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CRANIOTOPOGRAPHIC CHARACTERISTICS OF VENOUS-LIQUOR RELATIONSHIPS IN THE SAGITTAL PLANE

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This study was performed on 100 corpses of people of different ages and gender with the manufacturing of native preparations of the brain with membranes and liquor structures. Of the specified number of morphological objects, 70 preparations of veins and sinuses of the dura mater of the brain and 30 preparations of the cerebrospinal fluid system of the brain of adults were made. We used such research methods as: macro – and micropreparation of anatomical objects of the brain; cranio – and morphometry of veins, sinuses of the dura mater of the brain and liquor structures of the brain; manufacturing of corrosive (acrylic) casts-preparations of veins, sinuses of the dura mater of the brain and liquor formations of the brain; injection technique; variational-statistical analysis of morphometric data; computer-graphic analysis. The craniotopographic (metric) indicators of venous-liquor relationships in the sagittal plane obtained by us can be used to substantiate the insertion of a puncture needle into the cavity of the lateral ventricles or their departments, based on the maximum allowable depth of its insertion.

Key words: craniotopographic method, dura mater of the brain, venous sinuses, ventricles of the brain, shape of the structure of the head (skull).

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КРАНІОТОПОГРАФІЧНА ХАРАКТЕРИСТИКА ВЕНОЗНО-ЛІКВОРНИХ ВЗАЄМОВІДНОШЕНЬ У СТРІЛОВІЙ ПЛОЩИНІ

Дане дослідження виконано на 100 трупах людей різного віку та статі з виготовленням нативних препаратів головного мозку з оболонами та лікворними структурами. Із вказаної кількості морфологічних об’єктів виготовлено 70 препаратів вен та пазух твердої оболони головного мозку та 30 препаратів лікворної системи головного мозку дорослих людей. Нами були застосовані такі методи дослідження як: макро – та мікропрепарування анатомічних об’єктів головного мозку; краніо – та морфометрія вен, пазух твердої оболони головного мозку та лікворних структур головного мозку; виготовлення корозійних (акрилових) зліпків-препаратів вен, пазух твердої оболони головного мозку та лікворних утворень головного мозку; ін’єкційна методика; варіаційно-статистичний аналіз морфометричних даних; комп’ютерно-графічний аналіз. Отримані нами краніотопографічні (метричні) показники венозно-лікворних взаємовідношень у стріловій площині можна використовувати для обґрунтування проведення пункційної голки у порожнини бічних шлуночків або їх відділів, ґрунтуючись на гранично допустиму глибину її ведення.

Ключові слова: краніотопографічний метод, тверда оболона головного мозку, венозні пазухи, шлуночки головного мозку, форма будови голови (черепа).

The study is a part of the research project “Regularities of the morphogenesis of organs, tissues and vascular and nervous formations in normal, pathological and under the influence of exogenous factors”; state registration No. 0118U004457.

Currently, there is almost no information in the literature sources about the craniotopographical relationships between the venous collectors and liquor formations of the human brain.

The study of the issues of craniotopography of the sinuous-liquor relations of the brain of mature people is of great importance for modern clinical medicine. For example, there are data on the creation of models of chronic venous insufficiency in the sinuses of the dura mater and extracranial drainage veins with the detection of their association with the hyperintensity of white matter in patients with Parkinson's disease [3].

A number of works are devoted to the study of the pathology of vascular-liquor connections of the brain under the condition of the development of arteriovenous and arterio-sinuous malformations, aneurysms, hematomas, intracranial tumors, which lead to impaired outflow of cerebrospinal fluid [8, 9, 10].

Modern neuromorphology requires a clear theoretical substantiation of the data on the cerebrospinal fluid structures of the brain and its membranes, which can be used to improve surgical interventions and diagnostic manipulations.

From a clinical and morphological point of view, the specified individual variability of the craniotopographic features of the venous-liquor relationships in different parts of the brain is very important, considered from the standpoint of performing surgical interventions and creating intra and extracranial venous-liquor shunts.

The purpose of the study was to determine the craniotopographic indicators of sinuous-liquor relationships in the sagittal plane.

