The functional atrioventricular block caused by a premature ventricular beat from His-Purkinje system: Electrophysiological insights in permanent peri–left bundle branch area pacing

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Introduction

Left bundle branch pacing / peri–left bundle branch area pacing (peri-LBBAP) has emerged as a novel pacing strategy in patients with infranodal atrioventricular block (AVB) and left bundle branch block.[1,2] We herein reported an interesting case with high-degree AVB. Electrophysiological studies (EPS) revealed an antegrade functional infra-His block of atrial impulses after a premature ventricular beat from the His-Purkinje system in the presence of a complete right bundle branch block (RBBB) and left anterior fascicular block (LAFB).Thus, peri-LBBAP was successfully and safely performed beyond the conduction of block in the patient. We herein demonstrated the importance of EPS during the procedure of peri-LBBAP in the patient and discuss the possible mechanisms.

KEY TEACHING POINTS

- The atrioventricular block of the patient is not owing to a diseased conduction system but might be caused by a concealed retrograde penetration from the premature ventricular beat, preventing anterograde conduction through the His bundle and resulting in a functional block.
- Electrophysiological studies can be helpful in demonstrating the mechanism of atrioventricular block and targeting the left bundle branch /peri–left bundle branch area for pacing.
- Pacing beyond the site of conduction block in the left bundle branch area by using electrophysiological studies in the future might be helpful for patients' long-term safety.

Case report

A 76-year-old man had intermittent episodes of dizziness for 1 day. Baseline electrocardiogram (ECG) provided by the patient showed RBBB and LAFB with intermittent episodes of high-grade AVB (Supplemental Figure 1). A temporary pacemaker was placed after admission based on his ECG findings (Figure 1). Echocardiography findings revealed left ventricular ejection fraction of 64%. So, a dual-chamber pacemaker implantation was planned for this patient. During the procedure, the implantation was performed with Select Secure pacing leads (model 3830; Medtronic Inc, Minneapolis, MN) and delivery sheaths (models C304 and C315; Medtronic Inc). The pacing of the His bundle (HB) region on fluoroscopic images of right anterior oblique 30° was used as a reference by tricuspid valve annulus angiography (Figure 2A). The tip of the pacing lead was first placed at the His bundle region (Figure 2B). The HB potential was recorded and His-ventricle (HV) interval was noted to be 58 ms (Figure 2C). The HB was captured with an output of 5.0 V/0.5 ms and the pacing stimulus-to-peak left ventricular activation time in lead V_5 was 118 ms, and RBBB could not be recruited in Figure 2C. A significant premature contraction was noted during the procedure, which led to an AVB followed by a temporary cardiac pacing (Figure 2D). The AVB was at the level of the infra-His block and the premature contraction involves a short HV interval, suggesting it as a premature ventricular beat from the His-Purkinje system (Figure 2E). The R-wave sense stimulation was then used, which revealed a similar scenario of AVB with successful recording (Figure 2F). EPS was then performed. The basic stimulation cycle length (S1) of 500 ms was applied at the HB pacing site and the stimulation cycle length was shown to gradually reduce throughout the protocol. The paced QRS morphology

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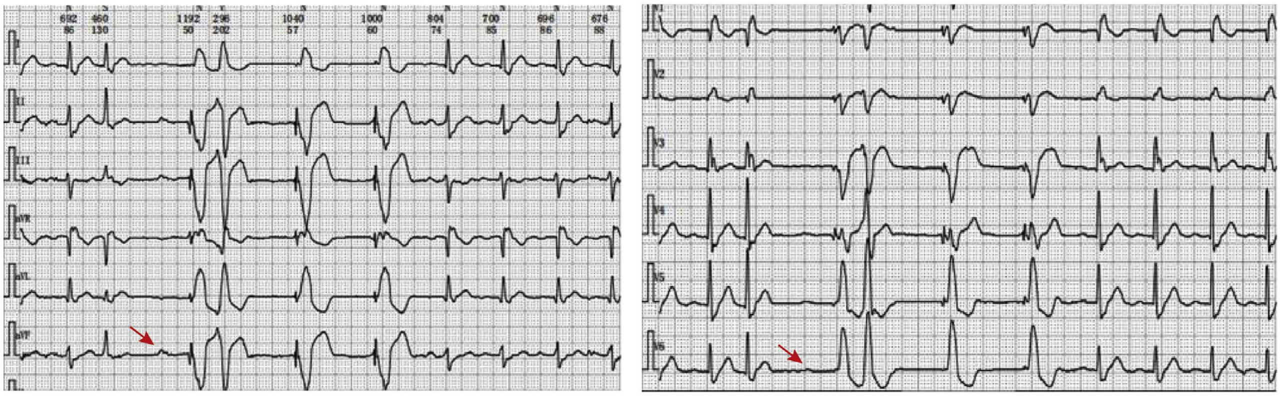

