CASE REPORT

Right Ventricular Electrical and Mechanical Synchronization by Properly Timed Septal Pacing in a Patient with Right Bundle Branch Block and First Degree AV Block—A Case Report

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We present a case of near-normalization of the QRS by septal pacing in a patient with dual-chamber pacemaker and underlying complete right bundle branch block and first degree atrioventricular block. The right ventricular mechanical synchronization suggested by the ECG was validated as such by strain echo. To the best of our knowledge, this is the first time it has been shown that the narrowing of the QRS corresponds to mechanical synchronization in a case of this seldom-recognized phenomenon.

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septal right ventricular pacing; right bundle branch block; QRS narrowing

INTRODUCTION

Narrowing of the QRS compared to baseline is encountered in two main situations: direct Hisian pacing and biventricular pacing (CRT). A third and unusual situation appears in patients with complete right bundle branch block (RBBB), where properly-timed right septal pacing is delivered. This case illustrates this latter phenomenon in a patient with baseline RBBB and first degree atrioventricular (AV) block.

CASE PRESENTATION

A 78-year old patient was referred to our clinic for a poorly tolerated persistent episode of typical atrial flutter. He had undergone dual-chamber pacemaker implantation in July 2008 (Medtronic Sensia SEDR01, Medtronic, Inc., Minneapolis, MN,

USA) for symptomatic sinus node dysfunction. At that time, his baseline ECG showed first degree AV block and complete RBBB (Fig. 1). The left ventricular (LV) ejection fraction was normal. The atrial lead was implanted in the low interatrial septum near the coronary sinus ostium and the ventricular lead in the midventricular septum (Fig. 2). The pacemaker was programmed with the *Search-AV+* algorithm turned on, in order to promote intrinsic AV conduction. The algorithm was subsequently automatically deactivated by the device, so we assumed that the AV conduction had worsened, and the pacemaker was reprogrammed in DDDR mode with "conventional" AV intervals: sensed AV interval (sAVI) 160 ms and paced AV interval (pAVI) 200 ms. With these settings, the stimulated QRS had left bundle branch block (LBBB) morphology and the patient was paced nearly 100% of the time in

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Figure 1. Baseline ECG before permanent pacemaker implantation showing sinus bradycardia, junctional escape beats, and complete right bundle branch block.

Figure 2. Fluoroscopic appearance of the permanent pacemaker leads in posterior-anterior (PA), right anterior oblique (RAO) 30°, and left anterior oblique (LAO) 30° views. The atrial lead is implanted in the posterior interatrial septum, with typical posterior orientation in RAO 30° (to the left of the image) and septal orientation in LAO 30° (to the right of the image). The ventricular lead is implanted in the midseptum (oriented to the right of the image in LAO 30°).

Figure 3. ECG after ablation of typical atrial flutter showing right ventricular pacing with fusion. See text for details.

both chambers. He remained asymptomatic until the tachyarrhythmic event, with no pathological findings on physical examination. He had no signs and symptoms of heart failure, and the LV ejection fraction on transthoracic echocardiogram was 60%.

The ECG on this admission (December 2012) showed typical atrial flutter with fully paced QRS complexes (mode-switching to DDIR). The patient underwent successful radiofrequency ablation of the cavotricuspid isthmus for typical atrial flutter. Post ablation, we kept the same settings for the pacemaker as described above. A routine 12-lead ECG showed a transient period of spontaneous sinus rhythm with striking narrowing of the paced QRS complexes, compared to both the baseline RBBB and the previous fully paced QRS. The measured P to ventricular spike interval was 260 ms, the sAVI being 160 ms; this unusual situation is explained by delayed P-wave sensing at the low interatrial septum (Fig. 3).

We further studied this ECG finding by performing conventional and tissue Doppler (TDI) echocardiography with 3 different pacemaker settings: AAI 60/min, DDD 60/min with the longest pAVI that provided fully paced QRS complexes (160 ms), and DDD mode 60/min with the pAVI that provided the narrowest QRS (240 ms). We chose to perform this study in atrial pacing and

Figure 4. Paced 12-lead ECGs. (A): atrial pacing (AAI) 60/min. (B): DDD pacing 60/min with paced atrioventricular interval (pAVI) of 160 ms. (C): DDD pacing 60/min with pAVI of 240 ms, illustrating electrical synchronization by right septal pacing with fusion.

not in sinus rhythm due to underlying marked bradycardia at the time.

