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Structure and topography of the Chinchilla lanigera's claustrum

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Summary

Structure and topography of claustrum have been earlier described in Primates and in other mammals. Similar examinations have not been carried out on brains of Chinchilla lanigera so far.

The aim of this paper was to study structure and topography of claustrum, analyse its shape, compare it with a shape of other animals especially rodents. Neurons forming this structure were analysed, morphometric analyses of a number of nervous cells in pars dorsalis and pars ventralis were made. Histological slides were stained with cresyl violet according to Klüver and Barrera's method.

Chinchilla's claustrum resembles a shape of a sand glass, made up of pars dorsalis and pars ventralis. In pars dorsalis numerous oval and round, large and medium size neurons arranged in clusters were observed. Pars ventralis was characterized by less numerous round, small and medium cells scattered irregularly. The carried out morphometric analyses correlate with quantity analyses. Structure and topography of Chinchilla lanigera's claustrum is similar to this nucleus' form especially in rabbit.

Keywords claustrum, telencephalon, chinchilla

Among all nuclei of telencephalon, the claustrum – a subcortical structure present only in mammals – is worth a special attention. It is localized between the base of nucleus lentiformis and the insular cortex. Capsula externa separates the claustrum from nucleus lentiformis and it is separated by capsula extrema from the insular cortex. In the claustrum one can distinguish *pars dorsalis* and *pars ventralis*, between which there is a narrowing lying on the level of olfactory groove. The claustrum's shape as well as the degree of its separation from surrounding brain structures depend on the animal species. The claustrum of rodents, i.e. mice and rats, has the appearance of a narrow band with endings slightly bent medially. *Capsula externa* and *capsula extrema* are weakly developed or they even do not exist, and the boundary between *pars dorsalis* and *pars ventralis* is unclear (1, 5, 7). In guinea pigs the *capsula externa* and *capsula extrema* are more distinct, thus the claustrum is more isolated (5, 7). A rabbit's claustrum resembles a sand glass in shape – its *pars dorsalis* is elongated, and *pars ventralis* is barrel-shaped, while between them there is a distinct narrowing (2, 5, 7). In primates the claustrum is a large structure with well developed *capsula externa* and *capsula extrema* of a characteristic shape. In cats it resembles a horn in appearance (4, 5, 7, 11), in dogs an irregular trapeze (8). The human claustrum, on the other hand, has a more complex structure: from the medial side it is smooth, from the lateral side it has an undulant surface appropriate for the grooves of the *insula* (7, 9).

The claustrum has numerous, bidirectional junctions with various sensory regions of the brain and its functions are not fully understood (3, 10). It forms feedbacks defined as the claustro-cortical neuronal loop. Thanks to them the claustrum performs an integrating function. The latest research also does not deny a role of the claustrum in epilepsy or in Alzheimer's disease.

Considering the lack of research on the structure and topography of the Chinchilla lanigera's claustrum, its shape has been defined and compared with the shape of other animals, especially in rodents. Moreover, the shapes of neurons forming this structure have been analyzed and an average number of nervous cells per mm^2 of surface has been measured in the *pars dorsalis* and *pars ventralis* of the claustrum.

Material and methods

Claustrum examinations were carried out on the brains of 6 sexually mature males of Chinchilla lanigera, aged 1.5 years. After removing brains from cranial cavity paraffin blocks were prepared with a routine histological technique, cut into 8 μm-thick frontal sections in microtome MIKROM HMB40 and stained with cresyl violet according to Klüver and Barrera's method (6). Next, claustrums were analyzed and photographed using a light microscope Axiolab (Zeiss brand).

For morphometric analyses 6 sections derived from each of the chinchilla brains were used. Neurons of *pars dorsalis* and *pars ventralis* were counted in a light microscope Olympus BX 40 linked with a digital camera Olympus Color View IIIu. In the determined areas (mm^2) of the 2 parts of claustrum an average number of neurons was assessed using Cell D program. Later average numbers of nervous cells were statistically analyzed (T-student). Statistical significance of differences was set at $p \leq 0{,}01$.

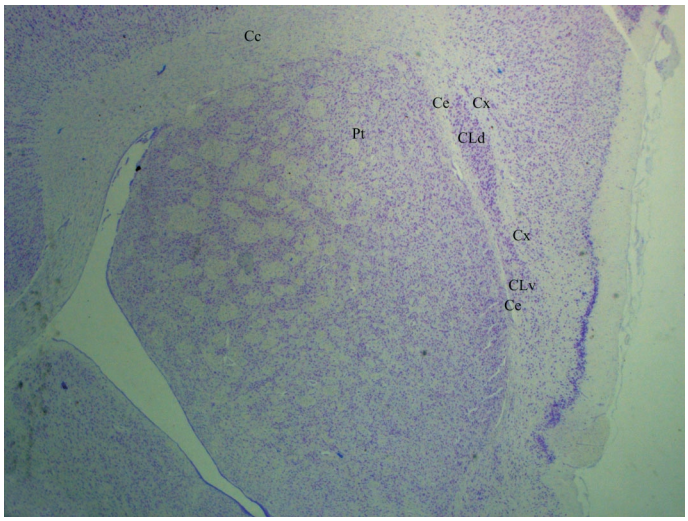

Fig. 1. Structure and topography of Chinchilla lanigera's claustrum (magn. approx. 50 ×). Staining according to Klüver and Barrera's method

