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FACTORS ASSOCIATED WITH HEARING IMPAIRMENT IN INFANTS WHO RECEIVED THERAPEUTIC HYPOTHERMIA

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Summary

Birth asphyxia and hypoxic-ischemic encephalopathy (HIE) are among the leading causes of neonatal brain injury. Therapeutic hypothermia (TH) reduces the risk of death or severe disability at 18-24 months of age in infants with severe asphyxia. However, a significant proportion of survivors remain at higher risk of long-term complications, including hearing impairment. Currently, the incidence of hearing disorders in children after TH, considering various technical modalities, remains insufficiently studied. Therefore, this study aimed to determine the frequency of hearing impairment in infants treated with TH simple cooling methods and to identify risk factors for sensorineural hearing loss (SNHL) in infants with HIE.

Materials and methods. *A retrospective cohort clinical study was conducted, comprising 82 infants in their first year of life (51 males [72.2%] and 31 females [37.8%]) who experienced severe birth asphyxia and underwent therapeutic hypothermia (systemic hypothermia utilizing simple cooling methods) between 2020 and 2023. Inclusion criteria were defined as follows: therapeutic hypothermia administered postnatally according to established indications (gestational age ≥35 weeks; evidence of perinatal depression [Apgar score <6 at 10 minutes postpartum or requirement for primary resuscitation lasting ≥10 minutes]; presence of moderate-to-severe hypoxic-ischemic encephalopathy [as classified by the modified Sarnat staging system] within 1-6 hours after birth). Exclusion criteria encompassed: gestational age <35 weeks, congenital malformations, confirmed genetic abnormalities, progressive obstructive ventriculomegaly, previous central nervous system infections, and neonatal hemolytic disease. A three-phase audiological screening protocol was implemented (initial two phases employing transient evoked otoacoustic emissions, followed by comprehensive diagnostic audiometry in the third phase). Statistical analyses included methods for evaluating dichotomous outcomes (two-tailed Fisher's exact test, χ^2 test), comparison of continuous variables between independent cohorts, and nonparametric analyses for small sample sizes (Mann-Whitney U test). The predetermined significance threshold (α-level) for all analyses was $p < 0.05$.*

This investigation was conducted as part of the Department of Pediatrics and Neonatology's research initiative entitled «Diagnostic and Therapeutic Approaches to Pediatric Disorders: A Patient Safety Perspective» (State Registration No. 0121U114304). The study protocol received ethical approval from the Dnipro State Medical University's Ethics Committee.

Results. *Adverse outcomes of hypoxic-ischemic injury, manifested as destructive cerebral tissue changes and diagnosis of cerebral palsy, were observed in 6 cases (7.3%). Abnormal otoacoustic emission results during the second screening phase were detected in 7 infants (8.5%). Sensorineural hearing loss (SNHL) was diagnosed in 6 patients (7.3%), with these findings demonstrating no statistically significant divergence from comparative studies where therapeutic hypothermia with simple cooling methods was not specified ($p > 0.05$). Among SNHL cases, 4 exhibited post-ischemic cerebral lesions while 2 demonstrated moderate lateral ventricular dilatation. Infants with SNHL required significantly prolonged respiratory support (8 (4-26; 7-14) vs. 14.5 (13-29; 13.5-22) days, $p < 0.05$), extended intensive care unit hospitalization (25 (9-106; 19-33) vs. 29 (15-85; 21-37) days, $p < 0.05$), and delayed initiation of oral feeding (7 (2-25; 5-9) vs. 19 (11-22; 19-21) days, p* **< 0.1).** *This cohort demonstrated significantly elevated incidence rates of primiparous delivery (p* **< 0.05***), cesarean delivery requirement, cardiopulmonary resuscitation with cardiac massage and medication administration during initial stabilization, need for postpartum hemodynamic support, and neonatal sepsis occurrence. A markedly higher prevalence of short-term adverse outcomes from asphyxia and hypoxic-ischemic encephalopathy at discharge was documented (2.7% vs. 66.7%, $p < 0.05$).*

Conclusions. *The incidence of auditory impairment following therapeutic hypothermia utilizing simple cooling methods demonstrated no significant variation from studies employing unspecified cooling techniques. Principal risk factors for hearing dysfunction included severity of birth asphyxia, degree of postnatal clinical compromise, extent of cerebral tissue injury, and occurrence of postnatal infectious complications.*

Keywords: *Asphyxia, Hypoxic-Ischemic Encephalopathy, Therapeutic Hypothermia, Hearing, Risk Factors, Neonates, Infants.*

Introduction

Birth asphyxia and hypoxic-ischemic encephalopathy (HIE) represent predominant etiologies of neonatal brain injury, with incidence rates of 1.5 per 1000 live births in developed nations and 2.3-26.5 per 1000 in low- and middle-income countries. Therapeutic hypothermia (TH) demonstrates efficacy in reducing mortality or severe disability risk at 18-24 months among neonates with moderate-to-severe HIE. However, survivors without cerebral palsy frequently exhibit elevated risks of motor deficits, cognitive impairments, and sensory dysfunction including auditory and visual deficits [1-4].

