Role of the His bundle in verapamil-sensitive idiopathic left ventricular tachycardia

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Introduction

Most cases of verapamil-sensitive idiopathic left ventricular tachycardia (ILVT) with right bundle branch block and superior axis pattern have been reported as a reentrant circuit with slow conduction to the left posterior fascicle through the septal Purkinje fiber.[1–4] However, the exact anatomic structure of the reentrant circuit, particularly upper turnaround, has not been fully elucidated.

Case report

A 30-year-old man without structural heart disease was referred for evaluation of tachycardia. During sinus rhythm, the 12-lead ECG was normal. During tachycardia, the ECG showed a right bundle branch block and superior axis pattern, QRS duration was 110 ms, and tachycardia cycle length (TCL) was 280–290 ms. The tachycardia was terminated by intravenous injection of verapamil (5 mg/3 min). After obtaining written informed consent, a conventional electrophysiologic study was performed without antiarrhythmic drug administration. Electrode catheters were positioned in the left ventricular posterior septum, His bundle, right ventricular midseptum, and coronary sinus (CS). During sinus rhythm, the His–Purkinje interval was 35 ms (Figure 1, left). During ILVT, atrioventricular dissociation was observed, and both the Purkinje potential and the His-bundle potential were recorded (Figure 1). The Purkinje potential was followed by the His potential, and the Purkinje–His interval was 35 ms. The QRS onset–His (V-His) interval during ILVT was 20 ms.

ILVT was induced by S1–S2 stimulation of 260 ms from the His bundle (Figure 2). During basic cycle length of 400 ms, the left posterior Purkinje potential was activated orthodromically through the left posterior fascicle. S2 stimulation captured the His bundle and the local septal ventricular myocardium but could not activate the left posterior Purkinje potential because of refractoriness of the left posterior fascicle. However, S2 stimulation activated slowly conducting septal Purkinje fiber from the His bundle to the left posterior fascicle. Activation of Purkinje fiber returned through either the left posterior fascicle antidromically or the other Purkinje fiber adjacent to the left posterior fascicle to the His bundle, and reentry around ILVT circuit was initiated.

During entrainment from the His1–2, the postpacing interval (PPI) of the His1–2 was 280 ms, which was equal to the TCL of 280 ms (Figure 3). The stimulation to QRS interval of 260 ms was also equal to the His bundle to QRS interval during ILVT. PPI of the basal septal ventricular myocardium at the His-bundle potential recording area was prolonged to 325 ms. During entrainment, the last captured ventricular beats at CS1–2 were the second beat after the stimulus (*), suggesting the orthodromically activated basal left posterior area had long conduction time from the reentrant circuit. After radiofrequency energy delivery to the left posterior fascicular Purkinje potential recording sites, ILVT became noninducible.

These findings suggest that, in the present case, the upper turnaround of the reentry was located at the His-bundle recording site. The retrograde pathway was dependent on either the left posterior fascicle or the adjacent Purkinje fiber and connected to the His bundle and was followed by anterograde slow conduction through the abnormal septal Purkinje fiber to the left posterior fascicle.

Discussion

Previous studies demonstrated that the common exit site of the reentrant circuit of ILVT was confined to the distal left posterior fascicular area.[1–4] They suggested that the reentrant circuit of verapamil-sensitive ventricular tachycardia consisted of slowly conducting anterograde Purkinje fibers and retrograde Purkinje fibers with fast conduction. Nogami et al[2] performed left ventricular septal mapping and found 2 distinct potentials: P1 was a mid-diastolic potential recorded earlier from the proximal rather than the distal electrodes, and P2 was a fused presystolic Purkinje potential

KEYWORDS Ablation; Entrainment; His bundle; Postpacing interval; Purkinje fiber; Reentry

ABBREVIATIONS **CS** = coronary sinus; **ILVT** = idiopathic left ventricular tachycardia; **PPI** = postpacing interval; **TCL** = tachycardia cycle length

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KEY TEACHING POINTS

- The upper turnaround of the reentrant circuit in verapamil-sensitive idiopathic left ventricular tachycardia is located near the His-bundle area.
- Findings during entrainment mapping, including postpacing interval and activation sequence of the last captured beats, could become critical to analyzing the reentrant circuit.
- The retrograde limb of the reentrant circuit of verapamil-sensitive idiopathic left ventricular tachycardia may vary from patient to patient.

recorded earlier from the distal electrodes. The authors showed that P1 represented a critical pathway composed of specialized Purkinje fibers that had decremental properties and verapamil sensitivity. They also demonstrated that P2 consisted of the left posterior fascicle or Purkinje fibers. However, the upper turnaround of the reentrant circuit was not determined.

