İstanbul Üniv. Vet. Fak. Derg.
34 (1), 67-74, 2008

J. Fac. Vet. Med. Istanbul Univ.
34 (1), 67-74, 2008

Araştırma Makalesi

MORPHOLOGICAL CHANGES IN SENSOMOTOR, LIMBIC AND ORBITAL CEREBRAL CORTEX UNDER DIFFERENT LEVELS OF FOOD MOTIVATION

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Geliş Tarihi : 10.01.2008
Kabul Tarihi : 22.01.2008

Besin Motivasyonunun Farklı Düzeylerinde Sensomotor, Limbik ve Cerebral Kortekste Meydana Gelen Morfolojik Değişiklikler

Özet: Bu çalışmanın amacı, besin motivasyonunun farklı düzeylerinde sensomotor, limbic ve cerebral kortekste meydana gelen morfolojik değişliklerin araştırılmasıdır. Çalışmada, maksatlı hareketleri kontrol eden bölge, diğer bölgelerden daha fazla değişikliğe uğramıştır. Böyle morfolojik değişiklikler vücut homeostazisindeki değişiklikler ilgili de olabilir. Açlığın uzaması durumunda sensomotor ve limbic kortekste daha fazla değişiklikler gözlendi. Aynı değişiklikler cerebral kortekste de gözlendi.

Sonuç olarak, açlık motivasyonuna ve süresine bağlı olarak cerebral kortekste morfolojik değişiklikler gözlendi.

Anahtar Kelimeler: Motivasyon, Nissl maddesinin morfolojisi, Sensomotor Korteks, Limbik korteks.

Abstract: The aim of this study was to investigate the morphological changes in various sites of cerebral cortex at different levels of food motivation. In the study, the region controlling intentional movement has undergone alteration much earlier than the other regions. Such morphological changes can also be associated with the change in homoeostasis of the body. In case of the prolonged periods of hunger, morphological changes of sensomotor and limbic cortex become more intense. Such a change was also be observed in cerebral cortex.

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In conclusion, we have observed that the morphological changes in cerebral cortex are due to the food motivation and its stage.

Key Words: Motivation, the morphology of nissl material, Sensomotor cortex, Limbic cortex.

Introduction

"Anatomical studies have revealed prominent afferent input to the CMAs [cingulate motor areas] from the limbic structures and the prefrontal cortex, which can send information about motivation and the internal state of subjects, as well as cognitive evaluation of the environment" **(13)**.

The limbic system is a group of brain structures that are involved in various emotions such as aggression, fear, pleasure and also in the formation of memory. The limbic system also affects the endocrine system and the autonomic nervous system. It consists of several structures located around the thalamus, just under the cerebrum:

Hypothalamus; controls the autonomic nervous system and regulates blood pressure, heart rate, hunger, thirst, and sexual arousal. Connected to the pituitary gland and thus regulates the endocrine system. (Not all authors regard the hypothalamus as part of limbic system.) The limbic system is among the oldest parts of the brain in evolutionary terms: it can be found in fish, amphibians, reptiles and mammals **(8)**.

The pleasure center is located in the limbic system. It is involved in sexual arousal and in the "high" derived from certain recreational drugs. Dopamine acts here. Rats with electrodes implanted into their limbic system will self-stimulate in preference over food and will eventually die of exhaustion **(1)**.

The limbic system is tightly connected to the prefrontal cortex. It has been conjectured that this connection is related to the pleasure obtained from solving problems. To cure severe emotional disorders, this connection was sometimes surgically severed, a procedure of psychosurgery. Patients who underwent this procedure often became passive and lacked all motivation **(7)**.

The data about morphological changes in the neocortex under different terms of food deprivation and saturation are very poor present time **(12)**. Nevertheless, different cortical regions play an important role in regulation of gluco-homeostasis and food motivation **(6, 10, 11)**. The studies of sensomotor, limbic and orbital cortex under different terms of food deprivation are of certain interest.

