Fortuitous distal right bundle branch pacing

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Introduction

Conduction system pacing is being increasingly adopted to provide a physiological form of pacing therapy in lieu of right ventricular (RV) or biventricular (BiV) pacing. Conduction system pacing included His bundle pacing (HBP) and left bundle branch area pacing (LBBAP). There have as yet not been any reports of right bundle branch pacing (RBBP). The present case describes distal RBBP in a patient with RV septal lead placement, which was incidentally observed during threshold testing.

Case report

An 85-year old patient with a medical history of chronic heart failure with left ventricular (LV) ejection fraction of 35% of nonischemic origin and rapidly conducted atrial fibrillation with narrow QRS complexes was scheduled for pace-and-ablate therapy. HBP was attempted with a Medtronic (Minneapolis, MN) 3830 lead and a C-315 His delivery catheter. Owing to high capture thresholds, BiV pacing was performed instead. The RV lead was positioned on the mid septum and a coronary sinus lead was implanted in a posterolateral tributary. Radiofrequency ablation of the atrioventricular node (AVN) was undertaken via femoral venous access, at a site slightly below the His bundle with complete atrioventricular block and an escape rhythm at 40 beats per minute and unchanged QRS morphology. Figure 1 shows the position of the leads and of the ablation catheter on the His bundle. Threshold tests of the RV septal lead were performed in bipolar pacing mode, and unexpectedly revealed 2 transitions in QRS morphology, which were visible in the limb leads (Figure 2). These transitions were reproducible and present both before and after AVN ablation. No major changes in QRS morphology were observed in the precordial leads, other than a slight prolongation of R-wave peak time in lead V_6 (V6RWPT) from 90 ms to 100 ms during the first transition in QRS morphology. Paced QRS width was 160 ms (measured from the pacing spike) and remained unchanged at different outputs. Pacing in the unipolar mode at 8 V @ 1 ms showed identical QRS morphology compared to bipolar pacing just before loss of capture. There were no transitions in QRS morphology during threshold testing with unipolar pacing. The 2 transitions in QRS morphology were still observed during threshold testing after 2.5 years of follow-up.

KEYWORDS Conduction system pacing; Right bundle branch pacing; Anodal capture; QRS transition; Septal pacing
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KEY TEACHING POINTS

- Distal right bundle branch pacing (RBBP) may occur with anodal capture from the ring electrode of RV septal leads and is described for the first time in this case report.
- Distal RBBP may be under-recognized owing to subtle changes in QRS axis in the frontal plane.
- Anodal myocardial capture from RV septal leads may also result in minor changes in frontal QRS axis.
- RBBP only slightly impacted V_6 R-wave peak time, and QRS duration remained prolonged (also with bifocal RV capture). Benefit on electrical synchrony therefore seems to be negligible, but should be further evaluated.

Discussion

This is the first case description of distal RBBP, which was fortuitously obtained by anodal capture with an RV septal lead. The electrocardiogram (ECG) findings observed during the threshold tests and by pacing in different polarities allowed the following deductions:

(1) Unipolar pacing at high output yielded a QRS morphology that was identical to that obtained by bipolar pacing just before loss of capture and did not display any transitions in QRS morphology, *indicating that the ring electrode was responsible for these transitions.*
(2) HBP was impossible, as the RV lead was positioned several centimeters from the His bundle (Figure 1), the

