

Catheter Technique for Recording His Bundle Activity in Man

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SUMMARY

A technique for the routine recording of His bundle (H) activity in man using a bipolar or multipolar catheter is described. The recording catheter is inserted percutaneously, via the Seldinger method, into the right femoral vein and advanced fluoroscopically into the right atrium. Placement of the pre-formed curve at the catheter tip across the tricuspid valve in nine patients resulted in stable recordings of His bundle activity in successive cardiac cycles. Right atrial pacing resulted in progressive lengthening of the P-H interval with increasing frequency but the H to S-wave interval remained constant at all rates. Similar lengthening of the P-H interval was produced during atrial pacing when pressure was applied to the carotid sinus. The use of this recording technique in man will facilitate diagnostic interpretation of the electrocardiogram and can be used in various investigations of atrioventricular and intraventricular conduction in man.

Additional Indexing Words:

Intracardiac recordings
P-R interval

Carotid sinus massage

Atrial pacing

THE RECORDING of the electrical activity of the His bundle has been accomplished in the dog heart by a number of methods with^{1,2} and without³ cardiectomy, as well as in the intact closed chest anesthetized animal.⁴⁻⁶ Similar recordings have also been demonstrated in the human heart during cardiac catheterization of patients with atrial septal defects⁷ and in one recently reported case of Ebstein's anomaly.⁸

Since our recent studies on intact, anesthetized dogs have demonstrated the relative ease and safety of recording electrical activity from the common bundle with a multipolar or bipolar electrode catheter,³⁻⁶ we

attempted to develop a similar method that would be generally applicable in patients.

Methods

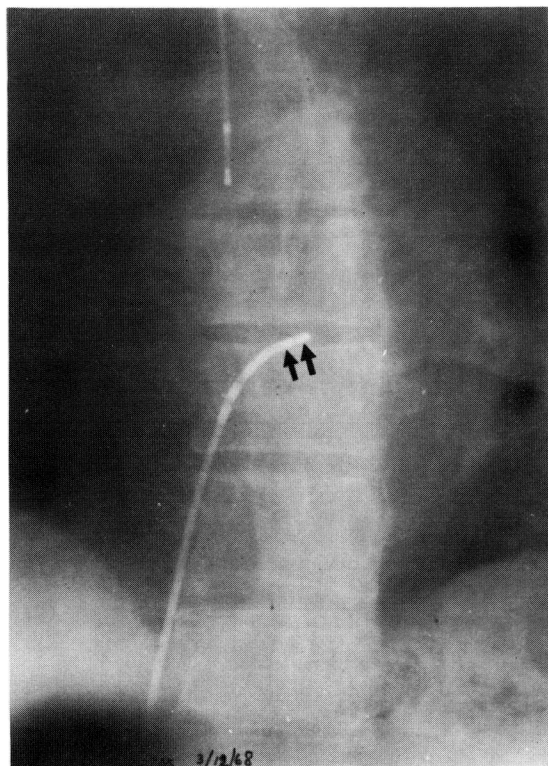
Right heart catheterization was performed on 10 patients who were in the postabsorptive non-sedated state. Lead II of the electrocardiogram was monitored and recorded throughout the procedure. Under local anesthesia, a 6 or 7 French bipolar or tripolar electrode catheter* was introduced percutaneously by the Seldinger method into the right femoral vein and under fluoroscopy positioned across the tricuspid valve (fig. 1). In some cases a special multipolar catheter (three bipolar pairs) was used.† The proximal terminals of the electrode catheter were led into the A-C input of an ECG amplifier to record either a unipolar electrocardiogram (Vhb) or a bipolar electrogram. In the present study, bipolar electrograms were used more frequently. His bundle activity was recorded at low (0.1 to

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This work was supported in part by the Bureau of Health Services, Division of Direct Health Services, U. S. Public Health Service Project Py 69-1 and Grant HE-11829.

*U. S. Catheter & Instrument Corp., Glens Falls, New York.

†Elecath Co. (Electro-Catheter Co.).



200 cps) and high (40 to 500 cps) frequency settings on the ECG amplifier. Lead II and the bipolar electrogram were monitored on the oscilloscopic screen as the electrode catheter was slowly withdrawn across the tricuspid valve until a biphasic deflection appeared between the atrial and ventricular electrogram and within the P-R interval of the surface electrocardiogram. All records were monitored and recorded on a switched beam oscilloscopic photographic recorder at paper speeds of 100 and 200 mm/sec. The average time necessary for placing the catheter properly, once the femoral vein was entered, was 2 to 5 minutes.