Hearing impairment may substantially compromise developmental trajectories, particularly in communication capacity, social adaptation, and quality-of-life metrics [2]. Despite its clinical significance, the precise prevalence of auditory dysfunction following TH remains uncertain, particularly regarding variability in cooling methodologies [2-4,5].

A 2013 Cochrane meta-analysis incorporating seven randomized controlled trials reported hearing impairment incidences of 3.8% (15/396) in TH survivors versus 5.8% (19/324) in normothermic controls, without conclusive evidence for TH's protective effect (risk ratio 0.66; 95% confidence interval (CI): 0.35, 1.26) [6]. Subsequent 2024 meta-analysis of 5,821 infants from 56 high-income and 15 low/middle-income countries documented overall hearing

impairment prevalence of 5% (95% CI: 3-6%; n=4868) in TH recipients versus 3% (95% CI: 1-6%; n=953) in non-cooled HIE counterparts. Geographical stratification revealed 7% prevalence (95% CI: 2-15%) in resource-limited settings versus 4% (95% CI: 3-5%) in high-income countries [5].

Park et al. (2023) analyzed data from 6,994 children (2012-2019), demonstrating significant reduction in cerebral palsy incidence (7.5%; Cochran-Armitage trend test $p = 0.0464$) without comparable declines in neurodevelopmental delay (11.8%; $p = 0.2244$) or sensorineural hearing loss (3.0%; $p = 0.0667$) [7].

Established risk factors for auditory impairment in HIE include depressed Apgar scores, HIE severity, mechanical ventilation requirement, ototoxic medication exposure, and neonatal intensive care hospitalization exceeding 7 days [8]. Despite disproportionate HIE burden in resource-limited settings, research remains scarce in these populations. Notably, no previous investigations have specifically evaluated outcomes following TH utilizing simple cooling methods.

Therefore, this **study aimed** to establish the incidence of hearing impairment following TH with simple cooling methods and identify associated risk factors for sensorineural hearing loss in HIE-affected neonates.

Materials and Methods

The study was conducted at neonatal clinics and follow-up clinics of the Municipal Institution «Regional Medical Center for Family Health» (Dnipro Regional Council) and the Municipal Institution «City Multidisciplinary Clinical Hospital of Mother and Child named after Prof. M. F. Rudnev» (Dnipro City Council). Ethical approval was obtained from the Dnipro State Medical University's Ethics Committee.

This retrospective cohort study enrolled 82 neonates (first year of life) who underwent therapeutic hypothermia (TH) between 2020-2023, utilizing systemic hypothermia using simple cooling methods. Inclusion criteria comprised: TH administration per standard indications (gestational age ≥35 weeks; perinatal depression evidenced by Apgar score <6 at 10 minutes or ≥10 minutes of primary resuscitation; moderate-to-severe hypoxic-ischemic encephalopathy (HIE) classified via modified Sarnat staging within 1-6 hours post-delivery). Exclusion criteria included: gestational age <35 weeks, congenital anomalies, confirmed genetic disorders, progressive obstructive ventriculomegaly, prior central nervous system infections, and neonatal hemolytic disease. Short-term poor prognosis was operationalized as: radiographic evidence of hypoxic-ischemic CNS lesions, seizure activity, abnormal neuromotor tone, or inability to establish full oral feeding by neonatal discharge [9]. Long-term adverse outcomes were defined as cerebral palsy diagnosis or structural brain abnormalities on neuroimaging.

Auditory assessment followed Order № 1144 (09.06.2021) of the Ukrainian Ministry of Health («On Approval of the Procedure for Conducting Children's Hearing Screening») [10]. Primary hearing screening employed elicited otoacoustic emissions (OAEs) prior to neonatal discharge. Failed screenings prompted secondary evaluation at 3 months via OAEs or Auditory Brainstem Response (ABR) testing by pediatric otolaryngology specialists.

All participants before age one received quarterly multidisciplinary surveillance by pediatrician and pediatric neurologists. Neurodevelopmental status was assessed using Ages & Stages Questionnaires® (ASQ) (https://www.broomfieldpediatrics.com/ages-stages-questionnaires/). Neurosonographic screening was routinely performed to detect post-ischemic cerebral pathology.

