The Normal P-R Interval in Infants and Children

By Mariano M. Alimurung, M.D., and Benedict F. Massell, M.D.

The value of the P-R interval in the study and evaluation of treatment of rheumatic carditis, a disease predominantly of the younger ages, has prompted a re-examination of the normal P-R standards for infants and children. This study reports these data as obtained from 506 normal infants and children. The data reveal that both age and heart rate exert a significant influence on the P-R interval. The minimum, average, and maximum values are given as related to different ages and different heart rates.

In previous papers\(^1\)-\(^4\) we have reported various data on the normal electrocardiogram in infants and children. The same electrocardiographic material offered a valuable source for other analyses, such as the P-R interval.

The P-R interval has been the subject of much interest for many reasons. While not specific for rheumatic carditis, changes in the P-R interval are of significant clinical value in the study of this disease. Thus a prolonged P-R has been described as the most common electrocardiographic finding\(^5\)-\(^7\) in active rheumatic carditis and occasionally the only evidence of this condition.\(^8\) A marked prolongation is considered by some observers as an indication of a poor prognosis.\(^9\) Shortening of the P-R interval to within normal limits is also valuable in determining subsidence of the rheumatic activity\(^10\) and, therefore, in assessing the success of therapy.\(^11\) In a recent review of 66 patients given corticotropin (ACTH) or cortisone, a prolonged P-R was found to reverse to normal during therapy in 54 instances although in some the P-R prolongation reappeared after the discontinuation of treatment.\(^12\)

A short P-R interval is a characteristic feature of nodal rhythm and of the Wolff-Parkinson-White syndrome. In thyrotoxicosis the P-R may also be shortened.

Physiological factors likewise play an important role in determining the P-R interval. Prolongation may be caused by vagotonia; whereas shortening is associated with sympathicotonia.

It is obvious that the normal values of the P-R interval are important in order that the aforementioned clinical applications of P-R changes can be correctly made. Particular emphasis must be placed on the values for children because of the current interest in certain forms of treatment of rheumatic carditis, a disease predominantly of the younger ages.

While there are published data on the normal P-R in children,\(^13\)-\(^37\) the need for a re-analysis of the subject seems indicated. In many reports attention is mainly directed to the average values of the P-R interval. In others, although the upper limits are specified, the lower limits of normal are not given. In some reports the age grouping followed seems so wide that the existing peculiarities due to age are not clearly appreciated. On the other hand there are reports in which the use of too many age groups makes it difficult to apply the data clinically. Again, there are studies which are limited to infancy alone or which, though concerned with all ages in childhood, are based on a relatively small number of observations; such studies fail to present an adequate picture of the P-R interval for the entire span of infancy and childhood.

In view of the foregoing considerations, the present study was undertaken.
CLINICAL MATERIAL AND METHOD OF STUDY

In this study, a total of 506 electrocardiograms of normal infants and children ranging in age from birth to 13 years were analyzed. The source of the clinical material and the method used for obtaining the electrocardiographic tracings have been described in our previous publications on other aspects of the normal electrocardiogram in children.1-4

For greater accuracy a special reflectoscope was often used in making the measurements. This reflectoscope magnified the tracing to approximately ten times its actual size. In this manner the difficulty of detecting a tiny Q wave was greatly minimized. Particular attention was paid to this point because nonrecognition of a tiny Q wave will lengthen erroneously the P-R measurement. While often called the P-R interval, it is really the P-Q interval that is measured whenever a Q wave is present.

The data herein presented were taken from lead II since nearly all available P-R data in the medical literature are based on lead II measurements. In cases with sinus arrhythmia the average figures for both the P-R interval and the heart rate were the ones considered.

RESULTS

In the first part of this study the average P-R interval was analyzed first in relation to heart rate and then in relation to age.

Figure 1 shows the influence of heart rate on the average P-R for the entire group of 506 infants and children. There appears to be an almost linear trend as the P-R interval shortens with increasing heart rate. At the two extremes are an average P-R of 0.146 second for an average heart rate of 65 per minute and an average P-R of 0.103 second for an average heart rate of 185 per minute.

