Atrial Depolarization in Wolff-Parkinson-White and Lown-Ganong-Levine Syndrome
* Vectorcardiographic Features

Olga Zoneraich, M.D., ** and Samuel Zoneraich, M.D.†

The atrial depolarization pattern was studied in 22 patients with Wolff-Parkinson-White and Lown-Ganong-Levine syndrome. The influence of the accessory pathways on the shape, magnitude and conduction pattern of the Ps loop was analyzed. An accurate evaluation of the beginning of the delta wave and of the P loop distortions was obtained by using high magnification (1 mV = 30 cm) recordings. The Frank lead system was used. The influence of atrial size (documented by echocardiography) on the Ps loop is emphasized. Special attention has been focused on the terminal vectors as compared to a control group. In Wolff-Parkinson-White syndrome the size of the Ps loop was smaller than in Lown-Ganong-Levine syndrome or in the normal group. When atrial conduction disturbances and/or atrial enlargement was present the Ps loop was larger and distorted. The terminal vectors were abnormally oriented in 75 percent of the patients with Wolff-Parkinson-White syndrome, but only in one with Lown-Ganong-Levine syndrome. The beginning of the delta wave in patients with Wolff-Parkinson-White syndrome was located to the left of the E point in all but two. When the “concertina” effect was present, the direction of the terminal vectors remained unchanged. In four patients with the Lown-Ganong-Levine syndrome, the Ps loop closed, and in three patients, a small opening was present. We suggest that the changes in contour, duration and amplitude of the Ps loop are due to an abnormal pattern of atrial depolarization in Wolff-Parkinson-White syndrome.

For the last decade, renewed interest has been focused on the Wolff-Parkinson-White syndrome. Cardiac mapping and echocardiographic studies have been employed to elucidate the location of the accessory pathways and to correlate them with abnormal patterns of contraction of the interventricular septum and of the posterior wall of the left ventricle. Few reports of vectorcardiography have centered on the Ps loop in patients with Wolff-Parkinson-White and Lown-Ganong-Levine syndromes.

The present study analyzes: 1) the influence of accessory atrioventricular pathways on the shape, magnitude and conduction pattern of the Ps loop with special attention to its terminal vectors, 2) the influence of atrial size (documented by echocardiography) on the above atrial parameters.

MATERIAL AND METHODS

The study group consisted of 22 patients with Wolff-Parkinson-White syndrome. They ranged in age from 18 to 84 years (mean 45.8 years). Fifteen were women and seven were men. Eleven patients had Wolff-Parkinson-White type A with the delta wave oriented anteriorly (right or left). Four patients had type B and the delta wave was oriented posteriorly to the left. Seven patients had Lown-Ganong-Levine syndrome. Sixteen of the total group were normal and six had associated cardiac diseases (two had hypertension, one patient had primary myocardial disease and three coronary artery disease).

Twenty-two normal subjects matched for age and sex served as a control group. Twelve lead electrocardiograms were recorded prior to recording the vectorcardiograms. Frontal, horizontal and right sagittal vectorcardiograms (using the Frank system) were recorded with a Hart-Electronics

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<th>Table 1—Magnitude in mV and Duration in Seconds of Ps Loop</th>
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LGL = Lown-Ganong-Levine syndrome; WPW = Wolff-Parkinson-White syndrome

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Figure 1. Forty-year-old marathon runner with Wolff-Parkinson-White syndrome. The upper panel shows type A QRS loop. The delta wave is oriented anteriorly and to the left. The lower panel shows the Ps loop. A large notch is seen on the efferent limb. The O point is located to the left of the E point.

PV-5 vectorcardiograph. By using an automatic adjustable beam blanking device, one can record less than a complete heart cycle. This procedure made it possible to record a very clear vector P loop.

The starting point of the delta wave was clearly visualized. The cut-off frequency response was 100 Hz. The vectorcardiographic loops were interrupted at a rate of 500/sec. In all tracings the inscription was interrupted by the large end of the time dash.

The study of atrial conduction requires a high degree of magnification. In this study, magnification of the Ps loop averaged 3 cm for 0.1 mV. Left atrial size was assessed by echocardiography.

Figure 2. Thirty-six-year-old woman with Wolff-Parkinson-White type B. The Ps loop is small and smooth with dense conduction delays. The anterior component is missing. The O point is to the left of the E point.
RESULTS

Table 1 summarizes the magnitude of the maximal vector and the duration of the Ps loop in patients with Wolff-Parkinson-White and Lown-Ganong-Levine syndrome. The Ps loop in normal subjects has been described elsewhere. In Wolff-Parkinson-White syndrome type A, the maximal vector varies between 0.08 to 0.15 mV with a mean of 0.12 mV (Fig 1). In type B, the maximal vector is smaller with a mean of 0.09 mV (Fig 2). In Lown-Ganong-Levine syndrome, the maximal vector is larger (mean 0.13 mV). The duration of the Ps loop is smaller in type B and is nearly normal in Lown-Ganong-Levine syndrome. The contour of the Ps loop is smoother in type B (Fig 2) than in type A (Fig 3). Four patients with type A Wolff-Parkinson-White syndrome and two patients with type B have a duration of the Ps loop of 0.12 sec or more. Three
of these six patients had an enlarged left atrium. In these three patients, the Ps loop was very distorted and larger (Fig 4).

