Value of the 12 Lead Electrocardiogram in Diagnosing Type and Mechanism of a Tachycardia: A Survey Among 22 Cardiologists

HEIN J. J. WELLENS, MD, FACC, PEDRO BRUGADA, MD, WILLIAM F. HEDDLE, MD
Maastricht, The Netherlands

Information from programmed electrical stimulation of the heart has improved our ability to diagnose the site of origin and mechanism of a tachycardia from the 12 lead electrocardiogram. To test this hypothesis, the 12 lead electrocardiograms of a 12 year old girl with the Wolff-Parkinson-White syndrome showing four different types of tachycardia were sent for interpretation to 30 leading electrocardiologists, 22 of whom responded. A correct diagnosis of all four tachycardias was made by 13. Three or two of the tachycardias were correctly diagnosed by four and five cardiologists, respectively.

The outcome of our study indicates that the pathway and mechanism of tachycardia can frequently be predicted from the 12 lead electrocardiogram alone.

Methods

The five electrocardiograms in the preceding article (Fig. 1) (7) were sent to 30 cardiologists. In the accompanying letter, the only information given was that the tracings were from a 12 year old girl suffering from paroxysmal tachycardia. The cardiologists were asked to interpret all five electrocardiograms. They were not informed that we were going to analyze their responses, or that the results would be published. The answers of the 22 cardiologists who responded were then compared with our own interpretations made after the electrophysiologic study (7).

After the electrophysiologic study (7), the following interpretations were considered correct:

Electrocardiogram A: Right-sided pre-excitation.
Electrocardiogram B: Antidromic circus movement tachycardia using a left-sided accessory pathway for atrioventricular (AV) conduction.
Electrocardiogram C: Antidromic circus movement tachycardia using a right-sided accessory pathway for AV conduction.
Electrocardiogram D: Orthodromic circus movement tachycardia using a right-sided accessory pathway for ventriculoatrial (VA) conduction.
Electrocardiogram E: Orthodromic circus movement tachycardia using a left-sided accessory pathway for VA conduction. The changing RR intervals in the limb leads of electrocardiogram E were the result of alternating AV nodal conduction times (dual AV nodal pathways).

The theoretical possibilities to explain the five electrocardiograms are listed in Table 1.

Results

The responses varied from lengthy discussions concerning the entire range of possibilities to a single diagnosis of each of the five electrocardiograms. The reasoning behind a certain diagnosis, therefore, is not clear for all observers.

Electrocardiogram A. All observers diagnosed right-sided pre-excitation. Several expressed doubts about their ability to localize the accessory pathway exactly without having information about the QRS configuration during “pure” pre-excitation (exclusive atrioventricular [AV] conduction over the accessory pathway only).

Electrocardiogram B. This tachycardia was rightly interpreted by 13 cardiologists. In five instances, orthodromic
Figure 1. Five 12 lead electrocardiograms recorded during the first electrophysiologic study. Panel A shows the electrocardiogram during sinus rhythm. Panels B and C are electrocardiograms during two different recording episodes of wide QRS tachycardia and Panels D and E are electrocardiograms during two different episodes of narrow QRS tachycardia. See text for further explanation.

circus movement tachycardia with right bundle branch block was considered to be the most likely diagnosis (possibility 3a in Table 1). In two instances AV nodal tachycardia with right bundle branch was selected (3b in Table 1) and in one instance, the possibility was raised of a combination of Mahaim fibers and an atrio-Hisian bypass.

Electrocardiogram C. This tachycardia was correctly diagnosed by the same 13 cardiologists who made the right diagnosis of electrocardiogram B. Four of the five who selected orthodromic circus movement tachycardia with right bundle branch block for electrocardiogram B now made the diagnosis of an orthodromic circus movement tachycardia with left bundle branch block. Also, the two who considered AV nodal tachycardia with right bundle branch as the most likely explanation for electrocardiogram B now selected the same type of tachycardia but with left bundle branch block. Again, the one cardiologist who postulated a combination of a Mahaim fiber and an atrio-Hisian bypass advanced this possibility for electrocardiogram C. Lastly, one observer raised the possibility of anterograde conduction over a third bypass tract to explain the QRS configuration of electrocardiogram C.

