Comparison of left ventricle segments contraction pattern by 3dimentional speckle tracking echocardiography in Right ventricular apical pacing with Right ventricular septal pacing

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Abstract: Background: Right ventricular (RV) pacing alters left ventricular (LV) mechanical activation, resulting in adverse impacts on LV function. This study was aimed to investigate the acute effect of RV apical (RVA) and septal pacing (RVS) on LV function using speckle-tracking echocardiography. **Methods and Results**: The 60 patients (74±9 years) with symptomatic bradyarrhythmia and preserved LV ejection fraction, were studied. All patients received a permanent pacemaker and were randomly assigned into two groups (RVA: n=30, RVS: n=30). After insertion, patients underwent an echocardiographic study during RV pacing. LV global strain parameters were analyzed using speckle tracking echocardiography. The GLS in RVA were the lowest among the 2 groups (GLS: Normal: –20.6±2.6%, RVA: –12.05±.9%, P<0.001 vs. control, RVS: –17.76±3.32%, P<0.01 vs. RVA). **Conclusions**: RVA created heterogeneous LV contraction, which resulted in deteriorated LV longitudinal contraction. RVS could be a better pacing alternative in terms of less LV dyssynchrony and better longitudinal function compared to RVA.

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1. Introduction

It is well known that right ventricular apical pacing (RVA) creates a non-physiological activation sequence and mechanical asynchrony in the left ventricle (LV) (Lee, 1994). The most study demonstrated that a longstanding RVA promoted an increased incidence of heart failure hospitalization and atrial fibrillation (Shukla, 2005). The adverse effects of RVA have been discussed again in the current era because patients with heart failure after longstanding RVA benefited from the additional LV lead implantation in order to obtain cardiac resynchronization. To avoid the LV dysfunction in patients with preserved LV function after the procedure of RVA, RV septal pacing (RVS) is reported to be one of the alternative pacingmethods to shorten the paced-QRS width and to attenuate mechanical asynchrony. Speckle tracking echocardiography is a novel echocardiographic technique without the angle dependence of an ultrasound beam and is able to measure regional deformation in any direction in the LV. Recently, speckle tracking-based global longitudinal strain (GLS) was reported as the robust parameter over standard LV ejection fraction to predict subclinical LV dysfunction and outcome(Delnoy, 2009). In addition, our recent report demonstrated less LV longitudinal dyssynchrony inpatients receiving RVS compared to RVA (Cano, 2010). Therefore, we tested our hypothesis that RVS had an advantage to preserve LV global function by attenuating LV asynchrony assessed by speckle tracking echocardiography over RVA in bradyarrhythmic patients with preserved LV function.

2. Material and Methods

Study Population

This study consisted of 60 patients with symptomatic bradyarrhythmia and preserved LV function who were scheduled for a permanent pacemaker implantation. Exclusion criteria included patients with coronary artery disease, prominent valvular heart disease, cardiomyopathies, and a LV ejection fraction less than 55% before device implantation (Nahum, 2010). Patients were randomly assigned into two groups according to the site of RV lead as follows; (1) RV apex (RVA); and (2) RV septum (RVS). The ethics committee of Tabriz University of Medicine approved this study, and all patients gave informed consent prior to participation.

Pacemaker Implantation Procedure

We performed pacemaker implantation via a trans venous approach in all patients. We used a traditional tined-tip pacing to anchor a lead in the RV apex in those patients randomized to the RVA group. In contrast, a screw-in type of ventricular pacing lead was used to anchor a lead in the RV mid-septum in patients randomized to the RVS group. We tried to anchor the ventricular leads at the RV mid-septum, with the achievement of narrower paced-QRS width during procedures using electrocardiographic and fluoroscopic guidance and referring to the method described by Mond et al(2007). Then, we tried to anchor the ventricular lead in the middle zone of the RV. After fixation of the ventricular lead, the left anterior oblique view of 45 degrees was used to confirm that the lead was successfully placed on the RV septum and not the free wall.

