The Ultrastructural Characteristics and Their Functional Significance of the Arcuate Nucleus and Median Eminence

ZHOU Chang-geng (朱长庚), DENG De-zhong (邓德忠),
LU Jin-huo (卢金浩), LIU Qing-ying (刘庆莹)
Department of Anatomy, Wuhan Medical College, Wuhan
SHI Hong-bo (石洪波)
Electron-microscope Laboratory, Wuhan Medical College, Wuhan

Summary: The ultrastructural characteristics of the arcuate nucleus and median eminence in rats have been studied by means of formaldehyde-osmium tetroxide fixation method. The observations showed that there are two kinds of neurons (dark and light) in the arcuate nucleus which might be responsible for producing both dopamine and releasing hormones. The tanycytes of the ependyma of the third cerebral ventricle pass longitudinally through the various zones of the median eminence and reach at pericapillary space of the portal vessels. The neurosecretory substance-containing nerve terminals may travel between ependymal cells and even enter the cavity of the third ventricle or end around the basal membrane of the capillaries of the median eminence. The axo-somatic and axo-dendritic synapses are formed at the perikaryon and dendrites of neurons in the arcuate nucleus. Both agranular type and granular type of axo-axonic synapses are encountered in the fibrous zone of the median eminence. There are also synaptic connections between the basic processes of tanycytes and the large granular vesicle-containing nerve terminals in the palisade zone of the median eminence. The ultrastructural characteristics mentioned above suggest that (1) the releasing (or inhibiting) hormones of the hypothalamus might be released through two routes: into the portal capillaries from nerve terminals directly or into the cerebrospinal fluid of the third ventricle first and uptaken by tanycytes, then transported to the portal capillaries by the basic processes of tanycyte; (2) each step of synthesis, storage, transport and release of the releasing (or inhibiting) hormones could be regulated by nervous mechanism.

Key words: arcuate nucleus, median eminence, tanycyte, releasing hormones, axo-axonic synapse, neurosecretory

For many years, the morphological characteristics of the hypothalamus have been investigated extensively and detected gradually. But some problems yet remain to be solved. For this reason, the present paper attempted to carry out researches into the ultrastructural characteristics and the functional significance of the hypothalamus by means of further studying its central area — arcuate nucleus and median eminence.
MATERIALS AND METHODS

Six adult healthy male albino rats (weighing 200—250 g) were anaesthetized with 20 % ethylcarbamate solution (I.P. 0.5 ml/100 g). Perfusion was performed with 0.05 M phosphate buffered 4 % paraformaldehyde (pH 7.4) through the ascending aorta and the fourth cerebral ventricle. The animal was decapitated and the hypothalamus was removed and immersed in 5 % glutaraldehyde in 0.1 M phosphate buffer (pH 7.4) for 3 hours. According to König and Klippel’s stereotaxic atlas, two parallel frontal sections (with 1 mm interval) were made just behind the optic chiasma. Then, the tissue around the upper two-thirds of the third ventricle was abandoned. In the remaining slice, the 0.5 mm lateral to the ventricular surface including arcuate nucleus and median eminence was taken up and immersed in 6.8 % sucrose-containing 0.2 M phosphate buffer overnight. Phosphate buffered 1 % osmium tetroxide solution was used for postfixation (2 h). The slides were dehydrated in ascending concentrations of acetone and embedded in Epon 812. Ultrathin sections were made by LKB ultratome and stained with uranyl acetate and lead citrate. Observations and photographs were made by Hitachi 11A electron microscope.

RESULTS

1. Ependyma and neurons

The ependyma of the arcuate nucleus and median eminence consists of ependymal cells and tanycytes. Tanyceyte displays slender body with microvilli (but no cilia) on its surface and dark cytoplasm which contains vacuolated structure and abundant mitochondria (fig. 1, 2). The basic process of tanyocyte contains a large number of microtubules, microfilaments and a small amount of large granular vesicles (LGV) 110 nm in diameter and extends as far as to the pericapillary space (fig.12). In addition, there are LGV-containing nerve terminals between ependymal cells (fig.4) and myelinated fibers (2 µm in diameter) in the cavity of the third ventricle (fig.7).

The neurons in the arcuate nucleus are 8—12 µm in diameter, belonging to the small type cells, and can be distinguished into two kinds: light and dark neurons according to the ultrastructural characteristics (fig.3, 5). The dark neuron has an irregular nucleus with folded nuclear membrane, rather dark matrix, dilated endoplasmic reticulum, well developed Golgi’s apparatus and abundant polyribosomes. Some LGVs (140—160 nm in diameter) are seen around the Golgi’s apparatus. The light one has a spherical shape and light matrix containing flattened endoplasmic reticulum, a few polyribosomes and poorly developed Golgi’s apparatus. LGVs can hardly be encountered.

2. The relationship between capillaries and nerve endings

There are a number of capillaries belonging to the portal vessels in the palisade zone of the median eminence. The pores (40—50 nm in diameter) of fenestrae on the endothelium are closed with or without diaphragms (fig.6). The endothelium is surrounded by basal membrane, which is enclosed by collagen fibers-containing pericapillary space. The nerve endings are in close contact with the pericapillary space.

3. Synaptic connections

(1) Axo-somatic synapses exist at the perikarya of light and dark neurons in the arcuate nucleus (fig.8). The axonal boutons contain small clear vesicles (40 nm in diameter) and LGVs (80—140 nm in diameter). The postsynaptic membrane is thickened asymmetrically.

(2) Axo-dendritic synapses exist extensively in the arcuate nucleus (fig.9). They have pronounced presynaptic projections and postsynaptic membrane thickens markedly. The presynaptic bouton contains small clear vesicles mixed with a few LGVs.

(3) Axo-axonic synapses in the neuropil of the fibrous zone of the median eminence include the following two types.