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PATHOPHYSIOLOGY OF CENTRAL CEREBRAL EDEMA LITERATURE REVIEW

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Abstract

The brain is a tissue with high metabolic activity, for which this organ, accounting for only 2% of body weight, consumes 20% of all incoming oxygen and glucose [6,7]. Brain damage leads to disruption of oxygen and nutrient supply with the development of energy deficiency, accompanied by cerebral edema (CEE), a severe life-threatening condition that worsens the prognosis of the disease. From the mid-20th century to the present, classical methods of CEE correction have been used that do not have a serious evidence base, such as the introduction of mannitol or hypertonic saline, hyperventilation, and in critical cases, decompression craniotomy. The past 30 years have been marked by significant discoveries in the physiology and pathology of fluid exchange in the central nervous system (CNS), including that accompanied by water accumulation in the brain parenchyma [1,5,14,]. This may facilitate a revision of approaches to the treatment of central cerebral edema based on the molecular biology of water and electrolyte transport systems across brain barriers.

Keywords: Cerebral edema, fluid of the brain, sinuses of the brain.

Introduction

The fluid component of the brain is represented by four separate spaces: an intracellular volume of about 1,100 ml; three extracellular (intravascular and interstitial with a volume of about 100 ml, as well as cerebrospinal fluid with the contents of the perivascular Virchow-Robin spaces - a volume of 150-170 ml). These fluid spaces are separated from each other by barrier systems that help maintain their unique composition, which is necessary for the most optimal f pi lue exchange at the capillary level and flowing out through the venous link. Arterial inflow is carried out by the internal carotid and vertebral arteries, which join at the base of the skull into the Willis circle, from which three large (anterior, middle and posterior cerebral) and many small arteries extend, penetrating the brain from its surface.[4,13]

The penetrating arteries are located in a funnel-shaped depression on the surface of the brain (pial funnel), lined with the pia mater, tightly adjacent to the surface of the hemispheres. In this case, perivascular Virchow-Robin spaces (VRS) are formed, accompanying the arteries to the capillary level and filled with cerebrospinal fluid (CSF) [3,8]. At the level of the capillary network, the vascular wall begins to fit tightly to the border glial layer and the VRS disappears. The capillary network drains into the venous system, also surrounded by VRS and represented by the system of deep and superficial veins of the brain. The deep veins of the brain drain into the great cerebral

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vein (of Galen), the superficial veins exit to the surface of the cerebral hemispheres, draining through the bridging veins and venous lacunae into the sinuses of the brain.

The intravascular space performs an important function of supplying neuronal tissue with oxygen and nutrients, as well as eliminating metabolic products from the brain.It is also worth noting that the intravascular space of the brain is the only water sector capable, unlike the intracellular space and CSF, of bringing fluid into the interstitial space of the brain from the outside, which plays an important role in the development of cerebral myocardial infarction.[10]

The interstitial space is filled with fluid that washes the cellular elements and acts as a reservoir of fluid, electrolytes, nutrients and neurotransmitters to provide neuronal tissue. Fluid, electrolytes, nutrients and other substances enter the neurons from the interstitial fluid. Metabolic products, neurotransmitters and electrolytes also enter it from the neurons. The optimal composition of the interstitial fluid is maintained by astrocytes, glial cells that maintain the optimal electrolyte balance and eliminate metabolic products and neurotransmitters from the interstitial fluid. The interstitial fluid is not static, it moves at a speed of 0.15-0.29 μg/min, mainly due to passive ce, large molecules, such as albumin, are limited in their speed of propagation and cover 1 mm in approximately 10 hours [16].

The cellular elements of the central nervous system are represented by neurons and glial elements: astrocytes, oligodendrocytes and microglia.

In the physiology of fluid and electrolyte exchange in the brain, the intracellular spaces of neurons and astrocytes are important [15]. The intracellular space contains a high concentration of potassium, the main intracellular cation necessary for the transmission of impulses along neurons,and also being an intracellular carrier of osmolarity. The preservation of the water-electrolyte composition of the cell is ensured by membrane transport systems.

CSF fills the ventricular system, cisterns and subarachnoid space of the brain, as well as perivascular spaces of the brain. CSF performs the function of mechanical support of the brain, water-electrolyte homeostasis, removal of metabolic products and neurotransmitters from the central nervous system.[12]

It is traditionally believed that CSF is synthesized in the choroidal plexuses of the ventricular system of the brain. Then CSF through the foramina of Monroe of the lateral ventricles penetrates into the third ventricle, and from there through the aqueduct of Sylvius into the fourth ventricle. From the fourth ventricle CSF through the foramina of Mogendie and Luschka penetrates into the cisterns and subarachnoid space of the spinal cord and brain. From the subarachnoid space CSF is excreted into the sinuses of the brain through the granulations of the putative membrane or into the lymphatic system through the cervical lymphatic vessels and perineural subarachnoid spaces [3]. Despite the fact that the clinical picture of CSF flow disorders generally confirms this theory, new data suggest the presence of CSF formation and reabsorption at all levels of the central nervous system, as well as the presence of retrograde CSF flow in some situations [3].

Due to the free penetration of CSF from the subarachnoid space along the course of the cerebral vessels, a number of authors suggest the presence of a circulation system along the PVP system, functioning as a cerebral lymphatic system [9]. It is believed that CSF, under the influence of arterial pulsation, moves toward the capillary network, at the level of which it penetrates into the paravascular space located between the pedicle of the astrocyte and the capillary, and from there into the interstitium [9]. At the venous end of the capillary network, the interstitial fluid is released into the venous PVP and moves into the subarachnoid space (Fig.) [9]. Other data refute the

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unidirectional arteriovenous movement of CSF along the cerebral vessels, leaving the question of the functioning of the paravascular circulation open [17].

Conclusion

The authors who first described the presence of circulation in the PVP called it, by analogy with the lymphatic system, the cerebral glymphatic (glial lymphatic) system [9]. Considering the high density of blood supply to the brain with an intercapillary distance in the gray matter of 17-58 μm, glymphatic circulation is capable of covering all areas of the brain, and it is assumed that it plays an important role in the intracerebral circulation of nutrients and metabolic products, signaling agents, immunoglobulins, new and immune cells [9]. Also, the glymphatic system can be the second most important site of both secretion (after the choroidal plexus) and reabsorption (after the arachnoid granulations) of CSF of the subarachnoid space.

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