Original Article

GOLGI MORPHOLOGY OF PYRAMIDAL NEURONS IN POSTERIOR PARIETAL CORTEX OF MAN

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Summary

Lobulus parietalis superior (LPS) and precuneus (P) in humans are the parts of the same posterior parietal cortical (PPC) cytoarchitectonic area (Brodmann's area 7). On 10 brains of adult persons of both sexes and without neurological disorders we used the Golgi impregnation of neurons of PPC (modification Drekić & Malobabić- Acta Veter, 1987). We excised the tissue blocks from LPS and from P near medial hemispheric margin. Impregnation of PPC neurons was successful in deeper cortical layers (III V). The morphology of selected well impregnated neurons was analyzed and described. In general, very specific was prominent radial pattern of blood vessels and neurons. Large pyramidal neurons in human PPC are rarer than in other agranular cortical areas. Basic morphological feature of large pyramidal neurons was location of their bodies in layer V. Only certain percentage of them were very large neurons, such as about 80x40µm. Pyramidal neurons had more triangular body than pyramidal neurons in motor cortex, and not so fusiform than in limbic cortex. Usually one of their basal dendrites was predominant, contributing to slightly fusiform body shape. From narrow apical dendrite branches were horizontally oriented. Dendrites had fewer spines than in primary motor cortex neurons. This study is first step in morphological mapping of different neuronal types in human parietal cortex and can contribute in studies of intracortical networks.

Key words: Superior parietal lobule, precuneus, man, pyramidal neurons, layer V

Introduction

Parietal lobe of a humans is 20% of surface of brain cortex, [1], and its parts are: postcentral gyrus, superior and inferior parietal lobule and precuneus. Posterior parietal cortex is also the part of important parietal association cortex. After severe damage of parietal lobe we can see different disturbances as ignorance of optical and tactile information from visual space or surface of body on the opposite side of damage; and also apraxia and parietal ataxia [2].

Parts of parietal lobe are located both on lateral and medial surfaces of hemisphere [3, 4]. Posterior parts of parietal lobe are lobulus parietalis superior and lobulus parietalis inferior, separated by sulcus intraparietalis, as well as precuneus or gyrus precuneus (P). Precuneus, gyrus nearly quadrangular in shape [5] and well developed only in humans [6], is medial continuation of superior parietal lobule [7]. According to most used Brodmann's cytoarchitectonic map [8], parts of parietal

cortical region are regio postcentralis and regio parietalis. Cortex of LPS and P mostly belongs to Brodmann's area (BA) 7 which is on superolateral, but also on the medial hemispheric surface [8], and only small part of precuneus is area 31 [9,10 -Vogt et al, 1995]. Actually, LPS of humans is made of cytoarchitectonic areas 5 and 7 which are divided by sulcus postcentralis superior [11].

Posterior parietal cortex (PPC) comprises the greatest part of parietal lobe behind BA 2, but without somatosensory area on the medial surface of the hemisphere. Parietal association cortex of primates comprises areas BA 5 and 7, also BA 39 and 40 [11]. Area of LPS contains BA 5 and 7, which are marked as area parietalis superior s. medialis [2] and superior parietal lobe accounts for 8.4% of the whole brain cortex [12]. Cortex of precuneus belongs to the medial part of BA 7, but is not clearly defined by all authors as PPC. In cerebral cortex of humans there are two basic types of neurons: pyramidal and nonpyramidal ones, and their numerical relationships are various in different brain areas [2]. Analysis of basic morphological characteristics of large pyramidal neurons in layer V of human posterior parietal cortex (PPC) using the Golgi method is the main goal of this study.

Materials and Methods

We used in our research (20 brains 40 hemispheres, both sexes, adults, 27-65 years) from Institute for pathology and from Collection from Institute of Anatomy, Medical Faculty in Belgrade. Brains we used were without visible pathological changes and the cause of death was not an illness of central nervous system. Brains were perfunded with physiological solution trough the catheters via internal carotid and basilar arteries, and after that also with formaline. By fine dissection we removed blood vessels and meninges, and then we obtained the blocks of tissue of LPS and P, near medial margin of hemisphere and in the middle between sulcus centralis and sulcus parietoocipitalis. Golgi impregnation of neurons in LPS is made by modification of Drekić and Malobabić [13]. We selected well impregnated pyramidal neurons of V layer and analyzed their morphology.

Results

Impregnation of neurons in PPC was completely successful in deeper cortical layers (III -V). In general, very specific for PPC was prominent radial arrangement of blood vessels and neurons (Fig. 1). Pyramidal neurons in PPC are much rarer then in other agranular areas of cortex.

Basic morphological feature of large pyramidal neurons of PPC was location of their bodies in layer Va. These neurons in layer V were slightly larger than in layer III. Some of them were very large (about 80 x40 μm) (Fig. 2). Pyramidal neurons in PPC had more fusiform cell body than pyramidal neurons in motor

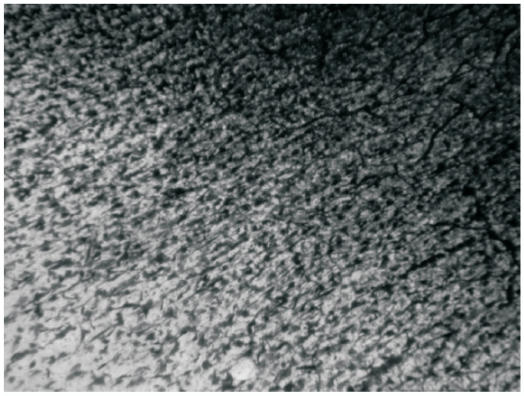

Figure 1. Typical radial arrangement of blood vessels and neurons in V layer of human PPC. (Golgi method; x 20)

cortex, but more triangular than in limbic cortex. One of their basal dendrites is predominant and contributes to the fusiform shape of neuronal body. They were often regularly triangular in shape with large basal dendrites.