Statistical analyses included methods for assessing effect in alternative response formats (two-tailed Fisher's exact test, χ^2 test), as well as for evaluating differences between two independent samples concerning any quantitative indicator, using the Mann-Whitney U test. For all types of analysis, the critical significance level (α-level) was set at $p < 0.05$.

Results and discussion

During the observation period, 82 neonates underwent therapeutic hypothermia. Baseline clinical characteristics are presented in Table 1.

Table 1

Characteristics of children who underwent therapeutic hypothermia

Parameter	Characteristic
Gestational age at birth, weeks, median (quartiles; min–max)	39.5 (38.0-41.0; 39.0-40.0)
Birth weight, grams, median (quartiles; min–max)	3400 (3300-3980; 3130-3940)
Apgar score at 1 minute, median (quartiles; min–max)	2 (1-4; 1.5-2)
Apgar score at 5 minutes, median (quartiles; min–max)	3 (2-5; 3-4)
Boys, n (%)	51 (72.2%)
Girls, n (%)	31 (37.8%)
Maternal risk factors during pregnancy, n (%)	56 (68.3%)
Intrapartum factors, n (%)	25 (30.5%)
Fetal/newborn risk factors, n (%)	46 (56.1%)
Feto-placental risk factors, n (%)	9 (11.0%)
Intrauterine events, n (%)	33 (40.2%)
Major instrumental deliveries, n (%)	20 (24.4%)
First births, n (%)	45 (54.9%)
Cesarean delivery, n (%)	3 (3.7%)
Meconium in amniotic fluid, n (%)	27 (32.9%)
Intubation in the delivery room, n (%)	82 (100%)

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Continuation of the table 1

Parameter	Characteristic
Need for heart compressions during initial resuscitation, n (%)	27 (32.9%)
Need for medications during initial resuscitation, n (%)	14 (17.1%)
Need for initial resuscitation >10 minutes, n (%)	82 (100%)
Need for mechanical ventilation (MV), n (%)	82 (100%)
Duration of MV, days, median (quartiles; min–max)	7 (3-17; 4-10.5)
Hemodynamic support, n (%)	27 (32.9%)
Duration of oliguria, days, median (quartiles; min–max) |	3 (0-13; 0-7)
Seizures, clinical and/or EEG-confirmed, n (%)	34 (41.5%)
Initiation of enteral feeding, days, median (quartiles; min–max)	0 (0-2; 0-3
Initiation of oral feeding, days, median (quartiles; min–max)	7 (2-25; 4-11)
Duration of NICU stay for survivors, days, median (IQR; min–max)	26 (9-106; 14-41)
Neonatal sepsis, n (%)	3 (3.7%)
Short-term adverse outcomes at discharge, n (%)	6 (7.3%)

During the observation period, 82 neonates underwent therapeutic hypothermia. Baseline clinical characteristics are presented in Table 1. All participants had confirmed birth asphyxia meeting criteria for therapeutic hypothermia according to the Order No. 225 (28.03.2014) of the Ministry of Health of Ukraine («Initial, resuscitation, and post-resuscitation care of newborns in Ukraine»). The study did not stratify participants by severity of hypoxic-ischemic encephalopathy (HIE) given potential levelling of specific clinical signs by hypothermia initiation within the first 6 postnatal hours. Short-term adverse outcomes occurred in 6 cases (7.3%), predominantly manifesting as post-ischemic cerebral injury (basal ganglia ischemia or diffuse hypoxic-ischemic encephalopathy).

Primary hearing screening identified 7 infants (8.5%) with abnormal otoacoustic emission results at neonatal discharge. Repeated examination including comprehensive audiological evaluation confirmed sensorineural hearing loss (SNHL) in 6 patients (7.3%), including 4 cases (66.7%) with radiographically evident cerebral ischemic lesions and 2 cases (33.3%) demonstrating moderate ventriculomegaly.

Differences between cohorts with and without SNHL are presented in Table 2.

Table 2

Characteristics of children with hearing impairments and without hearing impairments

