Analysis of the RSR' Complex in Lead V₁

By N. P. DePasquale, M.D., and G. E. Burch, M.D.

It is well known that an RSR' pattern in lead V₁ of the electrocardiogram may be a normal variant.¹ As yet, except for the R/S ratio, no satisfactory criteria are available for differentiating normal from abnormal RSR' complexes in lead V₁ for various age groups. In view of the high incidence of an RSR' complex in lead V₁ in some forms of congenital heart disease (table 1) there is need for such criteria.

Within the past few years electrocardiograms from 870 normal subjects ranging from a few minutes to 30 years of age have been recorded in this laboratory (table 2). The electrocardiograms of 44 of these subjects displayed an RSR' pattern in lead V₁ (table 2). This report describes the characteristics of the RSR' complex for various age groups. Furthermore, on the basis of a comparison of the RSR' complex in normal subjects with that in aged-matched patients with proved congenital heart disease criteria are suggested for differentiating normal from abnormal RSR' complexes.

Material and Methods

Electrocardiograms from 870 normal subjects ranging in age from a few minutes to 30 years were recorded with a Cambridge Simplitrol string electrocardiograph. Lead V₁ was recorded in the usual manner with the electrode in the fourth intercostal space at the right sternal margin. In infants a pediatric electrode 1.5 cm. in diameter was used, whereas in children and adults a standard Welsh self-retaining electrode 3 cm. in diameter was used. Lead V₁ was recorded at a paper speed of 25 mm. and 50 mm. per second. The subjects included newborn infants from the term nursery of the Charity Hospital in New Orleans, infants and children from the Well-Baby Clinic of Jefferson Parish Health Department, children of medical school personnel, and medical students.

An RSR' complex was present in 44 (5.1 per cent) of the 870 electrocardiograms obtained. Only QRS complexes in which the downstroke of the initial R wave or the upstroke of the S wave changed its polarity and crossed the isopotential line were considered to represent RSR' complexes (fig. 1). Some observers have published notched R or S waves as representative of RSR' complexes. To study the RSR' complex in detail these complexes were enlarged 15 times by projection and the following measurements were made: (1) interval between onset of QRS complex to peak of first R wave (Q-R interval), (2) interval between onset of QRS complex to peak of second R wave (Q-R' interval), (3) duration of QRS interval, and (4) amplitude of each deflection. Similar measurements were made for the electrocardiograms of 40 age-matched patients with proven congenital heart disease and who had a RSR' complex in lead V₁.

Results

Normal Infants and Children

Incidence. The incidence of RSR' pattern in lead V₁ according to age is shown in table 2.

Until 3 years of age the most common configuration of the QRS complex in lead V₁ was an rSR's' pattern, whereas after 3 years of age an rSR' pattern was found most frequently.

Q-R and Q-R' Interval and QRS Duration (table 3). It can be seen from table 3 that the Q-R and Q-R' intervals as well as the QRS duration increased with age. Until 5 years of age the duration of the Q-R' interval in-

Table 1

Incidence of RSR' Configuration in V₁ Noted Previously in the Laboratory for Various Types of Congenital Heart Disease

<table>
<thead>
<tr>
<th>Congenital defect</th>
<th>Incidence of RSR' in lead V₁ (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventricular septal defect</td>
<td>33</td>
</tr>
<tr>
<td>Atrial septal defect</td>
<td>32</td>
</tr>
<tr>
<td>Isolated pulmonary stenosis</td>
<td>25</td>
</tr>
<tr>
<td>Transposition of great vessels</td>
<td>6</td>
</tr>
<tr>
<td>Tetralogy of Fallot</td>
<td>5</td>
</tr>
<tr>
<td>Patent ductus arteriosus</td>
<td>3</td>
</tr>
</tbody>
</table>
RSR' in Lead V₁

Figure 1

RSR' patterns in lead V₁ for normal subjects and for patients with atrial septal defect. The R' wave in the normal subjects is narrow and has a sharp downstroke whereas in the patients with atrial septal defect the R' wave is wide and the downstroke tends to be slurred. The records were obtained at a paper speed of 50 mm. per second and the time lines occur at 0.02-second intervals.

creased proportionately more than did the total duration of the QRS complex. After 5 years of age the increase in the Q-R' interval and the QRS duration were proportional. The relative increase in the two intervals is expressed conveniently by the Q-R'/QRS ratio. This ratio increased until 5 years of age and then changed relatively little (fig. 2). The mean QRS duration for the normal subjects with an RSR' complex in lead V₁ was greater than that for the normal subjects without an RSR' complex in lead V₁ (table 3).

Amplitude. The amplitudes of the R and R' waves decreased with age, whereas the amplitude of the S wave increased until 3 years of age after which it remained essentially unchanged (table 3). The R/S ratio of amplitude decreased with age. The value of this ratio was not consistently less than one until 8 years of age.

