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PROGNOSTIC CLINICAL AND INSTRUMENTAL MARKERS OF LIVER CIRCULATION DISORDERS IN CHILDREN

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Abstract: Disorders of cerebrospinal fluid circulation in children represent one of the most pressing problems in modern pediatric neurology and neurosurgery. According to epidemiological studies, the frequency of hydrocephalus in newborns is 0.5-4 cases per 1000 live newborns, while congenital forms account for up to 70% of all cases of cerebrospinal fluid disorders in childhood.

Key words: cerebrovasculation, hydrocephalus, intracranial pressure, children, prognostic markers, neuroimaging, magnetic resonance imaging, computed tomography, ultrasound, Doppler imaging, electroencephalography, cerebrospinal fluid, ventricular system.

Introduction. CSF is a complex physiological process that involves the production of cerebrospinal fluid in the vascular plexuses of the brain ventricles, its circulation through the cerebrospinal fluid pathways, and its resorption into the venous system through paxion granulation. In children, this process is characterized by age-related features related to the immaturity of the nervous system and the ongoing morphogenesis of brain structures.

Disorders of cerebrospinal fluid dynamics in childhood can be caused by various etiological factors: congenital anomalies in the development of the central nervous system, intrauterine infections, birth trauma, brain tumors, inflammatory diseases. Regardless of the cause, cerebrospinal fluid disorders lead to increased intracranial pressure, which can cause irreversible damage to brain tissue and serious neurological disorders.

Timely diagnosis and prediction of the course of cerebrospinal fluid disorders are crucial for choosing optimal treatment tactics and preventing the development of severe complications. Currently, a wide range of clinical and instrumental research methods are used to assess the state of the cerebrospinal fluid system, including neuroimaging, neuro-physiological studies, laboratory diagnostics, and intracranial pressure monitoring. It is especially difficult to predict the course of the disease in young children, when the clinical manifestations may be absent or nonspecific. Under these conditions, the importance of objective instrumental diagnostic methods increases, allowing for the detection of early signs of cerebrospinal fluid decompensation and assessing the effectiveness of the ongoing treatment**.**

Modern neural imaging methods, such as contrasting magnetic resonance imaging, computed tomography, and brain ultrasound, allow for detailed assessment of the morphological changes in the cerebrospinal fluid system and the surrounding brain structures. Functional research methods, including cerebral vascular dopplerography, electroencephalography, and induced potentials, allow for the assessment of the functional state of the nervous system. The integration of clinical data with the results of modern instrumental studies opens up new possibilities for developing prognostic models that allow predicting the course of the disease, the effectiveness of various treatment methods, and long-term outcomes. This is especially important for determining indications for surgical treatment and choosing the optimal time for neurosurgical interventions.

Despite significant progress in the diagnosis and treatment of cerebrospinal fluid disorders, many issues of disease progression prognosis remain unresolved. There is no unified approach to assessing the prognostic significance of various clinical and instrumental parameters, and the age-related characteristics of prognostic factors in children of different age groups have not been sufficiently studied.

The relevance of this study is due to the need to develop a comprehensive system of prognostic markers based on the integration of clinical and instrumental data, which will optimize the management tactics of children with cerebrovascular disorders and improve the long-term outcomes of the disease.

The purpose of the study was to study the comparative analysis of clinical, neurosonographic, and tomographic data in children with cerebrospinal fluid disorders.

Research material and methods. The study included 49 children aged 6 months to 7 years with a diagnosis of hydrocephalus who were examined and treated in the pediatric neurology and neurosurgery departments of the multidisciplinary clinic of Samarkand State Medical University during the period 2023-2025. The average age of the examined children was 2.9±1.8 years. The inclusion criteria in the study were: the presence of congenital or acquired hydrocephalus (obstructive, communicating, or mixed form), confirmed by clinical and instrumental methods; the presence of informed consent of parents or legal representatives. Exclusion criteria were: combined severe developmental defects of the central nervous system incompatible with life; tumor processes of the CNS; pronounced somatic diseases that prevent comprehensive examination. By age, children were distributed as follows: from 6 months to 1 year - 21 children (42.9%); from 1 year to 3 years - 16 children (32.7%); from 3 to 7 years - 12 children (24.4%). By gender, the study group (main) consisted of 28 boys (57.1%), 21 girls (42.9%). Taking into account the etiological factors of hydrocephalus, patients were distributed as follows: congenital malformations of the cerebrospinal fluid pathways were identified in 17 children (34.7%); consequences of perinatal hypoxic-ischemic CNS damage in 14 children (28.6%); intraventricular hemorrhages and their consequences in 9 children (18.4%); post-infectious changes (meningitis, meningoencephalitis) in 6 children (12.2%); post-traumatic hydrocephalus in 3 children (6.1%).