Figure 1 The 24-hour Holter results showing normal sinus rhythm with right bundle branch block and left anterior fascicular block. In addition, a premature beat followed by an atrial impulse was recorded by 24-hour Holter. This atrial impulse cannot propagate down to activate the ventricle and was followed by the temporary right ventricular pacing.

was identified as normal sinus rhythm, which showed a typical selective HB pacing pattern. The refractory period of HB and ventricular beat was found to be less than 270 ms (Figure 2G). The sheath and the lead were subsequently moved into the ventricle toward the right ventricular apex and pace mapping was applied intermittently to identify the mapping position. Unipolar pacing at 5 V/0.5 ms was used to assess the paced QRS morphology. The pacing lead was successfully implanted at the distal end of the His-Purkinje system and was placed deeply in the interventricular septum at the LBB region. A sharp LBB potential was relatively close to the R wave (Figure 3A). Unipolar pacing at this site with an output of 5 V/0.5 ms demonstrated a narrow RBBB morphology (qR wave) pattern in lead V_1 with stimulus-to-peak left ventricular activation time (86 ms) (Figure 3B). The RBBB correction could be achieved by a high pacing output (10 V/0.5 ms) using unipolar pacing (Figure 3B). The pacing parameters were eventually measured, wherein the peri-LBBAP capture threshold was 1.0 V/0.5 ms and the RBBB correction threshold was 1.5 V/0.5 ms (Figure 3C). After that, an implantation of the atrial lead using the C304 sheath was performed. The 12-lead ECG and the

