Concealed Ventricular Extrasystoles due to Interference and due to Exit Block

By SHINJI KINOSHITA, M.D.

SUMMARY

Two cases of sinus rhythm with ventricular extrasystoles are reported in which extrasystoles arising from the same focus obey both the rule of "concealed bigeminy" and the "rule of bigeminy." In a comparatively rapid sinus rhythm, shortening of the sinus cycle favors the appearance of extrasystoles, and the extrasystoles obey the rule of "concealed bigeminy"; namely, sinus impulses intervene between extrasystoles in even numbers. The sinus impulses here include those both conducted and not conducted to the ventricles. Conversely, in a comparatively slow sinus rhythm, interectopic sinus impulses appear in odd numbers only, and the extrasystoles obey the "rule of bigeminy"; namely, lengthening of the sinus cycle favors the appearance of extrasystoles.

From these observations, a new mechanism governing both of the rules is suggested as follows. Ectopic impulses arise following all the interectopic sinus beats, but they become concealed extrasystoles of two types. One of them is the "concealed extrasystole due to interference at the external end of the ventricular-ectopic (V-E) junction." The other is the "concealed extrasystole due to exit block within the V-E junction" because of refractoriness following stimulation. They alternate with each other. In the rule of "concealed bigeminy," the last concealed extrasystole intervening between manifest extrasystoles is due to exit block, whereas in the "rule of bigeminy," it is due to interference.

When long electrocardiographic recordings contain ventricular extrasystoles in seemingly random distribution, careful analysis often discloses but a simple rule, phenomenon, namely, that sinus impulses intervening between two successive extrasystoles are always in multiples of a definite number (usually 2 or 3). The sinus impulses include both those conducted to the ventricles and those which cannot penetrate the atrioventricular node because of refractoriness following extrasystoles. This phenomenon was first reported by us in 1960 and termed the "rule of multiples" or the "rule of multiple interectopic sinus impulses." Later, the same phenomenon was reported by Schamroth and Marriott (1961; 1963), and the rhythm was termed "concealed bigeminy or trigeminy" due to the presence of "concealed ventricular extrasystoles." 2, 3

In the other cases of ventricular extrasystoles, another remarkable phenomenon is often revealed, viz., long R-R intervals favor the appearance of ventricular extrasystoles. The latter phenomenon was termed the "rule of bigeminy" by Langendorf, Pick, and Winternitz. 4 It has been believed that these two rules do not coexist in a case of ventricular extrasystoles from a single focus, though in a case of ventricular extrasystoles from two different foci, at times, extrasystoles from one focus obey one of the rules and extrasystoles from the other focus obey the other rule. 8

In the present report, two cases will be presented in which ventricular extrasystoles arising from the same focus obey both of the rules. A new mechanism governing both of them will be suggested.

Report of Electrocardiograms

The electrocardiograms were recorded from a healthy 23-year-old man (case 1) and a healthy 31-year-old woman (case 2). In both cases, an irregular pulse rate was disclosed on routine examination, and the rest of the physical examination revealed no abnormalities.

Their electrocardiograms showed sinus rhythm with ventricular extrasystoles arising from a single focus. In the early stage of recording, the sinus rhythm was usually somewhat irregular and somewhat rapid, showing a rate of 75 to 114 beats per minute in case 1 and a rate of 75 to 85 beats per minute in case 2. In these comparatively rapid sinus rhythms, sinus impulses* intervening between the extrasystoles were in even numbers only. Figures 1 and 2 are portions of long recordings in case 1, showing the comparatively rapid sinus rhythm mentioned above. The top and middle strips of figure 1 are continuous, and the three strips of figure 2 are also continuous. As shown in figures 1 and 2, sinus impulses* intervening between the extrasystoles fall in even numbers only. (Since the

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*Throughout this report, "sinus impulses" indicate those both conducted and not conducted to the ventricles.

