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MORPHOLOGY OF THE DURAL SINUSES OF THE BRAIN

Tirkashev Abduvahid Sharof o‘g‘li

Resident Master's student at the

Department of Human Anatomy,

Samarkand State Medical University

Kamalova Malika Ilkhomovna

Candidate of Medical Sciences, Associate

Professor of the Human Anatomy

Samarkand State Medical University

Abstract: Based on the literature review, clarified the main stages of development of the sinuses of the Dura mater of the brain in the antenatal period of development. Data on the sinus Dura brain is aligned with the international anatomical terminology. The process in which undifferentiated venous network consolidates in the venous sinuses and large veins of the brain, explains most of the numerous variants and anomalies of extracerebral veins. Knowledge of the development of the sinuses of the Dura mater of the brain facilitates the understanding of many anatomical facts.

Keywords: Morphogenesis, embryonic development, brain, sinuses of the brain.

Relevance

Recently, in connection with the demands of vascular surgery, neurosurgery, and computer diagnostics, there has been an increased interest in the development of brain blood vessels and their abnormalities. Despite the large number of studies dedicated to age, gender, and bilateral variability of brain arteries, the venous vessels of the brain are not sufficiently well studied [1-3]. Works related to the development of intra- and extracerebral veins are few and varied [4-8].

The aim of the study is to refine the main stages of extracerebral vein development based on a literature review, and to align the data on the dural sinuses of the brain with international anatomical terminology.

The formation of sinuses is associated with the development of both the brain vesicles and the cranial vault [7]. Sinuses develop from the primitive venous plexus, which gradually reduces to simple channels. In the early stages of embryogenesis, venous blood from the brain drains into paired ventrolateral channels — primary cranial sinuses — which continue into the anterior cardinal veins [1, 9].

The anterior venous plexus collects blood from the eyes, cerebral hemispheres, and structures of the midbrain. The middle venous plexus receives blood from the hindbrain. The posterior plexus collects blood from the medulla oblongata. Blood from these plexuses flows into the primary cranial sinus, which drains into the anterior cardinal vein [1, 4].

In an embryo of 10 mm in length, blood from the anterior, middle, and posterior venous plexuses is collected into the venous outflows, which drain into the primary cranial sinus. The anterior venous plexus expands near the hindbrain and midbrain, anastomosing with the middle plexus (future anastomosis with the transverse sinus) [4]. In an embryo of

10-16 mm in length, the primary cranial sinus begins to obliterate. The anterior cardinal vein is now referred to as the internal jugular vein [1].

At the beginning of the eighth week, in an embryo with a length of 16-21 mm, the vascular plexuses continue to develop. The anterior plexus drains the forebrain through the pineal diencephalic vein [10]. The vein of the forebrain is completely separated; it is intradural and is called the tentorial sinus [5, 7].

Between the growing cerebral hemispheres, the sagittal plexus begins to form from the anterior plexus, and above the midbrain, between the forebrain and the brainstem, the tentorial plexus forms [1, 11].

In the ninth week, as a result of the concentration of the sagittal plexus, the superior sagittal sinus may be detected [4, 5, 12, 13].

The straight sinus forms during the third month of development when the internal cerebral vein, the posterior thalamic vein, and the basal vein join, and it connects with the superior sagittal sinus via the sinus outflow [14].

In an embryo of 14-16 mm in length, the posterior cerebral vein gradually transforms into the sigmoid sinus. Posterior to the otic vesicle, blood begins to flow through the vein connecting the anterior and middle plexuses with the posterior plexus, into the developing sigmoid sinus – this vein is the precursor of the transverse sinus. As the otic vesicle grows, a large anastomosis develops between the middle and posterior plexuses; this anastomosis and the posterior stem together form the sigmoid sinus. The stem from the middle plexus reduces, but retains its connection with the anterior segment of the primary cranial sinus; together they form the preauricular sinus (the future cavernous sinus) [7].