Materials and Methods

The experiments were conducted on 50 Wistar rats of the same age culled into 5 groups; First group was used as control water ad. libitum; Animals on II, III, IV and V experimental groups that didn't receive any food correspondingly during 1, 3, 5 and 7 days while they received water ad. libitum. After the completion of experiments all animals were decapitated, The brains were quickly removed and the tissues were mixed in Carnoyn's fixture **(16)**. After dehydration, these samples were embaded in paraffin frontal sections were cut to 6-7 μm thickness. Then, tissues were stained by crezil-violet according to nissl technique **(2)**. The study of sensomotor cortex was conducted on the FP field, the study of frontal limbic cortex-on L^a field, the study of orbital cortex-on the point of the junction of the PAS and PA^m fields. The sections were examined on the level of III, IV and V layers by using light microscope (Ampliva City, Germany)".

Results and Discussion

Cytoarchitectonical patterns of neurons of the sensomotor limbic and orbital cortex were differed in intact animals (Fig.1).

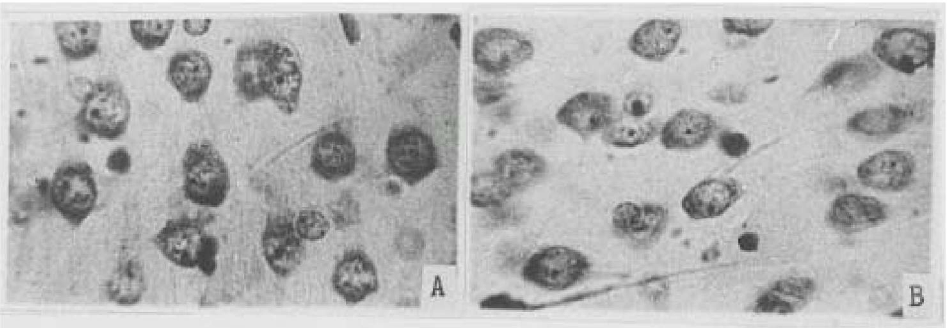

Figure 1: The spread of nissl substance on the third layer of orbital and sensomotor cortex of control animals. X630 A) Sensomotor cortex, B) Orbital cortex.
Şekil 1: Kontrol grubu hayvanların sensomotor ve orbital kortekslerin üçüncü tabakalarında nissl cisimciklerinin yayılımı, X630. A) Sensomotor korteks, B) Orbital korteks.

The sections analysis showed that after 1 day food deprivation in the pyramidal neurons of the III layer of the sensomotor cortex the profound intensive basophilic staining and its even distribution over the whole neuron nuclei were observed, while in cytoplasm the accumulations of tigroid conglomerates were noticed. The neurons formed the certain group consisting of several pyramidal and small neurons. In the neurons of the orbital cortex the significant morphological changes were not noticed.

The observed morphological changes bear functional character, i.e. relatively less expressed changes are related to the sensory afferent signals from somato-visceral afferental system that are mostly transformed to the III cortical layer. On the IV layer level of the sensomotor cortex intensification of the basophilic substance staining was observed; neurons and glial cells formed congregation. Such changes, probably, are related to the integration of incoming afferent signalization **(3)**.

On the level of V layer of sensomotor and limbic cortex in the large pyramidal neurons, the activation of the nuclear apparatus was observed; glial cells came close to the apical and basal dendrites. In cytoplasm of the neurons the transposition of the tigroid the apical parts of dendrites were observed. Such micrograph was observed in the large neurons of the sensomotor cortex as well.

Comparison to limbic cortex after one day-food deprivation more profound morphological changes in the sensomotor cortex indicate that the former one as an integrative centre of goal-directed reaction in the organism is responsible for realization of food behavior **(4, 15)**. As a collector, accepting all the incoming afferent information **(18)**, pyramidal neurons of V layer of the sensomotor cortex earlier than the all other cortex regions react to the defect of food deliver (regime). After-I-day-food deprivation there were not altered in the homeostatic system (gluco-homeostasis), so, neuronal organizations of the frontal limbic cortex changed relatively less significant.

As for the orbital cortex, then less prominent morphological changes after I-day food deprivation, probably, are related to its morphological peculiarities. It is known that orbital cortex in comparison to the other cortical regions is more responsible for realization of those levels of food-seeking behavior that are mostly related to the mechanism of sensory and metabolic saturation **(14)**. Perhaps, on the initial stages of the food deprivation the neurons of the orbital cortex are in the state of inhibition that is necessary CNS reaction for animal behavior correction. This conjecture is confirmed by results of the experiment, in which on the III and IV layers of the orbital cortex we observed numerous hyperchromal neurons of middle sizes (Fig. 2). Such conjecture coincides with the data **(5, 17)** that orbital cortex sends the inhibitory pulses to the reticular formation of the midbrain and medulla oblongata. Perhaps, the observed morphological picture is closely related to such functions of orbital cortex.

