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ELECTROENCEPHALOGRAPHY QUANTITATIVE INDICATORS OF PATIENTS SUFFERING FROM BILATERAL VOCAL FOLD PARALYSIS

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Ключевые слова: *параличи гортани, центральная нервная система, биоэлектрическая активность головного мозга*

Abstract. Electroencephalography quantitative indicators of patients suffering from bilateral vocal fold paralysis. Shydlovska T.A., Zemliak T.B. *Treatment of patients with bilateral peripheral paralyses of the larynx remains a complicated task. Study of central mechanisms of realization of larynx functions in case of stenosis is of interest. By electroencephalography method (EEG) patients with bilateral paralysis of the larynx were examined: 55 patients without surgical treatment (group I), and 51 patients who underwent chordoarytenoidotomy (group II). All the patients showed changes in percentage content of α - and β-rhythms and Δ- and θ-rhythms ("slow" waves). The group II patients demonstrated more pronounced rhythms, as compared with the control group. During the baseline recording, in group I the increase in the percentage content of the Δ-rhythms in frontal and parietal leads up to 28.2±2.3 and 29.2±2.4%, was seen, the group II patients showed the increase in Δ-activity up to 32.2±2.8 and 35.4±2.9% in frontal, temporal and parietal leads respectively. Besides, the group II patients proved to have an increasing of β-rhythms activity in all the leads, as compared to the control group, as well as an increasing of θ-rhythms in temporal and parietal leads. Herewith, the increase of θ-rhythms in temporal leads up to 21.4±2.2%, was reliably higher as compared to group I data 16.5±1.3%. Besides, all the patients showed decrease in α-rhythms amplitude. So, decrease in proportion of fluctuations of α-range and increase of slow wave activity (θ- и Δ- waves), as well as α-rhythms amplitude decrease in patients with motor disorders of the larynx testify to the prevailing influence of subcortical structures on phenomena of nervous processes depletion in the brain, against background of chronic hypoxia including.*

Реферат. Количественные показатели электроэнцефалографии у пациентов с двусторонними периферическими параличами гортани. Шидловская Т.А., Земляк Т.Б. *Лечение больных с двусторонними параличами гортани остается сложной задачей. Изучение центральных механизмов реализации функций гортани при наличии стеноза представляет интерес. Методом электроэнцефалографии (ЭЭГ) обследованы пациенты с двусторонними параличами гортани: 55 без хирургического лечения (I группа) и 51 пациент после односторонней эндоскопической хордоаритеноидотомии (II группа). У всех исследуемых выявлены изменения процентного содержания α- и β-, а также Δ- и θ-ритмов в сравнении с контролем, более выраженные во II группе. Так, в I группе доля Δ- ритма в лобных и теменных отведениях при фоновой записи была увеличена до 28,2±2,3 и 29,2±2,4%, у пациентов II группы увеличение доли Δ-активности достигало 32,2±2,8 и 35,4±2,9% соответственно. Во II группе определялась достоверно повышенная β-активность во всех отведениях, а также увеличение содержания θ-ритма в височных и теменных отведениях. При этом во II группе повышение θ-ритма в височных отведениях до 21,4±2,2% было достоверно выше показателей в группе I – 16,5±1,3%. Также в обеих группах выявлено снижение амплитуды α- ритма. Таким образом, уменьшение доли колебаний α-диапазона и увеличение медленноволновой активности (θ- и Δ- волны), а также снижение амплитуды α-ритма ЭЭГ у пациентов с двигательными расстройствами гортани свидетельствует о преобладании влияния подкорковых структур и явлениях истощения нервных процессов в головном мозге, в т.ч. на фоне хронической гипоксии.*

The central nervous system controls and coordinates the functions of various elements and structures of the vocal apparatus, ensuring the work of separate units as a whole. At the same time, a number of complex conditioned reflexes are formed in the subcortical centers and the cerebral cortex. There is a clear differential gradation of nervous structures in the regulation of certain mechanisms of voice formation. Unconditional regulation of respiratory function is combined with a complex reflex mechanism involving the reflexogenic zones of the larynx.

Such processes play an important role in the regulation of the respiratory system during vocalization [5]. There are works devoted to the study of the state of the nervous system in functional disorders of the voice [2-4]. At the same time, the nature of disorders of central nervous regulation in the presence of peripheral damage to the neuromuscular system of the larynx (paresis and paralysis) is studied insufficiently. In this regard patients with bilateral motor disorders of the larynx, being in conditions of chronic hypoxia need special attention. When providing respiratory function with endoscopic endolaryngeal dilation of fissure of glottis in such patients, the improvement of respiratory function is inversely proportional to the quality of the voice. However, these techniques cannot ensure the normal functioning of the larynx. The search for alternative methods of treatment of patients with bilateral laryngeal paralysis continues, in the context of which the study of the central mechanisms of realization of laryngeal functions in the conditions of pathological condition acquires special significance.

