Mechanism of Supraventricular Parasystole

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SUMMARY Two patients with supraventricular parasystole (one atrioventricular and one auricular) are reported. In both patients, reentrant extrasystoles appeared to occur as the result of Mobitz type I second-degree entrance block. We believe that when a sinus impulse fell soon after the absolute refractory period of the pathway containing the parasystolic focus, it reached and discharged the focus after marked delay, and thereafter became a reentrant extrasystole. In interectopic intervals containing more than one sinus beat, the number of intervening sinus beats was always even, suggesting the presence of concealed reentrant parasystolic bigeminy.

The observations in the present report and in our previous patients with ventricular parasystole strongly suggest that most cases of parasystole, whether ventricular or supraventricular, or whether intermittent or "continuous," may be governed by second-degree entrance block.

KINOSHITA1-8 showed that in most patients with ventricular parasystole, Mobitz type I second-degree entrance block is present. When a sinus impulse fell in the prolonged absolute refractory period of the pathway containing the parasystolic focus, the focus was protected from this impulse. However, when a sinus impulse fell shortly after this absolute refractory period, it reached and discharged the parasystolic focus after marked delay, and thereafter it occasionally became a reentrant ventricular extrasystole.

These features in ventricular parasystole suggest the possibility that such reentrant extrasystoles might also be seen in supraventricular parasystole. In the present report we discuss two patients with supraventricular parasystole in whom reentrant supraventricular extrasystoles appear to have occurred in the same manner as in ventricular parasystole.

Materials and Methods

ECGs were continuously recorded from two patients with supraventricular parasystole. Patient 1 had atrioventricular (AV) junctional and patient 2 had auricular parasystole. Neither patient had organic heart disease or was receiving digitalis or other antiarrhythmic therapy. These two patients and one previously reported patient with AV junctional parasystole6 represent all of the cases of supraventricular parasystole that we have analyzed.

The ECGs were analyzed by the same method we used in the patients with ventricular parasystole.9 The following interectopic intervals were measured: (1) the interectopic intervals (E1E2) containing one sinus beat (S), (2) those containing more than one sinus beat, and (3) those from the first ectopic beat in the interectopic interval to the first intervening sinus beat (E1S). In measuring these intervals, QRS complexes of ectopic and sinus beats were used in AV junctional parasystole (patient 1); in auricular parasystole (patient 2), P waves of those beats were used. To find the effect of sinus impulses on the ectopic rhythm, the relationships between the intervals 1 and 2 and between 1 and 3 were examined. Also, the number of intervening sinus beats in intervals containing more than one sinus beat was analyzed.

Results

The results are summarized in table 1.

Figure 1 shows parts of a long continuous recording from patient 1, a 62-year-old man with AV junctional parasystole. In patient 1, when a sinus beat occurred within 1.04 seconds after the preceding ectopic beat, this sinus beat was followed by another ectopic beat, and the interectopic interval containing this sinus beat was always 1.82-1.84 seconds. This suggests that the parasystolic focus was protected from this sinus impulse, as shown in the initial portion of the diagram below the top strip (the interval E1E3) in figure 1. Other examples of intervening sinus impulses are seen in interval E6E8 and E8E9 in the lower three strips. In table 1, such interectopic intervals are represented by "long E1E2."

When a sinus beat occurred 1.04-1.10 seconds after the preceding ectopic beat, the sinus beat was also followed by another ectopic beat, but the interval between these two ectopic beats was much shorter than the above-mentioned interectopic interval, ranging from 1.60-1.63 seconds. In table 1, such short interectopic intervals are represented by "short E1E2."

An example is the interval E6E8 containing the sinus beat S8 in the top strip of figure 1. These features are about the same as those in our previously reported cases of ventricular parasystole.5, 8 Therefore, these suggest that Mobitz type I second-degree entrance block was present, as shown in the diagram below the strip. The diagram shows that when a sinus impulse, S9, falls shortly after the absolute refractory period of the pathway containing the parasystolic focus, it reaches and discharges the focus after marked delay, and thereafter becomes a reentrant extrasystole, E6. Other examples of such short interectopic intervals are intervals E1E2 and E13E14 in the lower three strips.