In nine of the patients, the right atrium was paced using an additional electrode catheter

Figure 1

An anteroposterior view showing the location and position of a multipolar electrode catheter during His bundle recordings. The bipolar His bundle electrogram was recorded from the close bipolar electrode bands (arrows) located at the base of the atrial septum in the mid-tricuspid valve area. Note how the curvature of the electrode tip facilitates the proper positioning of the recording electrodes.

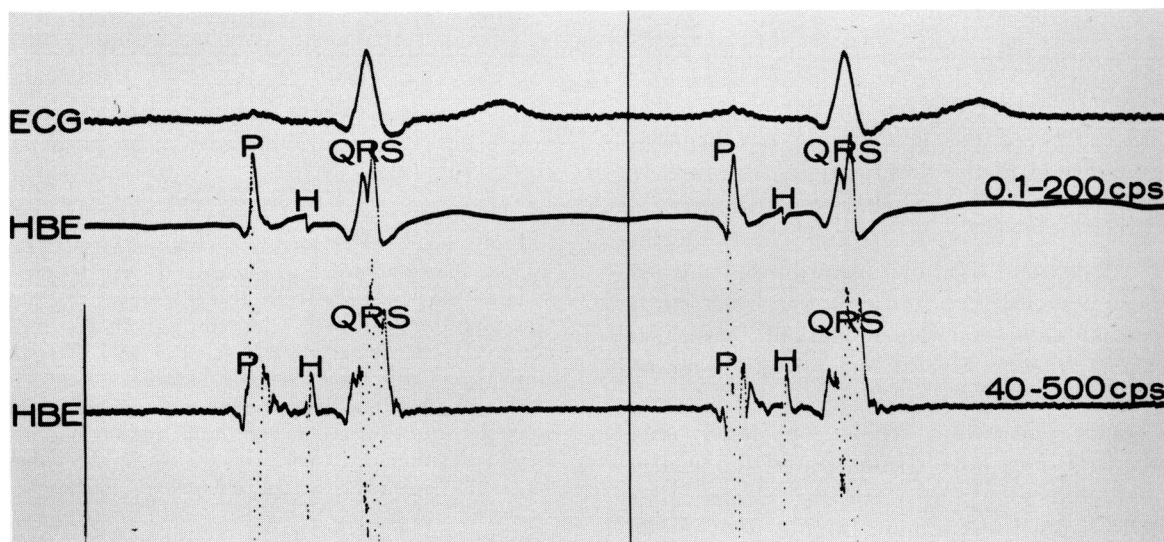


Figure 2

Simultaneously recorded bipolar His bundle electrograms recorded at different amplifier frequencies. Standard lead of the electrocardiogram (ECG). The His bundle electrogram (HBE) indicates rapid electrical activity (H), occurring at the same time during the P-R interval in several cardiac cycles. The middle tracing shows His bundle activity recorded with standard electrocardiographic frequency settings (0.1 to 200 cps). The lower tracing shows the atrial, His bundle, and ventricular components of the His bundle electrogram with frequency settings of 40 to 500 cps. At the latter frequency-levels His bundle activity tends to be somewhat more discrete and the trace more stable than with the standard ECG filtering.

