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Safety and Effectiveness of Magnetic Stimulation in the Rehabilitation of Children with Neurogenic Urinary Incontinence: a Prospective Open Randomized Controlled Clinical Study

Svetlana A. Volovets[1], Nazim G. Badalov[1,2], Irina V. Borodulina*[3], Vera I. Efimova[1], Maxim Y. Yakovlev[4]
[1]L.I. Shvetsova Scientific and Practical Center for Medical and Social Rehabilitation, Moscow, Russian Federation
[2]I.M. Sechenov First Moscow State Medical University, Moscow, Russian Federation
[3]Russian Medical Academy of Continuous Professional Education, Moscow, Russian Federation
[4]National Medical Research Center of Rehabilitation and Balneology, Moscow, Russian Federation

ABSTRACT

INTRODUCTION. Urinary incontinence in children is an interdisciplinary problem. The prevalence of urinary incontinence ranges from 3.1% to 8.6% and decreases with age. Urinary incontinence can be caused by both organic (diseases of the genitourinary system, neurological pathology) and functional causes. One of the methods of non-drug correction of urinary incontinence is extracorporeal magnetic stimulation, used in adult patients. At the same time, the effectiveness of the method among the pediatric population has not been sufficiently studied.

AIM. To study the effectiveness and safety of extracorporeal magnetic stimulation in the comprehensive rehabilitation of children with neurogenic urinary incontinence.

MATERIAL AND METHODS. A prospective open randomized controlled clinical study included 75 pediatric patients (from 5 years to 16 years and 6 months) with a clinical form of day and night urinary incontinence, who were divided by simple randomization into a main group (n=39), who received a standard rehabilitation and extracorporeal magnetic stimulation program for 21 days, and a comparison group (n=36), in which the standard rehabilitation program did not include the use of extracorporeal magnetic stimulation.

RESULTS AND DISCUSSION. A prospective open randomized comparative study revealed that the clinical effectiveness of the extracorporeal magnetic stimulation method in the comprehensive rehabilitation of children with neurogenic urinary incontinence is 94.8%, which is 25.4% higher than in the comparison group. After treatment, patients in the main group had a noticeable decrease in urinary incontinence episodes, an increase in the micturition volume, and an improvement in the quality of life. Patients with various background neurological pathology responded to treatment, which indicates the common pathogenetic mechanisms of the development of lower urinary tract symptoms in these conditions and the independence of the final effect from the basic diagnosis.

CONCLUSION. The use of the perineal extracorporeal magnetic stimulation method in children with neurogenic urinary incontinence increases the effectiveness of rehabilitation and is a promising and safe direction of rehabilitation treatment.

KEYWORDS: magnetic stimulation, urinary incontinence, children

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***For correspondence:** Irina V. Borodulina, e-mail: irina.borodulina@gmail.com

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Безопасность и эффективность магнитной стимуляции в реабилитации детей с нейрогенным недержанием мочи: проспективное открытое рандомизированное контролируемое клиническое исследование

Воловец С.А.[1], Бадалов Н.Г.[1,2], Бородулина И.В.[*3], Ефимова В.И.[1], Яковлев М.Ю.[4]

[1]Научно-практический центр медико-социальной реабилитации им. Л.И. Швецовой, Москва, Россия
[2]Первый Московский государственный медицинский университет им. И.М. Сеченова, Москва, Россия
[3]Российская медицинская академия непрерывного профессионального образования, Москва, Россия
[4]Национальный медицинский исследовательский центр реабилитации и курортологии, Москва, Россия

РЕЗЮМЕ

ВВЕДЕНИЕ. Недержание мочи у детей является междисциплинарной проблемой. Распространённость недержания мочи колеблется от 3,1% до 8,6% и уменьшается с возрастом. Недержание мочи может быть вызвано как органическими (заболевания мочеполовой системы, неврологическая патология), так и функциональными причинами. Одним из методов немедикаментозной коррекции недержания мочи является экстракорпоральная магнитная стимуляция, применяемая у взрослых пациентов. В то же время эффективность метода среди педиатрической популяции изучена недостаточно.

ЦЕЛЬ. Изучить эффективность и безопасность ЭМС в комплексной реабилитации детей с нейрогенным недержанием мочи.

МАТЕРИАЛ И МЕТОДЫ. Мы включили в проспективное открытое рандомизированное контролируемое клиническое исследование 75 пациентов педиатрического профиля (от 5 лет до 16 лет и 6 месяцев) с клинической формой дневного и ночного недержания мочи, которые были разделены методом простой рандомизации на основную группу (n=39), получавшую стандартную программу реабилитации и экстракорпоральную магнитную стимуляцию в течение 21 дня, и группу сравнения (n=36), в которой стандартная программа реабилитации не включала использование ЭМС.

