HISTOGENESIS OF MESENCEPHALIC TEGMENTUM IN GOAT FŒTUSES

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ABSTRACT

Prenatal histogenesis of the mesencephalic tegmentum was studied using 46 goat foetuses ranging from 2.5 cm CRL (40 days of gestation) to 41.5 cm CRL (full term). Standard procedures were adopted for histoarchitectural studies. Neuroepithelial cells occupying the mesencephalic tegmentum of foetal goat brain differentiated during the seventh week of gestation. In the basal plate region, neuroblasts aggregated to form nuclei during the same age. Tegmentum contained network of fibres and cells representing the reticular formation. The development of mesencephalon was dependent on the differentiation of other parts of brain. During third month, mesencephalic nucleus of trigeminal nerve, nuclei of oculomotor and trochlear nerves, tegmental nuclei, red nuclei and the substantia nigra were developed. Nissl granules started appearing in neurons of the midbrain tegmentum by the middle of fourth month. Ependyma lining the aqueduct was adult-like during fifth month. Myelination also began at this stage. All the nuclei constituting midbrain architecture were well developed by term. Cells of the red nucleus were one among the largest neurons that could be seen in the entire brain. The rubrospinal tract arising from the red nucleus is a major pathway of the extrapyramidal system and is of particular importance in domestic animals in postural control and locomotion.

Key words: Mesencephalic tegmentum, Foetal goat brain.

INTRODUCTION

Mesencephalon or midbrain represents the smallest segment of the brainstem between the diencephalon rostrally and the metencephalon caudally. Mesencephalon includes the tectum, tegmentum and crura cerebri in a dorsoventral sequence. Red nucleus is the major nuclear mass in the mesencephalic tegmentum. Though extensive research has been done on mammalian brain, information regarding the developmental aspects of the tegmentum in small ruminants is scanty. Therefore, a comprehensive study on the histogenesis of the mesencephalic tegmentum in goats seems to be a relevant area of research.

MATERIALS AND METHODS

Prenatal development of the tegmentum of midbrain was studied using 46 goat foetuses with a crown rump length (CRL) ranging from 2.5 cm (40 days of gestation) to 41.5 cm (full term). Body weight, body parameters and skull parameters of the subjects were recorded. Age of the foetuses was calculated from the formula, \( W^{1/3} = 0.096 \times (t-30) \) derived by Singh et al. (1979) for goat foetuses, where ‘W’ is the body weight of the foetus in g and ‘t’ is the age of the foetus in days. Based on the age, the foetuses were divided into four groups representing 2nd, 3rd, 4th and 5th months of gestation. The head was separated at occipito-atlantal junction and the midbrain was then carefully dissected out and fixed in 10 per cent neutral buffered formalin. Standard procedures were adopted for histological and histochemical studies. The sections were stained using Haematoxylin and Eosin (H&E), Holme’s silver nitrate luxol fast blue method for axis cylinder and myelin sheath, Holzer’s method for glial fibres, Sevier-Munger silver impregnation method for neural tissues, Aldehyde-thionine-PAS method for central nervous system, Phosphotungstic acid haematoxylin (PTAH) method for CNS tissue, Periodic acid Schiff’s reaction for carbohydrates and
Best’s carmine method for glycogen (Luna, 1968). Cellular measurements were taken using an ocular micrometer.

RESULTS AND DISCUSSION

Second month of gestation: A section across the mesencephalon in goat foetus at the beginning of second month of gestation revealed the same three zones of the neural tube wall namely ependymal, mantle and marginal layers. However, the lumen became narrow and thickness of the wall increased during the sixth week. Neuroepithelial cells occupying the mesencephalic tegmentum of foetal goat brain differentiated during the seventh week of gestation. In the basal plate, neuroblasts aggregated to form nuclei during the same age. This is in accordance with the observation made by Arey (1957) in man who found that the motor nuclei of the third and fourth cranial nerves appeared early in the second month. Tegmentum contained network of fibres and cells representing the reticular formation (Fig. 1). Multipolar neurons of the red nucleus started appearing during the seventh week. Cell body of such neurons measured 11.0 μm; the nucleus, 8.0 μm and nucleolus, 3.0 μm. Histomorphogenesis of mesencephalon was studied by Mc Ewen (1957) in pigs, Wenisch et al. (1997) in cattle and Sadler (2004) in man.

Basal plates of both sides were united by a septum-like raphe. This was formed by the processes of the ependymal cells of the floor plate that elongated to keep pace with the thickening of the ventral wall. The ependymal layer was thicker in the ventral commissure of the aqueduct than in the other regions. The development of mesencephalon was dependent on the differentiation of various parts of brain. Most of the tracts developed and passed up or down from different levels of CNS, through the ventral aspect of midbrain. The first nerve tract to become associated with the tegmentum in this way was the medial longitudinal fasciculus, an association tract connecting cranial nerve nuclei.

