Intermittent Parasystole Originating in the Reentrant Path of Ventricular Extrasystoles*

Shinji Kinoshita, M.D.

This report indicates the presence of intermittent ventricular parasystole alternating with ventricular extrasystoles caused by the reentrant mechanism, in which the parasystolic focus is located within the reentrant path. Intermittent parasystole in this case shows second-degree entrance block. When a sinus impulse falls in the absolute refractory period of the ventricular-ectopic junction, the ectopic focus is protected from it. When a sinus impulse falls in a considerably late period of the ectopic cycle, which is long after the absolute refractory period of the ventricular-ectopic junction, the parasystolic rhythm is also not disturbed by it. Although in this late period the sinus impulse enters the ventricular-ectopic junction, it interferes with the next ectopic impulse within the junction and therefore cannot reach the ectopic focus. When a sinus impulse falls before the previously mentioned period but still long after the absolute refractory period of the ventricular-ectopic junction, it reaches the ectopic focus after a comparatively short time of ventricular-ectopic conduction, which results in resetting of the parasystolic rhythm; however, when a sinus impulse falls shortly after the absolute refractory period of the ventricular-ectopic junction, it reaches the ectopic focus after a marked delay in conduction, and thereafter it occasionally becomes a reentrant extrasystole.

Until a recent date, it had been believed that in intermittent parasystole the first ectopic beat of each series is coupled to the preceding sinus beat by a fixed interval. In recent reports on intermittent parasystole by Steffens, Cohen et al., and by Kinoshita and Tanabe, it was demonstrated that the first ectopic beat of the series was not a "true" extrasystole coupled to the preceding sinus beat, but was a parasystolic beat coupled to the second preceding sinus beat by the escape interval; however, in comparatively few cases, it was clearly indicated that intermittent parasystole alternated with "true" extrasystoles arising from the same focus.

Our previously reported cases of intermittent parasystole showed that the site of incomplete entrance block was considerably distant from the ectopic focus, and that the time of conduction from this site to the ectopic focus was often markedly prolonged. These cases strongly suggested the possibility that "true" extrasystoles in intermittent parasystole might be caused by a reentrant mechanism, although in these cases, such an extrasystole could not be detected. In the present report, a case of intermittent ventricular parasystole alternating with extrasystoles caused by the reentrant mechanism will be presented, in which the parasystolic focus is located within the reentrant path.

Electrocardiographic Findings

Electrocardiograms were recorded from a healthy 43-year-old man. The ECGs showed sinus rhythm with ventricular ectopic beats of the same configuration. Figures 1 to 3 are parts of a continuous 30-minute recording.

Usually, the interval between two successive ectopic beats contained two or more intervening sinus beats, as shown in Figure 1. The four strips of Figure 1 are continuous. Coupling intervals of ectopic beats to the preceding sinus beats are markedly variable. A fusion beat (labelled E + S) is seen in the lower strip of Figure 3. Sometimes, none of the sinus beats intervened between two successive ectopic beats. Such interectopic intervals containing no intervening sinus beats were almost constant; the intervals varied within very narrow limits, ranging between periods of 172 and 177 (mean, 174.5) (all intervals herein are expressed in hundredths of a second). Figure 2 shows that when the sinus rate is decreased, owing to pressure on the eyeball (Aschner's test), a pure ectopic rhythm occurs. These findings suggest the presence of ventricular parasystole; however, this case is not a continuous parasystole, because interectopic intervals containing two or more intervening sinus beats were usually not equal to multiples of the length of such an ectopic cycle. Figure 1 shows that interectopic intervals containing two sinus beats are considerably shorter than twice the ectopic cycle. This feature is similar to those in the previously reported cases of intermittent parasystole. This suggests

*From the Second Department of Medicine, Hokkaido University School of Medicine, Sapporo, Japan. Manuscript received October 19; revision accepted December 21.

Reprint requests: Dr. Kinoshita, Second Department of Medicine, Hokkaido University School of Medicine, Sapporo, Japan

CHEST, 72: 2, AUGUST, 1977
the possibility that the sinus impulse conducted to the ventricles following the ectopic beat may discharge the ectopic focus and reset the parasystolic rhythm.

In Figure 2, the interval between the last sinus beat before occurrence of the pure parasystolic rhythm and the first ectopic beat of the rhythm (for example, the interval E₁-E₃ in the upper strip) is considerably longer than the ectopic cycle. This suggests that the time of conduction in the ventricular-ectopic junction is prolonged, and therefore, after considerable delay the sinus impulse reaches the ectopic focus and resets the parasystolic rhythm. The lower strip of Figure 2 shows that when a sinus impulse falls in a considerably late period of the ectopic cycle, the sinus impulse (labelled S₄) cannot disturb the parasystolic rhythm. The probable explanation for this is that such a sinus impulse interferes with the next ectopic impulse in the ventricular-ectopic junction and fails to reach the ectopic focus, as mentioned subsequently. Even when such a late sinus impulse was followed by another sinus impulse and when the interval between these sinus impulses was a period of 105 or less, the parasystolic rhythm was not disturbed, as shown in the interectopic interval E₄-E₅ of the upper strip of Figure 2. This indicates that the sinus impulse S₄ in the upper strip also cannot reach the ectopic focus because it falls in the absolute refractory period of the ventricular-ectopic junction, which is approximately 105, as indicated by the inability of most sinus beats to depolarize the ectopic focus at an interval shorter than this.