РЕЗУЛЬТАТЫ И ОБСУЖДЕНИЕ. Проспективное открытое рандомизированное сравнительное исследование показало, что клиническая эффективность метода экстракорпоральной магнитной стимуляции в комплексной реабилитации детей с нейрогенным недержанием мочи составляет 94,8%, что на 25,4% выше, чем в группе сравнения. После лечения у пациентов основной группы заметно уменьшилось количество эпизодов недержания мочи, увеличился объем мочеиспускания, улучшилось качество жизни. На лечение показало эффективность в случае с пациентами с различной фоновой неврологической патологией, что свидетельствует об общих патогенетических механизмах развития симптомов нижних мочевыводящих путей при этих состояниях и независимости конечного эффекта от основного диагноза.

ЗАКЛЮЧЕНИЕ. Применение метода экстракорпоральной магнитной стимуляции промежности у детей с нейрогенным недержанием мочи повышает эффективность реабилитации и является перспективным и безопасным направлением восстановительного лечения.

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***Для корреспонденции:** Бородулина Ирина Владимировна, e-mail: irina.borodulina@gmail.com

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INTRODUCTION

Urinary incontinence (UI) in children is an interdisciplinary problem that requires the attention of many specialists, such as urologists, neurologists, psychologists, physical therapists, pediatricians and others. In pediatric practice, urinary incontinence is involuntary leakage (excretion) of at least 1 ml of urine at least once a week in a child over 5 years of age [1]. UI can be observed both during the day and at night (enuresis). The incidence of various urinary incontinences is 3-3.5% among adolescents and up to 20% among children aged between 7 and 14 years [2]. The prevalence of UI, according to various epidemiological studies, ranges from 3.1% to 8.6% and decreases with age [3, 4]. Meanwhile, UI can be due to both organic (diseases of the urogenital system, neurological pathology) and functional causes. National and foreign researchers' observations show that functional disorders prevail in the structure of urinary disorders in 90% of cases, which are a consequence of modern psychosocial influences on the child [2, 5, 6].

Over the past decades, our knowledge of the mechanisms of the regulation of urination has increased considerably. This has provided a better understanding of the control of bladder accumulation and emptying under normal and pathological conditions, which has contributed to a more complete understanding of the principles of action of the existing treatment methods [7].

Lower urinary tract (LUT) functions: accumulation and periodic evacuation of urine – depend on the coordinated activity of the bladder muscles and the outlet, consisting of the bladder neck, urethra and urethral sphincter. The coordination between these organs is provided by a complex system of nervous regulation, the structures of which are located in the brain, spinal cord, peripheral and intramural ganglia [8-10].

Afferent information from the bladder is transmitted through the pelvic and hypogastric nerves, whereas from

the bladder neck and the urethra the signal is transmitted through the genital and hypogastric nerves [8, 11]. The afferent components of these nerves consist of myelinated (Aδ) and unmyelinated C-axons [12]. Aδ fibers respond to passive stretching and active contraction and thus transmit information about the bladder filling. C-fibers are insensitive to bladder filling under physiological conditions and respond mainly to strong stressors, such as chemical agents or cooling [12]. The spinal centers of the pelvic nerves are located in the lateral horns of the spinal cord at the level of segments S2-S4, and the hypogastric nerves – at the level of T10–L2 [13, 14]. Between themselves, as well as with the higher brain structures involved in the control of the lower urinary tract functions, the regulatory centers are connected by projective connections [13].

Urothelial cells also play a role in the sensory mechanisms of the bladder. The urothelium has signaling properties that allow it to respond to chemical and mechanical stimuli and to communicate with nerve fibers in the bladder wall by releasing active substances (e.g., acetylcholine, adenosine triphosphoric acid, nitric oxide) that can regulate the activity of the neurogenic response and, thereby, induce local vascular changes or reflex contractions of the bladder [15-19].

The accumulation phase of the bladder is provided by the activity of the sympathetic nervous system (hypogastric nerve, intermediolateral nuclei of the spinal cord segments Th10-L2, pontine storage/accumulation center), meanwhile the detrusor parasympathetic innervation is inhibited (pelvic nerve, sacral micturition center, pontine micturition center), and smooth and transversely striated parts of the urinary sphincter are activated, preventing the spontaneous emptying of the urinary bladder (Fig. 1) [20].