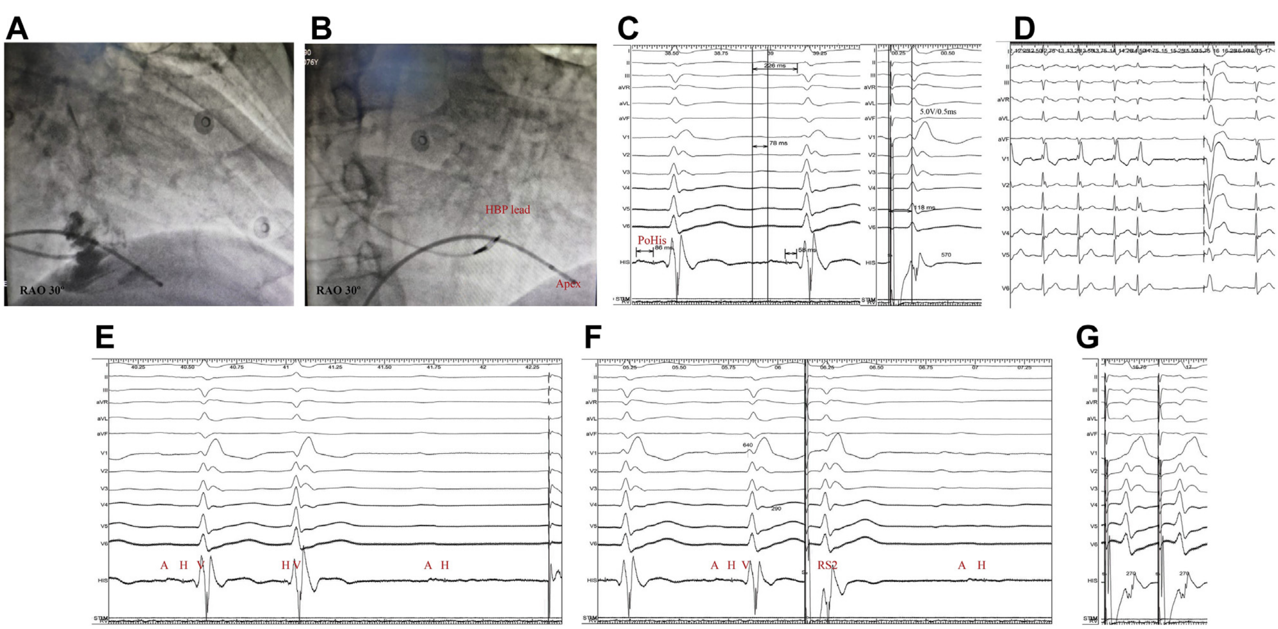

Figure 2 Demonstration of fluoroscopic images of His bundle (HB) area lead location. Electrocardiogram (ECG) and intracardiac electrograms (IEGM) from His bundle pacing (HBP) are shown. **A,B:** Right anterior oblique (RAO) 30° fluoroscopic view demonstrated the location of the tip electrode by tricuspid valve annulus angiography. **C:** HB potential was recorded on IEGM. The intrinsic ECG showed a prolonged PR interval of 226 ms in the setting of right bundle branch block (RBBB) and left anterior fascicular block (LAFB) with an HV interval of 58 ms. Pacing on this site at 5.0 V/0.5 ms showed a similar QRS morphology as an intrinsic rhythm with RBBB and LAFB, and the pacing stimulus-to-peak left ventricular activation time was 118 ms during selective HBP. **D:** Twelve-lead ECG was used to record in an electrophysiology recording system (BARD ELECTROPHYSIOLOGY LabSystem PRO v2.4a; Boston Scientific USA, Marlborough, MA) during the procedure. **E:** His electrograms with AH interval and HV interval. A premature ventricular beat from the His-Purkinje system resulted in infra-His block. **F:** R-wave sense stimulation can also lead to the same result with infra-His block. **G:** His pacing at incremental rates (270 ms) could propagate down to activate the ventricle.