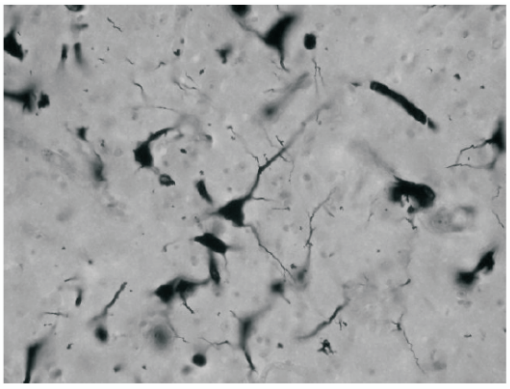

Figure 2. Typical large pyramidal neuron in V layer of posterior parietal cortex with horizontal branches arising from apical dendrite (Golgi method; x 40)

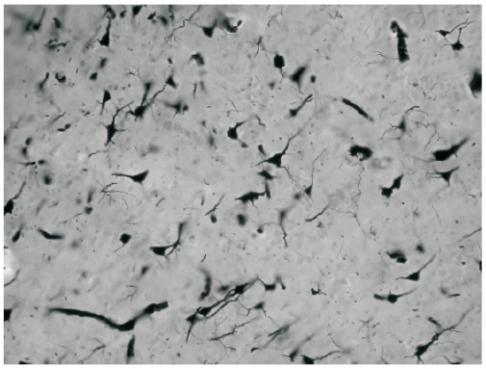

Figure 3. Inverted pyramidal neuron in V layer (white arrow; Golgi method; x 20)

Several basal dendrites from PPC pyramidal neurons projected laterally and had multiple spines. PPC pyramidal neurons had an apical dendrite reaching cortical lamina I, with horizontally directed

secondary and tertiary dendritic branches. We observed also some inverted pyramidal neurons in layer V (Fig. 3).

Discussion

Very impressive on Golgi sections, radial pattern of PPC vessels and neurons was observed also on Nissl stained sections [14] This radial arrangement of cortical neurons could indicate that great part of processing in PPC is located in deeper layers, also suggesting morphological base of associative functions of PPC.

Principal neurons of cerebral cortex can be divided in pyramidal and nonpyramidal (interneurons or stellate neurons) [2], and both principal types we found in PPC of man. It is known that the large pyramidal neurons in LPS of man are of middle size, with some distinction between the parts of this gyrus [15]. In the available literature we did not find related Golgi studies of human PPC neurons. Analysis of our findings therefore can be the comparison with Betz cells from motor cortex. Similar to our findings in human PPC, Betz pyramidal neurons are heterogeneous in shape, and include pyramidal, triangular, and spindle-shaped cell bodies [16]. Regarding the size of neurons as their name implies, the giant pyramidal cells of Betz were categorized initially by their size, ranging from as small as 30 μm x10 μm, to as large as 120 μm x 60 μm [8, 12]. So, the size of greatest neurons we described in human PPC (80 μm x 40 μm) is close to mentioned numbers and is in accordance with statements that gigantocellular neurons in human parietal cortex are in layers V and VI [14].

In fact, Betz cells differ from other pyramidal cells by their dendrite morphology. Our description of several basal dendrites corresponds better to the majority of pyramidal (non - Betz) cells, which dendrite arbors leave the cell body almost exclusively from basal angles and some of the largest cells have as many as six primary basal dendrites [17]. Horizontal orientation of both, basal and apical dendritic branches, fits well with hypothesis about the role of lamina V pyramidal neurons in intracortical selection of impulses which would leave cortex [18], and our finding of horizontal dendritic branching indicates their role in associative processing.

Complexity of PPC can be seen from the fact that disturbances are much heavier after its damage in nondominant (right) hemisphere. Maybe PPC of right hemisphere contains neuronal base of attention in both halfs of space, while the left hemisphere contains only such base for contralateral space [19]. Also should be kept in mind that morphology (asymmetry) can be modified by sex steroids, especially progesterone, which may reduce functional asymmetry of human hemispheres, as multiplying capability of left hemisphere in optical and spatial tasks [20].

Close relationship of pyramidal neurons with multiple types of nonpyramidal neurons (interneurons) in PPC of man, what we found, is in agreement with complex horizontal organization of deeper cortical layers in parietal association cortex. All these facts suggest that detailed Golgi studies related to sex and hemisphere dominance are necessary for better understanding of human PPC.

Conclusions

Radial pattern of neuronal arrangement, horizontal dendritic branching, greater similarity to majority of pyramidal (non- Betz) neurons and close relationship to nonpyramidal neurons are clear characteristics of large pyramidal neurons in lamina V of posterior parietal cortex of man.

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