After 3-day food deprivation on the level of the III neuron layer of sensomotor and limbic cortex in small pyramidal neurons the nucleolus disappearance, nuclear shape deformation and transposition of basophilic substance towards nuclear edge were observed. In same neurons of sensomotor cortex the nuclear shapes were disappeared, while in neuron cytoplasm the accumulation of tigroid in the area of apical dendrites and hyperchromatos of small neurons were noticed. Such picture was less prominent in the limbic cortex. In the orbital cortex in the neurons of the III layer the significant morphological changes didn't occur. On the IV layer level the accumulation of the tigroid and glial cells were becomes hyperchronial.

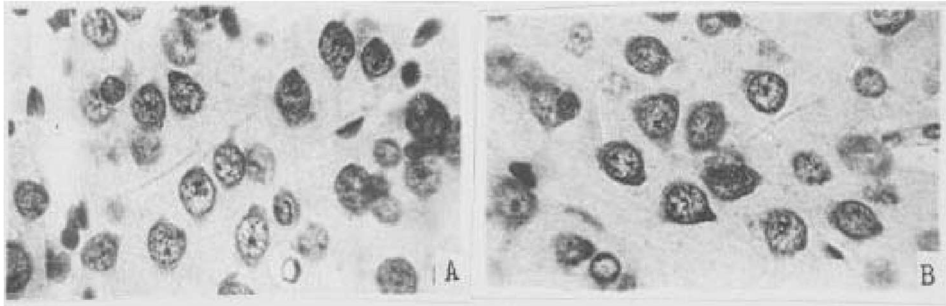

Figure 2: The hypercrom neurons located in orbital cortex after one-day food deprivation, X630 A) Third layer neuron, B) Fifth layer neron.

Şekil 2: Açlıktan bir gün sonra orbital kortekste hiperkrom neuronların lokalize olması, X630 A) Üçüncü tabaka neuronlar, B) Beşinci tabaka neuronlar

On the level of the V layer in the large pyramidal neurons of the sensomotor and limbic cortex the exocentric disposition of the nucleus and its shapes disappearance hyperchromatosis, swallow decrease and transposition of the tigroid in the apical dendrites region were observed.

In the orbital cortex in the pyramidal neurons of the III and V layers the nucleus enlightenment and the tigroid transposition towards peripheral portion of the neurons, decrease of glial cells swallow were noticed.

The data analysis indicate that neuronal organizations of the sensomotor and limbic cortex were in the state of the primary excitation **(9)** and neurons of the III and IV layers were in of hyper excitation. In the neuronal organizations of the Sensomotor and limbic cortex the significant rearrangements of neuronal plasticity occurred, i.e. some of then on the hyper excitation background were in the state of exhaustion while small ones on account of inhibitory mechanisms maintained structural plasticity perhaps, owing to the interneuronal interrelations. So, neurons, joining into one group, formed functional ensembles (Fig. 3). In the orbital cortex in this starvation term, perhaps, inhibition was withdrawn, and in neuronal organizations single neurons with excitation signs appeared.

After 5-days food deprivation on the level of the III layers of the sensomotor and limbic cortex the neurons with eccentric disposition of the nucleus and nucleolus, swallow of the atrocity glia and hyper chrome small neurons were observed. In the orbital cortex on the III layer level neurons had light nuclei with increased volume. On the III layer level of the sensomotor cortex the hyperchromal neurons and glia cells transposition of the basophilic substances of some neurons to the nucleus edge, activation of neuroglial interrelations in the sensomotor and limbic cortex were noticed.

