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EDITORIAL

Brain Protection

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Abstract

The brain is a vital organ, but it is also a very fragile tissue. In this article, we try to focus on its protective mechanisms. The brain is supported by external and internal means of protection. The brain's external protection consists of more than one layer, including the strong bones of the skull, followed by the three meningeal membranes: the dura mater, the arachnoid mater and the pia mater. This is in addition to the cerebrospinal fluid tube located in the subarachnoid space and extending within the brain cavities. These cavities are the two lateral ventricles, one within each cerebral hemisphere; the third ventricle, which is the diencephalon cavity separating the thalami; the fourth ventricle, which represents the rhombencephalic cavity located between the pons and medulla oblongata in front and the cerebellum in back; and the aqueduct of Sylvius located within the short midbrain. On the other hand, internal protection includes the Blood-Brain Barrier (BBB), which acts as a barrier against harmful substances that may be present in the blood, but unfortunately this is not a perfect barrier as some ingested substances can pass through it to reach the brain. This necessitates special care, including avoiding head injuries whenever possible, and refraining from taking medications or any harmful substances such as narcotics that may cross the BBB and negatively affect the brain.

Key Words: *Dura mater; Arachnoid; Pia mater; Blood-brain barrier; Cerebrospinal fluid*

The brain, located within the skull cavity and the spinal cord, located within the vertebral canal, together form the Central Nervous System (CNS). The brain is a vital organ responsible for memory, perception, motor control, sensation, emotional responses, and communication. In other words, the brain is the organ of sense of life. The tissues of the brain are extremely fragile, so even the slightest pressure can cause damage [1]. Even a tight bandage on a baby's skull, before the fibrous joints between the skull bones fuse at the sutures, can hinder brain development [2,3]. Therefore, the CNS requires special protection. This protection is achieved external and internal protection.

Internal protection consists of what is called the Blood-Brain Barrier (BBB) [1]. The BBB consists of the walls of the capillaries in the brain, which are made up of continuous endothelial cells that lack fenestrations, and are therefore the least permeable capillaries in the human body [4]. It protects the brain from harmful substances found in the blood. However, it does not represent a complete separation, but rather acts as a selective barrier between brain tissue and substances found in the blood. This system allows certain important substances for brain function, such as water, glucose, and essential amino acids, to reach brain tissue. Conversely,

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it prevents the entry of other substances, such as non-essential amino acids, potassium ions, and changes in hormone concentrations. However, this membrane does not prevent the passage of lipid-soluble molecules, which can easily pass through all cell membranes. This is why some substances, such as alcohol, anesthetics, opioids and drugs, can reach the brain [5,6]. Furthermore, dietary habits, environmental factors, and psychological stress can all affect the tightness of this barrier. Disruption of the BBB can lead to a number of neurovascular diseases. People who use cocaine may experience reduced blood flow to the brain, increasing their risk of hypoxia and ischemic stroke [7].

External protection of the CNS, from the outside in, includes the skull, which protects the brain; the vertebral column, which protects the spinal cord; the membranes called the meninges, which cover and protect the CNS; and the water cushion called the Cerebrospinal Fluid (CSF), which circulates around and within the cavities of the CNS. These cavities are the two lateral ventricles, one within each cerebral hemisphere; the third ventricle, which is the diencephalon cavity separating the thalami; the fourth ventricle, which represents the rhombencephalic cavity located between the pons and medulla oblongata in front and the cerebellum in back; and the aqueduct of Sylvius located within the short midbrain [8].

The skull consists of two main parts: the neurocranium, which is the surrounding skeleton that protects the brain, and the viscerocranium, which is the facial skeleton. The adjacent bones in the adult neurocranium are closely connected by sutures that are not straight lines, but twisted fibrous adhesions to increase bone stability, and thus increase brain protection [9].

The meninges surrounding the CNS consist of three layers, called from the inside out: the pia mater, the arachnoid mater, and the dura mater. This arrangement can be remembered by the word “PAD”. The pia mater is the thin, inner vascular membrane, closely covering the brain and spinal cord and following their fissures [10,11]. Its tubular sheath terminates at the end of the spinal cord, conus medullaris, opposite the lower border of the first lumbar vertebra. Filum terminale is a thin thread of pia mater that extends from the lower end of the pia mater’s sheath, descends into the spinal canal and exits through the sacral hiatus to attach to the back of the coccyx. Along its course on the surface of the spinal cord, the pia mater presents thick collateral ligaments on both sides, called the ligamentum denticulatum. These ligaments pass through the arachnoid mater to connect to the dura mater. The middle layer, arachnoid mater, is a thin, delicate web-like membrane surrounding the CSF, located in the subarachnoid space between the arachnoid and pia matter [8]. The arachnid mater and the pia mater together form what is called the leptomeninges, derived from the neural crest [10]. The outer layer, the dura mater, is a tough fibrous membrane supporting the delicate arachnid mater. The tube of dura and arachnoid maters terminates at the level of the second sacral vertebra. Pia means delicate; Arachnoid means spider-like; and Dura mater means hard mother [8,11].

Factors that stabilize or fix the spinal cord include: the filum terminale, which connects below to the posterior part of the coccyx; the denticulate ligaments, which extend laterally from the pia mater on both sides to connect to the dura mater; and the dura mater, which connects above to the rim of the foramen magnum and on both sides to the intervertebral foramina [8].

The functions of the meninges include protecting the CNS from trauma, such as a blow to the head, by acting as a shock absorber via the CSF within it. CSF provides a liquid medium in which the components of the CNS, including the brain, float [8]. In addition to absorbing shocks, CSF washes away and removes the metabolic byproducts of the CNS because nervous tissue is the most active tissue in the body. The volume

of CSF in adults is about 150 ml and is renewed about 5 times a day. CSF is secreted by the choroid plexuses located within the ventricles of the brain, especially the lateral ventricles and is absorbed by the arachnoid villi and granules located in the superior sagittal sinus to reach the venous blood [12]. This means that the CSF is secreted from the blood and is drained into the bloodstream.

Furthermore, the cranial dura mater sends folds of cranial dura mater between the main part of the brain to stabilize it and prevent it from moving within the skull, thus reducing the chance of post-concussion syndrome. The dura cranial folds include the falx cerebri located between the cerebral hemispheres, the falx cerebelli between the cerebellar hemispheres, the tentorium cerebelli which covers the cerebellum in the posterior cranial fossa, the diaphragma sellae covering the roof of the pituitary gland in the pituitary fossa, and the cavum trigeminale which is a pouch of dura mater containing the trigeminal ganglion [8, 13,14]. The meninges also support the blood vessels that supply the central nervous system, cranial nerves, and meningeal lymphatic vessels [8].

Conclusion

It is concluded that the brain is a vital organ, but a sensitive tissue affected by both external and internal factors. This necessitates special care, including avoiding head injuries whenever possible and refraining from taking medications or any harmful substances such as narcotics that may cross the BBB and negatively affect the brain.

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