STRUCTURAL-FUNCTIONAL UNITS IN THE PIAL MICROVASCULAR SYSTEM

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The pial arterial network on the surface of the cerebral hemispheres is the only source of blood supply to the neocortex [2, 4, 9]. These arteries are the principal vascular effector regulating an adequate blood flow in its microcirculatory system [6, 7]. They react actively to metabolic products and neurotransmitters [11]. Many interarterial anastomoses have been discovered in several species of animals and man at the level of large and small pial arterial branches [3, 4, 9, 1]. However, it is still not known whether specific structural-functional units exist in the pial microvascular system or how they develop in phylogeny.

The aim of the present investigation was to examine the general anatomical organization of the arterial microvascular system in the pia mater in a phylogenetic series starting with animals with a comparatively low level of development of the cortex and of its blood supply and ending with primates.

EXPERIMENTAL METHOD

The cerebral hemispheres of adult frogs (five), hens (five), rabbits (five), cats (seven), dogs (four), and monkeys (four) were removed from the skull after the animal's death and placed for 5-7 days in 10% formaldehyde. After fixation the pia mater was carefully removed under a binocular microscope from the surface of the hemispheres in the temporal, frontal, and parietal regions of the brain. The vascular network of pial arterial and venous branches was completely preserved in the detached pia mater together with segments of radial arteries up to 0.5 mm long, which were removed from the brain tissue during dissection. After staining with hematoxylin histological preparations of the pia mater were obtained.

By means of an ocular grid, by examination of microscopic preparations under a binocular microscope (magnification 70), the number of radial arteries per square millimeter of brain surface was counted, using the method of random sampling of individual areas of the brain surface.

Individual regions of the pial microvascular networks were projected from histological preparations on to a screen, where they were drawn on paper. After identification of the pial arterial microloops formed by branching and anastomosis of the terminal microvessels, their structural features were investigated; a random sample of microvascular regions also was used in this case.

The results were subjected to statistical analysis and are presented in the form of arithmetic means and their mean errors.

EXPERIMENTAL RESULTS

In representatives of amphibians virtually no pial arteries are present on the surface of the forebrain. The pial arterial network is comparatively simple in birds, in which it has a few branches and anastomoses. The density of bifurcations and anastomoses becomes greater in rabbits, and the pattern is more complex still in cats, dogs, and monkeys (Fig. 1).

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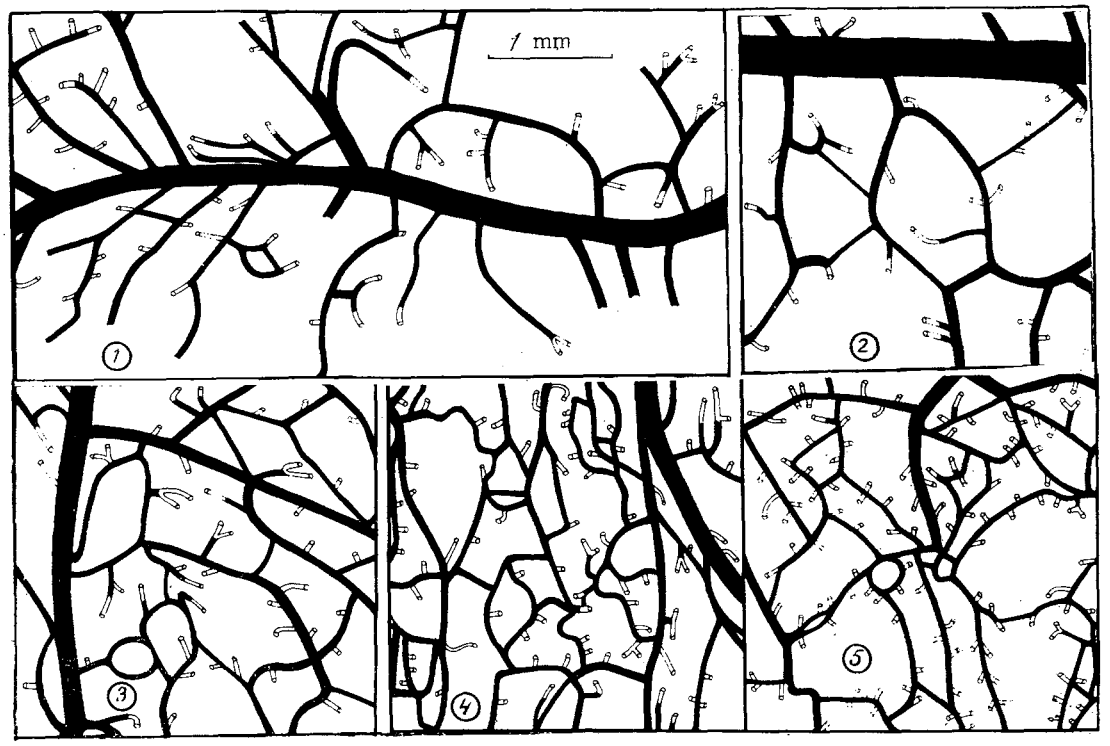

