



ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2020; 6(2): 631-635
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www.oraljournal.com
Received: 04-02-2020
Accepted: 06-03-2020

Zorii IA

Candidate of Medical Sciences, Associate Professor, Department of Nervous Diseases, Psychiatry and Medical Psychology, Higher State Education Establishment of Ukraine "Bukovinian State Medical University", Doctor of Functional Diagnostics, Regional Medical and Social Center for the Rehabilitation of Children with Organic Nervous System Damage, Chernivtsi, Ukraine

Pryimak HV

correspondence post-graduate student, the Department of Paediatric and Preventive Dentistry, Bogomolets National Medical University, Kyiv; Head, Medical Prevention Department of City Children's Dental Clinic, Chernivtsi, Ukraine

Corresponding Author:

Zorii IA

Candidate of Medical Sciences, Associate Professor, Department of Nervous Diseases, Psychiatry and Medical Psychology, Higher State Education Establishment of Ukraine "Bukovinian State Medical University", Doctor of Functional Diagnostics, Regional Medical and Social Center for the Rehabilitation of Children with Organic Nervous System Damage, Chernivtsi, Ukraine

Relationship of neurophysiological parameters and dental status indices in children with cerebral spastic infantile paralysis depending on the intensity of motor disorders

Zorii IA and Pryimak HV

Abstract

Cerebral spastic infantile paralysis or cerebral palsy (CP) is a collective term including numerous severe diseases of the nervous system. 80% of CP children suffer from spastic forms. Their main symptom is overactive muscular tension – spasticity.

Objective: Relationship of clinical neurophysiological peculiarities of spastic syndrome with caries affliction of teeth in children suffering from cerebral palsy.

Materials and methods: 122 children (an average age was $8,8 \pm 3,7$) with spastic forms of CP were examined. They were distributed into groups according to Gross Motor Function Classification System – Expanded and Revised (GMFCS E&R). All the patients underwent neurological examination, their dental status was determined, and their teeth state was analyzed depending on the degree of motor disorders. Electromyoneurography (EMNG) was conducted, the state of oral hygiene and intensity of dental caries were determined.

Results and discussion: The majority of the examined children were diagnosed to have spastic forms of CP. EMNG examination of CP patients found neurophysiological signs of supra-segmental disorders, determined degree of spastic syndrome intensity and motor disorders. A reliable 56,6% amplitude increase of F-wave was observed in children with intense motor disorders in comparison with patients having mild neurological changes. Caries occurrence in children with CP was found to be 100%, intensity of dental caries on an average was $6,27 \pm 1,19$, and its values were maximum among children with more intense disorders of motor functions. Correlations were found between EMNG values, oral hygiene index and permanent teeth caries (PTC).

Conclusions: Caries intensity among children with CP increases depending on intensity of motor function disorders. The more intensive motor disorders in children with CP are, the deeper neurophysiological changes become with increase of signs of supra-segmental disorders. Direct correlations between neurophysiological parameters and oral hygiene index found can be one of the causes stipulating increased affliction of teeth by caries in children with increase of intensity of motor disorders.

Keywords: Cerebral palsy, electromyoneurography, oral hygiene

Introduction

Topicality. Cerebral spastic infantile paralysis or cerebral palsy (CP) is a collective term including numerous severe diseases of the nervous system with most frequent affliction of the brain structures responsible for voluntary movements [2, 3, 6]. Hypoxic and ischemic changes, especially in the periventricular lobe of the brain, play a crucial role in CP pathogenesis resulting in pathological processes and leukomalacia with irreversible consequences [1, 7, 12, 18]. The main clinical sign of CP is non-progressive disorders of motor function and poses. 80% CP children suffer from spastic forms. Their main symptom is overactive muscular tension – spasticity formed due to a combined injury of the pyramidal and extrapyramidal structure on the levels of the brain and spinal cord [4, 8, 15].

