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EDITORIAL COMMENT

Disarming the Ticking Time Bomb

Post-Procedure Electrocardiography Predictors of High-Degree Conduction Disturbances After Transcatheter Aortic Valve Replacement*

Tamim M. Nazif, MD,[a,b] Shmuel Chen, MD, PhD,[b] Susheel K. Kodali, MD[a,b]

Transcatheter aortic valve replacement (TAVR) has increasingly been adopted as an alternative to surgery in patients with symptomatic, severe aortic stenosis. Although the rates of many complications of TAVR have decreased over time due to improvements in device technologies and operator experience, cardiac conduction disturbances remain a frequent concern. Extensive research has focused on the incidence, predictors, and clinical implications of conduction disturbances after TAVR, most notably new onset left bundle branch block (LBBB) and high-degree atrioventricular block (AVB) requiring permanent pacemaker (PPM) implantation (1,2). Meta-analyses suggest that PPMs are placed in 14% to 17% of patients overall, with a substantially higher risk among those treated with self-expanding or mechanically expanded valves (3,4). Although the majority of conduction disturbances occur during or early after TAVR, high-degree AVB may occur more than 48 h after the procedure in 2% to 7% of patients, presenting an important clinical dilemma (1,5).

More generally, the management of the spectrum of conduction disturbances that occur after TAVR is a frequent clinical challenge. Although the need for PPM in the setting of persistent high-degree AVB is obvious, there are many less clear circumstances, including transient AVB, new onset LBBB, and tachy-brady syndrome, leading to significant site-to-site variability in PPM rates. Although, certain electrocardiographic (ECG) findings, including baseline right bundle branch block (RBBB) and new LBBB, have been associated with cardiovascular mortality or sudden cardiac death after TAVR, the protective effect of PPM in treating these remains unknown. Furthermore, although the procedural risks of PPM implantation are low, it is increasingly recognized that there may be adverse long-term consequences, including left ventricular systolic dysfunction and iatrogenic tricuspid regurgitation (6–10). Complicating the decision-making process is the fact that conduction disturbances after TAVR often resolve with time and that a substantial proportion of patients who receive a PPM are not pacemaker-dependent at follow-up (1). Therefore, the optimal duration of telemetry monitoring, management of temporary pacemakers, and timing of PPM after TAVR is uncertain. These controversies are only intensified by the need to optimize resource utilization for TAVR and recent trends toward the minimalist approach and early discharge that mandate earlier decisions requiring the need for PPM.

Currently, there is limited literature examining post-TAVR ECG predictors of delayed conduction disturbances to help guide clinical decision making. Toggweiler et al. (5) recently reported an analysis of ECG predictors of delayed high-degree AVB in more than 1,000 patients undergoing TAVR with both balloon-expandable (52%) and self-expanding (48%) valves. Delayed high-degree AVB occurred after an initial post-procedure ECG and up to 8 days later in almost 7% of patients (44% of AVB) (5) and was found

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From the [a]Division of Cardiology, New York-Presbyterian Hospital/Columbia University Medical Center, New York, New York; and the [b]Cardiovascular Research Foundation, New York, New York. Dr. Nazif has received consulting fees from Edwards LifeSciences, Medtronic, Boston Scientific, and BioTrace Medical. Dr. Kodali has received consulting fees from Abbott Vascular and BioTrace Medical and serves on the advisory boards of Thubrikar Aortic Valve, Inc. and Dura Biotech. Dr. Chen has reported that he has no relationships relevant to the contents of this paper to disclose.

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by multivariable analysis to be associated with RBBB or LBBB on the post-TAVR ECG. Patients in sinus rhythm without first-degree AVB or bundle branch block did not develop late high-degree AVB, and those in atrial fibrillation without bradycardia or bundle branch block were at very low risk (<1%), leading to the conclusion that telemetry monitoring and temporary pacemakers were not necessary in these patients. In a recent, smaller study of patients undergoing TAVR with self-expanding valves, Takahashi et al. (11) also reported that there was no requirement for PPM in patients with QRS duration <120 ms immediately after TAVR and that it was safe to remove the temporary pacemaker in these patients. Two new studies in this issue of *JACC: Cardiovascular Interventions* build on this experience by analyzing ECG predictors of "late" high-degree conduction disturbances and PPM at different time points after TAVR.

