His Bundle Recordings in Children with Normal Hearts and Congenital Heart Disease

By Nigel K. Roberts, M.B., and P. M. Olley, M.B.

SUMMARY

His bundle potentials were recorded in 50 children. Eight had normal hearts, 11 had ventricular septal defects, seven had the tetralogy of Fallot, seven had secundum atrial septal defects, and eight had pulmonary valve stenosis. There were miscellaneous defects in nine children. Ages ranged from 2 weeks to 14 years. Two intervals were measured on recordings: (1) from the initial atrial activity (P') to the His bundle potential (H), the P'-H interval, and (2) from H to the initial ventricular activity (V), the H-V interval. The H-V interval lengthened with age. The P'-H and H-V intervals did not differ significantly when different cardiovascular lesions were compared.

Additional Indexing Words:
Atrial pacing  Atrial septal defects  Intracardiac electrocardiography
Pulmonary valve stenosis  Tetralogy of Fallot  Ventricular septal defects

Scherlag and associates described an electrical method for recording His bundle and other conduction tissue potentials during cardiac catheterization. The His bundle (H) potential has been recorded and two measurements have been made in children with normal P-R intervals on the standard electrocardiogram. The time taken for an impulse generated at the sinoatrial node to arrive at the His bundle and the time taken for the conduction of an impulse from the His bundle to the first ventricular activity were measured.

Method

Group Studied

Fifty children, aged 2 weeks to 14 years, with normal P-R intervals were studied during cardiac catheterization (table 1). Eight children had normal hearts; the others had various cardiac malformations (table 2). To facilitate analysis, they were grouped by age as follows: under 1 year of age, 10 children; 1 to 4 years, 15 children; 5 to 8 years, 17 children; and from 9 to 14 years, eight children (table 1).

Technic

The His bundle potential was recorded with either a unipolar or tripolar catheter (USCI no. 5 or 6) advanced from the saphenous vein in 47 children and from the right antecubital vein in three children. The catheter was advanced toward the tricuspid valve and then withdrawn until the His bundle potential was obtained (fig. 1). The recording equipment was a recorder (Electronics for Medicine DR 8) and a low-level filter of 12 Hz, and a high-level filter of 2,000 Hz were employed. The recordings were made on photographic paper using an Electronics for Medicine rapid writer and a paper speed of 100 mm/sec. Simultaneous standard lead II electrocardiograms were recorded. In two patients three intracardiac electrograms were recorded simultaneously with the external standard lead II, and it was found that the first atrial activity occurred later in the electrograms recorded farthest away from the sinoatrial node (fig. 2). The measurements in this series, therefore, have all been made by using the initial deflection in the intracardiac tracing to indicate the onset of atrial activity, rather than the external standard lead II. This first atrial deflection has been labeled P'. The P'-
Table 1

Duration of P'-R, P'-H, and H-V Intervals in Milliseconds of the Patients in Four Age Groups

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Under 1 yr</th>
<th>1-4 yr</th>
<th>5-8 yr</th>
<th>9-14 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>P'-R</td>
<td>P'-H</td>
<td>H-V</td>
<td>P'-R</td>
</tr>
<tr>
<td>110</td>
<td>80</td>
<td>30</td>
<td>100</td>
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<td>60</td>
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<td>70</td>
<td>30</td>
<td>130</td>
<td>100</td>
</tr>
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<td>115</td>
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<td>100</td>
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<td>25</td>
<td>130</td>
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<tr>
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<td>130</td>
</tr>
</tbody>
</table>

Range
85-120 | 70-100 | 20-30 | 80-140 | 60-115 | 20-30 | 70-140 | 30-100 | 20-40 | 105-140 | 70-100 | 30-40 |
Mean
109 | 85 | 24 | 111 | 86 | 25 | 112 | 81 | 31 | 119 | 83 | 36 |
Standard deviation
10 | 11 | 4 | 20 | 20 | 4 | 20 | 20 | 6 | 14 | 10 | 4 |

H and H-V intervals have been measured in five separate complexes, and the mean of these five measurements has been calculated.

Results
The results are tabulated in tables 1 and 2. In table 1 the 50 children are classified by ages into four groups, and the P'-R, P'-H, and H-V intervals are listed. All the measurements are made in milliseconds. (See also fig. 3).

In table 2 the series is classified by cardiac conditions. Table 3 collates the P values for the different age groups when the H-V intervals are compared.