Spasticity with CP is characterized by a number of peculiarities including available pathologic tonic reflexes, occurrence of pathologic synkinetic activity in performing voluntary movements, disorders of coordination interrelations of synergists and antagonists (contraction phenomenon), increase of general reflex excitability (pronounced start-reflex available).

Spasticity in CP children results in formation of pathological motor stereotype from minimal intensified muscular tonus at the early age to the formation of contractures at the late residual stage of the disease formation [9, 17, 19]

The degree of spastic intensity varies greatly in CP patients according to disorders of cerebral circulation and mainly depends on the location of injury focus, deepness of paresis and signs associated with paresis (sensory disorders on the side of paresis, cerebellum signs). Spasticity affects motor possibilities of patients differently: mild spasticity deteriorates walking function becoming more intensive during movement and limiting the distance a patient is able to cover without stopping. Moderate spasticity, especially in the leg, can be useful for a patient, since it enables him to use the leg as a support while walking. Severe spasticity levels remaining muscular strength causing development of contractures and deformity of the limb, occurrence of painful flexor spasms, and sever disability of patients [11, 14].

At the same time, examination of the pyramidal central motor neuron revealed its functional irregularity along the whole length. Therefore, affliction of its any part causes different spasticity manifestation, which determines different degree of severity of CP clinical signs. The state of muscular tonus can be objectified and spasticity dynamics can be controlled by means of the methods of biomechanics and electromyoneurography (EMNG) examination enabling to conduct a qualitative and quantitative study of the state of the nervous and muscular systems [13]. On the base of these examinations appropriate procedures can be indicated for patients, their effect can be controlled and rehabilitation prospects can be predicted in every particular case.

Pathologic changes of the dental-maxillary system are found in the majority of patients with perinatal organic brain lesions [10, 16]. Their signs can be congenital and acquired defects of

the dental tissue, malocclusion, bruxism etc. Due to certain difficulties to undertake necessary hygienic care of the oral cavity in CP children a high rate of lesions of the dental hard tissue is often diagnosed. Poor hygiene can be a source of chronic infection and intoxication, associated with concomitant injuries of the periodontal tissue and oral mucosa. At the same time, oral sickness rate correlates with severity of motor disorders and degree of hypertonus intensity. Considering structural changes of the maxillofacial area, hypertonus of the masticatory muscles and concomitant chronic diseases, children with CP diagnosis are in the risk group of occurring diseases of the hard dental and periodontal tissues.

Objective: relationship of clinical neurophysiological peculiarities of spastic syndrome with caries affliction of teeth in children suffering from cerebral palsy.

Materials and Methods: 122 children (an average age was $8,8 \pm 3,7$) with spastic forms of CP were examined. They were treated at the Regional Center of Medical-Social Rehabilitation of Children with Organic Lesions of the Nervous System (Chernivtsi). Children with CP were distributed into groups according to Gross Motor Function Classification System – Expanded and Revised (GMFCS E&R) (Table 1). Today Gross Motor Function Classification System (GMFCS) is internationally recognized as a tool to assess voluntary motor activity of children and young people with cerebral palsy categorizing them in 5 different levels according to gross motor function development. GMFCS classification enables to determine functional abilities of a child, the need in auxiliary means and possibility to move. The system appears to be a reliable, valid and reproduced method of clinical assessment in children with CP [5].

Table 1: Distribution of patients with cerebral palsy according to Gross Motor Function Classification System – Expanded and Revised (GMFCS E&R)

Groups of the examined patients with CP	Average age, years	Amount, n	%
1 st group (children perform gross motor skills without restrictions)	$8,16 \pm 3,02$	23	18,9
2 nd group (children perform gross motor skills with restrictions)	$10,05 \pm 4,20$	26	21,3
3 rd group (children walk using a hand-held mobility device)	$9,10 \pm 1,90$	26	21,3
4 th group (can walk with physical assistance)	$8,2 \pm 2,7$	25	20,5
5 th group (children are transported in a manual wheelchair)	$7,41 \pm 3,91$	22	18,0
Total	$8,8 \pm 3,7$	122	100

A careful neurological examination and EMNG examination were performed for all the patients. In assessment of a neurological status of patients with CP special attention was paid to disorders of muscular tonus of the upper and lower limbs, intensified tendon and periosteum reflexes and their asymmetry, spastic syndrome intensity of motor activity disorders in flexors and extensors of the foot and hand, changes of the muscular tonus in different muscular groups of legs and arms, ability to walk without assistance, disorders of urination and defecation available.

