SPECIAL ASPECTS OF THE RELATIONSHIP BETWEEN HUMAN CORPUS CALLOSUM AND FORNIX

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Abstract. It is commonly known that the body of the fornix belonging to the limbic brain is fused with the corpus callosum. Therefore, the question arises about the existence of commutation interactions between the limbic brain and the new pallium through the collector system of the corpus callosum, which is probably the mediating link between the subconscious and conscious spheres of a person's mental activity. However, in the literature this question is not discussed in this way.

Aim of research. The aim of this study is to establish whether the fornix has an organic connection with the myeloarchitectonics of the corpus callosum.

Materials and methods. The median whole mounts (about 4 mm thick) of the corpus callosum (including the transparent septum and the structures of the fornix) of 10 men aged 36 to 60 years were used in the course of the study. Some of the mounts underwent a complete plastination in epoxy resin. After this they were used to make polished slices, stained with a 1 % solution of methylene blue in a 1 % borax solution. The remaining mounts of corpus callosum were used to make serial paraffin sections with further hematoxylin and eosin and Van Gieson's stain.

Results. It has been established that the pillars of the fornix enter the body of the corpus callosum on the border between its trunk and splenium. In the area of contact between the fornix body and the corpus callosum there is a loosened scissura, which gradually narrows toward the splenium and then disappears leading to the complete consolidation of the fornix and corpus callosum. This consolidation is expressed in the fact that the interfunculary connective tissue septa of the latter penetrate into the body of the fornix and as a result it is divided into the cabled-like assemblies of myelinated nerve fibers. However, unlike the corpus callosum, this division is not complete: it concerns only the layer of the fornix that is directly attached to the corpus callosum.

Conclusions. On the boundary between the corpus callosum trunk and its splenium, that is, in the area of its isthmus, the commutation interconnection between the conducting system of the limbic brain and the commissural pathways of the neopallium is structurally fixed.

Keywords: the corpus callosum, the fornix, the transparent septum, the limbic brain, commissural cords, interfunicular connective tissue septum, plastination in epoxy resin.

1. Introduction

When studying the corpus callosum, the question arises about its connection with the fornix. In order to understand this issue better, one can not do without basic anatomical information about the latter. Its geometric configuration delineating arcual ringing of the formations between the trunk and the cerebral hemispheres is very indicative, as this feature is characteristic of the structural organization of the limbic system.

It is commonly known that the bottom surface of the corpus callosum in the anterior two-thirds is connected to the transparent septum, and posteriorly from the middle of the stem section it is in adhesion with the body of the fornix [1, 2], which belongs to the limbic brain [3, 4]. It is to be recalled that the fornix begins with two closely linked pillars from the mamillary bodies (near the gray tuber), then they unite in a body that fuses with the lower surface of the corpus callosum, from where they split, heading for the anterior poles of the temporal lobes, where they become a part of the right and the left hippocampus [5, 6]. In projection onto the horizontal plane it is similar to the letter X, whose ends are bent downward. The dual function of the cerebral vault is expressed in this form: on the one hand, it implements the associative link within one half of the limbic structures by means of pillars and legs containing fascicles of myelinated nerve fibers, and on the other hand, by means of a hippocampal spike (or fornicommissure), provides a commissural association between opposing halves of the an ancient pallium [7, 8].

But, apparently, this is not limited to the conductive role of the fornix. Given that its conjugated part, called the body, is fused from below with the corpus callosum, it can be supposed that there is some kind of the commutation interactions between the limbic brain and the new pallium in this place through the collector system of the corpus callosum, which may be the mediating link between the subconscious and conscious spheres of mental activity. However, this issue is not discussed in the literature in this way.

It is clear that at the present we are not able to puzzle out this extremely complex interlacing of the commissural-associative relationships of the corpus callosum. But we can find out whether these formations of the limbic brain are included directly in the myeloarchitectonics of the corpus callosum, and if so, how it is expressed in histological studies.

The aim of this study is to establish whether the fornix has an organic connection with the myeloarchitectonics of the corpus callosum.

2. Materials and methods of research

In the course of the study conducted in May 2017 median whole mounts (about 4 mm thick) of the corpus callosum (including the transparent septum and the structures of the fornix) of 10 men aged 36 to 60 years were used. They were segregated with a brain knife from whole brain mounts after their two-week fixation in a 10 % solution of neutral formalin. The whole mounts were obtained due to the contract between Kharkiv National Medical University and Kharkiv Regional Bureau of Forensic Medical Examination.

Three exemplary mounts were selected from all preparations (on grounds of the degree of integrity of the desired formations). They were subjected to plastination in epoxy resin, for which epoxy adhesive "Chemo-contact-Epoxy" was used. The process of plastination was carried out according to the method developed at the Department of Human Anatomy of the UMDA (Poltava) [9].

At the end of the final impregnation stage in pure epoxy resin, these plate preparations were placed between two glass plates of the appropriate size, insulated with polyethylene spacers (to avoid gluing of the mounts and the glasses). In the form of such a "sandwich", the preparations were compressed with the help of sparing clamps and they acquired a uniformly flattened unwarped form during the process of final polymerization.

After complete polymerization, the plates were used for making polished slices, which were stained with 1 % methylene blue solution in 1 % borax solution.

The remaining mounts of the corpus callosum were used to enclose the necessary sections taken from them into paraffin blocks, from which serial sections with traditional staining of hematoxylin and eosin and Van Gieson's were made.

