Recruitment of Complete Right Bundle Branch Block by Permanent Para-Hisian Pacing

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Summary

His-bundle pacing has recently emerged as a means to maintain a physiological ventricular activation and eliminate the risk of pacing-induced myopathy associated with traditional right ventricular pacing. With His-bundle pacing, the exact stimulated structure and resulting excitation wavefront may be highly dependent on the pacing output, dimensions of the stimulatory electrodes, and orientation of the cathode and anode relative to the approximated conduction tissue and surrounding myocardium, owing to the juxtaposition of tissues with very different conduction properties. We herein present an 89-year-old woman with an infra-Hisian conduction disease in whom lower output pacing resulted in pure His-bundle pacing, and higher output pacing resulted in para-Hisian pacing that recruited diseased portions of the conduction system, narrowing the QRS complex.

Key words: His-bundle pacing

The deleterious effects on the left ventricular function by chronic right ventricular pacing have been shown in numerous studies. This is because non-physiological, slow myocardial activation results in a dyssynchronous contraction with a delayed lateral left ventricular motion as compared to the interventricular septum. Cardiac resynchronization therapy was developed to overcome this issue by left ventricular pacing via a pacing lead placed in the coronary venous system, which has been shown to improve the rates of heart failure events and mortality. However, the optimal lead location and anatomic limitations of consistently placing the lead at the most beneficial site, limit the utility of cardiac resynchronization therapy. Recently, His-bundle pacing has emerged as a means of restoring normal myocardial activation. Theoretically, pacing the native conduction system enables a more physiological ventricular activation and the clinical benefit is expected. Here, we describe a case in which a native complete bundle branch block (BBB) was recruited by permanent para-Hisian pacing.

Case Report

An 89-year-old woman was transferred to our hospital due to symptomatic sinus node dysfunction. She had no past medical history except for senile dementia of an Alzheimer type. The electrocardiogram on admission exhibited sinus rhythm with complete right BBB, and the heart rate was 32 beat per minute. The transthoracic echocardiography revealed a normal ventricular function without any significant abnormalities. Following an isoproterenol infusion to increase her heart rate, she underwent a permanent dual chamber pacemaker (Advisa DR, Medtronic Inc., Minneapolis, MN, USA) implantation.

During the procedure, a quadripolar catheter was initially placed to map the His-bundle area. The baseline His-ventricular (HV) interval was 54 ms (Figure 1A). Subsequently, a Select Secure lead (model 3830, Medtronic Inc.) was delivered through a fixed curve sheath (C 315 HIS, Medtronic Inc.) to the site where a clear His-bundle potential was recorded on the mapping catheter. Figure 1B demonstrates the fluoroscopic location of the His-bundle pacing lead in the right anterior oblique and left anterior oblique projections. Lower output pacing from the lead (1.4 V, 1.0 ms) resulted in a wide QRS complex with complete right BBB, similar to the QRS morphologies as normally conducted beats with the same stimulus-to-QRS interval as the native HV intervals (54 ms), suggesting pure His-bundle pacing (Figures 1A, 2). Higher output pacing resulted in para-Hisian capture, evidenced by a 136 ms narrow QRS duration and the presence of a slurred upstroke indicating local myocardial capture (Figure 2). The threshold of the para-Hisian capture was 2.5 V at 1.0 ms. She was discharged without any complications after a successful pacemaker implantation (pacing mode: DDD 60-130 bpm, sense AV delay: 80 ms, pace AV delay: 100 ms, RA sensing 0.3 mV + auto capture managing on, RV sensing 0.9mV + auto capture managing off, RA output 2.5 V × 0.4 ms, RV output 4.0 V × 1.0 ms).
Figure 1. A: Intracardiac recordings from a mapping catheter placed in the His-bundle region and an implanted lead during sinus rhythm (left) and pacing from the lead (right). Note that the stimulus-to-QRS interval during low output pacing equals the native HV interval (54 ms). B: The position of the pacing lead on fluoroscopy. HIS indicates His-bundle; R (L) AO, right (left) anterior oblique view; RV, right ventricle; and Stim., stimulation.