In order to ascertain the presence of such an entrance block, a continuous 30-minute recording, including Figures 1 to 3, was analyzed according to the method previously described. Among interectopic intervals containing two intervening sinus

---

**Figure 1.** Intermittent ventricular parasystole alternating with reentrant extrasystoles. Four strips are continuous. Shaded areas in diagrams below strips represent absolute refractory period of ventricular-ectopic junction. Intraventricular conduction of sinus (or ectopic) impulse leading to the ventricular-ectopic junction is indicated by dashed lines. S, Sinus impulse (or beat) conducted to ventricles; (S), sinus impulse not conducted to ventricles; E, ectopic beat (or impulse giving rise to it); (E), parasystolic impulse that fails to become manifest; V, ventricles; and RP, reentrant path containing ventricular-ectopic junction, ectopic focus, and ectopic-ventricular junction. All time intervals are expressed in hundredths of a second.
beats, those in which the interval between these sinus beats was a period of 105 or less were chosen throughout the 30-minute recording. Examples are the interectopic intervals E₁₄-E₁₅ in Figure 1 and E₅-E₆ in the upper strip of Figure 2, in which the latter of the two intervening conducted sinus impulses appears to fall in the absolute refractory period of the ventricular-ectopic junction and the ectopic focus is protected from it. Therefore, the ectopic beats E₁₅ in Figure 1 and E₅ in the upper strip of Figure 2 seem to be parasystolic beats. Each of the interectopic intervals was divided by the beginning of the first intervening sinus beat into two parts; the early part is the interval between the former of the ectopic beats and the first intervening sinus beat (for example, the interval E₁₄-S₃₈ in Figure 1), and the late part is the interval between the first sinus beat and the latter ectopic beat (for example, the interval S₃₈-E₁₅ in Figure 1). The relationship in length between the early and late parts is represented by solid circles in Figure 4. The relationship represented is almost the same as that in my previous case of second-degree entrance block of the Mobitz type 1.¹⁰ Therefore, phases of the ventricular-ectopic junction after stimulation by the ectopic impulse can be divided in the same way. Points on the oblique dashed line in Figure 4 indicate that the sum of the early and late parts (ie, an interectopic interval) is equal to twice the mean length of the parasystolic cycle (ie, 2 × 174.5).

Figure 2. Pure parasystolic rhythm. Two strips are not continuous. Slowing of sinus rhythm is due to pressure on eyeball. S, sinus impulse (or beat) conducted to ventricles; E, ectopic beat (or impulse giving rise to it); (E), parasystolic impulse that fails to become manifest; V, ventricles; and RP, reentrant path containing ventricular-ectopic junction, ectopic focus, and ectopic-ventricular junction. All time intervals are expressed in hundredths of a second.

Figure 3. Ventricular parasystole and extrasystoles occasionally showing interectopic intervals containing one intervening sinus beat. Two strips are continuous. S, sinus impulse (or beat) conducted to ventricles; E, ectopic beat (or impulse giving rise to it); V, ventricles; and RP, reentrant path containing ventricular-ectopic junction, ectopic focus, and ectopic-ventricular junction. All time intervals are expressed in hundredths of a second.
In phase D (Fig 4), in which the first sinus beats occur beyond a period of about 157 after their preceding ectopic beats, the solid circles are on or near the dashed line, indicating that interectopic intervals are equal to twice the parasystolic cycle. An example is the interectopic interval E13-E14 in the upper strip of Figure 2. This shows that in phase D the sinus impulse conducted to the ventricles following the ectopic beat cannot discharge the ectopic focus.

In phases B and C (Fig 4), in which the first sinus beats occur within the period of about 157 after their preceding ectopic beats, the solid circles are below the dashed line. This indicates that the interectopic intervals here are shorter than twice the parasystolic cycle. It is suggested that in phases B and C, the first conducted sinus impulse reaches the ectopic focus and resets the parasystolic rhythm.

In phase C, in which the first sinus beats occur during a period of about 142 to 157 after the ectopic beats, the length of the late part is nearly constant, namely, approximately equal to a period of 192 (which is a period of 17.5 plus the mean parasystolic cycle length of 174.5). Examples are the interectopic intervals E13-E14 in Figure 1 and E5-E6 in the upper strip of Figure 3. This suggests that in phase C the time of ventricular-ectopic conduction of the first conducted sinus impulse plus the time of ectopic-ventricular conduction of the latter ectopic impulse is about the period of 17.5.

