Formation of the "P-R Segment"

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Variance of opinion among authors regarding the cause and duration of each succeeding portion of the P-R interval points out that knowledge regarding the physiologic basis for these waves is incomplete. Data regarding the P-R segment are scant in electrocardiographic literature. The necessity for precision in measurement and the need for better visualization of electrocardiographic waves to enhance their diagnostic value are illustrated by study of the generally ignored region between the P and QRS.

THE purpose of this report is to present data and tracings that define the region of the P-R segment more precisely than usual in clinical practice. By more precise measurement and better visualization of that portion of the electrocardiographic wave, factors of significance to its formation and of importance to the interpretation of the entire electrocardiogram are demonstrated.

MATERIALS AND METHODS

The electrocardiograms studied were from normal male subjects between the ages of 26 and 46 years. During the initial phase of the study electrocardiograms recorded on direct-writing electrocardiographs at 25 mm. per second with a standardization sensitivity of 10 mm. per millivolt were used, so that measurements could be related to those used for clinical interpretation. These electrocardiograms were optically magnified 10 times for better visualization of the beginning and end of waves to obtain more precise measurements.1 The P-R segment was measured in all 12 leads of 20 of these electrocardiograms. The P-R segment was defined as that portion of the electrocardiogram inscribed as an isoelectric line between the discernible termination of the P wave and the onset of the first deflection attributable to the ventricular complex.

Difficulty was experienced in measurement due to the usual thick baseline of tracings with the standard sensitivity of 10 mm. per millivolt. These 2 factors, regardless of instruments used, hinder detection and accurate interpretation of minor potential changes. To sharpen the points of potential change on the X axis of the electrocardiogram and for better visualization of the region of the P-R segment, a paper speed of 75 mm. per second was adequate if the electrocardiograph's sensitivity was increased to a range of 250 to 500 mm. per millivolt. This could be accomplished only with cathode-ray tube electrocardiographs. The latter instruments were used during the remainder of the study for verification of the findings suggested by the optically magnified directly written electrocardiograms.

RESULTS

In the directly written electrocardiograms, the average duration of the P-R segment was 0.06 second. Each group of standard, augmented, or precordial leads had approximately the same average value (table 1). Although the average value of the P-R duration was 0.06 second, the minimal P-R segment in each electrocardiogram ranged from 0 to 0.06 second (table 2). The lead with the shortest P-R segment was unpredictable. Virtual nonexistence of a P-R segment was noted in tracings from 4 subjects in which the terminal limb of the P wave fused with the initial deflection of the QRS (fig. 1).

After measurements of the average duration for each lead were contrasted with the measurements of the minimal durations, it was evident that the average or the range of average duration of the P-R segment in a single or a series of electrocardiograms provides no information comparable with physiologic processes. The shortest P-R segment measurable in a given electrocardiogram is the only meaningful value.

In the tracings recorded photographically from the cathode-ray tube electrocardiographs, points of potential change were more

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TABLE 1.—The Average Duration of the P-R Segment in Twenty Normal Subjects

<table>
<thead>
<tr>
<th>Lead</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>aV_R</th>
<th>aV_L</th>
<th>aV_Y</th>
<th>V_1</th>
<th>V_2</th>
<th>V_3</th>
<th>V_4</th>
<th>V_5</th>
<th>V_6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second</td>
<td>.06</td>
<td>.06</td>
<td>.07</td>
<td>.06</td>
<td>.06</td>
<td>.06</td>
<td>.07</td>
<td>.07</td>
<td>.05</td>
<td>.05</td>
<td>.05</td>
<td>.06</td>
</tr>
</tbody>
</table>

TABLE 2.—Incidence of Minimal P-R Segment Durations* in Twenty Normal Subjects

<table>
<thead>
<tr>
<th>Second</th>
<th>0.00</th>
<th>0.01</th>
<th>0.02</th>
<th>0.03</th>
<th>0.04</th>
<th>0.05</th>
<th>0.06</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

* In certain instances the minimum duration appeared in 2 or more leads.

Fig. 1. A. Lead II from electrocardiogram of normal subject. Direct-writer tracing at 25 mm. per second and standard sensitivity. B. At 10 X optical magnification it is difficult to discern the presence of a P-R segment, since the slope of the terminal limb of the P wave fuses with the earliest deflection due to the Q wave.

clearly evident. During the time an isoelectric P-R segment is inscribed in the conventional electrocardiogram, a rapid but low amplitude change in potential exists (figs. 2 and 3). This abrupt change in slope of the electrocardiographic curve occurs because the direction of the onset of the wave of ventricular depolarization is opposite to that of the terminal limb of the P wave. The inscription of an isoelectric segment between the P and the QRS in the routine electrocardiogram is due to the inability of electrocardiographs to respond to rapid low-amplitude