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230 Circulation, Volume 52, August 1975
CONCEALED VENTRICULAR EXTRASYSTOLES

Case 1. Intermittent (manifest) ventricular bigeminy with occasional quadrigeminy. The upper two strips are continuous. Numbers in the strips are coupling intervals of the extrasystoles to the preceding sinus beats. The shaded areas in the diagram represent the absolute refractory period. V = ventricles; V-E = ventricular-ectopic junction; EF = ectopic focus. All time intervals in this and in subsequent figures are expressed in hundredths of a second.

An analysis of the interectopic sinus impulses in the whole record showing such a sinus rate is presented in table 1. Table 1 reveals that, despite considerable changes in the sinus rate, ranging from 75 to 114 beats per minute, the interectopic sinus impulses are always in even numbers only. This fact makes parasystole unlikely, and indicates the presence of the "rule of multiples" so termed by us or "concealed bigeminy" by Schamroth and Marriott.

In both cases, about 15 to 20 minutes after the start of recording, the sinus rate decreased to a rate less

Figure 1
Case 1. Intermittent (manifest) ventricular bigeminy with occasional quadrigeminy. The upper two strips are continuous. Numbers in the strips are coupling intervals of the extrasystoles to the preceding sinus beats. The shaded areas in the diagram represent the absolute refractory period. V = ventricles; V-E = ventricular-ectopic junction; EF = ectopic focus. All time intervals in this and in subsequent figures are expressed in hundredths of a second.

Figure 2
Case 1. Ventricular extrasystoles obeying the rule of "concealed bigeminy" or the "rule of multiples of 2"; namely, that interectopic sinus impulses are in even numbers (i.e., multiples of 2) only. The three strips are continuous. E and E' = extrasystole and the next extrasystole; respectively; S and (S) = sinus impulses conducted and not conducted to the ventricles, respectively; S, and Si = the i-th sinus impulse after extrasystoles E and E', respectively; Si = last sinus impulse before the next extrasystole E'. The other abbreviations are the same as in figure 1.
than those in the early stage. At this point manifest extrasystoles were not seen for a long time, despite considerable fluctuations in the sinus cycle length. Thereafter (in case 1 about 30 minutes and in case 2 about 25 minutes after the start), extrasystoles from the same focus again appeared, where the sinus rate decreased further. However, it was disclosed that these extrasystoles did not obey the rule of "concealed bigeminy." In these comparatively slow sinus rhythms, lengthening of the sinus cycle beyond a certain period (about 90 in case 1 and about 85 in case 2) favored the appearance of extrasystoles. In case 1, when the sinus rate was slowed owing to pressure on the eye ball (Aschner's test), this feature was also seen. Figure 3 represents portions of a long recording in case 1, showing a comparatively slow sinus rhythm due to pressure on the eye ball. The upper three strips are continuous. Extrasystoles in figure 3 and those in figures 1 and 2 arise from the same focus. Extrasystoles here, however, do not obey the rule of "concealed bigeminy." Thus, these observations demonstrate that both of the seemingly different rules, namely, the rule of "concealed bigeminy" and the "rule of bigeminy" can govern the extrasystoles arising from the same focus, although the two rules are seen under different circumstances.

In order to elucidate the mechanism governing both of the rules, further detailed observations were made in case 1, both in the comparatively rapid sinus rhythm and in the comparatively slow sinus rhythm. (Although additional descriptions of case 2 are not made, about the same features were seen.)

Observations in the Rapid Sinus Rhythm (Case 1)

The electrocardiographic examinations were made three times on different days. In the initial portions of these long records, a rapid sinus rate more than 100 beats per minute was always seen, probably because of anxiety. Thereafter, the sinus rate was gradually decreased. Careful analysis of the relationship between the sinus rate and the appearance of extrasystoles disclosed additional remarkable features mentioned below.

1) When the sinus rate is above 103 beats per minute, manifest (not concealed) ventricular bigeminal rhythm always prevails, as represented in the top strip of figure 1.

2) When the sinus rate decreases so that the interval between the sinus beat preceding an extrasystole and the subsequent conducted sinus beat lengths to a period of 117 or more, the extrasystole following the latter sinus beat always fails to appear. As a result, the bigeminal rhythm disappears. Examples are shown in the middle and bottom strips of figure 1.

