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Clinical significance of using transcranial magnetic therapy in comprehensive non-drug recuperation of neonates with perinatal lesions of central nervous system

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Abstract:
The objective was to assess the effectiveness of the use of transcranial magnetic therapy in comprehensive non-drug recuperation of neonates with perinatal injury of the central nervous system.
Materials and Methods. Our research involved 214 newborns with corrected age of 30 weeks of gestation and perinatal lesion of the central nervous system. Main group (n=79): neonates underwent standard pharmacotherapy in combination with comprehensive non-drug recuperation (which included dry immersion, music therapy and orolingual massage), and transcranial magnetic therapy. Comparison group (n=74): newborns underwent standard pharmacotherapy in combination with non-drug recuperation. Control group (n=61): infants received conventional pharmacotherapy.
Results. In Main group, hyperexcitability syndrome was healed in 60% of infants, and autonomic visceral disorders were cured in 80% of children. CNS depression syndrome signs disappeared in 67% of neonates. A significant ($p<0.05$) decrease in the resistance index was noticed, along with reduction in elevated peripheral vascular resistance and expansion of physiological reflexes, especially of the oral automatism group. Odds ratio of normalization of oral reflexes by day 10 for Main group vs. Control group was 5.09 with 95% CI [1.8-13.8]; and for Main group vs. Comparison group, it was 3.0 with 95% CI [1.1-8.4]. Normalization of muscle tone and resistance index reduction by day 10 in Main group was observed 8 and 4 times more often, correspondingly, than in Control group. Odds ratios were 8.2 with 95% CI [1.8-16.3] and 4.05 with 95% CI [1.06-9.3], respectively.
Conclusion. Non-drug recovery methods in combination with magnetic therapy generated the sedative effect; provided stimulation of respiratory movements and spontaneous motor activity; and contributed to restoring proper reflex action. Hence, they are recommended for inclusion in the perinatal CNS lesion therapy of neonates.

Keywords: neonate, prematurity, perinatal lesions, non-drug recuperation, magnetic therapy.

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Introduction

A healthy population is the basis for the Russian Federation future potential. The development of modern technology in medicine contributes to an increase in demographic indicators and survival rate of the entire population. However, despite this, the leading part (about 60%) in the structure of children's disability is still taken by perinatal diseases of the central nervous system (CNS) in newborns [1]. The most important task of contemporary perinatology is to find a solution for reducing neonatal mortality, morbidity and early childhood disability.

Perinatal impairment of CNS is the most common pathology that clinicians of various medical fields have to deal with in the first year of a child's life.

The main pathogenetic cause of perinatal CNS damage is inadequate oxygen supply to the brain tissue due to a combination of hypoxia and ischemia [2]. These links of pathogenesis cause the redistribution of blood flow among organs, development of hypoxemia and hypercapnia, which, in turn, lead to disorders of vascular autoregulation. Besides, they initiate neuronal damage, causing the development of vasogenic and cytotoxic cerebral edema, as well as a release of procoagulants and formation of avascular areas in the brain. In the acute period, the main therapeutic tactic is aimed at provisioning vital body functions, improving metabolic processes in the affected brain, activating preserved structures, and preventing irreversible cerebral disorders leading to neurologic deficit [3].

The studied brain damage mechanisms of hypoxic genesis in newborns imply that timely therapeutic intervention may prevent damage to neuronal tissue and improve neurological prognostication [4, 5]. However, the use of pharmacological agents in neonates is often unsafe or contraindicated, and the factors, such as gestational age, morphological and functional traits, and dysfunction of the immune, endocrine and nervous systems are important. In

recent years, new attention has been paid to inclusion of physiotherapy and non-drug recuperation methods in the comprehensive treatment of perinatal CNS lesions [6].

