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EDITORIAL COMMENT

The Hidden Meaning Behind Alternating Bundle Branch Block*

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Transcatheter aortic valve replacement (TAVR) is an established treatment for severe aortic stenosis. An important peri-procedural complication of TAVR is new onset atrioventricular conduction disturbance (1) which occurs in 10.5% to 28.2% of patients in the early post-operative period. This complication results from close proximity of the aortic valve to the His-Purkinje system, particularly when the this system is relatively left-sided or courses under the membranous septum, as occurs in 30% and 20% of individuals, respectively (2). We now know that a large variety of complex atrioventricular conduction disturbances can occur post-TAVR.

In this issue of *JACC: Case Reports*, Kulkarni et al. (3) present a case of alternating bundle branch block (BBB) following TAVR.

The initial rhythm before TAVR is sinus with bifascicular block consisting of right bundle branch block (RBBB) and left posterior fascicular block, the latter evidenced by right-axis deviation, an rS pattern in lead I, and qR in leads III and aVF. The PR interval is normal at 170 ms. Following TAVR, the electrocardiogram shows loss of right-axis deviation and prolongation of the PR interval to 238 ms. Although it is possible that TAVR led to immediate reversal of the conduction disturbance in the left posterior fascicle, a much more likely explanation is that TAVR instead led to damage of the left anterior fascicle, thereby causing balanced delay in left-sided fascicles and normalization of the QRS conduction axis. This nicely accounts for concomitant prolongation of the PR interval.

A corollary to this explanation is that despite the sole appearance of RBBB following TAVR, there must also be a severe but inapparent delay in the left bundle branch (LBB). From observations such as this, together with invasive measurements in the electrophysiology laboratory, electrophysiologists now realize that RBBB and left bundle branch block (LBBB) often reflect delays in the bundle branches rather than actual, absolute conduction block (4-6). Such delays lead to so-called masking of disease in the contralateral bundle branch.

Tzogias et al. (6) have demonstrated this phenomenon elegantly in 50 patients with baseline LBBB who underwent right-sided heart catheterization and developed RBBB (rather than complete heart block) resulting from mechanical trauma to the RBB. This can plausibly be explained only by delayed conduction (instead of block) within the LBB. Furthermore, Tzogias et al. (6) teach us that an electrocardiographic pattern of RBBB but with an absent S-wave in leads I and aVL suggests concomitant LBB delay and enables a diagnosis of bilateral bundle branch delay. This is because the S-wave in leads I and aVL represent delayed right ventricular depolarization in RBBB, which can be normalized by concomitant LBB delay. If an S-wave is present, then this may signify isolated RBBB or bifascicular block. Interestingly and perhaps unexpectedly, in the present case we do see a small S-wave in leads I and aVL, which we hypothesize may be caused by unequal delay in the left anterior and posterior fascicles and/or insufficient relative delay in left ventricular depolarization to mask the S-wave. In

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the series reported by Tzogias et al. (6), the S-wave in leads I and aVL was observed for both isolated left anterior and isolated left posterior fascicular block with concomitant catheter-induced RBBB. Correspondingly, loss of the S-wave was shown to be a highly specific sign (100%) of masked LBB delay, but it seems only moderately sensitive (64%).

To clinch their hypothesis of bilateral bundle branch delay, Kulkarni et al. (3) present a telemetry strip showing alternation of QRS configurations consistent with LBBB and RBBB. A key observation is that each QRS configuration is tightly wedded to a specific PR interval. There is minimal change in the PP interval, making acceleration- and deceleration-dependent (phase III and phase IV) blocks unlikely. Instead, intermittent RBB conduction leads to alternating masking and unmasking of LBB delay. This seems to be the only reasonable explanation linking the PR interval with the QRS configuration.

This type of masking of 1 bundle branch block by the other has long been recognized. As far back as 1954, Richman and Wolff described LBBB "masquerading" as RBBB (7). This is most often seen as the coexistence of an RBBB pattern in the precordial leads but an LBBB pattern in the limb leads with absent S waves in leads I and aVL. The LBBB pattern in the limb leads with absent S waves in leads I and aVL is reminiscent of, and recapitulates the findings of, Tzogias et al. (6), as described earlier. Other reported variations of masking include left anterior hemiblock concealing RBBB (8). To our knowledge, a specific case of LBBB masking RBBB has not been reported, but the case presented here (3) could be regarded as such an example, albeit occurring intermittently.

What are the practical implications of these complex atrioventricular conduction disturbances following TAVR? To date, management of conduction disturbances post-TAVR varies widely among centers. For this reason, last year, a JACC Scientific Expert Panel reviewed the available evidence and published management recommendations (9). In this report, alternating bundle branch block does not appear as part of the definition of high-grade atrioventricular block, but as we convincingly see here, such a finding can only signify severe bilateral bundle branch disease. Although this may be transient following TAVR, we urge caution if such patients are managed without a pacemaker. As pointed out by Kulkarni et al. (3), Massumi et al. (10) published a series of 16 patients with alternating PR intervals and BBB who all developed high-grade atrioventricular block subsequently and needed pacemaker implantation. For practical purposes, the pattern of alternating BBB should be treated as equivalent to high-grade atrioventricular block or complete heart block.

We additionally note that the presence of pre-existing RBBB is already an important electrocardiographic feature identifying patients at risk for pacemaker implantation post-TAVR. However, for the reasons explained earlier, we can hypothesize that patients with pre-existing RBBB who also have absent S waves in leads I and aVL may be at even higher risk. This would be an important subject for further study.

In recent years, so-called physiological pacing using His bundle (HB) and LBB-area pacing systems has become increasingly prevalent. Success rates are lower in patients with atrioventricular conduction block, but early evidence suggests that implantation of such pacing systems is feasible post-TAVR (11,12). Presumably because the site of the block is at or near the HB, such pacing seems able to overcome the diseased conduction tissue in the HB that is predestined to become the LBB (13) (so-called longitudinal dissociation). Nevertheless, in the largest study to date (12), HB pacing was successful in only 63%. In many such patients, pacing more distally at the area of the LBB did permit correction of BBB (in 93% of patients who underwent an attempt at BBB correction). It is unknown whether there are electrocardiographic features predicting failure of HB pacing to overcome BBB. This case report would suggest that HB pacing is less likely to succeed if there are alternating PR intervals with alternating BBB. Possibly, RBBB with loss of the S-wave in leads I and aVL may also serve as a similar electrocardiographic warning. In such cases, adoption of LBB-area pacing may be preferred.

In conclusion, Kulkarni et al. (3) present an interesting case showing alternating PR intervals and BBB in a post-TAVR patient. Such an electrocardiographic appearance suggests significant disease in the bilateral bundle branches meriting treatment as for high-grade atrioventricular block. This case also serves as a reminder that BBB may not really be block and that so-called block may often really be hidden bundle branch conduction delay.

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