Fig. 1. Typical specimens of the pial arterial network on the surface of the forebrain in various representatives of vertebrates. Precortical and radial arteries are shown in white. Scale for all schemes is the same.

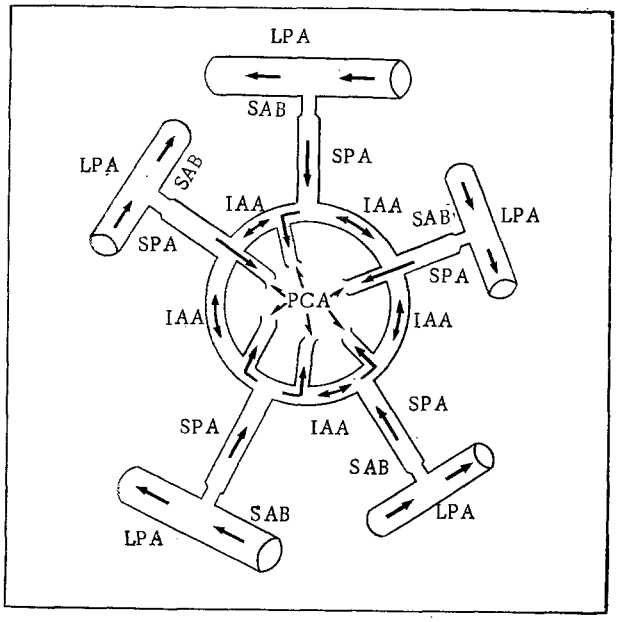

Fig. 2. Scheme of a pial arterial microloop with all its component parts. LPA) Large pial arteries, SAB) sphincters of arterial branches, SPA) small pial arteries, IAA) interarterial microanastomoses, PCA) precortical arteries. Arrows show typical direction of blood flow in microvessels.

A careful investigation of the pial arterial networks showed that, in all species of animals studied, because of consecutive branching and anastomoses pial arterial microloops are formed in the region of the terminal vessels and extend over the whole surface of the hemispheres of the forebrain.

TABLE 1. Morphological Characteristics of Pial Arterial Microloops in Different Representatives of Vertebrates

Parameters studied	Men	Rabbit	Cat	Dog	Monkey
Pial arterial loops formed only from small pial arteries, % of total number	33,3	57,6	78.5	79,3	93,4
Number of pial arterial loops per square millimeter of brain surface	0,73±0,076	1,7±0,28	3,7±0,51	3,6±0,09	3,79±0,51
Area of pial arterial microloops, rel. units	1,16±0,22 (n=11)	0,95±0,09 (n=58)	0,81±0,06 (n=79)	0,49±0,04 (n=139)	0,27±0,01 (n=181)
Distance between arterial branches supplying blood to pial arterial microloops, mm	0,87±0,06 (n=56)	0,67±0,05 (n=76)	0,5±0,038 (n=50)	0,43±0,02 (n=59)	0,36±0,02 (n=110)
Distance between terminal arterial branches penetrating cerebral cortex in the form of radial arteries, mm	0,5±0,047 (n=125)	0,47±0,032 (n=103)	0,3±0,027 (n=74)	0,25±0,015 (n=91)	0,15±0,013 (n=110)
Number of radial arteries penetrating into cerebral cortex in an area of 1 mm^2	3,11±0,69 (n=500)	5,2±0,04 (n=440)	15,75±1,21 (n=450)	19,6±0,85 (n=420)	19,8±1,08 (n=430)

Legend. n) Number of preparations studied.