3) When the sinus rate further decreases to the rate ranging from 69 to 97 beats per minute, none of the manifest extrasystoles are seen, as shown in the top strip of figure 2.

4) When the sinus rate again increases from the above rate to a rate of more than a certain critical value mentioned below, a manifest extrasystole reappears. Examples of this feature are represented in the middle and bottom strips of figure 2. This feature reveals that shortening of the ventricular cycle favors the appearance of ventricular extrasystoles, whereas in the "rule of bigeminy," lengthening of the ventricular cycle favors the appearance of ventricular extrasystoles. Therefore, the feature here is seemingly the reverse phenomenon of the "rule of bigeminy." As shown in figure 2, impulses labeled S and (S) indicate sinus impulses conducted and not conducted to the ventricles, respectively; impulses S1 and S1 indicate the ith sinus impulses after an extrasystole E and the next extrasystole E', respectively; and an impulse labeled S1 indicates the last sinus impulse before the extrasystole E'. The number 1 here is always even. The sinus impulses (S1) and (S1) are not conducted to the ventricles because of refractoriness following the preceding extrasystole. Therefore, the first conducted sinus impulses after the extrasystoles E and E' are the

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Table 1

<table>
<thead>
<tr>
<th>Number of sinus impulses occupying the interectopic intervals</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
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<th>18</th>
<th>20</th>
<th>22</th>
<th>34</th>
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<td>1</td>
<td>1</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of sinus impulses occupying the interectopic intervals</th>
<th>42</th>
<th>44</th>
<th>46</th>
<th>72</th>
<th>88</th>
<th>92</th>
<th>104</th>
<th>128</th>
<th>130</th>
<th>152</th>
<th>188</th>
<th>246</th>
</tr>
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<tbody>
<tr>
<td>Frequency</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
impulses $S_2$ and $S_0$, respectively. As represented in figure 2, when a $S_{2n-1}-S_{2n+2}$ interval (for example, the $S_9-S_6$ interval shown in the middle strip) shortens to a period of 122 or less (occasionally including 123), an extrasystole appears following the sinus impulse labeled $S_{2n+2}$ (where $2n$ represents an even number).

5) There is a small but distinct difference between the two critical values mentioned above. One of them is a critical length of 117. When the length of two sinus cycles containing an extrasystole (i.e., the $S_2-S_3$ interval) increases to this critical length or more, the following extrasystole disappears. The other is a critical length of 122 (occasionally 123). When the length of two sinus cycles containing no extrasystole (i.e., the $S_{2n}-S_{2n+2}$ interval) decreases to this critical length or less, the following extrasystole reappears. Consequently, when the length of two sinus cycles ranges between these two critical values — 117 and 122 — two sinus cycles containing an extrasystole alternate with those containing no extrasystole. This indicates quadrigeminy, i.e., the occurrence of an extrasystole after every third sinus beat. Examples of such extrasystoles are the last extrasystole in the middle strip of figure 2, and the second extrasystole in its bottom strip.

6) The couplings of extrasystoles to the preceding sinus beats are somewhat variable, ranging between periods of 36 and 42, as shown in figure 1. These coupling intervals are inversely related to the preceding two sinus cycle lengths. The longer the preceding two sinus cycles, the shorter the following coupling interval. Figure 1 shows the relationship between the length of two sinus cycles containing an extrasystole and the following coupling interval. The shortest interval of the two sinus cycles containing an extrasystole, i.e., a period of 105 is followed by the longest (or next longest) coupling interval, i.e., a period of 42 (or 41). Conversely, under the critical value of 117, the longest interval of the two sinus cycles containing an extrasystole, i.e., a period of 116 is followed by the shortest coupling interval, i.e., a period of 36. This shortest coupling interval is only a little longer than or approximately equal to the Q-T interval of the sinus beats, which is generally considered to indicate the time of ventricular unresponsiveness following stimulation.

