THE FINE STRUCTURE OF THE PARS INTERMEDIA OF THE PITUITARY BODY IN THE MONKEY, *MACACUS EUSCATUS*

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The pars intermedia of the pituitary body in the adult male monkey (*Macacus fuscatus*) was investigated by means of electron microscope. The pars intermedia contains glandular cells, agranular cells, and a great number of unmyelinated nerve fibers.

The glandular cells are further composed of three types of cells:

Type I contains numerous large secretory granules (about 2500 - 4000 Å in diameter) with variable electron density, and are most dominant in number.

Type II possesses smaller dense secretory granules (about 2000 - 2200 Å) and the well-developed rough-surfaced endoplasmic reticulum. Type III contains the smallest dense secretory granules (about 1300 - 1500 Å). Both types, II and III, are quite small in number.

Agranular cells have no granules suggestive of secretion, and may serve as the supporting cell.

In the monkey pars intermedia, three types of nerve endings can be distinguished: (I) nerve endings only containing synaptic vesicles of about 500 Å, (II) nerve endings with synaptic vesicles and large dense-cored vesicles (large granular vesicles), about 900 Å, and (III) nerve endings containing synaptic vesicles and elementary granules of neurosecretory substance, about 1500 Å.

The results may indicate that the pars intermedia of the adult male monkey is still active in secretory function.

The fine structure of the pars intermedia of the pituitary body has been investigated in many vertebrates, such as the human fetus (Murakami et al., 1968); cat (Bargmann et al., 1961); rabbit (Young et al., 1965); guinea pig (Wittkowski, 1967); rat (Kurosuni et al., 1961); Ziegler, 1963; Kobayashi, 1964; 1965; 1968); amphibians (Iturriza, 1964; Saland, 1968), and teleosts (Oztan, 1966; Vollroth, 1967); Jasinski et al., 1970).

The pars intermedia of some lower vertebrates is accepted as the site of melanocyte-stimulating hormone (MSH). Recently, the functional correlation not only between the pars intermedia and the neurohypophysis but also between the pars intermedia and the adrenal cortex has been discussed in the rat. In mammals including man, however, the
function of this part still remains obscure. To our knowledge, no report has been published dealing with the fine structure of the pars intermedia of the monkey. This paper is concerned with the ultrastructure of this part of the monkey pituitary body.

MATERIALS AND METHODS

The materials were taken from 10 adult male monkeys (Macaca fuscata) weighing about 10-12 kg. Under anesthesia with isozole, the animals was perfused, via the A. carotis communis, with a mixture of 2% formaldehyde and 2.5% glutaraldehyde plus 0.025% CaCl₂ buffered with cacodylate (pH 7.4), according to Karnovsky (1967). The brain was excised as soon as possible after opening the skull. A small piece of the hypophysis including the pars intermedia was directly immersed in the same Karnovsky’s fixative for 2 hours at about 4°C, then rinsed overnight in cold 0.1 M cacodylate buffer, and postfixed in 2% osmium tetroxide solution recommended by Millonig (1968) for 2 hours. After dehydration with acetone of increasing concentrations, the tissue blocks were embedded in Epon 812. Ultrathin sections were made with a Porter-Blum ultratome MT-I, stained with uranyl-acetate and lead citrate, and examined with a JEM-10s electron microscope. For light microscopy, Epon sections about 1 μ in thickness were also cut with the ultramicrotome, and stained with buffered toluidine blue.

OBSERVATION AND DISCUSSION

The pars intermedia of the pituitary body of the adult male monkey is a band-like zone. It is separated from the surrounding tissues such as the pars distalis and the pars nervosa by the connective tissue layer consisting of fibrocytes, collagen fibrils and blood vessels, by which the pars intermedia is incompletely divided into several lobules (Fig. 1). The pars intermedia in the adult monkey is extremely well-developed, while that in the adult human is not so well-developed, only showing an islet zone (Romeis, 1940). Rathke’s hypophysial lumen found in the majority of the mammals was mostly obliterated in the present materials. The pars intermedia of the monkey contained glandular cells, agranular cells and a great number of unmyelinated nerve fibers (Fig. 2).