Abbreviations' explanations: Cld – claustrum dorsalis; Clv – claustrum ventralis; Ce – capsula externa; Cx – capsula extrema; Pt – putamen; Cc – corpus callosum

Results and discussion

The chinchilla's claustrum has the shape of a sand glass made up of two parts. The *pars dorsalis* of this structure is bigger and elongated, resembling a drop. A smaller *pars ventralis* has a triangle shape and is less clear than *pars dorsalis*. Both parts of the claustrum are joined together by a weakly distinguished narrowing (fig. 1). The entire claustrum is clearly separated from the brain structures surrounding it. From the medial side it adjoins with the nucleus lentiformis by means of a well-developed *capsula externa*. Laterally, a thinner but well developed *capsula extrema* separates the claustrum from the insular cortex. The anterior pole of the claustrum does not reach the anterior pole of the caudate nucleus and putamen, whereas its posterior pole lies on the level of 1/3 of the posterior part of the putamen.

In the claustrum of Chinchilla lanigera round and oval neurons with distinct initial processes prevail. Big spherical or oval cell nuclei located centrally in the cell are surrounded by a small amount of intensively purple stained neuroplasm with numerous granules. Moreover, there are less numerous pyramidal, fusiform and rare stellate neurons. Weakly stained, large, spherical or oval nuclei are located in a center of intensively stained neuroplasm. In the *pars dorsalis* of the claustrum oval or round, large or medium size neurons forming irregularly scattered clusters prevail (fig. 2). In the *pars ventralis* of the examined structure the authors observed less numerous nervous cells, and round, small and medium neurons dominate (fig. 3).

Morphometric analyses of the claustrum have revealed that in the *pars dorsalis* of the examined structure there is a statistically greater number of neurons in comparison with *pars ventralis* (fig. 4) and the analyses prove that round and oval neurons predominate in the *pars dorsalis* of the claustrum (fig. 5). In the *pars ventralis*, on the other hand, oval neurons predominate (fig. 6).

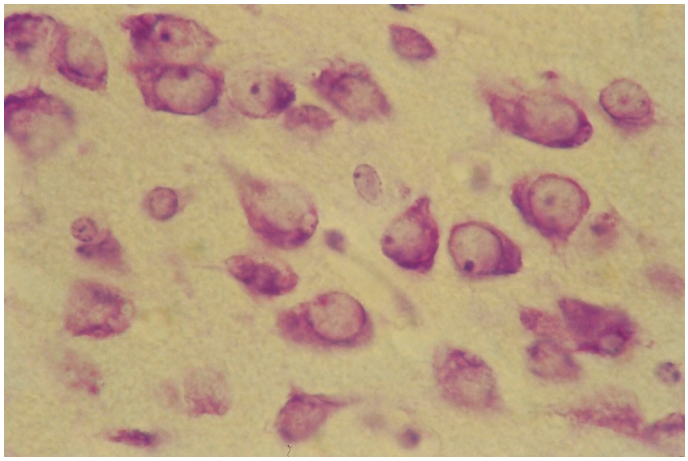

Fig. 2. Heteromorphic neurons of pars dorsalis of Chinchilla lanigera's claustrum (magn. approx. 400 ×). Staining according to Klüver and Barrera's method

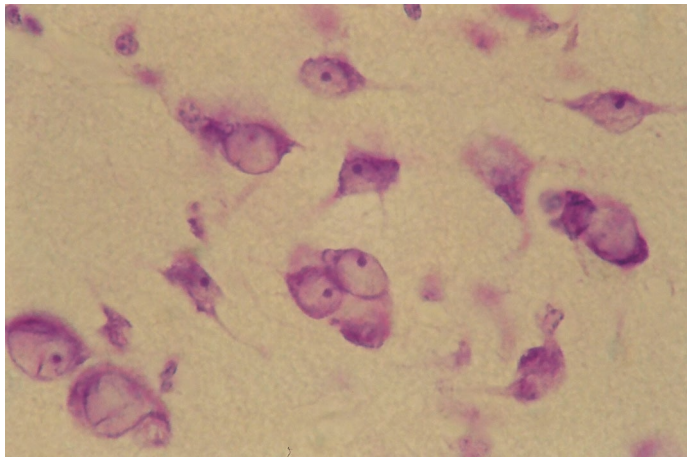

Fig. 3. Neurons of pars ventralis of claustrum in Chinchilla lanigera (magn. approx. 400 ×). Staining according to Klüver-Barrera's method

