A left bundle branch block morphology tachycardia with fragmented potentials at the His bundle area

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Case presentation

A 76-year-old man had a surgery of aortic valve replacement, mitral valve and tricuspid valve repair, and surgical pulmonary vein isolation (for severe aortic valve regurgitation, mitral valve regurgitation and paroxysmal atrial fibrillation). After the operation, he showed a low left ventricular ejection faction (LVEF 27%) with a QRS prolongation from 98 ms to 132 ms (Figure 1A). On the fourth postoperative day, he had a wide QRS tachycardia of left bundle branch block (LBBB)-like and superior axis deviation with a heart rate of 156 bpm. (Figure 1A). The baseline AH and HV interval was 90ms and 76ms. Programed stimulation from the right ventricular apex (RVA) produced a fragmented potential (Fg) following a spike potential (spike-Fg) at the His bundle region (Figure 1B). With extra-stimulations, the fragmented component was

prolonged and the sequence of these potentials became reversed (Fg-spike), thereby inducing the wide-QRS complex tachycardia. This tachycardia showed a LBBB-like morphology and superior axis deviation with the tachycardia cycle length (TCL) of 420 ms (Figure 1B) and atrioventricular (AV) dissociation. What is the mechanism of the LBBB morphology tachycardia with AV dissociation? What do the spike and Fg potentials produced by RVA stimulation indicate?

Discussion

A differential diagnosis of the LBBB morphology tachycardia with AV dissociation includes: (a) myocardial ventricular tachycardia; (b) bundle-branch reentrant ventricular tachycardia (BBR-VT); (c) verapamil-sensitive upper septal idiopathic left ventricular tachycardia (US-ILVT); (d) ventricular tachycardia associated with longitudinally dissociated His bundle[1].

We initially considered the mechanism of this tachycardia was bundle-branch reentry, because the patient underwent the valve replacement[2] and the QRS duration was increased with a slight deviation of the QRS axis following the operation. Moreover, the baseline HV interval was exceeded the normal range[3]. This indicated the His-Purkinje system (HPS) was disordered. However, the H-H (i.e. Spike-Spike) cycle length during the tachycardia did not determine the V-V interval, but rather the contrary. Besides, the long post pacing interval (PPI) (624 ms; a PPI – TCL $>$ 30 ms) following RVA pacing without manifest fusion (Figure 2A, 2B) made BBR-VT unlikely [4,5].

US-ILVT is a unique type of VT, half of which exhibited an identical QRS configuration as sinus rhythm and occurred after ablation of the common form of verapamil-sensitive fascicular VT[6]. US-ILVT is considered to be caused by a reentrant circuit incorporating the abnormal Purkinje fiber with slow conduction. However, the His bundle electrogram usually preceded the QRS complex during US-ILVT with a shorter HV interval than that during sinus rhythm.[6]

Arai H, et al reported myocardial ventricular tachycardia from the vicinity of the His bundle[7]. The entrainment from the RVA showed constant and progressive fusion, which was in contrast with our case (Figure 2A and 2B). In addition, pacing from the His bundle area during the tachycardia exhibited two different responses. In most instances, the Spike potential was captured as shown in the left panel of Figure 2C. The PPI was 578 ms and an interval between the last stimulation to fragmented potential (380 ms) was shorter than the TCL. Occasionally, the fragmented potential was captured selectively and concealed entrainment was observed with the stimulus to QRS interval of 162 ms, which was close to the fragmented potential to QRS interval (195 ms) during the tachycardia (the middle panel in Figure 2C). Shortening of the stimulation interval to 340 ms gradually prolonged the stimulus to QRS interval and terminated the tachycardia at the time between the fragmented and Spike potentials (the right panel in Figure 2C). The fourth stimulation (in the figure) directly captured ventricular myocardium with a different QRS morphology from that during the tachycardia, indicating some tissue insulated from the ventricular myocardium participated in the reentrant circuit. We thus considered that the longitudinally dissociated right-sided His bundle caused the fragmented potential during the tachycardia, whereas the Spike potential was attributable to retrograde activation of the main body of the His bundle (Figure 3A). As a turnaround area of the fragmented to Spike potentials, transverse spread of the propagating impulses had been demonstrated in the His-Purkinje system with longitudinal dissociation[8]. The tachycardia resembled ventricular tachycardia with an area of slow conduction in the longitudinally dissociated left-side His bundle[1]. In that case, the left-sided His bundle potential was converted into fragmented potentials at the initiation of the ventricular tachycardia (Figure 2A[1]).

