The Spatial Orientation of the Plane Including the Mean QRS and T Vector of the Normal Electrocardiogram

By Noboru Kimura, M.D., Ph.D.

For measurement of the spatial orientation of planes in the analysis of the spatial vectorcardiogram, a simple device is developed to be used with Simonson's vector analyzer for the conventional electrocardiogram. The prospective value of this method is shown for the measurement of the plane including the mean QRS and T vector.

There is some evidence\(^1, \, 2\) that the spatial angle between the mean QRS and T vector might serve as an important criterion for the diagnosis of ventricular hypertrophy or coronary insufficiency, although the angle was not actually measured. Recently, a method has been described\(^3\) to construct and measure this angle from the conventional electrocardiogram. With this method, a vector is defined in terms of its direction in the horizontal plane (H\(^\circ\)), its vertical angle (V\(^\circ\), elevation), and its magnitude. The method is simple; the measurement of a vector can be completed within three minutes or less.

For some purposes, at least, it may be desirable to analyze not only the spatial angle between the mean QRS and T vector, but also the spatial orientation of the plane included by these vectors. The present report indicates the findings in exploratory studies.

Method

The spatial orientation of a plane can be measured in terms of the spatial position of a vertical projection on that plane. Using vector analysis for the determination, the vertical projection must pass through the center (C) of the sphere (S, fig. 1) which is the theoretic electrical center of the heart.

The auxiliary equipment for measurement of the orientation of planes and its operation is shown in figures 1 and 2. It consists of a transparent triangle "T," with a semicircle "Y" of a radius of 1.25 inches to fit the surface of the sphere "S," and a bent metallic rod "E." The projection of E passes through the center C. Figure 1 shows the first two steps of the operation. Vector rod A\(_1\) is the mean QRS vector, and A\(_2\) is the mean T vector. The transparent triangle is placed on A\(_1\) and A\(_2\) and thus shows the plane included by the mean QRS and T vector. The prolongation of rod E passes through the center and thus defines the orientation of that plane. Vector rod A\(_3\) is now slid on the surface of S parallel to E.

The triangle T, and rods A\(_1\) and A\(_2\) can now be removed, and the spatial orientation of A\(_3\) measured (fig. 2). The measurement of the vertical angle V is identical with the procedure described before: the distance between the ends of A\(_3\) and the rod (O) in the center of the horizontal plane is measured with a special straight ruler, converting the distance into angles. For measurement of the horizontal angle (H\(^\circ\)), the moveable vector rod P is put in contact with A\(_3\) and the rectangular ruler "U" on the horizontal plane is moved to contact with P (fig. 2). The horizontal angle is now read at the edge of the ruler on the circular scale (left forefinger). The whole procedure of measurement of the spatial orientation of a plane can be done within approximately one minute.

Results and Discussion

Table 1 shows the means and standard deviations of the spatial mean QRS and T vectors of 44 normal men and in the last two columns the mean spatial orientation of the plane including these two vectors. In all normal persons, the plane is oriented posteriorly and upward.

For comparison, table 1 shows the values in six patients with various abnormalities. Patients Flo and Koch had left ventricular strain pattern (S-T depression and T inversion) in lead I and in V\(_6\) (Flo), and in lead I and in

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This investigation was supported (in part) by a grant from the Minnesota Heart Association.

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SPATIAL ORIENTATION OF PLANE

**FIG. 1.** Determination of spatial orientation of plane including the mean QRS and T vector. Step 1: Placing triangle on vectors \( A_1 \) and \( A_2 \). Step 2: Moving vector rod \( A_2 \) parallel to \( E \).

**FIG. 2.** Steps 3 and 4: Measuring of \( V^\circ \) and \( H^\circ \) of \( A_2 \).

leads \( V_4 \) to \( V_6 \) (Koch). Patient Mat had typical left bundle branch block in lead I and \( V_4 \). Patients Lyo and Slo had an abnormal Q with T inversion in lead I and \( V_3 \) to \( V_6 \) (Lyo), or \( V_4 \) and \( V_6 \) (Slo). In patient Slo the R wave was absent in \( V_4 \) to \( V_6 \) (anterior-lateral infarct). In patient Cla, an abnormal Q wave was present in lead III and \( V_6 \), with mainly negative QRS deflection and T inversion in leads I, II and \( V_6 \) (posterior-lateral myocardial infarct).

Among other abnormal characteristics of the spatial mean QRS and T vectors, the orientation of the plane defined by these vectors is very different from that of the normal group. The horizontal angle, of the projection on that plane points anteriorly instead of posteriorly; the plane is tilted anteriorly instead of posteriorly. In both patients with anterior-lateral myocardial infarct the vertical angle of the projection (last column) is definitely lower; this means that the plane is nearly vertical.

It appears that the determination of the spatial orientation of this plane adds to the precise differentiation between normal and abnormal electrocardiograms.

**SUMMARY**

A method is described for measuring the spatial orientation of the plane included by the mean QRS and T vectors, by means of Simonson's spatial vector-analyzer. The spatial orientation of a plane is determined by the horizontal (H) and vertical (V) angle of its perpendicular, central projection. Values of

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Category</th>
<th>QRS</th>
<th>T</th>
<th>QRS-T Plane</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>H  V  Mag.</td>
<td>H  V  Mag.</td>
<td>dA  H  V</td>
</tr>
<tr>
<td>44</td>
<td>Normal Means</td>
<td>-23.6 46.3 10.5</td>
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<td>+49.8 -21 136</td>
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<td>Flo</td>
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<td>-44 117 24.8</td>
<td>+170 77 4.7</td>
<td>+147 +103 150</td>
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<tr>
<td>Koc</td>
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<td>-65 93 21.0</td>
<td>+100 47 2.7</td>
<td>+108 +25.5 106</td>
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<tr>
<td>Mat</td>
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<td>-63 108 25.0</td>
<td>+120 89 4.5</td>
<td>+93 +32 106</td>
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<tr>
<td>Lyo</td>
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<td>-15 38 18.8</td>
<td>+171 83 1.7</td>
<td>+120 +80 85</td>
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<tr>
<td>Slo</td>
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</tr>
<tr>
<td>Cla</td>
<td>Post. Infaret</td>
<td>+130 113 7.6</td>
<td>+124 90 2.3</td>
<td>-23 +34 105</td>
</tr>
</tbody>
</table>

* The normal and abnormal material is identical with that in reference 3.
patients with various lesions show marked differences in the spatial orientation of the plane included by the mean QRS and T vectors, compared to a group of 44 normal men.

**SUMARIO ESPAÑOL**

Para la medida de la orientación espacial de planos en el análisis del vectorcardiograma espacial, un artefacto sencillo se ha desarrollado para usarse con el analizador de vectores de Simonson para el electrocardiograma convencional. El valor anticipado de este método se demuestra para la medida del plano incluyendo el QRS promedio y el vector T.

**REFERENCES**


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_Circulation_. 1953;8:261-263
doi: 10.1161/01.CIR.8.2.261

_Circulation_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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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:
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