A Balloon Tipped Catheter for Obtaining His Bundle Electrograms Without Fluoroscopy

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SUMMARY
A technique for recording His bundle activity in man without fluoroscopic guidance is described. Balloon tipped tri- or tetrapolar catheters were designed with pacing electrodes located at the catheter tip, and two fine sensing electrodes 4 and 5 cm behind it. The catheter tip was preformed into a "J" curve. Following percutaneous transfemoral insertion, the catheter is floated to the right ventricle under electrocardiographic control. This tip configuration and the transfemoral route of insertion typically directs the catheter into an inverted "J" position with its tip in or near the right ventricular apex. Subsequent catheter withdrawal carries the sensing electrodes through the superior portion of the tricuspid valve and permits recording from the His bundle. With this technique His bundle recordings were possible in 23 of 24 patients. Re-advancement into the right ventricular apex permits stable temporary pacing.

Additional Indexing Words:
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There has been mounting interest in the research and clinical applications of His bundle electrocardiography since the initial demonstrations of its feasibility in man by Scherlag and associates1 in 1969. However, the requirement for fluoroscopic guidance in order to position catheter electrodes near the anatomic location of the bundle of His has constituted a significant limitation to more widespread application of this technique. Previously, it has been necessary either to transport the patient to the catheterization laboratory or to utilize bedside fluoroscopy in order to perform His bundle electrocardiography.

The purpose of this report is to describe a new method for obtaining His bundle electrograms without the need for fluoroscopy, utilizing a "floating" balloon tipped electrode catheter.

Methods

Catheter Design
The tri- and tetrapolar catheters utilized in this study are 100 cm long, #5 French in diameter, and constructed of soft polyvinyl chloride.* They are banded at 10 cm intervals to permit recognition of the length inserted. A stainless steel pacing electrode is located at the catheter tip (fig. 1a). A thin-walled rubber balloon is mounted directly behind the pacing electrode. Two 0.1 mm sensing electrodes are located 4 and 5 cm behind the catheter tip. The distal 12 cm of the catheter is preformed into a "J" configuration with a radius of curvature of approximately 3.5 cm. Terminals for the three electrodes, as well as a Luer-type fitting with a two-way stopcock for the balloon lumen, are located at the opposite end of the catheter (fig. 1b). The tetrapolar catheters carry a second pacing electrode mounted 1.0 cm behind the tip electrode to allow bipolar pacing. Also, the two sensing electrodes are positioned 0.5 cm rather than 1.0 cm apart on this latter version.

Technique for Catheter Placement
Balloon integrity is checked immediately prior to use by test inflation and immersion in saline. Utilizing sterile technique, insertion is accomplished percutaneously into either femoral vein via a #7 French Sheath.† When the catheter has been introduced sufficiently for its tip to clear the sheath, the balloon is inflated with 1.0 cc of air, and the tip electrode is connected to the V lead of the electrocardiograph. The catheter is then "floated" to the right ventricle under electrocardiographic control. When the abrupt appearance of a characteristic large negative intraventricular QRS complex indicates that the catheter tip has crossed the

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*Prototypes kindly provided by Edwards Laboratories-Santa Ana, California
†Desilets-Hoffman Introducer™ - USCIR
tricuspid valve, the balloon is deflated and the catheter is advanced an additional 4 to 6 cm until ST segment elevations (local current of injury) appear. This maneuver typically positions the catheter in an inverted J configuration as in fig. 2 (top). At this point, the two sensing electrodes are connected to the AC input of an electrocardiographic amplifier with filters set to attenuate frequencies below 40 and above 500 cycles per second (40-500 Hz). Gain is increased to the maximum extent consistent with maintenance of a smooth baseline. The signal is displayed oscillographically at a sweep speed of 100mm/sec. As the catheter is slowly withdrawn, the two sensing electrodes are carried near the junction of the interatrial septum and tricuspid valve, causing the atrial and ventricular deflections to become nearly equal in amplitude (fig. 2, bottom). The catheter is then slowly withdrawn or advanced through this region until a clear His bundle deflection is seen.

All recordings were made using an Electronics for Medicine Model EEP electrocardiographic amplifier and DR-8 photographic recorder at paper speeds of 100 mm/sec. One or more surface electrocardiographic leads were recorded simultaneously with the His bundle electrograms to permit accurate determination of conduction intervals. Equipotential grounds of the recorder-amplifier system, as well as any other electrical equipment in contact with the patient was used.

**Results**

Utilizing this technique, technically satisfactory His bundle electrograms have been obtained in 23 of 24 patients studied. The quality of the tracings was entirely comparable to that obtainable with the conventional method in our laboratory (fig. 3).

In 17 patients, His bundle electrograms were obtained easily and with 10 minutes or less. In six individuals some initial difficulty and delay was encountered. In all but one instance this was due to specific identifiable and remediable technical problems of two types. In three patients initial difficulty was encountered in negotiating the femoral or iliac veins, or inferior vena cava. When this occurred it was usually accompanied by a slight, but detectable sensation of resistance to smooth passage of the catheter and could be definitely ascertained if greater than 60 cm of the catheter was inserted without the appearance of an intracardiac ECG. In all instances, this was corrected by partially withdrawing the catheter and re-advancing it beyond the point of obstruction with the balloon temporarily deflated.

In two patients initial repeated passage of the catheter through the tricuspid valve area failed to produce a satisfactory His bundle electrogram. In both instances it was eventually realized that the catheter tip was situated in the outflow tract of the right ventricle, rather than being directed toward the apex in the optimal inverted "J" configuration. This became apparent when a sudden drop in QRS voltage from the tip electrode lead on catheter advancement indicated entry into the pulmonary artery. This was readily corrected by withdrawing the catheter to the right atrium, re-inflating the balloon, and repositioning the catheter in the right ventricle.