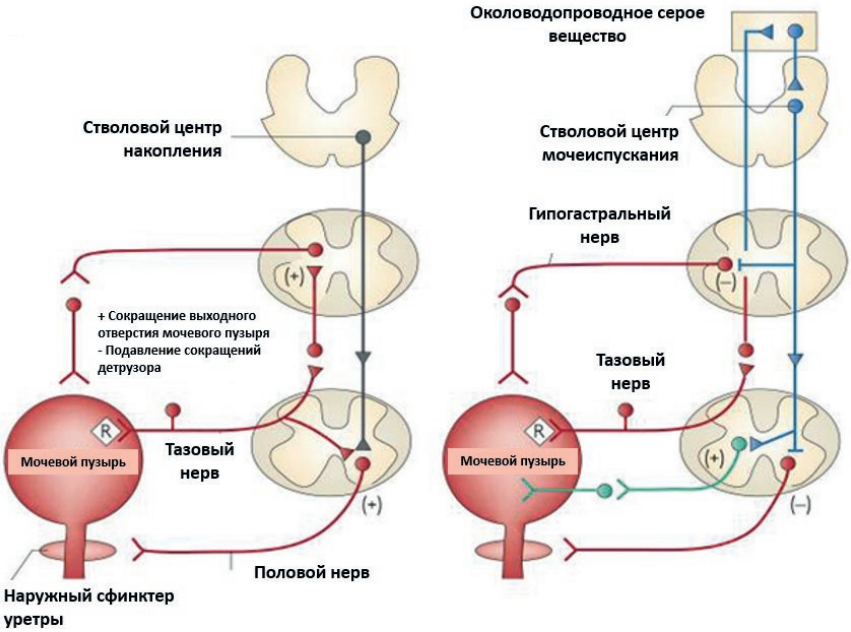

Fig. 1. *Neural pathways controlling urine retention and urination (adapted from [20])*

The bladder emptying phase is associated with the work of the parasympathetic nervous system and suppression of sympathetic influences. It is important to note that in this case urination is normally activated by relaxation of the external urethral sphincter, which is the only arbitrary mechanism of regulation of the lower urinary tract and mediated peripherally by the pudendal nerve.

The mechanisms involved in the accumulation and excretion of urine undergo noticeable changes during the prenatal development and in the period of infancy. Thus, in the fetus, the regulation of the evacuation phase of urine occurs through mechanisms at the level of the bladder; further, with development, the emptying is regulated by simple reflex pathways controlled by spinal cord centers. As the child grows and the central nervous system (CNS) matures, the reflex emptying eventually comes under the influence of higher brain centers and becomes a conscious process [21, 22].

Thus, the regulation of urination and urine accumulation is a complex, hierarchical process involving both peripheral and central neural control structures. In this connection traumas and diseases of the nervous system, some psychogenic conditions can result in a violation of the coordinated system of regulation, changes in the activity of cortical control centers, "disinhibition" of spinal centers and activation of simple reflexes of urination [23, 24].

UI in children may have the following forms:

1. Physiological urinary incontinence (children under 5 years of age;

2. Bedwetting- enuresis – involuntary intermittent urination while sleeping in a child over 5 years of age [25]. Enuresis may be due to a combination of several factors: polyuria (due to impaired daily secretion of antidiuretic hormone), bladder dysfunction against the background of delayed maturation at various levels of neural control, difficulty in awakening, family predisposition and psychological triggers. At the same time, some recent studies have shown that it is not psychological factors that cause enuresis, but instead enuresis causes behavioral abnormalities and social maladjustment [26]. Monosymptomatic enuresis is characterized by the absence of any symptoms of lower urinary tract dysfunction, while non-monosymptomatic enuresis is combined with other symptoms of lower urinary tract dysfunction, which occur mostly in the daytime;

3. Urinary incontinence in the daytime is caused by organic (bladder dysfunction due to the organic injury of the central nervous system (trauma, malformations), somatic diseases, diseases of the urinary system (epispadias, etc.)) and functional causes (Idiopathic urinary incontinence) [1, 27].

Prevalence of inappropriate urination in pediatric practice and lack of unified approaches to therapy result in the development and individualization of treatment programs, including pharmacotherapy and non-pharmacological technologies. In rehabilitation programs for pelvic organ dysfunction, methods of non-medical therapy are often used: therapeutic exercises, methods of instrumental physical therapy (electro stimulation (ES), laser therapy, hyperbaric oxygenation, drug electrophoresis, amplipulse therapy, heat therapy, ultrasound therapy), behavioral therapy. A rational combination of drug and physical therapy methods increases the effectiveness of rehabilitation programs for children with pelvic organ dysfunction. Thereby, the safety of the techniques used in pediatric practice and minimization of side effects are of paramount importance. From this point of view, the search for effective and safe nonpharmacological technologies and the development of therapeutic methods for children with pelvic organ dysfunction on their base seem to be relevant.