Materials and methods. In the course of our study, we used such research methods as: macro – and micropreparation of anatomical objects of the brain; cranio – and morphometry of veins, sinuses of the dura mater of the brain (DMB) and liquor structures of the brain; manufacturing of corrosive (acrylic) casts-preparations of veins, sinuses of the DMB and liquor formations of the brain; injection technique; variational-statistical analysis of morphometric data; computer-graphic analysis.

This study was carried in the conditions of the patho-anatomical departments of the Donetsk region (oblast) of the Department of Health of the Donetsk Regional State Administration and the Department of Human Anatomy of the Donetsk National Medical University (Lyman, Kropyvnyts′kyy) for the time period of 2015–2019 (obtaining material), and 2020–2022 – data processing and summarizing.

Among the listed methods there are well-known proven methods that were already used in other studies before ours (Antonyuk O. P., 2002; Vovk Yu. M., Fominykh T. A., Dyachenko O. P., 2002; Vovk Yu.M., Bohuslavs′kyy Yu.V., Vovk O.Yu., Cherno V.S., 2012; Vovk O.Yu., Bohuslavs′kyy Yu.V., Redyakina O.V., Vovk V.Yu., 2012), and those that appeared during our study, that is, new devices were developed, manufactured and applied, which are confirmed by patents of Ukraine for a utility model (patents No.: 142558, 142559, 142560, 142836, 144305).

Results of the study and their discussion. For each preparation, the main (cranial) index was calculated according to the formula:

$$\text{Ind} = \frac{\text{transverse dimension (width) of the skull (in cm)}}{\text{longitudinal dimension (length) of the skull (in cm)}} \times 100$$

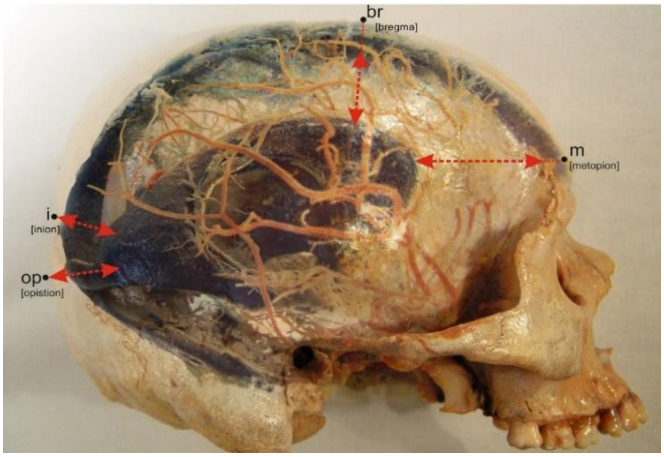

Fig. 1. Craniotopographic relationships between the SSS and the lateral ventricles at the level of craniological points m, br, i, op (scheme).

According to the method proposed by V. M. Shevkunenko (1935), first, the longitudinal dimension is determined using the craniodivider from the glabella to the external occipital protrusion (opistocranion), and the transverse dimension is determined between the remote points of the parietal humps (euryon). If the main (cranial) index is less than 74.9, this indicates that the person belongs to dolichocephals (dolichocranes); at 75.0–79.9 – to mesocephals (mesocranes); if more than 80.0 – to brachycephals.

According to the purpose of our study, we tentatively draw a sagittal plane in accordance with the classical median line, which divides the skull into two equal halves: left and right (Fig. 1).

Considering that the lateral ventricles of the brain are intraorganic structures, and therefore the precise craniometry of their location in relation to the large derivatives of the DMB is important (Table 1).

