

Demonstration of Entrance Block into the Atrioventricular Node of Man

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SUMMARY

Entrance block of an atrial premature beat (APB) into the atrioventricular node is demonstrated by its lack of effect on the A-V nodal conduction of a subsequent beat which is introduced before the full recovery time of the A-V node. This phenomenon was demonstrated in five patients by using programmed atrial stimulation and His bundle recordings. Entrance block into the A-V node occurred in a narrow range (28–33%) of the basic cycle length and concealed conduction occurred at coupling intervals longer than this range. It appears that entrance block of these early APBs is due to a “functional block” between the atrium and the A-V node. The concept of an entrance block into the A-V node is useful in explaining some forms of the supernormal phase of A-V conduction as well as in the interpretation of complex arrhythmias.

Additional Indexing Words:

Concealed conduction

Full recovery time of A-V node

His bundle recordings

Supernormal phase of A-V conduction

Premature atrial stimulation

IMPULSES which fail to propagate along the entire atrioventricular (A-V) conducting system are called “concealed.” “Concealed conduction” is an electrocardiographic term that refers to the effect which these concealed impulses have on the conduction of subsequent impulses.¹ A premature atrial impulse which is concealed (blocked) within the A-V node may cause delayed A-V nodal conduction of a subsequent atrial beat providing the latter follows the concealed atrial premature beat at a close coupling interval. If the subsequent beat occurs sufficiently late after the concealed

atrial premature beat, the A-V node will have recovered and A-V nodal conduction time of the subsequent beat will be normal. Thus, one of the determinants of seeing electrocardiographic evidence of concealed conduction is the occurrence of the subsequent beat before the full recovery time of the A-V node. A second determinant of concealed conduction is that the nonpropagated premature atrial beat must enter the A-V node. If the premature atrial impulse does not enter the A-V node, refractoriness of this structure is not altered, and consequently no conduction delay of subsequent beats would be expected.

This study was undertaken to demonstrate the phenomenon of entrance block into the A-V node by means of His bundle recordings and programmed atrial stimulation. The relationship of this phenomenon to clinical cardiac arrhythmias will be discussed.

Methods

Right heart catheterization was performed on a total of 15 patients in the postabsorptive, nonsedated state. All subjects were normal except

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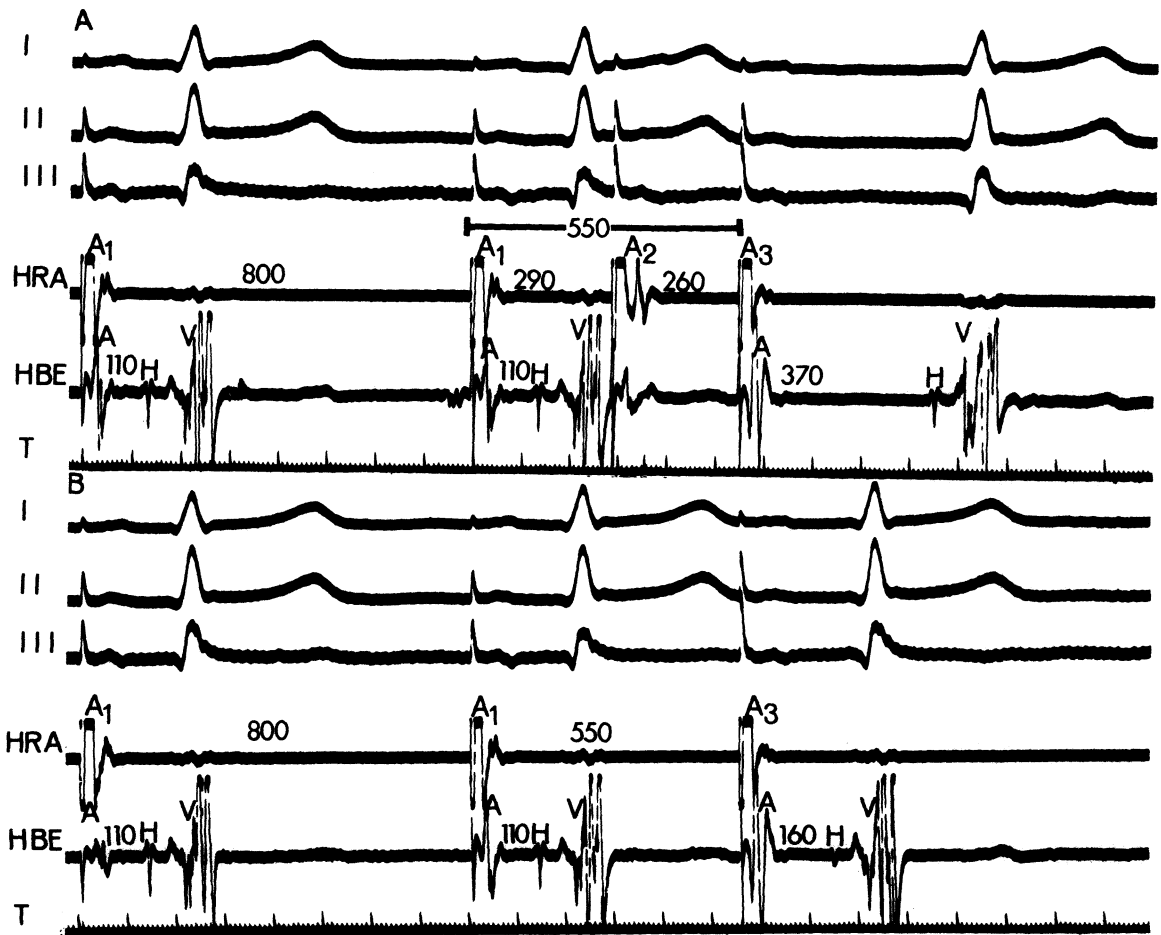


