Morphological Changes in the Some Centers of Hypothalamus During Food Deprivation

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Abstract

In this study, morphological changes in various sites of hypothalamus have been investigated in the state of hunger. The morphological changes occurred during different phases of the state of hunger have been observed in various regions of lateral hypothalamus. Our study has also shown that lateral hypothalamus functions as the hunger mechanism and therefore undergo intense morphological alterations. Essentially lateral hypothalamus was found to control the mechanism, operating at stages of hunger.

Key words: Hypothalamus, Hunger, Nissl substance, Morphologic alteration

INTRODUCTION

Researchers working on food motivation investigated the animal behavior affected by external environment. Since 1974, food and water-dependent behaviors have been investigated in the department of brain and behavior research, in the Institute of Physiology in n.a A.I. Karayev, Azerbaijan Academy of Science. In those studies morpho-chemical alterations occurred in limbic system of central nerve system have been investigated (1,4,5).

Cooms (7) and Juravlev (9) investigated the electric activity of neurons located in cerebral cortex of animals during food seeking. These researchers did not consider the morphological changes that occur in the sections of central nervous system, which controls the action. However, the nature of Nissl substance located in the cells of central nerve system is very important in terms of functional situation. Morphological changes were observed in these cells when organism changes its functions.

The aim of this study is to investigate the morphological changes in some parts of hypothalamus during hunger state.

MATERIALS AND METHODS

The experiments were conducted on 40 male rats, which were in same age and weight. Rats were divided into 4 groups of 10 rats each.

First control group received food and water ad. Libidium: 2 nd, 3 rd and 4 th groups did not receive any food during 1, 3 and 5 days correspondingly while they received water ad. Libidium.

After the completion of experiments, all animals were sacrificed and brains were
fixed as a whole in Cranney’s fixative. After paraffin embedding the samples was cut in frontal section in 10 µm, sections were stained with crazily-violet according to Nissl technique (19). Nissl substance was investigated in the centre of paraventricular (PV), suprachiasmatic (SO), lateral area (LA), ventromedial (VM), mamillary lateral (ML) and mamillary medial (MM) parts of hypothalamus.

RESULTS

The sections taken from control animals were investigated under the light microscope. The amount of cytoplasm in the cells located in neurons of SO and PV centers were found more than the other parts of hypothalamus. Nissl substance was homogeneously spread in cells. The large neurons in lateral hypothalamus were prismatic and contained small amount of Nissl substance. The nucleolus of neurons stained dark and each neurons contained 2-3 nucleoli in some state.

Tiny powder like basophilic substance was distributed homogeneously in the whole cytoplasm of glial cells located in the centers searched in this study. All of axons and dendrites were not stained. However, apical dendrites in some large neurons located in lateral centre were stained very well with Nissl technique. Bipolar neurons were in the form of prismatic. Nissl substance was in tiny particles in the small centers (VM, MM) and spread homogenously over whole cell. Nucleus of neurons stained in dark and nucleolus was as tiny as dots.

Middle size neurons surrounded and congregated large neurons and made clusters. These clusters were observed quite well in outer area and backside of lateral part. Neuralgia consists of basically oligodendro-gliosis. Astroglial cells were observed dominantly in back and front sides of lateral part. Glial cells in centers containing large cells especially SO and PV centers consist of astrocytes while glial cells in ventromedial and mamillary area consist of oligodendrocytes (Fig.1).

After one-day food deprivation, animals performed more activity to find food. The analysis of sections obtained from these animals showed that nissl substance in HL (outer lateral) and VM (ventromedial) centers of hypothalamus became less. Basophilic substance in glial cells spread homogeneously. The amount of Nissl substance...
substance in larger neurons and in cytoplasm of neurons located in SO and PV centers increased whereas basophilic substance in glial cells decreased.

After three-day food deprivation, animals became more active to find food while water consumption decreased. In the section analysis of this stage, the amount of deformed-neurons increased, while chromatolysis was noticed in large neurons, fornix and outer lateral area of hypothalamus. Transposition of Nissl substance towards nuclear edge in neurons located in SO and PV were observed. Moreover, hypertrophy in neurons and nuclei were noticed and morphological changes of large neurons increased in ventromedial center. Nucleus and nucleolus of most of the neurons were excentrically located. Although lateral centre of hypothalamus consisted of basically oligodendri-glial cells, the amount of satellitneuro-glial cells increased in this area (Fig.2).

![Figure 2](image)

**Figure 2.** The state of Nissl substance in neurons and glial cells located in (A) perifornical (B) outer lateral (C) supraoptic (D) paraventricular (E,F) ventromedial of lateral hypothalamus after three-day food deprivation, x630

After five-day food deprivation, action capacity and water consumption of animals decreased and they became aggressive. The section analysis of this stage showed considerable morphological
changes in all centers of hypothalamus. Especially ectopic and hydropic changes were noticed in nucleus and nucleolus of large neurons of lateral centre and cytoplasm of neurons in outer lateral and ventromedial centers, and the reaction of glia-neuronal compensatory was observed (Fig.3).

