POSTNATAL CHANGES IN THE PHASES OF RESPIRATION AND OXIDATIVE PHOSPHORYLATION IN THE CEREBRAL HEMISPHERES OF ANIMALS

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The metabolism and work of the living organism are inseparably connected with the intensity of formation and conversion of energy. The study of the age changes in the biological oxidation and oxidative phosphorylation in the brain is therefore of great theoretical and practical interest. The principles governing the changes in respiration and oxidative phosphorylation in the cerebral hemispheres in the postembryonic period of animal development have not yet been discovered. No significant changes in respiration or oxidative phosphorylation have been found in homogenates and mitochondria of the whole brain of old albino rats [3]. On the other hand, according to E. V. Parina and E. B. Saponitskaya [1], from the first days after birth the intensity of formation of high-energy phosphates – ATP and ADP – in the brain of albino rats progressively diminishes.

It was decided to study the changes in respiration coupled with phosphorylation in the cerebral hemispheres of albino rats at different periods of postnatal life but, in contrast to the experiments of Garbus [3] and other workers, without introducing enzyme systems (hexokinase, cytochrome c, etc.) and electron carriers in the respiratory chain into the incubation medium from outside sources. In preliminary experiments a careful study was made of the experimental conditions and the composition of the incubation mixture.

EXPERIMENTAL METHOD

Experiments were carried out on albino rats of different ages. Altogether six series of investigation were undertaken (20 animals were used in each series). The rats were sacrificed by instantaneous decapitation, after which the skull was quickly exposed and removed, the brain extracted, the hemispheres separated and dried with filter paper, weighed, and a sample weighing 1.0-1.2 g was homogenized in a glass homogenizer (buried in a mixture of ice and water) with 1 ml of a 0.15 M solution of potassium chloride for 2 min. The homogenate was washed into a centrifuged tube with 2.5 ml of 0.15 M potassium chloride solution, and with constant stirring, a 1 N solution of KOH was added drop by drop until the pH was 7.4, after which the contents of the tube were centrifuged at 200 g for 3 min to remove cell residues. The supernatant was decanted from the residue into a test tube, the volume of liquid in the tube was made up to 5 ml with 0.15 M potassium chloride solution, and this was then used immediately as the enzyme preparation for the experiments.

The composition of the incubation mixture was: 1.933×10^{-2} M solution of K_2HPO_4, 5×10^{-3} M solution of $MgCl_2$, 2.5×10^{-2} M creatine, 6.4×10^{-3} M solution of K-ADP, 2×10^{-2} M solution of sodium fluoride, 1.8×10^{-2} M solution of K pyruvate, 1.4×10^{-3} M solution of fumarate, 1.6×10^{-2} M solution of glucose, 8×10^{-3} M solution of K oxaloacetate, and 1 ml of the enzyme preparation made up in 0.15 M potassium chloride solution. The total volume of the incubation mixture was 3 ml. Incubation took place for 20 min at 37°. After determination of the oxygen absorbed, the reaction was stopped by the addition of trichloroacetic acid; the liquid was cooled and centrifuged, and the concentration of inorganic phosphorus determined in the filtrate thus obtained. The content of bound phosphorus was calculated from the difference between the content of inorganic phosphorus in the trichloroacetic filtrate of the control and experimental samples. The inorganic phosphorus was determined by a photometric method developed by the author [2].

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Content of Oxygen Absorbed and Inorganic Phosphorus Bound by Tissue of the Cerebral Hemispheres of Rats of Different Ages

Age (in days)	Absorption of oxygen (in 1)	Inorganic phosphorus bound (in mg)	P/O
5	224,1±1,54	0,755±0,031	1,21
20	241,3±2,00	0,972±0,051	1,45
60	252,59±8,17	1,36 ±0,084	1,94
400	247,13±2,12	1,29 ±0,067	1,91
800	247,22±2,29	0,97 ±0,052	1,41
1110	193,58±3,07	0,312±0,008	0,58

Note: The results were calculated for an enzyme preparation contained in 500 mg of fresh tissue during incubation for 20 min at 37°. The results of each series of investigations are the mean values from experiments on 20 rats.

EXPERIMENTAL RESULTS

The experimental results are given in the table.

It is clear from the table that after birth the absorption of oxygen and the intensity of oxidative phosphorylation in the cerebral hemispheres of rats gradually increase to reach a maximum on the 60th day of postembryonic life. During further development of the animals the intensity of oxidative phosphorylation in the cerebral hemispheres begins to fall, whereas the absorption of oxygen remains at a high level. In the terminal stage of aging (on the 1110th day of postnatal life), for instance, the P/O ratio showed a decrease of 70%, the content of bound inorganic phosphorus a decrease of 77%, while the oxygen absorbed by the tissue of the hemispheres fell by only 23% compared with the level of these indices for rats aged 2 months. Consequently, the sharp decrease in the P/O ratio for the tissue of the cerebral hemispheres of rats in the final stage of aging is due to a more marked fall in the intensity of binding of inorganic phosphorus in association with a moderate fall in oxygen absorption.

On the basis of these experimental results, three stages can be distinguished in the development of the processes of respiration and oxidative phosphorylation in the cerebral hemispheres: a stage of an increase in the intensity of respiration and oxidative phosphorylation (from the 5th until the 60th day), a stage of maximal increase (from the 60th until the 400th day), and a stage of decline (from the 400th until the 1110th day).

The experimental results thus show that the intensity of respiration and oxidative phosphorylation in the brain undergoes significant changes in the postnatal period of life.

LITERATURE CITED

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2. G. A. Uzbekov and M. G. Uzbekov, Lab. Delo, No. 6, 349 (1964).
3. J. Garbus, Am. J. Physiol., 183 (1955), p. 618.

All abbreviations of periodicals in the above bibliography are letter-by-letter transliterations of the abbreviations as given in the original Russian journal. *Some or all of this periodical literature may well be available in English translation.* A complete list of the cover-to-cover English translations appears at the back of the first issue of this year.