ACTION POTENTIALS OF RESPIRATORY MUSCULATURE IN PATIENTS HAVING RESPIRATORY DEFICIENCY

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Many important investigations, devoted to an experimental analysis of various phases of the activity of the respiratory system in animals, have fulfilled their goal with the aid of the electrophysiological techniques.

At the same time, this electrophysiologic method has been used but rarely in the study of respiration in man. Only quite recently have there appeared investigations devoted chiefly to the way in which the anterior abdominal muscles along with certain others participate in the respiratory act [3, 4, 5, 6]. It has been discovered that action potentials develop in abdominal muscles only in association with deep breathing and is connected with arise in intra-abdominal pressure. E. L. Golubova [1] was able to record the action potentials of the rib muscles in human individuals undergoing lung resection and thus observe whether regulation of breathing led to any peculiarities. These characteristics have been studied in great detail by her when she removed experimentally lungs in animals.

In proceeding with the present research we used as a basis preceding studies [2] which indicate that in a healthy man artificial interference with respiration sharply raises the bioelectric activity of the respiratory musculature.

In rabbits when resistance to respiration is increased the action potentials of the respiratory muscles increase gradually mainly by humoral stimulation. In man, however, there is immediate reflex response to the increased resistance and there does not appear to be any evidence of a humoral mechanism. This gave us ground for supposing that an analogous increase in action potentials would be detected in certain diseases of the respiratory system as, for example, pulmonary emphysema and bronchial asthma in which condition there is a present a resistance to the flow of air.

EXPERIMENTAL METHODS

We studied 10 persons who were well and 65 patients having respiratory inadequacies (principally patients with bronchial asthma and pulmonary emphysema). In order to record the action potentials of the respiratory musculature, electrodes were applied to the overlying skin. One pair of electrodes was fastened in the anterior axillary line between the seventh and eighth ribs, the other pair – on the skin over the abdominal wall overlying the external oblique muscle. The action potentials were recorded on photographic paper by means of a magnifying oscillograph built by the Leningrad Technological Institute. The time signal and the pneumogram were recorded simultaneously on the photopaper.

EXPERIMENTAL RESULTS

When breathing quietly (sitting) action potentials in normal people with the amplification we used (100 μV corresponded to a deflection by the beam of 5 mm) were almost unnoticeable or represented very weak salvos

of impulses during the inspiratory phase on the part of the intercostal musculature and was totally absent from the external abdominal musculature (Fig. 1).

In patients suffering from moderately severe bronchial asthma and in patients having pronounced pulmonary emphysema, the action potentials have a different character. In patients suffering from bronchial asthma there is observed an almost constant, markedly expressed activity by the intercostal muscles, reaching a maximum