Figure 1

Concealed conduction of an interposed atrial beat (A_2). (Panel A) An A_2 was introduced at a coupling interval of 290 msec and was not followed by a His bundle electrogram. Due to concealed conduction of A_2 the subsequent A_3 had a long A_3 - H_3 interval (370 msec). (Panel B) The influence of concealed conduction was further proved in this panel by omitting A_2 and demonstrating marked shortening of the A_3 - H_3 interval (160 msec). The illustration shows from top to bottom standard electrocardiographic leads I, II, and III, high right atrial electrogram (HRA), His bundle electrogram (HBE), and time lines (T) at intervals of 10 and 100 msec. A = atrial depolarization; H = His bundle depolarization; V = ventricular depolarization; S = stimulus artifact. This sequence and abbreviations are used also in the subsequent figures.

one who had evidence of left anterior fascicular block in the electrocardiogram. None of the subjects was taking cardiac medications. The nature of the procedure was explained in detail and signed consent obtained from each subject. Bundle of His electrograms were recorded as previously described.² Also, previously described,³ a quadripolar electrode catheter was positioned high in the right atrium for simultaneous bipolar atrial stimulation and recording. The right atrium was stimulated with a programmed digital

stimulator*, which delivered rectangular impulses of 1.5 msec at twice diastolic threshold. All equipment was properly grounded.

In all patients the sequence of atrial stimulation was as follows: The atrium was paced at basic cycle length (A_1 - A_1) which was slightly faster than the sinus rate. After every eighth basic beat (A_1) a premature atrial beat (A_2) was introduced. The coupling interval for A_2 (i.e., the

*F. B. N. Electronics, Philadelphia, Pennsylvania.

A_1 - A_2 interval) was the shortest interval producing atrial depolarization which was not followed by a His deflection. This A_1 - A_2 interval was very close to the absolute or effective refractory period of the atrium. The A_1 - A_2 interval was held constant and a third atrial depolarization (A_3) was introduced after A_2 . The A_1 - A_3 interval was then progressively shortened. The conduction time of A_3 to the ventricles was measured with and without A_2 at progressively shorter A_1 - A_3 intervals. The scan of A_1 - A_3 intervals was limited by that point at which A_3 was blocked proximal to the bundle of His.

Three simultaneous ECG leads and time marks at 10 and 100 msec were simultaneously recorded on magnetic tape and subsequently transferred to photographic paper.