Morishima et al[5] reported a case with a reentrant circuit consisting of left interventricular myocardium as a retrograde limb. They demonstrated that selective capture of the left posterior fascicle by the sinus beat during tachycardia did not affect TCL. In their case, entrainment from the midseptal site captured both the ventricular myocardium and the left posterior fascicle and only PPI of the ventricular myocardium was equal to TCL. They concluded that the retrograde limb of the circuit was the left ventricular muscle and not the left posterior fascicle. Maeda et al[6] reported another case of left posterior fascicle in a bystander circuit of ILVT. They demonstrated left posterior fascicular block without change in TCL during delivery of radiofrequency energy.

In the present case, PPI of the His potential was equal to TCL during entrainment from the His-bundle region, and PPI of the septal ventricular myocardium at the His bundle was prolonged to 325 ms compared with TCL of 280 ms. Our observations suggested that the His bundle was involved in the reentrant circuit of ILVT, and the retrograde limb of the circuit was not the septal ventricular myocardium.[7–9] To clarify the retrograde pathway, entrainment pacing should be done not only at the left posterior fascicle but also at the adjacent Purkinje fiber and the left ventricular myocardium. Although we could not observe selective capture of the left posterior fascicle by the sinus beat without change in TCL during ILVT, we observed a proximal-to-distal activation sequence of the His bundle during ILVT (Figure 1, arrow). This finding prefers the adjacent Purkinje fiber rather than the left posterior fascicle as the retrograde limb. The