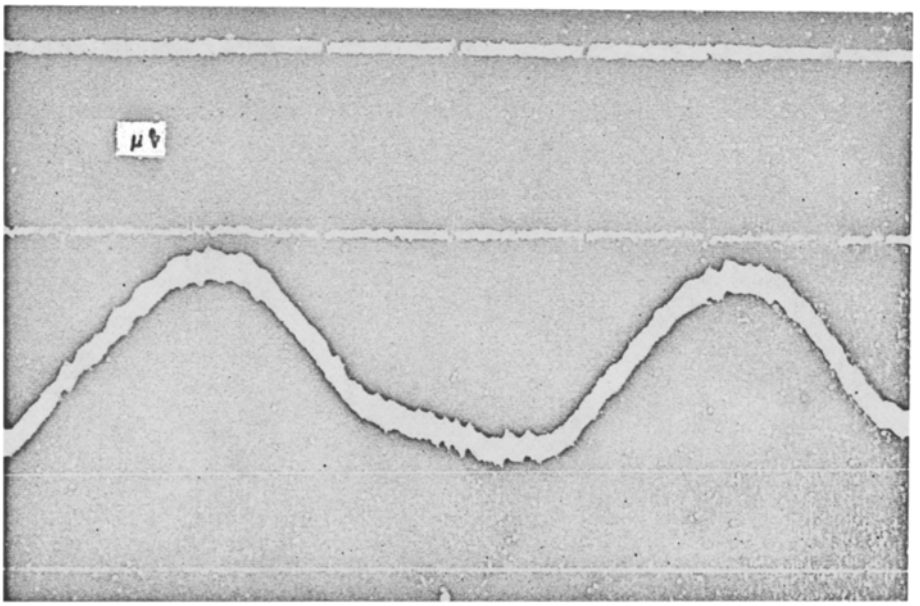

Fig. 1. Action Potentials in the respiratory musculature during quiet breathing of a healthy individual.
1) Electromyogram of intercostal muscles; 2) electromyogram of the external oblique of the abdomen; 3) pneumogram; 4) time markers (1 second). In this and the other figures there can be noticed the overlay of the electrocardiogram on the electromyogram.

during prolonged expiration; during this expiration there being noticed also activity on the part of the abdominal muscles (Fig. 2). Thus, the electromyograms document the action during expiration which in a healthy individual is a passive act thus permitting the observation of increased respiratory activity even when it appeared from the outside to be of almost normal rate and depth.

Patients suffering from pulmonary emphysema also show a marked increase in the action by the respiratory musculature. The lead from the intercostal musculature shows continuous activity throughout the entire respiratory cycle (Fig. 3), being most evident during inspiration; the action potentials, even if of much lesser amplitude, can be noticed also on the electromyograms of the abdominal musculature.

Thus, it is evident that electrophysiologic observations on patients suffering from respiratory inadequacies demonstrate that even when quiet there is compensatory increase in the activity of the respiratory musculature, this being an attempt to ensure the necessary ventilation of the lungs.

The electrophysiologic method for the study of the functioning of the respiratory system permits direct observation of the respiratory musculature and of the nature of the stimulation acting on the respiratory center. When doing research on the breathing of a normal individual, the degree to which the respiratory center is being stimulated is taken to be a function of pulmonary ventilation. Actually, however, this is really an end effect stimulating the respiratory center.

Of course, the nature of the impulses going from the respiratory center over the motor neurons to the respiratory musculature determines the character of the respiratory movements and therefore the depth and the

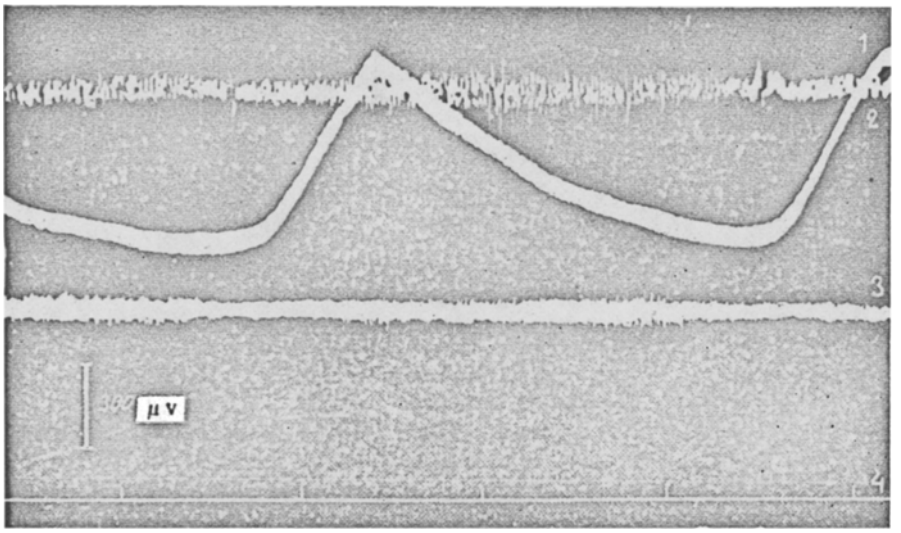

Fig. 2. Action potentials in the respiratory musculature during quiet breathing of a patient suffering from moderately severe asthma.
1) Electromyogram of intercostal muscles; 2) electromyogram of the external oblique of the abdomen; 3) pneumogram; 4) time markers (1 second). In this and the other figures there can be noticed the overlay of the electrocardiogram on the electromyogram.

