Experiences with Pulsus Alternans
Ventricular Alternation and the Stage of Heart Failure

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Three years' experience with pulsus alternans, including its production with exercise, has shown that alternans may exhibit at least 3 types of behavior, and has led the authors to believe that the type of behavior a patient presents is related to the degree of heart failure present. Those patients who developed alternans following exercise were not in cardiac failure clinically, and yet hemodynamic data indicated myocardial insufficiency. A sustained pulsus alternans at rest seems to have no special prognostic significance in heart failure.

THREE years' experience with pulsus alternans has suggested a correlation between the circumstances under which this phenomenon is present and the degree of myocardial insufficiency. The purpose of this communication is twofold: To develop this concept and to question the grave prognostic significance usually accorded to alternans.

Methods and Materials

The arterial pulse, obtained directly through an arterial needle with a strain-gage manometer, was recorded simultaneously with the electrocardiogram. Control observations were made in the recumbent position, and the subject was tilted to the vertical position for 10 to 15 min. Venous tourniquets were applied for 5 to 6 min. Exercise was carried out in the recumbent position and consisted of alternate flexion and extension of the legs for 5 to 10 min.

Pulsus alternans was produced in 4 patients by exercise. The resting and exercise pulse curves of 3 patients are shown in figure 1. The first patient, F. S., was a 31-year-old white man with rheumatic aortic insufficiency who had never had cardiac failure clinically and was not being treated for it. The second patient, G.N., was a 52-year-old white man with coronary disease who had been in moderate heart failure, but had made an excellent response to treatment and was entirely asymptomatic at the time of the study, although he was receiving a maintenance dosage of digitalis. The third patient, W.S., was a 38-year-old white man with rheumatic aortic insufficiency who had been treated successfully with penicillin for subacute bacterial endocarditis due to Staphylococcus aureus. He too was not in apparent heart failure when the alternans was produced and was receiving no treatment.

The fourth person in whom an alternans was brought out by exercise is of special interest. This patient, C.M., was a 62-year-old white man with syphilitic aortic insufficiency, and alternation was produced on 2 separate occasions approximately 10 months apart. He had not been in cardiac failure when these 2 observations were made. Quite significant was the clinical course during the 1-year period following the second observation, and the difference in the behavior of the alternans when a third observation was made. During this interval he had developed paroxysmal nocturnal dyspnea and had taken digitalis intermittently. His heart size had increased as can be seen in figure 2. This third study showed that he then had a small but definite alternans at rest, which was slightly increased following tilting for 15 min. and virtually disappeared after 3 min. of exercise. Representative pulse curves from the second and third observations are shown in figure 3.

Results

In all patients who had a sustained pulsus alternans at rest this phenomenon was exaggerated after tilting or venous tourniquets and was diminished with exercise and passive leg raising. This observation was made in 8 individuals and is similar to the experience of Friedman, Dailey, and Sheffield.1 Included in this group were the following types of heart diseases: hypertensive, coronary artery disease, rheumatic aortic insufficiency, and syphilitic aortic insufficiency. All these patients were, or had been, in heart failure clinically. An example is shown in figure 4.

As has been reported previously in 3 patients, the alternans virtually disappeared as con-
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Fig. 1. A. F.S., a 31-year-old white man with rheumatic heart disease with aortic insufficiency. 1. Rest. 2. After 3 min. of exercise. B. G.N., a 52-year-old white man with coronary artery disease. 1. Rest. 2. After 3 min. of exercise. C. W.S., a 38-year-old white man with rheumatic heart disease with aortic insufficiency, treated for subacute bacterial endocarditis. 1. Rest. 2. After 10 min. of exercise.

These and the following curves are reproductions of the actual arterial pulse tracings and electrocardiograms.

Fig. 2. Six-foot posteroanterior chest films of C.M., a 62-year-old white man with syphilitic aortic insufficiency. A. December 13, 1954. B. December 7, 1955.
gestive heart failure advanced. An example is seen in figure 5.

**Discussion**

The observations reported demonstrate that ventricular alternation can show at least 3 types of behavior, and the type exhibited seems to be dependent upon the degree of myocardial insufficiency present. The first is the appearance of alternans following exercise and may indicate myocardial insufficiency, although the patient does not have other clinical evidence of cardiac failure. Support for this concept is gained not only from our observations, but also from those of others. Cardiac catheterization showed patient W.S. to be in moderate cardiac failure at rest, as evidenced by elevations of pulmonary artery pressure and right atrial mean pressure (PA 46/32 mm. Hg, RA

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Fig. 4. J.S., a 42-year-old white man with coronary artery disease. A. Rest. B. After 5 min. of exercise. C. After venous tourniquets had been applied for 6 min.
The second type of behavior is sustained alternans at rest, which is exaggerated by a decreased venous return to the heart, such as following venous tourniquets and vertical tilting, and is diminished when the return is increased as by exercise or passive leg raising. We have not encountered an alternans at rest that did not react in this fashion. Patients with this type were either in or had been in clinical heart failure.