Since 2010, one of the scientific directions at our department was dedicated to the recovery of neonates, including premature infants with perinatal CNS lesions. Despite the decrease in the birth rate in Saratov Oblast over recent years, the frequency of preterm birth remains at a fairly high level of 6-8%, while the structure of prematurity has also changed: the number of children with extremely low and very low body weight at birth has increased. These children possess some specific traits during the neonatal period; hence, the methods of non-drug recuperation are especially relevant for them [7, 8, 9].

Magnetic therapy is among the most widely used methods in physiotherapy. The non-contact action of the running pulsed magnetic field allows for the therapy onset immediately after the birth. For neonatologists, the following magnetic field properties are important:

- penetrating capability, allowing to influence deep structures of the brain without thermal effects;

- vasodilating, anti-inflammatory, immunostimulating, sedative and neurotropic action;

- normalization of cerebrospinal fluid dynamics, improvement of microcirculation in the hypothalamic-pituitary region [10].

The study of music effect on the processes of newborn children recovery started in 1970s [11]. It is known that instant responses to vibroacoustic stimulation begin to appear at 24-25 weeks of gestation and gradually increase towards birth. Already at birth, a child can recognize the mother's and father's voices, along with the tunes heard during the last trimester of intrauterine life. For newborns, excessive noise correlate with reduced blood oxygen saturation, augmented heart rate, and sleep disorder. Controlling environmental sounds can help protecting sleep, maintaining stable vital signs, improving speech development, and reducing the potential for adverse effects on a child's auditory development [12]. According to a double-blind, randomized, placebo-controlled trial, conducted in Austria, there was a trend towards an improvement in the formation of sleep-wake cycles in children exposed to music [13].

It is known that music therapy helps coping with the acoustic stress of premature babies via concealment of the stationary noise [14]. With preterm birth, a rupture occurs in the mother-fetus system, which not only includes the adequate development of the baby's organs and systems, but also the long-term adaptation of the fetus to prenatal acoustic environment [15]. A premature infant needs substantial effort to adapt to a new environment: despite the therapeutic and protective regime (in the form of humidicribs with a constant temperature, metabolic correction, and reduction of light exposure), such auditory stimuli as high-frequency signals from monitor, or humidicrib engine noise, may cause the development of acoustic stress [16].

Dry immersion, which is also used in space medicine to simulate weightlessness, is a fairly simple non-drug method of neonate rehabilitation [17]. Immersion is closer to weightlessness than bed rest regimen, since with the former, there is a partial imitation of intrauterine conditions [18].

Studies conducted on newborns with CNS lesions, who received a course of dry immersion, have revealed that after the first procedure, the frequency and severity of hyperexcitability and depression syndromes declined, and indicators of vital functions (heart rate, respiratory rate, pulse) returned to normal. A reduction in the area of cephalohematomas by 73% was noted. In the peripheral blood, the activity of enzymes involved in the tricarboxylic acid cycle augmented. The study has revealed the dependence of the therapeutic effect on age, gestational age and duration of immersion [19].

When balancing a child on the water surface, the effect of gravitational forces declines, and the following improvements occur in the body: the deformation of tissues and organs decreases, the load on musculoskeletal system reduces, the hydrostatic blood pressure goes down, the redistribution of fluid takes place, and sensitivity changes. Since there is a redistribution of body fluid, the volume of excreted fluid goes up [20].

The objective of our study was to assess the effectiveness of using transcranial magnetic therapy in comprehensive non-drug recuperation of neonates with perinatal lesions of the CNS.

Materials and Methods

The study included 214 neonates born in 2019. We conducted a retrospective analysis of anamneses of pregnant women, whose children were included in the study, the histories of their labor management (forms 096u), and the histories of development of their newborns (form 097u).

The criteria for inclusion in the study were the presence of perinatal CNS lesion and the corrected age of over 30 weeks of gestation.

The exclusion criteria for our study were the need for intensive care, including invasive and non-invasive respiratory therapy, the presence of congenital malformations and genetic disorders, and common skin diseases.

All children included in the study underwent a standard examination, which included anamnesis data analysis, clinical examination, consultation with a neurologist with an assessment of neurosonography, and laboratory and instrumental examinations.