Parameter	Characteristic		
	Children without hearing impairments (n=75)	Children who did not pass the first screening (n=7)	Children with diagnosed sensorineural hearing loss (n=6)
Gestational age at birth, weeks, median (quartiles; min–max)	40 (38,0-41,0; 39,0-40,0)	39 (38-41; 39-41)	40 (38-41; 39-41)
Birth weight, grams, median (quartiles; min–max)	3700 (3000-3980; 3190-3940)	3650 (3300-3890; 3450-3795)	3700 (3300-3970; 3600-3890)
Apgar score at 1 minute, median (quartiles; min–max)	2 (1-4; 2-3)	2,0 (1-3; 1-2)	2,0 (1-4; 1-3)
Apgar score at 5 minutes, median (quartiles; min–max)	3 (3-5; 3-4)	3,0 (2-5; 3-5)	4,0 (2-5; 5-5)
Lactate in the first 6 hours of life, mmol/L, median (quartiles; min–max)	2,0 (2,0-5,0; 2,0-3,0)	6,45 (4,0-8,9; (4,0-8,9)	4,0 (2,0-8,9; 2,0-8,9)
Boys, n (%)	45 (60,0)	6 (85,7)	5 (83,3)
Girls, n (%)	30 (40,0)	1 (14,3)	1 (16,7)
Maternal risk factors during pregnancy, n (%)	49 (65,3)	7 (100)	6 (100)
Intrapartum factors, n (%)##	21 (28,0)	4 (57,1)	4 (66,7)
Fetal/newborn risk factors, n (%)##	45 (60,0)	1 (14,3)	1 (16,7)
Feto-placental risk factors, n (%)	7 (10,0)	2 (28,6)	2 (33,4)
Intrauterine events, n (%)	29 (38,7)	4 (57,1)	4 (66,7)
Major instrumental deliveries, n (%)	18 (24,0)	2 (28,6)	2 (33,4)
First births, n (%)#	38 (50,7)	7 (100)	6 (100)
Cesarean delivery, n (%)#	3 (4,0)	2 (28,6)	2 (33,4)
Meconium in amniotic fluid, n (%)	25 (33,3)	2 (28,6)	1 (16,7)
Intubation in the delivery room, n (%)	82 (100)	7 (100)	6 (100)
Need for heart compressions during initial resuscitation, n (%)#	21 (28,0)	6 (85,7)	6 (100)
Need for medications during initial resuscitation, n (%)#	10 (13,3)	4 (57,1)	4 (66,7)
Need for initial resuscitation >10 minutes, n (%)	75 (100)	7 (100)	6 (100)
Need for mechanical ventilation (MV), n (%)	75 (100)	7 (100)	6 (100)
Duration of MV in days, median (quartiles; min–max)	7 (3-15; 4-9)	6 (4-17; 5-9)	6 (4-17; 5-9)

Continuation of the table 2

Parameter	Characteristic		
	Children without hearing impairments (n=75)	Children who did not pass the first screening (n=7)	Children with diagnosed sensorineural hearing loss (n=6)
Duration of respiratory support (any method) in days, median (quartiles; min–max)*	8 (4-26; 7-14)	14,5 (8-29; 13-15)	14,5 (13-29; 13,5-22)
Need for hemodynamic support, n (%)#	21 (28,0)	6 (85,7)	6 (100)
Duration of hemodynamic support in days, median (quartiles; min–max)	3 (0-10; 3-4)	5 (3-7; 3-6)	4 (3-7; 3-6)
Duration of oliguria in days, median (quartiles; min–max)	0 (0-1; 0-0)	3 (1-3; 1-3)	3 (1-3; 1-3)
Seizures, clinical and/or EEG-confirmed, n (%)	30 (40,0)	4 (57,1)	4 (66,7)
Start of enteral feeding in days, median (quartiles; min–max)	0 (0-2; 0-3)	6 (5-10; 6-8)	7 (5-11; 6-10)
Start of oral feeding in days, median (quartiles; min–max**	7 (2-25; 5-9)	19 (19-21; 19-21)	19 (11-22; 19-21)
Duration of stay in NICU for survivors, days, median (IQR; min–max)*	25 (9-106; 19-33)	30 (21-85; 29-37)	29 (15-85; 21-37)
Neonatal sepsis, n (%)#	0	3 (42,9)	3 (50)
Short-term adverse outcomes at discharge from hospital, n (%)#	2 (2,4)	4 (57,1)	4 (66,7)

***Notes (Differences between the group of children without hearing impairments and the group with sensorineural hearing loss).*
** – Statistically significant differences (p < 0.05) according to the Mann-Whitney U test.*
*** – Statistically significant differences (p < 0.1) according to the Mann-Whitney U test.*
 # – Statistically significant differences (p < 0.05) according to Fisher's exact test.
– Statistically significant differences (p < 0.1) according to Fisher's exact test.

Comparative analysis revealed no significant differences in gestational age, birth weight, or Apgar scores between cohorts with and without SNHL.

