Alternate Ventriculoatrial Wenckebach Conduction

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SUMMARY Three cases are presented showing retrograde alternate Wenckebach periods. Retrograde alternate Wenckebach periods were defined as 2:1 ventriculoatrial (VA) block in which the conducted beats showed progressive prolongation of conduction (VA) time. The sequence terminates with two or three second-degree atrioventricular blocks in the atrioventricular (AV) node. In the other two, the level of block could not be clearly identified. This report provides further evidence for the concept of multilevel block within the AV node. Retrograde alternate Wenckebach periods may explain some instances of variation of atrial depolarization intervals during episodes of ventricular tachycardia and may be clinically significant.

ALTERNATE WENCKEBACH PERIODICITY has been recently the subject of several reports. \(^1\)\(^-\)\(^7\) This form of second-degree atrioventricular (AV) block is characterized by progressive lengthening of the PR interval of conducted beats until the sequence terminates with two or three blocked P waves. \(^8\) Antegrade alternate Wenckebach has been described as occurring in either a single structure, mainly the AV node, or in two structures. \(^5\)\(^,\)\(^6\) To our knowledge there has been no report of alternate Wenckebach periodicity in the retrograde direction.

In this report we present three cases of pacing-induced retrograde alternate Wenckebach conduction. In one patient, a retrograde His bundle potential could be identified during ventricular pacing that allowed localization of the block at the level of the AV node.

Material and Methods

Three patients were referred to our laboratory for electrophysiologic evaluation of palpitations (two patients) or dizzy spells (one patient). Electrophysiologic investigations were performed in the postabsorptive state. All medications had been discontinued for at least 48 hours and informed consent was obtained.

Catheters were inserted percutaneously through the right femoral vein. One bipolar catheter was positioned at the apex of the right ventricle and another across the tricuspid valve to record His bundle and low right atrial potentials. Electrical activity in the high right atrium or left atrium was recorded through a separate quadripolar electrode catheter. The left atrial electrogram was recorded from the distal coronary sinus in two patients. Simultaneous recordings of three surface leads (I, II and either III or VI) and intracardiac electrograms were displayed on a multichannel oscilloscope and recorded on a photographic recorder* at paper speeds of 50 and 100 mm/sec. The right atrium was stimulated at increasingly rapid rates at twice diastolic threshold. After atrial overdrive pacing retrograde conduction was assessed by pacing the right ventricular for 30 seconds at increasing rates (increments of 10 beats/min). Note was made of the minimal rate at which retrograde Wenckebach phenomenon, 2:1 block and the alternate Wenckebach phenomenon occurred. Retrograde activation of the atria was determined from the sequence of atrial activation, and the low right atrial electrogram recorded from the His bundle lead preceded that from the high right atrium. In two patients, recording of the left atrial electrogram after that from the low right atrium and before the high right atrium was helpful in defining retrograde activation of the atria.

Definitions

Retrograde Conduction Times

VA or SA interval: Ventriculoatrial (VA) conduction time was measured from the stimulus artifact to the earliest detectable atrial electrogram. This was taken as a measure of retrograde conduction time both through the His-Purkinje system and AV node.

Retrograde Alternate Wenckebach

This was defined as 2:1 VA block in which the ventricular beats conducting to the atrium showed progressive prolongation of VA time. This sequence terminated with two or three successively blocked beats.

Results

The pertinent clinical and electrophysiologic findings are summarized in table 1. In two of the patients retrograde alternate Wenckebach periods were terminated by three ventricular beats not being conducted to the atria. In the other patient they were terminated by two ventricular beats.

Retrograde Alternate Wenckebach Periods Terminated by Three Blocked Ventricular Beats

Figures 1–3 were recorded in a 73-year-old patient (case 1). Atrial pacing at increasing rates and premature atrial stimulation did not produce a tachy-

cardia. Ventricular pacing at a cycle length of 560 msec (110 beats/min) resulted in 1:1 conduction to the right atrium (fig. 1). Retrograde Wenckebach phenomenon occurred at a cycle length of 510 msec (115 beats/min) (fig. 2, panel A). Two-to-one VA block was noted (fig. 2, panels B and C) at cycle lengths from 430 msec (140 beats/min) to 370 msec (180 beats/min). Retrograde alternate Wenckebach sequences occurred at a cycle length of 320 msec (190 beats/min) (fig. 3). The exact level of block could not be ascertained because His bundle potentials were not identifiable. Thus, with the exception of the fifth ventricular beat, which terminated the retrograde alternate Wenckebach periods and which almost certainly must have occurred at an upper level, presumably the AV node, the level of block of all other beats cannot be accurately determined. Another example of retrograde alternate Wenckebach periods terminated by three ventricular beats was recorded in case 2 (fig. 4).

