

Міністерство охорони здоров'я України
Буковинський державний медичний університет

БУКОВИНСЬКИЙ МЕДИЧНИЙ ВІСНИК

Український науково-практичний журнал

Заснований у лютому 1997 року

Видається 4 рази на рік

Включений до Ulrichweb™ Global Serials Directory, наукометричних і спеціалізованих баз даних Google Scholar (США), Index Copernicus International (Польща), Scientific Indexing Services (США), Infobase Index (Індія), Ukrainian research & Academy Network (URAN), НБУ ім. Вернадського, “Джерело”

ТОМ 26, № 2 (102)

2022

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Чернівці: БДМУ, 2022

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Рекомендовано до друку та до поширення через мережу Інтернет рішенням вченої ради
Буковинського державного медичного університету
(протокол № 10 від 26.05.2022 року)

Буковинський медичний вісник

(Бук. мед. вісник) – науково-
практичний журнал, що рецензується
Bukovinian Medical Herald
(Buk. Med. Herald)

Заснований у лютому 1997 р. Видається 4
рази на рік

Founded in February, 1997 Published four
times annually

Мова видання: українська, англійська
Сфера розповсюдження загальнодержавна,
зарубіжна

Свідоцтво про державну реєстрацію: серія
КВ №15684-4156 ПР від 21.09.2009

Наказом

Міністерства освіти і науки України
від 17 березня 2020 року № 409 журнал
“Буковинський медичний вісник”
включено до категорії "Б" (медичні
спеціальності – 222) переліку наукових
фахових видань України

Адреса редакції: 58002, м. Чернівці,
пл. Театральна, 2

Тел.: (0372) 55-37-54,
52-39-63

Факс: (0372) 55-37-54

e-mail: bmh@bsmu.edu.ua

Адреса електронної версії журналу в
Internet: <http://www.bsmu.edu.ua>

CLINICAL AND ELECTRONEUROMYOGRAPHIC PECULIARITIES OF SPASTIC SYNDROME IN CHILDREN WITH ORGANIC LESIONS OF THE NERVOUS SYSTEMI.A. Zorii¹, N.V. Vasylieva¹, I.I. Krychun¹, O.M. Nicka¹, I.B. Kharmanska²

1 - Bukovinian State Medical University, Chernivtsi, Ukraine

2 - Bukovinian Center of Restorative Therapy and Comprehensive Rehabilitation of Children, Chernivtsi, Ukraine

Key words: children, infantile cerebral palsy, electroneuromyography, spasticity, Gross Motor Function Classification

Bukovinian Medical Herald.
2022. V. 26, № 2 (102). P. 57-62.

DOI: 10.24061/2413-0737.XXVI.2.102.2022.11

E-mail: zorij@ukr.net

Abstract. Topicality. Organic lesions of the central nervous system (CNS) are a group of neuropsychiatric disorders caused by various pathological factors affecting the brain. Infantile cerebral palsy (ICP) is the most common neurological disease diagnosed in children at an early age. 80 % of children with ICP suffer from spastic forms, the main symptom of which is an abnormal increase in muscle tone – spasticity. This syndrome can be objectified by electroneuromyographic (ENMG) examination which enables qualitative and quantitative assessments of the nervous-muscular system state.

Objective: to determine clinical and electroneuromyographic peculiarities of the spastic syndrome of ICP children depending on the intensity of motor disorders.

Materials and methods. 122 ICP children were examined (an average age $8,8 \pm 3,7$ years) and distributed into groups by the results of Gross Motor Function Classification Expanded & Revised (GMFCS E&R). All the patients underwent careful neurological examination and ENMG examination. To assess supra-segmental and segmental levels of nervous system lesions, the parameters of H-reflex and F-wave were analyzed.

Results. Spastic forms of ICP were diagnosed in the majority of the examined children. Orthopedic pathology was found more often among ICP children with marked motor disorders, including equinovalgus position and planovalgus foot deformity. According to ENMG parameters ICP patients presented conduction disorders manifested by increased amplitude of M-response, especially in testing the tibial nerve, increased Hmax/Mmax ratio and the amplitudes of H-reflex and F-wave.

Conclusions. According to the results of the conducted study, ENMG parameters changed on the side of deterioration depending on the degree of motor activity disorders by Gross Motor Function Classification.

