Characteristics and proposed meaning of intrinsic intracardiac electrogram morphology observed during the left bundle branch pacing procedure: A case report

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Introduction

Left bundle branch pacing (LBBP) is a novel physiological form of pacing. To successfully perform LBBP, the lead should be screwed in from the right ventricular septum (RVS) to the endocardial side of the left ventricular septum (LVS). Although different changes in unipolar paced QRS morphology during the LBBP procedure have been described,[1] the intrinsic intracardiac electrogram (EGM) morphology during the transseptal procedure has not been investigated. The present report describes a patient who received the LBBP procedure and the various intrinsic intracardiac EGM morphologies observed during the transseptal placement of the pacing lead. The morphology characteristics during lead penetration of ventricular septum (VS) from the right to the left were assessed in order to infer the meaning underlying each EGM morphology.

KEY TEACHING POINTS

- There are 4 types of morphologies for intrinsic intracardiac electrogram presented during lead transseptal procedure of left bundle branch (LBB) pacing.
- Distinct isoelectric interval in intracardiac electrogram indicates selective LBB pacing.
- Small LBB potential may not be a precise criterion to confirm LBB capture.

Case report

A 71-year-old woman presented with symptoms of dizziness over the course of 3 years. Electrocardiogram (ECG) results identified sinus bradycardia. Holter monitoring revealed an average heart rate of 43 beats per minute and 1036 long R-R intervals greater than 2 seconds, with the longest R-R interval of 5.2 seconds. The patient was indicated for permanent DDD pacemaker implantation and LBBP was performed. The pacing lead (Model 3830; SelectSecure, Medtronic, Minneapolis, MN) was successfully implanted, and both paced and intrinsic intracardiac EGM and ECG were continuously recorded while the pacing lead advanced from the RVS to the LVS in the subendocardium, with a unipolar pacing output of 2 V/0.5 ms. The duration of the lead screwing procedure was 117 seconds.

Over the course of the lead screwing procedure, different morphologies of intrinsic intracardiac EGM were identified during lead penetration through the RVS to the LVS, and we classified this into 4 patterns according to the huge change of waveform of adjacent 2 beats (Figure 1). The patterns were as follows: (A) at the beginning of penetration, the morphology of intrinsic intracardiac EGM presented as a biphasic waveform with nearly the same amplitude, which was labeled as RVS; (B) after a slight penetration into the VS, the amplitude of the negative waveform of intrinsic EGM morphology abruptly increased compared to its value in RVS, which was labeled as LVS; (C) upon deeper penetration into the VS, the amplitude of the positive waveform of intrinsic EGM morphology abruptly decreased compared to its value in LVS, and a small LBB potential was first recorded at 83 seconds (start time for lead screwing), which was labeled as endocardial side of the LVS; (D) after even deeper penetration into the VS, the amplitude of the negative waveform of intrinsic EGM morphology abruptly increased compared to its value in the endocardial side of the LVS, with LBB potential becoming bigger and then resulting in injury, which was labeled as the LBB area.

The paced ECG and EGM morphologies in patterns A–D are shown in Figure 2.

KEYWORDS Conduction system pacing; Left bundle branch pacing; Isoelectric interval; Intracardiac electrogram; Left bundle branch potential
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Discussion

The present case report describes 4 types of morphologies for intrinsic intracardiac EGM recorded during lead implantation. The unipolar LBBP lead EGM can accurately show local myocardial electrical activity and its special morphologic characteristics with high sensitivity.[2] Prior studies have demonstrated that myocardial fiber orientation determines the preferential electrical wave propagation, and the fiber orientation is different from right to left side of VS.[3–5] Based on these studies, we speculate the distinct change in morphology of intrinsic intracardiac EGM may indicate that the lead was in different VS locations with different fiber orientations. Therefore, investigating the intrinsic EGM characteristics that occur during lead penetration may help to determine the degree and direction of the lead penetration.

The 4 patterns were labeled as (A): RVS; (B): LVS; (C): endocardial side of the LVS; and (D): LBB area. Paced ECG identified components showing right ventricular excitation, such as notch or late R wave in lead V_1 and S wave in lead V_6, while R-wave peak time (RWPT) in lead V_5 represented the LV excitation. The phenomenon observed from pattern A to pattern D included the notch or late R shifting rightward and then a distinct isoelectric interval in EGM after the RWPT in V_5 abruptly shortened. It was hypothesized that the excitation occurred in the right or left ventricle through the VS myocardium with slow conduction in pattern A to pattern C. As the lead tip reached the endocardial side of the LVS, it took time to reach the RVS. Therefore, the right ventricular excitation occurred later on. After the lead reached the LBB area in pattern D, LV activation was conducted by both VS myocardial and LBB-Purkinje systems, so the RWPT in V_5 shortened abruptly. At the end of lead screwing, the lead reached the LBB, direct VS myocardial capture was absent, and left ventricular (LV) activation over the pacing lead thus occurred late following initial conduction only over the LBB-Purkinje system, such that a distinct isoelectric interval in the pacing lead could be recorded.

