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MAGNETIC RESONANCE IMAGING IN THE EVALUATION OF HYDROCEPHALUS

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Abstract. *Hydrocephalus is a pathological condition characterized by the accumulation of excess cerebrospinal fluid in the ventricles of the brain. This disease occurs in adults and children of any age and is associated with a violation of one of the mechanisms of cerebrospinal fluid circulation. This may be due to impaired fluid reabsorption or increased fluid production. Currently, magnetic resonance imaging (MRI) is the most effective method for the early diagnosis of hydrocephalus. Hydrocephalus is one of the most common diseases with a violation of the cerebrospinal fluid of the brain, and MRI is the most convenient and effective method for diagnosing any of its stages.*

Key words: *hydrocephalus, magnetic resonance diagnostics, magnetic resonance imaging criteria.*

МАГНИТНО-РЕЗОНАНСНАЯ ТОМОГРАФИЯ В ОЦЕНКЕ ГИДРОЦЕФАЛИИ

Аннотация. *Гидроцефалия — патологическое состояние, характеризующееся накоплением избыточного количества спинномозговой жидкости в желудочках головного мозга. Это заболевание встречается у взрослых и детей любого возраста и связано с нарушением одного из механизмов ликворного кровообращения. Это может быть обусловлено нарушением реабсорбции жидкости или ее повышенной продукцией. В настоящее время магнитно-резонансная томография (МРТ) является наиболее эффективным методом ранней диагностики гидроцефалии. Гидроцефалия — одно из самых распространенных заболеваний с нарушением ликворного кровообращения головного мозга, а МРТ — наиболее удобный и эффективный метод диагностики любой ее стадии.*

Ключевые слова: *гидроцефалия, магнитно-резонансная диагностика, критерии магнитно-резонансной томографии.*

Introduction.

Hydrocephalus is a condition characterized by brain atrophy due to excessive accumulation of cerebrospinal fluid (CSF) in the brain's ventricles, cisterns, and subarachnoid spaces. Hydrocephalus is one of the most common neurological disorders in children. Its prevalence in newborns is 0.1-0.4%, in inflammatory and degenerative nervous system diseases — 15-25%, postnatally and after traumatic brain injuries — 30-40%, and in brain tumor cases — 75%.

The fluid continuously circulating in the brain is cerebrospinal fluid (CSF). It fills the brain's ventricles, the channels connecting them, and the subarachnoid space. CSF protects the cerebral hemispheres, pituitary gland, and other brain structures from mechanical impacts and serves as an immunobiological barrier, preventing toxins, microorganisms, and viruses from entering brain tissue. Additionally, CSF participates in metabolic processes and maintains electrolyte and acid-base balance.

However, hydrocephalus develops if the amount of CSF increases or its outflow is obstructed. Hydrocephalus can be congenital or acquired. The congenital form often presents during pregnancy. Newborns with impaired CSF circulation typically exhibit an abnormally large head circumference along with delayed physical and neuropsychological development. In infants and young children, the symptoms are usually evident, with a noticeably enlarged skull. Normally, an infant’s head grows about 1.5 cm per month, but exceeding this rate may be a warning sign.

In adults, increased CSF volume in the cranial cavity does not lead to skull enlargement. Instead, it often results in increased intracranial pressure, manifesting as persistent headaches, often worsening in the early morning. However, similar symptoms can be observed in other conditions such as intracranial hematomas, cysts, tumors, and congenital disorders like Dandy-Walker syndrome. Therefore, the diagnosis requires confirmation through imaging studies such as MRI.

Magnetic Resonance Imaging (MRI) is the most informative and safe method for diagnosing hydrocephalus, assessing severity, and determining treatment strategies. MRI can effectively reveal various forms and stages of hydrocephalus, confirmed by lateral ventricle enlargement, periventricular edema, and hypothalamic displacement. External hydrocephalus is identified by CSF accumulation in the meningeal layers.

For precise diagnosis, MRI with a power of at least 1.5 Tesla is recommended, allowing detailed sectional imaging and identification of structural enlargement. Radiological criteria for assessing hydrocephalus severity include ventricular enlargement (Evans index > 0.3), decreased

distance between the mammillary body and upper pons border, and hyperintensity in T2 and T2-FLAIR sequences indicating interstitial edema. 3D T2-CUBE imaging helps exclude obstructive hydrocephalus.

Literature Review and Methodology.