КЛІНІКО-ЕЛЕКТРОНЕЙРОМІОГРАФІЧНІ ОСОБЛИВОСТІ СПАСТИЧНОГО СИНДРОМУ У ДІТЕЙ З ОРГАНІЧНИМ УРАЖЕННЯМ НЕРВОВОЇ СИСТЕМИI.A. Zorii¹, N.V. Vasylieva¹, I.I. Krychun¹, O.M. Nicka¹, I.B. Kharmanska²

Ключові слова: діти, дитячий церебральний параліч; електронейроміографія, спастичність, Шкала великих моторних функцій.

Буковинський медичний вісник. 2022. Т. 26, № 2 (102). С. 57-62.

Анотація. Актуальність. Органічні ураження центральної нервової системи (ЦНС) - це група нервово-психічних розладів, що виникають внаслідок впливу на мозок різних патологічних факторів. Дитячий церебральний параліч (ДЦП) є найбільш поширеним неврологічним захворюванням, що діагностовано у дітей раннього віку. 80 % дітей із ДЦП страждають на спастичні форми, основним симптомом яких є підвищення м'язового тону – спастичність. Цей синдром можна об'єктивізувати за допомогою електронейроміографічного (ЕНМГ) дослідження, яке дає можливість якісно та кількісно оцінити стан нервово-м'язової системи.

Мета - визначити клініко-електронейроміографічні особливості спастичного синдрому у дітей із ДЦП залежно від інтенсивності рухових порушень.

Матеріал і методи. Обстежено 122 дитини із ДЦП (середній вік $8,8 \pm 3,7$ року), розподілені на групи за результатами розширеної та переглянутої загальної класифікації рухових функцій (GMFCS E&R). Усім пацієнтам проведено неврологічне обстеження та ЕНМГ дослідження. Для оцінки надсегментарного та сегментарного рівнів ураження нервової системи проаналізовано параметри Н-рефлексу та F-хвилі.

Результати. У більшості обстежених дітей діагностовано спастичні форми ДЦП. Ортопедичну патологію частіше виявляли у дітей із ДЦП з вираженими

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руховими порушеннями, включаючи еквіновальгусне положення та плосковальгусну деформацію стоп. За даними ЕНМГ-параметрів ДЦП, у пацієнтів відзначалися провідникові розлади, що виражалися збільшенням амплітуди М-відповіді, особливо при дослідженні великогомілкового нерва, підвищенням співвідношення Нтах/Мтах та амплітуд Н-рефлексу та F-хвилі.

Висновки. *За результатами проведеного дослідження, параметри ЕНМГ змінювалися у бік погіршення, залежно від ступеня порушень рухової активності, відповідно, за Шкалою великих моторних функцій.*

Introduction. Organic lesions of the central nervous system (CNS) are a group of nervous-psychic disorders occurring due to the effect of various pathological factors on the brain at different stages of ontogenesis. A high-risk factor promoting the occurrence of CNS, organic lesions in the development of a child is cerebral-organic insufficiency which results from negative biological actions on the child's brain, especially at the early stages of ontogenesis during the intrauterine period (intoxication, infection, hypoxia, etc.), birth injury and postnatal asphyxia, immune incompatibility of mother and fetus, associated with immune conflict, prematurity, postnatal cerebral infections, injuries and intoxications [1, 2, 3].

Infantile cerebral palsy (ICP) is the most spread neurological disease diagnosed in children at an early age. The term «infantile cerebral palsy» includes a number of syndromes occurring due to organic brain lesions [4, 5].

The main clinical signs of ICP are non-progressing disorders of motor function and posture. 80 % of children with ICP suffer from spastic forms, the main symptom of which is overactive muscular tonus – spasticity formed due to a combined lesion of the pyramidal and extrapyramidal structures from the side of the brain and spinal cord [6].

Spasticity with ICP is characterized by a number of features, including pathological tonic reflexes, the occurrence of pathological synkinetic activity in performing voluntary movements, disorders in the coordination of movements between the synergist and antagonist muscles (co-contraction phenomenon), increased general reflex excitability (pronounced start-reflex available). Spasticity in ICP children results in the formation of pathological motor stereotype from minimal overactive muscular tonus at the early age to the formation of contractures at the late residual stage of the disease formation [7, 8, 9].

The degree of manifestation of spasticity ranges considerably in ICP patients due to cerebral circulatory disorders and depends mainly on the localization of lesion focus, the severity of paresis and symptoms associated with paresis (sensible disorders on the site of paresis, cerebellar signs). Spasticity influences the motor abilities of patients in different ways: mild spasticity deteriorates walking function, increasing with walking and limiting the distance the patient is able to cover without taking a break. Severe spasticity levels in the muscular tonus cause development of contractures and deformity of limbs, occurrence of painful flexor spasms, and severe disability in patients [1, 2, 10].

