OXYGEN TRANSPORT DURING ELECTRICAL STIMULATION OF EMOTIONAL HYPOTHALAMIC STRUCTURES

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Hypertensive structures of the hypothalamus were subjected to periodic electrical stimulation in unanesthetized, immobilized rabbits. After each period of stimulation, lasting 5 min and repeated at intervals of 5 min, the state of the mechanisms of oxygen transport (hemodynamics, affinity of hemoglobin for oxygen, oxygen capacity of the blood) was investigated. During the first two or three periods the oxygen consumption of the animals was increased, but later it fell because the function of the energy-dependent mechanisms of oxygen transport no longer corresponded to the requirements of the body. A decrease in the affinity of hemoglobin for oxygen under these conditions contributes to better deoxygenation of the blood in the tissues.

KEY WORDS: hypothalamus; emotional stress; oxygen consumption; oxygen transport; circulation; oxygen capacity of the blood; affinity of hemoglobin for oxygen.

The character of the somatic and autonomic changes developing in response to electrical stimulation of the hypothalamus necessitates increased energy expenditure and corresponding changes in the oxygen transport system. The arterial blood pressure (BP) rises [2, 4, 7-9], the blood flow is reduced in the intestine [13] and increased in the muscles [12, 15], and the arteriovenous difference (AVD) in oxyhemoglobin concentration is modified [10]. Activation of the circulation is an important and rapidly realized mechanism in the general oxygen transport system, but it is not the only mechanism; the functional characteristics of the system are also determined by the state of affinity of hemoglobin for oxygen and by the oxygen capacity of the blood (OCB) [6].

Considering the role of hypothalamic structures in the formation of the functional system of emotions, hypothalamic stimulation is widely used in order to reproduce their somatic and autonomic effects [1, 2, 4, 8]. For that reason the determination of the state of the various functional components of the oxygen transport system during hypothalamic stimulation may make an important contribution to the understanding of the mechanisms of development of adaptive responses in various forms of emotional stress and their sequelae.

EXPERIMENTAL METHODS

Experiments were carried out on 26 rabbits in which a hypertensive response was obtained to stimulation after insertion of a bipolar nichrome electrode into the middle or posterior group of hypothalamic nuclei. The electrode was inserted after preliminary catheterization and cannulation of the external jugular vein and the common carotid and femoral arteries under general anesthesia.

Electrical stimulation by square pulses (1 msec, 80-100 Hz, initial voltage 2-2.5 V) was applied to the unanesthetized animals fixed in a frame. The pulse voltage was increased by 0.5-1 V in each successive period. Stimulation continued for 5 min and was repeated at intervals also of 5 min. The strength of the current varied in different experiments from 30 to 210 μA.

The central venous pressure (CVP) and BP were measured by the direct method and the cardiac output (CO) was determined by the thermodilution method [5]. The ECG was recorded in three standard leads. The OCB was calculated after determination of the hemoglobin concentration. The oxyhemoglobin concentration in arterial and mixed venous blood was determined with the 057 oxyhemometer, calibrated against samples of rabbit's blood with different concentrations of oxyhemoglobin, made up by mixing completely deoxygenated and oxygenated blood. The cuvette and the solution for diluting the blood were kept at a constant temperature. To
estimate the affinity of hemoglobin for oxygen a sample of mixed venous blood in a saturator was brought to
equilibrium with a gas mixture containing 3.4% O2, 5% CO2, and 91.6% N2, after which the oxyhemoglobin con-
centration was determined. The values of pO2 corresponding to atmospheric pressure and the composition of
the gas mixture, and the oxyhemoglobin concentration in the blood sample were used to calculate pO2 and the
oxyhemoglobin dissociation curve [11]. The resistance to the blood flow (R), the work of the heart (A), the
oxygen consumption (O2), and AVD for oxygen were calculated from the results.

**Experimental Results**

Changes in the indices of oxygen transport and, in particular, in the hemodynamics, during the first
period of electrical stimulation were the result of the increased oxygen consumption of the animal (Fig. 1).
During the first 3-10 sec of increase of BP transient disturbances of cardiac rhythm were observed on the
ECG or BP kymogram. A sharp increase evidently led to an increase in BP, when the heart was unprepared
for the additional work. This was shown by the increase in CVP to 7.2±1.2 cm water. Very small increases
in the volume load (injection of 0.3-0.5 ml physiological saline into the region of the orifices of the venae
cavae during determination of CO) were often accompanied by omission of the next cardiac contraction and a
fall in BP. These findings suggest that the decrease in CO during the first few seconds of stimulation must
be regarded not only as reflex in origin, but also, evidently, as unprovided for energetically. Immediately
after this first response to electrical stimulation of the hypothalamus, the oxygen transport system became
established at a new level of function, characterized by an increase in CO, A, and AVD and by a relative
decrease in R. Changes in BP in each successive period of electrical stimulation were indistinguishable from

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Fig. 1. Changes in AVD for oxygen concentration (1), CO (2), V̇O₂ (3), BP (4), and R (5), in % of initial data
during 5 min of stimulation of hypothalamic emotiogenic structures. Ordinate, change in indices studied
(in % of initial values); abscissa, time (in min).

Fig. 2. Changes in V̇O₂, CO, and AVD for oxygen concentration, and ECG after each period of stimulation of hypothalamic emotiogenic structures. Ordinate, change in indices studied (% of initial data).