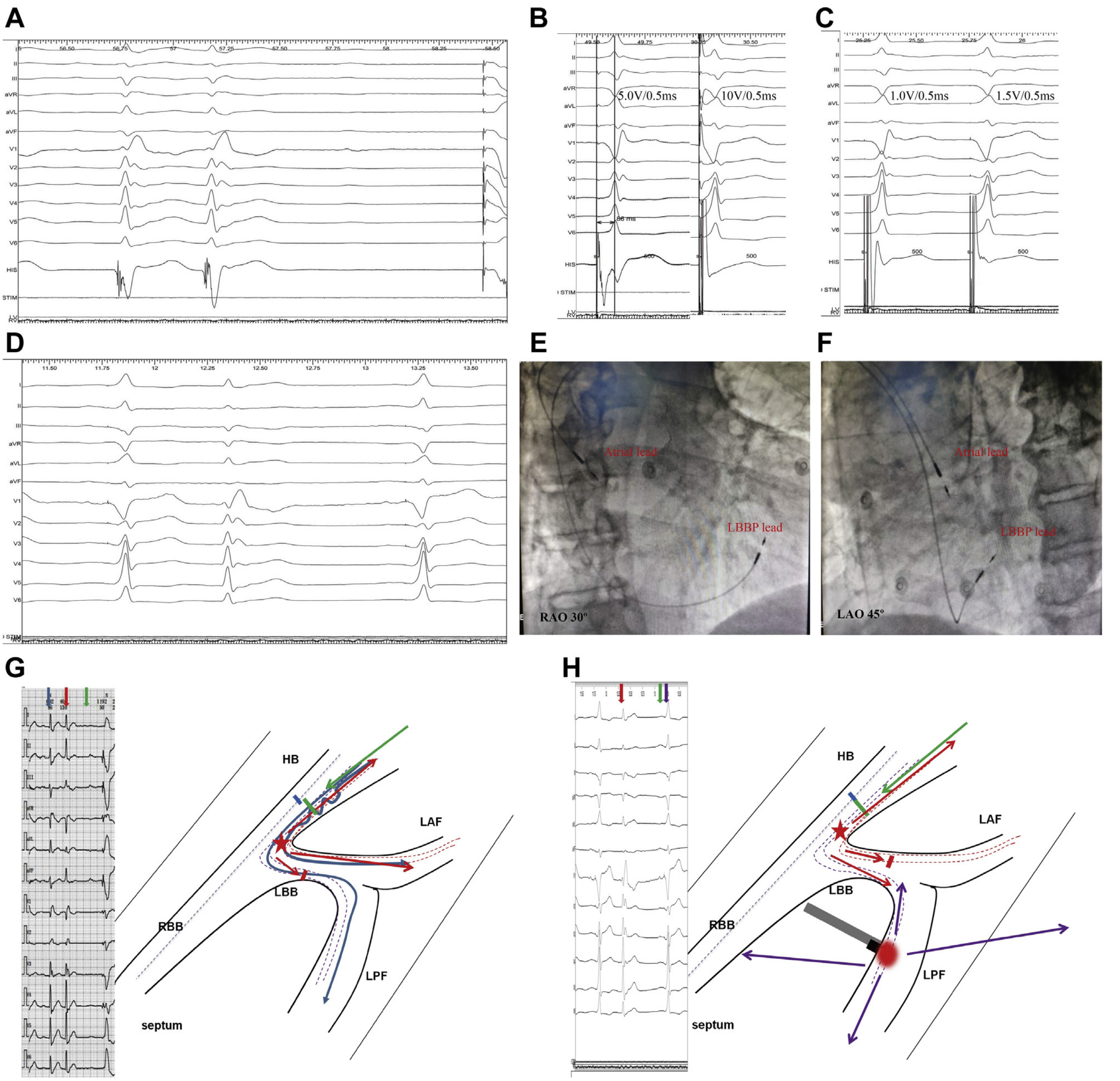

Figure 3 Electrocardiogram (ECG) and intracardiac electrograms from left bundle branch pacing (LBBP) leads of the patient and schematic representation of the underlying mechanism. **A:** The last panel of the intracardiac electrograms and ECG presents the intracardiac tracings during the procedure and recordings of the larger sharp distal Purkinje potentials. **B:** Unipolar pacing at 5 V/0.5 ms at this site resulted in narrowing of the QRS and stimulus-to-peak left ventricular activation time of 86 ms, in which the right bundle branch block (RBBB) was corrected by selective LBBP at a high output of 10 V/0.5 ms. **C:** During final fixation, unipolar pacing at 1.0 V/0.5 ms resulted in the same QRS morphology in lead V_1 and bipolar pacing at 1.5 V/0.5 ms at this site recruited RBBB. **D:** ECG was used to record after the procedure. **E,F:** The locations of the tip electrodes at peri–left bundle branch bundle area and atrial septum with right anterior oblique (RAO) 30° and left anterior oblique (LAO) 45° views. **G,H:** Schematic representation of cardiac conduction system. Blue line represents sinus rhythm; green line represents atrial impulse; red line represents activation propagation of premature contraction; and purple line represents LBBP lead location and activation. HB = His bundle; LAF = left anterior fasciculus; LBB = left bundle branch; LPF = left posterior fasciculus; RBB = right bundle branch.

fluoroscopic views of atrial lead and peri-LBBAP lead after the procedure are presented in Figure 3D–F.

Discussion

In this case, an antegrade functional infra-His block of atrial impulses due to a premature ventricular beat of the His-Purkinje system in the presence of a complete RBBB and LAFB was presented. The potential explanation for this phenomenon is that it is due to a functional block, which means that there is a repetitive concealed retrograde penetration of the His bundle.[3] During RBBB, the premature impulse from the His-Purkinje system revealed left anterior fasciculus or left posterior fasciculus in refractory period and propagated down the other fascicle, activating the left ventricle, traversing across the interventricular septum, activating the right ventricle, penetrating in a retrograde fashion into the His bundle at the same time, and resulting in a functional His bundle block. The subsequent antegrade impulse does not propagate down to the His bundle, and this demonstrated that the atrial beat was blocked in the His bundle, followed by a long interval. The schematic representation is shown in Figure 3G and H. However, there are several limitations in this report that should be acknowledged. Firstly, atrial stimulation cannot be performed, and therefore we could not demonstrate whether atrial premature beats can result in functional block of the His bundle. Secondly, the ventricular premature beat resulted in functional block in the His bundle but the range of block cannot be defined, although the Purkinje potential was recorded. Fortunately, some EPS was performed for this patient, and permanent peri-LBBAP was considered successful by overcoming bundle branch functional block. Additionally, the pacing parameters including capture threshold, R-wave amplitude, and lead impedance that were collected from the time of implantation and at each follow-up visit until 9 months after implantation remained stable and satisfactory.

The case presented here added the evidence with regard to the feasibility of left bundle branch pacing /peri-LBBAP, providing a viable alternative in patients with disease conduction that is not corrected by HB pacing. It is warranted for us to identify the mechanism of AVB by using EPS in the future, which might be very meaningful for patients' long-term safety.

Acknowledgments

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Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2020.06.001.

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