In our study, all neonates were distributed among three groups:

☐ Main group (n=79) with newborns, whose corrected age at the time of inclusion in the study was over 30 weeks of gestation and who was not in need of intensive therapy. All subjects were receiving treatment in accordance with the standard care routine for this nosology and comprehensive non-drug recuperation in combination with transcranial magnetic therapy using the running pulsed magnetic field device BIMP with the BRIDLE attachment;

☐ Comparison group (n=74) with newborns, whose corrected age at the time of inclusion in the study was over 30 weeks of gestation and who was not in need of intensive therapy. All subjects were receiving treatment in accordance with the standard care routine for this nosology and comprehensive non-drug recuperation;

☐ The control group (n=61) with newborns, whose corrected age at the time of inclusion in the study was over 30 weeks of gestation and who was not in need of intensive therapy. All subjects were receiving treatment in accordance with the standard care routine for this nosology.

Comprehensive non-drug recuperation included dry immersion in combination with orolingual massage and music therapy. The total duration of the recuperation complex procedure ranged 10–40 minutes.

The study used the music therapy technique proposed by Professor G.V. Yatsyk. Based on this technique, an individual music program was developed for the recovery of premature newborns. The preferred option involves live singing by the mother. However, for music playback, it is possible to use various sound output devices such as volume-controlled music speakers, an audio recorder, or a mobile phone. The important condition is compliance with the rule of sterility; hence, the equipment must be disinfected before use. The technique can be organized as background playback of compositions at the hospital room, or as an individual session, in combination with dry immersion and orolingual massage, while the volume should not exceed spoken speech. Music therapy (10-15 sessions) is carried out daily, one hour after morning and evening feedings, or during feeding, which contributes to the prethreshold enhancement of the food dominant [19]. With a stable condition of a neonate, music therapy can be performed immediately after birth; with CNS depression syndrome, from day 4; with hyperexcitability syndrome, from days 6–9. The duration of a session is directly proportional to the child age: at the age of 3–7 days, it is 5 minutes, at the age of 7–10 days, it is 10 minutes; for older newborns, it is 15 minutes [13].

If at the time of the session, there are children in the ward, for whom music therapy is not indicated, or a different composition is indicated, then for the time of listening, the ears of these infants are covered with a cotton swab fixed with a kerchief. Some newborns showed interest in more rhythmic compositions, while others 'enjoyed' exclusively instrumental pieces. We noted that if the melody suited the infant, it smiled and calmed down, the tremor decreased, blood oxygen saturation improved, some even closed their eyes during active wakefulness. With a negative reaction to the composition, we observed a grimace of displeasure, crying, pulling legs up, and chin tremor. According to the feedback by the medical staff of the department, after the evening sessions of music therapy, the infants spent the night calmer, their sleep pattern significantly improved, and sleep became deeper.

The method of dry immersion is based on filling the baby bath with water for two-thirds of its volume. On its surface, the oilcloth is laid and attached on the sides. For comfortable use, water temperature should not be higher or lower than 33-34 degrees. An undressed newborn is placed on an oilcloth covered with an individual sheet. The course of dry immersion included 5-12 daily sessions, once a day, one hour before or after feeding, with their duration from 10 to 25 minutes, depending on the condition and clinical situation. Such therapy was performed starting at a neonate age of 3 days with CNS depression and muscular hypertonicity, of 10 days with hyperexcitability syndrome, of 14 days for children with cephalohematoma, and immediately after birth with stable condition [12]. The positive effect was cumulative with simultaneous orolingual massage, a course of 10-15 sessions, three times a day half hour before feeding, 2-3 minutes in the first days, 10 minutes in subsequent days.

