Međunarodni simpozijum o eksperimentalnom tremoru: 1-3. april 1971. godine

Stern, Pavao

1972
Akademija nauka i umjetnosti Bosne i Hercegovine
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AKADEMIJA NAUKA I UMJETNOSTI BOSNE I HERCEGOVINE

POSEBNA IZDANJA
KNJIGA XVII

ODJELJENJE MEDICINSKIH NAUKA
KNJIGA 4.

MEĐUNARODNI SIMPOZIJUM

O EKSPERIMENTALNOM TREMORU

1 — 3. APRIL 1971. GODINE

Urednik
PAVEL ŠTERN,
redovni član Akademije nauka i umjetnosti
Bosne i Hercegovine

SARAJEVO
1972

NEDŽAD GLUHBEGOVIĆ

COMPARATIVE ANATOMICAL STUDY OF THE CORPUS STRIATUM

(Professional work)

As Johnston, Herrick and Obenchaim have demonstrated, striatal region of cyclostomes is partly invaginated in the hemisphere. Johnston describes the fibres, which originate from the striatal area to dorsal thalamus and probably to mesencephalon. He dit not find the hypothalamical connections.

According to Holmgren and Jansen, basal area in the brain of myxinoids lies in the ventral part of forebrain. They consider part of this area homologous with the corpus striatum of higher forms. It is however yet to be discussed, but there is no doubt that in the telencephalon of myxinoids dominate primary, secondary and, to some extent, terciary olfactory connections.

In plagiostomes part of striothalamic tract and striohypothalamic tract, which originate from striatum, can be compared with somatic projecting tract of Johnston. It terminates in the ventral thalamus and Johnston suggested that these fibres can represent the begining of the pyramidal tract. According to Huber and Crosby it is most probably that those fibres are forerunner of the ansa lenticularis of higher forms. Johnston has described the fibres, which connect the striatal area of one side with that of the oposite side and he considered them to be homologous to the corpus callosum.

In ganoids and teleosts Sheldon described an area within telencephalon, which is partly under the influence of the olfactory system and is partly supplied with somatic fibres, to which he gave the term paleostriatum. The term paleostriatum is used to describe the specific areas of the reptilian and avian brain. There exists a reason for believing that part of these areas in reptiles (paleostriatum augmentatum) can be compared with paleostriatal area in teleosts, but in the absence of a direct proof for it, we use the term olfactosomatic area, which is given by Herrick. This area is connected with the hypothalamic and certain thalamic areas of diencephalon.

Ventrolateral quadrant of the amphibian hemisphere contains primordium striati and amygdaloid complex (archistriatum or sometimes epistriatum of higher forms). Herrick has divided the striatal part of this area in dorsal, ventral part and caudate nucleus, with its medial extension n. accumbens. It seems that n. caudatus of these forms is probably homologous, at least partly, with the head of the caudate nucleus of higher forms, but it is not possible to find out the real homology between dorsal and ventral striatal areas in one hand and various nuclei (globus pallidus, putamen and the tail of caudate nucleus) on the other hand in higher forms. Descending pathways of striatal area are mainly homologous with those of lower forms, but here they are better separated and terminate in thalamic and hypothalamic regions. Of special importance are the striopallial connections, which are described by Herrick and which connect dorsal part of the striatum with primordium pallii, representing the important tract for impulses, regarding to the development of pallium.