EMNG examination was conducted on the computer software complex M-TEST («DX-system», Kharkiv, Ukraine). Three nerves (median, fibular and tibial) were examined by means of stimulation methods: conduction excitability velocity (CEV) by motor fibers, amplitude and form of M-response were assessed by the standard method. To assess supra-segmental (upper motor neuron) and segmental (α -motor neuron of the spinal cord and peripheral nerves) levels of lesion the parameters of H-reflex and F-wave were analyzed. F-wave parameters of the tibial and median nerves were

assessed by the indices of an average amplitude; parameters of H-reflex were determined by the indices of H-reflex amplitude (M-response), ratio of the maximum amplitude of H-reflex and M-response in per cent (H_{max}/M_{max}) [5].

The state of oral hygiene and caries intensity were determined for all the children by means of the Decayed, Missing, Filled (DMF) index expressed as the total number of teeth or surfaces that are decayed (D), missing (M), or filled (F) in an individual. Caries intensity was examined in children with temporary occlusion (79 children, an average age $4,3 \pm 1,1$), changing occlusion (84 children, an average age $9,1 \pm 1,4$) and permanent occlusion (70 children, an average age $13,6 \pm 1,7$). Significant Caries (SiC) index was calculated. SiC was calculated by the WHO method with further processing of the data obtained by means of Excel program. Hygienic state was assessed by means of oral hygiene index – simplified OHI-S (J.C.Green, J.R.Vermillon, 1964). According to OHI-S oral hygiene was assessed in the following way: with the index less than 0,6 hygiene was considered to be good, 0,7-1,6 – satisfactory, 1,7-2,5 – unsatisfactory, 2,6 and more – poor.

The findings of the objective examination were filled in a specially developed examination card.

The data were processed statistically by means of the applied programs using paired and unpaired Student t-criteria.

Results and Discussion

The majority of the children examined were diagnosed to be afflicted with spastic forms of CP: 40 (32,8%) children – with spastic diplegia, 25 (20,5%) – with hemiparetic form, 6 (4,9%) – with spastic tripareisis, 34 (27,9%) – spastic tetraparesis, hyperkinesia was diagnosed in 10 children (8,2%) and ataxic syndrome – in 7 (5,7%) children.

The majority of children with spastic forms of CP were characterized by retarded static-kinetic and psycholinguistic development: 108 (88,5%) patients were able to hold the head, turn from the back to abdomen and sit later. 49 (40,2%) children were able to stand and walk without assistance later than others, 41,8% children began to walk under 2-7 years of age but with support only. 18,0% of patients are transported only by means of others in a wheelchair. Functional disorders

of the arms were of different degree of severity: from mild disorders of minor motor activity to major pronator-flexor reflexes in the arms with a strong limitation of voluntary movements. In the majority of patients muscular tonus was intensified according to spastic type, and in a part of the patients – with hyperkinesia (8,2%); muscular dystonia was found against the ground of intensified tonus.

Neurological status of 67 (54,9%) children with CP was most often observed in the form of spastic tetraparesis. The signs of lesions of the cranial nerves were found caused by disorders of the cortical-nuclear ways. In 7 (5,7%) cases the signs of lesions of the stem structures of the brain were observed. In 14 (11,4%) patients from the 5th group pseudobulbar syndrome with formation of spastic-paretic dysarthria, disorders of articulation and swallowing function was diagnosed.