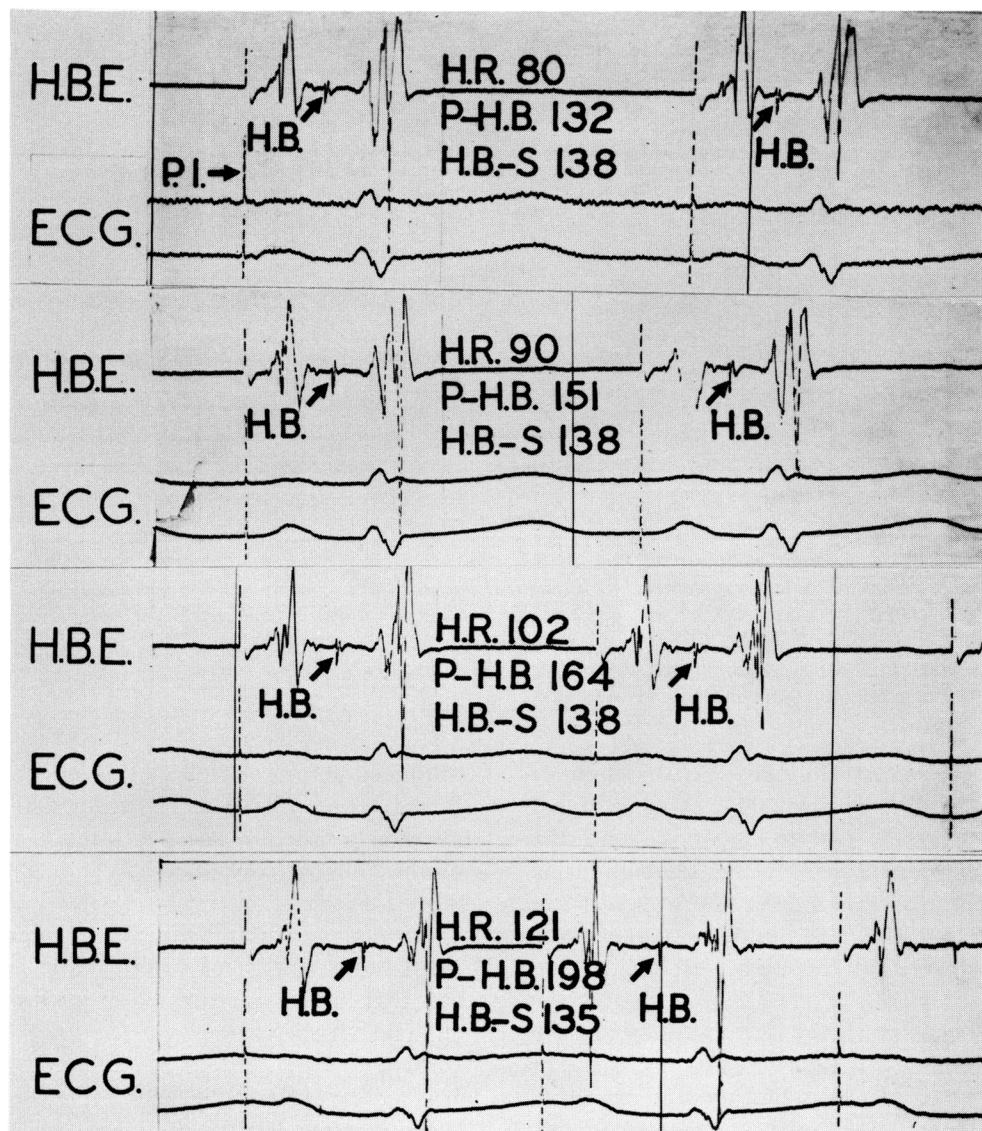


Figure 3

Effect of atrial pacing on the relationships of His bundle activity to atrial and ventricular activity. The upper trace (HBE) in each panel shows bipolar His bundle recording (arrow, HB); the two lower traces are standard ECG leads. Note that by increasing the heart rate with atrial pacing (PI = pacing impulse) from 80 to 120/min the PI-HB interval widens progressively (132 to 198 msec). However, the HB-S wave interval remains relatively constant (135 to 138 msec).

which was percutaneously introduced into an antecubital vein and fluoroscopically positioned against the lateral wall. Right atrial pacing was accomplished at rates of 80 to 140 per minute, using a Medtronic battery-powered pacemaker. All other equipment was properly grounded in order to avoid stray currents entering the system.

Circulation, Volume XXXIX, January 1969

Results

A His bundle electrogram or Vhb electrocardiogram was successfully recorded in nine of the 10 patients studied. Figure 2 shows typical recordings of His bundle activity during the P-R interval in several successive