**Table 1. Clinical and Electrophysiologic Data for Three Patients with Retrograde Alternate Wenckebach Periods**

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Symptoms and clinical diagnosis</th>
<th>ECG</th>
<th>Electrophysiologic findings</th>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>PR</td>
<td>AH (msec)</td>
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<tr>
<td>1</td>
<td>73</td>
<td>M</td>
<td>Palpitations; Old MI</td>
<td>155</td>
<td>65</td>
</tr>
<tr>
<td>2</td>
<td>80</td>
<td>M</td>
<td>Dizzy spells; SSS</td>
<td>230</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>46</td>
<td>M</td>
<td>Tachycardia V Aneurysm</td>
<td>190</td>
<td>100</td>
</tr>
</tbody>
</table>

*Intraventricular conduction delay.

Abbreviations: V = ventricular; MI = myocardial infarction; SSS = sick sinus syndrome; W = antegrade Wenckebach point; RAW = retrograde alternate Wenckebach point.

Retrograde Alternate Wenckebach Conduction
Within the AV Node Terminated
by Two Blocked Ventricular Beats

Figures 5 and 6 were taken from a 46-year-old patient who underwent ventricular aneurysmectomy for ventricular tachycardia. At a ventricular driving cycle length of 780 msec, 1:1 conduction to the atrium was noted (fig. 5, panel B). A Wenckebach phenomenon terminated by a ventricular echo beat occurred at a cycle length of 600 msec (fig. 5, panel C). Two-to-one VA block was recorded at a cycle length of 460 msec (fig. 5, panel D). At a cycle length of 350 msec, retrograde alternate Wenckebach phenomenon occurred (fig. 6). Retrograde His bundle potentials were recorded after the ventricular beats that were not conducted to the atria, localizing the site of block to the AV node. Therefore, 2:1 AV block probably occurred at the upper level of the AV node and the Wenckebach

**Figure 1.** Case 1. Tracings in each panel are ECG leads I, II, V1, high right atrium (HRA) and His bundle electrogram (HBE). Top lines are 1-second time lines. All measurements are in msec. Panel A shows normal sinus rhythm. Panel B shows retrograde conduction to the HRA for a driven cycle length (DCL) of 560 msec.
periodicity occurred at the lower level (fig. 6, ladder diagram).

**Discussion**

The alternate Wenckebach phenomenon has become recognized as a useful tool in the understanding of complex arrhythmias. Amat-y-Leon et al. found that the alternate Wenckebach phenomenon was a common electrophysiologic response during atrial pacing. In a previous study we could induce antegrade alternate Wenckebach periods in 80.5% of 36 patients. In all cases in that series we recognized the level of block at the AV node. This high incidence suggested that alternate Wenckebach periodicity at the AV node may be a physiologic phenomenon. Retrograde alternate Wenckebach periods (as defined) have not as yet been reported. It seems clear that this phenomenon can only be elicited by ventricular pacing if VA conduction is present and if the ventricular pacing rates are high enough. The latter is somewhat difficult to achieve because of the risks involved in pacing the ventricle at rates greater than 200 beats/min. The latter procedure does, however, seem justified in patients with serious ventricular arrhythmias in whom the objective is to induce ventricular tachycardia. Castillo et al. have shown that 2:1 VA block may be produced by ventricular overdrive pacing. These

**Figure 2.** Case 1. The broken lines indicate the stimulus artifacts which are clearly seen in the His bundle electrogram (HBE) lead (vertical lines). Panel A) A retrograde Wenckebach phenomenon occurs at a driven cycle length (DCL) of 510 msec. Panels B and C) A 2:1 ventriculoatrial (VA) block is observed from a DCL of 430 msec to a DCL of 370 msec. Note the increase in VA conduction intervals. HRA = high right atrial electrogram.

**Figure 3.** Case 1. At a driven cycle length (DCL) of 320 msec, retrograde alternate Wenckebach periods terminated by three blocked (to the right atrium) ventricular beats are present. In the diagram it is postulated that the phenomenon occurs at the atrioventricular node level. HRA = high right atrial electrogram; HBE = His bundle electrogram; A = atrium; VA = ventriculoatrial; V = ventricle.
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Figure 4. Case 2. Retrograde alternate Wenckebach period terminated by three blocked (to the atria) ventricular beats. LA = left atrial electrogram; LRA = low right atrial electrogram; A = atrium; VA = ventriculoatrial; V = ventricle.