Glandular cells

Two or three types of glandular cells have been described in the pars intermedia of some mammals, and it has been demonstrated that there is a considerable difference in ultrastructure depending upon the difference of the species of the animals. Bargmann et al. (1967) observed two types of glandular cells in the pars intermedia of the cat; one contained large granules (about 8000 Å) and the other small ones. In the rat the former was common and contained granules about 2000-3000 Å, while the latter was scarce in number and possessed small granules about 800-1000 Å (Kobayashi, 1968). Murakami et al. (1968) reported that the glandular cells of the human fetus could be classified into three types; Type I contained granules about 2000 Å in diameter and Type II cells larger ones about 3500 Å. These two types of cells were present commonly. Type III had small granules about 1200 Å and existed few in number.

The glandular cells in the pars intermedia of monkey are characterized by the presence of secretory granules of various sizes in the cytoplasm. From the size and electron density of the granules, they are roughly classified...
into three types. Type I cells are polygonal, and their nuclei are oval in shape. Chromatin substance is evenly dispersed throughout the nucleus but it appears somewhat condensed in the peripheral zone of the nucleus. The characteristic of the cells belonging to this type is the occurrence of numerous large secretory granules about 2500-4000 Å in diameter, of which electron density however varies considerably. They fill the entire space of the cytoplasm. Contrary to this, a few electron lucent vacuoles can also be seen in the periphery of the cytoplasm. They may be interpreted as a remnant of the secretory granules from which the content is discharged by means of the extrusion of type V proposed by Kurosumi (1961). The elements of rough-surfaced endoplasmic reticulum showing tubular profile are randomly scattered throughout the cytoplasm. The mitochondria are generally oval in shape, small in size and exist in a moderate amount. Most of them have longitudinally oriented cristae (Fig. 1). The Golgi apparatus in the cells of Type I are well-developed in the juxtanuclear position. Small dense materials suggestive of the precursor of secretory granules are often seen in the Golgi cisternae. Another small dense granules of about 2000 - 3000 Å enclosed by the limiting membrane are also frequent in the Golgi areas. They are thought to be an immature form of the secretory granules (Fig. 3). The cells of Type I are most dominant in the monkey pars intermedia. They may play the most important role in performing the function of the pars intermedia in monkeys. Considering from their appearance, the cells of this type may correspond to the epithelial cells containing large granules in the cat (Bargmann et al., 1967) and light cells in the rat (Kobayashi, 1968), although there is a little differences in size among the secretory granules of these three animals.

The cells of Type II are characterized by the presence of both electron dense secretory granules of about 2000-2200 Å and well-developed rough-surfaced endoplasmic reticulum which fill the entire cytoplasmic space. The secretory granules of these cells are smaller in size than those of the cells of Type I, of which granules are round or oval in shape and homogenous in electron density. The shape of the nucleus is usually oval. A well-developed Golgi apparatus containing a few immature secretory granules can be seen near the nucleus (Fig. 4).

The characteristic of Type III cells is the presence of small dense secretory granules, about 1300 - 1500 Å, especially in the peripheral regions of the cytoplasm. The organelles such as rough-surfaced endoplasmic reticulum and the Golgi apparatus are moderately developed (Fig. 5). It is interesting that the cells of both Types, II and III, appear morphologically to be similar to the parenchymal cells of the pars distalis. Though the number of the cells of both types are less in the present materials, they may also play some role in achieving the function of the pars intermedia.

Besides these three types of glandular cells, the dark glandular cells with irregular outline are observable infrequently in the pars intermedia. These cells are small in size in comparison to the other type of glandular cells, possessing electron dense secretory granules of about 2500 - 3000 Å (Fig. 6). Kobayashi (1969) has recently observed similar dark cells in the pars intermedia of the rat treated with corticosterone. Judging from the size of the secretory granules, this kind of the cells seem to be a degenerated form of the glandular cells of Type I.

