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Electrophysiological observations of acute His bundle injury during permanent His bundle pacing☆,☆☆,★

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Abstract

Background: Permanent His bundle pacing (HBP) is a physiological alternative to right ventricular pacing (RVP). Catheter manipulation during HBP can cause trauma to the His bundle during implantation. We sought to determine acute and long-term incidence of His bundle (HB) injury with HBP.

Methods: Patients undergoing permanent HBP at Geisinger Wyoming Valley Medical Center from 2006 to 2014 formed the study group. Patients with pre-existing His-Purkinje disease (HPD) were excluded from the study. Any development of new bundle branch block (BBB) or AV block (B) during acute HBP lead-induced block was recorded. Resolution of AVB and/or BBB was documented.

Results: HBP was attempted in 450 patients. In 358 patients without HPD, 28 (7.8%) developed acute HB injury in the form of complete AVB (4, 1.1%), RBBB (21, 5.9%) or LBBB (3, 0.8%) during HBP lead placement. In all 7 patients with AVB or LBBB, conduction completely recovered. The HB electrogram from the lead displayed injury current in all 7 patients. Lead-induced RBBB resolved in 12 of 21 patients and persisted in 9 (2.5%) patients. Pacing from the HBP lead resulted in correction of acute conduction block in 27 of 28 patients and 8 of 9 patients with chronic RBBB. None of the patients with transient conduction block developed new conduction disease during follow-up of 21 ± 19 months.

Conclusions: Despite acute trauma to HB in 7.8% of patients undergoing permanent HBP, complete resolution of conduction block occurred in 19 of 28 patients (68%). RBBB persisted in 9 patients (32%) but mostly normalized with HBP.

Keywords: His bundle pacing; His bundle injury; Bundle branch block; Complete heart block; Permanent His bundle pacing

Introduction

RV pacing has been associated with ventricular dyssynchrony, reduction in left ventricular ejection fraction and adverse clinical outcomes [1–3]. Permanent His bundle pacing (HBP) is a physiological alternative to right ventricular (RV) pacing. Since the original description of permanent His bundle pacing (HBP) by Deshmukh et al. [4], several investigators have adopted this form of pacing [5–9]. Catheter manipulation during electrophysiology studies or cardiac catheterization has been reported to be associated with transient or permanent bundle branch block [10,11]. However, the impact of targeted placement of HBP electrode on the His-Purkinje conduction system is unclear. The aim of our study is to report the acute and long-term incidence of injury to the His bundle following permanent HBP.

Methods

Patients

Permanent HBP has been performed at Geisinger Wyoming Valley Medical Center since 2006. Our analysis

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involved patients who had undergone attempts at permanent HBP from 2006 to 2014. All patients provided written informed consent prior to implantation. This was a retrospective study approved by our institutional review board.

Implantation technique

A detailed description of the permanent HBP has been reported previously [9]. Briefly, a 4.1 Fr bipolar active fixation lead (SelectSecure, model 3830, Medtronic) was implanted in the His bundle region using a dedicated delivery sheath (deflectable C304 or C315His, Medtronic Inc., Minneapolis, MN). Selective HBP (S-HBP) was defined as ventricular activation occurring solely over the His-Purkinje system: (1) His-Purkinje mediated cardiac activation and repolarization as evidenced by electrocardiographic (ECG) concordance of QRS and T wave complexes; (2) the paced-ventricular interval was almost identical to the His-ventricular interval. Non-selective HBP was (NS-HBP) was defined based on capture of basal ventricular septum in addition to His bundle capture as having: (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); (3) narrowing of QRS with higher output or vice versa.

Protocol

His bundle capture threshold, R wave amplitudes, pacing impedances and HV intervals were measured at implant. Twelve lead EKGs at baseline and during HBP, along with baseline and paced QRS duration were also recorded for each patient. Patients with pre-existing bundle branch block or infra-nodal AV block at the time of implantation were excluded from the study. Any development of new bundle branch block or complete heart block at the time of permanent HBP was recorded. Persistence or resolution of the induced block was recorded. The impact of HBP on correction of the induced block was documented. Patients were followed in device clinic at 2 weeks, 2 months, and 1 year, and annually thereafter.

Statistical analysis

Continuous data are presented as mean ± standard deviation. Differences between continuous variables were assessed by using a Student's *t*-test. The statistical significance was defined as a *p*-value less than 0.05.

Results

Patient characteristics

Between 2006 and 2014, 450 patients underwent attempt at permanent His bundle pacing at Geisinger Wyoming Valley Medical Center. Pre-existing bundle branch block or infra-nodal AV block was present at the time of implantation in 92 patients, who were excluded from the study. Permanent HBP was successful in 325 of 358 (91%) patients without underlying His-Purkinje system conduction disease. New bundle branch block or AV block was observed in 28 (7.8%) patients. Baseline characteristics of these patients are shown in Table 1.

Acute His bundle injury was noted in 28 patients (7.8%). Acute His bundle injury in the form of bundle branch block occurred in 24 (6.7%) patients; right bundle branch block in 21 (5.8%), left bundle branch block in 3 (0.8%). In these patients baseline HV interval acutely prolonged from 45 ± 8 ms to 54 ± 7 ms. Complete HV block occurred in 4 (1.1%) patients.

Timing of acute injury

In 21 of 28 patients, conduction block developed immediately after fixing the lead (4–5 passive rotations of the lead to anchor) (Fig. 1). In majority of these patients (15 of 21), current of injury (COI) was noted at the His bundle electrogram after the lead fixation (Figs. 2–3). In our first patient with complete AV block (Fig. 4), we did not immediately recognize the HV block due to large current of injury obscuring the His electrogram. In 7 patients, RBBB developed during His bundle mapping with the lead, before active fixation.

Recovery of conduction

In 19 of 28 patients, conduction completely recovered. In 12 of 21 patients with RBBB, conduction recovered within 5–60 min. In the remaining 9 (2.5%) patients RBBB persisted at 24 h and during follow-up. In the three patients with LBBB, conduction recovered within 1–24 h. In 3 of 4 patients who developed complete HV block, conduction recovered within 5–15 min (Fig. 5). In one patient who underwent AV node ablation despite complete HV block, junctional escape rhythm with narrow complex was noted at 24 h suggesting normalization of His-Purkinje conduction.

QRS duration

In patients who developed RBBB, QRS duration prolonged from 90 ± 8 ms at baseline to 132 ± 12 ms ($p < 0.05$) with minimal change in QRS axis from 64 ± 12° to 48 ± 22°. With the development of LBBB, QRS duration prolonged from 88 ± 12 ms to 146 ± 12 ms ($p < 0.05$) without a change in the axis.

His bundle pacing

Acute His bundle capture threshold at implant was 1.1 ± 0.5 V at 0.8 ± 0.2 ms in patients who developed bundle branch block. Despite the presence of BBB, His bundle pacing acutely corrected the conduction block (figure). In the

Table 1
Patient characteristics.

Number of patients (n)	28
Age (mean ± SD in years)	75 ± 4
Gender (males: n, %)	19 (66%)
Hypertension (n, %)	20 (71%)
Diabetes mellitus (n, %)	8 (28%)
Coronary disease (n, %)	14 (50%)
Atrial fibrillation (n, %)	13 (46%)
SN dysfunction (n, %)	17 (61%)
AV conduction disease (n, %)	11 (39%)