EMNG examination of patients with CP found neurophysiological signs of supra-segmental disorders correlated with pronunciation of spastic syndrome and motor disorders which are presented in Table 2.

Table 2: Electromyoneurography parameters by means of motor nerve stimulation method in children with organic lesions of the nervous system according to the Gross Motor Function Classification System

Parameters		Groups of children with CP				
		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 (mR)	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 p<0,05	2,43±0,57 p<0,01 p ₁ <0,05	2,03±0,22 p<0,01 p ₁ <0,01 p ₂ <0,05
	n. tibialis (m. adductor hallucis)	9,78±0,67	12,34±0,89 p<0,05	11,78±0,56	13,55±1,03 p<0,01	14,02±1,34 p<0,01
Conduction excitability 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
Average amplitude of F-waves, mcR n. tibialis (m. adductor hallucis)		766,14±44,52	909,82±76,58	1029,48±90,89	1281,30±140,91 p<0,01 p ₁ <0,05	1463,31±196,45 p<0,01 p ₁ <0,05
Amplitude of H-reflex (m. gastrocnemius(cap.lat.)) (mR)		4,27±0,53	4,85±0,42	5,83±0,51	6,25±0,57 p<0,05	6,18±0,63 p<0,05
H _{max} /M _{max} (%)		37,6±4,32	51,10±4,76 p<0,05	67,20±6,24 p<0,05	77,70±7,62 p<0,05 p ₁ <0,01	84,87±8,62 p<0,001 p ₁ <0,01

Notes: p – reliability of difference from the parameters of the 1st group; p₁ – reliability of difference from the parameters of the 2nd group.

According to the data obtained in our research (Table 2) ENMG parameters in children with CP changed by gradients depending on the motor activity according to GMFCS E&R. The most pronounced ENMG parameters were observed in the 4th and 5th groups of children with considerable motor disorders: testing of the fibular nerves determined a reliable decrease of the motor response amplitude (49,6% and 57,9% respectively) in comparison with the patients from the 1st group. It is indicative of a considerable decrease in the power of muscular contraction of the appropriate muscles and axonal depletion in the distal segments of the fibular nerve available. It is explained by the fact that orthopedic pathology was more often found among the children from the 4th and 5th groups including talipes equinovagum and planovalgus deformity of the feet. Clinical manifestation of those patients differed in the form of sensitivity disorders in the part of innervation of the fibular nerves, decrease or lack of protective reflexes and other signs of pyramidal insufficiency, hypotrophy of the extensor muscles of the feet, trophic disorders against the ground of dyshydrosis, mottled skin and temperature changes

on the feet. Examination of conduction excitability velocity by the motor fibers of the fibular nerves did not find any reliable differences in all the examined groups of patients. The above disorders might be of a secondary character, since these changes are formed gradually with increase of orthopedic pathology in children with CP and pronounced motor disorders. In its turn the amplitude of M-response while testing the tibial nerve was reliably higher in children from the 4th and 5th groups (children with pronounced motor disorders), which is indicative of a considerable tonus increase in the flexors of the foot and toes.

Examination of H-reflex while testing the tibial muscle found reliable changes in all the patients in comparison with that of the control, which was indicative of disorders in the supra-segmental innervation. A considerable decrease of the threshold of H-reflex appearance (with 2 mA) was found, which is indicative of an increased excitability of the spinal motor neurons. The threshold of M-response appearance was reduced as well, therefore a relative threshold of H-reflex did not increase considerably. A substantial decrease of the

threshold of the reflex excitability is evidenced by H-reflex appearance while testing the median nerve as well.

A reliable increase of the amplitude of H-response was registered in the 4th and 5th groups: 31,6% and 30,9% respectively, which is indicative of a pronounced degree of spasticity in these groups. A reliable gradient increase of Hmax/Mmax ration was found with intensification of motor functions according to GMFCS E&R. The highest parameters were observed among the children who were not able to move without assistance – 57,1% in comparison with those who could walk without support.