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Jørgensen et al. (12) present a single-center, retrospective analysis of 467 patients without PPM who underwent TAVR in 2015 to 2017 with a self-expanding valve in the majority (70%) and examine post-procedure ECG predictors of late high-degree conduction disturbances and the sufficiency of escape rhythms in these patients. "Late" high-degree conduction defects are defined as third-degree AVB, type 2 second-degree AVB, or atrial fibrillation with bradycardia, occurring between leaving the procedure room and 30 days. These occurred in 7.5% of the patients, primarily with high-degree AVB (83.0%). Patients with RBBB, LBBB with significantly prolonged QRS interval (≥150 ms) or significantly prolonged PR interval (≥240 ms) had a high risk of late high-degree conduction defects. On the other hand, patients in sinus rhythm with PR interval <200 ms and QRS interval <120 ms did not experience late high-degree conduction defects. Furthermore, among patients without RBBB, those in sinus rhythm with PR interval <240 ms and QRS duration <150 ms and those in atrial fibrillation with QRS duration <140 ms did not develop late conduction disturbances with insufficient escape rhythm, defined as syncope, requirement for cardiopulmonary resuscitation, or temporary pacing. In patients in sinus rhythm without RBBB, multiple logistic regression analysis identified longer PR and QRS intervals on post-TAVR ECG as significant predictors of late high-degree conduction defects and longer QRS duration as a predictor of conduction disturbances with insufficient escape rhythm.

This analysis builds on the prior studies in several important ways. The risk for late high-degree conduction defects is thoroughly analyzed as a function of 20-ms increments in both PR and QRS intervals. A more detailed analysis is also performed of various subgroups, including patients without RBBB and with atrial fibrillation. Importantly, certain findings differ from those of Toggweiler et al. (5). For example, the current analysis failed to confirm the absence of late high-degree conduction defects in patients with atrial fibrillation, normal heart rate, and QRS interval <120 ms, identifying a higher QRS threshold of 140 ms in this population. Finally, the inclusion of insufficient escape rhythm is extremely important as a clinically meaningful endpoint that defines the conduction disturbances that are most dangerous. On the basis of their analysis, the authors are able to propose an updated, detailed clinical decision-making tree that relies on the immediate post-TAVR ECG to determine the need for telemetry monitoring, daily ECGs, and temporary pacemakers.

Despite the practical utility of an immediate post-TAVR ECG for guiding clinical decisions, there may be limitations to this approach. For example, studies have shown resolution of a substantial proportion of new conduction disturbances during hospitalization and the potential for recovery may not be captured by an immediate ECG (1,13,14). Additionally, early ECGs may not detect the impact of certain pathophysiological mechanisms of delayed conduction system injury such as tissue edema or inflammation (15,16). Similarly, there may be continued injury to the conduction tissues from late expansion of a self-expanding stent, and studies have suggested lower rates of resolution with self-expanding valves (14,17,18).

A second study by Mangieri et al. (19) examines the utility of an ECG at a later time point, 48 h after TAVR, in predicting subsequent "late" high-degree conduction disturbances. Mangieri et al. (19) present a retrospective, single-center analysis of 611 patients without PPM with the goal of identifying ECG predictors 48 h after TAVR of late conduction disturbances requiring PPM. This study included more patients treated with balloon-expandable (51.7%) than self-expanding (33.7%) valves, and 8.8% required late PPM (51.0% of total PPM), most frequently for high-degree AVB (77.0%). Patients requiring late PPM were more likely to have received a self-expanding valve as well as to have baseline RBBB and greater PR and QRS prolongation at 48 h. By multivariable analysis, only baseline RBBB and the change in PR interval were found to be predictors of late PPM.