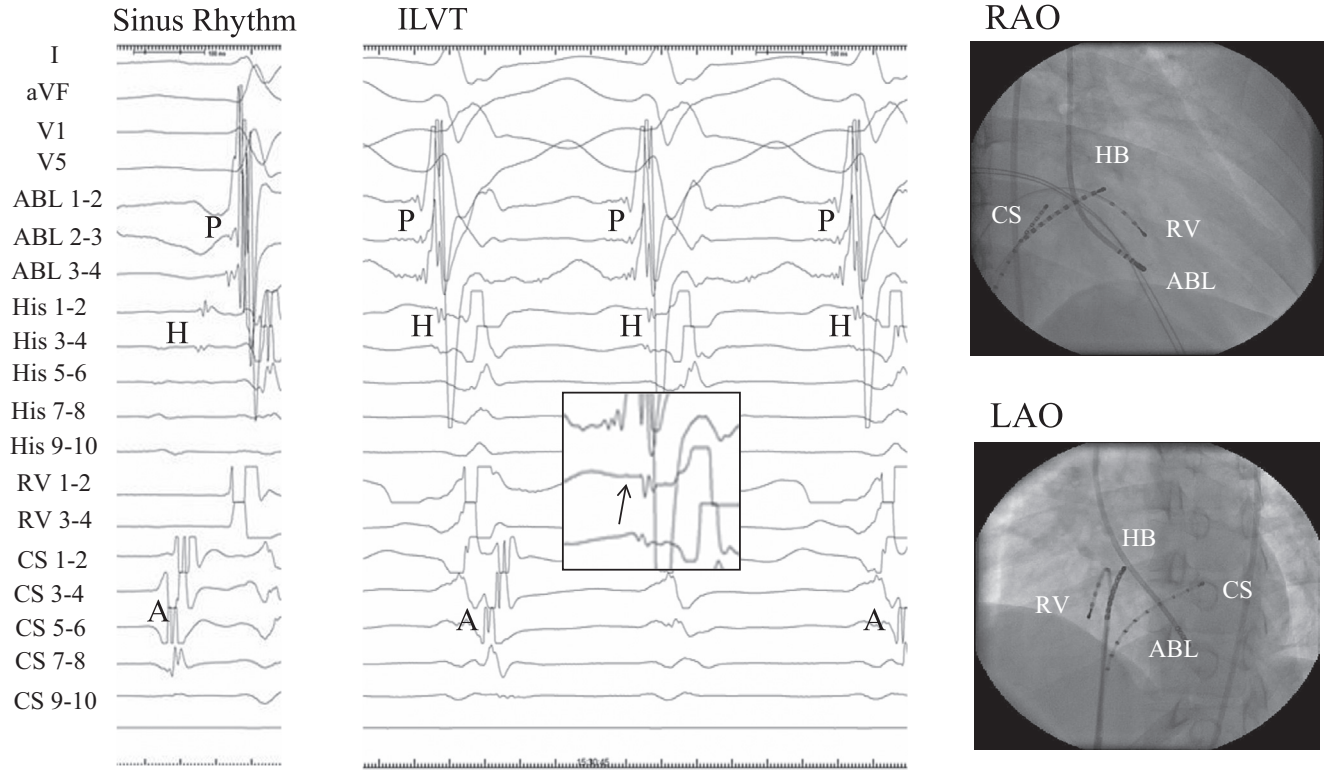

Figure 1 Purkinje and His potentials during sinus rhythm and idiopathic left ventricular tachycardia (ILVT). Simultaneous recordings of surface ECG leads I, aVF, V_1, and V_5, intracardiac recordings from ablation catheter (ABL) at the left posterior fascicular region, recordings from the His-bundle (HB) region, recordings from the midseptal right ventricle (RV), and recordings along the coronary sinus (CS). During sinus rhythm, the His–Purkinje interval was 35 ms. During ILVT, the Purkinje potential followed by the His potential was recorded, and Purkinje–His interval was 35 ms. Note that the activation sequence within the His potentials *(arrow)* was from His3–4 to His1–2, the same sequence during sinus rhythm. A = atrium; H = His; LAO = left anterior oblique view; P = Purkinje; RAO = right anterior oblique view.

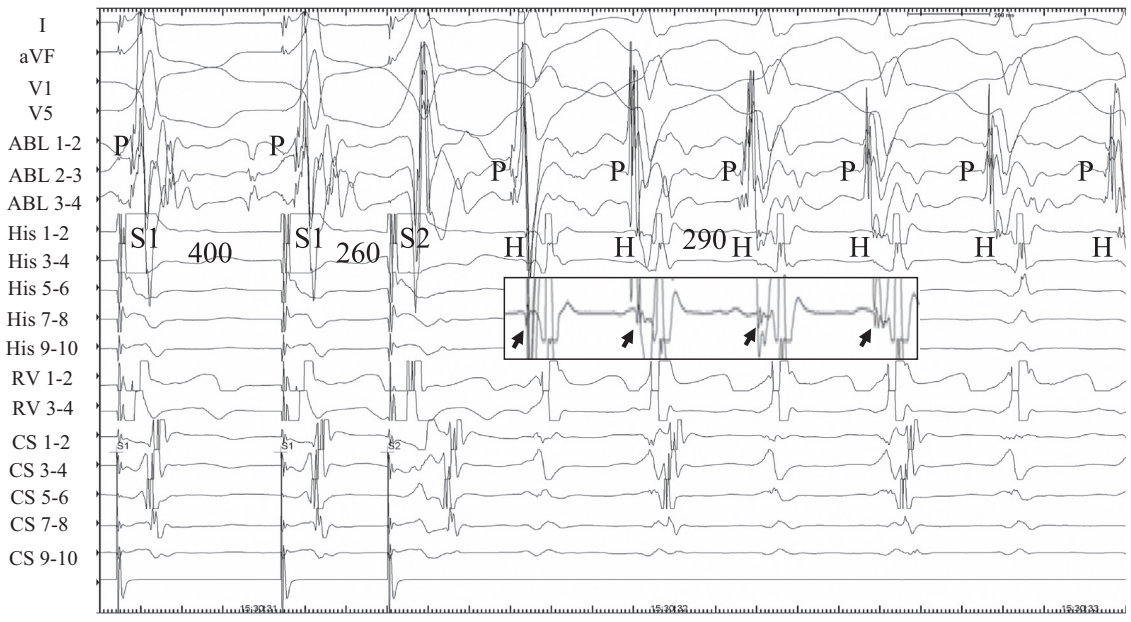

Figure 2 Induction of idiopathic left ventricular tachycardia (ILVT) by S1–S2 stimulation from the His-bundle area. Simultaneous recordings of surface ECG leads I, aVF, V_1, and V_5, intracardiac recordings from ablation catheter (ABL) at the left posterior fascicular region, recordings from the His-bundle (HB) region, recordings from the midseptal right ventricle (RV), and recordings along the coronary sinus (CS). ILVT was induced by S1–S2 stimulation of 260 ms from the His-bundle area. S1stimulation captured the His potential and the local septal ventricular myocardium. The His-bundle excitation conducted to the distal left posterior Purkinje fiber through the left posterior fascicle. S2 stimulation activated the His bundle but could not conduct the left posterior fascicle orthodromically. S2 stimulation activated the Purkinje potential at the left posterior fascicular area through the slowly conducting septal Purkinje fiber and initiated ILVT. *Arrows* within the box indicate His potentials.