According to the form and level of cerebrospinal fluid disorders, obstructive hydrocephalus was diagnosed in 20 children (40.8%), reported in 18 children (36.7%), mixed form in 11 children (22.5%). Predominant dilation of the lateral ventricles was noted in 31 children (63.3%), combined dilation of the lateral and third ventricles in 12 children (24.5%), and generalized dilation of the ventricular system in 6 children (12.2%). The control group consisted of 28 conditionally healthy children, comparable in age and gender to the main group, who underwent a preventive examination in outpatient settings, without clinical and instrumental signs of central nervous system pathology.

All children in the main group underwent a comprehensive examination, including clinical-neurological, instrumental, and additional research methods. Clinical and neurological examination included collecting a history with analysis of prenatal, perinatal, and postnatal periods, assessing neurological status (consciousness level, muscle tone, presence of convulsive syndrome, pyramidal symptoms, eye movement disorders), and assessing cognitive and psychomotor development. Additionally, an assessment of somatic status and anthropometric indicators was conducted, including measurements of head circumference, height, and body mass, with a comparison of age-related standards. Neurosonography was performed in young children transcranially through the open fontanelles, measuring the size of the lateral, third, and posterior ventricles, calculating the ventriculomegaly index, and assessing the structure of the periventricular zones. Particular attention was paid to identifying comorbid changes such as cysts, intraventricular hemorrhages, and signs of periventricular leukomalacia. Brain computed tomography was used to clarify the form of hydrocephalus, assess the degree of ventricular system dilation, the condition of subarachnoid spaces, and identify associated structural changes, including cortical atrophy, congenital malformations, and the consequences of traumatic or hemorrhagic lesions. In a number of cases, according to clinical

indications, magnetic resonance imaging of the brain was performed to more thoroughly assess the nature of cerebrospinal fluid dynamics disorders and clarify the associated pathology. In addition, all patients underwent ophthalmological examination with ophthalmoscopy and assessment of the condition of the optic nerves to identify signs of intracranial hypertension. Consultations were conducted with related specialists, including a pediatrician, neurosurgeon, ophthalmologist, and, if necessary, a geneticist.

Statistical processing of the obtained data was carried out using standard methods of variation statistics, on an individual computer. Student's t-test and $\chi 2$-test were used to assess intergroup differences. The correlation analysis was performed using Pearson's coefficient. Differences were considered statistically significant at a significance level of $p<0.05$.

Research results. Analysis of clinical data showed that in children with cerebrospinal fluid disorders, the clinical picture varied significantly depending on age. In the group of children aged 6 months to 1 year, the leading clinical manifestations were delayed psychomotor development, increased excitability, restlessness, and increased head circumference. Delayed psychomotor development was detected in more than half of children in this age group, reflecting the negative impact of intracranial hypertension on early neurodevelopmental processes. Vomiting and regurgitation were observed mainly in children of the first year of life and were considered as manifestations of decompensation of cerebrospinal fluid dynamics.

In the age group from 1 to 3 years, clinical symptoms became more pronounced. Along with persistent delayed psychomotor development, most children experienced headaches, restlessness, sleep disturbances, and episodes of nausea and vomiting. In this group, an increase in general cerebral symptoms was noted, which indicated the progression of cerebrospinal fluid dynamics disorders and an increase in intracranial pressure.

In children aged 3-7, the clinical picture was distinguished by the predominance of cephalgic syndrome, decreased attention concentration, fatigue, and behavioral disorders. Headache was the leading symptom and was registered significantly more often compared to younger age groups. In a number of cases, complaints of decreased school adaptation were noted, which emphasizes the long-term consequences of chronic cerebrospinal fluid disorders.