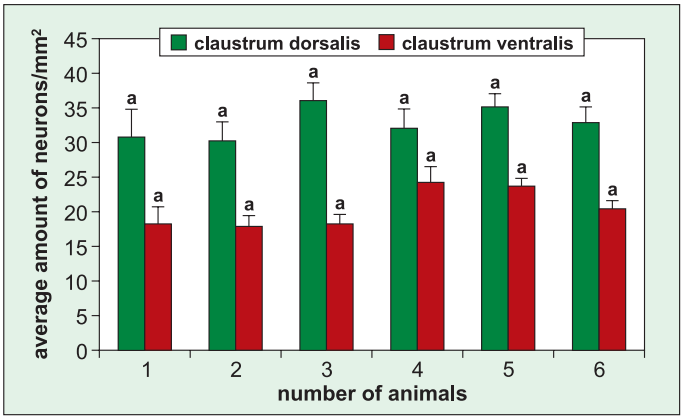

Fig. 4. Average number of neurons in pars dorsalis and pars ventralis of claustrum in Chinchilla lanigera

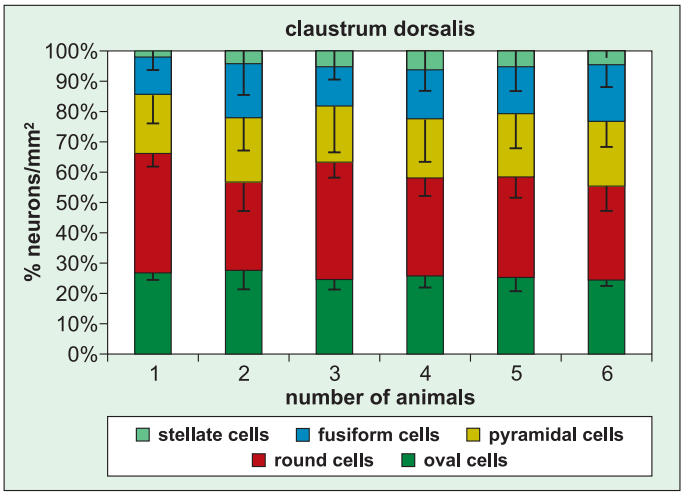

Fig. 5. Percentage ratio of neurons' shape in pars dorsalis of claustrum in Chinchilla lanigera

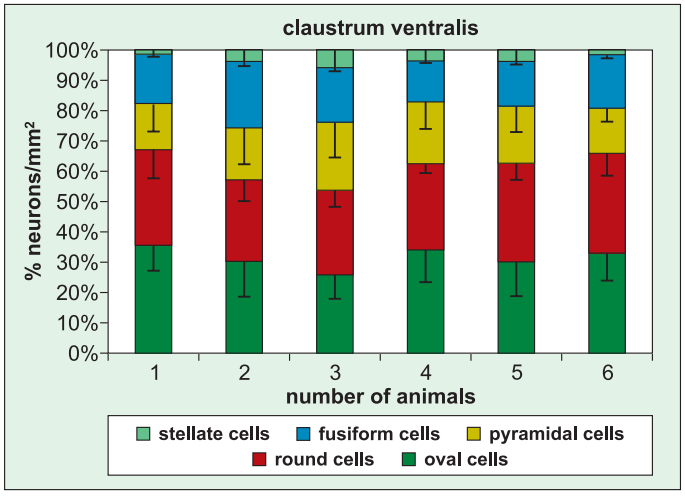

Fig. 6. Percentage ratio of neurons' shape in pars ventralis in claustrum in Chinchilla lanigera

Chinchilla lanigera is a small rodent belonging to the chinchilla family. The obtained results referring to the cytoarchitecture of claustrum in this rodent species show some similarities and differences in comparison with other animal species. Our own observations indicate dissimilarity in the claustrum's structure in comparison with other species of rodents, i.e. mice and rats (1, 5, 7). The form of a chinchilla's claustrum is similar to the one present in a rabbit (2, 7). In both animal species the claustrum looks like a sand glass. Most of the *pars dorsalis* is elongated, it occupies most of the surface and narrows towards the posterior part into a smaller *pars ventralis* of triangular shape. Both parts are joined by a narrowing. The *capsula externa* and *capsula extrema* are well developed, thus the claustrum of a Chinchilla lanigera and a rabbit is clearly separated from neighboring structures, i.e. the putamen and insular cortex.

In mice and rats, on the other hand, it is difficult to isolate the claustrum from the neocortex, which is the result of the small development of both capsules (1, 5, 7). In the cell structure of the chinchilla's claustrum round and oval cells prevail, but also few pyramidal, fusiform and stellate neurons are present. Similar neurocyte images were demonstrated in the claustrum of other species, both in rodents as well as in carnivorous animals, except in the rabbit's claustrum in which fusiform cells prevail, and in primates, in which pyramidal neurons dominate (7, 9).

The obtained results of morphometric analyses have revealed a greater number of neurons in *pars dorsalis* than in *pars ventralis*, and such a tendency was described in other species of mammals (7-9).

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