LBB potential has been regarded as a sign of LBB capture in prior research.[6] However, in this case, a small LBB potential was first recorded before the V_5 RWPT abruptly shortened. This indicated that the lead could not capture the LBB at the output of 2 V/0.5 ms when a small LBB potential was recorded. With the lead penetrating deeper into the VS adjacent to the LBB, the LBB potential increased and resulted in injury. Therefore, the meaning of LBB potential as a criterion for LBB capture should be reconsidered, and LBB capture may be overestimated in patients with a small LBB potential. Greater LBB potential or current of injury may be a better criterion to confirm LBB capture.

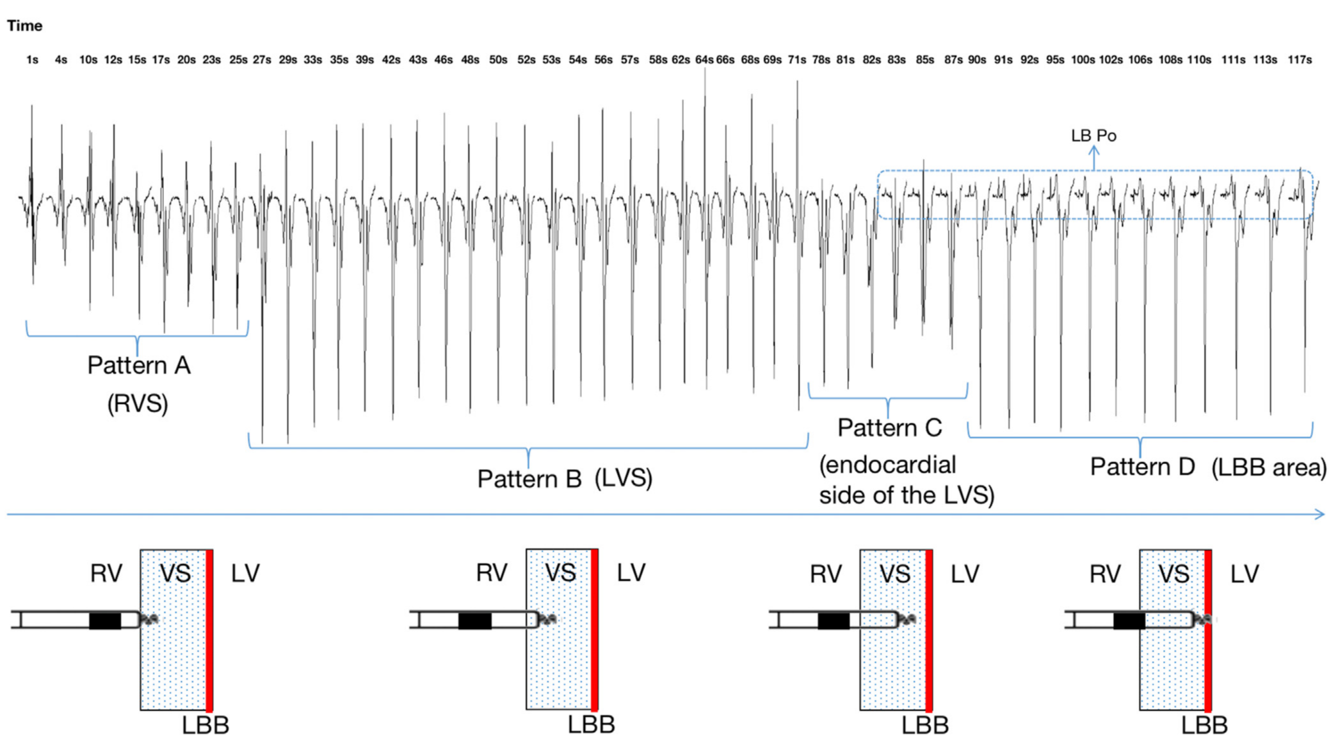

Figure 1 Morphologies of intrinsic intracardiac electrogram (EGM) during lead penetration through right ventricular septum (RVS) to left ventricular septum (LVS) and the following schematic representation of the position of the lead. All of the intrinsic intracardiac EGM that occurred during the lead screwing procedure were presented in picture and the associated occurrence time was marked. Four patterns of morphologies were shown as pattern A, pattern B, pattern C, and pattern D. LB Po = left bundle branch potential; LBB = left bundle branch; LV = left ventricular; RV = right ventricular; VS = ventricular septum.