At the same time, an investigation of the pyramidal central motor neuron found its functional irregularity along the whole length. It means, that in case of damage to any

area, a different manifestation of spasticity occurs, which determines the other degree of severity of ICP clinical manifestation. The condition of the muscular tonus and control over the dynamics of spasticity can be objectified using biomechanical methods and electroneuromyographic (ENMG) examination, which enables to get qualitative and quantitative assessment of the nervous-muscular system state [11]. On this basis appropriate procedures can be indicated for the patients, their effect can be controlled and future rehabilitation can be predicted in every particular case.

Objective: to determine clinical and electroneuromyographic peculiarities of the spastic syndrome in ICP children depending on the intensity of motor disorders.

Materials and methods. 122 ICP children were examined (average age of $8,8 \pm 3,7$ years). They were treated at the Regional Center of Medical-Social Rehabilitation of Children with organic lesions of the nervous system (Chernivtsi). ICP children were divided into groups according to Gross Motor Function Classification Expanded & Revised (GMFCS E&R) (Table 1). Nowadays GMFCS is generally recognized as an instrument to assess the voluntary motor activity of children with ICP and to divide them into five accurately determined groups according to the development of the gross motor function. GMFCS enables to determine functional abilities of a child, requirements in auxiliary means and possibility to move. This Classification is found to be a reliable, safe and reproduced method of clinical assessment in children with ICP [12].

All the patients underwent careful neurological examination and ENMG examination. Special attention to the neurological status of patients with ICP was paid to disorders of the muscular tonus of the lower and upper limbs, intensification of tendon and periosteal reflexes and their asymmetry, intensity of the spastic syndrome of motor activity disorders in the flexor and extensor muscles of legs and arms, ability to walk independently, possible disorders of urination and defecation.

ENMG examination was carried out on the computer software package M-TEST («DX-system», Kharkiv, Ukraine). Three nerves (median, fibular and tibial) were examined by means of the stimulation method. Stimulation conduction velocity (SCV) by motor fibers, the amplitude and shape of M-response according to the standard methods were assessed. To assess supra-segmental (upper motor neuron) and segmental (α -motor neurons of the spinal cord and peripheral nerves) levels of affliction, the parameters of H-reflex and F-wave were analyzed. Parameters of F-wave of the tibial and median nerves were

Table 1

Distribution of patients with infantile cerebral palsy according to the Gross Motor Function Classification Expanded & Revised (GMFCS E&R)

Groups of the examined patients with ICP	Average age, years	Number, n	%
1 st group included children walking without limitations	8,16±3,02	23	18,9
2 nd group – children walking with limitations	10,05±4,20	26	21,3
3 rd group – children who walk using a hand-held mobility device	9,10±1,90	26	21,3
4 th group – children whose self-mobility is limited, may use powered mobility	8,2±2,7	25	20,5
5 th group – children transported in a manual wheelchair	7,41±3,91	22	18,0
Total	8,8±3,7	122	100

assessed by the indices of the mean amplitude (mean AF, mcV); parameters of H-reflex were determined by the indices of H-reflex amplitude (mV), maximal H-reflex amplitude and M-response ratio was calculated in per cent (Hmax/Mmax) [13]. The data obtained were statistically processed by means of the applied programs using paired and unpaired Student t-criteria. Statistical processing was performed using applications MS® Excel® 2007tm, Biostat®, Statistika® 6.0.

Results and discussion. Spastic ICP forms were diagnosed in the majority of the examined children: in 40 (32,8%) children – spastic diplegia, in 25 (20,5%) – hemiparesis form, in 6 (4,9%) – spastic tripareisis, in 34 (27,9%) – spastic tetraparesis, hyperkinesia was found in 10 children (8,2%) and atactic syndrome – in 7 (5,7%) children.

The majority of children with spastic ICP forms developed with retardation of static-kinetic and psycho-speech development: 108 (88,5%) patients did not hold their heads, turn from the back to the stomach and sit at the usual age. 49 (40,2%) children were able to stand and walk independently later than others, 41,8% of children started walking under 2-7 years only with support. 18,0% of patients were transported in a manual wheelchair with the assistance of others. Functional disorders of the arms were of various degrees of severity: from mild disorders of minor motor function to gross pronator-flexor contractures in the arms with severe restriction of voluntary movements. The muscular tonus of the majority of patients was intensified by a spastic type, a part of the patients had hyperkinesia (8,2%); muscular dystonia was registered against the ground of an intensified tonus.