Surface and Device Electrocardiography, and Echocardiograpic Examination

After the device implantation, we used a managed ventricular pacing mode (Medtronic, Minneapolis, MN, USA) in the E stimation of the cumulative percent of ventricular pacing in each patient. If persistent loss of atrioventricular conduction was identified, we set a nominal atrioventricular delay (120 ms) in such patients. Echocardiographic studies were performed at 6 month after pacemaker implantation using a Vivid 7 Dimension ultrasound machine (GE Healthcare) with an M4S probe. Echocardiographic recordings were acquired during RV pacing in all patients. After an acquisition of standard echocardiographic parameters, 2-dimensional gray scale images with a high frame rate (72–102 frames per second) were digitally acquired from the short axis view at the papillary muscle level and from 3 apical views (4-chamber, 2-chamber and 3-chamber views). We made a great effort to obtain high quality 2-dimensional images for optimal analysis of speckle tracking echocardiography. LV volumes and ejection fraction were estimated by a biplane modified Simpson's rule. In addition, color-coded tissue Doppler image was recorded from the 4-chamber view.

Image Analysis of Speckle Tracking-Based LV Global Strain

We calculated the longitudinal directional global strain of LV. The value of longitudinal strain in 17 LV models from apical 3 planes was averaged to assess a LV GLS. The EchoPac software offers to obtain these global parameters of strain automatically after tracing the endocardial border of LV.

Statistical Analysis

Statistical analysis was carried out using SPSS version 16.0 for Windows. Continuous variables were expressed as the mean ± standard deviation. A 1-way ANOVA followed by Scheffe's post hoc test was used to compare the differences in clinical and echocardiographic parameters among RVA and RVS patients.

3. Results

Study Population

This study included 60 patients receiving RV pacing, who were randomly assigned into the two groups of RVA and RVS.

LV GLS during RV Pacing

Figure 1 shows the differences of LVEF between the two groups. The LVEF were significantly deteriorated in the RVA group compared to both the RVS and normal groups (LVEF: Normal: >55%, RVA: 42.67±3.2%, P<0.001 vs. control, RVS: 55.17±5.6%, P<0.01 vs. RVA). The GLS were significantly deteriorated in the RVA group compared to both the RVS and normal groups (GLS: Normal: –20.6±2.6%, RVA: –12.05±.9%, P<0.001 vs. control, RVS: –17.76±3.32%, P<0.01 vs. RVA). The pattern of LV longitudinal strain was relatively homogeneous and the GLS was preserved in a case of RVS compared to that in a case of RVA. The speckle tracking-based longitudinal strain curves in three apical planes in representative cases of the normal, RVA and RVS groups are shown in Figure 2.

4. Discussions and conclusion

The major findings of this study were: by the analysis of speckle tracking echocardiography: (1) RVS suppressed the adverse effect of LV dyssynchrony created by RV pacing compared to RVA; (2) the severity of LV longitudinal dyssynchrony created by RV pacing was proportionally associated with the deterioration of LV global longitudinal function; and (3) the LV global longitudinal function was significantly preserved in RVS compared to RVA.

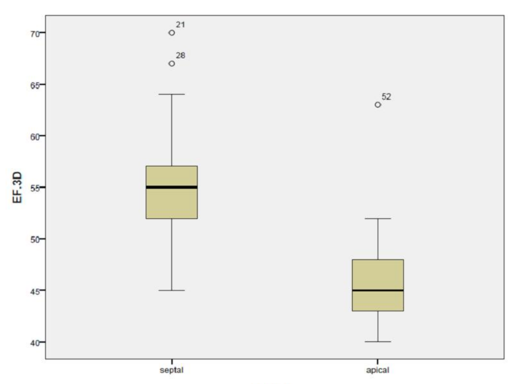

FIGURE1: Comparison of LVEF among two groups (RVS and RVA) by 3D echocardiography.