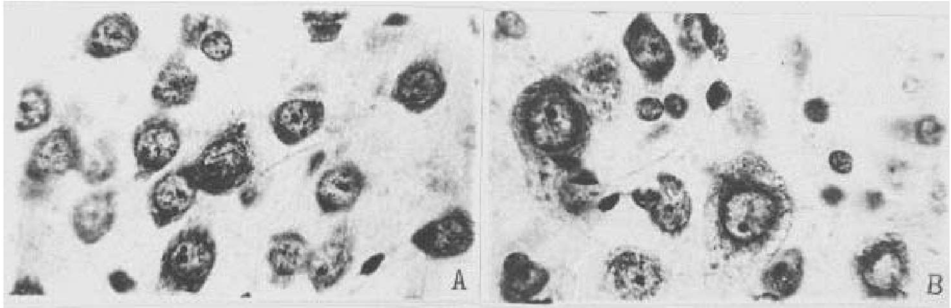

Figure 3: The large neurons in the state of excitation and the small neurons in the state of non-excitation located in the fifth layer of limbic and sensomotor after three-day food deprivation, X630. A) Limbic cortex, B) Sensomotor cortex.

Şekil 3: Açlıktan 3 gün sonra limbik ve sensomotor'un beşinci tabakasında uyarım yapılmadığında küçük neoronların ve uyarım yapıldığında da büyük neuronların lokalize oluşu, X630. A) Limbik korteks, B) Sensomotor korteks.

On the V layers level in the neurons of the sensomotor and limbic cortex big pyramidal neurons with dissolved nucleolus, disappearance of nuclei shapes, chromatolysis, swallow of the apical dendrites as well as volume decrease of the small neurons were observed. In the orbital cortex on the III and IV layers level the swallow of the nucleus while in some the nucleoli dissolvation were noticed (Fig. 4)

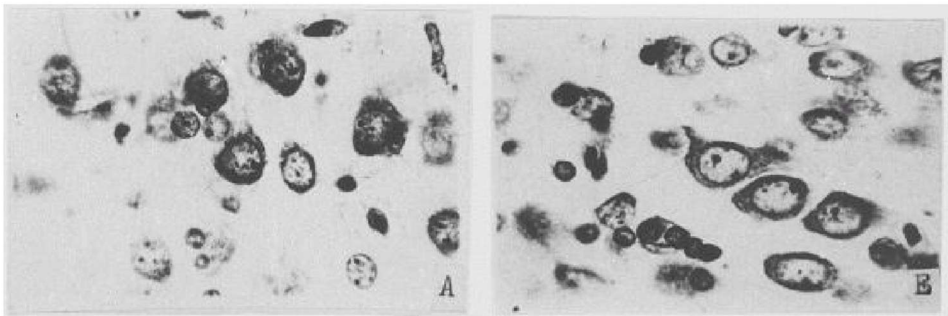

Figure 4: The morphological changes in sensomotor and orbid cortex after five days food deprivation, X630. A) Sensomotor cortex, B) Orbital cortex.

Şekil 4: Açlıktan beş gün sonra sensomotor ve orbital kortekslerdeki morfolojik değişimler, X630. A) Sensomotor korteks, B) Orbital korteks.

So, after 5 days food deprivation in neuronal constellations of the sensomotor and limbic cortex the profound morphological changes, expressed in disturbances of the intracellular regulatory processes in the neurons, that are responsible for the animal behavior initiation, take place. Apparently, the prolonged food uptake restriction was appeared stressful (nonspecific) effect and hyper excitation of the neurons of the II and V layers isn't compensated by the hunger factor.

Under starvation till 5-7 days the deepening of morphological changes were observed, especially in the sensomotor and limbic cortex, with involvement of big number of neurons and the neurons with pathological features appeared. All these indicate on direct relation of observed morphological changes with disturbances of just visceral sphere-experimental animals become quite inert, refuse from food and water even on their deliver.

So, the direct correlation exists between animal behavior and the morphological changes under different levels of food motivation.

In Conclusion

1. Among the studied regions of the neocortex, the morphological changes are observed earlier (1-3 days of starvation) in the sensomotor and limbic cortex that indicate on higher responsibility of these regions in organization of the goal-directed reactions of the organism caused by hunger.
2. The morphological changes in the orbital cortex are observed under more prolonged starvation terms (5-7 days) that are related to the disturbances of somato-vegetative reactions, that i.e. of inner milieu of the organism, caused by the prolonged starvation.

Aknowledgements

We thank to TUBITAK for assignment of Professor Fahrettin ASKEROV to the University of Yüzüncü Yıl for this research.

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