The neurological status of 67 (54,9%) children with ICP determined the symptoms of cranial nerves damage, more often in the form of spastic tetraparesis caused by disorders of the cortical-nuclear ways. The signs of lesions of the brain stem structures were found in 7 (5,7%) cases. Pseudobulbar syndrome was diagnosed in 14 (11,4%) patients from the 5th group with the formation of spastic-paretic dysarthria, disorders of articulation and swallow function.

ENMG examination of patients with ICP found neurophysiological signs of supra-segmental disorders correlated by severity of spastic syndrome and motor disorders presented in Table 2.

According to the results of the conducted study (Table

2), ENMG parameters changed on the side of deterioration depending on the degree of motor activity disorders by Gross Motor Function Classification (GMFCS E&R). The most pronounced values of ENMG parameters were found in the 4th and 5th groups of children with considerable motor disorders: testing of the fibular nerves registered a reliable decrease of the motor response amplitude (49,6% and 57,9%, respectively) of nerves in comparison with the patients from the 1st group which is indicative of a reduced power of muscular contraction of the appropriate muscles and axonal depletion in the distal segments of the fibular nerve. It is explained by the fact that orthopedic pathology was more often diagnosed in children from the 4th and 5th groups, that is, equinovalgus position and planovalgus foot deformity. Clinical manifestation of these patients possessed certain differences in the form of sensory disorders in the area of innervation of the fibular nerves, reduction or loss of protective reflexes and other signs of pyramidal insufficiency, hypotrophy of the extensor muscles of the feet, trophic disorders due to dyshydrosis, mottled skin (cutis marmorata) and temperature changes of the feet. Examination of stimulation conduction velocity (SCV) by motor fibers of the fibular nerves did not find reliable differences in all the examined groups of patients. The indicated disorders are most likely of a secondary character since these changes are formed gradually with increasing orthopedic pathology in children with ICP and severe motor disorders. In its turn, the amplitude of M-response in testing the tibial nerve was reliably higher in children from the 4th and 5th groups (children with intensive motor disorders), which is indicative of a considerable tonus increase in the flexor muscles of the feet and toes.

Examination of H-reflex in testing the gastrocnemius muscle found reliable changes in all the patients in comparison with the control group, which was indicative of disorders of the supra-segmental innervation. A considerable decrease in the threshold of H-reflex appearance was found (with 2 mA), which is indicative of increased excitability of the spinal motor neurons. The threshold of M-response appearance was lower as well. Therefore a relative threshold of H-reflex did not increase considerably. The appearance of H-reflex in testing the median nerve is indicative of a considerable decrease in the threshold of reflexive excitability.

A reliable increase of H-response amplitude was registered in the 4th and 5th groups: 31,6% in children from

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Table 2

Electroneuromyographic parameters by means of stimulation of motor nerves in children with organic lesions of the nervous system according to Gross Motor Function Classification

Parameters		Groups of children with ICP according to Gross Motor Function Classification				
		1 st group (n=23)	2 nd group (n=26)	3 rd group (n=26)	4 th group (n=25)	5 th group (n=22)
Amplitude of M-response (mV)	n. medianus (m. abductor pollicis brevis)	7,17±0,87	6,86±0,81	7,92±0,63	5,80±0,36	6,10±0,31
	n. peroneus (m. extensor digitorum brevis)	4,83±0,64	5,19±0,99	3,13±0,44*	2,43±0,57*/**	2,03±0,22*/**
	n. tibialis (m. adductor hallucis)	9,78±0,67	12,34±0,89*	11,78±0,56	13,55±1,03*	14,02±1,34*
Stimulation conduction velocity (m/sec) n. peroneus (m. extensor digitorum brevis)		45,12±2,03	44,74±1,82	46,12±2,31	43,87±2,36	44,65±1,92
Mean amplitude of F-wave, mcV n. tibialis (m. adductor hallucis)		766,14±44,52	909,82±76,58	1029,48±90,89	1281,30±140,91*/**	1463,31±196,45*/**
Amplitude of H-reflex (m. gastrocnemius(cap.lat.)) (mV)		4,27±0,53	4,85±0,42	5,83±0,51	6,25±0,57*	6,18±0,63*
H _{max} /M _{max} (%)		37,6±4,32	51,10±4,76*	67,20±6,24*	77,70±7,62*/**	84,87±8,62*/**

Notes: * – difference reliability from the parameters of the 1st group; ** – difference reliability from the parameters of the 2nd group.

the 4th group and 30,9% - in the 5th group, which is indicative of a severe degree of spasticity in these groups. A reliable pro-gradient increase of Hmax/Mmax ratio was determined with the intensity of motor disorders according to GMFCS E&R, and the highest parameters were found in children who were not able to move independently – 57,1% in comparison with patients who walked themselves.