The A_1 - A_1 , A_1 - A_2 , and A_1 - A_3 intervals were measured from the high-right atrial electrograms. The A-H intervals were used as a measure of A-V nodal conduction time.

Full Recovery Time of the A-V Node

The end of the full recovery time of the A-V node for a sinus or paced cycle length is defined as that point in time at which a premature atrial beat conducts with a longer A-H interval than the basic beat. The end of the full recovery time marks the beginning of the relative refractory period of the A-V node.

Results

For the purposes of this report, A_2 is the concealed or blocked beat, and A_3 is the subsequent beat.

The phenomenon of concealed conduction, as illustrated in figure 1, was demonstrated in all patients. In panel A, a premature atrial impulse (A_2) was blocked proximal to the bundle of His and the subsequent beat (A_3) was conducted with an A_3 - H_3 interval of 370

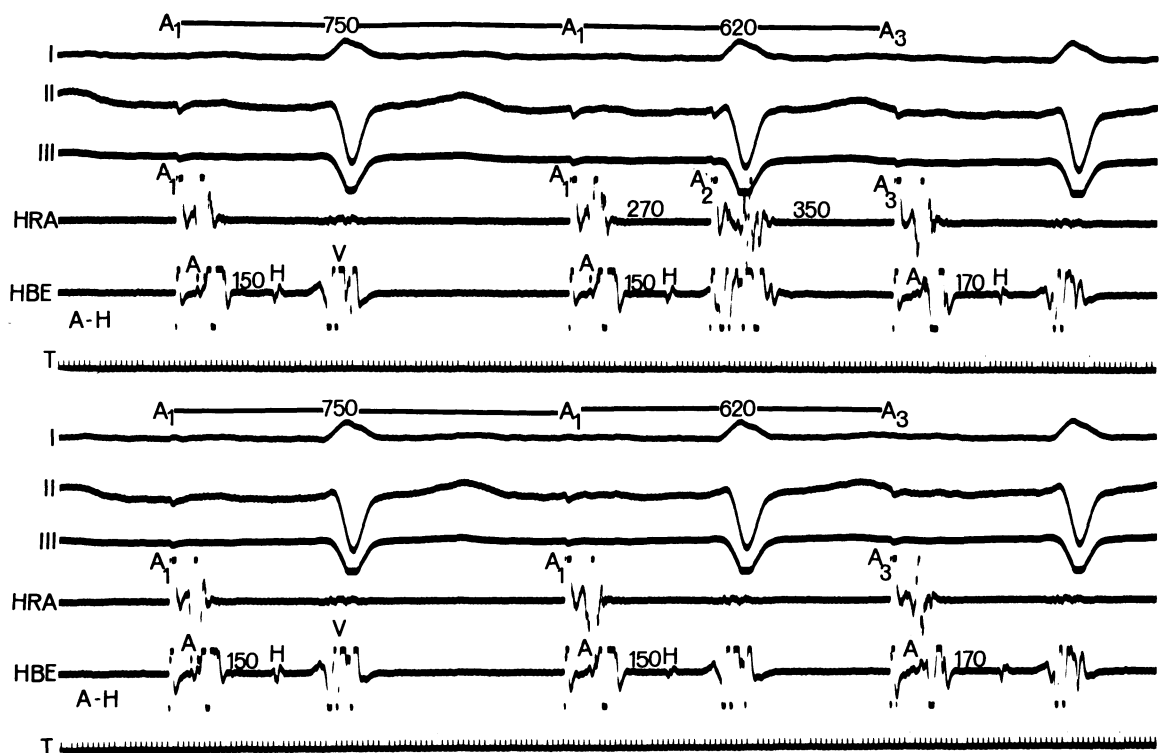


Figure 2

Entrance block into the A-V node for an interposed atrial premature depolarization. (Upper panel) An A_2 was introduced at a coupling interval of 270 msec and was not followed by a His depolarization. The subsequent beat introduced at a coupling interval of 620 msec (shorter than the full recovery time of the A-V node at that cycle length) showed an A_3 - H_3 interval of 170 msec. (Lower panel) The A_3 - H_3 interval remained the same in the lower panel even though A_2 was omitted. This lack of influence of A_2 on the subsequent A_3 - H_3 interval suggests that A_2 did not enter the A-V node.

msec. That A_2 affected the conduction of A_3 is shown in panel B, where A_2 was omitted and the A_3 - H_3 interval significantly decreased.

