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EDITORIAL COMMENT

Rocking and Flashing With RV Pacing

Implications for Resynchronization Therapy*

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Cardiac resynchronization therapy (CRT) has been an important advance to treat patients with heart failure (HF) with reduced ejection fraction (EF) and widened QRS complexes with the potential for dramatic improvements. Most of the large clinical CRT trials excluded patients with existing right ventricular (RV) pacemakers previously implanted for bradycardia indications. Accordingly, the clinical guidelines for CRT implantation have primarily focused on native QRS morphology, with left bundle branch block (LBBB) and QRS width having the most abundance of supportive data (1). Therefore, less information exists from clinical trials on patients with existing RV pacing and reduced EF who were upgraded to CRT devices.

SEE PAGE 1091

Stankovic et al. (2) in this issue of *iJACC* examined a large number of patients from their multicenter PREDICT-CRT experience (3). Specifically, they studied 117 patients with RV pacing and 797 with intrinsic LBBB. They examined visual echocardiographic features of septal flash and apical rocking as markers of CRT response (2). Their major findings were that clinical outcomes were similar in patients with RV pacing upgraded to CRT as those with native LBBB, and that septal flash and apical rocking at baseline were associated with favorable response in both groups. Unfortunately, the term "dyssynchrony" has come to mean several different things resulting in some confusion in the literature. Differences in peak-to-peak timing of left ventricle (LV) regional motion that is referred to as dyssynchrony can occur from contractile heterogeneity or scar that is not responsive to CRT (4–6). There has been improved understanding in patterns of regional contraction that represent the electromechanical substrate responsive to CRT (4). Stankovic et al. (2) report that septal flash and apical rocking are myocardial contraction patterns in RV-paced patients associated with CRT response, similar to their observations in patients with intrinsic QRS widening.

REGIONAL MECHANISMS OF CONTRACTION AND STRETCH

Recent studies have shown that an important component of response to CRT is a minimum of electrical delay, and CRT may not help patients with narrow QRS width and may even be harmful (6). With data derived from computer simulations, imaging has been useful to identify strain patterns that are related to an electrical delay. The electromechanical substrate responsive to CRT is identified by early septal contraction producing free-wall stretch, followed by posterolateral free-wall contraction causing septal stretch as in LBBB (4). Computer simulations of RV pacing also show similar patterns as LBBB with early septal myofiber contraction associated with posterolateral wall stretch, followed by a more vigorous posterolateral contraction producing septal stretch during ejection (**Figure 1**). In this present article by Stankovic et al. (2), the authors reported on relatively simple markers that could be interpreted from visual inspection of routine M-mode and 2-dimensional cine-loops, which is comparatively less quantitative than off-line strain analysis. LBBB results in early unopposed septal contraction (before aortic valve opening), which is seen as septal flash as a brief in-and-out movement. Early septal longitudinal shortening associated with posterolateral stretch resulted in movement of the LV apex toward the RV. Delayed and more forceful posterolateral contraction resulted in septal stretch and LV apical movement in the opposite direction. This gives the appearance of

