92. The Atrial Complex of the Spatial Velocity Electrocardiogram

By Toyomi SANO, Tadayuki HIROKI, Hirokimi HAZAMA, and Tomokiyo HENTONA
Institute for Cardiovascular Diseases, Tokyo Medical and Dental University
(Comm. by Tanemoto FURUHATA, M. J. A., May 13, 1968)

Since the concept of the spatial velocity electrocardiogram (sVECG) was introduced by Hellerstein and Hamlin in 1960, several reports have appeared, but none of them reported on a systematic and extensive study of sVECG of the atrial activity. Our previous reports were mainly limited to the ventricular complex. Subsequently the atrial component of the sVECG was studied, employing our spatial velocity electrocardiograph.

Methods and materials. Vectorcardiograms were obtained by Frank’s lead system from 60 cases of normal subjects with normal atrial activity, 75 cases of left atrial overloading in cases of mitral stenosis, mitral insufficiency, aortic insufficiency, patent ductus arteriosis and left heart failure in hypertension and myocardial infarction, 15 cases of right atrial overloading in cases of atrial septal defect, pulmonary stenosis, cor pulmonale and high ventricular septal defect, 12 cases of both atrial overloading in cases of both heart failure, mitral stenosis with tricuspid involvement, persistent atrioventricularis communis and trilogy of Fallot, 41 cases of hypertension without heart failure and 6 cases of atrial flutter. The component corrected electrocardiograms were led to our spatial velocity electrocardiograph. Spatial velocity electrocardiograms were obtained from a total of 209 cases. Details on apparatus and on the method of taking sVECG were reported elsewhere.

Results. The usual atrial sVECG was composed of three main deflections which we designated as \( \pi_1 \), \( \pi_2 \), and \( \pi_3 \). The whole group can be classified into four types A, B, C, and D (Fig. 1). In type A these three deflections had about the same magnitude and duration. In type B \( \pi_2 \) and \( \pi_3 \) were abnormally larger than \( \pi_1 \) in size and duration, and usually \( \pi_3 \) was larger than \( \pi_2 \), the ratio of \( \pi_3 \) to \( \pi_1 \) was more than 2, and yet \( \pi_1 \) was almost normal in size. In type C \( \pi_1 \) and \( \pi_2 \) were larger than \( \pi_3 \), and usually \( \pi_1 \) was larger than \( \pi_2 \), the ratio of

This paper is dedicated to Dr. Tanemoto Furuhata in celebration of his seventy-seventh birthday.
Fig. 1. Four types of the atrial sVECG in common states.

Fig. 2. Two types of the atrial sVECG in six cases of atrial flutter. The left column in each case was taken with time constant of 2 msec. and the right column with time constant of 15 msec.
\( \pi_1 \) to \( \pi_3 \) was more than 2, and yet \( \pi_3 \) was almost normal in size. In type D \( \pi_3 \) was the largest, \( \pi_1 \) or \( \pi_2 \) was larger than normal in size, and the ratio of \( \pi_2 \) to the larger was more than 1.5. With normal and each abnormal state the atrial sVECG features were more distinct with one another than the ventricular sVECG.

In cases of normal atrium without heart diseases the three deflections were most typically of about the same size. This was observed in 20 of the 60 cases (33.3%). In 6 cases (10%) \( \pi_1 \) was slightly greater than the other two deflections, but it was not so prominent as in type C. In 15 cases (25%) \( \pi_3 \) was slightly larger than the other two, but it was not so prominent as in type B. Therefore, all of these can be regarded as variants of type A and we can say that most of the normal hearts showed type A. In 15 normal cases (25%) only 2 main deflections were observed as was reported previously.\(^3\),\(^4\) A small notch was sometimes found on the rising or falling limbs. In one case (1.7%) four small deflections were noticed. In other 3 cases (5%), the atrial sVECG showed type B.

In cases of abnormal atria the features were more characteristic. Most of cases of left atrial overloading showed type B (77.3%), right atrial overloading type C (66.7%) and both atrial overloading type D (75%) (Table I).