Neonates with SNHL required significantly prolonged respiratory support (median 14.5 days [13-29; 13.5-22]) vs neonates without SNHL (median 8 days [4-26; 7-14], $p < 0.05$). They also exhibited an extended neonatal intensive care unit hospitalization (median 29 days [15-85; 21-37]) vs 25 days ([9-106; 19-33], $p < 0.05$), and delayed establishment of oral feeding (median 19 days [11-22; 19-21]) vs 7 days ([2-25; 5-9], $p < 0.1$ The SNHL cohort showed significantly higher prevalence rates ($p < 0.05$) of: primiparous delivery, cesarean delivery, cardiopulmonary resuscitation with medication administration, postoperative hemodynamic support requirement, and neonatal sepsis occurrence. Furthermore, this group demonstrated markedly increased incidence of short-term adverse outcomes at discharge (2.7% vs. 66.7%, $p < 0.05$). Prenatal risk factors for severe birth asphyxia were more frequently observed in SNHL cases ($p = 0.1$)

The global prevalence of hearing impairments in the general newborn population ranges from 0.1% to 0.4% [11], while among infants admitted to neonatal intensive care units, it reaches approximately 1.57% [12]. The prevalence of sensorineural hearing loss diagnosed after at least five years of follow-up in healthy newborns with a fifth-minute Apgar score of 7-10 and no intensive care hospitalization is approximately 0.6%, with equal distribution between sexes [13]. The risk of hearing impairment is significantly elevated in neonates with a history of birth asphyxia. A subset of infants with hypoxic-ischemic encephalopathy (HIE) will develop hearing deficits despite therapeutic hypothermia [7].

In the present study, sensorineural hearing loss was diagnosed in 6 (7.3%) children who underwent systemic hypothermia using simple cooling methods. A systematic review by Pawale et al. (2024), encompassing 71 studies and 5,821 infants, provided a detailed assessment of hearing disorder prevalence in children with hypoxic-ischemic brain injury. As previously reported, the overall prevalence of hearing impairment in surviving infants with HIE following therapeutic hypothermia was 5% (95% CI 3-6%, n=4,868 from 64 studies), compared with 3% (95% CI 1-6%, n=953 from 19 studies) under normothermic post-asphyxia conditions [5]. Notably, no statistically significant difference was observed between the incidence rates of hearing impairment after hypothermia in Pawale et al.'s (2024) study and our findings (p=0.3394, according to χ^2 test).

Among the 64 studies included in Pawale et al.'s (2024) systematic review, only one reported evaluated manually-regulated systemic hypothermia (employing simple cooling methods) [5, 14], finding comparable hearing outcomes between basic cooling (4/77 cases) and servo-controlled systems (2/63 cases; Fisher's exact test p=0.6904). Our results similarly showed no significant divergence from servo-controlled hypothermia data (p=0.4662, Fisher's exact test).

The 5% impairment rate in moderate-to-severe HIE contrasts with 3% [5] in mild HIE cohorts [5] and 10% in non-cooled moderate-to-severe cases [5]. The design of our study did not include an assessment of otoprotective effect; however, extensive animal studies demonstrate significant and clinically meaningful hearing preservation potential of induced hypothermia [13].

The etiological spectrum of neonatal hearing impairment encompasses diverse pathophysiological mechanisms. The While the precise pathways mediating auditory damage induced by birth asphyxia and hypoxia remain incompletely characterized [13], clinical and histopathological studies suggest hypoxia-induced injury to cochlear hair cells and

retrocochlear auditory pathways. Notably, infants with mild-to-moderate asphyxia exhibit significantly attenuated otoacoustic emissions compared to controls, even when standard neonatal hearing screening was normal. There is also evidence suggesting potential synergistic interactions between asphyxia and other pathological processes in auditory pathway disruption [13,15,16].

In hypoxic-ischemic encephalopathy (HIE), the vulnerability of the eighth cranial nerve to ischemic injury may underlie observed hearing deficits, typically manifesting as profound sensorineural loss. This frequently co-occurs with midbrain and brainstem pathology. Thalamic and basal ganglia lesions demonstrate particularly strong associations with auditory impairment, whereas isolated cystic encephalomalacia sparing brainstem structures less commonly affects hearing function [2]. Our data identify several clinically significant risk factors: severity of birth asphyxia, postnatal clinical status, and concurrent complications (particularly post-asphyxial sepsis). Notably, the cohort with hearing impairment exhibited significantly higher incidence of destructive post-ischemic cerebral lesions, likely reflecting vestibulocochlear pathway damage.

Multiple studies have identified various neonatal risk factors for hearing impairments in infants with HIE, including:

- Abnormal blood pH, base excess, lactate concentrations, and aminoglycoside administration (Smit et al., 2013) [17];
- Depressed Apgar scores, dysglycemia, multiorgan dysfunction, and elevated creatinine/liver transaminases (Fitzgerald et al., 2019) [18];
- Hyperlactatemia, hyperglycemia, and advanced HIE staging (Chen et al., 2021) [2];
- Abnormal blood pH, BE, and lactate (Michniewicz et al., 2022) [19];
- Five-minute Apgar score <7 combined with intensive care admission and mechanical ventilation requirement (Hemmingsen D et al., 2024) [13].