The morphological evidence mentioned
above may indicate that hormonal secretion of the pars intermedia is still vigorously activating in the adult male monkey. Saland (1964) has demonstrated large intracisternal droplets in the glandular cells of the frog pars intermedia and postulated that they may be a form of polypeptide precursor of MSH. Such droplets were never found in the monkey. In mammals including man, although the function of the pars intermedia is still unclear, it has recently been studied intensively by many investigators. Kurosumi et al. (1961) have suggested that there may be a functional correlation between the pars intermedia and the neurohypophysis in the rat. Furthermore, Kobayashi (1965), and Kobayashi, 1965, 1968; amphibians by Iturriza, 1964, and Saland, 1968; cats by Bargmann et al., 1967; guinea pig by Wittkowski, 1967; teleosts by Vollrath, 1967). In the pars intermedia of the monkey's hypophysis, three types of nerve endings can be distinguished.

Type I is endings only containing synaptic vesicles, approximately 500 Å in diameter, and a few mitochondria (Fig. 8). These nerve endings possibly belong to cholinergic in nature.

Type II is endings containing synaptic vesicles (about 500 Å), large dense-cored vesicles approximately 900 Å, and a few mitochondria (Fig. 7). These vesicles (about 900 Å) in Type II ending are larger than dense cored vesicles which are thought to be a typical adrenergic terminal (Richardson, 1964). Farrell (1968) found that the large dense-cored vesicles in an axon from rat vas deferens do not lose their core even upon treatment with reserpine and suggested that the inclusion is possibly an unidentified neurotransmitter or its precursor. It is unclear in this study what is the significance of the presence of the dense core in the large vesicles in glutaraldehyde and osmium fixed preparations. Both types of endings, I and II, are rather dominant in number, and appear to spread over the pars intermedia. They contact directly with the glandular cells of the pars intermedia. The contact seems to represent a synapse.

Type III endings contain synaptic
vesicles and large electron dense granules of about 1400-1500 Å (Fig. 8). These endings may be, from the appearance, interpreted as neurosecretory fibers which have wandered out of the neural lobe. They are few in number and present only very close to the border the neural lobe in the monkey pars intermedia.

The functional significance of the nerve endings found in the monkey pars intermedia is as yet obscure, although it is suggested that cellular activity in the pars intermedia is directly controlled through the neurons function.

REFERENCES

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EXPLANATION OF THE FIGURES

Fig. 1. Light micrograph of a frontal section of the monkey hypophysis. The pars intermedia shows a band-like zone and is incompletely divided into several lobules.


Fig. 2. Electron micrograph of the pars intermedia of the monkey. The pars intermedia contains glandular cells, agranular cells, and unmyelinated nerve fibers (arrow). The glandular cells which possess numerous large secretory granules with variable electron density belong to Type I cell (I). Agranular cell (A) containing no secretory granule is found among the glandular cells. Uranyl-acetate and lead citrate staining, ×5,000

Fig. 3. Golgi region in the Type I of the glandular cells. Small dense granules enclosed by the limiting membrane are observed. Note small dense materials (arrow) suggestive of the precursor of secretory granules. ×28,000

Fig. 4. Two types of the glandular cells in the pars intermedia. The cell with larger secretory granules represents a cell of Type I. Type II cells (II) possess numerous electron dense secretory granules and moderately-developed rough-surfaced endoplasmic reticulum. ×8,000

Fig. 5. Type III of the glandular cells (III). Small dense secretory granules are observed especially in the peripheral region of the cytoplasm. ×8,000

Fig. 6. A dark glandular cell containing a large number of dense secretory granules. This cell is characterized by an irregular outline and dark cytoplasm. ×8,000

Fig. 7–8. Electron micrograph of various types of nerve endings found in the pars intermedia of the monkey. They contact directly with the glandular cells.

Fig. 7. The first and second types of nerve endings are illustrated. The first type (I) only contains synaptic vesicles, while the second one (II) contains synaptic vesicles and large dense-cored vesicles. ×28,000

Fig. 8. The third type (III) of nerve ending containing synaptic vesicles and large dense granules of neurosecretory material is shown. ×28,000