Concealed Ventricular Extrasystoles

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An apparently haphazard distribution of ventricular extrasystoles may not be so haphazard as it appears and indeed may mask an underlying regularity. We previously reported a case in which careful analysis uncovered a simple but remarkable phenomenon, namely, that the interectopic intervals always contained an odd number of sinus beats. This was explicable on the assumption that a geminal rhythm persisted in a concealed form. Since then we have observed this and related phenomena on many occasions. Our purpose here is to present the concept of "concealed extrasystoles," which has not been previously reported except for brief mention in our earlier communication.

Concealed Bigeminy

The original observation was made possible by taking a long, uninterrupted tracing in a patient with ventricular bigeminy from digitalis intoxication. Between runs of bigeminal rhythm, isolated extrasystoles occurred with an apparently haphazard distribution. We then noticed, however, that in the intervals between extrasystoles, there was always an odd number of sinus beats (fig. 1). This could not be dismissed as coincidence, since the odds against this occurring by chance were astronomically great.

Figure 1 is a section of a 20-minute recording showing numerous ventricular extrasystoles. A tendency to bigeminal rhythm is evident, since on three occasions three consecutive bigeminal couplets occur. All the intervals between ectopic beats contain odd numbers of sinus beats, namely, 13, 1, 1, 5, 3, 1, 1, 7, 1, 1, 9, 11, and 13. This held true for the remainder of the 20-minute recording, and an analysis of the interectopic sinus beats in the whole record is presented in table 1. The simple explanation then dawned upon us—that the bigeminy had persisted in a concealed form. For it was obvious that the "odds-only" observation meant that the manifest extrasystoles were occurring only in those cycles where coupled extrasystoles would have appeared if the bigeminal rhythm had continued without interruption.

The situation is schematically represented in figure 2. A normally occurring extrasystole is represented by a which prevents the descent of sinus beat 2. In ordinary bigeminal rhythm the next coupled extrasystole would occur at b and the next at c. If, however, the second extrasystole, b, remains confined to its focus of origin and fails to invade the myocardium (as depicted at b), then the descent of sinus beat 4 will not be prevented and three sinus beats (3, 4, and 5) will appear between the extrasystoles a and c. If beat c were also confined to its focus, sinus beats 6 and 7 would also be included between the extrasystoles a and d, and the record would leave five sinus beats (3 to 7) between these manifest extrasystoles. Thus, if the bigeminal discharges are uninterrupted but one or more of them fails to invade the myocardium, an odd number of sinus beats will always intervene between manifest extrasystoles.

Another example of concealed bigeminy is shown in figure 3. The tracing begins with evidence of marked ventricular irritability (A and B) with a basic bigeminal rhythm together with extrasystoles in pairs and threes. After the intravenous injection of Rythmol*, an experimental anti-arrhythmie drug, the ventricular irritability was rapidly reduced to a simple bigeminal rhythm (C) and after a few minutes was abolished (D). When ectopic ventricular activity reappeared

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later, the extrasystoles were separated by only odd numbers of sinus beats (E to I), namely 3, 3, 3, 3, 15, 3, 11, 3, 3, 11, 3, 3, 3, and 3. For 90 seconds after the end of strip I this situation persisted, whereupon the rhythm reverted to manifest bigeminy.

Concealed Trigeminy

Our explanation of concealed bigeminy is reinforced by a corollary observation in a patient in whom ventricular extrasystoles occurred, not after every other sinus beat (bigeminy), but after every two sinus beats (a form of trigeminy). When this rhythm apparently intermitted, we noticed that the intervening runs of sinus rhythm always contained 5, 8, or 11 beats. Figure 4 shows sequences of 5 and 8 intervening sinus beats, while runs of 11 beats were seen elsewhere in the tracing. These inescapable figures clearly had an analogous significance to the invariable odd numbers in bigeminy; namely, that the trigeminal discharge was continuous, but that one or more consecutive discharges failed to invade the myocardium (concealed trigeminy). This situation is diagrammed in figure 5, in which a, c, and d are manifest extrasystoles preventing the descent of sinus beats 3, 9, and 12; b is a concealed extrasystole, permitting the descent of sinus beat 6. There are thus 5 sinus beats (4 to 8) between extrasystoles a and c. If extrasystole c were also concealed, there would then be 8 sinus beats.

Table 1

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<tr>
<th>Number of sinus beats occupying interectopic intervals</th>
<th>1</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>41</th>
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<td>71</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>8</td>
<td>0</td>
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<td>2</td>
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<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

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Figure 3

Strips A and B are continuous and show marked ventricular irritability (as well as nodal rhythm with atrioventricular dissociation). Strips C and D follow the administration of an anti-arrhythmic drug. Strips E to I are continuous and illustrate reappearance of ventricular extrasystoles with only odd numbers of intervening beats (concealed bigeminy).
Electrocardiogram showing manifest and concealed trigeminy.