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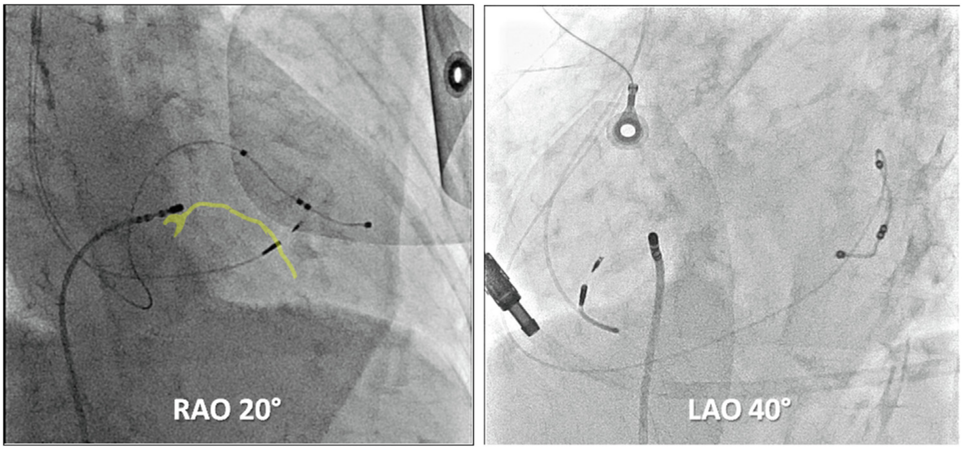

Figure 1 Positions of the pacing leads and of the ablation catheter on the His bundle. A depiction of the conduction tissue (atrioventricular node, His bundle, and right bundle branch) is depicted in yellow in the right anterior oblique (RAO) view (with contact between the right bundle branch and the ring electrode of the right ventricular lead). LAO = left anterior oblique.

QRS morphology was considerably different compared to intrinsic rhythm, and transitions in QRS morphology would have been observed during unipolar thresholding testing.

(3) LBBAP with transitions due to loss of anodal capture was not possible, as the lead was not implanted deep enough into the septum and the paced ECG did not show any characteristics of LBBAP. A QRS transition during a threshold test with bipolar pacing is often observed with LBBAP, but further transitions (ie, to selective LBBAP or myocardial-only capture) would have occurred owing to loss of tissue capture by the tip electrode and should also have been visible with unipolar pacing.