The third type, as previously reported, is alternans that disappears as congestive failure becomes more severe. Three such patients have been encountered. Thus, alternation can disappear even though cardiac function is deteriorating.

It is known that in certain patients, digitalis may cause pulsus alternans to disappear. As a rule, these patients do not have a severe degree of cardiac failure; since myocardial efficiency is increased by the effect of digitalis, cardiac function may be improved to such an extent that alternation disappears. Digitalis may also have a direct effect upon myocardial factors that permit alternation; thus, improved cardiac function might not be the sole explanation for the disappearance of alternans following digitalis.

As left heart catheterization becomes more widely used, it might be found that for a given heart, pulsus alternans occurs only over a critical range of ventricular filling pressure.

Excluding the type that normally occurs for the first 2 or 3 beats following a premature contraction, the authors have not encountered pulsus alternans in the absence of organic heart disease. Therefore, although the actual reasons for its inception and perpetuation are unknown, we believe myocardial factors peculiar to certain diseased hearts are necessary for the production of alternation.

Our experience indicates that a patient with a sustained alternans at rest has just as good a prognosis as one without alternans, but with a similar type of heart disease and degree of failure. This view is in variance with the prognostic implication usually ascribed to this phenomenon. On the other hand, if pulsus alternans is absent at rest, but can be pro-

Fig. 5. W.J., a 42-year-old Negro man with hypertensive heart disease. A. At the time of admission; on treatment for heart failure. B. One week after treatment for heart failure was discontinued. C. Five days after treatment was restarted. D. Seven weeks after treatment was restarted.

11 mm. Hg). After 10 min. of exercise the pulmonary artery pressure increased to 68/46 and the right ventricular enddiastolic pressure was 16, indicating a greater degree of failure at the time the alternans appeared. Sanet'a noted that both a systemic and pulmonary artery alternans developed as exercise further increased the moderately elevated resting right ventricular enddiastolic and pulmonary artery pressures of a patient with rheumatic aortic stenosis. This patient showed no clinical evidence of cardiac failure at the time of study. Ferrer and associates encountered a systemic pulsus alternans as exercise caused a moderate increase in the normal resting pulmonary artery pressure of a patient with hypertensive heart disease. Heart failure also was not clinically apparent in the individual.
duced by exercise, it may indicate myocardial insufficiency in an asymptomatic patient, and thus be of prognostic importance. Further observation, however, is necessary to substantiate this last point.

If our concept is correct, that there may be a relationship between the state of myocardial insufficiency and the type of behavior an alternans exhibits, it would seem theoretically possible for a single patient to manifest each of the 3 patterns of alternation as he progresses from an asymptomatic state to an advanced stage of heart failure. Although we have not observed all 3 in 1 individual, it appears that patient C.M. has shown 2 different types. First, when asymptomatic, the alternans was present only after exercise and later, as his disease progressed, it was apparent after tilting, but absent after exercise.

**Summary**

Three different types of behavior of pulsus alternans have been observed. The type a patient shows may be related to the degree of heart failure present. Pulsus alternans has been produced by exercise when it was absent at rest. Although this occurred in patients who showed little clinical evidence of cardiac failure, it may be indicative of myocardial insufficiency. A sustained alternans at rest seems to have no special prognostic significances.

**Summario in Interlingua**

Ha essite observate tres distincte typos de comportamento de pulso alternante. Le typo de pulso alternante manifeste in un certe patiente es possibilemente relationate al grado de su disfallimento cardiac. Pulso alternante ha essite producere per exercitio in cases in que illo esseva absent in stato de reposito. Ben que le patientes in question exhibiva pauc signos de disfallimento cardiac, le phenomenon es possibilemente un indication de insufficientia myocardial. Un sustenite pulso alternante in stato de reposito ha apparentemente nule special signification prognostic.

**REFERENCES**


I have three personal ideals. One, to do the day’s work well and not to bother about to-morrow. The second ideal has been to act the Golden Rule, as far as in me lay, toward my professional brethren and toward the patients committed to my care. And the third has been to cultivate such a measure of equanimity as would enable me to bear success with humility, the affection of my friends without pride, and to be ready when the day of sorrow and grief came to meet it with the courage befitting a man.—Sir William Osler, Farewell Dinner, May 2, 1905.
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Circulation. 1956;14:1099-1103
doi: 10.1161/01.CIR.14.6.1099

The online version of this article, along with updated information and services, is located on the World Wide Web at:
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