Analysis of F-wave parameters in patients with spastic forms of CP determined a reliable increase of F-wave amplitude, especially during stimulation of the tibial nerve. The highest parameters were observed in children from the 4th (40,1% as much) and the 5th (47,6% as much) groups in comparison with the 1st group, which is indicative of a considerable increase of synchronous excitability of α -motor neurons in the lumbar-sacral segments of the spinal cord and pronounced neurophysiological signs of the conduction (pyramidal) insufficiency with affliction of the cortical-cervical and cortical-lumbar ways.

Therefore, conduction of a comprehensive clinical-

instrumental examination in diagnostics of muscular tonus disorders among children with CP is important. It should include a careful assessment of the neurological status, orthopedic examination and ENMG examination with compulsory application of the late phenomenon of F-wave and H-reflex. The latest ENMG parameters determine the degree of spastic syndrome intensification which enables to determine a remote prognosis of motor disorders and choice of therapeutic-rehabilitation measures.

Dental examination of children with organic lesions of the nervous system found that caries occurrence was 100% contrary to healthy children from the comparison group where this index was 68,7 %. An average value of caries intensity in children with CP was $6,27 \pm 1,19$, which is 2,3 times higher than that of the healthy children ($2,72 \pm 1,17$). Analysis of the oral hygiene index found that in children with organic lesions of the nervous system this parameter was 2,0 times higher than that in healthy children ($2,00 \pm 0,25$; $p=0,0066$ against $0,98 \pm 0,26$).

In order to substantiate caries-preventive measures we have examined the state of the hard dental tissues in different groups of the examined children with CP depending on the degree of motor function disorders (Table 3).

Table 3: Assessment of dental caries intensity and oral hygiene in children with cerebral palsy depending on motor disorders

Parameters	Groups of children with CP 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)
dt (n=42)	3,85±1,02	4,25±1,06	5,42±0,77	6,00±0,50	9,00±2,28 p<0,05
DMF+dt (n=37)	5,88±0,79	7,25±0,81	7,10±1,10	8,78±0,69 p<0,01	10,42±1,04 p<0,01 p ₁ <0,05
DMF component in children with changing occlusion (n=37)	2,56±0,74	3,13±0,90	3,00±1,00	4,00±0,50	4,28±0,39 p<0,05
DMF (n=43)	3,43±0,49	5,30±0,82	5,42±0,77	4,75±0,56	6,00±0,50 p<0,01
SiC (DMF)	3,75±0,37	6,25±0,75 p<0,01	6,67±0,44 p<0,01	5,33±0,44 p<0,01	6,67±0,44 p<0,01
SiC (DMF component in children with changing occlusion)	3,25±0,75	4,0±0,5	4,0±0,67	5,67±0,44 p<0,05	6,0±0,66 p<0,01
SiC (dt)	4,75±0,37	5,25±0,75	6,0±0,50 p<0,05	6,50±0,50 p<0,01	11,67±1,77 p<0,01
SiC (dt component in children with changing occlusion)	4,25±0,37	4,75±0,75	5,50±0,50	5,75±0,75	6,67±0,67 p<0,01
Oral hygiene index	1,68±0,16	1,86±0,34	2,05±0,26	2,16±0,25	2,27±0,22 p<0,05

Notes: p – reliability of difference from the parameters of the 1st group; p₁ - reliability of difference from the parameters of the 2nd group.