Arterial microloops are supplied with blood from several arterial branches, and other, even smaller branches, arise from the microloops and, turning through a right angle, penetrate into the cerebral cortex, as shown schematically in Fig. 2.

These pial microloops are an element of the modular organization of microvessels already described previously in other microvascular regions [10]. The existence of microloops ensures high reliability in control of the blood supply to the smallest regions of the cerebral cortex, for blood can easily be redistributed in them among neighboring microvascular regions, and every radial artery supplying the cortex can be supplied with blood from several sources.

Investigation of the pial arterial microloops in different representatives of the vertebrates showed that they undergo definite changes in the phylogenetic series (Table 1). In the more highly developed species of animals pial arterial microloops are formed mainly from small pial arterial branches, which are characterized by a higher degree of vasomotor activity during regulation of the blood supply to the cerebral cortex [6, 13, 5, 12]. Two types of most active segments of sphincters of branches and of precortical arteries, which have a particularly rich innervation, have been identified here [1].

The results of this investigation indicate that during evolutionary development the pial arterial microloops did not appear on the surface of the forebrain from the very beginning. They developed gradually from initial dichotomous branching of pial arteries, parallel with the gradual development of microanastomoses here during vertebrate phylogeny.

Examination of the development of the pial arterial system in phylogeny gave a better understanding of its function under conditions of regulation of the microcirculation in the neocortex. It can be concluded from the results that among the species of vertebrates which were studies the level of phylogenetic development rises in the following order: frog, hen, rabbit, cat, dog, monkey. These investigations showed that the structural units of the pial arterial network described above, i.e., the pial arterial microloops, undergo corresponding development in this order. The higher the development of the animals, the smaller the region on the brain surface occupied by each pial arterial microloop, i.e., the smaller the weight of nerve tissue supplied with blood independently from neighboring regions. This means that an adequate blood supply to the neocortex can be better controlled in cases when its metabolic demands are increased or when obstacles arise to the blood flow along the course of individual pial arterial branches.

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AGE CHANGES IN OVARIAN STRUCTURE CORRESPONDING TO CHANGES IN FUNCTION

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The constant succession of heterogeneous and heteromorphic structures taking place in the ovaries is linked with the development of the female sex cells and with cyclic changes in sex steroid secretion. Age changes in endocrine activity of the female sex glands may be a pathogenetic component of diseases arising in old age and, in addition, they may lead to disturbances of various aspects of reproductive function, the extreme manifestation of which is sterility. Cessation of the reproductive function in women in the menopause is connected with gradual inhibition of follicle production. However, the histophysiological mechanisms lying at the basis of these processes are not clear. The problem of the cellular and tissue substrates of age changes in ovarian hormone production and also the problem of the role of vessels of the microcirculatory system in involutional changes in structure of the gonads likewise remain unsolved.

The aim of this investigation was to study the histochemical features of various structures of the rat ovary in the initial stages of involution.

EXPERIMENTAL METHOD

Ovaries of albino rats were studied in stages of the estrous cycle taking place under two different conditions: I) in young sexually mature animals (32 rats aged 3-4 months) with a regular 4-day cycle, II) in animals in the early stages of involution (30 rats aged 12-14 months) with lengthening of the cycle (6-9 days) on account of the diestrus phase. In animals of this age group, according to data provided by the veterinary service of the "Rappolovo" nursery, Academy of Medical Sciences of the USSR, signs of age-associated depression of reproductive function are observed. Material was collected, kept, and studied in accordance with the necessary requirements [4]. Activity of NAD- and NADP-diaphorases, glucose-6-phosphate dehydrogenase (G6PDH), 3β- 17β-, and 20α-steroid dehydrogenases (3β-, 17β-, and 20α-SD), esterase, and acid and alkaline phosphatases were determined in frozen section 10 μ thick. The intensity of the enzyme histochemical reactions in the different ovarian structures was estimated with the MUF-5 instrument. Computer analysis of the data included, besides estimating mean values of optical density and dispersion, comparison of histograms so that the prob-

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