From these features, the explanation of the mechanism governing concealed ventricular bigeminy is suggested as illustrated in the diagrams below the strips of figures 1 and 2. The last mentioned feature, namely, prolongation of the coupling interval during shortening of the preceding two sinus cycles does

\[ \text{Figure 3} \]

\[ \text{Case 1. Ventricular extrasystoles obeying the "rule of bigeminy"; namely, that extrasystoles arise only after long sinus cycles. The upper three strips are continuous. Numbers in parentheses below the strips represent } S_{2n-1}-S_{2n} \text{, intervals, where } 2n \text{ is an even number. Abbreviations are the same as in figures 1 and 2.} \]
seem to indicate the presence of conduction disturbance in the region surrounding the ectopic focus, i.e., in the ventricular-ectopic (V-E) junction. When the length of the two sinus cycles containing an extrasystole is a period of 116, the following coupling interval is a period of 36, as shown in the diagram of figure 1. These facts strongly suggest that, when the interval of the two sinus cycles containing an extrasystole lengthens to 117, as represented in the next portion of the same diagram, the coupling interval of the following expected extrasystole would shorten to a period less than 36, if the extrasystole could appear manifestly. However, this expected coupling interval is less than the Q-T interval of the sinus beats. As a result, we must assume that, although the impulse of the expected extrasystole is originated from the ectopic focus and passes outward through the V-E junction, it cannot cause a manifest extrasystole because of the ventricular refractoriness following the preceding sinus beat, as shown in the diagram. Therefore, the ectopic impulse here will become a concealed extrasystole due to interference at the external surface of the V-E junction, where the ectopic focus is protected from sinus impulses. The diagram of figure 2 reveals ventricular bigeminal rhythm in a concealed form, where such “concealed extrasystoles due to interference” occur alternately with “concealed extrasystoles due to exit block” mentioned below.

The possible explanation for the fifth feature mentioned above (that is, the discrepancy between critical lengths of two sinus cycles containing an extrasystole and those containing no extrasystole with regard to the disappearance and reappearance of the subsequent extrasystole) is as follows. When the length of two sinus cycles containing an extrasystole (i.e., the \( S\_2 - S\_1 \) interval) decreases, the coupling interval of the following extrasystole is prolonged, as shown in figure 1. This suggests that when the ectopic impulse arises after two sinus cycles from the preceding stimulation of the V-E junction, it falls within the relative refractory period of the junction, during which the conduction time is considerably delayed. If, under these circumstances, an ectopic impulse arises after one sinus cycle from the preceding stimulation of the V-E junction, it is likely to come in the absolute refractory period of this junction. This assumption suggests that, after an ectopic impulse stimulates the V-E junction and becomes the “concealed extrasystole due to interference,” the following sinus impulse (i.e., the impulse \( S\_n + 1 \)) may cause another ectopic impulse but it may be blocked at the V-E junction. Thus, in “concealed bigeminy,” as shown in the middle strip of figure 2, there may be a 2:1 exit block at the V-E junction. However, it is possible that this ectopic impulse may be blocked within the V-E junction after invading the small portion of the junction, thus further increasing the conduction delay of the subsequent ectopic impulse. Therefore, there may be concealed extrasystoles of two types: one, “concealed extrasystole due to interference at the ventricular surface of the V-E junction” caused by the sinus impulse \( S\_n \); and the other, “concealed extrasystole due to exit block within the V-E junction” caused by the sinus impulse \( S\_n + 1 \). The “concealed extrasystole due to exit block” here may somewhat lengthen the conduction time of the following extrasystole, whether or not this following extrasystole is concealed. This delayed conduction through the V-E junction, which may allow the extrasystole to become manifest because it would then occur after the refractory period of the ventricles, represents part of a “gap phenomenon.” Thus, when the length of two sinus cycles ranges between the two “critical intervals,” i.e., the periods of 117 and 122, two sinus cycles which do not contain a manifest extrasystole, do contain a “concealed extrasystole due to exit block.” This concealed extrasystole prolongs the exit of the next extrasystole, producing a gap phenomenon, and allowing this last extrasystole to become manifest. On the other hand, two sinus cycles which do contain a manifest extrasystole do not contain a “concealed extrasystole due to exit block.” Consequently, the last extrasystole does not have enough exit delay. It does not become manifest because it has fallen within the ventricular refractory period. In the latter situation, because of lack of delay produced by the concealed extrasystole, two sinus cycles must be shorter in order to allow the final manifest extrasystole. Thus, there are two different “critical intervals.” Further evidence for these explanations is shown in the additional observations mentioned below.