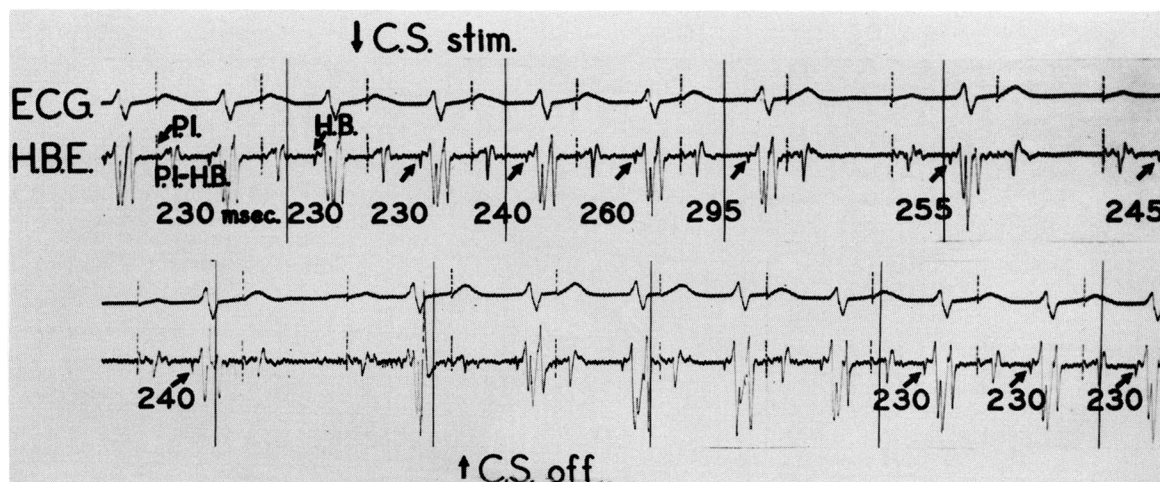


Figure 4

The effect of carotid sinus stimulation on A-V conduction at a fixed atrial pacing rate of 125/min. The upper trace is a standard ECG lead; the lower trace is a bipolar His bundle electrogram (HBE). With a fixed atrial paced rate (PI = pacing impulse), the initial PI-HB interval is 230 msec. Shortly after the application of carotid sinus stimulation (CS Stim ↓) the PI-HB widens to 295 msec with the occurrence of blocked beats. The PI-HB interval returns to control when carotid sinus massage ceases (↑ CS off).

cardiac cycles. At standard ECG frequency amplifier settings (0.1 to 200 cps) or at higher frequency levels (40 to 500 cps), the His bundle activity occurs at the same point in time within the P-R interval. However, it can be seen that the His bundle spike is more sharply defined at the higher frequency settings.

At any constant heart rate the interval from the beginning of the P wave to the His bundle spike (P-H) which represents atrial and A-V nodal conduction, showed a deviation of ± 3 msec. Figure 3 demonstrates that increasing the heart rate with atrial pacing causes a progressive widening of the P-H interval. However, the interval between the His bundle spike and the S wave of the electrocardiogram (H-S) which represents total intraventricular conduction remains relatively constant ($138 \text{ msec} \pm 3.0$).

The effect of carotid sinus stimulation is demonstrated in figure 4. Slowing of the rate with carotid sinus massage usually showed little or no change in the P-H interval during spontaneous pacemaker activity. However, at a given paced rate, carotid sinus stimulation

produced a more pronounced effect on the P-H interval increasing it from 230 to 295 msec at a rate of 125 per minute with the production of blocked beats (fig. 4). Again the H-S wave interval remained constant (112 msec) throughout these procedures. With the cessation of carotid sinus massage, the P-H interval returned to control levels (230 msec).

Discussion

Validity of the His Bundle Recording

Alanis and associates⁹ in 1958 described His bundle potentials recorded by the placement of fine needle electrodes along the A-V groove of the isolated, perfused dog heart. However, Alanis and his co-workers recognized that anatomic localization of the electrodes alone was insufficient evidence for validating their recordings of His bundle activity. Therefore, these investigators applied several interventions to determine that the rapid biphasic deflections of their recordings was the His bundle potential ("H potential") and not part of either contiguous atrial or ventricular electrical activity. Crushing the

S-A node led to ventricular activation preceded by His bundle activity with no corresponding atrial activity. In addition, the production of complete heart block below the His bundle region produced atrial activity with a consistent relationship to the His bundle electrogram but independent of ventricular activity. Furthermore, it was shown that the P-H interval was appropriately modified by increasing frequency of stimulation of the atrium, administration of acetylcholine, vagal stimulation, or asphyxia, and so on. The H-V interval showed remarkable stability under most circumstances.