Entrance block into the A-V node was demonstrated in only five of 15 studies. In 10 patients the atrium was refractory to the A_2 stimulus at relatively long A_1 - A_2 intervals. The phenomenon of entrance block into the A-V node is illustrated in figure 2 and is reflected in the fact that neither the presence nor absence of A_2 affected the conduction of A_3 .

In both figures 1 and 2 the A_3 occurs before the full recovery time of the A-V node, that is, within its relative refractory period, as evidenced by the fact that the A_3 - H_3 interval is longer than the A_1 - H_1 interval. A_3 was made to occur before the A-V node fully recovered from the basic driving cycle by making the A_1 - A_3 interval sufficiently shorter than the A_1 - A_1 interval.

Figure 3 is a representative curve demonstrating entrance block into the A-V node for the premature atrial beat (A_2) for various A_1 - A_3 coupling intervals which are less than the

full recovery time of the A-V node. Basic cycle length is 750 msec. The full recovery time of the A-V node ends at 660 msec as shown by a prolonged A_3 - H_3 interval. The curve demonstrates that the premature atrial beat (A_2) has no effect on the conduction of the subsequent beat (A_3) irrespective of whether A_3 is introduced before the full recovery time of the A-V node i.e., A_1 - A_3 is less than 660 msec or after the full recovery time of the A-V node (A_1 - A_3 greater than 660 msec). The lack of effect of A_2 on the A_3 - H_3 interval at longer coupling intervals than 660 msec does not necessarily demonstrate entrance block because at these long coupling intervals the A-V node may have recovered completely from partial penetration of A_2 . On the other hand, the fact that the A_3 - H_3 interval for shorter coupling intervals than the full recovery period is unaltered by the presence or absence of A_2 does confirm entrance block for A_2 .

The A_1 - A_2 coupling intervals at which entrance block into the A-V node occurred varied from 210 msec to 290 msec with a mean

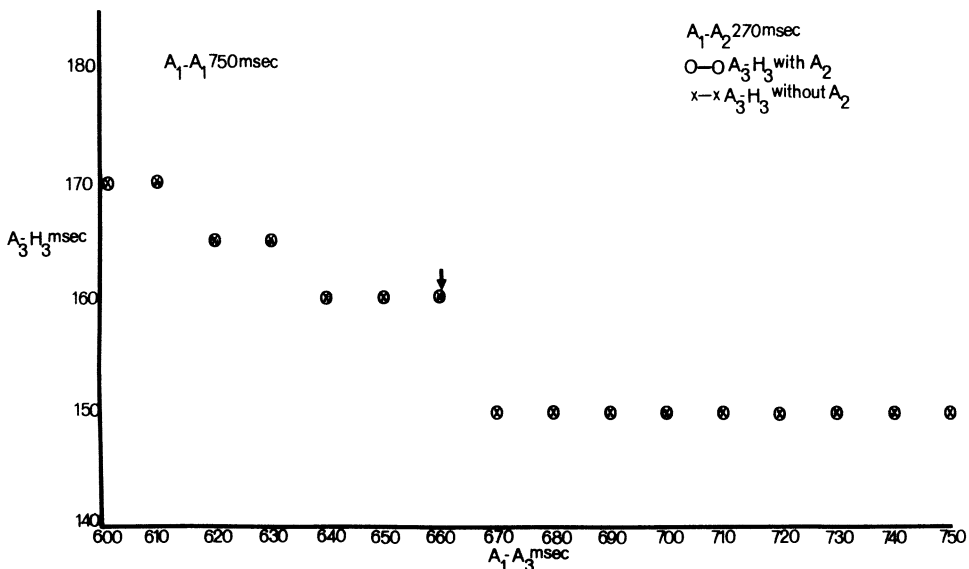


Figure 3

Entrance block into the A-V node of A_2 at varying coupling intervals of A_1 - A_3 . On the abscissa A_1 - A_3 intervals and on the ordinate A_3 - H_3 intervals are plotted. The circles indicate A_3 - H_3 with A_2 and the X's indicate A_3 - H_3 without an A_2 . The arrow indicates the full recovery period of the A-V node at that basic cycle length. The circles and the X's follow the same course. This indicates that A_2 has no influence on the subsequent A_3 - H_3 interval even at shorter coupling intervals than the full recovery period of the A-V node and confirms entrance block of A_2 into the A-V node.

value of 257 msec. The percentage of the basic cycle length at which entrance block of A_2 occurred varied from 28 to 33%.