Transcranial magnetic therapy with a running pulsed magnetic field was conducted using a physiotherapeutic AMO-ATOS-E device with the BRIDLE attachment (registration certificate of the RF No. FSR 2009/04781 of May 06, 2009, manufactured by TRIMA LLC. Therapeutic procedures were conducted daily for 10 days. The modulation frequency for the first two sessions was set at 1 Hz for 5 minutes, followed by a gradual increase in exposure in 1-minute increments, up to 10 minutes, and the modulation frequency up to 10 Hz.

Statistical processing of the results was carried out using Microsoft Excel and SPSS 15.0 software. The Shapiro–Wilk test was used to assess the normality of quantitative data distribution. The arithmetic mean (M) and standard error of the mean (±SD) were used as indicators for the values complying with a normal, or close to normal, distribution. Qualitative characteristics were presented as relative values (%). To compare the study groups for the frequency of detecting a certain outcome, the odds ratio was calculated. For independent and dependent samples, the Student's t-test with Bonferroni correction was used as a criterion for assessing the statistical significance of differences in sample means. The critical level of statistical significance of differences was considered at values of $p<0.05$.

Results

When studying the medical records, the obstetric and gynecological histories of mothers were analyzed. It was established that 94.6% of the mothers of examined newborns had a complicated course of pregnancy. The most common pathology was chronic intrauterine fetal hypoxia in 48% of women, as well as placental insufficiency and the threat of abortion in 27 and 15.3% of cases, respectively. Impaired uteroplacental blood flow, obesity and anemia of pregnant women were observed in 13, 8.3 and 4.7%, correspondingly. Diabetes mellitus was registered in 11.3% of cases.

The main characteristics of newborns included in the study, as well as pathological manifestations from their CNS, are presented in *Tables 1* and *2*.

Table 1. Core diseases of central nervous system in neonates in the study groups

Nosology, syndrome, sample size (%)	Groups		
	Main (*n*=79)	Comparison (*n*=74)	Control (*n*=61)
CI grade I	40 (50.9)	43 (58.6)	39 (63.9)
CI grade II	18 (22.8)	14 (19.7)	16 (26.2)
CI grade III	6 (8.4)	4 (6.3)	5 (8.1)
IVH grade I	9 (12.4)	8 (11.5)	8 (13.1)
IVH grade II	13 (17.6)	6 (9.3)	4 (6.5)
Convulsive syndrome	25 (32)	20 (28.2)	21 (34.4)
Hyperexcitability syndrome	13 (16.7)	19 (25.7)	14 (22.9)
CNS depression syndrome	66 (83.6)	53 (72.3)	47 (77.1)
Tone disorder syndrome	44 (56.2)	43 (59.1)	39 (65.2)

CI – cerebral ischemia; IVH – intraventricular hemorrhage; CNS – central nervous system.

Table 2. Focal traits of neonates included in the study

Indicators	Groups			*p*
	Main (*n*=79)	Comparison (*n*=74)	Control (*n*=61)	
BWB, g (*M±SD*)	1535.4±432.6	1611.3±383.1	1495.2±512.5	* <0.05
GA, weeks (*M±SD*)	34.3±2.1	34.9±1.8	33.5±2.0	
Male gender, sample size (%)	40 (51.6)	45 (60.8)	32 (52.4)	** <0.05
Bed days (*M±SD*)	12.4±4.6	14.6±2.4	19.2±3.3	* <0.05

BWB – body weight at birth; GA – gestational age; * – Student's *t*-test with Bonferroni correction; ** – criterion $\chi^2 = 6.23$, degrees of freedom $df=2$, $p=0.05$.

