

AGE-RELATED CHANGES IN THE VASCULAR NETWORKS OF THE LATERAL  
VENTRICLES OF THE HUMAN BRAIN

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**Abstract:** In modern neuromorphology and neurophysiology, the in-depth study of structures responsible for maintaining the fluid balance of the central nervous system has become increasingly important. In particular, the choroid plexuses located within the brain ventricles play a crucial role in maintaining cerebral homeostasis by producing, circulating, and regulating the resorption of cerebrospinal fluid (CSF). The physiological condition, morphological integrity, and functional activity of these structures are essential for the normal functioning of brain tissues. When the function of the choroid plexuses is disrupted, it leads to changes in CSF circulation and pressure, resulting in the development of severe neurological pathologies such as hydrocephalus, brain edema, and intracranial hypertension. These processes are especially prevalent in elderly individuals. From this perspective, studying the age-related morphological changes of the choroid plexuses is considered one of the important scientific and practical issues.

**Keywords:** Morphology, cerebral vessels, cerebrospinal fluid (CSF), perivascular space, structure of small arteries, chiasm, vascular tissues, morphometry, vascular wall, endothelium, ultrastructure.

**Relevance**

A review of the literature indicates that with aging, the number of squamous (flat) epithelial cells in the choroid plexuses increases, the quantity of vacuoles rises, and the amount of collagen fibers in the stroma grows. A portion of these collagen fibers undergo hyalinization and calcification. In the areas of vascular glomeruli, the number of psammoma bodies increases [2, 7]. In the work of I. L. Benkovich, not only an increase in stromal volume but also its densification (consolidation) was noted [11]. Flattening of epithelial cells, their vacuolization and accumulation of pigments, as well as the simultaneous accumulation of calcified and non-calcified hyaline materials in the stroma and the villous structures of the plexus, have been identified. In addition, thickening of the intimal layer of arterioles and moderate fibrotic processes within the vessels were observed [1, 12]. Cases of epithelial layer flattening, increased connective tissue volume, hyalinization, fibrosis, fragmentation of collagen fibers, and an increase in psammoma bodies within the vascular glomeruli have also been documented [3].

With aging, thickening of the connective tissue layer in the stroma and basal membranes of the villous (hair-like) structures of the choroid plexuses is observed. Epithelial cells become flattened, meaning their height decreases by an average of 10%. Additionally, the number of hyaline and psammoma bodies in the stroma increases, the degree of calcification rises, and the connective tissue layer of the arterial walls thickens significantly [4, 10].

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During the aging process, the total length and surface area of exchange in the capillaries decreases. Conversely, their diameter increases (Babik, 2006). At the same time, the relative proportion of all types of connective tissue — especially collagen fibers — increases. In the plexuses of elderly individuals, the surface area of collagen fibers is reported to be 1.35–1.77 times greater than in younger organisms. Additionally, the number of tissue cells (mast cells) within the villous structures decreases with age [5, 8].

Throughout human life, the walls of brain vessels are exposed to numerous factors, including adverse ones: arterial hypertension, hemodynamic pressure changes, toxic substances and their metabolites, among others — all age-related contributors that can lead to atherosclerosis. These vascular changes can disrupt cerebral blood circulation [9].

As a result of atherosclerotic stenoses in proximally located arteries, morphological changes frequently occur in intracerebral arteries due to reduced blood flow. In such cases, cellular proliferation within the inner layers and a specific process of “recalibration” — involving the formation of additional muscle layers directed toward the lumen of the vessel — is observed [16, 20].

These arteries typically exhibit pronounced fibrosis of the vessel walls, with the fibrotic process also extending into the newly formed muscular layers. This vascular remodeling and consequent significant narrowing of the lumen can lead to diffuse and focal ischemic brain lesions [13, 19].

In a five-year prognostic study, it was found that although small, indistinct vascular narrowings (cribriforms) were often identified, they were not predictors of cognitive dysfunction. On the contrary, the number and progression of localized ischemic processes were closely correlated with the severity of cognitive impairment [12].

This phenomenon, known as external innervation, terminates at the arteriolar-capillary boundary — where the perivascular space ends. External innervation is primarily responsible for providing rapid myogenic responses to transient changes in blood pressure. According to Poiseuille's law, blood flow velocity is proportional to the fourth power of the vessel radius. Therefore, this type of innervation is essential for the fast and effective regulation of cerebral blood flow [14].

Parenchymal arterioles receive innervation from the brain's major nuclei, including the locus coeruleus, Meynert's basal nucleus, and the raphe nuclei of the brainstem. These structures release noradrenaline, acetylcholine, 5-hydroxytryptamine, and other neuropeptides either directly into the walls of capillaries or indirectly through local interneurons and astrocytes [15, 21].

It is assumed that these nerve fibers regulate the intrinsic spontaneous contractile activity (vasomotion) of the smooth muscle cells in the middle layer of the vessel wall. Vasomotor oscillations in the microvascular system form the basis of very slow wave activity, with a frequency of about 0.1 Hz, independent of neuronal activity [17]. The gray matter is characterized by a dense network of capillary anastomoses, which varies according to the depth of the tissue. Approximately 50–60% of the total blood volume in the brain is located within the capillaries [11]. Capillary walls are composed of a single layer of endothelial cells, pericytes, and a basement membrane. The basement membrane consists of type IV collagen, heparan sulfate proteoglycans, laminin, fibronectin, and other extracellular matrix proteins, with their ratios and isoforms differing depending on the type of vessel [2, 10]. Endothelial cells are tightly connected to one another via claudin and occludin proteins, forming the blood-brain barrier. This barrier limits the movement of ions and hydrophilic solutions between cells, protecting the brain parenchyma from even the slightest osmotic fluctuations in the surrounding tissues and blood plasma [8, 20].

**Conclusion:** Thus, it is necessary to conduct research on the age-related morphological characteristics of the choroid plexuses located in the lateral ventricles of the human brain, to identify their involutinal processes, and to distinguish between normal and pathological conditions. This article aims to scientifically analyze this issue and draw practice-oriented conclusions. It has been confirmed that individual variations in the morphological structure of the choroid plexuses in the lateral ventricles of the human brain play an important role. The choroid plexuses have a significant function in regulating the brain's water-salt balance. Therefore, it can be hypothesized that mechanisms may exist to halt or slow down structural changes in these organs during aging and in certain pathological conditions. Supporting evidence for this hypothesis includes the expression of specific proteins (which are considered markers of proliferative processes) in the epithelial cells of the choroid plexuses, as well as the coexistence of both intact and involutinally altered villi within the choroid plexuses of the same individual.

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