RSR' Pattern in Congenital Heart Disease

To learn whether or not the RSR' pattern in patients with congenital heart disease could be consistently differentiated from that of normal people the RSR' complex in lead V₁ in 30 patients with atrial septal defect and 10 patients with ventricular septal defect was compared to that in the normal subjects. The age distribution in the two groups was comparable.

The mean Q-R' interval, QRS duration, and R/S ratio of amplitude in the patients with congenital heart disease were significantly greater than those for the normal subjects (p = 0.005, 0.001, and 0.001, respectively).

Table 2

Incidence of an RSR' Pattern According to Age in Electrocardiograms Obtained in 870 Normal Subjects

<table>
<thead>
<tr>
<th>Age group</th>
<th>Number of subjects</th>
<th>Per cent incidence of RSR' in V₁</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 Week</td>
<td>126</td>
<td>0</td>
</tr>
<tr>
<td>1 Week-1 month</td>
<td>60</td>
<td>1.6</td>
</tr>
<tr>
<td>1 Month-3 months</td>
<td>62</td>
<td>3.2</td>
</tr>
<tr>
<td>3 Months-6 months</td>
<td>66</td>
<td>3.0</td>
</tr>
<tr>
<td>6 Months-1 year</td>
<td>65</td>
<td>7.7</td>
</tr>
<tr>
<td>1-3 Years</td>
<td>88</td>
<td>9.1</td>
</tr>
<tr>
<td>3-5 Years</td>
<td>80</td>
<td>6.3</td>
</tr>
<tr>
<td>5-8 Years</td>
<td>61</td>
<td>6.6</td>
</tr>
<tr>
<td>8-12 Years</td>
<td>70</td>
<td>4.3</td>
</tr>
<tr>
<td>12-16 Years</td>
<td>61</td>
<td>8.2</td>
</tr>
<tr>
<td>16-20 Years</td>
<td>66</td>
<td>6.1</td>
</tr>
<tr>
<td>20-30 Years</td>
<td>65</td>
<td>7.7</td>
</tr>
</tbody>
</table>

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Table 3
Duration and Amplitude of the Various Components of the RSR' Complex in 44 Normal Subjects. For Comparison the Duration of the QRS Complex in Lead V1 Is Shown in the Last Three Columns of the Table.

<table>
<thead>
<tr>
<th>Age group</th>
<th>No of subjects</th>
<th>Q-R interval Mean Max.</th>
<th>Q-R' interval Mean Max.</th>
<th>QRS duration Mean Max.</th>
<th>R Mean Max.</th>
<th>R' Mean Max.</th>
<th>S Mean Max.</th>
<th>S' Mean Max.</th>
<th>R/S Mean Max.</th>
<th>QRS duration, without RSR'</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 Year</td>
<td>10</td>
<td>.014 .010</td>
<td>.044 .045</td>
<td>.069 .075</td>
<td>6.7</td>
<td>9.0</td>
<td>5.1</td>
<td>9.0</td>
<td>4.9</td>
<td>10.0</td>
</tr>
<tr>
<td>1-3 Years</td>
<td>8</td>
<td>.016 .020</td>
<td>.048 .055</td>
<td>.070 .078</td>
<td>3.1</td>
<td>7.2</td>
<td>4.0</td>
<td>8.0</td>
<td>3.5</td>
<td>7.0</td>
</tr>
<tr>
<td>3-5 Years</td>
<td>5</td>
<td>.015 .020</td>
<td>.056 .072</td>
<td>.072 .080</td>
<td>4.1</td>
<td>6.3</td>
<td>1.8</td>
<td>4.0</td>
<td>6.5</td>
<td>13.2</td>
</tr>
<tr>
<td>5-8 Years</td>
<td>4</td>
<td>.020 .025</td>
<td>.058 .073</td>
<td>.074 .082</td>
<td>1.4</td>
<td>1.3</td>
<td>3.1</td>
<td>5.0</td>
<td>6.7</td>
<td>12.3</td>
</tr>
<tr>
<td>8-12 Years</td>
<td>3</td>
<td>.021 .025</td>
<td>.065 .072</td>
<td>.082 .086</td>
<td>2.5</td>
<td>4.0</td>
<td>2.0</td>
<td>2.8</td>
<td>6.5</td>
<td>9.3</td>
</tr>
<tr>
<td>12-16 Years</td>
<td>5</td>
<td>0.022 .025</td>
<td>0.067 .074</td>
<td>0.086 .095</td>
<td>2.1</td>
<td>3.6</td>
<td>1.8</td>
<td>2.5</td>
<td>6.9</td>
<td>11.2</td>
</tr>
<tr>
<td>16-20 Years</td>
<td>4</td>
<td>0.023 .028</td>
<td>0.068 .075</td>
<td>0.087 .098</td>
<td>2.6</td>
<td>4.0</td>
<td>1.9</td>
<td>4.2</td>
<td>6.2</td>
<td>7.0</td>
</tr>
<tr>
<td>20-30 Years</td>
<td>5</td>
<td>0.023 .028</td>
<td>0.070 .075</td>
<td>0.095 .105</td>
<td>3.9</td>
<td>5.3</td>
<td>1.7</td>
<td>3.0</td>
<td>6.1</td>
<td>11.8</td>
</tr>
</tbody>
</table>