In the present study an attempt was made to meet several of the criteria for validation of the His bundle recording as established by previous workers. The position of the monitoring electrodes during His bundle recordings, confirmed by fluoroscopic examination, always consisted of a relatively stable location at the base of the atrial septum in the middle of the tricuspid valve area. This location conforms to the established anatomic position of the His bundle (fig. 1). The electrical activity recorded from the His bundle appeared as a rapid biphasic or triphasic deflection occurring at the same point of the P-R interval (± 3.0 msec) in several successive cardiac cycles. Furthermore, the configuration and temporal relationships of these deflections are the same as that obtained in experimental studies in which placement of recording electrodes on the His bundle was performed by direct visualization during cardiomy. ^{2, 9} Although the amplitude of the deflection varied slightly throughout the recording period, the general configuration did not change. The amplitude variation was probably due to the slight catheter movement resulting from cardiac contraction. Once the electrode was properly positioned, recordings of His bundle activity could be obtained for prolonged periods (2 hours or more).

It was also possible to separate the His bundle electrogram in time from atrial activity during atrial pacing at various heart rates as well as during carotid sinus massage at a fixed atrial rate. Although the P-H in-

terval varied widely, the H-Q interval was relatively constant in duration. It might be argued that the "His bundle deflection" which was recorded in the present study, arose from some other area within the specialized conduction system, such as the A-V node or right bundle branch. Although this consideration cannot be entirely discounted, the available evidence, albeit indirect, leads the authors to believe that the recordings obtained are indeed from the common bundle. For example, the configuration, duration, and location within the P-R interval are the same as that reported when recordings were obtained in experimental animals by direct impalement of the common bundle. Furthermore, the response of the His bundle deflections during carotid sinus massage and atrial pacing parallels that which has also been observed in the experimental animal and is unlike any properties which have heretofore been ascribed to the right or left bundle branch.

Safety and Facility of the His Bundle Recording Technique

As mentioned above, a His bundle electrogram could be recorded within 2 to 5 minutes after insertion of the electrode catheter into the femoral vein. The previous reports of His bundle recordings from the human heart have implicitly or explicitly indicated the difficulty in recording electrical activity from the common bundle. These records have been reported in cases of anomalous cardiac anatomy which were thought to favor such recordings. ^{7, 8} The relative ease and safety in obtaining His bundle electrograms in the patients in the present study confirm the previous extensive experience in the experimental animal. ³⁻⁶ Advancing the catheter across the tricuspid valve occasionally produced a premature ventricular contraction. Once the catheter was withdrawn across the tricuspid valve and positioned in the appropriate area no further ectopic beats occurred. In only one of the 10 patients in whom studies were performed were His recordings not obtained.

Importance and Uses of the Procedure

The P-H interval represents a more accurate measurement of the A-V conduction time than the commonly used P-R interval since part of the P-R interval (that is, the H-Q wave) represents impulse transmission through the specialized conducting system of the ventricles. Although the P-H interval does include atrial as well as A-V conduction time, the order of magnitude of changes in atrial conduction seen clinically is relatively much smaller than the changes in A-V conduction time. The H-S interval encompasses total intraventricular conduction time as opposed to the more commonly used measurement, the QRS duration.

In the course of our investigations, using this technique, it was found that increasing the heart rate by atrial pacing progressively widened the P-H interval. Previous studies have shown that the P-R interval also lengthens progressively with increments in heart rate during atrial pacing.¹⁰ This effect has been investigated in a recent study and the results indicate that the site of delay in A-V transmission with pacing is above the bundle of His.¹¹

In some cases the effects of carotid sinus massage on cardiac conduction were studied. Pressure applied to the bifurcation of a common carotid artery slowed the sinus rate with either little change or some lengthening of the P-H interval. At any given paced rate, however, carotid sinus pressure consistently increased the P-H interval. Total intraventricular conduction was not affected since the H-S wave interval was the same before, during, or after these maneuvers (fig. 4). The His bundle recording technique is now being used in our laboratory in patients for diagnostic, physiological, or both types of investigation.

Addendum

Since the preparation of this manuscript, an additional 20 patients have been studied and His bundle electrograms have been recorded in all with the same facility described for the initial series of patients.

Acknowledgment

We gratefully acknowledge the assistance of Anne Mazzella, Audrey Pedersen, Joan Cumming, Loretta Coniff, Michael Moretti, David Berry and James Brown.

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