The purpose of our work is to study the quantitative indicators of bioelectrical activity of the brain according to EEG data in patients with bilateral peripheral laryngeal paralysis.

MATERIALS AND METHODS OF RESEARCH

Quantitative indicators of the state of bioelectrical activity of the brain according to EEG results (percentage of dominant rhythms and amplitude of α-activity) in patients with bilateral laryngeal paralysis were studied: 55 people who did not receive surgical treatment of laryngeal stenosis (group I) and 51 patients (group II), who received surgical treatment of stenosis (more than 3 months after endoscopic chordoarytenoidotomy). In all patients, laryngoscopy determined the median and/or paramedian position of the vocal folds at the time of maximal inspiration, the duration of motor disorders was more than 6 months. The control group consisted of 15 practically healthy individuals without abnormalities in the voice-forming apparatus and signs of respiratory failure.

EEG studies were performed using a computer electroencephalograph of "DH-systems" company (Ukraine) by conventional methods. For the analysis of the obtained results the methods of mathematical variation statistics with the use of licensed software (STATISTICA v.13.3) according to the generally accepted recommendations were used [1]. The average statistical value of the indicators – (M) and its error (±m) were calculated. The reliability of the obtained results was evaluated by the criterion t of Student and Fisher.

RESULTS AND DISCUSSION

Analysis of quantitative indicators of the percentage distribution of the main EEG rhythms and the amplitude of the α-rhythm revealed deviations from the norm in all examined groups of patients already in the baseline recording being expressed in varying degrees (Table 1-4). This was primarily evidenced by the change in the ratio of representation (percentage) of α-, β-rhythm, as well as Δ- and θ-rhythm ("slow" waves). First of all, patients had a general tendency to decrease in the percentage of α-rhythm and increase in the representation of Δ-waves. It should be noted that at different stages of EEG recording and in different leads, these tendencies had different severity, but in many cases were confirmed by a significant difference in the values of the corresponding averages compared with the control group. But if in group I there was a probable difference in the frontal and parietal leads only for α- and Δ-rhythm, and in the temporal and in relation to α- and Δ- and θ-rhythm, then in group II (patients with bilateral paralysis of the larynx who underwent endoscopic chord-arythenoidectomy) negative changes were reliable in relation to the representation of all studied α-, β-, θ- and Δ-rhythms, except for θ-rhythm in the frontal lead. Probable changes in the negative direction were observed in group II not only in relation to the control, but also in relation to some indicators in group I. Thus, the statistical analysis of the studied EEG indicators showed marked reliable changes in the percentage content of dominant rhythms with a predominance of total slow-wave activity, more pronounced in group II.

In group I the largest decrease in the content of α-rhythm in the frontal, temporal and parietal leads in the baseline recording to 30.2±2.2, 37.3±2.8 and 30.7±2.4%, respectively was determined. In patients of this group there was a significantly increased content of Δ-rhythm in the frontal, temporal and parietal leads in the baseline recording to 28.2±2.3, 24±2.8 and 29.2±2.4% as well. In the temporal leads the percentage of θ-rhythm increased to 17.6±1.7% as well, which is probably higher than the control value – 12.1±1.8%.

Even more pronounced changes were observed in patients of group II. Thus, a probable increase in the proportion of Δ-activity to 32.2±2.8; 26.8±2.1 and 35.4±2.9% in the frontal, temporal and parietal leads was observed. Patients in this group showed increased β-activity in all leads, as well as an increase in the content of θ-rhythm in the temporal and parietal leads.

Moreover, the increase in the θ-rhythm in the temporal leads in group II to 21.4±2.2% was probably higher than the control, as well as the value in group I. When analyzing the EEG results, we also recorded a significantly higher percentage of β-rhythm in the frontal, parietal and temporal leads in group II than in group I.

