The Contribution of His Bundle Recording to the Understanding of Cardiac Conduction in Man

By KENNETH M. ROSEN, M.D.

IN 1969, Scherlag and coworkers reported the recording of bundle of His electrograms in man. The technique consists of passing an electrode catheter into the right heart and positioning the electrodes in the area of the tricuspid valve. With proper catheter positioning, amplification and frequency filtering, the His bundle (H) potential can reliably be recorded as a bi- or triphasic deflection between the atrial and ventricular electrograms. The procedure is simple and has a low morbidity. With a little experience, recording of His bundle electrograms could be accomplished in most cardiac laboratories. Careful attention must be given to elimination of electrical hazards before attempting this procedure.

The technique has been applied to the study of both normal and abnormal conduction in man. Many of the findings demonstrated had previously been predicted by the physiologist, the electrocardiographer, and the cardiac pathologist.

The recording of the H potential allows subdivision of the P-R interval into two subintervals, P-H (A-H) and H-Q (H-V) (fig. 1).

P-H is conduction time from the onset of atrial depolarization (P wave) to that of His bundle depolarization and is a measure of intra-atrial and A-V nodal conduction times. H-Q is conduction time from His bundle depolarization to the onset of ventricular activation (initial deflection of QRS) and is a measure of conduction in the distal His bundle and bundle branches. The normal P-H ranges from 80–140 msec and the normal H-Q from 35–55 msec.

Analysis of these intervals in response to varied physiologic and pharmacologic interventions furthers understanding of conduction (table 1). Of the two intervals, P-H is most vulnerable to intervention. Atropine, isoproterenol, and diphenylhydantoin shorten P-H, while digitalis and propranolol prolong P-H. None of these agents change H-Q. Lidocaine has an insignificant effect on P-H and H-Q, while procainamide often prolongs both of these intervals. Presumably, changes in P-H reflect slowing or speeding of conduction in the A-V node, while changes in H-Q reflect similar alterations of conduction in the His-Purkinje system.

Increase in heart rate with atrial pacing results in prolongation of P-H and has no effect on H-Q. At rapid paced rates, second degree A-V block proximal to the His bundle is noted in patients with normal conduction. Thus, under ordinary circumstances, the area of the conduction system with the lowest safety factor for conduction is the A-V node. This has also been demonstrated in patients with atrial fibrillation and flutter, where block of most atrial impulses occurs proximal to the His bundle. Those impulses reaching the His bundle are conducted to the ventricles.

With premature atrial stimulation, prolongation of P-H and sometimes of H-Q is noted in the coupled beat. The H-Q prolongation is usually accompanied by QRS widening,

From the Department of Adult Cardiology of the Hektoen Institute for Medical Research and Cook County Hospital, and the Department of Medicine of the Abraham Lincoln School of Medicine, University of Illinois College of Medicine, Chicago, Illinois.

Supported in part by Grant HE-08834-07 from the National Heart and Lung Institute, U. S. Public Health Service, and C.R.R. Grad. Grant 2413330311 from the University of Illinois College of Medicine.

Circulation, Volume XLIII, June 1971
reflecting functional block in the bundle branch system (aberrant conduction). Thus, premature atrial stimulation may provoke slowing of conduction at the A-V node and in the His-Purkinje system. The clinical counterpart of this is frequently seen with spontaneous atrial premature beats, and occasionally in atrial fibrillation when there are marked variations in cycle lengths.

First degree A-V block occurring in the absence of bundle-branch block generally reflects prolongation of P-H interval (fig. 2).3, 8 In the presence of bundle-branch block, P-R prolongation may reflect prolongation of either or both P-H and H-Q.3, 8, 12, 13 H-Q prolongation in a patient with bundle-branch block is especially significant in that it may represent delay of conduction in the contralateral bundle branch and thus be a sign of bilateral bundle disease.

The usefulness of His bundle recording in the evaluation of patients with suspected conduction disease is enhanced by the use of atrial pacing at varied rates. Atrial pacing stresses the conduction system, often allowing demonstration of block not apparent during normal sinus rhythm.12-14 The development of second degree block proximal to the His bundle at low paced rates (below 130 beats/min) probably reflects A-V nodal dysfunction. Development of second degree A-V block distal to the His bundle at any heart rate (up to 200 beats/min) probably represents disease in the His-Purkinje system. We have found the combined techniques of atrial pacing and His bundle recording helpful in the evaluation of patients with suspected Stokes-Adams attacks who are in sinus rhythm at the time of study.

Recording of His bundle electrograms in patients with second degree A-V block, allows delineation of the site of block.8, 15 The relationship of site and type of block has also been clarified. Mobitz type I block (Wenckebach) generally reflects conduction delays proximal to the His bundle (fig. 3A). Mobitz type II block usually reflects block in the His bundle or bundle branches (fig. 3B).

Table 1

<table>
<thead>
<tr>
<th>Agent</th>
<th>P-H</th>
<th>H-Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isoproterenol</td>
<td>Decrease</td>
<td>No change</td>
</tr>
<tr>
<td>Propranolol</td>
<td>Increase</td>
<td>No change</td>
</tr>
<tr>
<td>Atropine</td>
<td>Decrease</td>
<td>No change</td>
</tr>
<tr>
<td>Lidocaine</td>
<td>No change</td>
<td>No change</td>
</tr>
<tr>
<td>Procainamide</td>
<td>No change or increase</td>
<td>Increase</td>
</tr>
<tr>
<td>Diphenylhydantoin</td>
<td>Decrease</td>
<td>No change</td>
</tr>
</tbody>
</table>
First degree A-V block reflecting prolongation of P-H. Simultaneous electrocardiogram (ECG) and His bundle electrograms (HBE) are shown. P wave is labeled P, QRS labeled R, and His bundle potential labeled H. P-H is 220 msec and prolonged while H-Q of 45 msec is normal. Time lines on this and subsequent illustrations are at 1 sec. Paper speed is 200 mm/sec.

