STUDIES ON THE BRAIN STEM OF THE ALBINO RAT WITH SPECIAL REFERENCE TO THE PONS

A THESIS

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By

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Introduction And Aim Of Work

INTRODUCTION AND AIM OF WORK

The classic structure of the human brain stem is well established in different textbooks of anatomy and neuroanatomy ***(Ranson and Clark, 1959; Romans, 1966; Williams, Warwick, Dyson and Bannister, 1989; and Carpenter, 1991).***

The anatomy of the brain stem of the rat was demonstrated in "Graigie's Neuroanatomy of the Rat" by ***Zeman and Innes (1963).***

The basilar part of the pons of the rat has been the subject of a number of researches. ***Mihailoff, Burne and Woodward (1978)*** described the appearance of adult projection patterns for the sensorimotor and visual corticopontine system, while ***Mihailoff, Mc Ardle and Adams (1981)*** mentioned the different varieties of pontine nuclei.

The postnatal developmental studies of the pontine neurons of the basilar pons of the rat were carried out by ***Adams, Parnevelas, Mihailoff and Woodward (1980); and Mihailoff and Bourell (1986).*** Other developmental studies on the time of origin of neurons in the pontine region were conducted by ***Altman and Bayer (1980).*** Moreover, an autoradio-graphic study of the postnatal development of sensorimotor and visual components of the corticopontine system in the albino rat was done by ***Mihailoff, Adams and Woodward (1984).***

Intracellular localization of cholinesterase enzyme in the rat brain was done by ***Giacobini (1960)***. The occurrence of acetylcholinesterase in the central nervous system neurons was verified by ***Palkovits and Jacobowitz (1974)*** who visualized cholinesterase in some noradrenaline-containing cell groups and little or none in other neurons by the thiocholine technique. Later, ***Bieger and Harley (1982)*** ensured a more widespread distribution of esterasic reactivity in catecholamine neurons. They established the presence of cholinesterase in all pontomedullary catecholamine neurons of the adult albino rat. Moreover, localization of acetylcholinesterase in the cochlear and superior olivary nuclei of the rat pons was performed by ***Osen, Mugnaini, Dahl and Christiansen (1984).***

Reviewing the available literature on the postnatal development of the pons in albino rat, it was found that most of the studies were performed on the basilar part of the pons. Meanwhile, scanty work was conducted on the postnatal development of the tegmental part of the rat pons especially concerning the vestibulocochlear nuclei ***(Karhunen, 1973; and Ivanova, 1984),*** and trigeminal nuclei ***(Altman and Bayer, 1980).*** Nothing was mentioned regarding the abducent nucleus.

The aim of the present work was to investigate the morphological postnatal changes in the whole brain stem as well as the postnatal development of the pons of the albino rat, with special reference to the tegmental part containing the abducent and mesencephalic nuclei. Furthermore, a study of the enzymatic activities was included for detection of the levels of true and pseudocholinesterase enzymes in the pons with special reference to the selected nuclei.

Review Of Literature

REVIEW OF LITERATURE

I- MACROSCOPIC FEATURES OF THE BRAIN STEM

Greene (1963); Zeman and Innes (1963); and Chiasson (1975) mentioned that the brain stem of the albino rat consisted of three parts namely; the midbrain, pons and medulla oblongata. Two crura cerebri were described to extend on each side of the interpeduncular fossa as two thick diverging bands. These together with the dorsal optic lobes constituted the midbrain. Ventrally but more caudal, was described a transverse bridge of tissue which was called the pons. The pons was described to be rostral and parallel to the trapezoid body, which covered the ventral surface of the medulla. The medulla oblongata projected backwards through the foramen magnum to continue as the spinal cord. A ventral median fissure was described in the middle line of both the medulla and the pons lodging the basilar artery. This fissure was called the basilar sulcus. The pyramids of the medulla were seen stretching lengthwise on both sides of the basilar sulcus. On either side of the sulcus basilaris was a slight longitudinal swelling which marked the position of the pyramidal tracts covered by the superficial transverse fibers of the pons. The trigeminal nerve was seen emerging from the lateral region of the pons by two roots, a small motor root lying medial to a large sensory root. At the periphery, the nerve broke up into ophthalmic, maxillary and mandibular divisions. The abducent nerve emerged lateral to the ventral median fissure near the middle line in the caudal part of the pons at the junction with the medulla oblongata. The facial nerve emerged from the lateral part of the pons and was separated from the flocculus cerebelli by the eighth nerve. The vestibulocochlear nerve which was made up of two divisions, the cochlear and the vestibular, emerged at the lateral border of the pons near the flocculus and paraflocculus.

The pons was demarcated from the medulla and the cerebral peduncles by two transverse grooves, and laterally by the roots of the trigeminal nerves. The dorsal surface was covered by the cerebellum and formed the anterior part of the floor of the fourth ventricle and the rhomboid fossa.

The pons was divided into two parts, a ventral or basilar part called the basis pontis and, a dorsal or tegmental part called the tegmentum pontis. The ventral part was made up of bundles of the pontocerebellar fibers which traversed the ventral surface from side to side and crossed the middle line to form the middle cerebellar peduncle (brachium pontis). The dorsal part of the pons was considered to be an extension of the dorsal part of the medulla oblongata.