On the other hand, in phase B, in which the first sinus beats occur within a period of about 142 after the ectopic beats, the late part is longer than that in phase C; and the shorter the early part, the longer the late part. An example is the interectopic interval E6-E7 in the lower strip of Figure 3. It seems that in phase B the time of ventricular-ectopic conduction of the first conducted sinus impulse is considerably longer than that in phase C.

These observations indicate that phase C corresponds to the nonrefractory phase of the ventricular-ectopic junction, during which the time of ventricular-ectopic conduction is comparatively short, and that phase B corresponds to the relative ventricular-ectopic refractory phase during which the time of ventricular-ectopic conduction is consider-
ably prolonged. As mentioned earlier, the sum of the ventricular-ectopic and ectopic-ventricular conduction times in the nonrefractory phase seems to be a period of about 17.5. This suggests that in phase D, in which the first sinus beat occurs beyond a period of about 157 (ie, the mean length of the parasystolic cycle of 174.5 minus the period of 17.5) after the ectopic beat, the first conducted sinus impulse enters into the ventricular-ectopic junction but fails to reach the ectopic focus because it interferes with the next ectopic impulse in the ventricular-ectopic junction, as illustrated by the diagram below the upper strip of Figure 2. The longest one of the sums of the ventricular-ectopic and ectopic-ventricular conduction times calculated from the solid circles in Figure 4 is about a period of 33.5.

In Figure 4, when the early part is shorter than a period of 116, none of the solid circles is found, despite the fact that this period is considerably longer than the absolute ventricular-ectopic refractory period of 105. In the upper strip of Figure 3, the sinus beat S3 fails to be followed by an ectopic beat, although the preceding interval S2-S3 is shorter than the period of 105. The interval E1-S2 is a period of 108, which is a little longer than the absolute ventricular-ectopic refractory period. This fact shows that the sinus impulse S2 falls a little after the absolute ventricular-ectopic refractory period, and, therefore, after marked delay, it reaches the ectopic focus and resets the parasystolic rhythm. As a result the next ectopic beat cannot occur before the sinus beat S4. This is the reason that when the early part in Figure 4 is shorter than a period of 116, none of the solid circles is found. The calculated ventricular-ectopic plus ectopic-ventricular conduction time of the sinus impulse S3 is about a period of 47 or a little more, which is approximately equal to the Q-T interval of the sinus beats. These findings suggest the possibility that if a sinus impulse occurs a little less than the period of 108 after the ectopic beat, it might cause an extrasystole due to reentry after discharging the ectopic focus.

In Figure 3, interectopic intervals containing one intervening sinus beat are seen. The two strips of Figure 3 are continuous. The interectopic interval E7-E8 in the lower strip is exactly equal to the parasystolic cycle, in which the interval E7-S90 of 98 is much shorter than the absolute ventricular-ectopic refractory period. This indicates that the sinus impulse S90 falls in the absolute ventricular-ectopic refractory period, and therefore the ectopic focus is protected from it. On the other hand, the interectopic interval E5-E6 containing one sinus beat in the upper strip of Figure 3 (ie, a period of 161) is much shorter than the parasystolic cycle, which ranges between periods of 172 and 177, as mentioned previously. Here, although the interval E5-S7 of 107 is a little longer than the absolute ventricular-ectopic refractory period, it is further less than the interval E1-S2 in the same strip, in which the sinus impulse S2 shows marked delay of conduction in the ventricular-ectopic junction. These facts strongly suggest that after more marked delay, the sinus impulse S7 may reach the ectopic focus, and thereafter it may become an extrasystole (E8). Therefore, it seems that the ectopic beat E8 is not a parasystolic beat but a "true" extrasystole due to reentry.

In the second strip of Figure 1, the interval between the sinus beats S12 and S13 is a period of 110, which is considerably longer than the absolute ventricular-ectopic refractory period of 105. In spite of that, these two sinus beats intervene between the ectopic beats E4 and E5. From the previously mentioned observations, it is clear that the sinus impulse of S12 discharges the ectopic focus and resets the parasystolic rhythm. The interval between the sinus beat S12 and the latter ectopic beat E5 is a period of 165, which is definitely shorter than the parasystolic cycle. This indicates that the ectopic beat E5 is not a parasystolic beat. Thus, it seems probable that because the sinus impulse S13 falls a little after the absolute ventricular-ectopic refractory period, it reaches the ectopic focus after marked delay and subsequently becomes a reentrant extrasystole (E5). The diagrams below the strips in Figure 1 illustrate such a mechanism according to the manner shown in our previous report on intermittent parasystole. Another example of such interectopic intervals is the interval E1-E2 in Figure 1.

