Influence of postoperative magnetotherapy on homeostasis central regulation efficiency

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Abstract
The world scientific literature is rich in sources considering pathological changes in the central nervous system (CNS) in case of tumor growth. The topical issue is the study of mechanisms providing a stable performance of the brain as the highest section of nervous system which largely predetermine the oncology patients life quality.

Aim
The aim of the present research is to study the dynamics of bioelectric markers of the CNS functional state in lung cancer patients during an early postoperative period for the purpose of evaluation of the conducted magnetotherapy adaptive and correcting effects.

Materials and methods
25 lung cancer male patients have been examined. The reference group patients received a standard postoperative therapy, while in the main group it has been accompanied by the complex modulated ultra low frequency magnetic field exposure applied to the occipital area. Before the operation and 10 days after it in all the patients EEGs have been recorded unipolarly, according to system “10/20” as well as the galvanic skin resistance measured in reference points using the R. Voll electro-acupuncture method.

Results
It is demonstrated that the postoperative magnetotherapy application in lung cancer patients is accompanied with a significant exceedance of the spatial synchronization values over the corresponding markers only in case of surgical treatment: in alpha band between the central and temporal area in the left hemisphere; and between the similar areas in the right hemisphere; in beta-band between the symmetrical areas in the temporal and central cortex. The observed compensatory-reduction processes in the lung cancer patients brain bioelectric activity correlate to a 1.8 times decrease in the frequency of asymmetries in the galvanic skin resistance values in 2 pairs of hypothalamus reference points, that may indicate a certain improvement in the organism higher vegetative regulation.

Conclusions
Thus, we may assert that the trend to the symmetrization of the spatial synchronization markers and the electro-acupuncture measurement results indicate a better preservation of the CNS functional state in the main group patients, that is the result of the weak low frequency magnetic field anti-stressor and protective effect on the brain.

Keywords
Magnetotherapy, Ultra low frequency magnetic field, Brain bioelectric activity, Cortical biopotential spatial synchronization, Electro-acupuncture, Hypothalamus, Homeostasis, Adaptation, Lung cancer

Imprint

Introduction
Nowadays the effect of low frequency varying magnetic fields of weak intensity (ULF MF) is attributed to information-related exposures, which are effective remedies for the regulatory system state correction and the organism non-specific resistance increase [1, 2]. It is demonstrated that electromagnetic fields of weak intensity with the multi-frequency signal, which includes the frequencies of the brain endogenous rhythmic activity, have an anti-stressor effect and contribute to a rise in the organism non-specific resistance, including the anti-tumor one [3, 4]. The role of the ULF MF in the anti-tumor effect initiation...
is related to a possibility of response rearrangement of the regulation central mechanisms, which forms the basis for directed correction of homeostasis.

According to A.A. Ukhtomsky, a biological rhythm, or a physiological interval of time, is a system-forming factor. Equalization of these physiological intervals, or lability, provides interaction between different structures, their incorporation in a certain working ensemble. Just the idea of A.A. Ukhtomsky about the isolability role in establishing the relations between separate nervous centers has allowed us to consider that the distribution over the cortical surface of the segments with similar bioelectric rhythmic activity on certain stages of the conditioned reflex system formation is a direct evidence of the identical course of processes in time, and reflects the mutual adjustability of neural structures permitting the possibility of their working connections. In relation to the above, the study of the cortical biopotential spatial synchronization processes under the effect of the complex modulated ULF MF is reasonable and urgent.

Besides, evaluation of the functional state of hypothalamus as a central controlling segment of the developing adaptation state and the most important center of vegetative regulation, as well as the organs and systems under its control, has provoked our great interest. It is well-known that examination of the reference points (RP) in the paired meridians of general measuring profile by the method of electro-acupuncture according to Voll (EAV) allows judging disbalances in the organism subsystems under malignant tumors of different localizations [6, 7]. Informativity of the method in evaluation of adequacy, tolerance and efficiency of the anti-tumor treatment [8, 9] has been demonstrated. The results of the EAV electrical parameters measurement in lung cancer have been obtained [10].

Thus, the aim of the present research is to study the dynamics of bioelectric markers of the CNS functional state in lung cancer patients during an early postoperative period for the purpose of evaluation of the conducted magnetotherapy adaptive and correcting effects.

Materials and methods

25 male lung cancer patients have been examined. The reference group patients (n=12) received a standard postoperative therapy, whereas in the main test group (n=13) it has been accompanied with the complex modulated ultra low frequency magnetic field exposures to the occipital area. Before the operation and 10 days after it in all the patients the EEG has been recorded and the galvanic skin resistance measured in reference points using the EAV method.