Between extrasystoles \( a \) and \( d \) with each additional consecutive concealed extrasystole, the number of intervening sinus beats will increase by 3 (11, 14, 17, etc.). Interpolated extrasystoles will result in the addition of one sinus beat in each interectopic interval. Consequently the interectopic intervals all contain 6, 9, or 12 sinus beats, except for the interval following this non-interpolated extrasystole, which contains the expected 8 sinus beats. Theoretically, if interpolation complicates concealed bigeminy—a situation we have not yet encountered—all the interectopic intervals will contain an extra sinus beat, changing the odd numbers to even.

**Relationship to Parasystole**

As we have previously indicated, extrasystolic bigeminy may be a stepping-stone between pure extrasystolic and parasystolic rhythms. We have now observed several cases in which the rhythm changed back and forth between bigeminy and parasystole from the same ventricular focus. We previously reported the first instance of transition between concealed bigeminy and parasystole. Another striking example of parasystole alternating with extrasystolic bigeminy is shown in figure 7A and B. In this patient the extrasystolic and parasystolic rhythms came and went day by day for 24 days. A notable feature of this case was the markedly differing discharge rates of the parasystolic focus on different days, ranging from 44 to 60 per minute.

**Discussion**

Concealed extrasystoles, though hitherto unrecognized, are by no means rare. The most likely reason they have escaped notice for so long is probably the almost universal tendency to economize on electrocardiographic
Figure 6

I and II are sections from the same recording showing concealed trigeminy complicated by interpolation.

Figure 7A

Parasystole alternating with concealed bigeminy. Shows the classical criteria of parasystole, viz., variable coupling of ectopic beats and interectopic intervals with a common denominator (133 to 136 hundredths of a second); a fusion beat is seen at the end of strip 2.
Parasystole alternating with concealed bigeminy. Manifest bigeminal rhythm alternates with runs of concealed bigeminy (only odd numbers of sinus beats in the interectopic intervals).

The confinement of an ectopic discharge to its focus, and its consequent inability to invade the myocardium, is a well-established phenomenon. For example, in ventricular parasystole calculation often indicates that the ectopic focus has discharged but that its impulse has not invaded the myocardium, despite the fact that the myocardium was not refractory at the time. This is explained by "exit block," which may well account for the "concealment" of extrasystoles also.

Recognition of concealed extrasystoles may have practical importance, since concealment implies a state of greater ectopic irritability than is apparent.

Extrasystoles usually show fixed coupling, i.e., they occur at a fixed interval following the preceding sinus beat. This suggests that the preceding sinus beat is in some way involved in the genesis of the extrasystole. There are two prevailing concepts of this relationship: the re-entry theory and the enhancement theory. The re-entry theory assumes a localized area of refractoriness in the pathway of the sinus impulse which, after depolarizing the surrounding tissue, approaches the previously refractory area from

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another direction. The area meanwhile has again become excitable and is thus able to propagate the re-entering impulse so that an extrasystole results. The enhancement theory assumes that the sinus impulse in some way enhances the excitability of the ectopic focus resulting in its discharge. The development of both an automatic (parasystolic) and a forced (extrasystolic) discharge from the same focus suggests that the extrasystole represents a forcing or premature precipitation of the parasystolic discharge by the sinus impulse. If this is so, it adds to the many cogent arguments already advanced against the re-entry theory and makes it quite untenable.

Conclusion
When a heart demonstrates the tendency to bigeminal rhythm and when, in the intervals between apparent bigeminy, the numbers of sinus beats are invariably odd numbers (i.e., a multiple of 2 plus 1), the conclusion is compelling that the bigeminal rhythm has remained uninterrupted though latent (concealed bigeminy). Further, when a heart demonstrates the tendency to the form of trigeminy in which an extrasystole occurs after every two sinus beats and when, in the intervals between apparent trigeminy, the number of sinus beats is invariably a multiple of 3 plus 2, i.e., 5, 8, 11, 14, etc., the conclusion is inescapable that the basic trigeminal rhythm persists in a concealed form. The concept of concealed extrasystoles is therefore firmly established by the empiric observation that there is a definable and consistent rhythmic pattern underlying what appears at first sight to be a haphazard distribution of extrasystoles.

Summary
Evidence is presented for the new concept that ventricular extrasystoles can be "concealed," i.e., that the extrasystolic focus may be discharged without its impulse invading the surrounding myocardium, as in the "exit block" of parasystole. Concealed bigeminy is recognized when only odd numbers of sinus beats intervene between consecutive extrasystoles. Concealed trigeminy is recognizable when a multiple of 3 plus 2, i.e., 5, 8, 11, 14, etc., sinus beats invariably occupy the interectopic intervals. These concealed extrasystolic rhythms are illustrated and discussed.

A genetic relationship between ventricular bigeminy and parasystole is reaffirmed.

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References
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