Third month of gestation

Histological pattern was similar to that in the second month until the middle of third month. By 76 days of gestation, the mesencephalon revealed numerous nuclear masses. Mesencephalic nucleus of trigeminal nerve, nuclei of oculomotor and trochlear nerves, tegmental nuclei, red nuclei and the substantia nigra were the main nuclei (Fig. 2). The undifferentiated neurons of these nuclei showed vesicular nuclei with prominent nucleoli and eosinophilic cytoplasm. These are in agreement with the observations of Jenkins (1978) in dogs.

Tegmentum lay between the substantia nigra and cerebral aqueduct and the red nucleus formed the largest nuclear mass in this area. At 76 days of age, multipolar neurons of the red nucleus possessed relatively less number of processes. By 81 days of

FIG. 1: L.S. of the mesencephalon (48 days). H&E x 100.
1. Aqueduct of Sylvius,
2. Ependymal layer,
3. Tegmentum,
4. Basalplate ependyma.

FIG. 2: C.S. of the mesencephalon showing mesencephalic nucleus of trigeminal nerve (81 days). H&E x 100.
1. Unipolar neurons,
2. Eccentric nucleus.
age, the magnocellular and the parvocellular parts of the red nucleus could be distinguished (Fig. 3). Axons of the cells of magnocellular part formed the rubrospinal tract. Parvocellular part showed smaller neurons (Fig. 4). Numerous fibre bundles including the oculomotor nerve fibres traversed the red nucleus (Fig. 5). In man, Truex and Carpenter (1969) reported that the spreading of the root fibres through and around the red nucleus is an expression of intraradicular expansion of the red nucleus during embryonic development.

In addition to the red nucleus, tegmentum showed a number of smaller aggregations of cells collectively called the tegmental nuclei. A number of fibre tracts also ascended and descended through it, and there were several decussations. The nuclei of the oculomotor and trochlear nerves appeared as masses of nerve cells ventral to the aqueduct close to the mid plane at 81 days of age, which were in agreement with the findings of Dyce et al. (1996) in the adult brain of domestic animals. The cells of oculomotor nuclei were arranged as two lateral large celled nuclei and an unpaired median nucleus composed of smaller cells that connected the lateral nuclei of the two sides.

**Fourth month of gestation:** Histological picture did not change much during the fourth month. Size and number of neurons and glial cells increased during this period. Klekamp et al. (1987) reported that later stages of brain growth were related to neuronal maturation, glial proliferation and myelination. Mesencephalic nucleus of trigeminal nerve showed a flower-like arrangement of neurons. These neurons measured 30.0µm in length and 21.8µm in width at 101 days. The nucleus was eccentric in position.

Neurons of the magnocellular part of the red nucleus were much larger during this stage (Fig. 6). Cells of the red nucleus were one among the largest neurons that could be seen in the entire brain during the fourth month. King (1987) reported that the rubrospinal tract arising from the red nucleus was a major pathway of the extrapyramidal system and of particular importance in domestic animals in postural control and locomotion. Cells of the lateral paired portion of the oculomotor nucleus measured 37.5µm with the nucleus of 20.6µm and the nucleolus of 5.6µm. Cells of the unpaired median part measured 26.3µm, 13.1µm and 3.8µm respectively. In some neurons of the midbrain tegmentum, Nissl granules started appearing in the middle of fourth month.

**Fifth month of gestation:** Neurons of the mesencephalon were differentiated by 144 days of
gestation. The nerve cell distribution was diffused rather than focal. Cytoplasm of these neurons showed basophilia. Myelination also began. All these indicated that development of midbrain was almost completed towards the terminal stage of pregnancy. The principal vessels supplying the midbrain were the caudal cerebral, rostral cerebellar, caudal communicating branch and rostral choroidal arteries as reported in domestic animals by Dellmann and McClure (1975). Ependyma lining the aqueduct was adult-like during fifth month.

Various nuclei of the midbrain tegmentum increased progressively in size. Periaqueductal gray appeared as distinct entity and showed fusiform and stellate neurons. Similar observations were made in young cats by Herrera et al. (1988). The oculomotor, trochlear, tegmental and red nuclei all were well developed by the last week of gestation. The median raphe between the two halves of mesencephalon was also well developed. In the rapheal region of the ventral tegmentum was the interpeduncular nucleus, a collection of medium-sized, multipolar cells (Fig. 7). This nucleus was situated immediately dorsal to the interpeduncular fossa. All the nuclei constituting midbrain architecture, were well developed by 144 days of age. Truex and Carpenter (1969) reported that this nucleus was prominent in most mammals, but comparatively small in man. In the kids that walk within an hour after birth, the all the nuclear masses in the mesencephalic tegmentum were found to be well developed at birth.
REFERENCES