Table 1

The percentage of dominant EEG rhythms (baseline recording) in patients with bilateral peripheral paralysis of the larynx in the frontal leads, M±m

Study groups	Rhythms, leads		F 7 left		Rhythms, leads		F8 right	
	δ	θ	α	β	δ	θ	α	β
I	27.7±2.3	18.6±1.4	32.4±2.3	19.7±1.4	28.2±2.3	18.9±1.4	30.2±2.2	21.67±1.5
II	29.3±2.3	21.1±2.1	35.9±2.6	32.2±2.4	32.2±2.8	22.9±2.3	33.1±2.6	32.95±2
K	8.6±1.8	18.3±2.4	52.2±3.8	22.6± 2.3	8.6±1.8	16.5±2.6	52.3±3.2	22.8±1.9
t (C-I)	6.54**	0.11	-4.46**	-1.08	6.54**	0.82	-5.70**	-0.47
t (C-II)	7.17**	0.88	-3.53**	2.99*	6.97**	1.85	-4.68**	3.73**
t (I-II)	-0.51	-0.99	-1.00	-4.73**	-1.11	-1.49	-0.87	-4.59**

Notes: here and in table 2-4 *p<0.05; **p<0.01- statistical significance between indicators in groups; I and II – study groups, C – control group.

Thus, the most pronounced redistribution of the percentage of baseline rhythms in the structure of the EEG pattern was found by us in group II. For the most part, this was relevant to the indicators of α-, β- and Δ-rhythms compared to the control group. At the same time, there was no significant difference in the indicators between groups I and II, except for the content of β-rhythm and θ-rhythm in the parietal leads.

Table 2

The percentage of dominant EEG rhythms (baseline recording) in patients with bilateral peripheral paralysis of the larynx in the temporal leads, M±m

Study groups	Rhythms, leads		T5 left		Rhythms, leads		T6 right	
	δ	θ	α	β	δ	θ	α	β
I	24±2.8	16.5±1.3	38.8±2.5	21.2±1.8	23.3±1.8	17.6±1.7	37.3±2.8	20.2±1.52
II	28.1±2.2	21.4±2.2	43.3±2.4	35.1±2.3	26.8±2.1	19.3±2.1	48.8±3.2	32.2±3
C	5.6±1.8	11.5±1.9	59.5±3.8	20.9±2.6	5.8±1.9	12.1±1.8	64.2±4.2	21.2±2.2
t (C-I)	6.33**	2.15*	-4.56**	0.10	6.62**	2.26*	-5.36**	-0.39
t (C-II)	7.94**	3.38**	-3.62**	4.11**	7.37**	2.57*	-2.94**	2.98**
t (I-II)	-1.30	-1.90	-1.3	-4.81**	-1.27	-0.61	-2.74*	-3.61**

Table 3

The percentage of dominant EEG rhythms (baseline recording) in patients with bilateral peripheral paralysis of the larynx in the parietal leads, M±m

Study groups	Rhythms, leads		P3 left		Rhythms, leads		P4 right	
	δ	θ	α	β	δ	θ	α	β
I	24.5±2.4	16.7±1.3	37.7±2.6	20.4±1.5	29.2±2.4	17.4±1.5	30.7±2.4	20.9±1.6
II	28.7±2.1	21.6±2.1	33.5±2.4	32.4±2.1	35.4±2.9	22.9±3	28.5±2.3	32.5±2.7
C	6.8±1.2	12.4±1.8	64.2±4.2	17.1± 2.6	6.9±1.6	12.3±1.8	64.2±4.2	17.1±2.6
t (C-I)	6.60**	1.91	-5.36**	1.12	7.81**	2.17*	-6.90**	1.25
t (C-II)	9.10**	3.38**	-6.34**	4.60**	8.68**	3.05**	-7.43**	4.09**
t (I-II)	-1.31	-2.02	1.19	-4.71**	-1.67	-1.65	-0.67	-3.71**

We also investigated the intensity (amplitude) of the α-rhythm. At the same time, in both groups there was a decrease in the bioelectrical activity of the brain, expressed in varying degrees. The largest, including a sharp decrease in amplitude, was in patients of group I. To some extent, this may indicate a certain exhaustion of nervous processes on the background of chronic hypoxia in patients with laryngeal stenosis of paralytic origin (Table 4).

Table 4

Amplitude of EEG α-rhythm of frontal, temporal, parietal, occipital leads in patients with bilateral peripheral paralysis of the larynx, mkV, M±m

Study groups	EEG leads							
	F7	F8	T5	T6	P3	P4	O1	O2
I	17.7±1.3	27.5±2.8	57.7±2.8	45±2.9	45.8±2.3	22.2±2.6	60.5±3.7	62.7±3.9
II	23.7±1.6	39±2.3	63.15±3.8	39.4±2.3	34.8±3.7	23.3±2.1	63.5±3.8	65.7±3.9
C	52.2±2.9	54.9±2.4	57.8±2.7	58.5±2.8	59.5±2.6	61.2±2.4	63.2±2.9	62.9±2.8
t (C-I)	-11.83**	-7.42**	-0.02	-3.34**	-3.27**	-10.94**	-0.57	-0.05
t (C-II)	-9.53**	-4.81**	1.15	-5.24**	-5.45**	-11.83**	0.06	0.58
t (I-II)	-2.97**	-3.16**	-1.15	1.51	2.23*	0.34	-0.56	-0.55

Note. Non-pair leads – left side, pair – right one.