In our cohort, neonates with sensorineural hearing loss required significantly prolonged NICU hospitalization, extended respiratory support, delayed oral feeding initiation, and more frequent hemodynamic stabilization. These parameters collectively reflect the severity of post-asphyxial clinical compromise.

Early recognition of these prognostic markers proves critical for timely audiological intervention. Prompt diagnosis and rehabilitation initiation substantially improve neurodevelopmental outcomes, particularly for speech acquisition and cognitive function [13].

The present study is subject to certain limitations, primarily due to the relatively small sample size employed for the analysis of risk factors, a factor which may lead to a certain degree of bias in the conclusions drawn.

Conclusions. The incidence of auditory impairment following systemic hypothermia utilizing simple cooling methods demonstrated no significant divergence from studies employing alternative or unspecified cooling approaches during post-asphyxial management. Principal determinants of hearing dysfunction included severity of birth asphyxia, degree of postnatal clinical compromise, extent of hypoxic-ischemic cerebral injury, and occurrence of postnatal infectious complications. Enhanced comprehension of these etiopathogenetic mechanisms remains imperative for developing preventive strategies, refining prognostic accuracy, and identifying high-risk populations requiring targeted surveillance.

Conflict of Interest

The authors declare no conflicts of interest or personal financial interests that could potentially influence the results or interpretation of this manuscript.

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Author Contributions

M. V. Solomenko – concept and design of the study, data collection and analysis, manuscript writing; O. N. Kharitonova – data collection and analysis, manuscript writing.

References:

1. Robertsson Grossmann K, Eriksson Westblad M, Blennow M, Lindström K. Outcome at early school age and adolescence after hypothermia-treated hypoxic-ischaemic encephalopathy: an observational, population-based study. Arch Dis Child Fetal Neonatal Ed. 2023 May;108(3):295-301. doi: 10.1136/archdischild-2022-324418. Epub 2022 Dec 9. PMID: 36600485; PMCID: PMC10176399.

2. Chen D-Y, Lee I-C, Wang X-A, Wong S-H. Early Biomarkers and Hearing Impairments in Patients with Neonatal Hypoxic-Ischemic Encephalopathy. Diagnostics (Basel). 2021;11(11):2056. DOI: https://doi.org/10.3390/diagnostics11112056. PMID: 34829404; PMCID: PMC8620896.

3. Lee BL, Glass HC. Cognitive outcomes in late childhood and adolescence of neonatal hypoxic-ischemic encephalopathy. Clin Exp Pediatr. 2021;64(12):608-18. DOI: https://doi.org/10.3345/cep.2021.00164. PMID: 34044480; PMCID: PMC8650814.

4. Eunson P. The long-term health, social, and financial burden of hypoxic-ischaemic encephalopathy. Dev Med Child Neurol. 2015;57(Suppl 3):48-50. DOI: https://doi.org/10.1111/dmcn.12727. PMID: 25800493.

5. Pawale D, Fursule A, Tan J, Wagh D, Patole S, Rao S. Prevalence of hearing impairment in neonatal encephalopathy due to hypoxia-ischemia: a systematic review and meta-analysis. Pediatr Res. 2024. DOI: https://doi.org/10.1038/s41390-024-03261-w. PMID: 38769399.

6. Jacobs SE, Berg M, Hunt R, Tarnow-Mordi WO, Inder TE, Davis PG. Cooling for newborns with hypoxic ischaemic encephalopathy. Cochrane Database Syst Rev. 2013;2013(1): CD003311. DOI: https://doi.org/10.1002/14651858.cd003311.pub3. PMID: 23440789; PMCID: PMC7003568.

7. Park J, Park SH, Kim C, Yoon SJ, Lim JH, Han JH, et al. Growth and developmental outcomes of infants with hypoxic ischemic encephalopathy. Sci Rep. 2023;13(1):23100. DOI: https://doi.org/10.1038/s41598-023-50187-0. PMID: 38155236; PMCID: PMC10754824.

8. Karaca CT, Oysu C, Toros SZ, Naiboglu B, Verim A. Is hearing loss in infants associated with risk factors? Evaluation of the frequency of risk factors. Clin Exp Otorhinolaryngol. 2014;7(4):260-3. DOI: https://doi.org/10.3342/ceo.2014.7.4.260. PMID: 25436043; PMCID: PMC4240481.

