Short Review

Unraveling the Function of Claustrum

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Abstract

Claustrum is a thin sheet of gray matter located between external and extreme capsules of lentiform nucleus (basal ganglia). Functions of claustrum are still not clear. Positron emission tomography (PET) studies have been helpful in measuring the cerebral blood flow responses, as reflection of regional neuronal activity to various sensory stimuli. With PET it was seen that claustrum of healthy males displayed one of the highest activity with visual sexual stimuli.Bilateral activation of claustrum was seen to be involved in motivational processed, which direct behavior to a sexual goal.

Introduction

Knowledge regarding the anatomical and functional aspects of claustrum is scanty. Still in our latest editions of textbooks of anatomy we cannot find its functions. Claustrum is a thin sheet of gray matter located between

external and extreme capsules of Lentiform nucleus. It is grouped in basal nuclei, and consists of at least two structurally and functionally distinct zones; Insular claustrum and temporal or endopiriform claustrum.[1] The ventrally situated part is endopiriform; whereas insular part is dorsally placed. Endopiriform claustrum originates from ventral pallium, the insular claustrum originates from both lateral and ventral pallial portions.[2,3]

We know most of the connections and functions of rest of the basal nuclei but Claustrum remains mysterious. To solve this mystery a review was done of the latest research works.

Ultrastructure of Claustrum

Cat's dorsal claustrum (insular) was studied by electron microscopy and by anterograde and retrograde tracer techniques. It receives a convergent retinoptic projection from several visual cortical areas. The commonest cell type in the claustrum was a neuron with large spiny dendrites and axon that leaves the cell after giving off local collaterals. There were also cells with beaded dendrites and a locally arborizing axon. Electron microscopy of the claustrum after ablation of the visual cortex showed degenerating type 1-axon terminals synapsing on spiny and beaded dendrites, suggesting a direct cortical input to both cell types. The visual claustrum projects back to the visual cortex, to same areas from which it receives an input. The claustrocortical axons terminate in all cortical layers.[4]

Claustrocortical Connections

Although all cerebral cortical areas are reciprocally connected with the claustrum, but the posterior part of the claustrum is mainly connected to two main cortical related zones, sensorimotor and visoauditory. Between these two zones only scanty overlap was observed.[5-7]

All auditory areas have reciprocal connections with ipsilateral and contralateral claustrum. Main projection is in intermediate part of claustrum.[8]

The ventral part of claustrum is connected with limbic system.[9] The dorsal insular part has reciprocal connections with the insular cortex. It is also connected to many regions of neocortex.[10,11] Cat's insular cortex and claustrum were investigated with horseradish peroxidase retrograde technique. Their findings confirm the previous view that claustrum projects to most regions of cerebral cortex and also insular cortex.[12] Visual cortex received considerable number of claustral projections.[13,14]

Functions of Claustrum

Functions of claustrum are still not clear. Differences in morphology and the cellular structure of two parts of the claustrum may suggest differences in functions of two parts of the nucleus. One method of assessing the function of claustrum is through Positron emission tomographic studies, as this helps to measure the cerebral blood flow responses, as reflections of regional neuronal activity, to various sensory stimuli. Second method is to work out the functions through its connections with different parts of brain.

Evidence of role of Claustrum in Emotions and Sexual Arousal

In a study Positron emission tomography was used to investigate responses of regional blood flow in healthy males represented with visual sexual stimuli of graded intensity. The claustrum displayed one of the highest activity. The additional activations were recorded in right insular, paralimbic areas, striatum and the posterior hypothalamus.[13,15] This study confirms the results of previous study of Stoleru et al.[16] in which they proposed a behavioral model of "sexual arousal" comprising of four coordinated components i.e., cognitive, emotional, motivational and physiological. Briefly the cognitive component comprises a process of appraisal through which a stimulus is categorized as a sexual incentive. The emotional component includes the specific hedonic quality of sexual arousal i.e., the pleasure associated with arising arousal and with perception of specific bodily changes such as penile tumescence. The motivational component comprises the process that direct behavior to a sexual goal, including the perceived urge to express overt sexual behavior. Physiological component include various responses (e.g. cardiovascular, respiratory, genital) leading subject to a state of physiological readiness for sexual behavior. The highly significant bilateral activation of claustrum was one of the striking findings, which was seen to be involved in motivational processes.[17] There is further evidence for the role of claustrum in emotional and motivational responses in rats[16] and in man.[18]

Arnow et al[19] in a study employed functional MRI to examine the relationship between brain activation and sexual arousal. Strong activations specially associated with penile turgidity were observed in right subinsular regions including the claustrum.[19] In addition to above, more evidence of claustrum in sexual arousal is through its connections with surrounding brain areas. Penile erection and subjective sexual arousal were assessed by bold functional MRI, using erotic films as visual stimuli. It was observed that cingulated gyrus and insula were significantly activated.[19,20] Claustrum is also connected to limbic system. The connecting neurons are mainly localized in anterior and central parts of claustrum. So there is a role of claustrum in control of emotions, behavior and drive.[21,22]

It is thus concluded that claustrum has reciprocal

It is thus concluded that claustrum has reciprocal connections with all cortical areas. Insular cortex and visual cortex received considerable number of claustral projections. Cingulate cortex also receives inputs from claustrum. Insula and cingulated gyrus are widely thought to be involved in regulations of emotions; so claustrum was thought to be involved in regulation of emotions. By Positron emission tomography and MRI it was seen that claustrum showed highest activations with visual sexual stimuli. The highly significant bilateral activation of the claustrum was one of the striking findings, which was seen to be involved in motivational processes.

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