The Wolff-Parkinson-White (WPW) Syndrome with Supernormal Conduction Through the Anomalous Bypass

By Paul L. McHenry, M.D., Suzanne B. Knoebel, M.D., and Charles Fisch, M.D.

Since the original description of the Wolff-Parkinson-White (WPW) syndrome in 1930, a number of mechanisms have been proposed to explain this electrocardiographic syndrome consisting of a short P-R interval and a prolonged QRS with slurring of the upstroke. One of the theories postulates the existence of one or more muscular connections between the atria and ventricles allowing for early and aberrant excitation (pre-excitation) of the ventricles. The anomalous connections have been demonstrated histologically, and there is indirect evidence that these may be truly functional atrioventricular (A-V) bridges.

It has been suggested that the anomalous bypass tissue represents remnants of the embryonic atrioventricular canal displaced before the latter differentiates into specialized conduction tissue. Similar embryonic tissue has been shown to have the capability of conduction of the sinoatrial (SA) impulse to the ventricles. If these bridges are electrophysiologically similar to other cardiac tissues, it should be possible to demonstrate in these tissues supernormal excitation or conduction or both, as first described by Adrian and Lucas in nerve-muscle preparation, subsequently demonstrated in the mammalian heart by Hoff and Nahum and, more recently, documented in man.

The following case of second degree A-V block with intermittent pre-excitation can best be explained by assuming the existence of a period of supernormal excitation or conduction of an anomalous bypass, or both.

Report of Case

The patient, a 72-year-old male, was admitted to the hospital July 21, 1965, because of the recent onset of nausea, anorexia, and loss of weight thought to be due to digitalis. He was first hospitalized in 1961 for active, far-advanced pulmonary tuberculosis. In March 1965, he was digitalized and then placed on 0.1 mg of digoxin daily because of increasing dyspnea and pedal edema.

Physical findings on admission revealed blood pressure of 90 mm Hg systolic and 60 mm Hg diastolic. The heart was normal as to size, rate, rhythm, and sounds. Cardiac fluoroscopy revealed a heart shadow of normal size and configuration. Laboratory studies including blood count, urinalysis, and determinations of blood urea nitrogen (BUN), plasma K, Na, Cl, P02, PCO2, were all within normal limits. Upon withdrawal of digitoxin the patient's symptoms improved rapidly and he was discharged from the hospital.

Electrocardiograms

The ECGs shown in figures 1 to 4 are representative of numerous tracings recorded during this patient's hospitalization.

Figure 1

In this tracing, which was recorded on admission a sinus arrhythmia varies in rate from 90 to 103 per minute. The P-R and QRS intervals measure 0.14 and 0.17 second, respectively. The QRS complexes are aberrant and are upright in all the precordial leads. The ST-T segment shows changes secondary to altered intraventricular...
WOLFF-PARKINSON-WHITE SYNDROME

Figure 1

WPW syndrome type A, with a P-R interval of 0.14 and a P-J interval of 0.30 second.

conduction. On the basis of this and subsequent tracings, an interpretation of WPW syndrome type A was made, with ventricular activation predominantly, if not entirely, through the anomalous pathway.

Figure 2

This tracing, recorded 2 days after admission, demonstrates normal intraventricular conduction, first degree A-V block, and a SA rhythm at a rate of 75 per minute. The P-R interval measures 0.32 second. The QRS is normal in appearance and 0.06 second in duration. The ST-T segments show no abnormalities.

Figure 3

The dominant rhythm is SA in origin with a second degree A-V block and a regular P-R interval measuring 0.68 second. The sinus rhythm is occasionally interrupted by premature P waves (P'). These could represent blocked atrial premature beats, atrial echoes, or retrograde conduction through an anomalous bypass. Three types of QRS complexes can be identified. These include the WPW and normal complexes described in figures 1 and 2 and a third type that is slightly aberrant and terminates the longest R-R intervals (N). The latter QRS complexes probably represent A-V nodal escape beats.

The second degree A-V block varies from 2:1 to 6:5. There are cycles, such as exemplified by the first six P waves and five QRS complexes in aVr, in which the P-R interval preceding the normal QRS shows a gradual prolongation from 0.26 to 0.38 second followed by a blocked P wave, strongly suggesting a Wenckebach type of second degree A-V block. The WPW complexes with a P-R interval of 0.12 to 0.15 second never initiate a series of conducted beats but always follow a normally conducted QRS. Measurement of 118 R-P intervals disclosed that the WPW complexes followed R-P intervals of 0.26 to 0.40 second. P waves with R-P intervals shorter than 0.26 second or longer than 0.40 second were either blocked or demonstrated normal intraventricular conduction (fig. 5).

The cycles of A-V conduction are interrupted either by (1) a blocked sinus P wave (PX) or (2) by a premature P wave with an R-P' of 0.12 to 0.15 second. P' never follows WPW.