Figure 2

A. Type I

B. Type II

(Panel A) Type I second degree A-V block proximal to H. Note progressive P-H prolongation from 140 to 235 msec. The third P wave is blocked proximal to H. The fourth P wave is conducted and the cycle begins again.

(Panel B) Atrial pacing with development of type II second degree A-V block in a patient with left bundle-branch block. The pacing spikes (labeled with arrows) are each followed by atrial electrograms (P). The fourth and fifth paced atrial complexes are blocked distal to H. P-H is 150 msec in all beats, and H-Q is 100 msec in all beats conducted to the ventricles. Neither interval prolongs prior to block.

In acute myocardial infarction with heart block, His bundle recording has documented two major types of block. In inferior infarction, block usually occurs proximal to the His bundle, reflecting A-V nodal dysfunction. In anterior infarction, block usually occurs distal to the His bundle, reflecting involvement of the ventricular septum with bilateral bundle-branch block.

Thus, His bundle recording has been extremely useful in delineating sites of conduction delays in all forms of heart block. Several questions remain in regard to the application of this technique. Can recording of His bundle electrograms with or without...
Complete A-V block distal to H, the most common site of complete heart block. The atrial rate (AR) is 88 beats/min. Ventricular rate (VR) is 40 beats/min. Each atrial electrogram is followed by a His bundle spike. There is a slow idioventricular rhythm characterized by wide QRS without preceding His bundle spikes. Conduction proximal to the His bundle is normal with a P-H of 110 msec.

Congenital complete A-V block proximal to H. None of the P waves is conducted. The escape is A-V junctional characterized by a narrow QRS with preceding His bundle spike. The normal H-Q interval of 35 msec suggests unimpaired conduction distal to the His bundle.

The differentiation of ventricular and supraventricular beats with the His bundle recording technique.

(Panels A) Recording from a patient with recurrent premature beats and tachycardias with aberrant beats which were of ventricular origin. The first conducted beat is followed by two aberrant QRS complexes, neither of which is preceded by a His bundle potential. These are ventricular premature beats. The prolonged P-H of the last conducted beat probably reflects retrograde concealed conduction into the A-V junction from the preceding ventricular beat.

(Panels B) Recordings during an episode of tachycardia in a patient with a history of recurrent tachycardias. Shown are simultaneous ECG leads I, II, III, and V1. The QRS is widened (110 msec) with right bundle-branch block pattern (r' in V1). His bundle electrogram shows that H potentials precede each QRS, demonstrating that this is a supraventricular tachycardia.
atrial pacing in patients with less advanced conduction defects be of value in the prediction of future behavior? If the occurrence of Stokes-Adams attacks could be accurately predicted, prophylactic demand pacemakers could be implanted. A second question concerns the pathologic significance of abnormal findings noted during these conduction studies. There is a need for correlation of the results of His bundle recordings with that of disease as defined by serial histologic sectioning of the conduction system. As in electrocardiography, correlations must be made with pathologic findings, so that the accuracy and limitations of the His bundle recording technique in detecting lesions can be determined.

His bundle recording has been useful in demonstrating the mechanisms responsible for the Wolff-Parkinson-White (WPW) syndrome. With atrial pacing at increasing rates, most patients with WPW show lack of prolongation of the P-delta (P-R) interval while P-H progressively prolongs. The H potential is often noted inside the QRS. These findings suggest that two pathways coexist in these patients, one which is not affected by an increase in atrial rate (the anomalous pathway) and one which slows with rate increase (normal pathway). QRS morphology depends on the relative rates of conduction in these two competing pathways. In one patient with WPW syndrome, an infranodal pathway was suspected because of a shortened H-Q. Further work documenting the functional properties of the varied pathways producing WPW syndrome is necessary.

The technique of His bundle recording is useful in the interpretation of complex arrhythmias. Recording of H potentials allows the determination of whether wide QRS beats are supraventricular or ventricular in origin (fig. 6). The consistent demonstration of His bundle deflections prior to wide ectopic QRS complexes establishes the beats in question as being supraventricular with aberrant conduction as the mechanism of QRS widening. This may be useful information in determining therapy.

The His bundle technique also allowed the demonstration of electrocardiographically invisible premature His bundle depolarizations, which were concealed because of antegrade and retrograde block. These depolarizations effected subsequent cardiac cycles by retrograde conduction into the A-V junction, producing P-R prolongations or blocked P waves. The existence of this previously postulated arrhythmia could not have been proven without recording of H potentials.

Recording of His bundle electrograms has been useful in understanding cardiac conduction in health and disease. Up to the present, the technique has been primarily utilized in the research laboratory. However, it is expected that His bundle potentials will be recorded in many clinical laboratories. Recording of His bundle electrograms can contribute significantly to the diagnosis and management of selected patients.

References


The Contribution of His Bundle Recording to the Understanding of Cardiac Conduction in Man
KENNETH M. ROSEN

Circulation. 1971;43:961-966
doi: 10.1161/01.CIR.43.6.961
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1971 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/43/6/961.citation

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/