Among adult patients with lower urinary tract dysfunction (stress and imperative UI), the method of extracorporeal magnetic stimulation (EMS) has been quite widespread since the 1990s. In contrast to electrical stimulation, which is a well-studied and popular method for treating this category of patients, with direct stimulation of afferent and efferent nerve fibers, pulsed magnetic field (PMF) causes mediated secondary depolarization of the nerve fiber through the emerging voltage difference, which results in further spread of excitation and subsequent effects [28, 29]. Direct ES of the tissue triggers electrochemical reactions, which can be the reason for possible tissue damage, and also reduces the stimulating effect by changing the impedance. Similar effects are not observed when exposed to a magnetic field, which freely passes through the tissue in the area where the inductor is applied. Thus, despite similar physical and biological mechanisms, magnetic stimulation is the preferred method due to its higher effectiveness and safety. This is evidenced by the following facts:

1. the ability of magnetic stimulation to penetrate all tissue structures without attenuation of the impulse;

2. loss of electric field strength induced by the magnetic impulse is much less than when it is generated by applying surface electrodes during electro stimulation, which allows stimulating deep-seated structures without pain and discomfort associated with the generation of current on the skin surface;

3. magnetic stimulation does not require any special preparation of the skin and a full physical contact with it, i.e. the effect is achieved even at a distance of several tens of millimeters of the stimulated surface from the inductor [29].

A lot of published data testify to the apparent influence of magnetic stimulation on lower urinary tract function. When using magnetic stimulation, many researchers have achieved the effect of treating pathogenetically heterogeneous forms of urinary dysfunction, which suggests the activation of various structures involved in the regulation of the lower urinary tract function when exposed to magnetic field [30, 31].

Currently, the mechanism of action of magnetic stimulation on the physiology of the lower urinary tract remains incompletely studied. The multi-stage and complex nervous regulation of the process of urinary retention and urination act suggests the possibility of involvement of various structures in response to the effects of magnetic field. It was demonstrated that the clinical and urodynamic effects of magnetic stimulation are most likely associated with the restoration of integration of regulatory reflexes, with a neuromodulation effect, when there is a change in activity (inhibition or excitation) of structures of the central, peripheral and vegetative nervous systems [31]. According to some researchers, during magnetic stimulation of the pelvic floor, the suppression of hyperactivity of the bladder is realized by mechanisms similar to those of electrical stimulation [30, 31]:

– stimulation of afferent fibers in the pudendal nerve with subsequent activation of hypogastric nerve at low intravesical pressure in the phase of urine accumulation;

– direct suppression of the pelvic nerve at high intravesical pressure;

– supraspinal inhibition of the detrusor activating reflex.

The results of clinical and experimental studies indicate that the method of extracorporeal magnetic stimulation of the pelvic floor has a predominantly neuromodulatory effect and is effective against irritative forms of urinary dysfunction**.** Thus, extracorporeal magnetic stimulation is a promising method of physical therapy in the rehabilitation of patients with urine incontinence. At the same time, the clinical data on the application of the method in pediatric practice that were published are insufficient, which explains the relevance of the present study.

AIM

To study the effectiveness and safety of extracorporeal magnetic stimulation in the comprehensive rehabilitation of children with neurogenic urinary incontinence

MATERIAL AND METHODS

Study design: An open, prospective, randomized controlled clinical study was conducted. Informed consent had been obtained from the child's legal representative and the child's consent to participate in accordance with the Declaration of Helsinki before the study began. The study was approved by a local ethics committee of L.I. Shvetsova Scientific and Practical Center for Medical and Social Rehabilitation (Minutes No. 5 of 21.12.2021.).

The study included 75 children (between 5 and 16, 5 years old), who received a rehabilitation course in L.I. Shvetsova Scientific and Practical Center for Medical and Social Rehabilitation, between January 2021 and February 2022. The group of participants included 35 girls and 40 boys.

Inclusion criteria: pediatric patients with urinary dysfunction as a clinical form of daily (imperative) and nocturnal urinary incontinence.

Exclusion criteria: Inflammatory processes in the pelvic organs in the acute stage; Urinary incontinence due to

inflammatory infectious diseases of the genitourinary system; presence of acute infectious diseases; implanted metal objects that are incompatible with exposure to the magnetic field; implanted electronic devices that control physiological functions of the body; neoplasms or suspected tumor process; exacerbation of hemorrhoids; recurrent thrombophlebitis; pelvic bleeding (hematuria, metrorrhagia, rectal bleeding); presence of systemic blood diseases; refusal to sign informed consent by the child's legal representative; lack of consent of the child to participate in the study.

