STRUCTURE OF THE RESPIRATORY CYCLE DURING EXTINCTION AND RESTORATION OF VITAL FUNCTIONS

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S. V. Tolova

Laboratory of Experimental Physiology on Animate Organisms, USSR Academy of Medical Sciences, Moscow
(Presented by Academician V. V. Parin)
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When the brain is subjected to oxygen starvation, produced by circulatory interruption, various types of respiratory derangement is observed [2, 3, 11, 18, 19, 25, 28, etc.]. Recording of the currents in respiratory muscles during clinical and experimental studies permits a more detailed study of the activity of the respiratory center both in the normal and in pathologic states of the organism [4, 7, 10-16, 21, 22, 26, 27, 29, 31, etc.].

The present work was designed to study the structure of the respiratory cycle by electromyographic analysis of the main and accessory respiratory muscles in different stages of the extinction of vital functions during dying from blood loss and in the first 1\frac{1}{2}-3 h after resuscitation of the animals undergoing 3-5 min of clinical death.

METHOD

Thirteen experiments were performed on adult dogs weighing 8-25 kg. Under fluothane inhalation anesthesia electrodes were placed in the respiratory muscles to record the EMG [6] and in the cerebral cortex to record the electrocorticogram (ECoG). The electrical activity of the following muscles was investigated: inspiratory (diaphragm, external intercostals), expiratory (internal intercostals, rectus, transversus and obliquus externus abdominis), and the accessory muscles (transverse thyroid, sterno-cephalic and tongue muscles). The EMG, ECoG, EKG, and pneumogram (PG), recorded by a thermosensitive element fixed in the incubator, were inscribed on "Al'var" electroencephalographic

![Fig. 1. Change in respiratory cycle structure in the process of dying from blood loss. EMG (scale of amplification 50 microvolts) and PG (marks at 5 sec intervals) of experiment on dog weighing 23.5 kg performed 9/25/62. From top to bottom in all segments of EMG: diaphragm, transversis abdominis, and cricothyroid muscle. A) Before blood loss; B) 1st min; C) 5th min; D) 11th min; E) 19th min; F) 22nd min of dying; G) last agonal inspiration at 22nd min of dying.](image)
Fig. 2. Change in respiratory cycle structure during restoration of vital functions after clinical death. EMG (scale of amplification 50 microvolts) and PG (marks at 5 sec intervals) of experiment on dog weighing 17 kg. From top to bottom in all segments of the EMG: diaphragm, transversis abdominis, and cricothyroid muscle. A-3rd, B-6th, C-8th, D-9th, E-10th, F-12th, G-15th, H-22nd, I-46th, and J-88th min after beginning of resuscitation.

film and in parallel on a trace oscillograph MPO-2. The arterial pressure in the femoral artery, the PG and the pulmonary ventilation volume [8] were recorded on a tape kymograph. Observations were made of the dynamics of the eye reflexes and the total condition of the animal. After the animal came out of anesthesia (EEG served as control) it underwent a massive blood removal from the femoral artery (0.8% solution of heparin, 0.5 ml/kg had previously been injected) until the appearance of clinical death. The animals were resuscitated by the method developed by V. A. Negovskii and co-workers (intra-arterial pumping of the blood which had been removed with adrenalin, artificial respiration).

RESULTS

Changes in the Structure of the Respiratory Cycle During Dying. Up to the bloodletting the activity of the inspiratory and some accessory neck muscles, which contracted either on inspiration or on expiration, were recorded on the EMG. Electrical activity, as a rule, was lacking in the expiratory muscles—expiration usually proceeded passively (Fig. 1A). During the process of dying from blood loss certain stages of change in respiration were observed: respiration became deeper and more rapid, there was alternating respiration, decreased amplitude and frequency of respiratory movements, a terminal pause, after which agonal respiration followed. In the stage of deeper and more rapid respiratory movements in the inspiratory and accessory respiratory muscles the amplitude variation on the EMG rose 2-3 times, while during expiration electrical activity appeared in the expiratory muscles (Fig. 1B). The EMG fluctuations of the inspiratory muscles reached greatest amplitude during intercalary inspirations with predominant amplitude of the respiratory movements. In the stage of decreasing frequency and depth of respiratory movements the amplitude of EMG fluctuation from the respiratory muscles exceeded the initial value by 4-5 times and fell only before the terminal pause. In the accessory respiratory muscles of the neck, for example in the transverse thyroid muscle, during dying, the amplitude of the burst initially increases during inspiration, the activity decreases during expiration, increases again during inspiration; this muscle still contracts only during inspiration up to the occurrence of the terminal pause (Fig. 1A-D). The sterno-cephalic muscle and the tongue muscles, as a rule, take no part in quiet respiration, but during dying phasic activity during inspiration appears on a background of constant tonic activity.