9. Mietzsch U, Radhakrishnan R, Boyle FA, Juul S, Wood TR. Active cooling temperature required to achieve therapeutic hypothermia correlates with short-term outcome in neonatal hypoxic-ischaemic encephalopathy. J Physiol. 2020;598(2):415-24. DOI: https://doi.org/10.1113/jp278790. PMID: 31777079.

10. Ministerstvo okhorony zdorov'ia Ukrainy. Pro zatverdzhennia Poriadku provedennia skryninhu slukhu ditei [On approval of the Procedure for conducting hearing screening for children]. Nakaz MOZ Ukrainy № 1144 vid 09.06.2021r. Verkhovna Rada Ukrainy; 2021 [tsytovano 2025 Kvi 2]. Dostupno: https://zakon.rada.gov.ua/laws/show/z1010-21#Text (in Ukrainian)

11. Edmond K, Chadha S, Hunnicutt C, Strobel N, Manchaiah V, Yoshinga-Itano C, et al. Effectiveness of universal newborn hearing screening: A systematic review and meta-analysis. J Glob Health. 2022;12:12006. DOI: https://doi.org/10.7189/jogh.12.12006. PMID: 36259421; PMCID: PMC9579831.

12. Busse AML, Hoeve HLJ, Nasserinejad K, Mackey AR, Simonsz HJ, Goedegebure A. Prevalence of permanent neonatal hearing impairment: systematic review and Bayesian meta-analysis. Int J Audiol. 2020;59(6):475-85. DOI: https://doi.org/10.1080/14992027.2020.1716087. PMID: 32011197.

13. Hemmingsen D, Moster D, Engdahl B, Klingenberg C. Hearing impairment after asphyxia and neonatal encephalopathy: a Norwegian population-based study. Eur J Pediatr. 2024;183(3):1163-72. DOI: https://doi.org/10.1007/s00431-023-05321-5. PMID: 37991501; PMCID: PMC10950958.

14. Buchiboyina A, Ma E, Yip A, Wagh D, Tan J, McMichael J, et al. Servo controlled versus manual cooling methods in neonates with hypoxic ischemic encephalopathy. Early Hum Dev. 2017;112:35-41. DOI: https://doi.org/10.1016/j.earlhumdev.2017.06.011. PMID: 28686927.

15. Ribeiro GE, Silva DP, Montovani JC. Transient evoked otoacoustic emissions and auditory brainstem response in infants with perinatal asphyxia. Int J Pediatr Otorhinolaryngol. 2016;89:136-9. DOI: https://doi.org/10.1016/j.ijporl.2016.08.009. PMID: 27619044.

16. Leite JN, Silva VS, Buzo BC. Otoacoustic emissions in newborns with mild and moderate perinatal hypoxia. Codas. 2016;28(2):93-8. Portuguese. DOI: https://doi.org/10.1590/2317-1782/20162015086. PMID: 27191870.

17. Smit E, Liu X, Gill H, Sabir H, Jary S, Thoresen M. Factors associated with permanent hearing impairment in infants treated with therapeutic hypothermia. J Pediatr. 2013;163(4):995-1000. DOI: https://doi.org/10.1016/j.jpeds.2013.06.012. PMID: 23885964.

18. Fitzgerald MP, Reynolds A, Garvey CM, Norman G, King MD, Hayes BC. Hearing impairment and hypoxia ischaemic encephalopathy: Incidence and associated factors. Eur J Paediatr Neurol. 2019;23(1):81-6. DOI: https://doi.org/10.1016/j.ejpn.2018.10.002. PMID: 30366758.

19. Michniewicz B, Wroblewska-Seniuk K, Amara JA, Al-Saad SR, Szyfter W, Karbowski LM, et al. Hearing Impairment in Infants with Hypoxic Ischemic Encephalopathy Treated with Hypothermia. Ther Hypothermia Temp Manag. 2022;12(1):8-15. DOI: https://doi.org/10.1089/ther.2020.0043. PMID: 33512300.

ФАКТОРИ, ПОВ'ЯЗАНІ З ПОРУШЕННЯМ СЛУХУ У НЕМОВЛЯТ, ЯКІ ОТРИМУВАЛИ ЛІКУВАЛЬНУ ГІПОТЕРМІЮ

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Резюме.

Асфіксія при народженні та гіпоксично-ішемічна енцефалопатія є основною причиною ушкоджень головного мозку немовлят. Лікувальна гіпотермія знижує ризик смерті або тяжкої інвалідності у віці 18-24 місяців у дітей з важкою асфіксією. Але серед тих, хто вижив, частка дітей має підвищений ризик порушень стану здоров'я, в тому числі і порушень слуху. Мало вивченою на теперішній час є частота порушень слуху у дітей після лікувальної гіпотермії з урахуванням різних технічних різновидів її проведення.