To record the EEG the brain electrical activity analyzer Encephalan-131-01, Medikom MTD, Taganrog, has been applied. The electrodes on the patient’s head have been placed according to international system 10/20, the biopotentials recorded unipolarly. The degree of interrelation between the neocortex areas (levels of spatial synchronization) has been defined according to the cross-correlation coefficient (CC), calculated for 16 intra- and interhemispheric pairs of leads: front (F), central (C), temporal (T) and occipital (O) in alpha- and beta-range frequencies. Studied have been the global and local SSCB. For the global SSCB the sum of correlation coefficients (CC) between all the cortical areas has been determined, and for the local SSCB the CC for separate segments of neocortex have been calculated. Relations between the global and the local SSCB are rather complicated and still not clarified. Therefore, it is recommended to perform a parallel control using both markers to better evaluate the human brain functional state [11].

Reflex-diagnostic complex Rista-EPD, OKB RITM, Taganrog, has been used to carry out the EAV measurements. Using this complex the evoked electrical conductivity (resistance) in reference points (RP) of skin surface has been measured. The loading galvanic skin test with constant current up to 12.25 µA and voltage up to 2.07 V has been applied for measurements. The result of interaction “stimulus-receptor” has been recorded in conventional units (c.u.). The obtained data are interpreted as deviations in the organ and system energetic and functional state appeared at the given moment and enrich available laboratory, instrumental and clinical results [6].

Results and discussions

When studying the total level of synchronization in alpha range it has been demonstrated that it has not changed in relation to the preoperative values, and in the end of the treatment course it has been identically evident in both main test group and reference group of patients. The analysis of this marker in beta-range has demonstrated absence of changes in the main test group and a tendency to reduction in the reference group by the end of the treatment course (p<0,1) (Table. 1).
The data obtained by M.N. Livanov [5] show that the global SSCB marker reflects readiness of a subject to act. However, it is not always possible to differentiate various functional states using the level of global SSCB. In these cases the local SSCB marker is used. Intensification of the local SSCB in the cortical areas, which are mostly specifically involved depending on execution of certain functions, is considered as an optimal functional state marker necessary for their effective realization. Besides, determinative may be not the change in total synchronism but the formation of foci of bioelectric process maximum synchronism.

In our investigation the analysis of the spatial synchronization marker in separate pairs of leads has allowed revealing reliably significant differences between the groups at postoperative stage of examination both in alpha- and beta-range of frequencies. It has been established that the values of synchronization between the leads in both main and reference groups have undergone slight changes in the end of the treatment. However, the direction of these changes in the compared groups has been exactly opposite, as a rule. As a result, on day 14 after the operation the differences in average group values of synchronization between some neocortex area biopotentials have reached a reliable level, the main test group having greater values at that.

Thus, in alpha range of frequencies a reliable difference in the marker values has been detected for symmetrical central temporal pairs of leads to right (C₃T₃) and left (C₄T₄) hemisphere. For pair C₃T₃ these values in the main test group have made 0,91 ± 0,03 as against 0,72 ± 0,08 in the reference group (p < 0,05), for pair C₄T₄ – 0,88 ± 0,02 and 0,78 ± 0,05, respectively (p < 0,05). Between the symmetrical temporal leads T₃T₄ observed has been similar correlation in values of the synchronization marker in the compared groups (0,33 ± 0,09 and 0,51 ± 0,07, respectively), however, only on the level of tendency (p < 0,1) (Fig. 1a).

The analysis of the spatial synchronization markers in beta-band has demonstrated presence of reliable differences between the groups in pairs of symmetrical central (C₃C₄) and temporal (T₃T₄) leads, as well as in the occipital temporal pair of the right hemisphere (O₂T₂). Thus, for pair of C₃C₄ leads the average group synchronization marker after the ULF MF course has value 0,54 ± 0,05 as against 0,41 ± 0,04 in the reference group (p < 0,05), for pair T₃T₄ the value is 0,25 ± 0,05 and 0,06 ± 0,04 (p < 0,05), for O₂T₂ – 0,38 ± 0,06 and 0,15 ± 0,09, respectively (p < 0,05) (Fig. 1b).

The detected peculiarities of the SSCB marker dynamics in pair of leads T₃T₄ for beta-rhythm have allowed us to assume that the tendency to increase in synchronization between the temporal areas of cortex, which has been outlined in alpha range of frequencies after the magnetotherapy course, has not been accidental. In our opinion, the tendency to symmetrization of the CC values, as well as to the increase in the spatial synchronization of cortical processes between symmetrical segments in the large hemisphere cortex, is a natural reflection of optimization in medullary processes caused by the poly-frequency electromagnetic exposure.

