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Original Research Article

The value of ultrasonography and Doppler sonography in prognosticating long-term outcomes among full-term newborns with perinatal asphyxia

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ABSTRACT

Background and objective: The aim of the study was to determine the correlation of hypoxic-ischemic (HI) brain injury in full-term neonates detected via ultrasonography (USG) and blood flow parameters evaluated via Doppler sonography (DS) with long-term outcomes of mental and neuromotor development at the age of 1-year.

Materials and methods: In total, 125 full-term neonates (78 subjects of case group and 47 subjects of control group) were studied. During the first five days of life, the subjects daily underwent cerebral USG and DS. At the age of 1-year the neuromotor condition and mental development was evaluated.

Results: The HI injury groups detected during USG significantly correlated with the mental development groups ($r = 0.3$; $P = 0.01$) and the neurological evaluation groups ($r = 0.3$; $P < 0.001$). In the presence of brain swelling (edema) and thalamus and/or basal ganglia (E/T/BG) injury, USG demonstrated high accuracy values when prognosticating spastic quadriparesis and severe mental development impairment in 1-year-old subjects: sensitivity – 100%, specificity – 93–100%, positive predictive value (PPV) – 60–100%, and NPV – 100%.

In subjects with spastic quadriparesis, mean end-diastolic velocity (Vd) values were significantly higher ($P \leq 0.05$), and mean resistive index (RI) values were significantly lower

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($P < 0.05$) than those in subjects with normal neuromotor development. In subjects with severe mental retardation, mean Vd values in ACA were statistically significantly higher, and mean RI values in ACA and ACM were statistically significantly lower than those in subjects with normal mental development.

Conclusions: Hypoxic-ischemic brain changes detected during ultrasonography and cerebral blood flow parameters associated with long-term outcomes of mental and neuromotor development at the age of 1-year.

1. Introduction

Perinatal asphyxia is one of the most common causes of neonatal morbidity and mortality in most countries of the world. Perinatal asphyxia results in hypoxic-ischemic brain injury, whose long-term outcomes include severe disability (impaired mental and motor development, cortical blindness, sensorineural hearing loss, epilepsy, and cerebral palsy) and death. Early diagnostics of hypoxic-ischemic brain injury would help to identify neonates who require early rehabilitation for the improvement of long-term outcomes and the reduction of disability. In clinical practice, hypoxic-ischemic brain injury in neonates is usually diagnosed via ultrasonography. Nevertheless, data on the associations between hypoxic-ischemic brain injury detected via ultrasonography (USG) in full-term neonates and late psycho-motor development outcomes are scarce [1,2]. Literature for the last 5-years recommends magnetic resonance tomography and spectrography as the principal techniques for the diagnostics of hypoxic-ischemic brain injury in full-term neonates [3–6]. However, a number of researchers indicated that in daily practice, less sophisticated and more readily available radiological examination techniques – ultrasonography and Doppler sonography – should be used, although the prognostic abilities of these techniques are under-researched [7–9]. It has been proven that impaired cerebral blood circulation plays the main role in the pathogenesis of hypoxic-ischemic brain injury in neonates, yet studies conducted so far have been insufficient to explain how changes in blood circulation parameters are related to long-term outcomes. The aim of the study was to determine the correlation of hypoxic-ischemic (HI) brain injury in full-term neonates detected via ultrasonography (USG) and blood flow parameters evaluated via Doppler sonography (DS) with long-term outcomes of mental and neuromotor development at the age of 1-year.

2. Materials and methods

This prospective case–control study was conducted at the Clinic of Neonatology, Hospital of Lithuanian University of Health Sciences, from April 2008 to June 2011. The studied group consisted of 78 full-term (≥37 weeks of gestation) neonates who suffered from hypoxia or asphyxia during birth. The control group consisted of healthy full-term neonates born at the Clinic of Obstetrics and Gynecology, Hospital of Lithuanian University of Health Sciences.

The inclusion criteria for the case group neonates were as follows: full-term (≥37 weeks of gestation) neonates born with perinatal hypoxia or asphyxia required resuscitation, Apgar score at 5 min after birth ≤7 points, fetal acidosis (umbilical artery blood pH < 7.2) [10] or neonatal acidosis (capillary blood pH within the first hour after birth < 7.3) [11].

The exclusion criteria for the case group neonates were as follows: full-term (≥37 weeks of gestation) neonates with congenital developmental or chromosome abnormalities, hemolytic disease of the newborn, congenital brain infection or severe sepsis with hemodynamic disturbances, or suspected metabolic diseases.

The inclusion criteria for the control group neonates were as follows: full-term (≥37 weeks of gestation) neonates who did not require resuscitation, Apgar score on the first and the fifth minute of life ≥8 points, and no neonatal pathologies.

The structure of the study is presented in Fig. 1. The characteristics of the subjects are presented in Table 1.

2.1. *Hypoxic-ischemic encephalopathy (HIE) clinical evaluation*

The neurological status was evaluated every day for the first three days of life. The HIE stage was evaluated using the modified Sarnat and Sarnat scale [12].

2.2. *Brain ultrasonography*

During the first days of life, every subject underwent once-daily brain scanning conducted by an experienced sonographer operating a digital ultrasound device Xario SSA-660A (Toshiba) with a sector 5–9 mHz transducer, and a linear 7–14 mHZ transducer. Brain structures were visualized using acoustic windows: the frontal, the occipital, the temporal, and the mastoid fontanelles. The brain was evaluated in the anterior, the posterior, the lateral, the diagonal, and the axial planes. In this study, we evaluated anatomical brain structures, brain maturity, echogenicity ratio between the cortex and the white matter, echogenicity of the cortex, echogenicity and homogeneity of the white matter, echogenicity and homogeneity of the basal nuclei (thalamus and basal ganglia), the ventricle system (size, contour, and echogenicity of the cerebrospinal fluid), subarachnoid space width, midline position, structures of the posterior cranial fossa and their