According to scientific studies, MRI is the most informative method for the early diagnosis of hydrocephalus, both in the antenatal period and in children of various age groups. MRI allows not only the identification of the type and severity of ventriculomegaly but also the level of obstruction and the etiology of the condition . MRI is also highly informative in diagnosing perinatal traumatic and hypoxic-ischemic central nervous system injuries, early stages of periventricular edema, obstructive processes in the posterior parts of the third ventricle, as well as pathologies of the cerebral aqueduct and cerebrospinal fluid flow.

According to many authors, the long-term prognosis of hydrocephalus depends on numerous factors, including the etiology of the condition, the rate and severity of ventricular dilation, comorbid pathologies, and the specifics of surgical treatment. Emphasizing the negative impact of prolonged initial ventriculodilation, the authors stress the importance of timely surgical intervention, which can improve the prognosis even in severe cases of ventriculomegaly . The importance of assessing the posterior cranial fossa, including the brainstem, is also highlighted .

MRI technology continues to evolve. For example, scientists have developed an algorithm capable of analyzing children's brain scans and detecting ventricular enlargement.. The researchers used a color neural network, specifically the U-net network, to segment the brain's ventricles and adapt it to MRI scans. The model operates on a "coder-decoder" principle: the coder breaks down the image into low-level abstract features, while the decoder reconstructs these features into a fully segmented image, where each pixel corresponds to a specific part of the brain's ventricles.

Discussion.

When diagnosing the condition, it is essential to consider the dynamics of pathological changes. For example, a single MRI scan showing ventricular enlargement does not yet indicate hydrocephalus. In many cases, this sign may resolve on its own. However, if follow-up studies conducted at several-month intervals reveal worsening conditions, it becomes a different matter. Only in such cases can the diagnosis be confirmed. If the ventricular size increases but remains stable, treatment is generally not required.

The traditional classification of hydrocephalus includes its division into open and closed, external and internal, acute and chronic, compensated and decompensated forms. Each form is

characterized by specific structural changes in the brain. MRI can differentiate between types of hydrocephalus, determine the cause and degree of obstruction, and identify the stages of the pathological process.

The stages of hydrocephalus treatment include:

Acute hydrocephalus. This requires urgent surgical intervention aimed at reducing the volume of CSF in the ventricles and lowering intracranial pressure. This often involves ventricular drainage to remove excess fluid.

Chronic hydrocephalus. Often treated with a valve-shunt surgery, which creates an artificial pathway for CSF drainage.

Conservative therapy. Used only in cases of minor hemorrhages or when there is no significant inflammatory process.

Results.

According to the obtained MRI images, a "gold standard" exists for the diagnosis of hydrocephalus, which allows for the identification of:

- the type and severity of hydrocephalus;
- the degree of obstruction of cerebrospinal fluid pathways;
- deformation of the ventricular system and subarachnoid spaces;
- the level of cerebrospinal fluid circulation decompensation;
- the etiology of the disease.

Obstructive Hydrocephalus in the Sylvian Aqueduct.

MRI findings in a patient with obstructive hydrocephalus revealed:

a) In T2-FLAIR mode: significant enlargement of the lateral ventricles (Evans index 0.36) and increased signal intensity in the periventricular white matter, indicating interstitial brain edema.

b) In FIESTA-C mode, sagittal projection: aqueductal stenosis as the primary cause of lateral and third ventricular enlargement.

Open Hydrocephalus on MRI.

In sagittal projection using the 3D T2-CUBE sequence:

- pronounced dilation of all ventricular parts, including the Sylvian aqueduct,

low signal intensity due to accelerated CSF flow,

- reduced signal intensity in the fourth ventricle and major brain cisterns.

Colloid Cyst of the Third Ventricle and Obstructive Decompensated Hydrocephalus.

On MRI in T2-FLAIR mode, axial projection:

- around mass located in the projection of the Monro foramina,
- significant enlargement of the lateral ventricles,
- periventricular edema.

In children over one year old and in adults, MRI results should be used to assess the condition of the ventricular system and cerebrospinal fluid flow for accurate diagnosis. MRI imaging helps determine ventricular size and identify factors obstructing CSF flow.

Conclusion.

Early diagnosis of hydrocephalus plays a crucial role in symptom relief, improving quality of life, preventing complications, and determining long-term outcomes, including metabolic, cardiovascular, and psychosocial factors. MRI helps accurately diagnose the disease in its early stages and assists in developing a treatment strategy.

Modern MRI capabilities have significantly expanded, enabling not only the identification of the disease's stage but also its cause, location, and the presence of comorbid conditions. Detecting the specific signs of hydrocephalus using MRI is now performed without difficulty, allowing for identification even in the initial stages of the disease's progression.

Early detection and an individualized approach to treating patients with hydrocephalus are essential for selecting appropriate treatment strategies and predicting the course of the disease.

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