In patients with laryngeal paralysis, no significant decrease in the mean values of the amplitude of the α-rhythm of the EEG in the occipital leads was observed. This indicator decreased in the frontal, temporal, parietal leads as for control. The amplitude of α-rhythm in the frontal and parietal leads in group I differed from those of group II. Thus, in group I in the frontal lead the amplitude of the α-rhythm was 17.7±1.3 μV, in the parietal lead – 45.8±2.3 μV, while in group II the amplitude value reached 23.7±1.6 μV and 34.8±3.7 μV, respectively. Thus, in patients of group

II in the frontal leads, the amplitude of the alpha α-rhythm was significantly higher and in the temporal leads – significantly lower than without surgery.

The redistribution of EEG rhythms in the direction of reducing the proportion of α-range fluctuations and increasing slow-wave activity (θ- and Δ-waves) in patients with bilateral peripheral laryngeal paralysis indicates the predominance of the influence of subcortical structures on the bioelectrical activity of the brain. It should be noted that such changes were observed to the greatest extent in patients who, according to spirometry, had signs of severe respiratory failure. In such patients there was a decrease in the percentage of α-rhythm and an increase in the representation of Δ-waves, especially in the anterior projections (frontal and temporal leads). The appearance of these signs is evidence of dysfunction of deep brain structures, primarily diencephalic-stem and in some cases – of mediobasal. The above functional changes in the bioelectrical activity of the brain occur in such patients on the background of ventilatory obstructive insufficiency of external respiration, and, as a consequence, respiratory and tissue hypoxia. In our opinion, this can be explained by the unconditional response of the central regulation of the body, directed at compensatory adjustment of the main indicators of respiration: depth, rhythm and frequency to maintain the basic homeostatic parameters of the body within the physiological norm.

It should also be noted a certain increase in the negative changes in the EEG pattern after surgical treatment of stenosis, namely endoscopic chordoarytenoidotomy (group II). This raises thought process. Such changes persist or intensify against the background of providing compensation of the state of external respiration, which is confirmed during the spirometric examination. Thus, hypoxia phenomena after surgical treatment of stenosis are reduced or eliminated. This situation can be explained to some extent by the regulation of the respiratory function of the larynx, which is also performed due to the complex reflex mechanism with feed-back. In this case, signals from the reflexogenic zones of the larynx come to the nuclei of the optic thalamus and the cerebral cortex, which causes a number of reflex effects on the larynx from the subcortical and cortical centers. The change in the architecture of the larynx, which occurs during the static method of surgical treatment of stenosis of paralytic origin complicates the coordination of reflexogenic zones of the larynx and brain structures, which is perceived by the latter as a "breakdown" of the larynx apparatus and "distorts" the integrative mechanism of central and peripheral departments of nervous regulation of its activity. Also, the need to restructure the whole body in response to the new emerging conditions of aerodynamics of the upper respiratory tract may also be a significant burden. Of particular importance is the regulation of the basic homeostatic parameters of the organism in the new conditions and so on.

In connection with the above, it is important to consider not only the state of the peripheral neuromuscular apparatus of the larynx, but also the central circuit of regulation of the multistage process of voice formation for adequate assessment of voice function in patients with bilateral laryngeal paralysis. This is especially important at the present stage of development of medicine and science, when the main area of research in the development of new methods of surgical treatment of paresis and paralysis of the larynx is to restore the dynamic profile inherent in normal laryngeal function, not just respiratory function.

CONCLUSIONS

1. The study of bioelectrical activity of the brain according to EEG data in patients with peripheral bilateral laryngeal paralysis objectively revealed the disorder of the functional state of the CNS.
2. In patients with peripheral bilateral paralysis, the dominant EEG rhythms are redistributed. First of all, there are significant reductions in the percentage of α-rhythm and increase in the representation of Δ-waves, especially in the frontal and temporal leads, both in the baseline and at functional loads. 3. Taking into account EEG data in the general assessment of patients with bilateral laryngeal paralysis creates the preconditions for finding more effective treatment and rehabilitation measures in such patients.

Conflict of interest. The authors declare no conflict of interest.

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