Table 1

Craniotopographic characteristics of sinuous-liquor formations of the brain in the sagittal plane of mature people (in cm)

No.	Head shape / Research parameters	Dolichocephals		Mesocephals		Brachycephals	
		Male	Fem.	Male	Fem.	Male	Fem.
1	Height of the SSS clearance	1.0–1.5	1.0–1.5	1.1–1.3	1.0–1.3	1.0–1.2	0.9–1.2
2	Height of the cerebral falx	4.5–5.0	4.3–4.8	4.1–4.3	4.0–4.3	3.5–4.0	3.4–3.8
3	Height of the ISS clearance	0.9–1.1	0.8–1.0	0.7–0.9	0.7–0.9	0.6–0.8	0.6–0.8
4	Body height of the lateral ventricle	1.8–2.2	1.8–2.3	2.1–2.5	2.1–2.4	2.2–2.9	2.2–2.7

According to the data obtained by us, the height of the superior sagittal sinus (SSS) clearance in the middle third varies from 0.9 to 1.5 cm with a tendency to increase in people with a dolichocephalic head shape. The height of the cerebral falx ranges from 3.5 to 5.0 cm in men and from 3.4 to 4.8 cm in women, respectively, the height of the inferior sagittal sinus (ISS) clearance – from 0.6 to 1.1 cm and from 0.6 to 1.0 cm, also predominates in dolichocephals. This regularity leads to a gradual decrease in height indicators in people with meso –and brachycephalic head shapes.

It was established that, depending on the craniological points used, there are craniometric relationships between the SSS and the lateral ventricles (Table 2).

Table 2

Craniometric relationships of sinuous-liquor formations at the level of defined craniological points of mature people (in cm)

No.	Research parameters / Craniologic point		Metopion	Bregma	Inion	Opistho-cranion
1	Height of the SSS clearance	Male	0.3–0.6	0.4–0.7	0.8–1.0	0.9–1.5
		Female	0.3–0.5	0.4–0.7	0.7–0.9	0.9–1.3
2	Height of the cerebral falx	Male	1.5–1.9	1.8–2.1	2.3–2.6	3.0–3.8
		Female	1.4–1.8	1.7–2.0	2.2–2.5	2.9–3.6
3	Height of the ISS clearance	Male	0.2–0.5	0.3–0.5	0.4–0.7	0.5–0.8
		Female	0.2–0.4	0.2–0.5	0.4–0.7	0.4–0.8
4	Body height of the lateral ventricle	Male	1.7–2.0	2.0–2.9	2.0–2.6	2.3–2.9
		Female	1.6–1.9	1.8–2.4	2.0–2.4	2.2–2.7

Along with this, it was established that along the perimeter of the skull vault, along the sagittal line from front to back, there are changes in the craniometric relationships of the above structures of the brain. Thus, at the level of the metopion point, there is variability in the studied height parameters in men and women: the SSS clearance – from 0.3 to 0.6 cm; the cerebral falx – from 1.4 to 1.9 cm; the ISS – from 0.2 to 0.5 cm; the lateral ventricles – from 1.6 to 2.0 cm.

Using the bregma points for puncture, the following morphometric ratios of height dimensions can be distinguished: the SSS – 0.4–0.7 cm; the cerebral falx – 1.7–2.1 cm; the ISS – 0.2–0.5 cm; body of the lateral ventricle – 1.8–2.9 cm.

Similarly, at the level of the inion point: the SSS – 0.7–1.0 cm; the cerebral falx – 2.2–2.6 cm; the ISS – 0.4–0.7 cm; body of the lateral ventricle – 2.0–2.6 cm, respectively at the level of the opisthocranion point: the SSS – 0.9–1.5 cm; the cerebral falx – 2.9–3.8 cm; the ISS – 0.4–0.8 cm; body of the lateral ventricle– 2.2–2.9 cm.

The maximum allowable penetration depth of a puncture needle through the soft tissues of the brain in mature people is: through the metopion point – from 3.5 to 5.0 cm; bregma – from 4.2 to 6.1 cm; inion – from 5.3 to 6.9 cm; opisthocranion – from 6.4 to 8.5 cm.

The presented parameters of penetration of a puncture needle are conditional and depend on the configuration of the lateral ventricles and their departments, as well as on the pressure of the cerebrospinal fluid, which affects the height of the clearance of these structures.

It should be noted that a puncture of the anterior horns of the lateral ventricles can be performed through the metopion point; through the bregma point – the middle part of the lateral ventricles; through the inion point (opisthocranion) – the posterior horns of these ventricles.

It is known that it is better to puncture the lateral ventricles from the side, penetrating through the thickness of the parietal lobes of the brain. The obtained morphometric data have large oriented craniotopographical values.