Influence of Age on Various Intervals of the RSR' Complex in Lead V1

- Age: 0-1 Year
- No of subjects: 10
- Q-R interval: Mean = 0.014, Max = 0.010
- Q-R' interval: Mean = 0.044, Max = 0.045
- QRS duration: Mean = 0.069, Max = 0.075
- R: Mean = 6.7, Max = 9.0
- R': Mean = 5.1, Max = 9.0
- S: Mean = 4.9, Max = 10.0
- S': Mean = 1.2, Max = 3.2
- R/S: Mean = 2.1, Max = 3.2

Influence of Age on the QRS and Q-R' intervals and QRS duration in the QRS complex.

In order to differentiate normal from abnormal RSR' complexes on an individual basis, maximal normal values for age were used: (1) Q-R' interval, (2) QRS duration, and (3) R/S ratio of amplitude. When the RSR' complexes were considered abnormal, the following criteria were used: (1) Q-R' interval was above the upper limits for age normal in 16 patients. The RSR' complex was considered abnormal on the basis of one criterion alone in 10 patients, on the basis of two criteria in 14 patients, and on three criteria in only two patients. In the patients in this category, (2) R/S ratio of amplitude was greater than the upper limits for age normal in 16 patients. The RSR' complex was considered abnormal on the basis of one criterion alone in 10 patients, on the basis of two criteria in 4 patients, and on three criteria in 14 patients. DePasquale and Burch (1963).
normal on the basis of only one criterion this criterion was the QRS duration in four patients and the R/S ratio of amplitude in six patients. In all of the patients in whom a prolonged QRS duration was the only abnormal criterion the RSR' complex would have been considered to be of normal duration if the limits of normal for the next oldest age group listed in table 3 had been used. Thus age must be considered when interpreting the RSR' complex in lead V1.

Discussion

The incidence of R' waves in lead V1 in adults has been reported to be as high as 9 per cent. Furthermore, the incidence increases sharply as additional leads are recorded lateral to as well as above and below the conventional site of electrode placement for V1. Some investigators have attributed the R' wave to be a manifestation of late depolarization of the free wall of the right ventricle due to varying degrees of incomplete right bundle-branch block. Milnor and Bertrand considered an RSR' pattern in lead V1 to indicate some degree of intraventricular block because the QRS interval in subjects with right ventricular hypertrophy and an RSR' pattern in V1 was of greater duration than in normal subjects. They also found the QRS duration to be more prolonged in patients with right ventricular hypertrophy and an RSR' pattern in lead V1 than in patients with right ventricular hypertrophy without an RSR' pattern in lead V1. The data presented in this paper show that the QRS duration is greater in normal patients with an RSR' pattern in lead V1 than it is in normal patients without an RSR' pattern in lead V1 (table 3). The above findings suggest that the mere presence of an R' wave in lead V1 is associated with a prolonged QRS interval in both normal subjects and patients with right ventricular hypertrophy. Kossmann and associates showed from simultaneously recorded endocardial and surface leads that the R' wave is inscribed during depolarization of the crista supraventricularis or possibly during depolarization of the base of the septum. Electrocardiograms recorded with endocardial leads have shown that the late vectors responsible for the appearance of the R' wave in tracings obtained from leads recorded from the surface of the body were directed superiorly and to the right, whether they were oriented anteriorly or posteriorly depended, among other things, upon the spatial orientation of the heart within the thorax. Because of the anatomic relations of the crista supraventricularis it is reasonable to assume that the greater the clockwise rotation of the heart along its longitudinal axis the more an RSR' complex is likely to be found in lead V1. From these considerations it appears that an R' wave in lead V1 merely reflects the fact that the late electric forces of ventricular depolarization which are usually not displayed in lead V1 may be found in this lead in some people. The presence of these late forces increases the duration of the QRS complex (fig. 3).