Figure 2 presents the relation between the average P-R and age, irrespective of the heart rate in each age. As with the heart rate, there seems to be definite evidence that age also exerts a significant influence on the P-R interval. In spite of certain fluctuations in the curve corresponding to the first twelve months of life, the figures for this age period are still significantly shorter than those in succeeding years. Moreover, as the child grows older, it is evident that the average P-R interval likewise lengthens progressively from an average value of 0.114 second at 1 year of age to 0.15 second at 13 years.

It is generally supposed that a relationship exists between the P-R interval on the one
Table 1—Heart Rate

<table>
<thead>
<tr>
<th>Age Groups</th>
<th>Below 71</th>
<th>71-90</th>
<th>91-110</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
<td>Av.</td>
<td>SD</td>
</tr>
<tr>
<td>I (a) Below 1 month (new-born)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 1 month (new-born)</td>
<td>1</td>
<td>.130</td>
<td>.005</td>
</tr>
<tr>
<td>II 10 months-2 years</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III 3-5 years</td>
<td>34</td>
<td>.129</td>
<td>.012</td>
</tr>
<tr>
<td>IV 6-13 years</td>
<td>24</td>
<td>.142</td>
<td>.014</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I (a) Below 1 month (new-born)</td>
<td>7</td>
<td>.106</td>
<td>.005</td>
</tr>
<tr>
<td>(b) 1-9 months</td>
<td>14</td>
<td>.114</td>
<td>.007</td>
</tr>
<tr>
<td>II 10 months-2 years</td>
<td>40</td>
<td>.117</td>
<td>.012</td>
</tr>
<tr>
<td>III 3-5 years</td>
<td>21</td>
<td>.128</td>
<td>.014</td>
</tr>
<tr>
<td>IV 6-13 years</td>
<td>13</td>
<td>.134</td>
<td>.013</td>
</tr>
</tbody>
</table>

Average values as well as the range (minimum and maximum limits) of the P-R interval are given for the different age groups and for different heart rates. The number of observations is also given for each age group with heart rates within the heart rate range indicated.

hand and heart rate and age on the other. Such a relationship is substantiated by the curves just presented. In the second part of this study, therefore, an analysis was made of the combined effects of age and heart rate on the P-R interval. In order to accomplish this purpose, it was necessary to divide the cases into certain age groups. Since any age subdivisions would necessarily have to be arbitrary, it was decided to follow the same age groupings that we had used in previous reports3, 4 on other data of the normal child's electrocardiogram. These age groups are as follows: Group I, from birth to 9 months; group II, from 10 months to 2 years; group III, from 3 to 5 years and group IV, from 6 to 13 years. The newborn (under 1 month of age) were further separated into another subgroup within group I because of the comparatively shorter P-R intervals noted in the first month of life.

Figure 3 shows the relation of the average P-R interval to heart rate for each age group. It is evident that the P-R interval is longer in the older ages for any given heart rate. Thus, for instance, at a heart rate of 120 per minute the average P-R interval is 0.106 second for the newborn, 0.114 second for children between 1 month and 9 months, 0.117 second for those between 10 months and 2 years, 0.128 second for ages 3 to 5 years, and 0.134 second for 6 to 13 years of age.

Finally in table 1, the same data depicted in figure 3 are shown together with the range of the P-R interval and the standard deviation for those groups in which a sufficient number of cases allowed for its calculation. In this table it is shown that, on the whole, at any given heart rate the maximum as well as the average values for P-R were longer for the older ages. Not shown in table 1 is that only one child had a P-R of 0.18 second at rates below 71 and only one child each had P-R intervals of 0.18 and 0.17 second in the heart rate range between 71 and 90 per minute. In contrast to the average and maximum values the minimum limits do not vary appreciably with age and with heart rate. It should be noted that the number of observations, as shown in the table, was small for some of the groups of cases.