In an embryo of 20 mm (8 weeks), the majority of the blood exits the skull through the sigmoid sinus and internal jugular vein. From the remaining primary venous cranial sinus, located in the region of the trigeminal nerve ganglion, the cavernous sinus is formed. At this stage, the direct path from the cavernous sinus to the internal jugular vein disappears. Blood from the cavernous sinus is partially drained through the vein of the middle dura mater plexus. This vein then transforms into the superior petrosal sinus [7].

In an embryo of 18-26 mm (8 weeks), a well-defined plexus-like stage is still present [7]. The vascular plexuses of the lateral ventricle of the forebrain now drain blood through the primitive Galen vein – the medial prosencephalic vein of Markowski – into the straight sinus [15]. This vein posteriorly forms the primary straight sinus within the tentorial plexus [6, 14, 16]. The continuing expansion of the otic vesicle completely obliterates the corresponding segment of the primary cranial sinus, and blood flow is now redirected through a collateral, which, along with the stem from the posterior plexus, forms the sigmoid sinus.

In an embryo of 40 mm (9 weeks), the main elements of the mature venous system begin to appear. However, this stage is still plexus-like, with the vein of Markowski predominating. The anterior portion of the preauricular sinus, medial to the trigeminal ganglion, forms the cavernous sinus [7].

The formation of the superior sagittal sinus occurs from the sagittal venous plexus, initially forming as a paired structure located in the region of the forebrain [17]. Subsequently, the paired sagittal sinuses merge to form a single sinus that lies dorsally along the midline.

During the fifth month of development, a falcine sinus becomes noticeable between the leaves of the falx cerebri. It begins near the junction of the straight sinus and the Galen vein and joins the posterior third of the superior sagittal sinus. The bulbous protrusion of the Galen vein, in the absence of a fistula, may represent remnants of the falcine sinus. This is a normal variant in asymptomatic patients and may be mistakenly taken for a Galen vein aneurysm [7, 14, 18]. The falcine sinus normally disappears by birth but may persist in association with certain congenital anomalies, particularly with Galen vein malformation [19].

Rapid expansion of the sinuses occurs between the fourth and sixth months of antenatal development. Developmental anomalies of the transverse sinus that form during this period manifest as asymmetry in position and diameter and are often detected postnatally during angiography [6].

The transverse sinuses begin to enlarge in the fourth month of development [19]. The expansion begins at the lateral end of the sinus and proceeds medially, reaching the confluence (torcular). With the continued enlargement of the forebrain, the area where the straight sinus connects with the superior sagittal sinus gradually decreases. As a result, the tilt of the lateral parts of the transverse sinuses becomes less noticeable as the fetus develops [6].

The internal and external vertebral plexuses are the main drainage for the brain in the vertical position. There is an opinion [19] that in a child who has started walking, the blood flow to the vertebral plexuses increases in the vertical position, while the flow into the internal jugular vein decreases. This is said to explain the reduction in the size and number of occipital sinuses in older children and adults. According to their data [19], in 82% of cases, the occipital sinuses are not visualized and may be atretic or so collapsed that the slow blood flow within them is not detected by MR venography.

Conclusion: Thus, the study is dedicated to the development of the venous system of the brain and the processes related to its anomalies. The results of the research show that the venous system of the brain, including sinuses and venous plexuses, undergoes complex stages of development during the embryonic period. During these developmental processes, distinct topographic and functional changes occur, such as the formation and evolution of the falcine sinus and the transverse sinuses. Anomalies in the development of the venous system of the brain, such as Galen vein aneurysms or atretic occipital sinuses, are usually asymptomatic and can be detected through MR venography. Additionally, new data was presented on the functioning and changes in the blood circulation of the brain venous system in healthy children and adults in the vertical position. This study highlights the importance of further in-depth research into the normal development of the venous system and its anomalies, which is crucial for the diagnosis and treatment of neurological diseases.

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