Figure 3. The state of Nissl substance in the small (A) and large (B) cells located in VM and in neurons and glial cells located in the middle (C,D) and back side (E,F) of outer lateral of hypothalamus after five-day food deprivation, x630

Total chromatolysis was noticed in the majority of neurons located in the middle-outer lateral area and in some neurons of the other areas.

DISCUSSION

Food intake is stimulated by hypothalamus through the intrareceptive impulses such as chemical, thermic and osmotic incoming from the digestion tractus system and all over the body. This statement was confirmed by electrophysiological, biochemical and neurochemical tests (10,15).

Morphological changes occurred in neurons and glial cells in some centers of hypothalamus because of the functional changes of neurons and glial cells. The results obtained from this research were in agreement with Leantovič (16) and Papova's (21) findings. The first study in this area was conducted by Kogan and Sibikova (11). Their findings indicated some morpho-
chemical changes in hypothalamus and thalamus centers of central nerve system during food deprivation, which was parallel to our results.

Morphological changes observed in outer lateral side of lateral center after one-day food deprivations were quite clear. These changes were as follows; swelling in cells, perinuclear chromatolysis, relations between glial cells and neurons and interrelations of neurons.

In this area the amount of Nissl substance in cytoplasm of large neurons increased. This state makes clear that outer lateral centre was over-sensitive to food deprivation.

This result is in accordance with Kyrkouli et al., (12) and Menendez (18) research on rabbits. The VM centre was informally chromatolyed in this level of starvation and this pattern shows that ventromedial centre is less sensitive to food deprivation compared to lateral centre.

Electrophysiologists supported our result. Oomura et. al., (20) and Weiss et. al., (23) worked out that the neurons of ventromedial centre were less-sensitive than the neurons of HL centre when animals were exposed to starvation and sleeplessness. No morphological changes were observed in PV and SO centers during this period. This state indicated that PV and SO were not sensitive to the early period of starvation.

The activity of animals accelerated and the amount of the deformed neurons located in outer lateral and fornix of lateral hypothalamus increased after three-day food deprivation.

These morpho-structural deformations which are the swelling of cells, hydropic changes, central chromatolysis and the exocentric location of nucleus and nucleolus, indicate the high functional activity of neurons due to the adaptation-compensation reactions occur in the body of organism during food deprivation.

It is reported that the shape of Nissl substance is changeable during afferent signals (8). However, recent studies indicated that there was an interaction between the shape of the vesicle of Nissl substance and afferent impulses, incoming from specific ways. This state is supposed in parallel to the state of excitation of neurons (24,3).

The data obtained from this research explained that the large neurons of hypothalamus were mainly responsible for goal-directed behaviors of food seeking. Such findings coincide with the data of Beck (6) and Leibowitz (13) who reported that hypothalamus created the system of food dominance and motivation like 'pacemaker' during food deprivation.

The lysis of Nissl substance located in neurons of ventromedial centre after three-day's food deprivation indicates that these neurons work synchronistical. In terms of anatomical and physiological basis, the neurons in ventromedial centre were small, reticular, glicosensor and have many adjuncts (16,22), which provide synchronistical activation of neurons. Also the neurons located in ventromedial centers are sensitive against the change of blood pressure. Some morphological changes were observed in the frontal centers of hypothalamus during this period of food deprivation. The nuclei of neurons located in paraventricular center swelled and became translucent. This state indicated that these neurons were more activated.

This part of hypothalamus plays an important role and in the main time adrenoreactiv neurons became activated during food motivation (16). Hydropic changes were observed in some neurons of supraoptic centre owing to instability of ion-water exchange during this stage of hunger (14,17).

Morph-structural changes occurred in all centers studied in this research, especially in outer lateral area of lateral centre after 5 days food deprivation. Prominent changes in interneurons and interglial relations were detected in this area. This study revealed that the first morphological changes occurred in neurons of lateral centre during food deprivation. Morphological changes were observed in VM, PV and MM centers of hypothalamus when the period of food deprivation was extended.

Abuþev and Verbacskaya (2) obtained similar results with electron microscopy studies.

In conclusion, most of the morphological changes were observed in neurons of lateral centre during the first stage of food deprivation.
Morph-structural changes also increased in VM and PV centers when starvation period was extended. The major changes were observed in starvation center located in outer area of lateral centre of hypothalamus.

**ÖZET**

Bu çalışmada, açıklık zamanı hipotalamusun değişik merkezlerinde meydana gelen morfolojik değişiklikler araştırılmıştır. Lateral hipotalamusun farklı bölgelerinde, açığın değişik sahlarında meydana gelen morfolojik değişiklikler görüldü. Bu araştırma lateral hipotalamusun açığın bütün sahlarının idare edilmeye mekanizmasını kontrol ettiği göstermektedir.

**ANAHTAR SÖZÇÜKLER:** Hipotalamus, Açıklık, Nissl maddesi, Morfolojik değişiklikler

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