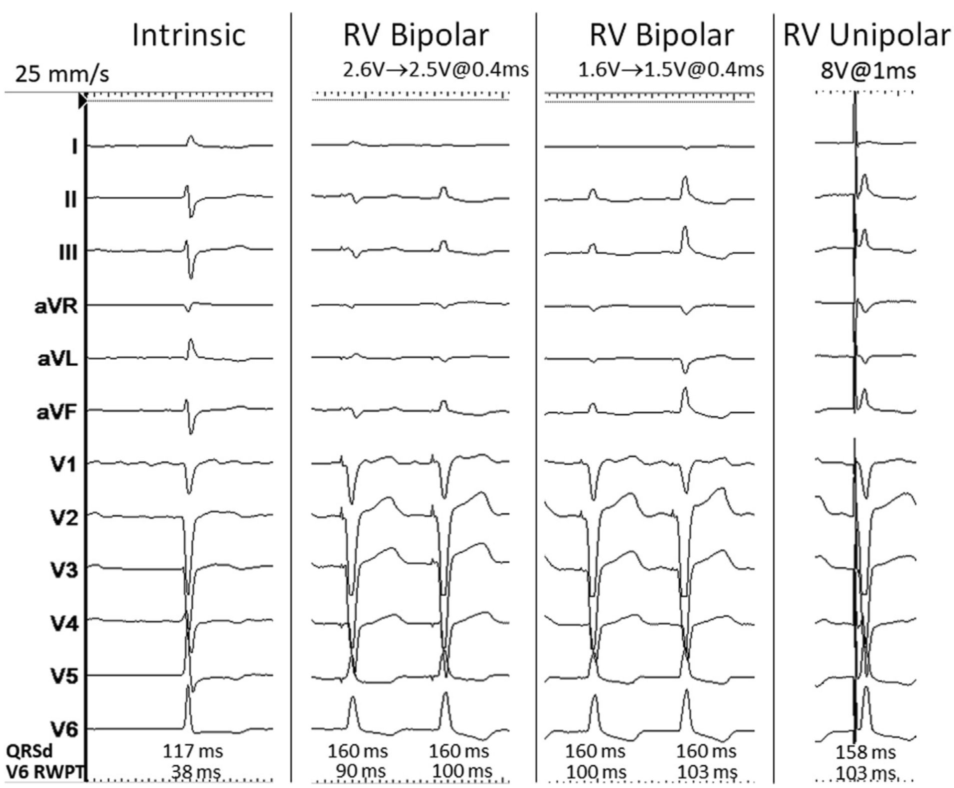

Figure 2 QRS morphologies in intrinsic rhythm after atrioventricular nodal ablation and during pacing at different outputs and with different polarities. Note the 2 transitions in QRS morphology in the inferior leads with decrementing pacing output with bipolar pacing from the right ventricular (RV) lead. QRS morphology with high-output unipolar pacing resembles that during bipolar low-output pacing (ie, with myocardial capture only). This implies that transitions in QRS morphology are due to loss of anodal capture from the ring electrode. QRS durations (QRSd) and V_6 R-wave peak times (V6 RWPT) are shown at the bottom of the figure.

(4) During the threshold tests with bipolar pacing, the *first transition* at 2.5 V @ 0.4 ms with loss of QRS negativity in the inferior leads was attributed to *loss of anodal RBBP*. The right bundle branch (RBB) is a cord-like structure that usually takes a short intramuscular course within the septum before it emerges in the subendocardium of the RV at the base of the medial papillary muscle.[1,2] The superficial course of the RBB explains why it was able to be captured simply by surface contact with the ring electrode. In the RV septum, the RBB continues superficially in the subendocardium of the septomarginal trabeculation and divides before reaching the RV apex, with a branch that courses within the moderator band to continue into the RV free wall.[2] This explains the loss of superior-directed forces (ie, transition to a more positive QRS in the inferior leads) with loss of anodal RBBP, as well as the slight prolongation of the V6RWPT, owing to loss of retrograde activation of the left-sided conduction system. Retrograde activation to the left conduction system was able to occur despite AVN ablation, probably owing to the proximal ablation site.

(5) The *second QRS transition* occurred at 1.5 V @ 0.4 ms with increased positivity in the inferior leads and was attributed to loss of *anodal myocardial capture*, leaving only myocardial capture by the lead tip. As the ring electrode lay inferior to the lead tip, the pacing vector resulting from loss of anodal myocardial capture resulted again in greater positivity in the inferior leads.

Anodal capture by the ring electrode by simple surface contact was therefore possible for both the RBB and the myocardium.

Distal RBBP is a rare phenomenon, bearing in mind the high number of RV septal lead implantations. As QRS transition seems to be relatively subtle without significant changes in QRS width or in precordial QRS morphology (mainly in frontal QRS axis), it is likely to be missed during threshold testing.

Anodal myocardial capture with standard RV pacing is usually not noticeable on the ECG. The visible (albeit slight) changes in QRS morphology were probably related to the orientation of the lead dipole in our case. Conversely, anodal capture of the RV lead is a well-known phenomenon with BiV pacing.[3] It has also been described with HBP when the His lead is plugged to the LV port and programmed to an extended bipolar pacing configuration with a backup RV lead.[4] Anodal capture is also encountered with bipolar pacing with coronary sinus leads (which equates to multipoint pacing) and with LBBAP.

LV electrical delay (as evaluated by V6RWPT) and biventricular electrical delay (as evaluated by QRS duration), remained prolonged at all pacing outputs. This indicates that there was little benefit to be gained in terms of electrical synchrony from distal RBBP (or bifocal RV pacing) in this patient. Whether our case is representative of RBBP is unknown and should be further evaluated.

This case was performed before LBBAP had been adopted at our institution, which would today be considered to be our pacing modality of choice with a "pace-and-ablate" strategy in patients with a narrow baseline QRS.

References

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