The children with CP the most pronounced disorders of the motor functions were found to have reliably higher Significant Caries (SiC) index in comparison with patients with mild motor disorders according to GMFCS E&R. Analysis of DMF indices demonstrated high caries activity in children with pronounced motor disorders. DMF+dt index was reliably higher in patients from the 4th group (33,2% higher) and the 5th group (43,6% higher) in comparison with the indices from the 1st group ($5,88 \pm 0,79$, $p<0,01$). Examination of the 5th group determined 30,4% increase of DMF=dt index in comparison with the similar one in children from the 2nd group ($10,42 \pm 1,04$ against $7,25 \pm 0,81$, $p=0,02$). Moreover, reliable differences were found by caries intensity index of the permanent occlusion in children with pronounced motor disorders (the 5th group) in comparison with children from the 1st group (DMF $6,00 \pm 0,50$ against $3,43 \pm 0,49$,

$p=0,0055$) – caries intensity was 42,8% higher. Considerable differences were observed among children with temporary occlusion from the 5th group in comparison with the 1st group: dt index was 56,2% higher in children from the 5th group ($9,00 \pm 2,28$ against $3,85 \pm 1,02$; $p=0,044$).

Moreover, the results of the study conducted found that SiC was higher in comparison with DMF in all the children with CP. The lowest SiC parameters were found in children from the 1st group who were able to walk without limitations both with permanent occlusion ($3,75 \pm 0,37$) and changing occlusion ($3,25 \pm 0,75$). Parameters of this index in children with changing occlusion were 42,6% higher in the 4th ($5,67 \pm 0,44$; $p=0,010$) and 45,8% higher in the 5th ($6,0 \pm 0,66$; $p=0,011$) groups in comparison with the patients from the 1st group. A reliably higher caries intensity of the permanent teeth in children with CP was observed in the 2nd, 3rd, 4th and 5th

groups, though there was no correlation found of this index depending on motor function intensity. Analysis of SiC with temporary occlusion and dt with changing occlusion determined that in children from the 5th group the parameters were 2,5 and 1,6 times higher ($11,67 \pm 1,77$ and $6,67 \pm 0,67$ respectively; $p < 0,01$) in comparison with the 1st group ($4,75 \pm 0,37$ – dt with temporary occlusion and $4,25 \pm 0,37$ – dt component with changing occlusion).

Analysis of hygienic index found that in children with CP and pronounced motor disorders this parameter was 1,4 times higher ($2,27 \pm 0,22$, $p = 0,035$) in comparison with the similar index in the 1st group. It was assessed as poor in the patients from the 5th group.

Correlation analysis between ENMG parameters and indices of the oral hygiene determined close relationships with H-reflex parameters ($r = 0,746$; $p < 0,001$) and F-wave parameters ($r = 0,783$; $p < 0,001$), as well as a weak relation between H-reflex parameters and DMF indices ($r = 0,462$; $p = 0,0020$) and F-wave parameters ($r = 0,405$; $p = 0,077$). Close correlation was found between ENMG parameters and SiC indices (figure 3.4.1): H-reflex ($r = 0,733$; $p < 0,001$) and F-wave ($r = 0,664$; $p < 0,001$).

The correlation found confirms that oral hygiene index in children with disorders of the muscular-skeletal system due to CP can be associated with restricted motor function, reduced motion abilities, associated with peculiarities of minor motor function and intensity of spastic syndrome in children with CP.

Disorders of major motor functions in children with CP correlating with changes of ENMG parameters stipulate considerable limitations in self-service of such children and undertaking measures of individual oral hygienic care in particular. These disorders make the oral hygienic care from the parental side difficult as well. It can be a factor stipulating high affliction of the teeth with caries and its increased intensity with increase of intensity of motor function disorders.

Conclusions

1. Conduction supra-segmental disorders in children with cerebral palsy are manifested by reliable changes of the neuromyographic parameters: increased M-response amplitude, especially in testing of the tibial nerve, increased H_{max}/M_{max} ratio, increased H-reflex amplitude and F-wave amplitude.
2. Degree of spastic syndrome intensity increased according to the electromyographic parameters while testing the tibial nerve increased in the 4th and 5th groups of children with CP according to GMFCS E&R.
3. Direct correlations are found between neurophysiological parameters and oral hygiene index which can be one of the factors stipulating higher affliction of the teeth by caries in children with an increased intensity of motor disorders.

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