ROLE OF TONIC ACTIVITY OF THE RESPIRATORY MUSCLES IN REGULATION OF HUMAN RESPIRATION

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Respiratory and tonic postural impulses were shown to converge on motoneurons of the intercostal muscles and on interneurons, giving rise not only to postural reflexes from the neck and labyrinth, but also to afferent influences from the thoracic structures themselves.

When the latter are intensified, respiratory activity of the intercostal muscles may be weakened, although the sensitivity of their motoneurons to respiratory influences is not lost.

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In our previous investigation [1, 5] we showed that deformation of the chest, accompanying surgical operations on the lungs, is accompanied by increased bioelectrical activity of the intercostal muscles, which is usually greater on the side of the operation.

The change observed in the biopotentials of the intercostal muscles could be the result not only of respiratory, but also of tonic postural activity characteristic of this group of muscles [2]. Since the significance of this activity in the general system of regulation of respiration is not perfectly clear, the present investigation was carried out to study this question.

EXPERIMENTAL METHOD AND RESULTS

Tests were carried out on 62 persons in whom the shape of the chest was altered to some extent as a result of operation (thoracoplasty, partial and extensive resection of the lung). Potentials of the intercostal muscles were recorded by two pairs of bipolar surface electrodes placed on symmetrical points of the chest (6th-8th intercostal space on the right and left sides), and the pneumogram was recorded at the same time.

In the great majority of subjects (43) the amplitude of impulses from the chest on the side of the operation was greater than on the intact side (Fig. 1), and frequently the difference in amplitude reached 36-60 μV. As a rule the impulse activity was continuous and recorded uniformly throughout the respiratory cycle irrespective of the phase of respiration. Introduction of an additional resistance to respiration (for periods of up to 2 min) caused no changes in the electromyogram (EMG). On the healthy side of the chest activity was either within normal limits or very slightly increased during inspiration.

The continuity of the bioelectrical activity, its uniformity, and its independence of the phases of the respiratory cycle suggested that this was a manifestation of the tonic postural activity of the intercostal muscles. The absence of EMG changes on introducing an additional resistance to respiration confirmed this view.

Massion and co-workers [8] consider that tonic postural activity of the intercostal muscles is under the control of reflexes originating from the receptors of the neck muscles and from the labyrinth. In our cases afferent impulses from the receptors of the intercostal muscles themselves and, perhaps, from other structures of the chest, were also of undoubted importance. This claim is made because traction of the muscles of the chest wall as a result of its deformation and limitation of movement of the ribs by pleural adhesions was present in the patients who were investigated. These combined to strengthen afferent influences from the receptors of the intercostal muscles on their own motoneurons. The validity of this hypothesis is also confirmed by some aspects of the EMG structure found in 26 of our subjects. Instead of the fast, multiphase fluctuations of potential, variable in amplitude and frequency, low, biphasic, fluctuations

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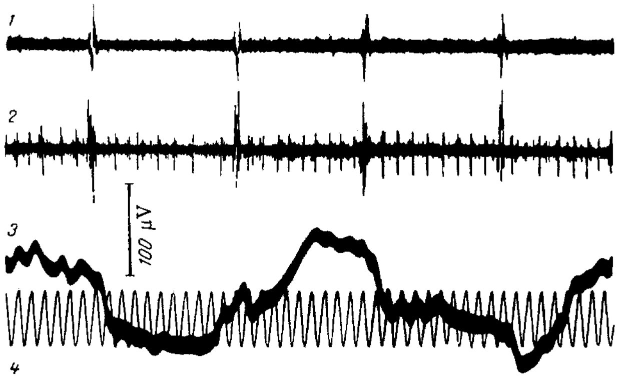

Fig. 1. Electromyogram of intercostal muscles. 1) On the right; 2) on the left, and pneumogram (3) of a patient after thoracoplasty involving 8 ribs on the left side. Time marker, 0.1 sec, below (4).

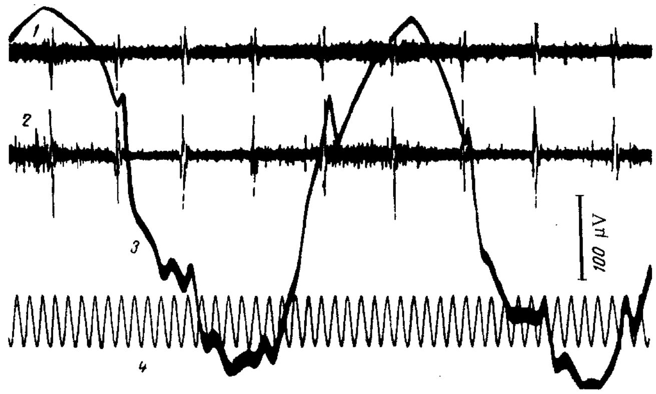

Fig. 2. Electromyogram of intercostal muscles and penumogram of patient after thoracoplasty involving 8 ribs on the left side, during physical exertion (normal phasic activity). Legend as in Fig. 1.

appeared, against the background either of absence of impulses or of fast impulses of low amplitude. Sometimes volleys of impulses were observed (EMG of types 2a, 2b, and 3 according to Yusevich's classification). In agreement with published data [4, 6, 7], an EMG of this character indicates changes in the state of the motoneurons of the corresponding muslces.

Massion and co-workers [8] claim on the basis of their investigations on decerebrate animals that strengthening of tonic postural influences on the motoneurons of the intercostal muscles makes these muscles less sensitive to influences from the respiratory center. However, during stimulation of respiration by physical exertion, the activity of the intercostal muscles again became phasic in character in 18 of 26 subjects and the normal structure of the EMG was largely restored (Fig. 2). Consequently, motoneurons of the intercostal muscles remain sensitive to respiratory influences even when tonic postural influences are considerably increased.

We consider that reflex mechanisms similar to the mechanisms of the stretch reflex may lie at the basis of the changes in tonic postural activity of the intercostal muscles. The possibility of afferent impulses from the parietal pleura, in the nature of a pleuro-thoracic reflex as described by Kocherga [2], likewise cannot be ruled out. Stimulation of receptors of the pleura may affect motoneurons via polysynaptic reflex arcs. The important role of interneurons in the transmission of excitation to the respiratory muscles has been shown by the work of Sumi [9] and Kocherga [3]. Mechanisms in the spinal cord therefore lie at the basis of the observed changes in bioelectrical activity of the intercostal muscles.

LITERATURE CITED

1. E. N. Domontovich and I. A. Panchenko, In: Medical Assessment of Fitness for Work in Patients with Tuberculosis [in Russian], Moscow (1964), p. 90.
2. D. A. Kocherga, In: Advances in the Physiology and Pathology of Respiration [in Russian], Moscow (1961), p. 111.
3. D. A. Kocherga, Dokl. Akad. Nauk SSSR, 151, No. 2, 468 (1963).
4. L. N. Pankova, Byul. Éksperim. Biol. i Med., No. 2, 58 (1962).
5. I. A. Panchenko, Byul. Éksperim. Biol. i Med. No. 11, 27 (1961).
6. R. S. Person, In: Function Tests in Medical Assessment of Working Fitness [in Russian], Moscow (1962), p. 171.
7. Yu. S. Yusevich, Electromyography in Clinical Neurology [in Russian], Moscow (1958).
8. J. Massion et al., Arch. Int. Physiol. Biochim., 68, 314 (1960).
9. T. Sumi, Ann. N. Y. Acad. Sci., 109, 561 (1963).