In AAI mode, the atrial spike-to-R-wave onset time was 240 ms, depending on native conduction, and the QRS had RBBB morphology, with a QRS width of 160 ms (Fig. 4A). In DDD mode with pAVI 160 ms, the QRS was fully paced, with LBBB morphology and a QRS width of 200 ms; this finding rules out direct hisian capture (Fig. 4B). In DDD mode with pAVI 240 ms, which corresponds to the native conduction time, the

Table 1. Echocardiographic Parameters with Three Different Pacemaker Settings: AAI 60 /min, DDD 60/min with the Longest pAVI that Provided Fully Paced QRS Complexes (160 ms), and DDD Mode 60/min with the pAVI that Provided the Narrowest QRS (240 ms)

	AAI 60 bpm	DDD pAVI 160ms	DDD pAVI 240ms
Baseline ECG data			
PR interval (ms)	240	160	240
QRS duration (ms)	160	200	130
QRS morphology	RBBB	LBBB	Near-normal
QT interval (ms)	440	440	460
Baseline echocardiographic data			
LV end-diastolic volume (ml)	70	80	74
LV end-diastolic diameter (mm)	45	46	45
LV ejection fraction	60%	55%	60%
RV diameter (mm)	26	26	26
Mitral regurgitation severity	Minimal	Minimal	Minimal
Cardiac output (L/min)	4.6	4.0	4.6
E-wave velocity (cm/s)	37	39	41
A-wave velocity (cm/s)	47	44	55
DTE (ms)	267	275	293
Diastolic filling time (ms)	506	506	511
A-wave duration (ms)	170	165	178
Peak LV septal strain	17%	14%	16%
Peak LV lateral wall strain	38%	29%	27%
Peak RV free wall strain	27%	19%	23%
Left ventricular dyssynchrony indices			
QRS to peak septal strain delay (ms)	395	415	480
QRS to peak lateral wall strain delay (ms)	465	500	460
Septal-to-lateral wall peak strain delay (ms)	70	85	–20
Right ventricular and interventricular dyssynchrony indices			
QRS to peak RV free wall strain delay (ms)	545	380	470
LV lateral wall-to-RV free wall peak strain delay (ms)	80	–120	10

LV, left ventricle; RV, right ventricle.

QRS was fused and was narrower than in both previous instances, with a QRS width of 130 ms (Fig. 4C). The TDI analysis (EchoPAC PC, GE Medical Systems) showed that the narrowest QRS was accompanied by the best right ventricular myocardial synchrony (Fig. 5). There was no difference in LV function (normal ejection fraction) or AV synchrony (similar transmitral pulsed-wave spectral Doppler curves and duration of diastole) in any of the 3 programming modalities (Table 1).

Based on these findings, permanent pacemaker programming was left as DDDR with pAVI = 240 ms and sAVI = 160 ms. With these settings, 18 months later (May 2014), the patient remained asymptomatic, with excellent exercise tolerance (no heart failure symptoms) and similar QRS morphology on ECG.

DISCUSSION

Not only complete LBBB but also complete RBBB have been shown to be associated with higher cardiovascular morbidity and mortality in the general population with the QRS duration being a poor prognostic factor.^{1,2}

RV pacing and paced QRS duration have also been incriminated as being related to worse long-term outcomes (morbidity, heart failure) in subjects with permanent pacemakers.^{3–5} While there is a large medical literature dealing with imaging of delayed LV activation, LV dyssynchrony, and its reversal by biventricular pacing in patients with LBBB or RV pacing, little is known regarding the mirror situation, i.e., delayed RV activation, RV dyssynchrony, and eventual synchronization of RV contraction in patients with RBBB. The

Figure 5. Tissue Doppler-derived myocardial strain imaging of the basal right ventricular free wall (yellow tracing), basal septum (blue tracing), and basal lateral left ventricular wall (red tracing) during atrial pacing and spontaneous right bundle branch block (A), fully paced QRS complexes (B), and pacing with fusion (C). During atrial pacing, peak strain of the basal septum occurs first, followed by basal left ventricular lateral wall and lastly by the basal right ventricular free wall. During fully paced QRS complexes, the peak strain sequence changes with the basal right ventricular free wall occurring first, followed by the basal septum and lastly by the basal left ventricular lateral wall. During fusion, peak strain of all walls occurs almost simultaneously. In each panel, the time from the onset of the QRS (marked by the vertical white line) to the peak systolic strain (marked by the vertical dotted lines—yellow: basal right ventricular free wall; blue: basal septum; red: basal lateral left ventricular wall) is depicted.

reports addressing this issue are sparse, mainly ECG-based and without documented detailed echocardiographic analysis.^{6,7} We provide echocardiographic proof of synchronization of the RV by properly timed RV pacing for our case. Patients with RBBB treated with RV “synchronization” may benefit from QRS shortening because this favors, in a paced heart, the activation of both ventricles through the native conduction system. Of note, data regarding the clinical effects of this phenomenon in patients with RBBB and moderate to severe heart failure will be provided by the ongoing PACE-RBBB Trial (ClinicalTrials.gov NCT01169493).

In summary, this case demonstrates both electrical and mechanical RV synchronization by RV septal pacing, without affecting AV synchrony, in a patient presenting with RBBB and first degree AV block. For the patient described here, the pacemaker was programmed such as to provide RV synchronization; however, the stability of this phenomenon over time and its clinical significance remain to be further studied.

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