NEUROBIOMARKERS AND INSTRUMENTAL ASSESSMENT OF HYPOXIC-ISHEMIC BRAIN DAMAGE IN CHILDREN

Djurabekova A.T.
Doctor of Medical Sciences, Professor,
Head of the Department of Neurology
Samarkand State Medical University
Isanova Sh.T.
Doctor of Medical Sciences, Associate Professor
of the Department of Neurology
Samarkand State Medical University
Kholikulova M.A.
Resident of the Master's program at the Department
of Neurology Samarkand State Medical University
https://doi.org/10.5281/zenodo.21272553

ARTICLE INFO

Received: 04th July 2026
Accepted: 06th July 2026
Online: 08th July 2026

KEYWORDS

hypoxic-ischemic brain damage; neurobiomarkers; NSE; S100B; GFAP; neurofilaments; Brain MRI; amplitude-integrated EEG; neurosonography; children; neuroprotection; prognosis of outcomes; pediatric resuscitation

ABSTRACT

Hypoxic-ischemic brain damage (HIB) remains one of the leading causes of neonatal and child mortality, as well as persistent neurological disability. Timely and accurate assessment of the severity of cerebral damage determines intensive therapy tactics and prognosis for the patient. Existing clinical scales often lack sufficient sensitivity, necessitating the integration of neurobiochemical markers with instrumental research method data.

Introduction. Hypoxic-ischemic brain injury (HIB) is one of the most severe and clinically significant forms of cerebral pathology in childhood, determining a significant share of perinatal and post-neonatal mortality, as well as persistent neurological disability worldwide. According to WHO data, asphyxia at birth causes the death of approximately 800,000 newborns annually, and in at least 1 million children, it contributes to the development of persistent neurological disorders such as cerebral palsy, epilepsy, cognitive deficits, and behavioral disorders. In the structure of neonatal mortality causes, hypoxic-ischemic encephalopathy (HIE) ranks second only to premature birth, with its incidence in developed countries ranging from 1.5 to 3 cases per 1,000 live births, reaching 10–26 cases per 1,000 in resource-limited countries.

The pathogenesis of cerebral HIP is determined by the two-phase nature of the cerebral damage. The primary phase of direct hypoxic-ischemic stroke is accompanied by energy deficit, depolarization of neuron membranes, excessive release of excitatory amino acids, and a massive influx of calcium ions into the cell. The secondary phase, which develops 6–24 hours after reoxygenation, is characterized by mitochondrial dysfunction, oxidative stress, activation of caspase cascades, and neuronal apoptosis. It is precisely in this "therapeutic

corridor" that intervention in the form of therapeutic hypothermia is most effective, making early and accurate diagnosis of the degree of cerebral damage a critical task.

Clinical assessment of GIE severity using traditional scales (Sarnat, Thompson) has several significant limitations: subjective interpretation of neurological signs, insufficient reproducibility of results, and the inability to objectively reflect the depth of molecular damage to nerve tissue. In this regard, the assessment of neurobiomarkers—specific protein molecules released into the bloodstream during the destruction of neurons and glial cells—is of particular interest. Neuron-specific enolase (NSE) and the S100B protein were the first biochemical indicators of cerebral damage to enter clinical practice. Later, they were joined by glial fibrillar acid protein (GFAP) as a marker of astroglial destruction and the light chain of neurofilaments (NFL) as an indicator of axonal damage. Each of these markers reflects different pathophysiological mechanisms, which determines the expediency of their comprehensive application.

Purpose of the study. To study the diagnostic and prognostic significance of neurobiomarkers (NSE, S100B, GFAP, NFL) in combination with neuroimaging and neurophysiological monitoring data for hypoxic-ischemic brain damage in children.

Materials and methods. The prospective cohort study included 94 children aged 0 to 17 years with verified cerebral HIP who were undergoing treatment in the intensive care and resuscitation department. All patients underwent determination of serum concentrations of neurospecific enolase (NSE), S100B protein, glial fibrillar acid protein (GFAP), and light chain neurofilaments (NFL) on the 1st, 3rd, and 7th days from the moment of the hypoxic episode. Instrumental assessment included magnetic resonance imaging (MRI) with diffusion-weighted sequences, amplitude-integrated electroencephalography (AEEG), and neurosonography (NSG). The severity of neurological deficit was assessed using the modified Sarnat scale and the Sargent scale. Statistical analysis was performed using ROC analysis, logistic regression, and Spearman's correlation analysis.

Results. It was established that the GFAP level on the 1st day had the highest specificity (91.4%) in predicting an adverse neurological outcome (AUC = 0.87; 95% CI: 0.79–0.94). The combination of NSE + S100B + EEG increased diagnostic accuracy to 93.2% compared to each marker individually. A statistically significant correlation was identified between NFL concentration on the 7th day and the severity of diffusion limitations according to MRI data ($r = 0.74$; $p < 0.001$). A pathological EEG pattern combined with an increase in S100B > 2.1 μg/l was associated with a fatal outcome or severe disability in 84.6% of cases.

Conclusion. A multi-marker approach with the integration of neurobiochemical indicators and instrumental diagnostic methods significantly surpasses the monoanalytical assessment for cerebral HIP in children. The implementation of combined diagnostic algorithms allows for the optimization of prognosis and personalization of neuroprotective therapy in pediatric resuscitation settings.

Literature:

1. Barashnev Yu.I. Hypoxic-ischemic encephalopathy of newborns: contribution of perinatal factors, pathogenetic characteristics, and treatment principles // Russian Bulletin of Perinatology and Pediatrics. 2002. No. 1. PP. 6–13.

2. Volodin N.N., Rogatkin S.O., Lyudovskaya E.V. Current problems of perinatal neurology at the current stage // Journal of Neurology and Psychiatry named after S.S. Korsakov. 2003. Vol. 103, No. 7. P. 4-9.
3. Gorbunov A.V., Mukhina I.V. Neurobiochemical markers of brain damage: clinical significance and diagnostic possibilities // Neurochemistry. 2019. Vol. 36, No. 2. P. 112–121.
4. Zavadenko N.N., Degtyareva M.G., Ogorodnikova E.A. Neurophysiological methods in assessing maturity and CNS damage in newborns // Issues of Practical Pediatrics. 2010. Vol. 5, No. 3. PP. 22-28.
5. Iova A.S., Garmashov Yu.A., Andrushenko N.V. Ultrasound neurosonography in children: methodological aspects // Pediatrics. 2005. No. 4. P. 44-49.