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Electrophysiologic Insights Into Site of Atrioventricular Block

Lessons From Permanent His Bundle Pacing

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ABSTRACT

OBJECTIVES This study sought to report the feasibility of permanent His bundle pacing (HBP) in patients with advanced atrioventricular block (AVB) and electrophysiological observations into site of block in patients with infranodal AVB.

BACKGROUND HBP is a physiological alternative to right ventricular pacing. Historic studies have reported a low incidence of intra-His AVB. Recent studies of permanent HBP reported limited success in patients with infranodal AVB.

METHODS Consecutive patients with advanced AVB underwent permanent HBP using Medtronic 3830 lead (Minneapolis, Minnesota) and a fixed-shaped catheter (C315 His). The HB was mapped using unipolar recording from the lead tip or by pace mapping. Success of HBP, type of AVB, and pacing outcomes were documented. Patients were followed at 2 weeks, 2 months, and then yearly.

RESULTS A total of 100 patients with advanced AVB (age 75 ± 12 years; male 62%; AV nodal 46%; infranodal 54%) underwent permanent HBP. HBP was successful in 84 patients (84%; AV nodal 93%, infranodal 76%). Mean procedure time was 71 ± 21 min, mean fluoroscopy time was 11 ± 6 min. Baseline QRS duration was 122 ± 27 ms; paced QRSd was 124 ± 22 ms. The HB pacing threshold at implant, 2 weeks, 2 months, and last follow-up (19 ± 12 months; range: 6 to 46 months) was 1.3 ± 0.9 V, 1.6 ± 1.0 V, 1.6 ± 1.1 V, and 1.7 ± 1.0 V at 0.5 ms, respectively. Five patients required lead revision.

CONCLUSIONS Permanent HBP was successful in 84% of unselected patients with AVB. His-Purkinje conduction could be normalized in 76% of patients with infranodal block, suggesting intra-His block. Incidence of infra-His AVB was low (24%) in this series. Routine HBP in patients with AVB is feasible and safe for at least up to 18 months.
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The right ventricular (RV) apex is the most commonly used site for ventricular pacing in patients with atrioventricular (AV) conduction disease and bradycardia. RV apical pacing has been associated with ventricular dyssynchrony, reduction in left ventricular (LV) ejection fraction, and adverse clinical outcomes (1-5). RV outflow tract and septum have been used as alternative sites without proven clinical benefit (6-8). Cardiac resynchronization therapy has been proposed as an alternative to RV pacing in patients with heart block and heart failure (9).

After the original description of permanent His bundle pacing (HBP) by Deshmukh et al. (10) in 2000, there have been multiple reports on permanent HBP demonstrating its feasibility (11-16). Permanent HBP has been successfully performed in patients with AV block (AVB) and preserved His-Purkinje conduction, but the success rates have varied from 52% to 84% (10,15-18). Interestingly, HBP can also correct

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ABBREVIATIONS AND ACRONYMS

AV = atrioventricular

AVB = atrioventricular block

HB = His bundle

HBP = His bundle pacing

NS-HBP = nonselective His bundle pacing

RV = right ventricle

S-HBP = selective His bundle pacing

infranodal conduction disturbances (17). However, the success rates of permanent HBP in patients with infranodal AVB have been reported to be very low (19,20). Early studies using His bundle (HB) recordings have suggested that intra-His block contributes only 15% to 20% of patients with infranodal AVB (20–23). More than 70% of infranodal AVB has been attributed to infra-His (distal to the HB) block. We recently reported the feasibility and clinical outcomes of permanent HBP compared with RV pacing (16). During this study, we unexpectedly observed a higher degree of success in patients with infranodal AVB than previously reported. The aim of our single-center, observational study was to report the success rates and outcomes of permanent HBP in consecutive patients with advanced AVB, especially in patients with infranodal block.

METHODS

PATIENT SELECTION. From January 2011 to June 2014, all patients referred for pacemaker implantation routinely underwent an attempt at permanent HBP at Geisinger Wyoming Valley Medical Center by 2 experienced operators (P.V., G.D.). Patients undergoing device implantation for cardiac resynchronization therapy, pulse generator changes, sinus node dysfunction, and first- or second-degree AVB were excluded from the study. Patients who met the following criteria were included in the study: 1) complete AVB; 2) advanced AVB with 2:1 or greater (3:1) AV conduction ratio; and 3) AV node ablation. This retrospective study was approved by our institutional review board.

HB PACING. HBP was performed using the Select Secure (Model number 3830, 69 cm, Medtronic Inc., Minneapolis, Minnesota) pacing lead delivered through a fixed-curve sheath (C315 His, Medtronic Inc.), as previously described (15,16). The delivery sheath was inserted into the RV, just beyond the tricuspid annulus. Subsequently, the pacing lead was advanced through the sheath such that only the distal electrode/screw was beyond the tip of the catheter. A unipolar electrogram was recorded from the lead tip at a gain setting of 0.05 mV/mm and displayed on Medtronic Pacing System Analyzer (model number 2290) at a sweep speed of 50 mm/s. HB electrogram was identified by mapping the AV septum. The lead was then screwed into position with 4 or 5 clockwise rotations. HB capture threshold was assessed and accepted if found to be <2.5 V at 1.0 ms and only if 1:1 His-ventricular conduction at a minimum of 120 bpm was demonstrable during pacing. If acceptable HB capture could not be achieved after 5 attempts at lead positioning or fluoroscopy duration of <20 min, the lead was then placed in the mid-RV septum. When the HB electrogram was not recordable during mapping, pacing was performed in unipolar fashion to identify the successful site. During implantation, attempts were made to obtain selective His bundle pacing (S-HBP) in patients with AV nodal block, but if HBP with fusion (nonselective His bundle pacing [NS-HBP]) was obtained, this position was accepted. If the patient had infranodal AVB, NS-HBP was preferred to ensure local RV myocardial capture in addition to HB capture. A mapping catheter to locate the HB and a backup RV pacing lead was not routinely used in these implants. In patients undergoing AV node ablation, biventricular pacing using a LV lead in addition to the HBP lead was performed in patients with reduced LV ejection fraction.

DEFINITIONS. S-HBP was defined based on the criteria published by Williams et al. (24) as evidenced by ventricular activation occurring solely over the His-Purkinje system. These included: 1) His-Purkinje-mediated cardiac activation and repolarization as evidenced by electrocardiographic concordance of QRS and T wave complexes; and 2) the paced ventricular interval was almost identical to the His-ventricular interval (**Figure 1**).

NS-HBP was defined based on capture of basal ventricular septum in addition to HB capture as: 1) no isoelectric interval between pacing stimulus and QRS; 2) the electrical axis of the paced QRS must be concordant with the electrical axis of the spontaneous QRS (if known); and 3) narrowing of QRS with higher output. Paced QRS complexes may be narrower than the escape rhythm or the conducted beats (**Figure 2**).

HB and ventricular (myocardial) pacing thresholds, R-wave amplitudes, intracardiac electrograms, and pacing lead impedances were measured at implantation. Total fluoroscopy time and procedure duration for each patient were recorded. A 12-lead electrocardiogram at baseline and during HBP, along with baseline and paced QRS duration, were also recorded for each patient.

FOLLOW-UP. Patients were followed in the device clinic at 2 weeks, 2 months, 1 year, and yearly thereafter. R-wave amplitudes, pacing thresholds, and lead impedances were recorded at each visit. Patients were also followed by remote monitoring every 3 months. Any significant increases in pacing