Subvalvular His bundle pacing for pseudo-pacemaker syndrome and mitral regurgitation

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Introduction
Pseudo-pacemaker syndrome due to a prolonged PR interval is a recognized entity that can lead to poor exercise tolerance related to atrioventricular (AV) dyssynchrony. This can manifest echocardiographically with diastolic mitral regurgitation (MR). Implantation of a dual-chamber pacemaker with shorter programmed AV delay may improve AV synchrony, symptoms, and exercise tolerance. Traditionally, a dual-chamber pacemaker with a right atrial lead and right ventricular (RV) lead has been used; however, RV pacing causes interventricular dyssynchrony and, over the long term, can cause pacing-induced cardiomyopathy. His bundle pacing (HBP) more closely mimics physiological AV conduction, but HBP is sometimes limited because of the lower success rate and higher mean thresholds and may often require longer pulse widths in comparison to RV pacing. The reported success rate for HBP is in the range of 80%–90% in clinical trials, with a mean threshold of 1.2–2.0 V. We present an interesting case of a patient with a markedly prolonged PR interval after AV nodal reentrant tachycardia ablation leading to AV dyssynchrony, diastolic MR, and exercise intolerance who was treated with subvalvular HBP with excellent pacing thresholds and improved exercise tolerance.

Case report
A 67-year-old man with a remote history of AV nodal reentrant tachycardia postablation presented to our clinic with poor exercise tolerance. He was noted to have a first-degree AV block with a PR interval of 600 ms (Figure 1A). He underwent a graded exercise stress test, and his exercise was limited by fatigue. The patient’s symptoms were likely related to poor AV synchrony, especially during exercise, from his marked first-degree AV block. A transthoracic echocardiogram was obtained, which showed diastolic MR (Figures 2A and B). The patient’s diastolic MR was likely from his prolonged PR interval leading to AV dyssynchrony and incomplete closure of the mitral valve. The patient was brought to the electrophysiology laboratory, and an electrophysiology study was performed. The electrophysiology study showed a prolonged AV Wenckebach cycle length of 820 ms, an AH interval of 653 ms, and an HV interval of 52 ms. Given that the patient’s symptoms were consistent with pseudo-pacemaker syndrome due to poor AV nodal conduction, HBP was chosen to restore AV synchrony and reduce interventricular dyssynchrony in comparison to RV apical pacing. As the patient would be treated with ventricular pacing 100% of the time to improve his AV synchrony, HBP was decided upon. The His bundle lead was placed in the standard fashion (Figure 3A), but instead of placing the lead on the atrial aspect where the thresholds for selective His capture were higher, it was placed in the membranous septum just below the tricuspid valve. This position was confirmed by echocardiography (Figure 3B and Supplemental Video 1), which also showed a significant improvement in his diastolic MR (Figures 2C and D). The acute threshold in this location was 1.0 V at 0.4 ms with His bundle capture (Figure 1B). A right atrial lead was placed for sensing the native atrial rhythm, and an RV lead was placed as a backup lead because the stability and long-term threshold of the subvalvular HBP position are unknown. A cardiac resynchronization therapy–pacemaker pulse generator was used, and the device was programmed DDD with subthreshold RV lead output to ensure only HBP. A computed tomography scan was obtained, which confirmed the subvalvular HBP position (Figures 3C and D). The patient had a significant improvement in exercise tolerance and resolution of symptoms. At 3-month clinic follow-up, his HBP thresholds improved to 0.25 V at 0.4 ms.

Discussion
Patients with a markedly prolonged PR interval can have decreased exercise tolerance owing to pseudo-pacemaker syndrome. A dual-chamber pacemaker has been traditionally...
implanted in these patients to improve AV synchrony with improvement in exercise tolerance. With the deleterious effect of RV pacing,5,6 HBP provides physiological activation of both ventricles by recruiting the conduction system, which has obvious advantages. We describe a case of pseudo-pacemaker syndrome due to a markedly prolonged PR interval that improved with subvalvular HBP. Subvalvular HBP has previously been described as a viable option.8 In these cases, the lead is located in the membranous septum accessed from the ventricle. A backup RV lead can be considered, as the long-term thresholds of the subvalvular His lead are unknown, but this may come at an increased risk of lead-induced tricuspid regurgitation.

This case provides several interesting teaching points. First, patients with a prolonged PR interval and decreased exercise tolerance should be considered in patients with a prolonged PR interval.

His bundle pacing should be considered in patients with pseudo-pacemaker syndrome, as it restores atrioventricular synchrony while maintaining interventricular synchrony.

If supravalvular His bundle pacing capture thresholds are high, then one should consider placing the His lead subvalvularly.

Figure 1  A: Pre-HBP implant echocardiogram showing a markedly prolonged PR interval (arrows showing P waves). B: Post-HBP implant echocardiogram showing normalization of the PR interval with a close-up lead V1 showing a stimulus to QRS of ~ 45 ms (red arrow showing an interval), which is similar to the HV interval of 52 ms seen during the electrophysiology study. HBP = His bundle pacing.
Figure 2  Pre-HBP implant transthoracic echocardiogram showing diastolic mitral regurgitation with (A) color Doppler and (B) continuous wave Doppler. Post-HBP implant transthoracic echocardiogram showing resolution of diastolic mitral regurgitation with (C) color Doppler and (D) continuous wave Doppler. HBP = His bundle pacing.

Figure 3  A: Post-HBP implant chest radiograph showing RA lead, His bundle lead, and RV lead. B: Post-HBP implant transthoracic echocardiogram showing a His bundle lead in the subvalvular position. C, D: Post-HPB implant computed tomography scans showing a His bundle lead in the subvalvular position. AV = atrioventricular; HBP = His bundle pacing; RA = right atrial; RCA = right coronary artery; RV = right ventricular.
exercise tolerance should be carefully evaluated for AV dysynchrony as the cause of their symptoms. Second, HBP should be the preferred mode of pacing in these patients, as it not only restores AV synchrony like dual-chamber pacing but also maintains interventricular synchrony, which may further improve diastolic MR as seen in this case and can prevent pacing-induced cardiomyopathy. Third, although the anatomical location of the His bundle lead is atrial in most cases, it is possible to achieve HBP from the ventricular aspect as seen in this case. His bundle electrograms can be recorded with a mapping catheter over a length of 7–9 mm. In case high pacing thresholds are encountered proximally, targeting a slightly more distal His bundle electrogram may provide better stability and thresholds in a subvalvular location. Further data on the long-term lead performance in this location are needed.

**Conclusion**

HBP is an effective way to manage pseudo-pacemaker syndrome due to a prolonged PR interval as it provides AV synchrony while maintaining interventricular synchrony. It is possible to achieve HBP from subvalvular location with excellent stability and thresholds.

### Appendix

**Supplementary data**

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2018.06.008.

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