To perform extracorporeal magnetic stimulation (EMS) "Avantron Pro" device was used. The spectrum of frequencies that can be achieved by the device is from 1 to 100 Hz. Various frequency parameters of extracorporeal magnetic stimulation have been used in previous and published clinical studies, while there was no significant difference in the therapeutic effect of pulsed magnetic field with different frequencies on irritative symptoms of the lower urinary tract dysfunction.

The following protocol of extracorporeal magnetic stimulation was applied in this study: The treatment was applied to the pelvic floor area (for this purpose the child was offered to sit in a chair with a magnetic inductor built into the seat) at a frequency of 5 Hz (exposure for 4 sec, pause for 5 sec) during the first 5 sessions and at a frequency of 10 Hz (exposure for 5 sec, pause for 6 sec) during the following 5 sessions. The exposure intensity was selected individually and averaged 40% of the maximum possible stimulator power of 0.45 Tesla (the reference point was the child's physical sensations in the form of vibration). The total duration of the procedure was 15 minutes. The treatment course was 10 procedures with a frequency of 3 times a week.

Before the treatment, all the patients had undergone an ultrasound examination of the bladder to rule out inflammatory changes and the presence of residual urine.

To evaluate the results of the course of therapy, a diary of urination for 72 hours was used (frequency of urination, volume of excreted urine, volume of consumed liquid). In order to estimate the rhythm of voluntary urination in relation to physiological age norm we used the table developed by A.V. Papayan and N.D. Savenkova [32]. To evaluate the degree of urinary incontinence and its impact on patients' quality of life, we used a questionnaire on the impact of urinary incontinence on quality of life ICIQ – SF (International Conférence on Incontinence Questionnaire Short Form) [33]. The impact of a course of comprehensive rehabilitation on the quality of life of patients, as perceived by parents, was evaluated using the PedsQL (Pediatric Quality of Life Inventory) questionnaire for different age groups.

Statistical analysis of the dynamics of the studied indicators between the groups was performed by Wilcoxon rank sum test; the data in the tables are presented as quartiles and median. The relationship was examined using correlation analysis, calculating the Spearman correlation coefficient. The significance level of differences was defined as ≤0.05.

When examining the background diagnosis on admission, it was found that all the patients had a neurogenic nature of urinary incontinence: 45.2% of the patients were diagnosed with ICP (infantile cerebral palsy), In 32.4% of cases, an organic damage of the central nervous system (stroke, congenital developmental anomalies) was detected, which was accompanied by childhood autism in 13.2% of cases; myelodysplasia was diagnosed in 22.4% of cases, with Arnold-Chiari syndrome concomitant in 3 observations.

At the treatment stage, one patient was excluded from the study due to exacerbation of chronic inflammation of the lower urinary tract with elimination of pathogenic microflora from urine. From the past medical history, it was known that a month before admission the child had received a course of treatment on the "Avantron pro" device at another treatment and prevention facility without urine examination, which caused an increase in episodes of dysuria and urinary incontinence. In our opinion, this deterioration could be related to an exacerbation of chronic inflammation in the bladder wall due to increased blood supply to the pelvic organs against the background of an undetected infection in the lower urinary tract (which was established after the discharge) under the influence of EMS.

The patients were randomly divided into two groups. There were 39 patients in the main group, who received the standard program of a comprehensive rehabilitation for 21 days (therapeutic exercises, a course of psychological rehabilitation, medical electrophoresis, laser therapy, amplipulse therapy) and a course of extracorporeal magnetic stimulation procedures with "Avantron Pro" device. Other physiotherapeutic interventions (electrophoresis, laser therapy, amplipulse therapy) were performed on areas not related to lower urinary tract. The patients in the comparison group (n=36) received only a standard rehabilitation program.

RESULTS AND DISCUSSION

All the patients completed the course of treatment; no adverse reactions associated with exposure to magnetic stimulation were registered. According to the results of the study, the rhythm of daily urination normalized in the main group after a course of complex rehabilitation, the volume of urination was restored. These changes were reliable. There was a significant decrease in the incidence of urinary incontinence, a significant decrease in the severity of urinary incontinence according to the questionnaire ICIQ – SF. The results of the parents' survey demonstrated an improvement in the quality of life of children in the main group (Table 1).