Table 2 summarizes the orientation of the terminal vectors of the Ps loop. In patients with Lown-Ganong-Levine syndrome, the orientation of the terminal vectors in all but one was the same as in normal subjects, ie, to the right superiorly and posteriorly. In patients with Wolff-Parkinson-White type A or B a different orientation of these terminal vectors is seen.

The starting point (O) of the QRS loop (delta wave) was to the left of the E point (Fig 1,2) in all but two of the patients with Wolff-Parkinson-White syndrome type A or B. In the normal subjects, the O point is always to the right, superior and posterior to the E point (Fig 5).

The Ps loop in patients with Lown-Ganong-Levine syndrome has a nearly normal configuration, but the O and E points are superimposed (Fig 6). In three patients, a small aperture was present.

**Discussion**

It is generally agreed that in Wolff-Parkinson-White syndrome some areas of the ventricles are activated early through accessory conduction pathways.

These abnormal pathways have been located at different sites of the heart: the Kent bundle between the atrial and ventricular muscle, James fibers between the atrial septum and His bundle, and Mahaim fibers between His bundle or bundle branches and the septal myocardium.

It was proved by cardiac mapping that the duration of the QRS complex is influenced by the location of the accessory pathways.

Patients with left ventricular preexcitation have a relatively shorter ventricular activation time, the delta wave is less prominent and QRS complex presents less aberrancy. This fact is explained by the longer pathway between the sinus node and the input to the left sided connection, and thus, more of the ventricular muscle could be activated through the normal pathways.

Boineau et al suggested a dynamic relation between the pattern of atrial activation and the degree of anomalous ventricular excitation in this syndrome. These authors believe that non-uniformity of atrial activation also influences the pattern of QRS complex.

![Figure 5. Electrocardiogram and vectorcardiogram of a 35-year-old normal subject. The electrocardiogram shows a P wave duration of 0.10 second. The Ps loop is smooth. The maximal vector is oriented inferiorly, posteriorly and to the left. An initial conduction delay is seen in the efferent limb between the 20 and 25 msec vectors. A second notch is seen in the afferent limb. In all tracings the straight line indicates 0.1 mV. F = frontal; H = horizontal; S = sagittal.](image-url)
It could be expected that the early input to the ventricles through the accessory pathways will distort the known pattern of the Ps\textsubscript{E} loop. This distortion will depend upon the number and location of the abnormal A-V bridges but also upon the activation pattern of the atria. The duration of the Ps\textsubscript{E} loop in our cases varied between 0.06 sec and 0.12 sec. The fast input to ventricles through one or more accessory pathways can change the Ps\textsubscript{E} loop. A superimposed delta vector distorts the P-vector and changes the contour and duration of the Ps\textsubscript{E} loop.

Despite recent progress in cardiac mapping, the location of the accessory pathways requires further elucidation. Hence, it would seem premature to describe a typical pattern of Ps\textsubscript{E} loop in Wolff-Parkinson-White types A and B. Furthermore, recent studies, making things more complicated, described five or even six types of Wolff-Parkinson-White syndrome.\textsuperscript{1,2,13}

Our data showed that with the exception of some overlapping: a) the duration and the magnitude of the Ps\textsubscript{E} loop in type A is greater than in type B (Table 1); the Ps\textsubscript{E} loop is smoother in type B than in type A; c) when intraatrial conduction disturbances and/or when atrial enlargement is present the shape of the Ps\textsubscript{E} loop is distorted (type A or B).

The existence of abnormal pathways at the atrial level in patients with Wolff-Parkinson-White syndrome is yet to be proved. This is a challenging problem which could explain some very distorted patterns. When the conduction at the ventricular level shifted completely, through the abnormal pathway, (concertina effect) the Ps\textsubscript{E} loop became somewhat smaller with denser conduction but the shape and the direction of the terminal vectors remained unchanged. The orientation of the terminal vectors fails to indicate the location of the accessory pathways due to large variations in vector directions. The starting point of the QRS, i.e., beginning of the delta wave, is well visualized in the tracings (Fig 2). Whereas in normal subjects (Fig 5) this point is located to the right, superior and posterior to the E point, in patients with Wolff-Parkinson-White syndrome the delta waves starts to the left of the E point (Fig 2) in all but two patients.

In patients with Lown-Ganong-Levine syndrome, the shape, magnitude and conduction pattern is nearly normal (Fig 6). In four cases, the Ps\textsubscript{E} loop is closed (O and E points coincide). In the rest of the cases, a small aperture is present. Whether this pattern is due to conduction through James fibers or to a “fixed difference in the degree of pre-excitation”\textsuperscript{12} is questionable. Further studies in a larger number of patients including cardiac mapping, will undoubtedly contribute to the elucidation of this mechanism.

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