Circulation, Volume XXXIV, November 1966
complexes, but only normal QRS complexes which are preceded by the longest P-R intervals, namely 0.36 to 0.40 second (lead III).

**Figure 4**

The rhythm is SA with the P-R intervals preceding the normal QRS complexes showing a gradual prolongation from 0.26 to 0.32 second. Each series of conducted beats is interrupted by a premature P wave after an R-P interval of 0.12 to 0.16 second. The duration of the P-R interval of the WPW complex is equal to that of the R-P interval. The P-J interval of the second normal QRS in each cycle measures 0.38 second while the P-J of the WPW complex measures 0.30 second.

**Discussion**

The diagnosis of WPW syndrome is based on the classical criteria shown in figure 1 and confirmed by the subsequent tracings which demonstrate normalized A-V and intraventricular conduction. Activation of the ventricles appears to proceed entirely through the anomalous pathway as shown in figure 4 in which the P-J interval of the WPW complex measures 0.30 second and the comparable P-R interval of the normalized complex measures 0.32 second. A P-R interval of such duration precludes the possibility of fusion of impulses arriving in the ventricles through the normal A-V junctional tissue and the bypass.

P waves falling after an R-P of 0.26 to 0.40 second give rise to a WPW complex. If the R-P interval is shorter than 0.26 or longer than 0.41 second, the P wave is followed by a normally conducted QRS or is blocked entirely. This relationship is clearly demonstrated in figure 5. Such dependence of the WPW complexes on the R-P interval can best be explained by assuming that the P wave falling within an R-P interval of 0.26 to 0.40 second

*Figure 2*

Normalized A-V and intraventricular conduction. The P-R and P-J intervals measure 0.32 and 0.38 second, respectively.
finds the bypass tissue in a supernormal state of excitation or conduction or both. The supernormal state of the bypass tissue can be best explained by assuming concealed retrograde conduction into the bypass of the immediately preceding normal ventricular wave of excitation. Such concealment is supported by the presence of retrograde P waves, provided one assumes that P' is due to retrograde conduction via the anomalous bypass.

An alternate explanation, namely that the tracings can be interpreted by assuming an intermittent bilateral bundle-branch block (BBB) of second degree is possible but not very likely. Assuming that such a concept was correct the WPW complexes with their short P-R intervals would have to be explained on the basis of complete RBBB and normal conduction via the LBB. Considering the fact that the WPW complexes follow an R-P interval shorter than the normally conducted QRS complexes, one would still have to assume supernormality of LBB while at the same time postulating complete RBBB.

Summary

An unusual case of WPW syndrome demonstrating a supernormal phase of conduction of the anomalous bypass is reported. It is suggested that the supernormality in the bypass tissue was due to concealed retrograde conduction into the bypass of the preceding normal ventricular wave of excitation.

References

Each cycle of atrioventricular conduction is terminated by a retrograde P wave. The P-R interval of the normal QRS complex shows a gradual prolongation from 0.24 to 0.32 second. The P-J of the WPW complex and of the normal complexes measure 0.30 and 0.32 to 0.38 second, respectively, and preclude fusion between impulses arriving through the bypass and A-V junctional tissue.

Of a total of 118 P waves analyzed, 45 fell within R-P intervals of 0.26 to 0.40 second and were followed by WPW complexes. P waves within R-P intervals shorter than 0.26 or longer than 0.40 second were either blocked or conducted with a normal QRS.


Cicero on Aging

We must make a stand, Laelius and Scipio, against old age, and its drawbacks must be atoned for by perseverance; we must fight against old age just as we fight against the force of disease. We must have regard for our health; moderate exercise must be taken, only just so much food and drink used that the strength may be recruited, not oppressed. Nor indeed must the body alone be assisted, but the intellect and the soul, and in a much greater degree; for these also, unless you drop oil on them as on a lamp, are extinguished by old age. And while our bodies grow heavy with the weariness caused by exercise, our minds are rendered buoyant by activity. For as to those whom Caecilius calls "foolish old men of comedy," by these he means the credulous, the forgetful, and dissolute—faults which belong not to old age, but to a lazy, indolent, and sleepy old age. Just as wantonness and lust are faults rather of the young than the old, yet not of all young men, but of those only who are not virtuous, so that foolishness of old age, which is usually called "dotage," is a mark of worthless old men, and not of all.—W. F. MASOM and J. F. STOUT: CICERO: De Senectute: A Translation. London, University Tutorial Press Ltd., p. 14.
The Wolff-Parkinson-White (WPW) Syndrome with Supernormal Conduction Through the Anomalous Bypass
PAUL L. MCHENRY, SUZANNE B. KNOEBEL and CHARLES FISCH

Circulation. 1966;34:734-739
doi: 10.1161/01.CIR.34.5.734
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1966 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/34/5/734

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/