According to neurosonography performed on young children, ventriculomegaly was detected in most examined individuals, with the most pronounced dilation of the lateral and third ventricles observed in children under 3 years of age. The ventriculomegaly index exceeded age norms, confirming the presence of intracranial hypertension. A significant portion of patients, according to NSG data, also exhibited concomitant changes in the form of periventricular zones of increased echogenicity, cystic formations, and intraventricular hemorrhages, especially in children with congenital forms of hydrocephalus.

Computed tomography, performed primarily in children over 3 years of age, allowed for a detailed examination of the nature of the cerebrospinal fluid disorders. According to CT data, some patients were diagnosed with obstructive form of hydrocephalus, caused by impaired cerebrospinal fluid outflow at the level of the cerebral aqueduct or posterior cranial fossa. In other children, the communicating form of hydrocephalus prevailed, characterized by a uniform expansion of the ventricular system and subarachnoid spaces. In some cases, a mixed form of hydrocephalus was identified. Also, according to CT data, signs of cortical atrophy and expansion of subarachnoid spaces were noted, especially in children with a prolonged course of the disease.

Comparative analysis of age groups showed that in young children, clinical manifestations are less specific and are more often represented by developmental delays and general cerebral symptoms, while in older children, a more typical clinical picture is formed with a predominance of headaches and cognitive impairments. Neurosonography proved to be the most informative method for early detection of cerebrospinal fluid disorders, while computed tomography made it possible to clarify the

form and degree of hydrocephalus in older children and determine the tactics for further management of patients.

To assess the prognostic significance of clinical, neurosonographic, and tomographic indicators in children with cerebrospinal fluid disorders, a ROC analysis (Receiver Operating Characteristic) was conducted. The presence of moderate to severe hydrocephalus, accompanied by progressive neurological symptoms and pronounced structural changes in the ventricular system, was considered an unfavorable prognostic outcome.

During the analysis, it was established that the clinical signs of intracranial hypertension (vomiting, increasing anxiety, delayed psychomotor development) have a moderate prognostic value (AUC=0.71; 95% CI 0.63-0.79), which indicates their limited independent diagnostic informativeness in predicting disease progression. Neurosonography indicators demonstrated higher prognostic significance. Thus, the ventriculomegaly index had high sensitivity and specificity in predicting the unfavorable course of cerebrospinal fluid disorders (AUC=0.82; 95% CI 0.75-0.89). Expansion of the third ventricle was also characterized by a good discriminatory ability (AUC=0.79; 95% CI 0.71-0.86), especially in children under 3 years of age. The highest values of the area under the ROC curve were obtained for tomographic indicators. The degree of ventricular system dilation according to CT data had a high prognostic value (AUC=0.88; 95% CI 0.82-0.94), which allows for a high probability of differentiating patients with a favorable and unfavorable clinical course. The obstructive nature of hydrocephalus according to CT data was also associated with an unfavorable prognosis (AUC=0.85; 95% CI 0.78-0.92). A comprehensive model, including clinical signs of intracranial hypertension, neurosonography indicators, and tomographic data, demonstrated the highest prognostic efficacy (AUC=0.91; 95% CI 0.86-0.96), which indicates the expediency of an integrated approach to assessing cerebrospinal fluid dynamics disorders in children. Thus, the conducted ROC analysis showed that neurosonographic and tomographic indicators have the greatest prognostic value, while clinical signs enhance diagnostic and prognostic accuracy when used comprehensively.

The conducted ROC analysis demonstrated the high prognostic value of instrumental methods for assessing cerebrospinal fluid dynamic disorders in children. Tomographic indicators reflecting the degree of ventricular system dilation according to CT data (AUC=0.91) had the greatest diagnostic value, which indicates their high sensitivity and specificity in predicting clinically significant forms of hydrocephalus. Neurosonography indicators, in particular the ventriculomegaly index and the size of the third ventricle, were also characterized by high prognostic informativeness (AUC>0.80), which emphasizes their value as a screening and dynamic method in young children. Clinical assessment, despite its moderate prognostic ability (AUC=0.74), retains its significance as a mandatory component of comprehensive examination and interpretation of these instrumental methods.

Conclusion. A comprehensive analysis of clinical, neurosonographic, and tomographic data allows for an objective assessment of the severity of cerebrospinal fluid disorders in children. The conducted ROC analysis showed the high prognostic value of key instrumental indicators, especially when used in combination, which emphasizes the value of an integrative approach for early diagnosis and prognosis of the disease course.

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