Electrocardiogram D. Twenty-one cardiologists correctly diagnosed an orthodromic circus movement tachycardia with AV conduction over the atrio-Hisian pathway and ventriculoatrial conduction over an accessory AV pathway. One of the 21 did not specify the location of the accessory pathway. The others predicted a right-sided location. One made a diagnosis of an AV nodal tachycardia with anterograde conduction over a slowly conducting AV nodal pathway and retrograde conduction over a fast AV nodal pathway.

Electrocardiogram E. Twenty-one cardiologists diagnosed an orthodromic circus movement tachycardia with ventriculoatrial conduction over an accessory pathway. Fifteen diagnosed the accessory pathway as being left-sided. Four did not specify the location of the accessory pathway, and two thought this to be right-sided. One made a diagnosis
Table 1. Differential Diagnosis of the Electrocardiograms Shown in Figure 1

<table>
<thead>
<tr>
<th>Panel</th>
<th>Features</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>The ECG recorded during sinus rhythm suggests a right lateral location of the accessory pathway (4).</td>
</tr>
<tr>
<td>B</td>
<td>Regular wide QRS tachycardia, rate 185 beats/min; QRS width 0.14 second. The QRS complex has a right bundle branch block configuration with a concordant pattern in the precordial leads. <strong>Possibilities:</strong> 1) Supraventricular tachycardia with atrioventricular (AV) conduction over a posterolateral left-sided accessory pathway. This includes: a) atrial tachycardia with AV conduction over the accessory pathway; b) antidromic circus movement tachycardia with ventriculoatrial conduction over the AV node or another accessory pathway. 2) Ventricular tachycardia. 3) Supraventricular tachycardia with functional right bundle branch block. This includes: a) orthodromic circus movement tachycardia; b) AV nodal tachycardia; c) atrial tachycardia.</td>
</tr>
<tr>
<td>C</td>
<td>Regular wide QRS tachycardia, rate 185 beats/min; QRS width 0.14 second. The QRS complex has a left bundle branch block configuration. <strong>Possibilities:</strong> 1) Supraventricular tachycardia with AV conduction over a right-sided accessory pathway. Including: a) atrial tachycardia with AV conduction over the accessory pathway; b) antidromic circus movement tachycardia with ventriculoatrial conduction over the AV node or a second accessory pathway. 2) Ventricular tachycardia. 3) Supraventricular tachycardia with functional left bundle branch block. Including: a) orthodromic circus movement tachycardia; b) AV nodal tachycardia; c) atrial tachycardia.</td>
</tr>
<tr>
<td>D</td>
<td>Regular narrow QRS tachycardia, rate 175 beats/min. P waves follow the QRS complex and are negative in leads II, III, aVF and positive in lead aVL. The PR interval is longer than the RP interval. These findings suggest an orthodromic circus movement tachycardia using a right-sided accessory pathway for ventriculoatrial conduction.</td>
</tr>
<tr>
<td>E</td>
<td>Initially irregular (in limb leads) narrow QRS tachycardia. P waves follow the QRS and are negative in leads I and II and positive in lead aVR. These findings suggest an orthodromic circus movement tachycardia with ventriculoatrial conduction over a left-sided accessory pathway. The irregular RR intervals with a constant RP interval suggest differences in AV nodal conduction as in the presence of more than one AV nodal pathway.</td>
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of atrial tachycardia. Fifteen commented on the irregular RR intervals seen in leads I to aVF. All indicated that dual AV pathways was the most likely explanation. Thirteen electrocardiographers gave the correct interpretation of all five electrocardiograms as their first diagnosis.

**Discussion**

Intracardiac recordings and programmed electrical stimulation of the heart have been of great help in defining the electrocardiographic characteristics of the different types of regular narrow (<0.12 second) QRS tachycardias and in making the distinction between a supraventricular and a ventricular origin of a wide (≥0.12 second) QRS tachycardia (1–6). In patients with the Wolff-Parkinson-White syndrome, the correlation between the electrocardiograms during sinus rhythm and the findings during intraoperative epicardial mapping has opened the possibility of predicting the site of the ventricular end of the accessory AV pathway (8).

Electrocardiogram A (Fig. 1) clearly shows the Wolff-Parkinson-White syndrome. Using the classification of Gallagher et al. (8), the ventricular insertion of the accessory pathway has to be localized on the anterior right ventricle. As they noted, one has to be careful in using the electrocardiogram during sinus rhythm for localizing the accessory pathway if only a small part of the ventricle is activated by way of the accessory pathway. In our patient, the P-delta wave interval and the width of the delta wave and QRS complex indicate that there is an important contribution to ventricular excitation by activation over the accessory pathway (9).