Telencephalon of reptiles differs from that of lower vertebrates by greater structural differentiation and increase of its size in the relation to the size of the other parts of the brain. However there exists a difference in the development of various reptiles. The telencephalon of sphenodon and turtle is more primitive than that of the snake. Telencephalon of lizard is to some extent similar to that of aplacental mammals (monotremata and marsupialia), whereas on the other side it is similar to the telencephalon of crocodiles and birds. The telencephalon of crocodiles can be compared with that of birds. In reptiles the striatal complex is highly developed. Even in lower reptiles, as in turtle, the increasing size of this region is remarkable, if it is compared with that of amphibians. Johnston has subdivided the striatal area of turtle in caudate nucleus, lentiform nucleus and dorsal ventricular ridge. The medial extension of caudate nucleus is usually considered as n. accumbens. On the dorsal and dorsolateral side of caudate nucleus lies lentiform nucleus. Earlier Johnston had considered the dorsal ventricular ridge as somatic as a whole and showed its connections with pallial areas, to which he gave the term general pallium. That indicates the great development of the somatic area in the lateral wall of the hemisphere. Later Johnston had shown that the dorsal ventricular ridge of the turtle appears as a thickening of the lateral border of pallium and that its continous growth causes it to project to the ventricul.

Smith in the study of corpus striatum of sphenodon, has subdivided the lateral hemisphere wall in paleostriatal and hypopallial areas. According to him paleostriatal part is homologous to globus pallidus of the mammals. He considered the hypopallial region as a representativ of the greater part of caudate nucleus and putamen. He gave a special importance to the relations of the lateral striatal artery and he confirms that »if the relations of the lateral striate artery be compared in a series of reptilian and mammalian brains they afford a striking corroboration to the hypothesis that a large part of the mammalian corpus striatum is homologous with the reptilien hypopallium and is therefore cortical in origin«. Cairney has subdivided the striatal areas, except archistriatum, in olfactostriatum, somatic striatum and hypopallium. Olfactostriatum and somatic striatum he consideres together as paleostriatal. Hypopallium anterius, which is continous with the general cortex, Cariney consideres as striatal, and above all neostriatal. Hypopallial ridge as a whole can be compared with the dorsal ventricular ridge in turtle and its caudal part Cairney and Johnston consider as amygdaloidal. As it is seen from this it is difficult, because of the differences in relationships in various reptiles as well as in variations in terminology, to corelate the results of different investigators in order to get the basic plan or pattern of the striatal part of reptilian hemisphere. Striatal region of reptiles is connected by means of corresponding tracts with the thalamic, hypothalamic and mesencephalic regions.

The paper of Edinger, Wallenberg and Holmes of the year 1903 marks the begining of modern investigations of avian telencephalon. And Kalisher and Rose dealt with these investigations. Huber and Crosby have shown the nuclear configuration of the lateral wall of the sparrow's telencephalon, with temporary comparisons with the conditions in other birds. These centers can be subdivided in n. basalis, paleostriatum with its two parts- paleostriatum primitivum and paleostriatum augmentatum, ectostriatum, neostriatum, hypostriatum, n. intercalatus hyperstriati, hyperstriatum accessorium, archistriatum and n. teniae. Johnston had shown that the area, which is equivalent to paleostriatum augmentatum and to its extention n. accumbens, developes in mammals in the head of caudate nucleus and it can form a smaller part of putamen, as Kappers has shown. Paleostriatum primitivum is probably the forerunner of globus pallidus in mammals. Johnston has shown that neostriatum, which is much better developed in birds than in reptiles, represents putamen in mammals. In mammals the development goes in the direction of the forming of superficial layers, which fold and form the gyri and sulci. In reptiles and birds the development goes together with thickening of the wall, prodeced by the thickening of periventricular gray. Hyperstriatal area of birds acts to certain extent in a similar way as the cortical area of some lower mammals. In sparrow, pigeon and duck accessory hyperstriatal area is relatively well developed, as it is seen from its size and from its fibre connections. In the majority of avian brains olfactory system is reduced, although exeptions exist. Somatic center of the hemisphere have grown, which represents further differentiation in relation to reptiles. This differentiation goes together with the increase of the dorsal thalamus differentiation in birds, compared to reptiles.

Basal nuclei of the mammalian hemisphere include amygdaloid complex, n. caudatus and lentiformis, claustrum and certain gray which join these big nuclear groups.

