Time Relation Between Two Pacemakers in Atrial Parasystole

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The term "parasystole" denotes an arrhythmia, in which two pacemakers drive the myocardium independently. It is possible, however, for an ectopic focus to give rise to both a parasystolic and an extrasystolic rhythm, the latter usually in the form of bigeminy or trigeminy (Scherf and Schott, 1930; Schamroth, 1966).

Two cases of a complex arrhythmia are presented here. Their analysis on the basis of the synchronization phenomenon may aid the understanding of the mechanism of parasystole.

"Synchronization" implies that two oscillating systems with slightly different idiofrequency acquire the same frequency when they function either in phase or at a certain phase difference. Synchronization may exist when the two frequencies are either approximately equal or in simple mathematical relation (3:2, 2:1, etc.).

Some analogy of the coupling between oscillators to the interplay between different autochthonous pacemakers in the heart was previously suggested by van der Pol and van der Mark (1929) and has also been pointed out by Grant (1956). The hypothesis may help to provide a relatively simple explanation of complex arrhythmias.

CASE REPORTS

Case 1. An 80-year-old woman was treated in hospital for ischaemic heart disease with congestive failure.

On the electrocardiogram (Fig. 1a) two P waves (P_1 and P_2), different in shape, alternate, the P_1 - P_2 interval being shorter than the P_2 - P_1 . The P_1 -R interval is longer (0.14-0.15 sec.) than the P_2 -R (0.11-0.12 sec.). Occasionally there is no ventricular response to the P_2 wave.

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Both P_1 - P_1 and P_2 - P_2 intervals are almost constant, around 1300 msec. The P_1 - P_2 interval usually varies between 380 and 540 msec., but rare longer P_1 - P_2 intervals may result from an early appearance of P_1 (rather than from a late appearance of P_2) while the P_2 rhythm is maintained. The P_1 - P_2 interval, abruptly increased at the beginning, thereafter gradually acquires the previous value.

Three days later (Fig. 1b) the P_2 waves still appear at regular intervals of approximately 1300 msec., or a simple multiple of this value. The remaining P waves, however, appear at more or less random intervals.

The regularity of P_2 waves in this case, while the appearance of the remaining seems quite unpredictable, indicates that P_2 is produced by a parasystolic focus.

Case 2. A 35-year-old woman, without cardiac symptoms, was admitted for a gynaecological operation. An arrhythmia was found and the electrocardiogram of Fig. 2 obtained.

There are two P waves (P_1 and P_2) different in shape in the tracing. P_1 appears at regular intervals of 500 to 760 msec. or 1200 to 1520 msec. In the longer intervals a P_2 wave is found between two P_1 waves. The P_2 wave appears at varying distances from the P_1 , and at regular intervals of 1320 to 1560 msec., or at longer intervals, which are simple multiples of about 1500 msec. (Fig. 2).

The P_2 - P_2 intervals being multiples of a certain value, together with the varying length of P_1 - P_2 intervals, suggests that the P_2 originates from a parasystolic focus.

However, the P_1 - P_2 intervals seem to vary in a special way. After a series of consecutive P_1 waves (without any P_2 present in the tracing), one P_2 wave appears at a distance of about 450 msec. from P_1 . Thereafter, each P_1 wave is followed by a P_2 wave at a distance which is gradually increasing. The rate of this increase, however, is minimal when the P_1 - P_2 interval length reaches approximately 550 msec. (Fig. 2). Thus, the difference in length between overlapping P_2 - P_2 and P_1 - P_1 intervals for the whole tracing was found to vary from a mean of 115 msec. for the shortest P_1 - P_2 intervals, to 5 msec. for P_1 - P_2 intervals of 550-560 msec., and again up to 50 msec. for the longest P_1 - P_2 intervals.

FIG. 1.—Two electrocardiograms (a and b) of Case 1 obtained at a three-day interval (lead V1). Second and third row continuous tracing. Time intervals in sec. P_1 - P_2 intervals in (a): 470, 430, 430, 480, 450, 460, 460, and 430 msec.

DISCUSSION

In both cases of arrhythmia presented here there are at least two types of P waves, each with its own independent rhythm. The parasystolic nature of the arrhythmia is more or less clear in Fig 1b and 2.

The two types of P waves of Case 1 appearing alternately on the tracing of Fig. 1a, with a more or less constant P_1 - P_2 interval, suggest a bigeminal type of extrasystolic arrhythmia. The P_1 - P_2 interval, however, is not strictly constant, and its abrupt change with gradual return to the usual value following a premature P_1 suggests some degree of "independence" of the P_2 focus from the P_1 focus.

On the other hand, the two foci of Case 2 are not entirely independent from each other. Fig. 2 and the correlation of the difference in length between overlapping P_2 - P_2 and P_1 - P_1 intervals to the corresponding P_1 - P_2 interval show clearly that the

two foci tend to attain the same frequency when P_1 precedes P_2 by approximately 550 msec. So, for some time, the two types of P wave appear alternately, with an almost constant interval between them, displaying a pattern of arrhythmia which seems apparently to be a form of bigeminy.

The possibility for a parasystolic focus to fire in a bigeminal way has been described by others (Scherf and Schott, 1930; Schamroth, 1966). In these two cases the gradual transition from the one type of arrhythmia to the other is indicated.

The "Wedensky facilitation" phenomenon (Wedensky, 1903), proposed by Schamroth (1966) to explain this alternation of parasystolic and extrasystolic bigeminal rhythm, does not seem to apply in the cases presented here, because of the gradual way in which this alternation takes place.

Instead, the equalization tendency of the rates of

FIG. 2.—Continuous tracing from Case 2. P_2 is indicated by arrows. The P_1 - P_2 intervals are designated in sec. The long intervals without P_2 are 7500 ($= 1500 \times 5$), 4560 ($= 1520 \times 3$), and 4440 ($= 1480 \times 3$) msec., respectively.

the two foci when their cycles attain a certain phase difference is the characteristic feature of the synchronization phenomenon, as this was described in frog ventricles (Segers, 1946), in complete A-V block (Segers, Lequime, and Denolin, 1947), and in an electronic pacemaker driving the heart both clinically (Burchell, 1963) and experimentally (Mouloupoulos, Kardaras, and Sideris, 1965).

However, some difference between the cases presented here and Segers' cases must be pointed out. In our cases the synchronization does not take place at a zero phase difference, as in Segers' cases, but at a constant phase difference (around 450 msec. for Case 1, and around 550 msec. for Case 2).

In Segers' cases the synchronization between two anatomically and functionally separate units was observed: between the ventricles of two different frog hearts (Segers, 1946) or between atria and ventricles in complete A-V block (Segers *et al.*, 1947). In the present report, however, it is the activity of two atrial foci which has been followed. There is no obvious explanation for the difference in the two types of synchronization (in phase and at a phase difference).

SUMMARY

Two cases of atrial parasystole are described. The time relationship of the intervals between the

presumably nomotopic and the ectopic foci suggests some similarity with the synchronization of two oscillators.

The two atrial foci show a tendency to function at a steady phase difference. Aberrations from this condition are infrequent and appear or disappear gradually.

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