The comparison group showed less significant results after the standard rehabilitation program. There was only a trend of improvement in the rhythm of daily urination, a significant decrease in the incidence of urinary incontinence and correction of urinary incontinence severity according to the questionnaire ICIQ – SF. All other parameters under study showed no significant positive changes (Table 1).

Table 1. *Dynamics of the studied indicators before and after the rehabilitation course in the main group and the comparison group*

Indicators	Main group (n=39)	Comparison group (n=36)
Frequency of daily urination, qty	10[7;11,5]^ 8[5,5;9]*	10,5[8,5;11,25]# 8,5[6,25;9]*
Frequency of nocturnal urination, qty	3[2,5;4] 1[0,645;2]*	3,5 [3;4] 3 [3;3,25]
Episodes of urinary incontinence, qty	7[5;10] 2[0;4]*	6[4,5;6] 4[3,5;5]*
Single urination volume, ml	95[80;130] 125[98,75;172,5]*	95[87,5;95] 95[92,5;95]
ICIQ-SF, points	14,5[11;18] 10[8;14]*	12[10,25;13,5] 9,5[7,5;10,5]*
PedsQL, points	55[46,5;60] 56,5[49,25;60,75]*	55[49,5;61,5] 55[47,5;60,5]

Note: **the reliability of intergroup differences before and after the treatment was p≤0.05; # the numerator shows the results before the treatment; the denominator – after the treatment; ^ the data are presented as median (Me), lower (Q1. 25%) and upper (Q3. 75%) quartiles*

The results of treatment in the main group of patients were additionally analyzed by subgroups according to the background neurological diagnosis. It was found that children with cerebral palsy demonstrated a significant improvement in the rhythm of daily urination and an increase in the volume of single urine. Moreover, there was a significant decrease in the incidence and severity of urinary incontinence according to the questionnaire ICIQ-SF (Table 2). The results of PedsQL parents' survey demonstrated a reliably positive trend in the integral index of the quality of life (Table 2).

Table 2. *Dynamics of the studied indicators in children with cerebral palsy in the main group after the rehabilitation course (n=17)*

Indicators	Before	After	Reliability (p)
Frequency of daily urination, qty	9[7;15]	7[5,5;11]	0,026*
ICIQ-SF, points	11[11;17]	8,5[7,25;12,75]	0,011*
PedsQL, points	48[41;55]	51,7[36,25;55]	0,048*
Single urination volume, ml	75[57,5;92,5]	105[85;120]	0,050*
Episodes of urinary incontinence, qty	5[3;8,5]	2[0;3,5]	0,038*

Note: **the reliability of differences was p≤0.05*

After a course of complex rehabilitation for patients with organic lesions of the central nervous system in the main group (n=13), there was a significant decrease in the frequency of daily urination (Table 3). Meanwhile, the dynamics of the index of the single urination volume was statistically insignificant. The same group demonstrated a significant reduction in the incidence of urinary incontinence. A comprehensive rehabilitation using EMS contributed to a significant reduction in the severity of urinary incontinence according to ICIQ-SF questionnaire. The results of PedsQL parents' survey demonstrated a reliably positive trend in the integral index of the quality of life (Table 3).

Table 3. *Dynamics of the studied indicators after the rehabilitation course in patients with organic lesions of the central nervous system in the main group (n=13)*

Indicators	Before	After	Reliability (p)
Frequency of daily urination, qty	10[6;12]	8[6;9]	0,041*
ICIQ-SF, points	14[9;17]	10[7;13]	0,017*
PedsQL, points	58[52;60]	59[54;63]	0,038*
Episodes of urinary incontinence, qty	4[3;5,5]	2[0;2,5]	0,007*
Single urination volume, ml	135[87,5;210]	145[97,5;205]	0,498

Note: ** the reliability of differences was p≤0.05*

The results of the study in patients with myelodysplasia in the main group (n=8) showed a correction of the rhythm of nocturnal urination after the course of rehabilitation and the volume of a single portion of urine (Table 4). There was also a positive trend in the dynamics of the daily urination rhythm index, but the results were not statistically significant. A course of comprehensive rehabilitation contributed to a significant reduction in the severity of urinary incontinence according to ICIQ-SF questionnaire, which was also accompanied by a positive trend in improving the quality of life of the patients according to their parents, as shown the data from PedsQL survey (Table 4).