Amygdaloid nuclei (archistriatum) were subjects of investigation of many observers. 1896 von Kölliker discovered four nuclei in the basal part of the hemsiphere of the rabbit, which belong to the amygdaloid group, but he gave the term n. amygdale to only one of them. Wölsch, working on monkeys, has identified seven nuclear groups of archistriatal complex. De Vries found four nuclei within this complex. Johnston and Humphrey subdivided the nuclei of amygdaloid complex in one group, which is more primitive in its development and which originates from olfactory area of lower forms and which is of basal origin, and another group, of cortical origin, which appears later in philogenetical history. The relations of the amygdaloid complex differ according to the changes of general morphology of telencephalon.

N. caudatus and n. lentiformis form clear and vivid mass in the mammalian brain. Lentiform nucleus is usually divided into medial part — globus pallidus and lateral nucleus — putamen. According to Kappers putamen, together with caudate nucleus form the main mass of neostriatum. However part of n. caudatus is considered as paleostriatal by origin. Dividing the caudate- putamen complex in two parts by internal capsule is a secondary consideration and it is not the same in all mammals. Paleostriatum is philogenetically older, as we see from its earlier ontogenetical differentiation. According to Johnston, the caudate nucleus has two origins, consisting philogenetically of a ventral and a dorsal part. The ventral part or olfactostriatum, Cairney considered as a reptilian homologue for a part of the head of the caudate nucleus. Johnston considered the rest of the head and part of the tail as homologous to the dorsal ventricular ridge of the turtle. So, in caudate nucleus we can rekognize, according to its origin, subpallial part, which is olfactiv in relation to its type of fibre connections and the pallial part, which is closely related to the cortex. Putamen, as Johnston has found, is also pallial by origin, but its development is faster than that of caudate nucleus. Generally it is accepted that globus pallidus is philogenetically old and has its representative in paleostriatum primitivum (or somatic area) lower forms.

Fibre connections of the corpus striatum in mammals are divided in thalamic connections, internuclear connections, efferent pathways to lower centers and cortical connections. Many authors have described the connections of the medial thalamic nucleus with corpus striatum. Von Monakow believed that even the connections between the anterior thalamic nuclei with c. striatum exist. Internuclear connections among various parts of corpus striatum are relatively numerous. Lateral and medial medullary lamina, which separates globus pallidus from putamen and medial from lateral parts of globus pallidus, consist of internuclear fibres, supplemented with passing fibres. The main efferent paths of the corpus striatum are elements of the ansa lenticularis. These were studied by many investigators (von Monakow, Wallenberg, Economo, Kleist, C. and O. Vogt, Bickel, Pollak, Riese, Jakob, Morgan, Kodama and others). These fibres terminate in Forel's nucleus, in tegmentum of mesencephalon, in red nucleus, in substantia nigra and in hypothalamic nuclei. Muskens showed the connection between corpus striatum and nucleus interstitialis and Jakob had found striofugal fibres, which terminate in the nucleus of Darkschewitsch. Riese has found that these fibres join the medial longitudinal tract. The caudate - lenticular complex of mammals is homologous to the neostriatal and paleostriatal areas of lower forms, and ansa lenticularis is the representative of efferent components of lateral forebrain bundle of these lower forms. Tilney and Riley describe that in fish within the corpus striatum lies the highest correlating centre for motor impulses and that swimming movements represent the main motor activity of the body. These movements are characterized by rytmical continuity and automatic association. In course of evolution, when terrestrial life became the order of the day, these constant movements became useless and the neostriatal areas developed as inhibitors of activity of primitive paleostriatal areas and so at last caudate - lenticular complex of lower forms developed.

One of the problems which interests the investigators is the relation between the cortex and the caudate - lenticular complex. Ramon y Cajal, Déjérine, Economo and others pointed out the connections of nucleus caudatus with the cortex, through internal capsule. However, there are authors who insist that these connections do not exist or that they are very poorly developped (Wilson, Jakob). The proofs of the present time show the existense of these connections.