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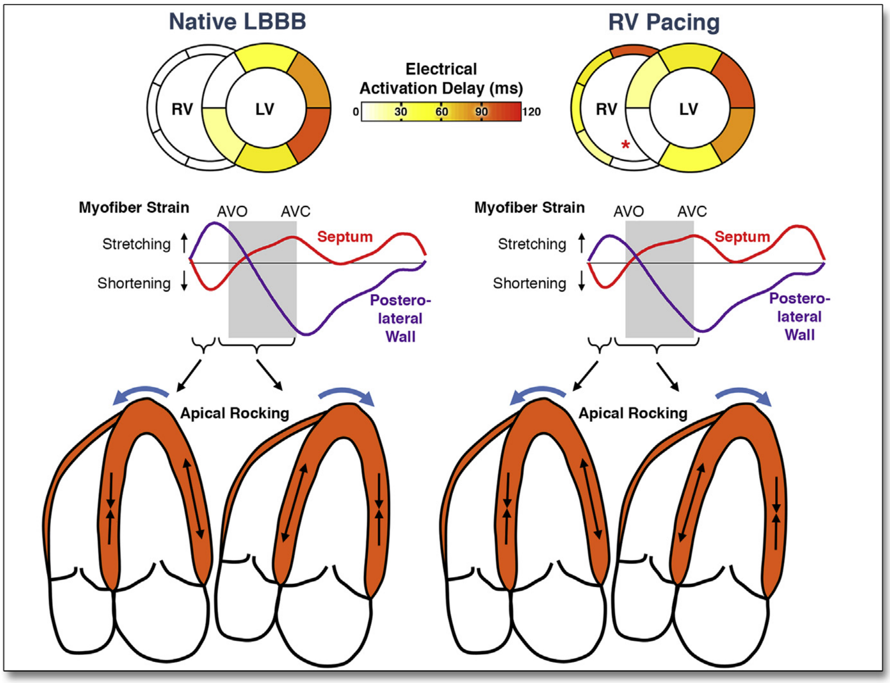
FIGURE 1 Comparison of Computer Simulations of Myofiber Strain in Native LBBB and RV Pacing and Their Influence on Apical Rocking



Both demonstrate early septal shortening before aortic valve opening (AVO) associated with posterolateral pre-stretch and apical movement toward the septum. During ejection until aortic valve closure (AVC) there is posterolateral shortening and septal stretch with associated rocking of the apex. These mechanical patterns are associated with response to cardiac resynchronization therapy. *RV pacing lead. LBB = left bundle branch block; RV = right ventricular.

apical rocking that can be visually appreciated by the trained eye. These phenomena of septal flash and apical rocking are consistent with studies of more quantitative measures of systolic stretch by strain imaging (4), and likely relate to the same electromechanical pathophysiology.

ELECTROMECHANICAL ACTIVATION IN RV PACING

In an elegant electrocardiographic imaging mapping study, Varma et al. (7) demonstrated similarities in electrical activation in patients with HF with LBBB and RV pacing. Tops et al. (8) were among the first to demonstrate abnormalities in mechanical activation using radial strain imaging with RV pacing that were corrected with CRT and resulted in LV reverse remodeling. Tanaka et al. (9) used 3-dimensional strain echocardiography in patients with HF with reduced EF to show that there were differences in the LV site of earliest activation with RV pacing occurring apically, and native LBBB occurring at the basal anterior septum. However, both RV pacing and native LBBB typically resulted in similar LV mechanical delays with contraction terminating in posterolateral regions. Furthermore, similar improvements in mechanical activation occurred with CRT in both groups, with similar LV reverse remodeling and EF response rates.

CLINICAL OUTCOMES WITH UPGRADE OF RV PACING TO CRT

Previous studies have shown that RV pacing in patients with HF with reduced EF is associated with deleterious effects on LV function and unfavorable clinical outcomes. Furthermore, in the BLOCK-HF trial, patients with atrioventricular block had better clinical outcomes when treated with CRT than RV pacing (10). Gage et al. (11) compared upgrades of CRT in 190 patients with RV pacing with 465 patients with intrinsic QRS widening and observed a 33% lower risk for HF hospitalization and death in patients in the RV pacing patients. Lipar et al. (12) reported identical 65% CRT response rates in 116 patients with RV pacing upgraded to CRT as in 165 patients with newly implanted CRT devices by routine criteria. Tayal et al. (13)

reported comparatively more favorable clinical outcomes after CRT in patients with prior RV pacing than those with wide LBBB (>150 ms in duration). These studies combine to support the concept that RV pacing may result in unfavorable cardiac mechanics of contraction that may result in LV remodeling, which may be prevented or reversed with CRT. The multicenter experience by Stankovic et al. (2) supports these previous reports and extends the potential role of echocardiography using identification of simple visual patterns of septal flash and apical rocking to assist in identifying patients who have the electromechanical substrate that is most likely to respond to CRT. Most importantly, the body of evidence continues to expand to support consideration of CRT in patients with systolic dysfunction who have a bradycardia indication for pacing, or upgrade to CRT in those with previous RV pacing who develop LV dysfunction.

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