Table 4. *Dynamics of the studied indicators after the rehabilitation course in patients with myelodysplasia in the main group (n=8)*

Indicators	Before	After	Reliability (p)
Frequency of daily urination, qty	9[7,5;12]	6,5[4;9,75]	0,068
Frequency of nocturnal urination, qty	3[2;4,5]	1[0;1]	0,039*
Single urination volume, ml	90[60;130]	120[90;150]	0,039*
ICIQ-SF, points	15,5[12,5;18,5]	11[8,75;14,5]	0,024*
PedsQL, points	50[45,5;60,25]	53[50,75;60,25]	0,066

Note: ** the reliability of differences was p≤0.05*

To evaluate the effectiveness of the rehabilitation course, the following criteria were used: the result was considered "good" if the episodes of daytime and nighttime urinary incontinence stopped completely, and the urinary portions corresponded to the physiological age norm. The result was considered "satisfactory" if the incontinence episodes were reduced by at least 50%, and the urine portions were close to the physiological norm. The result was considered "unsatisfactory" if there was no positive change in the function of the pelvic organs.

The program of the comprehensive rehabilitation using EMS in the main group was effective in 94.8% of patients, which was 25.4% more than in the comparison group. A good result was observed in 55.3% of the patients, a satisfactory result in 39.5%, and an unsatisfactory result in 5.2% (Fig. 1). In the comparison (control) group, where the patients underwent the standard comprehensive rehabilitation program, 33.3% of the patients showed a good result and 36.1% showed a satisfactory result. In 30.6% of cases, a satisfactory result could not be achieved. Thus, the effectiveness of treatment in the comparison group was 69.4% (Fig. 2).

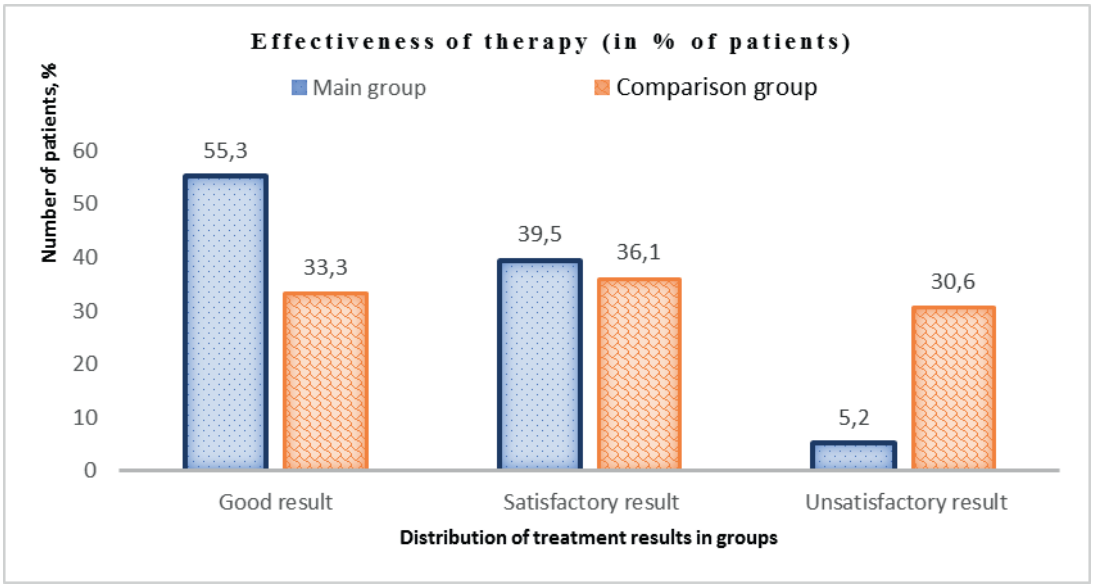

Fig. 2. *Effectiveness of therapy in the main and comparison groups*

Among the patients with unsatisfactory results (5.2% of observations) in the main group, most of them were children with organic lesions of the central nervous system. Our experience in this study suggests that for this category of patients, along with EMS, behavioral therapy of "forced" urination should be used to improve voluntary control of lower urinary tract function. For this purpose, a physiological norm of fluid consumption is defined according to the child's weight; the daily volume is divided into 7-8 intakes, after which urination is initiated by reminder at intervals of 1.5-2 hours, depending on the child's age and bladder volume. It should be noted that the regimen of forced urination in behavioral therapy is prescribed strictly on an individual basis. Additionally, it is recommended to educate parents regarding the child's drinking habits, urination and bladder training at home.