It was established that there are characteristic morphometric data between the SSS and the parts of the lateral ventricles, taking into account the craniological points generally accepted in anthropology and craniology.

Thus, at the level of point **m** (metopion), the depth of the anterior horn of the lateral ventricle is in the range from 5.0 and 7.8 cm in men and from 5.0 and 7.2 cm in women. At the level of point **br** (bregma) in relation to the body of the lateral ventricle, this distance does not exceed 5.0–6.5 cm (men) and 5.0–6.1 cm (women). At the level of point **i** (inion), the posterior horn from the SSS wall is at the depth of 4.7 to 6.2 cm in men and 4.6 to 6.2 cm in women. Accordingly, this distance at the level of the craniological point **op** (opisthocranion) is in the range of 5.8–7.5 cm (men) and 5.7–7.3 cm (women).

The most important values of these distances are in mature people, taking into account the structure of the head. Consequently, in male dolichocephals, the maximum value of the location of the anterior horn of the lateral ventricles is from 6.0 to 7.8 cm and from 6.0 to 7.2 cm in women, taking into account the metopion point (m). At this level, the height of the SSS clerance reaches 0.3–0.6 cm. The minimum values of this distance for brachycephals of both genders are from 5.0 to 5.9 cm and from 5.0 to 5.6 cm. Intermediate options are usually found in mesocephals.

At the level of point **(br)**, which corresponds to the highest point of the cranial vault, the distance between the edge of the SSS and the central part of the body of the lateral ventricles ranges from 5.0 to 6.5

cm in men of mature age and from 5.0 to 6.4 cm in women. According to the extreme types of head structure: in dolichocephals this distance varies from 5.0 to 5.8 cm in men and from 5.0 to 5.3 cm in women; ranges from 5.2 to 5.6 cm and from 5.1 to 5.5 cm were found in mesocephals; in brachycephals – from 5.7 to 6.5 cm and from 5.6 to 6.4 cm. This is explained by the fact that in people with a brachycephalic form, an increase in the height of the cranial cavity is observed, which leads to a deeper location of the lateral ventricles.

At the level of the inion point **(i)**, the distance between the SSS and the posterior horn of the lateral ventricle also has individual differences. In male dolichocephals, this distance varies from 5.5 to 6.2 cm, in females – from 5.4 to 6.2 cm; in mesocephals it does not exceed 5.0-5.6 cm and 5.0–5.5 cm; in brachycephals it decreases to 4.7–5.2 cm (men) and to 4.6–5.3 cm (women).

The distance between the opisthocranion point (op) and the posterior horn of the lateral ventricle also has an individual difference. Thus, in men with a dolichocephalic head shape, this parameter ranges from 6.5 to 7.5 cm, in women – from 6.4 to 7.3 cm; mesocephalic form, respectively, from 6.2 to 6.7 and from 6.3 to 6.8 cm; brachycephalic form – from 5.8 to 6.4 and from 5.7 to 6.3 cm.

The obtained data were confirmed by variational statistical analysis.

It was established that the distance at the level of point m in dolichocephals is the most increased, which is evidenced by x = 6.91 cm, σ = 0.87, m = 0.34 (male) and x = 6.62 cm, σ = 0.77 , m = 0.48 (female). The average values are typical for mesocephals, in whom x = 6.57 cm, σ = 0.68, m = 0.28 (male) and x = 6.44 cm, σ = 0.59 and m = 0.41 (female). This distance decreases in brachycephals: x = 5.53 cm, σ = 0.81, m = 0.38 (male) and x = 5.29 cm, σ = 0.79, m = 0.51 (female).

A similar distance between the SSS and the lateral ventricles in mature people at the level of point br does not exceed in men with a dolichocephalic head shape x = 5.40 cm, σ = 0.73 and m = 0.38; in women – x = 5.17 cm, σ = 0.68 and m = 0.44. In people with a mesocephalic form – x = 5.48 cm, σ = 0.41 and m = 0.43 (men) and x = 5.26 cm, σ = 0.64 and m = 0.52 (women). In people with a brachycephalic head shape, this distance increases in men to x = 6.32 cm at σ = 0.73 and m = 0.47; in women – up to x = 6.22 cm at σ = 0.61 and m = 0.36.