**Observations in the Slow Sinus Rhythm (Case 1)**

When the sinus rate decreased to about 80 beats per minute, extrasystolic impulses were no longer manifest. These electrocardiographic recordings were made on three different days. The recording on the last day was continued for a longer period of time. As the sinus rate decreased further, either spontaneously or owing to pressure on the eye ball, extrasystoles from the same focus reappeared. These extrasystoles obeyed the “rule of bigeminy.”

Careful analysis of the extrasystoles in the slow sinus rhythm disclosed additional remarkable features which were not seen in the rapid sinus rhythm. From these features, which are listed below, the explanation for a mechanism governing the activation of both of the rules will be presented.

1) The sinus impulses intervening between extrasystoles are almost always in odd numbers, as shown in figure 3. (Conversely, conducted sinus beats intervening between extrasystoles are almost always in...
CONCEALED VENTRICULAR EXTRASYSTOLES

An analysis of the interectopic sinus impulses in the whole record of the late stage is presented in table 2. Table 2 reveals that the interectopic sinus impulses are, with only two exceptions, all in odd numbers. This feature is quite the reverse of that in the early stage where the interectopic impulses are in even numbers only.

The explanation of the mechanism governing the "rule of bigeminy" in this case is suggested in the diagram below the third strip of figure 3. (The explanation for the exceptions is excluded because it can be derived from the features (3) and (4) mentioned below.) Sinus impulses in figure 3 are labeled in the same way as in figure 2. In the late stage, the number l, which belongs to the last sinus impulse S1 before the next extrasystole E′, is always odd. For example, the sinus impulse S1 in the third strip of figure 3 is the impulse S11. This feature indicates that the extrasystole here always appears following one of the sinus impulses labeled S2n+1. In addition long S2n-S2n+1 intervals (for example, the S10-S11 interval in figure 3) favor the appearance of the following extrasystoles. In the early stage, all of the extrasystolic impulses caused by the sinus impulses S2n+1 may possibly become "concealed extrasystoles due to exit block within the V-E junction," because these extrasystolic impulses may come in the absolute refractory period of this junction, as mentioned above. Therefore, when the S2n-S2n+1 interval is long, the extrasystolic impulse caused by the sinus impulse S2n+1 may come after the absolute refractory period of the V-E junction, and passing through the junction, it may become the manifest extrasystole. This is probably the mechanism governing the "rule of bigeminy" here. The features mentioned below confirm this analysis.

2) Whereas long S2n-S2n+1 intervals favor the appearance of extrasystoles, lengthening of S2n-S2n+1 intervals to the same extent is never followed by manifest extrasystoles. Examples of such S2n-S2n+1 intervals are the intervals of S11-S6 and S10-S11 in the third strip of figure 3. The S10-S11 interval here is longer than the S10-S11 interval that is followed by the manifest extrasystole. Among the interectopic sinus cycles, accordingly, the longest cycle is not always the last one that is followed by the extrasystole. From the features shown in the early stage, the following explanation is suggested. When the S2n-S2n+1 interval is long enough to increase the S2n-S2n+1 interval beyond the critical length mentioned above, the extrasystolic impulse caused by the sinus impulse S2n always becomes the "concealed extrasystole due to interference." For example, when the long S5-S10 interval in the third strip of figure 3 increases the S23-S10 interval beyond the critical length of 123, the extrasystolic impulse caused by the impulse S10 becomes the concealed extrasystole.

3) When the S2n-S2n+1 interval lengthens further to a period more than about 108, the sinus impulse S2n+1 is not followed by a manifest extrasystole. This feature is seen in the two exceptions mentioned above, in which interectopic sinus impulses are in fours, that is, not in odd numbers. One of them is shown in the late portion of the bottom strip in figure 3. The explanation for this is illustrated by the diagram below the strip. Here, the S11-S12 interval is so long that the V-E conduction delay of the extrasystolic impulse originated by the sinus impulse S11 is not enough to cause the manifest extrasystole. Consequently, the extrasystolic impulses caused by the sinus impulses S11 and S12 become "concealed extrasystoles due to interference" in succession. Then, the extrasystolic impulse caused by the impulse S12 becomes manifest after the S11-S12 interval that is considerably shorter than the S12-S13 interval.

