AN EXTRAVAGAL RESPIRATORY REFLEX FROM NOCICEPTORS OF THE LUNGS

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Limited injury to the parenchyma of the lungs before vagotomy intensifies the inspiratory volleys of the diaphragm and reduces the respiration rate. Similar injury to the lungs in vagotomized animals only intensifies the inspiratory volleys, for the respiration rate changes, if at all, not significantly. The increase in the depth of respiration caused by stimulation of the lung nociceptors innervated by extravagal fibers would appear to be very important for pulmonary ventilation and is provided most satisfactorily by deep breathing. Probably not only the afferent fibers of the vagus nerves but also afferents running in the composition of the extravagal nerves must be taken into account when relations between the depth and frequency of respiration in the pulmonary ventilation are analyzed, especially under pathological conditions.

KEY WORDS: vagotomy; extravagal afferents of the lungs; frequency and depth of respiration; pulmonary pathology.

Breuer showed originally that division of the vagus nerves abolishes respiratory reflexes evoked by changes in lung volume. This has frequently been confirmed later [1, 7]. Reflex changes in respiration evoked by lesions of the lungs can also be explained by the spread of impulses along afferent fibers of the vagus nerves [7], although some workers under these circumstances ascribe an important role to impulses spreading along extravagal afferents from the lungs, running in the composition of sympathetic nerves [3, 6].

In the investigation described below the role of the extravagal component of respiratory reflexes from pathologically changed lungs is confirmed and its distinguishing features are established for the first time.

EXPERIMENTAL METHOD

Experiments were carried out on 10 rabbits under superficial anesthesia (pentobarbital, 15 mg/kg, intravenously). The animals were fixed in the supine position. Electrodes were sutured to the sternal part of the diaphragm. The vagus nerves were divided in the neck. Focal injury to the parenchyma of the lungs was produced by injection of 2 ml water at a temperature of 70-80°C through the chest wall, a procedure giving maximal limitation of the disturbances of the mechanical properties of the parenchyma and respiratory passages arising in association with diffuse lesions of the lungs. The arterial partial CO_2 pressure (P_aCO_2) was determined by the micro-Astrup apparatus on blood taken from the femoral artery.

EXPERIMENTAL RESULTS AND DISCUSSION

Preliminary injury to the lung parenchyma before vagotomy caused increased inspiratory volleys in the diaphragm and increased respiration rate (Fig. 1) from 62.3 ± 2.7 to 78.6 ± 4.2/min. Similar injury to the lung parenchyma after vagotomy only intensified the inspiratory volleys (Fig. 2). The respiration rate either remained unchanged or fell very slightly from 45.5 ± 2.5 to 43.2 ± 3.0/min, which was not statistically significant. The response developed rapidly. In some experiments, as a result of hyperventilation a slight hypocapnia developed (P_aCO_2 fell from 32.0 ± 3.3 to 30.0 ± 1.9 mm Hg in animals with intact vagus nerves and from 31.2 ± 2.7 to 29.6 ± 1.4 mm Hg in vagotomized animals).

In deeply anesthetized animals (pentobarbital 30-40 mg/kg) this circumscribed lung injury caused no significant changes in respiration. Reflex changes of respiration to an increase in lung volume, by contrast with

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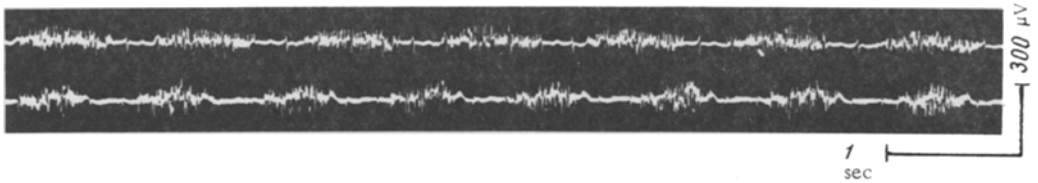

Fig. 1. Inspiratory volleys of diaphragm of animal with intact vagus nerves before (above) and after (below) circumscribed lung injury.

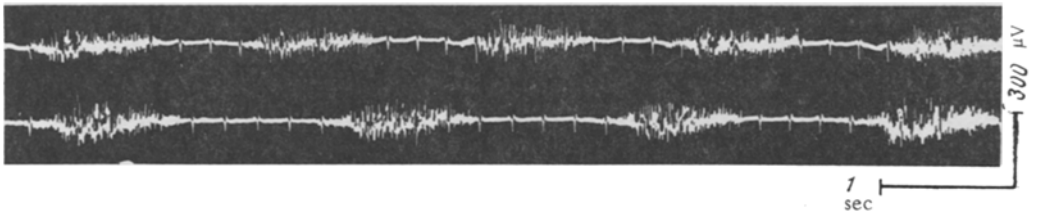

Fig. 2. Inspiratory volleys of diaphragm of vagotomized animal before (above) and after (below) circumscribed lung injury.

circumscribed injury, on the other hand, were more marked in anesthetized animals and hardly demonstrable at all in waking animals, especially if their attention was distracted [2].

In previous investigations [2] reflex hyperpnea in animals with lung injury and with intact vagus nerves was shown to be evoked from the pulmonary receptors innervated by C fibers, which constitute 80% of all the fibers of these nerves, and not from pulmonary stretch receptors as was hitherto considered [4].

It is interesting to note that extravagal afferents from the lungs belong to the class of Aδ fibers running in the composition of sympathetic nerves [5], and along which, as also along C fibers, nociceptive impulses spread. Intensification of inspiratory volleys from these nerves after lung injury in vagotomized animals probably also leads to deepening of the inspiratory volleys of the respiratory muscles. The results of these experiments suggest that these impulses affect mainly the central mechanisms regulating the depth and not the frequency of respiration. It may be that this important fact was not discovered previously because earlier investigators [3, 6] used stimuli (phosgene, sulfur dioxide) which caused diffuse injury to the lungs and, consequently, which caused changes in the mechanical properties of the lungs (expansibility, resistance of the respiratory passages). In our own experiments, however, circumscribed injury to the lungs was used, and this evoked a respiratory reflex mainly from the pulmonary nociceptors themselves.

The reflex deepening of respiration, evoked from extravagal afferent pathways of the lungs, is of great importance to compensation, for it ensures the pulmonary ventilation most effectively.

The results described above are also evidence that besides impulsation from the vagus nerves, impulsation spreading along extravagal afferents of the lungs must also be taken into account in the analysis of the relations between depth and frequency of respiration, especially under pathological conditions.

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