The presence in some normal people of late electric vector forces which are directed to the right and anteriorly in the horizontal plane projection may be an expression of individual differences in the rate of depolarization of the...
crista supraventricularis, possibly due to variations in the density of the Purkinje fibers in this region of the myocardium. It would be interesting to know if the RSR' pattern in lead V1 has a genetic basis. In any case the R' wave may be a manifestation of slow conduction in the last few hundreds of a second of ventricular depolarization and is not necessarily due to "incomplete bundle-branch block." In patients with cardiac diseases associated with hypertrophy of the crista supraventricularis it is to be expected that depolarization of this structure should be prolonged simply on the basis of a larger mass of muscle that must be depolarized. In such instances an R' wave may also appear in lead V1 with no delay in the rate of depolarization of the crista supraventricularis. Furthermore, it is possible that some normal people have an R' wave in lead V1 on the basis of physiologic hypertrophy or a relatively large mass of crista supraventricularis.

The problem of the RSR' complex would be of little more than electrophysiologic interest were it not for the fact that such complexes are encountered frequently in patients with congenital heart disease (table 1), mitral stenosis, or cor pulmonale. No criteria for distinguishing normal from abnormal RSR' complexes at different ages could be found in the medical literature. The present study was undertaken in an attempt to provide such criteria. The need for this is apparent when one considers the many reports on the comparison of aspects of the RSR' complex between various groups of people with and without heart disease without regard for age. Obviously too few normal people with RSR' complexes in lead V1 were available for study to establish statistically satisfactory normal standards. In view of the fact that the over-all incidence of an RSR' complex in lead V1 is about 5 per cent, 16,000 electrocardiograms from carefully screened normal subjects would have to have been studied to establish adequate statistical values for all the age groups considered. This quantity of satisfactory tracings was not available. Because of the small number of individuals in each age group maximal values were used to establish standards rather than twice the standard deviation. It is hoped that the data presented may be used tentatively until standards based on a greater number of subjects become available.

Fourteen of the 40 patients with proved congenital heart disease had RSR' complexes that were within normal limits according to the criteria suggested. Three of these 14 patients had small left-to-right shunts (less than 1.0 times systemic blood flow). It may be postulated that these patients had little volume overloading of the right ventricle. The other patients had significant left-to-right intracardiac shunts. It became apparent in examining the configuration of the RSR' complexes in the normal subjects and in the patients with congenital heart disease that the R' wave in the normal subjects usually had a sharp downstroke, but that in the patients with congenital heart disease the downstroke of the R' wave often was slurred (fig. 1). In some instances slurring of the downstroke of the R' wave did not result in sufficient widening of the QRS duration to increase its duration abnormally. It was therefore considered advisable to search for a measurement that expressed the interval between the R' wave and the end of ventricular depolarization. This was obtained simply, and without the need for making additional measurements, from the ratio of the Q-R' interval to the duration of the QRS complex. This ratio was 0.60 or greater in all of the normal subjects and below 0.60 in 12 of the patients with congenital heart disease. The RSR' complex in five of the 12 subjects in whom the ratio of the duration of Q-R':QRS was low had normal RSR' complexes by the other criteria indicated earlier in this paper.

On the basis of the above data criteria for differentiating the RSR' complexes in normal and abnormal hearts are:

1. Q-R' interval
2. QRS duration
3. Q-R' interval
4. R/S ratio of amplitude

Thus, to obtain the criteria it is necessary
to make only four measurements from the electrocardiogram. If the three patients with small intracardiac shunts are rejected from the 40 patients with congenital heart disease in this series, then these criteria were 85 per cent successful in distinguishing the RSR' complexes of patients with congenital heart disease from those with normal hearts.

Summary

An RSR' complex was present in lead V₁ in the electrocardiograms of 44 of 870 normal people from birth to 30 years of age; an overall incidence of 5 per cent. Analysis of the RSR' from these 44 patients demonstrated the importance of considering age when interpreting the RSR' complex. Criteria for distinguishing normal and abnormal RSR' complexes for various age groups was suggested.

These criteria were 85 per cent successful in distinguishing the RSR' complex in patients with congenital heart disease from the RSR' complex in normal subjects.

References


Technic and Conceptual Thinking

Only within very narrow boundaries can man observe the phenomena which surround him; most of them naturally escape his senses, and mere observation is not enough. To extend his knowledge, he has had to increase the power of his organs by means of special appliances; at the same time he has equipped himself with various instruments enabling him to penetrate inside of bodies, to dissociate them and to study their hidden parts. A necessary order may thus be established among the different processes of investigation or research, whether simple or complex: the first apply to those objects easiest to examine, for which our senses suffice; the second bring within our observation, by various means, objects and phenomena which would otherwise remain unknown to us forever, because in their natural state they are beyond our range. Investigation, now simple, again equipped and perfected, is therefore destined to make us discover and note the more or less hidden phenomena which surround us.

But man does not limit himself to seeing; he thinks and insists on learning the meaning of the phenomena whose existence has been revealed to him by observation. So he reasons, compares facts, puts questions to them, and by the answers which he extracts, tests one by another. This sort of control, by means of reasoning and facts, is what constitutes experiment, properly speaking; and it is the only process that we have for teaching ourselves about the nature of things outside us.

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