4) The couplings of extrasystoles to the preceding sinus beats are considerably variable, ranging between periods of 39 and 49.5, as shown in figure 3. The majority of these coupling intervals are longer than those seen in the early stage. Figure 4 shows the relationship between the S2n-S2n+1 intervals here and the appearance of the following extrasystoles; and the relationship between the S2n-S2n+1 intervals followed by extrasystoles and the coupling intervals of these extrasystoles. In the late stage shown in figure 4, slowing of the sinus rhythm occurs spontaneously (solid circles) and owing to pressure on the eye ball (open circles). When S2n-S2n+1 intervals are below a certain critical length, none of the following extrasystoles appear. This critical length is a period of 88 during the spontaneous slowing, and a period of 91 during the slowing due to pressure on the eye ball. On the other hand, when S2n-S2n+1 intervals are longer

Table 2

Analysis of the Number of Sinus Impulses Intervening between Extrasystoles from the Entire Record in the Late Stage (Case 1)

<table>
<thead>
<tr>
<th>Number of sinus impulses occupying the interectopic intervals</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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<th>12</th>
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<tr>
<td>Frequency</td>
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<td>7</td>
<td>2*</td>
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<td>0</td>
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<td>3</td>
<td>0</td>
<td>1</td>
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</tr>
</tbody>
</table>

*Exceptions to the rule.

Circulation, Volume 52, August 1975
than 107, the following extrasystoles also fail to appear, as mentioned in the two exceptions. When $S_{2n} - S_{2n+1}$ intervals are longer than the short critical length of 88 or 91 but shorter than the long critical length of 107, the extrasystoles always follow. (When $S_{2n} - S_{2n+1}$ intervals equal the short critical length, the following extrasystoles sometimes appear and at other times fail to appear.)

In figure 4, when the length of the $S_{2n} - S_{2n+1}$ interval becomes longer than the critical short length, the coupling interval of the following extrasystole gradually becomes shorter to the minimum length of 99, which is only a little longer than the Q-T interval of the sinus beats here. Subsequently, the following extrasystole fails to appear. This indicates that the extrasystole here fails to appear because the extrasystolic impulse becomes the "concealed extrasystole due to interference at the external end of the V-E junction" as mentioned above. Conversely, in figure 4, when the length of the $S_{2n} - S_{2n+1}$ interval decreases from the long critical length, the coupling interval of the following extrasystole gradually becomes longer to the maximum length of 49. Subsequently, the following extrasystole also fails to appear. From this fact and the features mentioned above, we must assume that the coupling interval is prolonged because of the conduction delay in the V-E junction, and then the extrasystole here fails to appear because the extrasystolic impulse falls within the absolute refractory period of the V-E junction and is blocked within the junction. Therefore, the long critical length of 107 will be termed the "critical value for interference," and the short one of 88 or 91, the "critical value for exit block."

The small difference that is noted between the "critical values for exit block" during the spontaneous slowing and during the slowing due to pressure on the eye ball may be explained by a more prolonged refractory period of the V-E junction during pressure on the eye ball. The "critical length for exit block" will be about equal to the absolute refractory period of the V-E junction.

5) When all the sinus cycle intervals range between the above two critical values, i.e., a period of 88 or 91 and a period of 107, a ventricular trigeminal rhythm is seen, as shown in the early portion of the bottom strip in figure 3. The diagram below the strip reveals that the sinus impulse $S_2$ here is always followed by the manifest extrasystole, after the extrasystolic impulse caused by the impulse $S_2$ becomes the "concealed extrasystole due to interference."