It is well recognized that RVA creates the iatrogenic left bundle branch block and heterogeneous LV contraction, which result in the adverse impacts on LV function and structure (Nakai, 2009). The cumulative percentage of RVA is considered as a greater risk of cardiovascular events in adult patients receiving RVA (Mond, 2007). In addition, pediatric patients paced for complete atrioventricular block are at risk of developing dilated cardiomyopathy features after long-term cardiac pacing from the RV apex (Bax, 2003). RV pacing from the RV septum (RVS) is considered as a good alternative for RVA because it allows a narrower paced QRS with good lead threshold and stability (Suffoletto, 2006; Saito, 2009).

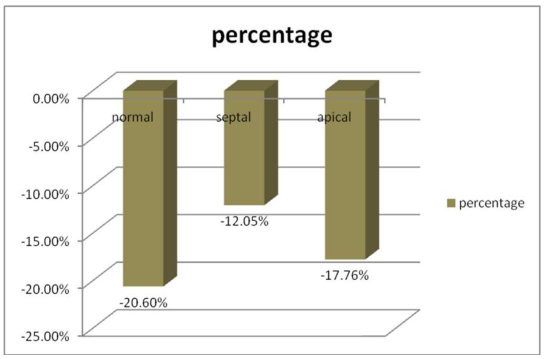

FIGURE2: GLS in RVS and RVA groups and comparison them with normal value.

In this study, RVS was successfully performed, by an experienced operator, in all patients who were randomized to the RVS and RVA groups. Our recent study showed that RVS had an advantage of a lower frequency of worsening LV mechanical function in patients with sick sinus syndrome without structural heart diseases by the analysis of speckle tracking echocardiography (Inoue, 2010). This study was consistent to this results that RVS served more homogeneous LV contraction than RVA in patients with bradyarrhythmia including atrioventricular block. Two-dimensional speckle tracking echocardiography is a feasible echocardiographic technique with an angle independency and high frame rate, which is capable of obtaining any directional strain. According to previous reports, the assessment of global systolic function by speckle tracking-based GLS was superior to the standard variables such as LV ejection fraction and wall motion score index for the prediction of outcome in patients undergoing echocardiography with good reproducibility (van Oosterhout, 1998; Sweeney and Hellkamp, 2006). We evaluated the LV global function using a speckle tracking-based strain during RV pacing, addressing the fact that GLS during systole was more deteriorated in RVA than that in RVS.

Therefore, RVA could worsen LV longitudinal systolic function, but RVS minimizes these adverse effects from RVA pacing.

Study Limitations

This study has several limitations. First, this study cannot be extrapolated to the long-term impact on LV function between RVA and RVS. Ongoing randomized prospective multicenter clinical trials will clarify this issue. But this study addressed the fact that GLS was significantly preserved in RVS compared to RVA. Because GLS is powerful in evaluating subclinical LV dysfunction and in predicting poor outcome over LV ejection fraction (Chen, 2009), the preservation of GLS could be very important regarding global cardiac function. Second, we could not evaluate other speckle tracking-derived parameters in a circumferential and radial direction. Definition of global circumferential and radial strain on a short axis view is difficult in terms of the setting of slice level, which actually resulted in poor reproducibility of these parameters. Three dimensional speckle tracking technology might resolve this issue (Rosso, 2010). In addition, speckle tracking-based parameters including dyssynchrony and global strain and strain rate depend on the B-mode echocardiographic image quality itself. Therefore, we had to exclude cases with suboptimal echocardiographic images that resulted in tracking failure. Finally, the lack of standardization of RVS procedure might be related, in part, to conflicting results about RV alternative pacing (Yu, 2007; Stanton, 2009).

Although we carefully tried to anchor the ventricular lead in the RV mid-septum, there might be a possibility to include the suboptimal procedure of RVS because of a variability of RV anatomy and cardiac rotation among patients in this study.

Conclusions

By the analysis of speckle tracking echocardiography, the pacing from the RV apex creates LV asynchronous contraction, which could worsen LV global longitudinal function. The RV septal pacing is a better alternative in terms of less dyssynchrony and better global longitudinal function in LV compared to RV apical pacing.

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