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When a sinus beat occurred more than 1.10 seconds after the preceding ectopic beat, it was not followed by an ectopic beat, and an even number of sinus beats intervened between this preceding ectopic beat and the subsequent manifest ectopic beat. Interectopic intervals that contained more than one sinus beat were not equal to any multiple of the interectopic interval containing one sinus beat (whether it was a long $E_1E_2$ or a short $E_1E_2$); nor did they have a common denominator. An example of such interectopic intervals is interval $E_2E_3$ in the top strip of figure 1. The diagram below the strip shows that the sinus impulse $S_1$ reaches the parasystolic focus after some delay and becomes a concealed reentrant extrasystole, $(E_3)$. The "even-number" form of concealed extrasystolic biform rhythm continues until a parasystolic impulse occurs again. Other examples of such interectopic intervals containing an even number of sinus beats are intervals $E_5E_6$, $E_5E_8$, and $E_{14}E_{17}$ in the lower three strips. All of these features in patient 1 are similar to those in our patients with ventricular parasystole.

Figure 2 is a His bundle electrogram from patient 1, suggesting that the ectopic impulse originated in the lower part of the His bundle. The QRS configuration of ectopic beats was slightly different from that of

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**TABLE 1. Electrocardiographic Data in Two Patients with Supraventricular Parasystole**

<table>
<thead>
<tr>
<th>Pt</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Origin of parasystole</th>
<th>$E_1E_2$* containing one $S^*$ (sec)</th>
<th>$E_1E_2$ containing more than one $S$: the numbers of $S$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62</td>
<td>M</td>
<td>AV junctional</td>
<td>1.82-1.84 1.60-1.63 0.215 1.04</td>
<td>Even</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>M</td>
<td>Auricular</td>
<td>1.93-1.95 1.82-1.85 0.105 1.28</td>
<td>Even</td>
</tr>
</tbody>
</table>

*In measuring these intervals, QRS complexes of ectopic and sinus beats were used in atrioventricular junctional parasystole; in auricular parasystole, P waves of those beats were used.

†In the long $E_1E_2$ interval, the $E_1S$ interval was always shorter than this critical $E_1S$ interval; in the short $E_1E_2$ interval, the $E_1S$ interval was always longer than the critical $E_1S$ interval.

Abbreviations: $E_1E_2$ = interectopic interval; $S$ = intervening sinus beat; $AV$ = atrioventricular.
sinus beats. This suggests the presence of functional longitudinal dissociation of conduction within the His bundle.\textsuperscript{7-10}

Figure 3 shows parts of a long recording from patient 2, a 21-year-old man with auricular parasystole. The first three strips are continuous. This patient had features similar to those in patient 1, suggesting the presence of Mobitz type I second-degree entrance block. In patient 2, when a sinus P wave occurred 1.03–1.28 seconds after the preceding ectopic P wave, the sinus beat was followed by another ectopic P wave, and the interval between these two ectopic P waves was always 1.93–1.95 seconds. Examples of such interectopic intervals are intervals $A_1A_2$ and $A_{13}A_{14}$ in the first three strips, and $A_1A_2$, $A_2A_3$, and $A_3A_4$ in the bottom strip. When a sinus P wave occurred 1.28–1.43 seconds after the ectopic P wave, the sinus beat was also followed by another ectopic P wave, but the interval between the two ectopic P waves was distinctly shorter, 1.82–1.85 seconds. Examples of short interectopic intervals are intervals $A_2A_3$ in the second strip and $A_1A_2$ and $A_3A_4$ in the fourth strip. In this recording, intervals between the ectopic P wave and the following sinus P wave did not exceed 1.43 seconds. These features in patient 2 suggest that Mobitz type I second-degree entrance block occurred in a way similar to that in patient 1. The diagrams below the strips in figure 3 illustrate such second-degree entrance block.

When a sinus P wave occurred within 1 second after the preceding ectopic P wave, this sinus beat was not followed by an ectopic P wave, and an even number of sinus beats intervened between this preceding ectopic P wave and the subsequent ectopic P wave. An example of such interectopic intervals is the interval $A_{12}A_{13}$ in the third strip of figure 3. The parasystolic focus is protected from the sinus impulse $P_{22}$, but the next sinus impulse, $P_{23}$, reaches and discharges the parasystolic focus before occurrence of the next parasystolic impulse because the interval $A_{12}P_{23}$ is somewhat shorter than the parasystolic cycle. After that, concealed reentrant extrasystolic bigeminal rhythm continues until a reentrant extrasystole, $A_{13}$, becomes manifest. Other examples of such interectopic intervals are intervals $A_2A_3$, $A_4A_5$, and $A_{10}A_{11}$ in the first three strips. When a sinus P wave occurred 1.00–1.03 seconds after the ectopic P wave, the next sinus and ectopic impulses occasionally occurred almost simultaneously. As the result, an auricular fusion wave was occasionally found. An example is the auricular wave $A_{17} + P_{90}$ in the third strip.