Discussion

The observations reported here demonstrate that extrasystoles from the same focus obey the rule of "concealed ventricular bigeminy" at a certain stage, and at another stage, the "rule of bigeminy." As far as I know, such a phenomenon has never been reported before. On the basis of these observations it is postulated that the absolute refractory period of the V-E junction here is markedly long. A new mechanism governing both of the rules can be developed from this assumption. In our previous reports, such a long V-E refractory period was also present in cases of
intermittent ventricular parasystole. This mechanism will be related to others that have been proposed.

Mechanism of "Concealed Ventricular Bigeminy (or Trigeminy)"

Schaumoeth postulated that even when none of the manifest extrasystoles appear in concealed ventricular bigeminy (or trigeminy), an extrasystolic impulse arises following every second (or third) sinus beat. He suggests exit block as the explanation for their failure to appear.\(^2\) He believes that such concealed extrasystoles reflect a continuous rhythmic ectopic discharge rather than a localized re-entry mechanism.\(^8\) The observations in this report, however, suggest that extrasystolic impulses arise following all the sinus beats in concealed bigeminy (or trigeminy). Therefore, I think that concealed bigeminy (or trigeminy), i.e., the "rule of multiples" neither implies the ectopic automaticity nor militates against the concept of the re-entry mechanism. Although in this report I use the term "V-E junction," i.e., the region surrounding the "ectopic focus," according to Schaumoeth's theory, the term "re-entry path" might be preferable to the "V-E junction."

Actually, some of the features shown in this report, which lead to the mechanism here, can be found in previously reported cases of concealed bigeminy,\(^1\)\(^,\)\(^3\)\(^,\)\(^6\) as mentioned below.

1) In most of the previous cases, the coupling intervals of extrasystoles also were short, namely, only a little longer than the Q-T interval of the sinus beats.

2) In some of the previous cases, the coupling intervals also varied considerably with changes in the rhythm. In others, however, the coupling intervals varied in a narrow range, and the shortest one was considerably longer than the Q-T interval of the sinus beats. The possible explanations for this may be that in these cases interference occurs not at the ventricular side of the V-E junction, but at the somewhat inner portion of the junction into which sinus impulses have penetrated.

3) In case 55 of Schamroth,\(^8\) shortening of the \(S_{2n}-S_{2n+2}\) interval favored the appearance of the following extrasystole, and the "critical length for interference" was slightly but significantly longer in regard to the \(S_1-S_{2n+2}\) interval to the \(S_1-S_2\) interval. These features reflect my case 1. In the other cases, however, these features were not clearly disclosed. The explanation may be as follows: The sinus cycle length may vary in a narrow range, whereas the length of the absolute V-E refractoriness fluctuates in a somewhat wider range, though it remains between one and two sinus cycles.

Recently, in the experimental work of Lee, Levy, and Zieske,\(^8\) in which stimuli were generated electrically on alternate sinus beats to simulate a 2:1 block in the postulated re-entry path, it was demonstrated that, when the propagation time in the re-entry path was made just less than the refractory period of the ventricular myocardium, similar concealed bigeminy was produced. An odd number of conducted sinus beats greater than five lay between manifest extrasystoles. On the basis of these experiments, they said finally, "the most reasonable explanation for such occasional manifest extrasystoles is that the propagation time temporarily exceeds the refractory period for reasons that have not been ascertained." These reasons have been suggested in the cases here.

Mechanism of the "Rule of Bigeminy"

It has been previously postulated that, in cases showing the rule of bigeminy, extrasystolic impulses arise only after long ventricular cycles,\(^4\) because the ectopic focus is protected by diastolic depolarization.\(^6\) In the cases reported here, however, I have suggested that, even when extrasystoles obey the rule of bigeminy, ectopic impulses arise following all the sinus beats, though most of them are not seen. Therefore, the mechanism hitherto postulated will not apply to the cases here. The feature that many long R-R intervals fail to be followed by a manifest extrasystole, is found both in cases of Langendorf, Pick, and Winternitz,\(^4\) and in the cases here. The mechanism presented here explains this feature. Accordingly, there is the possibility that the "rule of bigeminy" shown in their cases of atrial fibrillation may be governed by the same mechanism as in the cases here. This possibility will be described in greater detail in a future report.

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Concealed ventricular extrasystoles due to interference and due to exit block.

S Kinoshita

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