A 3.5 mm tip ablation catheter (ThermoCool SmartTouch SF; Biosense Webster, Diamond Bar, CA, USA) was placed at the slightly more ventricular site (as compared to the His bundle area) where the fragmented potential was recorded 49ms earlier from the onset of QRS complex (Figure 3B). Pacing from this site demonstrated concealed entrainment (Figure 3A). A delivery of radiofrequency energy (30W) terminated the tachycardia in 20 seconds with no change in the QRS configuration during the baseline rhythm. The

tachycardia became no inducible after this radiofrequency application.

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Figure legends

Figure 1. A : Twelve-lead ECGs before and after the operation, and during the tachycardia. After the operation, QRS duration was prolonged to 132ms with slight left axis deviation which was noted by a deep S wave in lead II. The tachycardia showed a left bundle branch block (LBBB)-like morphology with superior axis deviation and the QRS width of 200 ms.

B : Induction of the tachycardia. At the baseline, an HV interval was 76 ms. Pacing from right ventricular apex (RVA) produced a spike potential (Spike, red arrows) followed by a fragmented potential (Fg, red underlines) (Spike-Fg) in a bipolar electrode (His 1-2) placed at the His bundle. When the stimulation interval was shortened, the fragmented component was further prolonged with reversal of the sequence to Fg-Spike, thereby inducing the tachycardia. During the tachycardia with a cycle length of 420 ms, the Fg to QRS interval was 189 ms and the QRS to Spike interval was 87 ms. Each dotted vertical line indicates onset of the QRS complex. Shown are the surface ECGs and intracardiac electrograms recorded from the low lateral right atrium (LLRA), His bundle (His) area, and right ventricular apex (RVA). Fg = fragmentated potential. Spike = spike potential. 1-2 = distal pairs of electrodes of the catheter. S = stimulus.

Figure 2. A : Pacing from RVA during the tachycardia. Post pacing interval of 624ms was much longer than the tachycardia cycle length of 430ms.

B : Twelve-lead ECGs during the burst pacing. Paced QRS morphologies from RVA with the cycle length of 400 ms during baseline (RVA(B)) and tachycardia (RVA(Tachy)) were identical, which indicated absence of constant and progressive fusion. The stimulation captured His bundle potential (i.e., Spike potential) (His p) and fragmented potential (Fg p). B = baseline rhythm. Tachy= tachycardia, His p= His bundle (i.e., Spike potential) pacing, Fg p= fragmented potential pacing.

C : Pacing at the His bundle area during the tachycardia. The pacing captured His bundle, i.e., Spike potential. The stimulus to QRS interval of 71 ms quasi-equaled the HV interval during the baseline rhythm. The post pacing interval was 578 ms and the interval from the last stimulation to fragmentation was 380 ms. The fragmented potential to QRS interval was 198 ms during the tachycardia (left panel). The pacing captured the fragmented potential (Fg) selectively with the stimulus to QRS interval of 162 ms and concealed fusion. The interval from the last stimulation to the fragmented potential was 479 ms (middle panel). At the pacing cycle length of 340 ms, the stimulus to QRS interval gradually increased and the tachycardia was terminated with a seeming Fg-Spike block. A direct ventricular capture immediately after termination produced a different QRS morphology from that during the tachycardia (right panel). Abbreviations are the same as in Figure 1.

Figure 3. A : A proposed mechanism of this tachycardia. AV node = atrioventricular node. RBB = right bundle branch. LBB = left bundle branch. Fg = fragmented potential. Spike = spike potential. See text for details.

B: Before the radiofrequency catheter ablation. A brief fragmented potential was recorded from bipolar electrodes of the ablation catheter (ABL). The electrogram was 49 ms earlier than the onset of QRS complex at the successful ablation site. At this site, concealed entrainment with the stimulus to QRS interval of 46 ms was observed. The His bundle catheter was displaced to a more distal (ventricular) site. ABL = ablation catheter. Other abbreviations are the same as in Figure 1