**The interpretation of electrocardiogram B** will at first be influenced by the information given by electrocardiogram A. Therefore, the diagnosis of a circus movement tachycardia with AV conduction over the atrio-Hisian pathway and subsequent right bundle branch block is understandable. The QRS configuration of lead V1, showing a “rabbit ear” pattern, the concordant pattern in the precordial leads (5,10) and electrocardiogram E should, however, strongly suggest the possibility of a second accessory AV pathway located on the left side of the heart. For electrocardiogram B, a
Table 2. Results of the Interpretation by 22 Observers of the Electrocardiograms Shown in Figure 1

<table>
<thead>
<tr>
<th>ECG</th>
<th>Correct Diagnosis</th>
<th>Observers With Correct Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Pre-excitation via right-sided accessory pathway</td>
<td>22 of 22</td>
</tr>
<tr>
<td>B</td>
<td>Antidromic circus movement tachycardia over left-sided accessory pathway</td>
<td>13 of 22</td>
</tr>
<tr>
<td>C</td>
<td>Antidromic circus movement tachycardia over right-sided accessory pathway</td>
<td>13 of 22</td>
</tr>
<tr>
<td>D</td>
<td>Orthodromic circus movement tachycardia with right-sided accessory pathway</td>
<td>19 of 22</td>
</tr>
<tr>
<td>E</td>
<td>Orthodromic circus movement tachycardia with left-sided accessory pathway</td>
<td>15 of 22</td>
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ECG = electrocardiogram.

circus movement tachycardia with AV conduction over a left-sided accessory pathway then becomes the most attractive explanation.

The diagnosis of electrocardiogram C as being the result of a circus movement tachycardia with anterograde conduction over a right-sided accessory pathway is supported by electrocardiogram A. Again, this diagnosis is reached by combining the information from the different electrocardiograms. However, several other interpretations can be correct if one looks at electrocardiogram C alone (Table 1).

Electrocardiograms D and E show tachycardias with a narrow QRS complex. Statistically in the patient with the Wolff-Parkinson-White syndrome, a circus movement tachycardia with AV conduction over the AV node and ventriculoatrial (VA) conduction over an accessory pathway becomes the most likely diagnosis (9). VA conduction over an accessory pathway is supported by the P wave following the QRS complex during tachycardia (6). The configuration of the P wave supports a right-sided atrial insertion in electrocardiogram D (11) and a left-sided insertion in electrocardiogram E (2). An additional problem is presented by the changing RR intervals seen in the limb leads of electrocardiogram E. Most cardiologists correctly interpreted this finding as being the result of more than one anterograde AV nodal pathway.

By weighing and combining the different possibilities, 13 observers (58%) made a correct diagnosis of all four tachycardias. This is not only a compliment to the abilities of the electrocardiographers who reviewed the tracings, but also illustrates that the pathway and mechanism of a tachycardia can frequently be predicted from the 12 lead electrocardiogram alone.

We are indebted to the following colleagues who were willing to spend time and effort to interpret the electrocardiograms: Masood Akhtar, MD, Milwaukuee, Wisconsin; Agustin Castellanos, MD, Miami, Florida; Phillippe Coumel, MD, Paris, France; Pablo Denes, MD, Chicago, Illinois; Jéronimo Farré, MD, Madrid, Spain; Guy Fontaine, MD, Ivy, France; Mark E. Josephson, MD, Philadelphia, Pennsylvania; Dennis M, Krikler, MD, London, England; Henri Kulbertus, MD, Liége, Belgium; Richard Langendorf, MD, Chicago, Illinois; Jay W. Mason, MD, Salt Lake City, Utah; Robert J. Myerburg, MD, Miami, Florida; Paul Puech, MD, Montpellier, France; David Ross, MD, Westmead, Australia; Leo Schamroth, MD, Johannesburg, South Africa; Roworth A. J. Spurrell, MD, London, England; Paul Touboul, MD, Lyons, France; John Uther, MD, Westmead, Australia; Albert L. Waldo, MD, Birmingham, Alabama; Menashe B. Waxman, MD, Toronto, Ontario, Canada; Christopher J. Wyndham, MD, Houston, Texas and Douglas Zipes, MD, Indianapolis, Indiana.

References