<table>
<thead>
<tr>
<th>Atrial loading</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>95.0(57/60)</td>
<td>5.0(3/60)</td>
<td>0(0/60)</td>
<td>0(0/60)</td>
</tr>
<tr>
<td>Left atrial overloading</td>
<td>20.0(15/75)</td>
<td>77.3(58/75)</td>
<td>0(0/75)</td>
<td>2.7(2/75)</td>
</tr>
<tr>
<td>Right atrial overloading</td>
<td>20.0(3/15)</td>
<td>13.3(2/15)</td>
<td>66.7(10/15)</td>
<td>0(0/15)</td>
</tr>
<tr>
<td>Both atrial overloading</td>
<td>0(0/12)</td>
<td>16.7(2/12)</td>
<td>5.3(1/12)</td>
<td>75.0(9/12)</td>
</tr>
</tbody>
</table>

Figures in the brackets show number of cases with above-mentioned types as the numerator and the total cases as the denominator.

To decide which atrium is more overloaded from the ordinary electrocardiogram only is sometimes difficult. In such cases sVECG was often helpful.

It is natural that cases of hypertension with left heart failure showed type B. But it was rather unexpected that cases of hypertension with no evidences of heart failure often showed type B. This was evident in cases with a systolic pressure of more than 180 mmHg and with a diastolic pressure of more than 100 mmHg (Table II).

Cases of atrial flutter showed two types of atrial sVECG so far. One type composed of 3 cases showed an abnormally large \( \pi_2 \) and the
other type composed of 3 cases showed three or four small deflections of about the same size (Fig. 2). The former type was obtained from cases in which the F vector loop inscribed a seemingly continuous loop (No. 1, No. 2, and No. 4 in reference 7) and the latter form was obtained mostly from cases in which the F vector loop originated from a point as the usual P loops (No. 5, No. 6, and No. 3 as an exception in the same reference).

Discussion. Judging from the time of appearance of \( \pi_1 \) and \( \pi_3 \) we assumed that the 2 deflections were related to the excitation of the right and left atrium, respectively. In the time when \( \pi_1 \) is inscribed, probably both atria are excited. The fact that \( \pi_1 \) or \( \pi_3 \) is the largest at right or left atrial overloading means that a conduction velocity increase overcomes a larger distance to cover due to stretch.

The reason why hypertensive cases without left heart failure showed a sVECG type similar to left atrial overloading is obscure. Increased sympathetic tone may have played a role.

Summary. Depending upon normal, left, right or both atrial overloading, the spatial velocity electrocardiogram usually showed characteristic features which were often helpful to decide it, when the ordinary electrocardiogram failed to do so.

### Table II. Percentage incidence of types of the atrial complex of the sVECG in cases of the hypertension without left heart failure

<table>
<thead>
<tr>
<th>Blood pressure</th>
<th>sVECG types</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic</td>
<td>&gt;180 mmHg</td>
<td>30.4( 7/23)</td>
<td>60.8(14/23)</td>
<td>4.4(1/23)</td>
<td>4.4(1/23)</td>
</tr>
<tr>
<td></td>
<td>&lt;180 mmHg</td>
<td>66.5(12/18)</td>
<td>27.9( 5/18)</td>
<td>0(0/18)</td>
<td>5.6(1/18)</td>
</tr>
<tr>
<td>Diastolic</td>
<td>&gt;100 mmHg</td>
<td>18.6( 3/16)</td>
<td>68.8(11/16)</td>
<td>6.8(1/16)</td>
<td>6.8(1/16)</td>
</tr>
<tr>
<td></td>
<td>&lt;100 mmHg</td>
<td>64.0(16/25)</td>
<td>32.0( 8/25)</td>
<td>0(0/25)</td>
<td>4.0(1/25)</td>
</tr>
</tbody>
</table>

Figures in the brackets represent the same as in Table I.

References