The Effect of Leads Utilized Upon Discrepancies Between Spatial Vectors Recorded by SVEC and by Mean Vector Methods

By Ernst Simonson, M.D., Otto H. Schmitt, Ph.D. and Henry W. Blackburn, Jr., M.D.

In a former study significant differences were found in the orientation and magnitude of spatial ECG vectors as determined using two different methods. The results presented in this series show that the difference in the leads used account for the major part of these discrepancies and thus emphasize the importance of a standardization of electrode position for spatial vectorcardiography.

In a former study, a statistical comparison was made between mean vectors, constructed from conventional ECG leads by means of a mechanical vector analyzer—method I—and the maximum instantaneous vectors as recorded with the SVEC (stereovectorelectrocardiograph, method II). These two methods differ in regard to the leads used and the method of measurement of spatial vectors. The results were considered as representative for the discrepancies between the various vectorcardiographic methods in current use by various authors. The spatial QRS and T vectors were expressed in terms of azimuth, elevation, and magnitude, and also the angle between the vectors was measured (dA°). The group means of 48 normal middle-aged men differed significantly in all seven items of spatial vector analysis, but there was also a highly significant correlation between the instantaneous maximum vectors (SVEC, method II) and the mean spatial vectors, constructed from conventional ECG leads (method I). It was concluded, that the two methods were not equivalent and interchangeable, but that closely related events were recorded.

One of the factors involved which may account for the differences between the two methods is the difference in the leads used. In method I, the three standard leads were taken and 6 to 8 precordial leads in the conventional vertical positions, but all at the same horizontal level (fifth intercostal space at the sternum). In method II (SVEC), three bipolar leads were used: a transverse lead X at the level of the fourth intercostal space at the sternum, about 2 cm. forward of the left and right midaxillary line, a vertical lead Y from forehead to left foot, and a sagittal lead Z from the right parasternal line at the 5th intercostal level to the directly opposite point on the back.

In order to evaluate the relative importance of the different electrode positions, scalar time based electrocardiograms of the three bipolar leads X, Y, Z of method II were taken in 25 normal middle aged men who were included in the former group of 48 men. The mean spatial QRS and T vectors were constructed by means of the mechanical vector analyzer with a slight modification of the procedure. This method called (III) is a modification of method I utilizing Einthoven's definition of a mean vector, and in the construction of the spatial vectors from scalar ECG's, but using the leads X, Y, Z of method II instead of the conventional ECG leads. Aside from the anatomically different electrode location, this procedure eliminates the assumption required for method I that a unipolar lead referred to the Wilson terminal is equivalent to a geometrically similar bipolar lead.

Method

The determination of mean spatial QRS and T vectors from conventional ECG leads (method I) and the measurement of instantaneous maximum...
vectors (method II) was the same as that used in the
previous study, the first method utilizing the con-
ventional Einthoven's frontal plane axis determina-
tion combined with the precordial null point for
azimuthal direction, while method II utilizes
simultaneous measurements of X, Y, Z at maximal
total vector time. The simple procedure to obtain
the maximum projection of the spatial QRS and T
loop through continuous rotation of the azimuth
and elevation control (method II) has been de-
scribed.

Using the mechanical vector-analyzer for con-
struction of the mean spatial vectors from scalar
X, Y, Z leads, lead X was substituted for lead I,
lead Z was set on the sagittal ordinate of the hori-
zontal plane, and lead Y was set on the movable
vertical rod, with correction for the distance of 21
units between the horizontal plane and the center.
The coordinate conventions of method II were
used also for method I and III; for azimuth (H de-
gree) zero degrees front, 90 degrees left side, 180
degrees back, 270 degrees right side; for elevation
(V degree) —90 degrees straight down, +90 degrees
straight up; magnitude (Mag) is given in mv. The
angle (da*) between the spatial QRS and T vectors
was measured with the mechanical vector analyzer
for all three methods.

Table 1.—Spatial QRS and T Vectors

<table>
<thead>
<tr>
<th>Method</th>
<th>H°</th>
<th>V°</th>
<th>Mag.</th>
<th>H°</th>
<th>V°</th>
<th>Mag.</th>
<th>da*</th>
</tr>
</thead>
<tbody>
<tr>
<td>I—ECG</td>
<td>114.4</td>
<td>-38.6</td>
<td>0.81</td>
<td>65.7</td>
<td>-34.4</td>
<td>0.32</td>
<td>53.3</td>
</tr>
<tr>
<td></td>
<td>20.1</td>
<td>22.8</td>
<td>0.25</td>
<td>19.5</td>
<td>12.8</td>
<td>0.15</td>
<td>17.9</td>
</tr>
<tr>
<td>II—SVEC</td>
<td>103.4</td>
<td>-24.4</td>
<td>2.33</td>
<td>74.6</td>
<td>-21.1</td>
<td>0.56</td>
<td>23.8</td>
</tr>
<tr>
<td></td>
<td>10.2</td>
<td>10.1</td>
<td>0.45</td>
<td>11.3</td>
<td>7.5</td>
<td>0.18</td>
<td>13.3</td>
</tr>
<tr>
<td>III—XYZ</td>
<td>105.7</td>
<td>-26.2</td>
<td>1.67</td>
<td>70.0</td>
<td>-30.8</td>
<td>0.57</td>
<td>33.0</td>
</tr>
<tr>
<td></td>
<td>12.0</td>
<td>12.0</td>
<td>0.61</td>
<td>12.4</td>
<td>8.5</td>
<td>0.18</td>
<td>17.0</td>
</tr>
</tbody>
</table>