Figure 5. Case 3. Panel A) Normal sinus rhythm. Panel B) Retrograde conduction to the atria is present for a driven cycle length (DCL) of 780 msec. Note that the left atrium (LA) is activated before the high right atrium (HRA). The ventriculoatrial (VA) intervals are measured from the stimulus artifact to the left atrium (LA) because the right atrium electrogram on the His bundle electrogram (HBE) lead is not clearly seen in every panel. Panel C) A retrograde Wenckebach phenomenon terminated by a ventricular echo-beat (third beat) occurs at a DCL of 600 msec. Panel D) A 2:1 supra-Hisian VA block at a DCL of 460 msec.

Figure 6. Case 3. Retrograde alternate Wenckebach period terminated by two blocked (to the atria) ventricular beats. The last part of the period is shown. Retrograde His bundle potentials are clearly identified. The nonconducted ventricular beats are blocked above the His bundle recording site, probably at the atrioventricular (AV) node. Two levels of block in the AV node are postulated in the ladder diagram. DCL = driven cycle length; HRA = high right atrial electrogram; LA = left atrium; HBE = His bundle electrogram.

The authors attributed VA prolongation to concealed retrograde conduction in the AV node that was terminated by one blocked ventricular beat. If they paced the ventricle at a higher rate the retrograde alternate Wenckebach phenomenon might have been observed.
We have postulated that in our two patients where the precise level of block could not be ascertained because of the absence of observed retrograde His bundle potentials, the block was located within the AV node, as suggested by Schuilenburg. This is supported by our observation in the third patient, in whom retrograde His potentials were recorded after each blocked ventricular beat. However, block in the proximal part of the His bundle or within the atrium cannot be completely excluded.

The mechanism of alternate Wenckebach periodicity is hypothetical. Several authors5, 6, 11, 10 have postulated that the phenomenon may represent horizontal dissociation in the AV node. Amat-y-Leon et al.5 have suggested that the level of block may be different in the AV nodal antegrade Wenckebach periods terminated by two blocked P waves compared with periods terminated by three blocked P waves. He suggests that when two blocked P waves are present the level of the 2:1 block is at the lower site in the AV node than when three blocked P waves are present. To explain alternate Wenckebach periods terminated by three blocked P waves it is suggested that 2:1 block occurs at the upper level, whereas the Wenckebach phenomenon takes place at the lower level. Such explanations may be applied to alternate Wenckebach periods in the retrograde direction. Since it has been postulated that in case 1 the two levels of block were located in the AV node, the level of block during 2:1 block was probably in the lower AV node, with the Wenckebach phenomenon occurring at an upper level. We feel that in case 3 the blocked ventricular beat during 2:1 block occurred at the upper part of the AV node and the second ventricular beat not conducted to the atrium was blocked in a lower level of the AV node.

An alternate mechanism for retrograde alternate Wenckebach is based on longitudinal dissociation of the AV node as suggested by the occurrence of ventricular echo-beat terminating VA Wenckebach periods. Concealed antegrade conduction in the antegrade limb of the reentry circuit may influence retrograde conduction, resulting in two or more blocked ventricular beats. However, such an explanation implies that ventricular echo-beats should also be present at higher pacing rates; we did not observe this.

Clinical Implications

In the presence of tachycardia with wide QRS complexes AV dissociation is one of the major criteria for the diagnosis of ventricular tachycardia. The variations of P waves (or A waves on an esophageal or intracardiac lead) observed during the tachycardia are sometimes interpreted as being related to sinus arrhythmia. We postulate that some of these instances may be related to retrograde Wenckebach conduction15 or to retrograde conduction to the atrium on the basis of retrograde alternate Wenckebach patterns. However, difficulty in differentiating antegrade from retrograde conduction may be present when only a single bipolar intra-atrial lead is recorded because of the possibility of sinus node escapes.

Demonstration of retrograde alternate Wenckebach patterns adds further evidence to the concept of multi-level block within the AV node. Increasing interest in retrograde conduction may show that retrograde alternate Wenckebach phenomenon is more frequent than previously suspected.

References

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*Circulation.* 1980;61:648-652
doi: 10.1161/01.CIR.61.3.648

*Circulation* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1980 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

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