E.A. Soroka and coauthors accentuate the necessity for combined activity of temporal areas in both hemispheres for adequate implementation of complex organized functions [12]. According to D.M. Tsarapina and coauthors [13], intensification of interhemispheric relations of EEG, especially temporal and lower frontal segments, accompanies a coordinated cooperative activity of the left and right hemispheres. It is known that an extremely significant biological meaning is attached to pair work of large hemispheres, which consists in providing integral performance of the organism [14], determining a successful result of the self-regulation processes [15].

In the present study of the EAV markers special attention has been paid to the state of paired RP of hy-
The preoperative examination of patients in the studied groups using the EAV method has shown that the state of sympathetic and parasympathetic divisions of vegetative nervous system has been sufficiently balanced and expressed in normoergic response at a "hand-to-hand" lead. After the operation the normoergic state has changed to hypoergic, being evident to a greater or lesser extent in both groups of patients (Table. 2). As known, the hypoergic state corresponds to prevalence of parasympathetic part in regulation of vegetative functions of the organism [18].

The percentage of acute asymmetries in reference points of general measuring profile, which reflects a degree of deregulation in the organism bioenergetic state, under the stress action of surgical intervention has reliably increased as compared with the initial values only in the reference group of patients (р<0,05). In the first group due to the protecting ULF MF action this growth has been insignificant (by only 2 % as against 75 % in the reference group) (Table. 2).

We have paid special attention to the asymmetries in pairs of hypothalamic points, which reflect the state of regulatory center of the organism adaptive capabilities. The frequency of occurrence of acute asymmetries in one or two pairs of measuring points in hypothalamus has changed (in relation to the preoperative values) depending on the treatment method. Thus, after the course of postoperative magnetotherapy the similar marker has decreased by 43 %, On the contrary, in the reference group after surgical interven-
Table 2. Dynamics of the organism functional state markers according to EAV on the stages of surgical treatment of lung cancer patients

<table>
<thead>
<tr>
<th>Groups of patients</th>
<th>Investigated markers</th>
<th>Stages of investigation</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Preoperatively</td>
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<tr>
<td>Reference (n=14)</td>
<td></td>
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<tr>
<td></td>
<td>Hand-to-hand (c.u.)</td>
<td>84,5±1,2</td>
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<tr>
<td></td>
<td>As. total (%)^1</td>
<td>17,7±3,5</td>
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<tr>
<td></td>
<td>As. Hypothalamus RP (%)^2</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Δ Hypothalamus RP^3</td>
<td>3,1±0,5</td>
</tr>
<tr>
<td>ULF MF (n=14)</td>
<td>Hand-to-hand (c.u.)</td>
<td>82,8±1,4</td>
</tr>
<tr>
<td></td>
<td>As. total (%)^1</td>
<td>34,4±6,4</td>
</tr>
<tr>
<td></td>
<td>As. Hypothalamus RP (%)^2</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Δ Hypothalamus RP (c.u.)^3</td>
<td>6,9±1,2</td>
</tr>
</tbody>
</table>

Note: ^1 – percentage of acute asymmetries in general measuring profile; ^2 – percentage of patients with asymmetries in paired RP of hypothalamus; ^3 – difference in values of markers in paired RP of hypothalamus

Fig. 3. Dynamics of quantity (in percents) of patients with presence of asymmetries in paired measuring points of hypothalamus

Fig. 4. Dynamics of difference in values between symmetrical measuring points of hypothalamus in the studied groups of patients

the vegetative function disregulation is a high specific weight of acute asymmetries in both pairs of the hypothalamus measuring points. In its turn, we consider a decrease in their quantity as a sign of the regulatory process optimization under the effect of weak low frequency electromagnetic field.

Thus, we may assert that the spatial synchronization marker dynamics in alpha- and beta-range of frequencies, as well as the EAV results in the main test group patients indicate the better preservation of the CNS functional state resulting from anti-stressor and protective effect of weak low frequency magnetic field on brain.

Conclusions

The postoperative magnetotherapy application in lung cancer patients is accompanied with a reliable (p < 0,05) exceedance of the spatial synchronization values over the corresponding markers only in case of surgical treatment: in the alpha range of frequencies between the central and temporal area in left hemisphere, between the similar areas in the right hemi-
sphere, in the beta range between the symmetrical areas in the temporal and central cortex. The observed compensatory-reduction processes in the lung cancer patients brain bioelectric activity correlate to a 1.8 times decrease in the frequency of asymmetries in the galvanic skin resistance values in 2 pairs of hypothalamus reference points (according to EAV), that may indicate a certain improvement in the organism higher vegetative regulation under the effect of weak low frequency magnetic field.

Statement on ethical issues
Research involving people and/or animals is in full compliance with current national and international ethical standards.

Conflict of interest
None declared.

Author contributions
The authors read the ICMJE criteria for authorship and approved the final manuscript.

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