Automaticity of the Kent Bundle: Confirmation by Phase 3 and Phase 4 Block

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Automaticity in the Kent anomalous atrioventricular bundle has been postulated to occur on the basis of electrocardiographic recordings. This hypothesis was confirmed using intracardiac recordings and programmed stimulation in a patient with pre-excitation. It was supported, in part, by demonstrating the presence of phase 3 and phase 4 block in the Kent bundle during decremental atrial pacing. The existence of automaticity in the Kent bundle may explain the manifestation of intermittent pre-excitation in certain patients. Furthermore, the presence of phase 3 and phase 4 block makes the likelihood of rapid antidromic conduction over the Kent bundle pathway unlikely within this subgroup.

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Case Report

A 60 year old man was referred to the hospital for electrophysiologic evaluation of atrial fibrillation and wide complex tachycardia. The patient had a 9 year history of palpitation and nonsustained ventricular tachycardia. Prior cardiac catheterization revealed significant narrowing of the left anterior descending and circumflex coronary arteries. Medications on admission included digoxin and propranolol. Blood pressure, pulse rate and physical examination were normal. An electrocardiogram at rest disclosed atrial fibrillation with a ventricular response of 70 beats/min and intermittent wide and bizarre conducted beats.

Electrophysiologic evaluation. The patient was studied in the postabsorptive, nonsedated state after elective direct current cardioversion was performed. Four quadripolar catheters, introduced percutaneously, were positioned under fluoroscopic control in the right atrial appendage, across the tricuspid valve for recording of the His bundle, coronary sinus and right ventricular apex. The distal pair of electrodes was used for stimulation and the proximal pair for recording local electrical activity. Intracardiac electrograms were filtered at 30 to 500 Hz and were simultaneously displayed with three surface electrocardiographic leads on a multichannel oscilloscope (Electronics for Medicine VR-16). A specially designed programmed digital stimulator (Bloom Associates) with an isolated constant current source delivered rectangular impulses of 1 ms duration at twice diastolic threshold. All data were stored on magnetic tape (Honeywell 5600 14 channel analog tape recorder) and were later retrieved on photographic paper at speeds of 100 m/mls for illustrative purposes. Real time recordings were obtained with an ink-jet recorder (Siemens Elema Mingograph) at paper speeds of 100 to 200 m/mls. The stimulation protocol included the introduction of single and double extrastimuli and rapid pacing from multiple atrial and ventricular sites at several paced cycle lengths.

During sinus rhythm, the AH interval was 85 ms (normal 60 to 125) and the HV interval was 45 ms (normal 35 to 55). Atrial pacing at cycle lengths from 460 to 370 ms from
the high right atrium resulted in progressive pre-excitation and inscription of the His deflection after the onset of the QRS complex (Fig. 1). Pre-excitation was not evident at longer cycle lengths, and pacing at shorter cycle lengths resulted in 2:1 conduction over the His-Purkinje system. Delta wave configuration during pre-excitation localized the accessory pathway to the right posterior or posterior paraseptal area (7). Atrial fibrillation that developed after a spontaneous atrial premature depolarization prevented further programmed atrial stimulation.

A representative recording of atrial fibrillation is shown in Figure 2. The third and fourth beats are narrow complexes and are preceded by a His bundle potential with an HV interval of 45 ms. The second complex, which has an intermediate coupling interval compared with the other beats, is aberrantly conducted without a preceding His bundle potential. It has a similar configuration and axis compared with the pre-excited beats induced during atrial pacing.

**Discussion**

**Causes of intermittent pre-excitation.** Approximately 50% of patients with Wolff-Parkinson-White syndrome demonstrate intermittent pre-excitation (8). In contrast to patients who exhibit constant pre-excitation, they have longer anterograde refractory periods and are less likely to develop ventricular fibrillation. Several factors may account for intermittent pre-excitation, none of which was responsible for the findings in our study. In addition to depressed conduction of the accessory pathway, the presence of two anterograde accessory pathways that conduct simultaneously may result in intermittent fusion resembling normally (narrow QRS complex) conducted beats (9,10). Alteration of sympathetic tone can differentially improve conduction of an impulse across the AV node and accessory pathway and is usually observed during exercise or after isoproterenol infusion (11). Intermittent pre-excitation due to Wenckebach periodicity of the accessory pathway has been reported to occur infrequently (12). Intermittent pre-excitation can also result from retrograde concealed conduction in the accessory pathway (13,14). This can be shown during atrial pacing when narrow complex beats are observed and pre-excitation is only manifest during periods of AV nodal block. There was no