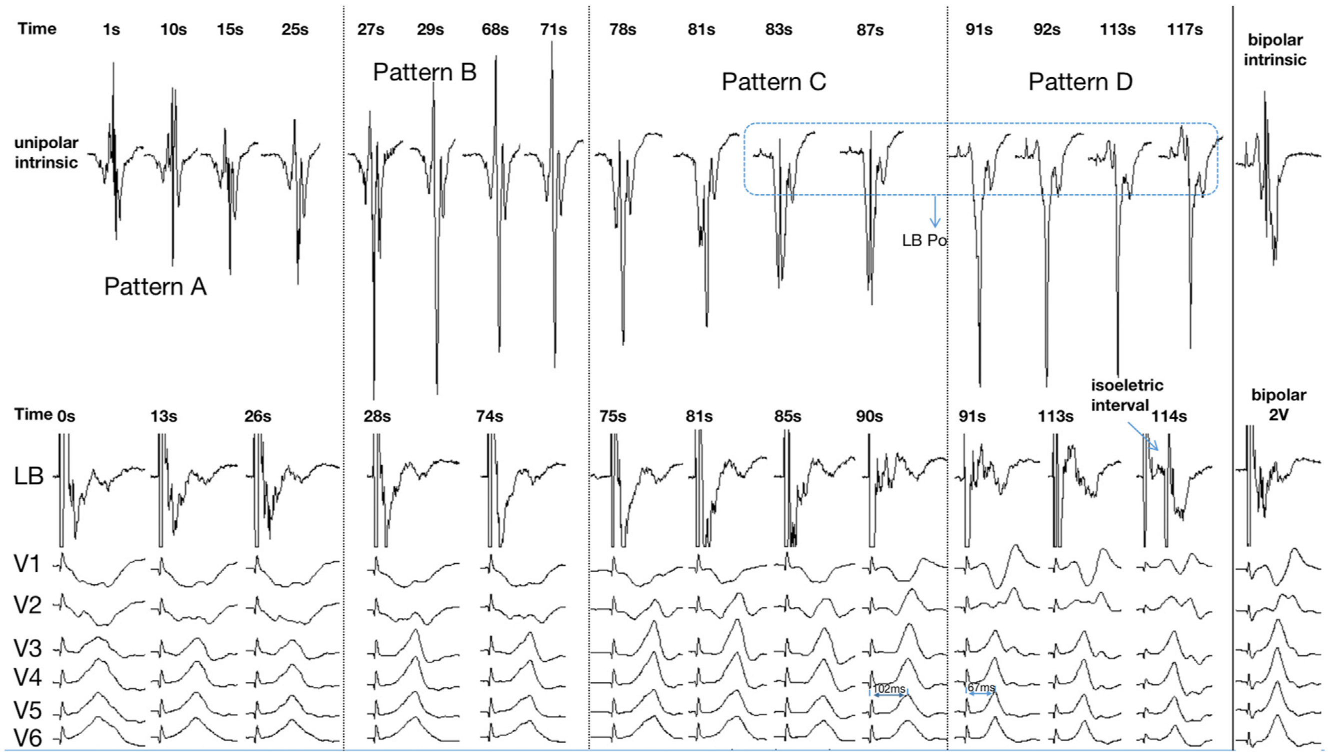

Figure 2 Morphologies of the paced electrocardiogram (ECG) and electrogram (EGM) in patterns A–D. Pattern A: Precordial transition of paced ECG between V_2 and V_3 and classic W pattern with a notch in the middle of the QRS in lead V_1. Pattern B: Transition zone changed to V_2. Pattern C: Transition zone changed to between V_1 and V_2 and notch shifted rightward without a late R wave in V_1. Pattern D: Transition zone changed to lead V_1, rSR pattern was observed just after the appearance of late R wave in V_1, S wave was present in lead V_6, the time from stimulus to R-wave peak time in V_5 suddenly shortened from 102 ms to 67 ms in 91 seconds, and a distinct isoelectric interval in EGM was observed. LB Po = left bundle branch potential.

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