Concealed and Supernormal Atrioventricular Conduction

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Concealed Conduction

The failure of a cardiac impulse to traverse the entire atrioventricular (A-V) conducting system is called concealed conduction. Electrocardiographically, the effects of concealed conduction are reflected in the conduction and/or formation of subsequent beats. The concept of concealed conduction can be applied to explain (1) post-extrasystolic prolongation of the P-R interval, (2) the irregularity of the ventricular response during atrial fibrillation, (3) the slower ventricular response during atrial fibrillation as compared to atrial flutter in the same patient, and (4) alternation of the P-R interval, etc. The recording of His bundle electrograms has permitted us to localize more precisely the area within the A-V conduction system where the impulse is blocked and also the area where conduction of subsequent beats is prolonged. By means of His bundle electrogram recordings, the P-R interval can be divided into the A-H (atrium-to-His bundle) interval which is a measure of A-V nodal conduction time, and the H-V (His bundle-to-ventricle) interval which is a measure of conduction along the His-Purkinje system.

Antegrade Concealed Conduction

An example of antegrade concealed conduction caused by a single premature atrial beat is illustrated in figure 1. The normal P-R interval, of the first sinus beat, is approximately 0.18 sec (A-H plus H-V intervals). An atrial premature contraction (the second P wave) is blocked in the A-V node (proximal to the bundle of His). The partial penetration of this premature beat (concealed) prolongs the refractory period of the A-V node and causes prolongation of the P-R interval of the next sinus beat, which measures 0.23 sec. The His bundle electrogram recording localizes the conduction delay to the A-V node as reflected in the increased A-H interval of 180 msec.

This same mechanism is involved in the prolongation of the P-R interval as shown in figure 2 in which the atrial rate was doubled with 2:1 A-V block. The A-V node is the region of both the concealment of the nonconducted atrial impulses and the subsequent A-V delay. During 2:1 A-V block, when the degree of penetration of the nonconducted atrial beats into the A-V node varies, the subsequent P-R intervals may also vary in their degree of prolongation. Whenever two or more successive impulses are concealed and cause conduction delay of subsequent impulses, repetitive concealed conduction is produced.

Retrograde Concealed Conduction

An example of retrograde concealed conduction caused by an interpolated premature beat II, P, P, P, is shown in figure 3. The nonconducted atrial premature beat prolongs the P-R interval of the next atrial beat. Since retrograde conduction is involved, the P-R interval of this beat is prolonged to 0.23 sec. The ratio of the atrial P wave to the H-V interval is now 3:2. The conduction delay is again to the A-V node and is reflected by the increased A-H interval of 180 msec.

Figure 1

Antegrade concealed conduction. A nonconducted atrial premature beat (second P wave) causes conduction delay within the A-V node (long A-H interval) of the next atrial beat. I, II, III = standard leads; HBE = His bundle electrogram. All simultaneous.

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ventricular contraction is illustrated in figure 3. The premature ventricular beat (second beat) is retrogradely concealed in the A-V node. The next sinus impulse enters the A-V node when this structure is in a state of relative refractoriness, resulting in a prolonged P-R interval. This prolongation of the P-R interval is reflected in the longer A-H interval, i.e., delayed conduction in the A-V node.

Figure 4, with its conventional ladder diagram, illustrates an example in which concealed retrograde conduction of coupled premature ventricular beats results in the A-V nodal Wenckebach phenomenon of subsequent sinus beats. Relative refractoriness of the A-V node induced by retrograde partial penetration (concealment) of the first ventricular premature beat causes the following P-R interval of a sinus impulse to be prolonged from 0.22 to 0.30 sec. The next premature ventricular beat penetrates the A-V node to a greater extent and the subsequent P-R interval is more prolonged than the preceding one, namely to 0.34 sec. Retrograde penetration of the third ventricular premature beat causes such refractoriness of the A-V node that the subsequent sinus impulse is not conducted at all, i.e., the P wave is blocked or nonconducted.

Altered Pacemaker Discharge by Ventricular Premature Beats

An example of a concealed premature ventricular beat altering the discharge rate of
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Figure 4

Retrograde concealed conduction of coupled premature ventricular beats resulting in the A-V nodal Wenckebach phenomenon of subsequent sinus beats (see text).

Figure 5

Concealed retrograde conduction altering the discharge rate of a junctional pacemaker. The H-H interval (HBE lead) denotes the firing rate of the junctional pacemaker. The premature ventricular beat after the third junctional pacemaker beat depolarizes the His bundle and delays the next firing of a junctional pacemaker beat. Arrows indicate expected site of junctional beat.

Figure 6

A type of so-called supernormal A-V conduction. As the R-P interval is shortened from 550 to 265 msec, A-V conduction fails (panels A and B), then resumes (panel C) with further R-P shortening to 240 msec, and again fails when the R-P interval is still further shortened to 200 msec (panel D). The preceding R-R cycles are approximately the same. (See text for discussion.)

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a junctional pacemaker is shown in figure 5. There is an A-V block with the nonconducted P waves being blocked in the A-V node. The ventricles are being activated by a junctional pacemaker (bundle of His). Following the third junctional beat a spontaneous premature ventricular beat occurs. The bundle of His is retrogradely depolarized, thereby resetting the junctional pacemaker. Had the premature ventricular beat not occurred, the next junctional beat would have been expected at the point of the open arrows.

**Supernormal A-V Conduction**

Supernormal A-V conduction is the term applied to the phenomenon in which conduction of impulses is better than expected. Since the phenomenon generally occurs during depressed states of A-V conduction, the term applies not to conduction which is faster than normal but rather to conduction which is less abnormal or totally unexpected. The prevailing view has been that supernormal conduction occurs within a limited period of the cardiac cycle and is a fundamental property of the A-V conducting system.

Figure 6 illustrates a type of so-called supernormal A-V conduction in which, as the P wave moves closer to the preceding R wave, A-V conduction fails (panel B). At still shorter R-P intervals A-V conduction resumes (panel C) and finally at even shorter R-P intervals A-V conduction again fails (panel D).

His bundle recordings indicate the electrophysiologic explanation for this phenomenon. At a given R-P interval A-V conduction fails within the His-Purkinje system because this system has the longest effective refractory period (panel B). At shorter R-P intervals (panel C) A-V conduction resumes because the atrial impulse encounters sufficient A-V nodal delay (long A-H interval) to permit its arrival within the His-Purkinje system after the latter has repolarized more completely. In 15 patients the zone of so-called supernormal A-V conduction was found to be between 30 and 50 msec. At the shortest R-P intervals A-V conduction again fails because the effective refractory period of either the A-V node or atria is encountered (panel D).

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