Тож, метою нашого дослідження було визначення частоти порушень слуху у немовлят після лікувальної гіпотермії з використанням простих засобів охолодження, а також дослідження факторів ризику, пов'язаних з нейросенсорною втратою слуху у немовлят з гіпоксично-ішемічною енцефалопатією.

Матеріали та методи. Було проведене ретроспективне когортне клінічне дослідження, куди були включені 82 дитини першого року життя (51 (72,2%) хлопчики та 31 (37,8%) дівчаток), які мали важку асфіксію пля народження і яким проводилась лікувальна гіпотермія (системна гіпотермія з використанням простих засобів охолодження) протягом 2020-2023 років. Критеріями включення були проведення лікувальної гіпотермії після народження відповідно до показань (гестаційний вік ≥35 тижнів; ознаки перинатальної депресії (оцінка за шкалою Апгар (ОША) < 6 на 10-й хвилині життя або проведення первинної реанімації протягом не менше 10-хвилин); помірна або важка гіпоксично-ішемічна енцефалопатія (за даними модифікованої шкали Sarnat), наявна у віці 1-6 годин). Критеріями виключення були гестаційний вік менше 35 тижнів, діагностовані вроджені вади розвитку, генетичні дефекти, прогресуюча вентрикуломегалія обструктивного характеру, перенесені нейроінфекції, гемолітична хвороба новонародженого.

Проводився трьохетапний скринінг слуху (перші два етапи з залученням отоакустичної емісії, третій етап – повне аудіологічне обстеження).

Статистична обробка результатів проводилась з використанням методів оцінки ефекту при альтернативній формі результату реакції (точний критерій Фішера, двосторонній; хі-квадрат), оцінки відмінностей між двома незалежними вибірками за рівнем будь-якої ознаки, виміряної кількісно, між малими вибірками (критерій Манна-Уітні). Для всіх видів аналізу критичне значення рівня значущості (p) приймалося < 0,05.

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Виконання роботи проводилося в рамках НДР кафедри Педіатрії 3 та неонатології «Підходи до діагностики та лікування хвороб дитячого віку з позиції безпеки пацієнта», № держреєстрації – 0121U114304. Дослідження схвалене комісією з етики Дніпровського державного медичного університету.

Результати. Несприятливі наслідки гіпоксично-ішемічного ушкодження у вигляді деструктивних змін мозкової тканини та діагнозу дитячого церебрального паралічу були зафіксовані у 6 (7,3% дітей). Сім дітей (8,5%) продемонстрували аномальні (позитивні) результати другого етапу отоакустичної емісії. Діагноз нейросенсорної туговухості був встановлений у 6 (7,3%) дітей (ці дані достовірно не відрізнялись від результатів інших досліджень, де не була заявлена лікувальна гіпотермія з використанням простих засобів охолодження). Серед дітей з нейросенсорною туговухістю у 4 були виявлені деструктивні постішемічні ураження мозку, а у 2 виявлялась вентрикулодилатація бічних шлуночків помірного ступеня. Немовлята з проявами нейросенсорної туговухості мали достовірно довшу тривалість респіраторної підтримки (8 (4-26; 7-14) проти 14,5 (13-29; 13,5-22) днів, p<0,05), тривалість перебування у відділенні інтенсивної терапії (25 (9-106; 19-33) проти 29 (15-85; 21-37) днів, p<0,05) та довший час до початку орального харчування (7 (2-25; 5-9) проти 19 (11-22; 19-21) днів, p<0,1). Діти з порушеннями слуху мали достовірно вищу частоту (p<0,05) народження під час перших пологів, необхідності проведення кесарева розтину, потреби проведення непрямого масажу серця та введення медикаментозних препаратів під час первинної реанімації, потреби проведення гемодинамічної підтримки в післяпологовому періоді та частоти розвитку сепсису новонародженого. Достовірно вищою також була частота виявлення короткотермінових несприятливих наслідків асфіксії та гіпоксично-ішемічної енцефалопатії на момент виписки з лікарні (2,7% проти 66,7%, p<0,05).

Висновки. Таким чином, частота порушень слуху у дітей після лікувальної гіпотермії з використанням простих засобів охолодження не відрізнялась від результатів досліджень, де не був заявлений подібний спосіб охолодження. Факторами ризику порушень слуху були важкість асфіксії при народженні, тяжкість стану дитини в післяпологовому періоді, тяжкість ураження мозкової тканини та постнатальні інфекційні ускладнення.

Ключові слова: асфіксія, гіпоксично-ішемічна енцефалопатія; лікувальна гіпотермія; слух; фактори ризику; новонароджені; немовлята.

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