Fig. 2. Simultaneous tracings of lead II taken with cathode-ray tube electrocardiograph. Paper speed, 75 mm. per second; time lines, 0.02 second. Standardization is 10 mm. per millivolt in lower tracing and 250 mm. per millivolt in the upper tracing. There is fusion of the termination of the P wave and a slight 1 mm. upstroke preceding a minute Q wave not evident on the comparison tracing. S-T segment elevation is hardly noticed at 10 mm. per millivolt standardization; the S-T segment is shown to be the slow upstroke of the T wave. A U wave is clearly present, but not detected at the ordinary standardization.
Fig. 3. Tracings are of lead II taken in succession from a normal 28-year-old man. Upper tracing. Standard directly written electrocardiogram with paper speed of 25 mm. per second and standardization sensitivity of 10 mm. per millivolt. Middle tracing. Cathode-ray tube electrocardiograph tracing recorded photographically at a paper speed of 75 mm. per second. Time lines, 0.02 second. Standardization sensitivity, 500 mm. per millivolt. Only the midportion of the tracing is shown. The onset and termination of the P wave are clarified and its duration can be accurately measured to be 0.13 second. The end of the P wave does not occur opposite to its onset, since the downstroke of the wave continues without change in character to meet the upstroke of the QRS. The time of the P-R segment does not exceed 0.02 second. Lower tracing. Approximately double the previous standardization sensitivity. Only the portion of the tracing showing sharp points of potential change is shown. The increased amplitude allows clear visualization of the junction of the downstroke of the P wave and the upstroke of the R wave. The U wave, which was undetectable at standard sensitivity, is evident.
potential variations because of their frequency and mechanical limitations, particularly when used with the standard sensitivity of 10 mm. per millivolt.

**Discussion**

The importance attributable to a P-R segment is its representation of the interval of time between the end of atrial depolarization and the beginning of ventricular depolarization. Electrocardiographically that time interval may be nonexistent.

Uninterrupted visualization of the terminal slope of the P wave can be obtained only in individuals with heart block after inscription of an isolated P wave (fig. 4). When the entire terminal slope of the P wave is seen adequately, it is apparent that the portion inscribed prior to the P-Ta wave may be masked in the routine electrocardiogram, since the duration of the terminal portion of the P wave may overlap the time during which the limb lead QRS is inscribed. Similarly, ventricular potential variations are occasion-

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**Fig. 4.** Upper tracing. Lead II, from a patient with heart block. Atrial rate, 65 per minute. Variable ventricular rate. Paper speed, 75 mm. per second. Time lines, 0.02 second. Standardization sensitivity, approximately 500 mm. per millivolt. The configuration of the isolated P wave, and the contribution of its terminal descending limb or the potential of the P-Ta wave to the formation of the P-R segment is evident. The duration of the P wave measured from the onset of the wave to a point opposite its onset is 0.12 second. The duration from onset to the point where the terminal slope of the wave changes in character is 0.16 second. Middle and lower tracings are simultaneous, lead II and aVR respectively at decreased standardization sensitivities. When precisely measured, the points of onset and termination of all waves are coincident in all leads.

**Fig. 5.** Tracing obtained during cardiac catheterization of patient with pulmonary hypertension. Paper speed, 75 mm. per second. Time lines, 0.02 second. Uppermost tracing is lead I with large S wave due to right axis deviation. The second tracing is the right ventricular intracavitary lead. After inscription of the P wave in the intracavitary lead, an upstroke denoting rise in potential follows. This is not reflected in the limb lead. The simultaneous tracings below are brachial artery pulse pressure, an esophageal lead, and right ventricular pulse pressure.
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ally recorded in intracavitary leads prior to the onset of the limb lead QRS and during limb-lead P-wave inscription (fig. 5). The close approximation of the terminal slope of the P wave and the beginning of the QRS complex within a short interval of time in routine limb-lead electrocardiograms further suggests that an isoelectric segment between P and QRS is derived from either the junction of electrical signals from the termination of atrial depolarization and the onset of ventricular depolarization or the algebraic summation of the simultaneous potential changes from these events. Detailing of each event separately or of the potential variations at their points of junction is not possible with present instrumentation.

In instances in which the potential from the terminal portion of the P wave may have ceased prior to the onset of ventricular depolarization, the P-Ta wave potential is an unsubtractable component of the wave form inscribed by the electrocardiograph during the time of ventricular depolarization. Thus, potential variation from atrial electrocardiographic activity is intimately related with potential from the initial portion of the ventricular depolarization process at points between P and QRS. Clinically, aberrations of the QRS complex, particularly of its initial portion, must be considered possibly to be due to the continuation of the relationship of the same electrophysiologic events.

SUMMARY

Limitations in the methods of recording and limitations inherent in instrumentation account for the inscription of an isoelectric segment between the P and QRS in routine normal electrocardiograms. During its inscription rapid low-amplitude potential variations are present due to the junction or summation of atrial and ventricular waves. The sources of potential variation that influence the formation of the apparent isoelectric segment need not terminate their activity between the P and QRS and, thus, become of significance in interpretation of QRS abnormalities.

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SUMMARIO IN INTERLINGUA

Limitationes del methodos registratori e limitationes inherente in le instrumentation explica le inscription de un segmento isoelectric inter le P e le QRS de normal electrocardiogrammas routinari. Durante le inscription de iste segmento, rapide variationes de potential de basse amplitude es presente como effetto del junction o del summation de undas atrial e ventricular. Le fontes del variation de potential, le quales influentia le formation del apparenente segmento isoelectric non termina lor activitate necessariamente inter le P e le QRS e deveni assi un factor de signification in interpretar anormalitates de QRS.

REFERENCE

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