Figure 2. Intracardiac recording during atrial fibrillation. The second beat is a spontaneous wide complex beat without a preceding His bundle potential and represents conduction over the accessory pathway. This beat has the same configuration and axis as those of the pre-excited beats demonstrated in Figure 1. This beat occurs at an intermediate coupling interval compared with other beats shown. The third and fourth beats represent examples of phase 4 and phase 3 block, respectively. See text for explanation. Abbreviations are as in Figure 1.
conduction across the accessory pathway during 2:1 AV nodal block in our study (Fig. 1d).

Evidence for Kent bundle automaticity. Definitive electrophysiologic confirmation of Kent bundle automaticity has been lacking. In this study, the demonstration of phase 3 and 4 block in the Kent bundle provides evidence for automaticity. Phase 3 block occurs when an impulse reaches the conduction fiber during its phase of rapid repolarization, thereby resulting in impaired conduction (15). Phase 4 block occurs in fibers that exhibit automaticity and requires that an impulse reach the fiber during electrical diastole at a resting membrane potential less negative than that achieved immediately after repolarization (16).

During decremental atrial pacing in our study, long and short cycle lengths were conducted across the AV node–His-Purkinje system without evidence of pre-excitation. However, at intermediate pacing lengths, pre-excitation became manifest. This response is atypical in that atrial pacing, particularly from the ipsilateral side of the accessory pathway, produces progressive pre-excitation until refractoriness of the pathway is reached. Conduction then proceeds solely over the His-Purkinje system, provided that the refractory period is shorter than that of the accessory pathway. The response observed in our patient is most readily explained on the basis of latent pacemaker activity of the accessory pathway. Pacing at long cycle lengths resulted in phase 4 block of the accessory pathway. Pacing at short cycle lengths resulted in phase 3 block in the accessory pathway. It is proposed that spontaneous diastolic depolarization of the accessory pathway produces a less negative than normal resting membrane potential at the moment the atrial impulse reached the pathway and resulted in conduction block in the accessory pathway. Conduction of the atrial impulse, therefore, proceeded down the His-Purkinje system, accounting for the narrow conducted complexes. This is contrary to the effects of phase 4 block in the His-Purkinje system where aberration occurs since block occurs in one of the bundle branches.

Atrial pacing at intermediate cycle lengths produced pre-excitation because capture occurred at maximal diastolic membrane potential in the accessory pathway. Pacing at shorter cycle lengths resulted in phase 3 block in the accessory pathway since impulses reached the accessory pathway during phase 3 recovery of the action potential, before membrane potential had fully recovered. An alternative explanation, suggesting that the effective refractory period of the accessory pathway was reached, cannot be completely ruled out.

Phase 3 and phase 4 block also were observed to occur spontaneously. During atrial fibrillation, narrow QRS complexes occurred at short and long ventricular coupling intervals. Aberrantly conducted beats were manifest at intermediate coupling intervals. These latter beats were not preceded by a His bundle potential. They may, therefore, represent spontaneous premature ventricular depolarizations or pre-excited beats. Support for the latter hypothesis includes both the configuration and axis of the beats, which are similar to those of the pre-excited beats induced during atrial pacing, and the intermediate ventricular coupling interval.

Clinical implications. A requirement for phase 4 block includes spontaneous diastolic depolarization of the involved structure. Therefore, its presence in the accessory pathway lends support for the existence of automaticity in the Kent bundle. Phase 4 block in Purkinje fibers usually occurs in diseased tissues. Whether this is also true for the Kent bundle remains speculative. However, the presence of phase 3 and phase 4 block in the Kent bundle has at least two significant consequences. It diminishes the clinical likelihood of rapid antidromic conduction over the Kent bundle since phase 3 block in the pathway is likely to occur; and it may also explain the manifestation of intermittent pre-excitation, particularly that which is dependent on the coupling interval of impulses reaching the accessory pathway.

References