Discussion

The influence of age on the P-R interval is well accepted. The fact that the heart of a child is many times smaller than that of an
adult explains why the P-R is significantly shorter in a child than in an adult. Studies on adults further indicate that the P-R increases with age even at constant heart rates, especially "in the second and the fifth to sixth decades." This observation was recently substantiated by Packard, Graettinger and Graybiel in their follow-up study in 1950 on healthy aviators, whom they had previously examined in 1940. These authors noticed an increase of the mean P-R from 0.154 to 0.159 second in spite of an increase of average heart rate from 64 to 75 per minute. At any given heart rate the 1950 mean P-R was consistently longer than the 1940 value. Careful study of their data led these authors to the conclusion that the difference noted was due to chance or to change in either blood pressure or body weight but was most likely due to "some factor associated with aging."

That the P-R interval is likewise influenced by heart rate is also generally supposed. In fact some workers have proposed formulae to express the relationship between heart rate and P-R. Obviously such formulas cannot express completely the standards for the P-R interval unless the role of age is simultaneously represented. Other authors doubt that there is an important influence of heart rate on the P-R interval.

As far as our own findings are concerned, there seems to be sufficient indication that, at least in infants and children, both age and heart rate exert a definite influence on the P-R interval. What factor has a greater influence cannot be determined from our study. Nevertheless, it is evident from our data that observations relating the P-R interval to either age or heart rate alone are unsatisfactory especially if such data are to be applied clinically.

The lower limit of the normal P-R interval has not been studied as much as the upper limit. Thus Kossman has recently stated that "a precise definition of the lower limit must await more precise statistical study." In our study, therefore, the data for the lower limit of the P-R interval were also collected.

An attempt was made to compare our results with those of other reports in the medical literature. This comparison could be done only to a very limited degree because of two main reasons. First, in some reports the P-R interval was studied in relation to either heart rate or age alone but not to both. Second, when consideration was given to both age and heart rate, the age grouping followed was different from that used in our study.

Such a limited comparison could be made with the data furnished by Ashman and Hull. Their table, a widely used reference for the normal values of the P-R interval, provides data on the upper limits of the normal P-R for various age groups, including children and adults, and for various heart rates. As far as the comparison was feasible, it can be noted that our data are very similar to those of Ashman and Hull. Thus, for instance, for children between 7 and 13 years of age, Ashman and Hull give for upper limits of P-R 0.18 second for rates below 70 per minute, 0.17 second for rates between 71 and 90, 0.16 second for rates between 91 and 110, and 0.15 second for rates between 111 and 130. Our data for the comparable age group, 6 to 13 years, show upper limits for P-R of 0.18 second, 0.18 second, 0.16 second, and 0.16 second for corresponding heart rates. The other age groupings for younger children, new born to 1½ years and 1½ to 6 years, followed by Ashman and Hull are different from our age grouping in this age span; hence, no comparison could be made in these age periods. Furthermore, our data suggest that more age subdivisions are needed in the younger ages. Finally, Ashman and Hull do not furnish the average and minimum values of the P-R in their table.

**Summary**

Because of the value of the P-R interval in evaluating the treatment of rheumatic carditis, a disease occurring predominantly in the younger age groups, the normal P-R for infants and children was re-examined. This study was based on the electrocardiograms of 506 normal infants and children, ranging from birth to 13 years of age.

Both age and heart rate were found to exert a significant influence on the P-R interval.
Normal values must therefore be related to both factors.

The average normal P-R interval and the minimum and maximum limits of normal for various age groups and for different heart rates are given.

ACKNOWLEDGMENT

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SUMMARY IN INTERLINGUA

A causa del significacion del intervallo P-R in evaluare le tractamento de carditis rheumatic—a morbo que occurre predominante al etates plus juvenes—le norma de P-R pro infantes e juveniles eseva re-examineare. Nostre studio es basate super le electrocardiogrammas de 506 infantes e juveniles normal, de etates ab infra un mense usque a 13 annos.

Il eseva constatate que le etate e le frequentia cardiac exercer un influentia significative super le intervallo P-R. Valores normal debe consequentemente esser relationate a ambe iste factores.

Nos lista le valor median del normal intervallo P-R e le limits minimal e maximal del norma pro varie etates e varie frequentias cardiac.

REFERENCES


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