiographic recording: toward a better understanding of arrhythmic events after transcatheter aortic valve replacement. Circulation 2015;131:469–77.

14. Tops LF, Schalij MJ, Bax JJ. The effects of right ventricular apical pacing on ventricular function and dyssynchrony implications for therapy. J Am Coll Cardiol 2009;54:764–76.

15. Dizon JM, Nazif TM, Hess PL, et al. Chronic pacing and adverse outcomes after transcatheter aortic valve implantation. Heart 2015;101:1665–71.

16. Urena M, Webb JG, Tamburino C, et al. Permanent pacemaker implantation after transcatheter aortic valve implantation: impact on late clinical outcomes and left ventricular function. Circulation 2014;129:1233–43.

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