Globus pallidus is terminal station of the influences from corpus striatum. Neuron chains of the interal part of globus pallidus, which is under the influence of caudate nucleus and putamen, represent important afferent paths for cortical areas. These cortical areas are the main source of pyramidal tract. In that way this part of extrapyramidal system becomes an afferent path for pyramidal tract. Striatal system depends on cortical areas and used the pyramidal tracts as efferent pathways, so that the pyramidal tract can be considered as part of the mechanism of extrapyramidal activities.

The different morphological development of the extrapyramidal structures in man and animals, the development of the up- right posture, the prevailing of the pyramidal system in man and the different order of the motor mechanismus for keeping certain position, are factors at least partly responsible for the differences which exist between the results of experiments on animals and neurological diseases in man. Characteristic appearances of human extrapyramidal diseases are the different hiperkinetic syndroms, which are unknown in animals or they apper rarely. According to Hess the antagonistic »tonic forces« of the central motor regulating systems are normally in the balance, although they are in the latent movement. Visible movements appear only after the change of that balance. Unbalance, cuased by inhibition or lost of one or more balanced forces of the nervous system, can result unwilling movements. Much more differentiated balance of motor functions in man, including manipulation with hands and regulation of the up- right position, make them liable to diseases, which appear in the form of unwilling movements.

NEDŽAD GLUHBEGOVIĆ

KOMPARATIVNO-ANATOMSKA STUDIJA KORPUS STRIATUMA

KRATAK SADRŽAJ

Komparativno-anatomskom studijom striatalnih predjela različitih vrsta vertrebrata moguće je izvesti vrlo interesantan zaključak u pogledu mjesta, izgleda i karaktera njegovih vlaknastih veza.

Striatalne zone vodozemaca pojavljuju se kao recepsivni centri uzlaznih talamo-kortikalnih putova i kao eferentne ćelije iz kojih proizlaze vlakna lateralnog prednjomoždanog snopa. Amigdaloidni kompleks (ili arhistriatum), manje ili više diferenciran, prisutan je sa svojim karakterističnim vlaknastim vezama.

Striatalne zone reptila pokazuju vidljiv napredak u odnosu na one kod vodozemaca, ali je taj napredak sada ka avian-formama koje nalazimo više ili manje nagoviještene. Izvjesni dijelovi striatalnih zona reptila su homologni s onim u sisara. Može se naglasiti da je cefalična i hipopalialna hrptenjača somatska po tipu veza i vjerovatno je predstavnik amigdoloidnih kompleksa sisara.

U većini sličnih mozgova olfaktorni sistem je relativno reduciran. Somatski centri hemisfere su povećani velikim razvojem striatalnih zona.

Ova diferencijacija ide zajedno sa povećanom diferencijacijom dorsalnog talamusa ptica u poređenju sa dorsalnim talamusom reptila.

Bazalni nukleusi hemisfere sisara su nucleus caudatus, nucleus (globus pallidus+putamen) claustrum i nukleus amygdale. Nucleus caudatus i putamen primaju impulse iz talamusa i korteksa, a oni daju eferentna vlakna za globus pallidus i iz tog predjela ansalentikularna vlakna stižu u suptalamičke i srednjomoždane centre, služeći kao centri za združene pokrete. Funkcije kalustruma su neizvjesne. Amigdaloidni kompleks je centar bolje razvijen u nižih sisara nego u čovjeka.

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DISCUSSION

Schnieden: 1) Have you any information on the presence of dopaminergic fibres in striatal areas of reptiles you examined? 2) I was interested in the hypothesis, that in fish, striatal areas are responsible for swimming movements could be used as a piscine model for tremor studies in higher animals.

Gluhbegović: 1) It was emphasized the importance of continual impulses for the movements of swimming of fishes which come from paleostriatum. After their coming out to the shore these movements appeared as disadvantageous and the neostriatum was developed as the inhibitor of these continual impulses from paleostriatum. Maybe, it could be connected with tremor in certain diseases of mans corpus striatum, as well in cases of experimentally provoked tremor of animals.