Analysis of F-wave parameters in patients with spastic forms of ICP found a reliable increase in F-wave amplitude, especially with stimulation of the tibial nerve. The highest values were registered in children from the 4th (by 40,1%) and 5th (by 47,6%) groups in comparison with the 1st group, which is indicative of a considerable increase in synchronous excitability of α -motor neurons of the lumbar-sacral segments of the spinal cord and marked neurophysiological signs of the conductive (pyramidal) insufficiency with damage of the cortical-cervical and cortical-lumbar ways.

Thus, a comprehensive clinical-instrumental examination of children with ICP is valuable in diagnostics of muscular tonus disorders, which must include a careful assessment of the neurological status, orthopedic examination and ENMG examination with compulsory use of the phenomenon of F-wave and H-reflex. The latter ENMG parameters determine the degree of severity of spastic syndrome which enables a remote prediction of motor disorders and choosing appropriate therapeutic-rehabilitation measures.

Conclusions

1. Conductive supra-segmental disorders in children with infantile cerebral palsy are manifested by reliable changes in the neuromyographic parameters: increased amplitude of M-response, especially in testing the tibial nerve, an increase of Hmax/Mmax ratio, increased amplitude of F-wave and H-reflex.

2. Axonal lesion of the fibular nerve in the distal segments of stimulation and paresis of the extensor muscles of the feet and toes were found in the 4th and 5th groups of children with ICP according to GMFCS E&R who were afflicted with valgus foot deformity.

3. The degree of severity of spastic syndrome by the electromyographic parameters in testing the tibial nerve increased in the 4th and 5th groups of children with ICP according to GMFCS E&R.

Prospects for further research. Continuation of the study of spastic syndrome in children with organic lesions of the nervous system, taking into account the severity of the basic disease.

Conflicts of interest: authors have no conflict of interest to declare.

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Відомості про авторів

Зорій Ірина Анатоліївна – канд. мед. наук, доцент кафедри нервових хвороб, психіатрії та медичної психології Буковинського державного медичного університету, м. Чернівці, Україна.

Кричун Ігор Іванович – д-р мед. наук, професор кафедри нервових хвороб, психіатрії та медичної психології Буковинського державного медичного університету, м. Чернівці, Україна.

Васильєва Наталія Володимирівна – канд. мед. наук, доцент кафедри нервових хвороб, психіатрії та медичної психології Буковинського державного медичного університету, м. Чернівці, Україна.

Ніка Ольга Михайлівна – канд. мед. наук, доцент кафедри нервових хвороб, психіатрії та медичної психології Буковинського державного медичного університету, м. Чернівці, Україна.

Харманська Ілона Борисівна – обласний дитячий невролог, медичний директор Буковинського центру відновного лікування та комплексної реабілітації дітей, м. Чернівці, Україна.

Оригінальні дослідження

Information about the authors

Zorii Iryna – PhD, Associate Professor of the Department of Nervous Diseases, Psychiatry and Medical Psychology, Bukovinian State Medical University, Chernivtsi, Ukraine.

Vasylieva Nataliia – PhD, Associate Professor of the Department of Nervous Diseases, Psychiatry and Medical Psychology, Bukovinian State Medical University.

Krychun Igor – Doctor of Medical Sciences, Professor of the Department of Nervous Diseases, Psychiatry and Medical Psychology, Bukovinian State Medical University.

Nicka Olha – PhD, Associate Professor of the Department of Nervous Diseases, Psychiatry and Medical Psychology, Bukovinian State Medical University.

Kharmanska Iona – Regional Pediatric Neurologist, Medical Director of the Bukovinian Center of Restorative Therapy and Comprehensive Rehabilitation of Children, Chernivtsi, Ukraine.

Надійшла до редакції 20.04.22

Рецензент – проф. Нечитайло Ю.М.

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О.М.Ніка, І.Б.Харманська, 2022