Table 2

The P'-R, P'-H, and H-V Intervals in Milliseconds of Patients with Various Conditions

<table>
<thead>
<tr>
<th>Normal (8 children)</th>
<th>Ventricular septal defect (11 children)</th>
<th>Tetralogy of Fallot (7 children)</th>
<th>2° Atrial septal defect (7 children)</th>
<th>Pulmonary valve stenosis (8 children)</th>
<th>Miscellaneous* (9 children)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P'-R</td>
<td>P'-H</td>
<td>H-V</td>
<td>P'-R</td>
<td>P'-H</td>
<td>H-V</td>
</tr>
</tbody>
</table>
| Range
130 | 110 | 40  | 140 | 115 | 15  | 130 | 100 | 35  | 140 | 105 | 40  | 135 | 105 | 40  | 140 | 100 | 40  |
Mean
108 | 81  | 27  | 112 | 86  | 26  | 116 | 86 | 30  | 114 | 84  | 30  | 108 | 81  | 27  | 113 | 82  | 31  |
Standard deviation
21 | 23  | 6   | 15  | 15  | 5   | 7   | 9   | 6   | 22  | 13  | 7   | 18  | 14  | 6   | 17  | 14  | 5   |

*Miscellaneous group comprises, cardiomyopathy in three cases; mitral regurgitation in two cases; aortic stenosis, subaortic stenosis, persistent ductus arteriosus, and transposition of the great arteries in one case each.
**Figure 1**

Standard lead II electrocardiogram (ECG) and His bundle electrogram (HBE) demonstrating P wave, His bundle (H), and QRS complex. Times lines = 1 sec.

**Discussion**

The P-R interval in a standard electrocardiogram represents the time taken for an impulse originating in the sinoatrial node to arrive at the ventricular myocardium. Alanis and others using an isolated heart preparation were able to record a biphasic potential from the His bundle which they designated the H potential. Scherlag and associates later showed that this (H) potential could be recorded consistently during cardiac catheterization. There have been several subsequent reports of His bundle recordings in adults but to date only two reports of such studies in children. The P'-H and H-V intervals in children might be expected to differ from those in adults for two reasons: (1) The child’s age influences the P-R interval, and this

**Table 3**

P Values for the H-V Intervals when the Four Different Age Groups (under 1 Year, 1 to 4 Years, 5 to 8 Years, and 9 to 14 Years) are Analyzed

<table>
<thead>
<tr>
<th>Age group</th>
<th>1-4 yr</th>
<th>5-8 yr</th>
<th>9-14 yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 yr</td>
<td>&lt;0.20</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>1-4 yr</td>
<td>—</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>5-8 yr</td>
<td>—</td>
<td>—</td>
<td>&lt;0.10</td>
</tr>
</tbody>
</table>

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may affect the P'-H or the H-V interval, or both. (2) The heart rate influences the P-R interval and thus similarly affects either the P'-H or the H-V interval, or both.

Experimental evidence suggests that under certain conditions the two parts of the P'-R interval may vary differently; therefore, although there are mathematical formulae to correct the P'-R interval for heart rate, we feel that it is not legitimate to use these formulae when the P'-R interval is divided into its integral parts.

Our earlier report suggesting that the technic of His bundle electrography can be safely and accurately applied to children from 2 weeks of age agrees with that by Brodsky and co-workers, who recently published details of His bundle measurements in 35 children whose ages ranged from 3 months to 14 years.

We attempted to standardize the heart rate by atrial pacing and found that the P'-H interval increased in length with increasing frequency of stimulation whereas the H-V interval remained the same at different rates (fig. 4). This has been demonstrated in adults by Lister and associates and thus this method for standardization was invalid and abandoned as being unphysiologic. The use of atropine to increase the heart rate to predetermined levels was also employed. Atropine infusion produced increases of as much as 85% in the heart rate, and despite the P'-H or H-V intervals (fig. 5) remaining unchanged we thought that this method also was unphysiologic and was abandoned.

Our work has demonstrated that the prolongation in P-R interval which occurs with the
increase in age occurs at the H-V interval (fig. 3). There was a significant increase in the H-V interval when the four groups of children were compared, and the adult results of Scherlag and associates were used. There was, however, no significant difference in the P'-H intervals.

When the conduction times of the various cardiac conditions were compared, no significant differences in the P'-H or H-V intervals were found. This observation suggests that in the groups studied these intervals were not influenced by the lesion (fig. 6).

This is perhaps surprising in the cases of secundum atrial septal defects, some of which have been reported as having prolonged intratrial conduction times. A possible reason is that all the atrial septal defects in the series were small and the pulmonary-to-systemic flow ratios were less than 2:1. We could not obtain His bundle potential recordings in large atrial septal defects, because the catheter could not be positioned at the region of the His bundle due to the flow of blood. It is possible that if the His bundle in these cases had been recorded, abnormalities would have been discovered in the P'-H or the H-V interval or in both.

References

Figure 5
Effect of intravenous atropine on the P'-H and H-V intervals.

Figure 6
P'-H and H-V intervals and intracardiac findings.
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