Accordingly, there is a corresponding range of individual variability of the above distances at the level of the craniological point **i**. Thus, mature dolichocephalic men have a predominance of this parameter, confirmed by statistical indicators: x = 5.84 cm at σ = 0.82 and m = 0.28; in women – x = 5.66 cm at σ = 0.89 and m = 0.40. In mesocephals of both sexes, a decrease in distance is observed: x = 5.30 cm at σ = 0.76 and m = 0.32 (men) and x = 5.25 cm at σ 0.69 and m = 0.46 (women). The minimum value of the parameter is typical for brachycephals: x = 4.96 cm at σ = 0.58 and m = 0.30 (men) and x = 4.82 cm at σ = 0.46 and m = 0.36 (women).

The distance between the SSS and the posterior horn of the lateral ventricle in mature people slightly increases at the level of the craniological point **op**. It was established that in dolichocephals of both sexes it reaches x = 7.18 cm at σ = 0.59 and m = 0.32 (males) and x = 6.72 cm at σ = 0.63 cm and m = 0.42 (females); respectively, in mesocephals it does not exceed x = 6.52 cm at σ = 0.72 and m = 0.66 (males) and x = 6.40 cm at σ = 0.81 and m = 0.71. Brachycephals are characterized by a decrease in this distance, in the former, to x = 6.03 cm at σ = 0.48 and m = 0.52, in the latter, to x = 5.88 cm at σ = 0.51 and m = 0.44.

In the literature sources, there are still no clear ideas about the craniotopographic relationship between the venous and liquor collectors of the brain depending on age, gender, and extreme types of human head (skull) structure.

Only some scientific sources contain data on the morphological features of the location, shape, size, and relationship between individual brain vessels and components of the liquor system [1, 2, 5, 6].

In our study, for the first time, craniotopographic indicators of venous- liquor relationships in the sagittal plane in people of the first and second periods of mature age, based on the maximum permissible depth of its introduction. It is quite possible to use these data for a justified puncture in the cavity of the lateral ventricles and their components, based on the maximum allowable depth of its introduction.

It is necessary to take into account the practical need for puncture and catheterization of various formations of the liquor system of the brain and spinal cord [4]. We have established a range of craniototographic indicators that will allow correct orientation during surgical interventions.

The study of the components of the cardiovascular system (arterial and venous) is of great importance for modern morphology and clinical medicine [7].

Conclusions

1. Using the bregma point for puncture, the following morphometric ratios of height dimensions can be distinguished: the superior sagittal sinus – 0.4–0.7 cm; the cerebral falx – 1.7–2.1 cm; the inferior sagittal sinus – 0.2–0.5 cm; body of the lateral ventricle – 1.8–2.9 cm.

2. The maximum allowable penetration depth of a puncture needle through the soft tissues of the brain in mature people is: through the metopion point – from 3.5 to 5.0 cm; bregma – from 4.2–6.1 cm; inion – from 5.3 to 6.9 cm; opisthocranion – from 6.4 to 8.5 cm.

3. A puncture of the anterior horns of the lateral ventricles can be performed through the metopion point; through the bregma point – the middle part of the lateral ventricles; through the inion point (opisthocranion) – the posterior horns of these ventricles.

4. At the level of point m (metopion), the depth of the anterior horn of the lateral ventricle is in the range from 5.0 to 7.8 cm in men and from 5.0 to 7.2 cm in women. At the level of point br (bregma) in relation to the body of the lateral ventricle, this distance does not exceed 5.0–6.5 cm (men) and 5.0–6.4 cm (women). At the level of point i (inion), the posterior horn from the SSS wall is at a depth of 4.7 to 6.2 cm in men and 4.6 to 6.2 cm in women. Accordingly, this distance at the level of the craniological point op (opisthocranion) is in the range of 5.8–7.5 cm (men) and 5.7–7.3 cm (women).

5. The data obtained in our study can be used to substantiate the insertion of a puncture needle into the cavity of the lateral ventricles or their parts, based on the maximum allowable depth of its insertion.

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