The study of all mounts (epoxy slices and paraffin sections) and their photodocumentation was carried out with the help of microscope MBS-9 and "Conus" equipped with a digital photo adapter.

3. Results of research

It has been established that the pillars of the fornix enter the body of the corpus callosum on the border between its trunk and splenium (**Fig. 1**). In the area of contact between the fornix body and the corpus callosum there is a loosened scissura, which gradually narrows toward the splenium and then disappears leading to the complete consolidation of the fornix and corpus callosum (**Fig. 2, 3**). This consolidation is expressed in the fact that the interfunculary connective tissue septa of the latter penetrate into the body of the fornix and as a result it is divided into the cabled-like assemblies of myelinated nerve fibers. However, unlike the corpus callosum, this division is not complete: it concerns only the layer of the fornix that is directly attached to the corpus callosum.

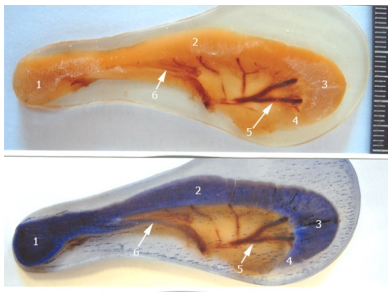

Fig. 1. Sagittal section of the corpus callosum of a man: upper snapshot – after epoxy plastination; lower snapshot – its slice when stained with methylene blue: 1 – the splenium; 2 – the trunk; 3 – the genu; 4 – the rostrum; 5 – venous vessels of the transparent septum; 6 – pillars of the fornix

Fig. 2. The place of the spike of the fornix body and the corpus callosum. Epoxy slice, stained methylene blue. ×7: 1 – substance of the corpus callosum; 2 – matter of the fornix body; 3 – interfunicular connective tissue septum of the corpus callosum

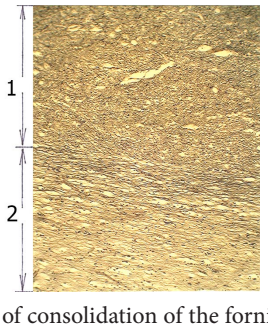

Fig. 3. The place of consolidation of the fornix body with the corpus callosum. Paraffin section, Van Gieson's stain. ×10: 1 – substance of the corpus callosum; 2 – substance of the fornix body

4. Discussion

On the total mounts of the corpus callosum, it is clearly seen that the pillars of the fornix, curving archingly, along the tangential trajectory, enter the body of the corpus callosum at the boundary between its trunk and splenium, that is, near the isthmus (**Fig. 1**). This place is imprinted on a micrograph obtained with a slight increase in the light microscope MBS-9 in reflected light (**Fig. 2**), which corresponds to the fornix body.

It can be seen that in the area of contact between the fornix body and the corpus callosum there is a loosened scissura, which gradually narrows toward the splenium and then disappears leading to the complete consolidation of the fornix and corpus callosum. This consolidation is expressed in the fact that the interfuniculary connective tissue septa of the latter penetrate into the body of the fornix. Here an explanation is needed regarding such a concept as "interfuniculary connectivetissue septa", which was first introduced by authors in the course of study of the internal structure of the corpus callosum [10]. It turned out that it is not a continuous mass of transiently passing nerve fibers transversely passing through it, but it consists of a number of aggregate formations that authors named commissural cords (funicular subunits) of the corpus callosum, which are separated by thin layers of loose fibrous connective tissue containing blood microvessels; it is these layers that received the name mentioned above. Consequently, at the place of consolidation of the fornix body with the corpus callosum, the same portioned division of the former into the cabled-like assemblies of myelinated nerve fibers occurs. However, unlike the corpus callosum, this division is not complete: it concerns only the layer of the fornix that is directly attached to the corpus callosum (**Fig. 2**).

A more subtle distinction between their structures along the line of consolidation was obtained with the help of paraffin sections (**Fig. 3**). In this photomicrograph, a linear boundary between the structures of the corpus callosum and the fornix is clearly visible. It happens due to the different orientation of the nerve fibers in them. If in the corpus callosum they look chaotically located, the myeloarchitectonics of the fornix is more ordered. Due to the fact that this slice is obtained in the longitudinal direction of the sagittal section of the corpus callosum, the orientation of the nerve fibers in the fornix body basically corresponds to the trajectory of its tangential introduction into the corpus callosum. But on the boundary between them, there is no clear separation in the orientation of their nerve fibers, since in this zone they are in a mixed state, perhaps due to the fact that some of the nerve fibers go from the fornix to the commissural cords of the corpus callosum, and possibly as a result of mutual exchange between them.

Unfortunately, at present it is impossible to solve this problem unequivocally using only morphological methods. But, taking into account the proposition that the mental activity of the brain is based on the exchange of information between the conscious and subconscious spheres, the second option seems to be more plausible.

Thus, it can be assumed that the interconnection between the conductor system of the limbic brain and the commissural ways of the neopallium is structurally fixed on the boundary between the trunk of the corpus callosum and its splenium, that is, near its isthmus. Now the matter is left open, as well as many other things, regarding the connective interlinks of the corpus callosum, as the largest spike of the new pallium, with the structures of the limbic brain, since at present everything that can be

said concerning this issue will be regarded as some guesswork. But there are no doubts that the issues touched upon in this research, should be considered as a new scientific direction in studying the structure and function of the corpus callosum. At this stage of the study, we obtained only the initial data that significantly complement modern knowledge concerning the features of morphological connections of the fornix and the corpus callosum.

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