The effectiveness of magnetic therapy as a constituent of comprehensive non-drug recuperation was confirmed by positive dynamics, based on the results of examination by a neurologist and ultrasound examination of the brain. Analysis of the obtained medical records on the state of cerebral circulation sensu neurosonography data allows us concluding the following: in the Main group, there was an improvement in blood flow through the basal cerebral vessels and a decrease in the resistance index by 52.8%; the latter for comparison group and control group amounted to 41.2% and 26.4%, respectively (statistical significance of differences between groups, $p<0.05$). The clinical effect was also exhibited in a of elevated peripheral vascular resistance by 21, 17.3 and 7.6% ($p<0.05$) in Main, Comparison and Control groups, correspondingly. Venous outflow improved by 31% in the Main group, by 26% in Comparison group, and by 9.31% in Control group, with detected statistical significance of the differences between groups, $p<0.05$. The dynamics of cerebral blood flow presented in *Table 3* suggests that in the main group, there was a significant positive effect ($p<0.05$), manifested by a decrease in resistance index and blood flow velocity in the anterior cerebral and internal carotid arteries.

Muscle tone, deep reflexes, including periosteal reflexes, and response to irritation recovered on day 10 of the treatment in 85% of neonates in Main group, in 74% of those in Comparison group, and in 51% of infants in the Control group (statistical significance of intergroup differences, $p<0.05$). In Main group newborns with symptoms of encephalopathy of hypoxic and ischemic genesis, regression of the pathological process occurred, which was expressed in the relief of convulsive manifestations, restoration of muscle tone and increased resistance of physiological reflexes sensu the dynamic examination by a neurologist.

The dynamics of changes in congenital reflexes in the groups before and after the study is presented in *Table 4*: it allows us concluding that there was a statistically significant ($p<0.05$) restoration of reflexes of oral and spinal automatism in neonates of the Main group.

To compute the outcome probability, specifically, the normalization of oral group reflexes, the odds ratio was calculated. For Main vs. Control groups, it was 5.09 with 95% CI [1.8-13.8], and for Main vs. Comparison groups, it was 3.0 with 95% CI [1.1-8.4]. This finding implied that the probability of restoring oral automatism reflexes by day 10 in neonates of Main group was 5 times higher than in newborns of Control group, and 3 times higher than in infants of Comparison group. Normalization of muscle tone and reduction of resistance index by day 10 in Main group were observed, respectively, 8 and 4 times more often than in the Control group. The odds ratios were 8.2 with 95% CI [1.8-16.3] and 4.05 with 95% CI [1.06-9.3], correspondingly. We should emphasize that confidence intervals did not include 1; hence, differences were statistically significant at $p<0.05$.

After the treatment, the infants of Main and Comparative groups exhibited regression of most clinical manifestations. However, in the patients of the Main study group, who received transcranial magnetic therapy in combination with music therapy, dry immersion, and orolingual massage, the most pronounced statistically significant positive outcomes were noted ($p<0.01$): the hyperexcitability syndrome was arrested in 60% of neonates who had it prior to the treatment; autonomic visceral disorders were healed in 80% of children, and signs of CNS depression disappeared in 67% of neonates. According to the examination results by an ophthalmologist, the phenomena of angiopathy and spasm of retinal arteries in neonates of the Control group were noted 2.5 times more often than in Main and Comparative groups.

Conducting magnetic therapy as part of comprehensive recuperation allows to reliably ($p<0.05$) reduce the average number of bed days of the hospital stay: neonates of the Main group spent 7 days less at the hospital than newborns of the Control group. Magnetic therapy also contributes to the normalization of their sleep-wake cycle and an increase in the threshold of pain sensitivity during medical procedures.

Discussion

Lesions of the CNS in the perinatal period predominate most often in the first year of life and lead to an increase in early childhood disability. Recuperation of neonates is a promising direction in the development of perinatal medicine. The method of comprehensive non-drug recuperation is available for implementation by institutions of any level, as well as for the continuation of therapy at home, after the child was discharged from the hospital, under the supervision of an outpatient service.

The effects of dry immersion, music therapy and orolingual massage are cumulative in combination with the physiotherapeutic effects of transcranial magnetic therapy.

The basis for the pathogenesis of CNS lesions is constituted by ischemia and hypoxia, causing neuronal damage, development of vasogenic and cytotoxic cerebral edema, and the release of procoagulants with formation of avascular areas in the brain.