Figure 2. A: Baseline electrograms during sinus rhythm and atrial pacing showing complete right BBB. B: Low output pacing from the lead captured the conduction system selectively with an identical QRS duration and QRS morphology resembling the native conduction (pure His-bundle pacing). An isoelectric interval was noted after the pacing. C: Higher output pacing from the lead recruited the blocked right bundle, resulting in a narrowing of the QRS complex (para-Hisian pacing). Note that the stimulus-to-QRS is simultaneous due to local myocardial capture.
Discussion

The human cardiac conduction system is suited to deliver coordinated electrical impulses resulting in synchronous and mechanically efficient ventricular myocardial contractions. Direct His-bundle pacing maintains a physiological ventricular activation, eliminating the risk of pacing-induced myopathy associated with traditional right ventricular apical pacing. The implantation technique of a pacing lead in the His region has evolved as implantation tools specifically designed for selective site pacing, consisting of steerable sheaths and newer leads, have become available. The results of the prior studies have suggested that permanent His-bundle pacing is feasible and safe, and that the risk associated with this procedure is not greater than that of conventional right ventricular pacing. Moreover, various small and larger studies have demonstrated the clinical benefit of His-bundle pacing versus conventional right ventricular pacing with the preservation of the left ventricular ejection fraction, decreased heart failure hospitalizations, and an improvement in the quality-of-life and NYHA functional class.

The His-bundle is a chord-like structure that traverses from the compact AV node through the membranous interventricular septum and measures an average of 20 mm in length by 4 mm in diameter. Because of the close proximity of tissues with very different conduction properties, permanent His-bundle pacing can result in different paced QRS morphologies depending on the output of the pacing, position of the His lead, and anatomy of the His-bundle region in each individual patient. Selective His-bundle pacing is the term used when there is fusion and a para-Hisian morphology with high output pacing and pure His-bundle pacing at lower outputs. If the lead tip is anchored to the His-bundle, at high output, the surrounding myocardial fibers are also recruited along with the His-bundle resulting in fusion. At low outputs, the current density is low enough that the His-bundle is preferentially recruited, resulting in pure His-bundle pacing.

In the present case, lower output pacing resulted in pure His-bundle pacing and higher output pacing resulted in para-Hisian pacing characterized by the presence of a slurred upstroke after the stimulus artifact. The area of myocardial capture is represented by a slurring in the QRS prior to capture of the His-Purkinje system. The postulated mechanism for the recruitment of the specialized conduction system in patients with BBB is longitudinal dissociation in the His-bundle with pacing distal to the site of block or neighboring myocardium. Narula, et al. first described the concept of longitudinal dissociation in the His-bundle and postulated that BBB could be due to a delay within the fibers in the His-bundle that are predestined to become either right or left BBB, and that pacing distal to the site of a conduction delay could recruit fibers predestined to become the bundle branches and thereby narrowing the QRS duration. In patients with a very proximal BBB, stimulation by pacing electrodes that capture bundles distal to the level of the block may normalize the QRS and overcome any infra-Hisian abnormalities. Other mechanisms, including differential source-sink relationships during pacing versus intrinsic impulse propagation, and/or a virtual electrode polarization effect, were also proposed. The advantages of His-bundle pacing in overcoming an intraventricular conduction delay are expected and should be further explored.

The limitations of permanent His-bundle pacing are the inability to implant the lead on the His-bundle in 10-20% of the patients, lack of available randomized large scale data to justify the use of His-bundle pacing in all cases, progressive conduction disease distal to the paced site, possibility of a pacing threshold elevation during the chronic phase, and battery longevity wherein the average capture thresholds tend to be higher than routine right ventricular pacing due to the surrounding fibrous tissue around the His-bundle. A randomized study comparing permanent His-bundle pacing to biventricular pacing is ongoing to clarify the further advantages of permanent His-bundle pacing. There also needs to be technical advances in developing better delivery systems to allow for His-bundle mapping and the delivery of pace/sense leads in patients with a challenging cardiac anatomy.

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Disclosures

Conflicts of interest: None.

References

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