Intraoperative Delineation of the Conduction System in Corrective Surgery for Congenital Heart Disease

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Introduction

Intraoperative recording of the specialized cardiac atrioventricular conduction system during open heart surgery has been widely used for approximately one decade. It has proved to be a valuable technique for the cardiac surgeon in the delineation and protection of the specialized conduction tracts in patients with various forms of congenital heart disease.

In 1960 Stuckey et al. (1) demonstrated in the canine heart that electrophysiologic techniques could be used to identify the specialized atrioventricular conduction system during open heart surgery and reported its first use in man. Kaiser et al., (2) improved the technique and showed its usefulness in a series of repairs of various types of congenital heart disease. Over the ensuing years, a number of observers (3-11) have confirmed the accuracy, use, and value of the technique during surgical correction of congenital cardiac defects, especially in the more complex lesions.

Electrophysiologic mapping has been and continues to be used in essentially two ways during open heart surgery: first, as a research tool to delineate the location of the specialized conduction tissue within the living human heart, both in normal hearts and in variants of congenital heart disease; and, second, as a clinical tool for identifying the specialized conduction pathways in complex congenital heart disease in an attempt to reduce the incidence of operative heart block. In addition, the technique may be a useful educational adjunct in the training of cardiac surgeons.

Method

The technique of intraoperative mapping of the bundle of His has been fully described elsewhere (2) and has undergone little change. Originally an acrylic plaque containing five silver electrodes was held at the junction of the superior vena cava and right atrium in the area of the sinus node in order to pace the atrium to insure a conducted atrial rhythm during mapping, or to record atrial electrograms. When recording of atrial electrograms is not required, a simple unipolar pacing clip may be placed upon the right atrium for atrial pacing if a clear sinus rhythm is not present.

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For mapping the bundle of His, an electrode probe, 5 mm in diameter, whose tip contains 3 silver electrodes arranged triangularly 1 mm apart, is used to record bipolar electrograms from selected sites in the low right atrium, atrioventricular junction, or in the ventricular septum. A characteristic deflection representing the electric activity of the bundle of His is seen during the isoelectric portion of the P-R interval in the recorded electrograms.

The technique of the His Bundle Electrogram mapping has proved to be reproducible and reliable. Dick et al., (12) studied the precision of the technique using a specially designed probe which simultaneously recorded six bipolar electrograms arranged parallel to the His bundle at a distance of 1 mm apart. Analysis of this data indicated that the maximum His bundle electrogram amplitude was usually greater than 1 mV and that there was a 50% decrease in the potential recorded 1 mm on either side of the maximal electrogram. At 2-3 mm distance from the maximal electrogram, the His bundle potential in man disappeared. They concluded that when a recorded His bundle electrogram was smaller than 1 mV, the electrode probe was at least 2-3 mm from the His bundle and that a fine adjustment would place it within 1 mm of the His bundle.

Application and Results

Extensive application of this recording technique by Krongrad et al., (4) demonstrated predictable locations for the proximal His bundle in living patients with common forms of congenital heart disease. Intracardiac electrograms of the His bundle were usually recorded along a line extending from the ostium of the coronary sinus toward the medial aspect of the tricuspid valve. On this line the electrograms were most commonly found along an area 5-10 mm wide, starting about 10 mm anterior to the coronary sinus. While the location of the recorded electrograms varied somewhat among patients with the same type of congenital heart disease, certain patterns were evident. The location of the electrograms of the proximal His bundle were similar in patients with secundum type atrial septal defect, tetralogy of Fallot, ventricular septal defect, and transposition of the great vessels.

In most patients with endocardial cushion defects, the electrograms were recorded immediately adjacent to the coronary sinus, confirming a posterior shift of the His bundle in these patients. Others (12,13) have confirmed these intraoperative recordings and advocated their routine use in patients with all types of endocardial cushion defects.

Variable location of the proximal His bundle has been found in patients with common atrium (12). The delineation of the His bundle in Ebstein's anomaly of the atrioventricular valve has been helpful in avoiding heart block in patients with this condition (6,12). Thus, it has appeared that intraoperative mapping is indicated in patients with abnormal atrial anatomy.

Delineation of the specialized conduction tracts distal to the tricuspid valve ring have outlined the distal His bundle and right bundle branch block in patients with uncomplicated ventricular septal defect, tetralogy of Fallot, double outlet right ventricle, and others (5). With the possible exception of the atrioventricular canal or the canal-type posterior ventricular septal defect, mapping of the distal bundle appears to have little to offer to the surgeon in the uncomplicated forms of congenital heart surgery.

However, with the advent of this technique, risk of injury to the conduction system and subsequent complete heart block has been decreased in operations on the more complex congenital heart lesions. Somerville