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VARIABILITY OF THE SINUS RHYTHM OF THE HEART DURING DEEP BREATHING

B. M. Tsukerman, A. M. Svetukhin,
A. R. Abul'khanov, K. A. Sergeeva,
and V. A. Kryukov

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Ever increasing attention is being paid nowadays to the study of the characteristics of the sinus rhythm of the heart as an important source of information on a person's state. This information is obtained from long-term continuous recording of the ECG (2-5 min), by calculating various statistical characteristics of the sequence of RR intervals of the ECG. This approach has been used to study neurohumoral regulation of the cardiac rhythm [1] and also to study problems in applied physiology. In particular, investigation of the characteristics of the sinus rhythm is widely used in aviation and space physiology [2], in sport physiology [3], work physiology, and engineering psychology [4]. Finally, analysis of the cardiac rhythm is becoming increasingly important in clinical physiology. It has been found that the greatest change in the sinus rhythm (physiological arrhythmia) occurs in healthy people; when pathological states (essential hypertension, angina pectoris, myocardial infarction, burns, etc.) arise the intensity of the physiological arrhythmia is reduced and an absolutely regular pulse may be established [5]. These features of the behavior of the sinus rhythm have enabled its analysis to be effectively used as a means of monitoring preoperative preparations and the patient's state during operations [6], to predict postoperative complications [7], for individual selection of drugs for the treatment of disturbances of cardiac rhythm [8], and in many other cases.

During investigation of the characteristics of the sinus rhythm of the heart, attempts have been made to increase their information content by the use of various function tests. The orthostatic test [9] and graded physical exertion [10] are most frequently used. Various pharmacological tests, such as injection of atropine [11], also are used.

A promising trend in the investigation of variability of the sinus rhythm is the development of methods for the objective evaluation of the severity of a patient's state on this basis. To increase the informativeness of the investigation, function tests must evidently be useful in this case also. The function tests already mentioned, as a rule, cause an increase in the pulse rate and a decrease in physiological arrhythmia; however, the cardiac rhythm may also change in the same direction under the influence of diseases. Accordingly, in patients with acquired heart disease the results of a function test with physical exertion have proved uninformative [12]. This points to the need for carrying out a function test which would cause a shift in the opposite direction, i.e., which would increase the dispersion of the rhythm. Breathing with increased depth of inspiration has been shown to have this effect [13]. This suggested that the change in variability of the sinus rhythm of the heart during deep breathing might prove a useful indicator of the functional state of the subjects tested. The object of the present investigation was to test this hypothesis.

EXPERIMENTAL METHOD

Three groups of patients with suppurating wounds, admitted for treatment to the A. V. Vishnevskii Institute of Surgery, Academy of Medical Sciences of the USSR, were investigated.

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The state of 54 patients was severe, of 49 moderately severe, and of 68 patients satisfactory. The degree of severity of their state was judged on the basis of a group of clinical signs. The ECG of each patient was recorded on a magnetic recorder initially at rest and later during deep breathing. Continuous recording of the ECG lasted 5 min. The records obtained were analyzed on the Promin-2 computer to obtain simple statistical characteristics of the cardiac rhythm: the mean value of intervals between neighboring cardiac contractions (RR) and the standard deviation (σ).

To perform the function test the patient was instructed to breathe as follows: to breathe in as deeply as possible, breathe out normally, rest. The rest was to prevent hyperventilation, and was made as long as possible. Breathing must be smooth, without jerks or breath holding during inspiration. When the patient was accustomed to the new rhythm of respiration the ECG was recorded. This function test was performed easily by the majority of subjects, who made no complaint of weakness or dizziness (symptoms of hyperventilation).

EXPERIMENTAL RESULTS AND DISCUSSION

As a result of the switch from normal to deep breathing the frequency of respiratory movements was considerably reduced in most patients. This is evidence that the respiratory volume must have significantly increased under these circumstances,

The cardiac frequency changed only slightly during the function test with deep breathing (Fig. 1). In the overwhelming majority of patients (87%) changes in the cardiac frequency did not exceed $\pm 5\%$. In a few cases changes in the cardiac frequency during deep breathing were more marked, but as Fig. 1 shows, the probability of an increase and decrease compared with the original frequency was practically identical, evidence of the random character of the changes.

The deep breathing function test had a significant effect on the change in pulse rate; the degree of this change was found to depend on the subjects' state -- it was greatest in patients in a satisfactory state and smallest in those in a severe or very severe state. The results of the test are given in Table 1. They show that in most seriously ill patients (76%) the deep breathing test caused a minimal response of the cardiac rhythm, and in 20% the value of σ decreased. Among patients in a satisfactory state, on the other hand, σ increased sig-

TABLE 1. Changes in σ during Deep Breathing by Patients with States of Different Severity

Change	State of patients		
	severe	moderately severe	satisfactory
Considerable increase (by more than 1.5 times)	2 (4)	18 (37)	32 (47)
With no change or a small increase (by less than 1.5 times)	41 (76)	25 (51)	32 (47)
Decrease	11 (20)	6 (12)	4 (6)

Note. Percentage of patients shown in parentheses.

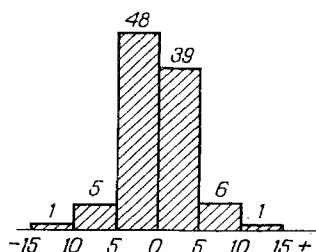


Fig. 1. Ratio of mean \overline{RR} interval of ECG during deep (d) and quiet (q) breathing (in %). +) Increase, -) decrease in ratio $\overline{RR}_d/\overline{RR}_q$. Numbers indicate number of patients (in % of total number) with value of $\overline{RR}_d/\overline{RR}_q$ indicated along abscissa.

nificantly in almost half, the number of cases in which the cardiac rhythm was almost unchanged was reduced by 60%, and the value was reduced only one-third as often as in the seriously ill patients.

The results show that during the change to deep and slow breathing changes in the pulse rate largely correlate with the patients' functional state. The function test suggested above thus increases the information obtained on the subjects' state and it must evidently be recommended for use in cases in which assessment of the subject's state is based on quantitative characteristics of the sinus rhythm of the heart.

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