In one patient no His bundle electrogram was obtained with this technique. This individual had advanced mitral valve disease and marked distortion of cardiac architecture. Great difficulty was also encountered with the standard technique (using fluoroscopy) in this patient, and only a poor quality tracing was obtained.

Validation of His bundle electrograms by His bundle pacing was attempted in ten patients. In the first four of these, catheters with sensing electrodes spaced 1.0 cm apart were used, and satisfactory His bundle pacing was achieved in only one. In the subsequent six patients, an interelectrode distance of 0.5 cm was used and His bundle pacing was possible in four of these. In the twelve patients in whom His bundle pacing was not attempted, validation was accomplished using paced or naturally occurring atrial premature beats, or comparison to sequentially obtained and validated conventional recordings.

**Figure 1**

*Design of the tripolar catheter. a: The pacing electrode (1) is at the catheter tip. Sensing electrodes (2, 3) are located 4 and 5 cm behind the tip. The tetrapolar catheter has a second pacing electrode directly behind the balloon, and sensing electrodes 4.0 and 4.5 cm behind the tip. b: The proximal end of the catheter with connections for the electrodes and balloon lumen.*
Discussion

Both conventional and floating catheters entering the right heart via the inferior vena cava have a strong propensity to pass directly to the right ventricular apex rather than to the pulmonary artery. The resulting catheter orientation (fig. 2) is particularly advantageous for recording from the bundle of His. We have consistently been unable to obtain His bundle recordings with either conventional or flotation catheters when the tip has been directed into the right ventricular outflow tract or pulmonary artery.

The degree of preformed curvature applied to these flotation catheters has been of particular importance in this regard, insofar as too gentle a curve (longer radius of curvature) may permit the catheter to float into the right ventricular outflow tract rather than to the apex. We now routinely test for this malposition by initially advancing the catheter (while monitoring the ECG from the tip electrode) until appearance of an injury current indicates contact with ventricular endocardium or an abrupt drop in QRS voltage indicates entry into the pulmonary artery.

Initially, we arbitrarily chose to inflate the balloon with 1.5 cc of air. However, occasional difficulties in negotiating the femoral or iliac veins occurred when this volume was used. In the seven most recent patients only 1.0 cc of air was used and there have been no further instances of this problem. Use of the smaller inflation volume has not affected the ease of crossing the tricuspid valve. Accordingly, 1.0 cc of air has now been adopted as the standard inflation volume.

It must be emphasized that His bundle electrograms cannot be satisfactorily recorded on standard direct writing electrocardiograph machines since these have neither the frequency response, filtering, nor adequate paper speed for this purpose. Suitable amplifier-photographic recording systems are com-
Many patients in whom His bundle electrograms are of interest may also require temporary pacing. The original catheters in this series were designed with only one pacing electrode, principally for convenience in construction. This permitted either unipolar pacing using an indifferent electrode attached to the skin or bipolar pacing utilizing one of the sensing electrodes in addition to the tip electrode. Neither system provided satisfactory long term temporary pacing stability and so a second pacing electrode was added to later models. Our experience with a similarly constructed balloon tipped bipolar pacing catheter for femoral insertion indicates that quite satisfactory stability characteristics can be expected with this modification.

For optimal pacing stability upon completion of His bundle studies, the catheter should be advanced until ST segment elevations in the electrocardiogram from the tip electrode indicate endocardial contact. In most instances this maneuver will place the catheter tip in a stable position in or near the right ventricular apex. This should, of course, be confirmed by X-ray.

Since catheter diameter is slightly greater over the deflated balloon than elsewhere, it is necessary to utilize a number 6 or 7 French sheath for insertion of this number 5 French catheter. This permits some slow bleeding between the catheter and sheath, and requires that the sheath be re-
moved from the femoral vein (by drawing it back over the catheter) as soon as satisfactory position is attained.

For longer term temporary pacing, periodic surveillance for possible iliofemoral phlebitis on the side used for insertion is essential. The experience of Cheng and Furman, both of whom paced large numbers of patients transfemorally for long periods without anticoagulants, is reassuring in this regard. Their combined total of 392 cases included only one recognized episode of iliofemoral thrombophlebitis. We have nevertheless given prophylactic low dosage heparin to patients with concurrent conditions known to predispose to venous thromboembolic disease.

Premature ventricular beats were encountered occasionally during catheter manipulation, but were rare when the catheter was stationary in the recording or pacing position. No sustained arrhythmias were induced. However, since any intracardiac catheter has the potential for inducing dangerous arrhythmias, it is essential to have defibrillating equipment available during insertion or manipulation.

We have attempted a systematic comparison of "blind" and conventional techniques with regard to ease and rapidity of obtaining His bundle recordings. Although we have been impressed that these are quite comparable in the majority of instances, there can be little doubt that fluoroscopic visualization will be required in the occasional difficult case, particularly when major distortion of cardiac anatomy is present. Nevertheless, our experience to date has indicated that with patience and careful attention to technical detail, His bundle electrograms can be obtained without fluoroscopy in nearly all patients.

The availability of a bedside technique may permit bundle of His electrograms to be made independently of busy catheterization laboratory schedules, and without the necessity for transporting seriously ill patients. More specifically, His bundle electrograms permit correct identification and rational treatment of some complex arrhythmias. The ability to make repeated measurements at the bedside may facilitate controlled usage of cardiosuppressive agents in situations where cardiac conduction defects and dangerous arrhythmias coexist. They may also permit assessment of the need for prophylactic temporary pacemaker insertion in patients with acute myocardial infarctions complicated by development of bundle branch blocks.

References

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