Among interectopic intervals containing two intervening sinus beats, those in which the interval between these sinus beats is a period of 110 or more were chosen throughout the continuous 30-minute recording including Figures 1 to 3. The period of 110 is somewhat longer than the absolute ventricular-ectopic refractory period of 105. Examples of such interectopic intervals are seen in the top strip of Figure 1. In the same way as mentioned previously, the relationship between the early and late parts of these interectopic intervals is represented by the open circles in Figure 4. It is clearly shown that the late parts represented by open circles are shorter than those represented by solid circles. This also indicates that in these interectopic intervals represented by open circles, the latter of the intervening conducted sinus impulses reaches the ectopic focus and thereafter becomes an extrasystole due to reentry.

CHEST, 72: 2, AUGUST, 1977

INTERMITTENT PARASYSTOLE 205
DISCUSSION

The observations in this report demonstrate the presence of an intermittent parasystole originating in the reentrant path of ventricular extrasystoles. Recently, Singer and co-workers\(^1\) also reported a similar case, in which fixed coupled extrasystoles suggested a reentrant mechanism within the focus of a "ventricular parasystole;" however, I think that the ECGs presented in their report appear to show a ventricular escape rhythm without entrance block, rather than a ventricular parasystole. It seems that in a comparatively slow sinus rhythm, ectopic rhythm is often not disturbed because of interference of sinus and ectopic impulses within the ventricular-ectopic junction, not because of entrance block, for example, as shown in the lower strip of Figure 2 in the present report. To clearly indicate the presence of entrance block, whether complete or incomplete, there must be an interectopic interval showing one length of the ectopic cycle and containing one intervening sinus beat, as shown in the lower strip of Figure 3 in the present report. This indicates that the ectopic focus is protected from the intervening sinus impulse. In the report by Singer and co-workers,\(^1\) such protection is never seen. It therefore appears that the ectopic rhythm in their report is an escape rhythm with occasional interference within the ventricular-ectopic junction; however, the observations in their report strongly suggest the possibility that also in intermittent parasystole, extrasystoles might be caused by the re-entrant mechanism. Thus, I believe that the present report is the first one on reentrant extrasystoles co-existing with parasystole.

In our previous reports, the presence of 2:1 block in the ventricular-ectopic junction was indicated both in concealed bigeminal extrasystoles\(^2\) and in intermittent parasystoles.\(^3,4,6\) Marked prolongation of the time of ventricular-ectopic conduction was also indicated in both of these rhythms.\(^6,8,9\) Recently, Lightfoot\(^9\) reported a case of intermittent parasystole in which the presence of a concealed bigeminal rhythm due to 2:1 entrance block was demonstrated. These cases reveal that the features in conductivity of the ventricular-ectopic junction are almost the same in parasystole and concealed bigeminy. This suggests the possibility that the sinus impulse discharging the parasystolic focus might become a reentrant extrasystole, although in these previous cases, extrasystoles and parasystole did not coexist. In the present report, ventricular parasystole coexisting with reentrant extrasystoles can be disclosed.

I think that such intermittent parasystole co-existing with reentrant extrasystoles, although hitherto unrecognized, is not an extremely rare phenomenon. It appears to me that in some of the cases previously reported as intermittent parasystole with extrasystoles, the extrasystoles are those caused by such a reentrant mechanism. An example is case 1 of Schamroth and Marriott,\(^7\) in which the relationship between the lengths of the sinus cycles during extrasystolic rhythm and during parasystolic rhythm was similar to that in the present case; in their case a small, but distinct, difference between the lengths of the sinus cycles during these two rhythms was found, although Schamroth and Marriott\(^7\) stated that "this small but distinct difference remains unexplained." It was also indicated in their case that concealed bigeminal rhythm alternated with parasystolic rhythm. Another example suggesting the coexistence of parasystole and reentrant extrasystoles is case 37 of Schamroth.\(^8\) These observations in the previous and present cases also suggest that even in cases where they are not coexisting with parasystolic rhythm, ventricular extrasystoles showing concealed bigeminal rhythm may possibly be those caused by the reentrant mechanism.

REFERENCES

1 Scherf D, Boyd Lj: Three unusual cases of parasystole. Am Heart J 39:650-663, 1950
2 Mueller P, Baron B: Clinical studies on parasystole. Am Heart J 45:441-447, 1953
7 Schamroth L, Marriott HJL: Intermittent ventricular parasystole with observations on its relationship to extrasystolic bigeminy. Am J Cardiol 7:799-809, 1961
12 Kinoshita S: Concealed ventricular extrasystoles due to interference and due to exit block. Circulation 52:230-237, 1975
13 Lightfoot PR: Intermittent parasystole with concealed extrasystolic bigeminy during myocardial infarction. Am Heart J, to be published