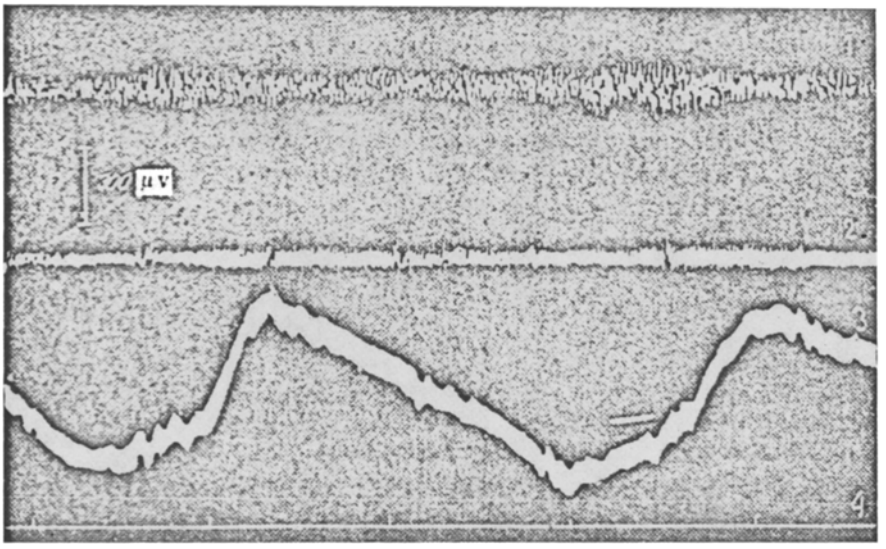

Fig. 3. Action potentials in the respiratory musculature during quiet breathing of a patient with pulmonary emphysema.
1) Electromyogram of intercostal muscles; 2) electromyogram of the external oblique of the abdomen; 3) pneumogram; 4) time markers (1 second). In this and the other figures there can be noticed the overlay of the electrocardiogram on the electromyogram.

respiratory rate which determine the magnitude of the lung ventilation. Still, this can be true only if there is a direct relation between the stimulus arising in the respiratory musculature and the resulting activity-pulmonary ventilation. But in many instances, when the pulmonary ventilation is upset by external causes or pathological processes, this normal relationship cannot be maintained.

In such instances direct electrophysiological studies and not simply observation of the pulmonary ventilation give us the possibility of judging truly the nature of the impulses going from the respiratory center to the respiratory muscles, i.e., the true condition of the respiratory center. For this reason the study of action potentials in patients having respiratory malfunction offers important evidence of the true condition of respiratory regulation.

Many of the patients we observed had normal pulmonary ventilation breathing rate and depth. Yet the clinical picture of dyspnea pointed to respiratory inadequacy.

In such cases, as demonstrated by the marked increase in action potentials, the pulmonary ventilation was made to approach normal by a marked increase in the activity of the respiratory musculature, this being attained by a constant over-stimulation of the respiratory center. This seems to be the principal compensatory reaction without which there would be no guarantee of an adequate pulmonary ventilation under conditions of interference with the apparatus for external respiration.

It may be supposed that the continued over-activity of the respiratory system produces frequently alterations in the state of the respiratory center and its cerebral radiations which express themselves as oppressive sensations (dyspnea, in the beginning), decreased work capacity and other symptoms. The action potentials in many patients at rest are as great as in normal people performing heavy physical labor.

It can thus be seen that this method of evaluating the action potentials present in the respiratory musculature, along with other methods, gives objective aid in clarifying many important problems of respiratory physiology as well as pathology in man, aids in uncovering the qualitative characteristics and the mechanisms producing those clinical states presenting a picture of respiratory inadequacy.

SUMMARY

Normal action potentials in respiratory muscles were studied. Then these were compared with action potentials observed in patients, chiefly those ill with bronchial asthma and pulmonary emphysema. It was noted that the muscles of the patients registered a marked rise in activity even when the usual external indicators such as rate, depth and pulmonary ventilation appeared to be near normal. This was taken to indicate that the respiratory center was being subjected to compensatory stimulation.

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