anterograde limb was the slowly conducting Purkinje fiber connected to the distal left posterior fascicle. The Purkinje–His interval during ILVT was similar to the His–Purkinje interval during sinus rhythm. This suggested that the retrograde limb of the Purkinje fiber started at the distal area of the left posterior fascicle.

According to a study by Nogami et al,[2] the QRS onset–His (V-His) interval during ILVT ranged from 0 to 59 ms (mean 24 ms). These data suggested that the role of the His bundle for the ILVT circuit may be different depending on the site of upper turnaround. In the present case, the V–His interval during ILVT was 20 ms. The shorter V–His interval

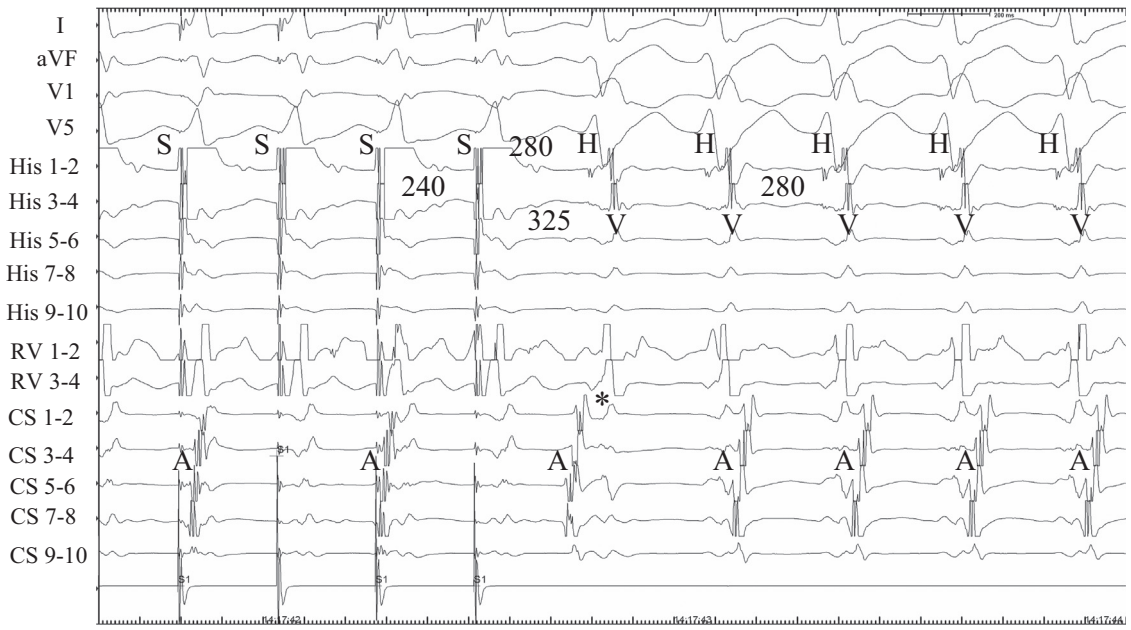

Figure 3 Entrainment from the His bundle. Simultaneous recordings of surface ECG leads I, aVF, V_1, and V_5, intracardiac recordings from the His-bundle region, recordings from the midseptal right ventricle (RV), and recordings along the coronary sinus (CS). The postpacing interval (PPI) of 280 ms was equal to the tachycardia cycle length, and the PPI of septal ventricular myocardium at the His bundle was prolonged to 325 ms. Note that during entrainment from the His bundle, the last captured ventricular beats at CS1–2 were the second beat after the stimulus *(asterisk).* A = atrium; H = His; S = stimulus; V= ventricle.

was compatible with involvement of the adjacent Purkinje fiber along the posterior fascicle in the retrograde limb of the circuit.

This patient may have a reentrant circuit of ILVT consisting of a retrograde fast pathway through the Purkinje fiber adjacent to the left posterior fascicle and an anterograde slow pathway through the septal Purkinje fiber. The upper turnaround of both limbs may be located and connected at the His bundle.

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