II- HISTOLOGICAL STRUCTURE OF THE PONS

(A) BASIS PONTIS :

Zeman and Innes (1963) mentioned that the basilar part was made up of bundles of the pontocerebellar fibers which were connected with different parts of the cerebral neocortex through corticopontine fibers to form the corticopontocerebellar system. These corticopontine fibers synapsed with pontine nuclei, which were small masses of grey matter scattered in the ventral part of the pons (nuclei pontis). In between these pontocerebellar fibers were massive collections of descending fibers. These descending fibers constituted the pyramidal or the corticospinal tract which was central in position. The corticopontine fibers formed other bundles having the same direction like corticospinal tract but split successively to terminate in the pons. They synapsed with the nerve cells of the pontine nuclei.

1. Pontine Nuclei :

Adams, Parnevelas, Mihailoff and Woodward (1980) studied the morphology of the basilar pontine neurons of an adult rat and their postnatal development using different Golgi techniques. The perikarya were of different shapes either multipolar or oligopolar (primarily fusiform and bipolar). They gave rise to 2-7 dendrites and ranged in size from 8-45 μm. There were four groups of dendritic patterns, the most common of which was multipolar arrangement of relatively long dendrites which were studded with protrusions. The second pattern showed a large cell with thick gradually tapering dendrites, devoid of surface spines or protrusions. The third pattern showed an intermediate cell with thin long uniform dendrites. The least common pattern showed a small ovoid or spindle-shaped cell with a bipolar configuration of dendrites that branched infrequently. The axons of these neurons arose from the cell body or the proximal dendrite and gave collaterals within the pontine grey. At birth, the cells were small and irregular in shape. The dendrites and axons were thin, short and showed bulbous growth cones on their terminal segments and along their lengths. By the end of the first postnatal week, the cells had increased in size, their dendrites had become uniform in diameter. The surface appendages on the somata and dendrites appeared on the 10^{th} - 12^{th} day after birth being greater in density and wider in distribution than in the adult. By the end of the second postnatal week, there were major dendritic growth spurts. The dendrites increased in length, diameter and branching patterns. There was gradual disappearance of proximal dendritic appendages but with persistence of the distal ones. By the 24^{th} day, the basilar pontine neurons attained the adult morphology.

Mihailoff, Mc Ardle and Adams (1981) stated that there were four major subdivisions of the pontine nuclei of rat seen in Nissl stained frozen sections which were medial, ventral, lateral and peduncular nuclei according to their positions relative to the longitudinally descending bundles of corticofugal axons (pyramidal tracts). These divisions didn't indicate any cytological similarities or differences between each cell group but were useful only for descriptive purposes. The authors as well described the previously mentioned varieties of pontine neurons and their dendritic patterns.

Mihailoff and Bourell (1986) observed that the basilar pontine nuclei of the rat exhibited three maturational phases postnatally which overlapped to some degree. The early postnatal period (from birth to the fifth postnatal day) was the period of relative immaturity. The cell density was higher than in the adult. The somata of the pontine neurons were quite small. The neuropil was immature and showed wide expanses of extracellular space and few synaptic boutons by electron microscopy. During the second phase which extended till the 13^{th} day postnatally, there was marked synaptic proliferation. Various types of synaptic boutons similar to that of the adult were observed. During these two postnatal periods, there was a process of spontaneous axon terminal elimination going on. The third maturational phase began on postnatal day 14 and extended through day 21. In this phase, the adult-like picture of the basilar pontine nuclei was reached. Also no new types of synaptic boutons appeared but there was an increase in their number in a uniform manner in all types.

Brodal and Bjaalie (1992) studied the organization of the pontine nuclei. Such an organization ensured that information from various functionally diverse parts of the cerebral cortex and subcortical nuclei were brought together and integrated in the cerebellar cortex. The pontine nuclei provided the cerebellar hemispheres with the majority of their mossy fiber afferents. Neurons projecting to a single cerebellar folium appeared to be confined to a lamella-shaped volume in the pontine nuclei. They received their main input from the cerebral cortex.

2. **Corticopontocerebellar System :**

Wiesendanger and Wiesendanger (1982) investigated the projections from various cortical areas to the pontine nuclei of rats. They stated that the sensorimotor and visual cortices provided the bulk of the corticofugal fibers. Contributions from association areas were noted as well. The authors observed that there was a medial to lateral succession of the pontine nuclei projection fields from the motor, somatosensory, and visual cortices (i.e. frontal areas of the cerebral cortex projected to the medial portions of the pontine nuclei while the posterior cortical areas projected to the lateral portions). They concluded that each cortical area had its private projection territory in the pontine nuclei, besides an extra-projection territories which received convergent inputs from two or more cortical areas.

Mihailoff and Adams (1983) stated that sensorimotor and visual cortical axons entered the pontine grey neuropil during the first postnatal week. The projection field patterns characteristic of the adult system were attained by day 18. By the end of the first week, few morphologically mature synapses were observed. During the day 10-16, considerable quantitative and qualitative changes occurred which included an increase in the number of synapses, emergence of most classes of axonal boutons observed in the adult and presence of degenerated axons and boutons. This observation was due to a process of axon collateral elimination. During the second postnatal week, there were proliferation of synapses, alteration of functional properties and constriction of projection fields. By the third postnatal week. the corticopontine system almost exhibited an adult-like configuration.