**Discussion**

The observations in the present report suggest that in patients with supraventricular parasystole, reentrant extrasystoles occurred as the result of Mobitz type I second-degree entrance block. The configuration of the reentrant extrasystoles was the same as that of the parasystolic beats. These features are similar to those in our patients with ventricular parasystole.\textsuperscript{2, 3}

We previously reported a patient with AV junctional parasystole\textsuperscript{4} in whom the presence of Mobitz type I second-degree entrance block was suggested, although manifest reentrant extrasystoles were not found. Thus, our observations strongly suggest that most cases of parasystole, whether ventricular or supraventricular, or whether intermittent or “continuous,” may be governed by second-degree entrance block.

In figure 4, the upper diagram shows the effect of sinus impulses on the ectopic rhythm in our clinical cases of ventricular or supraventricular parasystole. The ordinate represents interectopic intervals ($E_1E_2$) that contain one or no intervening sinus impulse ($S$) conducted to the ventricles. The abscissa represents intervals from the first ectopic impulse to its subsequent conducted sinus impulse ($E_1S$). When a conducted sinus impulse falls in period $A$, i.e., early in the parasystolic cycle, the interectopic interval containing this sinus impulse is always equal to the “pure” parasystolic cycle containing no intervening sinus impulse. This suggests that the parasystolic focus is protected from this sinus impulse because of entrance block.

When a sinus impulse falls in period $B$ of the upper diagram, namely, later in the parasystolic cycle, the interectopic interval containing this sinus impulse is shorter than the pure parasystolic cycle, except in a short terminal part of period $B$. This suggests that entrance block failed to occur in period $B$ and that, except in the terminal part, the sinus impulse reaches the parasystolic focus after some delay and thereafter becomes a reentrant extrasystole. We suggest that the ectopic impulse ($E_2$) after this sinus impulse is a reentrant extrasystole. When the coupling interval of this reentrant extrasystole to the preceding sinus beat ($SE_2$) is shorter than the absolute refractory period of ordinary myocardium (the thinly shaded bar in period $B$), the reentrant extrasystolic impulse cannot become manifest (concealed extrasystole). When a sinus im-
Pulse falls in a short terminal part of period B, the next parasystolic impulse ($E_2$) occurs before the sinus impulse can reach the focus; the parasystolic rhythm is not disturbed by this sinus impulse because of interference of parasystolic and sinus impulses, and not because of entrance block.

When a sinus impulse falls in period C of the upper diagram, i.e., when the interectopic interval ($E_1E_3$) contains no intervening sinus impulse, a pure parasystolic cycle appears. This pure parasystolic cycle is equal in length to the interectopic interval containing one sinus impulse in period A.

Recently, Moe et al. postulated two principal features of parasystole on the basis of the results of their experiments using a bundle of canine Purkinje fibers (fig. 4, lower diagram). One feature is that when a supraventricular impulse falls late in the parasystolic cycle (period B, fig. 4, lower diagram), it hastens the discharge of the pacemaker, or "captures" the pacemaker. This feature is similar to that observed in our clinical cases of parasystole; the only difference between their interpretation and ours might be a semantic one, as they suggested. The other feature postulated by Moe et al. is that when a supraventricular impulse falls earlier in the parasystolic cycle (period A, fig. 4, lower diagram), it delays the next discharge of the pacemaker. We never documented this feature in our patients with parasystole.

In clinical cases of parasystole, the interval from the parasystolic beat to the next sinus beat conducted to the ventricles ($E_2S$) is usually longer than the sinus cycle length, indicating the presence of a postectopic pause. Therefore, so that a conducted sinus impulse may fall in the first half of the parasystolic cycle, the sinus cycle length here usually must be shorter than half the parasystolic cycle length. As a result, when a conducted sinus impulse falls in the first half of the parasystolic cycle, the next sinus impulse usually falls late in the same parasystolic cycle and discharges the parasystolic focus before the next parasystolic impulse ($E_2$) occurs; this parasystolic impulse ($E_2$) usually fails to occur. In clinical cases, only when a sinus impulse
whether the long interectopic interval containing one sinus beat is equal to or longer than the pure parasystolic cycle. Therefore, such cases might be explained both by the mechanism postulated by Moe et al. and by us, as Moe and Jalife pointed out (personal communication).

However, in our cases in which the long interectopic interval containing one sinus beat coexists with the pure parasystolic cycle, it is never shown that this interectopic interval containing one sinus beat is longer than the pure parasystolic cycle. Recently, Castellanos et al. also showed the absence of such lengthening of the interectopic interval in patients with intermittent ventricular parasystole. Thus, we do not believe that the mechanism postulated by Moe et al. can explain all cases of parasystole.

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