The positive properties and effects of magnetic therapy include its high penetrating capability, lack of thermal effects, improved microcirculation of the hypothalamic-pituitary region; along with vasodilating, anti-inflammatory, sedative and neurotropic effects [7, 10]. Our study has revealed a positive effect of the impact of non-drug treatment methods on the neurological status of a newborn, with an improvement in cerebral blood flow and a decrease in the incidence of retinal angiopathies.

Table 3. Dynamics of changes in groups before and after the study based on neurosonography data

Indicators	Groups					
	Main (*n*=79)		Comparison (*n*=74)		Control (*n*=61)	
	before	after	before	after	before	after
Resistance index (relative units)	0.86±0.03	0.65±0.04*	0.85±0.04	0.68±0.03*	0.75±0.08	0.71±0.06*
υ_{max} ACA (m/s)	0.38±0.09	0.47±0.12*	0.37±0.10	0.45±0.09*	0.41±0.10	0.44±0.06*
υ_{min} ACA (m/s)	0.05±0.03	0.13±0.04*	0.07±0.04	0.12±0.02*	0.08±0.03	0.10±0.03*
υ_{max} ICA (m/s)	*0.36±0.17*	*0.52±0.14**	*0.34±0.20*	*0.50±0.13**	*0.42±0.09*	*0.49±0.12**
υ_{min} ICA (m/s)	*0.07±0.04*	*0.15±0.07**	*0.06±0.04*	*0.16±0.03**	*0.08±0.04*	*0.12±0.05**

* – paired Student's *t*-test, $p<0.05$; υ – blood flow velocity; ACA – anterior cerebral artery; ICA – internal carotid artery.

Table 4. Dynamics of congenital reflexes in groups before and after the study

Reflexes, sample size (%)	Groups					
	Main (*n*=79)		Comparison (*n*=74)		Control (*n*=61)	
	before	after	before	after	before	after
Sucking reflex	33 (42.2)	79 (100)*	28 (37.8)	68 (91.8)*	29 (46.7)	41 (66.5)*
Kussmaul (search) reflex	29 (37.7)	76 (96.5)*	32 (43.2)	60 (81)*	21 (33.8)	48 (77.6)*
Snout reflex	24 (30.5)	66 (84.5)*	39 (52.7)	51 (37.7)*	30 (48.7)	42 (68.6)*
Upper protective reflex	42 (53.3)	77 (97.5)	37 (50)	68 (50.3)	44 (71.6)	51 (88.5)
Support and automatic gait	17 (22.7)	76 (96.5)*	11 (14.8)	72 (53.2)*	12 (18.9)	45 (72.6)*
Robinson reflex	43 (55.2)	68 (86.5)	35 (47.2)	62 (45.8)	32 (51.7)	40 (65.6)
Crawling reflex	9 (11.7)	64 (81.5)*	10 (13.5)	53 (39.2)*	5 (8.9)	23 (36.8)*
Bauer reflex	22 (28.6)	66 (84.5)*	25 (33.7)	49 (36.2)*	13 (20.9)	35 (57.7)*
Galant reflex	35 (45.5)	52 (66.7)	38 (51.3)	48 (35.5)	23 (37.8)	31 (50.7)
Moro reflex	29 (37.7)	61 (77.6)	21 (28.3)	56 (41.4)	16 (26.8)	34 (54.7)

* – paired Student's *t*-test, $p<0.05$.

Conclusion

Conducting dry immersion, music therapy and orolingual massage in combination with transcranial magnetic therapy has sedative and antispasmodic effects, promotes the stimulation of respiratory movements, sucking, spontaneous motor activity, restoration of adequate unconditioned reflex and conditioned reflex activity, which is especially important for the recovery of premature infants. The advantages of including these treatment methods in the traditional therapy of newborns with perinatal CNS damage have been revealed. In our opinion, it is necessary to involve mothers of neonates in implementation of orolingual massage, dry immersion, and music therapy in order to continue therapeutic treatment at home.

Conflict of interest. None declared by the authors.

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