(M = means, S.D. = standard deviations) measured in 26 normal middle-aged men with three different methods: I—conventional ECG; II—SVEC; III—scalar bipolar leads X, Y, Z.

Table 2.—Means (Δ), Standard Deviations (S.D.), and Statistical Significance (t) of Individual Differences in Spatial QRS and T Vectors, Between Three Different Methods

<table>
<thead>
<tr>
<th>Methods</th>
<th>Diff.</th>
<th>Δa</th>
<th>S.D.</th>
<th>H°</th>
<th>V°</th>
<th>Mag.</th>
<th>Δa</th>
<th>S.D.</th>
<th>H°</th>
<th>V°</th>
<th>Mag.</th>
<th>Δa vs Δb</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>I—II</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Δa vs 0</td>
<td></td>
<td>t</td>
<td></td>
<td>3.03</td>
<td>4.03</td>
<td>15.5</td>
<td>2.90</td>
<td>21.8</td>
<td>9.95</td>
<td></td>
<td>7.50</td>
<td></td>
<td></td>
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<tr>
<td>III—II</td>
<td></td>
<td></td>
<td></td>
<td>2.3</td>
<td>-0.8</td>
<td>-0.96</td>
<td>-4.6</td>
<td>-2.4</td>
<td>-0.08</td>
<td></td>
<td>4.16</td>
<td></td>
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<tr>
<td>Δb vs 0</td>
<td></td>
<td>t</td>
<td></td>
<td>1.37</td>
<td>0.56</td>
<td>3.8</td>
<td>1.43</td>
<td>9.9</td>
<td></td>
<td>3.0</td>
<td>2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δa vs Δb</td>
<td></td>
<td></td>
<td></td>
<td>2.67</td>
<td>4.43</td>
<td>9.83</td>
<td>1.59</td>
<td>9.8</td>
<td>6.68</td>
<td></td>
<td>5.98</td>
<td></td>
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</tbody>
</table>

* I—conventional ECG; II—SVEC; III—scalar leads X, Y, Z. *p = 0.05; † = 0.01; $ = 0.001.

RESULTS AND CONCLUSION

Table 1 shows the group means and standard
deviations of the spatial QRS and T vectors as
determined with method I (conventional ECG
leads, upper two rows), method II (SVEC, middle rows), and method III (scalar X, Y, Z
leads), lower two rows.

The means of method III lie between those of
method I and method II, but much closer to
method II. The standard deviations of most
items of method III are also closer to method II
than to method I. Table 2 shows a statistical
evaluation of the differences between the three
methods. The mean individual differences Δa
between method I and II are quite large, and
statistically highly significant in agreement
with the former results.† The differences Δb
between method III and II are surprisingly
small, and do not reach the 5 per cent level of
statistical significance in three items. The differ-
ences between Δa and Δb are also statistically
significant in all but one item (T-H degree).

The results show that most of the differences
between method I and II are due to the differ-
ent leads utilized, the total of all other variables
involved accounting only for a small part of the
differences. Construction of spatial vectors
from scalar bipolar XYZ leads still does not give equivalent results to the SVEC records
(method II), because four items show small, but
significant mean differences, and the standard
deviation of the individual differences (table II)
is quite considerable in some items. However,
method III gives a much better approximation
to the SVEC records than construction of the
spatial vectors from conventional ECG leads.
(method I). The results show also that the concept of a mean spatial vector is, in spite of theoretical objections, a practical and workable approach to vector analysis, at least for normal subjects. It is questionable, however, whether this concept holds as well for abnormal electrocardiograms. The results also demonstrate the importance of a standardization of the electrode position for spatial vectorcardiography.

**Summary**

In 25 normal middle-aged men, spatial QRS and T vectors (azimuth, elevation, magnitude, angle between QRS and T vectors) were determined with three different methods; method I: construction of mean vectors from conventional ECG leads by means of a mechanical vector analyzer; method II: oscillographically recorded instantaneous maximum vectors by means of the SVEC, from three bipolar orthogonal leads X, Y, Z; method III: construction of mean vectors from scalar ECG's with the three bipolar X, Y, Z leads used for method II.

The group means of the spatial vectors determined with method III were between those measured with methods II and I, but much closer to method II.

Most of the differences in orientation and magnitude of the spatial QRS and T vectors between method I and II are due to the difference in the leads used.

**REFERENCES**


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