UI is classified as an irritative symptom of lower urinary tract dysfunction and is a condition that significantly impairs the quality of life of pediatric patients, regardless of age and sex [34, 35]. One of the causes of UI is nervous

system pathology, as this study demonstrated: all the children in the sample had a background neurological diagnosis. Among the non-pharmacological methods of correction of neurogenic urinary incontinence, the magnetic stimulation is used and well-studied in adult patients, while studies in pediatric practice are quite rare. A double blind placebo-controlled study demonstrated the efficacy of magnetic stimulation of the sacral root area in monosymptomatic enuresis in children of different ages [36]. The present work is devoted to the study of effectiveness and safety of extracorporeal magnetic stimulation on the perineal area in children with urinary incontinence of neurogenic nature.

Pulsed magnetic field during extracorporeal magnetic stimulation acts locally on the perineal area, while through the mechanism of magnetic induction causing action potentials to spread in the nerve endings. The main target when influencing the pelvic floor area with EMS is the pudendal nerve, stimulation of which causes both secondary activation of the hypogastric nerve and sympathetic influences, and activation of the central mechanisms involved in the process of conscious control over the function of the lower urinary tract [37, 38]. The general effect of these influences is a reduction of irritative symptomatology in the form of reduction of UI episodes, increase in the volume of single urine.

This study demonstrates the effectiveness and safety of the extracorporeal magnetic stimulation method on the perineal area using the original protocol in children with urinary incontinence of neurogenic nature. Clinical effectiveness was observed in 94.8% of patients in the main group. Patients with different background neurological pathology responded to treatment, which indicates the common pathogenetic mechanisms of the lower urinary tract dysfunction in these conditions and the independence of the final effect from the basic diagnosis. Nevertheless, it should be noted that most of the 5.2% of unsatisfactory results were children of the subgroup of organic damage of the CNS, which may be due both to a more complex mechanism of lower urinary tract dysfunction and the size and peculiarities of the sample. This circumstance encourages further studies in this direction. Furthermore, it is interesting to evaluate the effect of extracorporeal magnetic stimulation on defecation disorders (encopresis and neurogenic constipation) in this category of patients.

It is necessary to point out that in some cases it is appropriate to use behavioral therapy – forced urination to improve arbitrary control and formation of a stereotype of "urinary behavior" with the help of the doctor and adults.

CONCLUSION

Extracorporeal magnetic stimulation of the perineal area is a promising method for rehabilitation of children with pelvic organ dysfunction and can be viewed as one of the alternative safe measures in the treatment of this category of patients, which contributes to reducing the severity of symptoms. The clinical effectiveness of extracorporeal magnetic stimulation in neurogenic urinary incontinence in children is 94.8%. Meanwhile, all the patients completed the treatment course and no adverse reactions associated with exposure to magnetic stimulation were observed, which demonstrates a favorable safety profile of the method. One should note that the patients in the active group with different background neurological pathology responded to the treatment, which indicates common pathogenetic mechanisms of the lower urinary tract dysfunction development in these conditions and independence of the final effect from the basic diagnosis. Further studies are planned to evaluate the delayed effect of the method, as well as to study the possibility of its use in children with combined pelvic organ dysfunction: urinary incontinence and fecal incontinence.

ADDITIONAL INFORMATION

Information about the authors:

Svetlana A. Volovets, Dr. Sci (Med.), Professor, Chief L.I. Shvetsova Scientific and Practical Center for Medical and Social Rehabilitation, Russia.
E-mail: info@cmir.info, ORCID ID: http://orcid.org/0000-0001-5560-6235

Nazim G. Badalov, Dr. Sci. (Med.), Professor, L.I. Shvetsova Scientific and Practical Center for Medical and Social Rehabilitation, Russia.
E-mail: prof.badalov@gmail.com, ORCID ID: http://orcid.org/0000-0002-1407-3038

Vera I. Efimova, Pediatric Andrologist-Urologist, Department of Outpatient Rehabilitation, L.I. Shvetsova Scientific and Practical Center for Medical and Social Rehabilitation, Russia.
E-mail: legerdemain@yandex.ru, ORCID ID: http://orcid.org/0000-0003-1666-8147

Irina V. Borodulina, Dr. Sci. (Med.), Associate Professor of the Department of Physical Therapy, Sports Medicine and Medical Rehabilitation of Russian Postgraduate Medical Academy, Russia.
E-mail: irina.borodulina@gmail.com, ORCID ID: http://orcid.org/0000-0001-7526-1553

Maxim Yu. Yakovlev, Dr. Sci. (Med.), Deputy Director for Strategic Development of Medical Activities, National Medical Research Center of Rehabilitation and Balneology; Associate Professor of the Department of Hygiene, I.M. Sechenov First Moscow State Medical University, Russia.
E-mail: masdat@mail.ru, ORCID ID: http://orcid.org/0000-0002-5260-8304

Authors' contribution:
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