Discussion

Concealed conduction has been extensively studied and has proven a valuable concept in the understanding of simple and complex cardiac arrhythmias.⁴⁻¹⁰ Less well studied has been the concept of entrance block which has heretofore been applied to certain characteristics of parasystolic foci¹¹ and the sinus node.¹² In the present study, the requisite conditions for entrance block of premature impulses into the A-V node have been studied. These include premature atrial impulses (A_2) which occur at 28 to 33% of the preceding cycle length (A_1-A_1) and lack of A-H prolongation of a subsequent beat (A_3) which occurs prior to the full recovery time of the A-V node.

One could argue that the interposed beat (A_2) might have entered only the upper part of the A-V node and by the time the subsequent beat (A_3) had reached the A-V node the upper part had recovered completely. To support this hypothesis one would have to assume that the full recovery time is different for various portions of the A-V node. Moreover, this hypothesis seems unlikely since, as shown in figure 3, we studied the A-V conduction of the subsequent beat at varying coupling intervals with and without an interposed beat, and even at the shortest coupling interval the interposed atrial premature beat had no effect on A-V conduction. A small degree of penetration cannot be entirely excluded without mapping the whole of the upper part of the A-V node with microelectrodes.

The atrial premature depolarizations that have demonstrated entrance block into the A-V node were introduced at 28 to 33% of the basic cycle length. One could speculate that these early stimuli would produce only a local response and that entrance block is due to the inability of the atrial activation front to reach the A-V node. However, the atrial premature depolarizations that demonstrated entrance block activated the whole atrium as shown by

the high and low atrial electrograms and the P wave on the surface ECG. Entrance block of these atrial premature depolarizations is not the result of a local response but is due to a "functional block" at the junction of the atrium and the A-V node.

An alternate explanation for the lack of influence of A_2 on the A-V conduction of a closely coupled subsequent beat (A_3) can be offered by suggesting that A_2 had entered only one pathway or a portion of the A-V node and the other was free and unaffected to conduct A_3 to the ventricle. But A_2 showed concealed conduction at long coupling intervals, and to explain this on the basis of the above hypothesis, one has to assume that at long coupling intervals A_2 engaged both pathways or portions of the A-V node while at short coupling intervals A_2 entered only one pathway or a portion of the A-V node. This theory has not been proved, and these events can be more easily explained on the basis of an entrance block into the A-V node for A_2 .

Supernormal conduction has come to denote conduction which is "better" than anticipated under the circumstances and not to conduction which is faster than normal.¹³ If the concept of entrance block is not applied to explain some of our figures, one might label them as examples of supernormal A-V conduction. A typical example is shown in figure 2. If one assumes that A_2 did enter the A-V node, then for such a short A_2-A_3 interval A_3 should have a longer A_3-H_3 interval than it did. The absence of a prolonged A_3-H_3 interval might tempt one to designate supernormal A-V conduction for A_3 . The mechanism was demonstrated by omitting A_2 in the subsequent panel and A_3-H_3 was unaffected indicating that A_2 never entered the A-V node. The concept of entrance block would help to explain some forms of the so-called supernormal phase of A-V conduction.

In rapid atrial tachyarrhythmias concealment and entrance block may both be occurring. In atrial tachycardia with block and in atrial flutter with varying block some of the blocked beats may not be entering the A-V node. The occasional failure of a single atrial

premature beat to affect a reentrant A-V nodal tachycardia may relate to entrance block into the A-V node of that premature beat. The concept of entrance block might be useful in elucidating some of the complex arrhythmias.

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