Optimization electroencephalography system for the registration of the frontal localization patterns

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Abstract. Modern concepts of pathogenesis, peculiarities of disease course, technical and technological conditions of electroencephalography analysis require optimized registration of bioelectric patterns of frontal localization. The aim of the study was to simplify the registration and analysis of bioelectric patterns of frontal localization electroencephalography. The methods of electroencephalography registration using a wiring diagram of 9 electrodes arranged symmetrically sagittal head line: Fp1, F7, T5, Fp2, F8, T6, O1 and O2. Due to the low demand for quantitative and frequency-amplitude characteristics of the obtained electroencephalographic curves, the most important electroencephalographic patterns of the brain in General and frontal localization in particular were evaluated. The innovative system using 9 electrodes for electroencephalography allows to minimize technical and technological means and the amount of time spent, and also causes the modernization of the traditional system of registration of electroencephalography to simplify and make more accessible the registration and analysis of bioelectric patterns of frontal localization. This innovation involves the simplification and greater availability of providing diagnostic and therapeutic medical care or medical services electroencephalography in different conditions.

1. Introduction

The process of registering the electroencephalogram (EEG), a person proposed by Hans Berger in the 20s of the twentieth century, to date, little has changed. In conventional systems, EEG signals applied from electrode 21 international 10-20 system (Figure 1).

![Figure 1. The placing of electrodes for EEG recording. International system “10-20”.
](image-url)
Modern concepts of pathogenesis, current features of diseases, technical and technological analysis of the EEG conditions make it possible to create and use a different instrument system with respect to the clinical needs and research [1-7]. Various biosignal recording systems cannot always guarantee an adequate quality of signals [1, 4, 8, 9]. To register a sufficient EEG signal level necessary to consider the various clinical aspects nosologies, particularly registration frontal localization patterns [1, 3, 10].

The aim of this study was the modernization of the traditional EEG recording system for simplification and greater availability of registration and analysis of frontal localization patterns in different conditions providing diagnostic and therapeutic medical care or medical services.

2. Methods and Materials

One of the key conditions required for the detection of various pathological brain dysfunction is the choice of electrode wiring diagrams. In this regard, we offer a completely new EEG recording system using a 9 electrodes. From a technical point of view, this will simplify the system, to minimize the amount of travel time and money. Electrode were chosen from the international 10-20 system, symmetrically sagittal line head: Fp1, F7, T5, Fp2, F8, T6, O1 and O2 (Figure 1).

Frontal localization patterns registration system (9EEG) consists of three distinct properties: a head mounted on the patient's measuring EEG electrodes; analyzer monitor the biopotentials “Neyrovizor-PMM” the brain, which measures the bioelectric activity of the brain, and transmits measured data to a personal computer in real time; writing software EEG Studio, which displays and stores data that allows to annotate and share them in real time to a remote server.

To confirm the performance of our optimized system every record made in 9EEG system was preceded by a standard clinical registration of bioelectric activity of the brain, performed with the use of traditional EEG system. The duration of the registration of each record is from 12 to 15 min [2-3, 7-8].

3. Experimental part

We have carried out studies in 6 patients with verified clinically, neurophysiologic, radiologically and neurologically encephalopathy of various origins, but with a mandatory localization of the neurophysiological and/or clinical and neurological patterns in accordance with the lesion in the frontal part and the frontal parts of the brain.

Recordings were made at the following specifications:
1) Patients were awake;
2) Before and after the calibration has been carried out the registration;
3) The sensitivity of the instrument at routine EEG studies was 5-10 $\mu$V/Mm;
4) Low-frequency filters did not exceed 1.6-5.3 Hz, which corresponded to a constant time of at least 0.1-0.03 seconds;
5) High-pass filters were not lower than 70 Hz;
6) 50 Hz line filter (50 Hz – in Europe);
7) The speed used was 120 mm/s;
8) Background recording, eye opening test, eye closing test, hyperventilation test, background after hyperventilation for at least 2 min were recorded, photostimulation tests with a frequency of 3 to 15 Hz;
9) Recording was analyzed in monopolar and bipolar leads.

After EEG recording was carried out verification of the brain patterns in general and frontal localization in particular.

4. Results and discussion

Since among other things being equal conditions from the point of view of the researcher and to evaluate the results obtained EEG curves and quantity of frequency-amplitude characteristics of little interest and little demand, and the most important EEG brain patterns in general and frontal localization in particular, we assessed flattening biorhythms EEG, degree of disorganization-rhythm zonal differences in degree
of flatness, the degree of the activation state of the reaction, the presence of bilaterally synchronous flashes and / and Whether sharp wave complexes.

All six of the selected contact observations using the international 10-20 system and our proposed EEG systems using only registered electrodes 9 expressed brain changes (Figure 1-13): with flattening of the EEG rhythms; disorganized or substantially disorganized alpha rhythm; smoothed or flattened sharply zonal differences; reduced or greatly reduced activation reaction; the presence in 3 cases bilaterally synchronous outbreaks of acute waves in the background recording and closing the eyes; complexes of low amplitude wave theta range of duration 0.2 to 0.6 seconds during hyperventilation, background recording after hyperventilation.

Figure 2. EEG recording in the international “10-20” system.

Figure 3. EEG recording in “9EEG” system.

Figure 4. Record hyperventilation in the international “10-20” system.
Figure 5. Record hyperventilation “9EEG” system.

Figure 6. Background record after hyperventilation in the “10-20” system.

Figure 7. Background record after hyperventilation “9EEG” system.

Figure 8. Recording of the EEG at 3Hz photostimulation in the “10-20” system.
Figure 9. Recording of the EEG at photostimulation 3 Hz “9EEG” system.

All six of the selected contact observations using the international 10-20 system and our proposed EEG systems using only registered electrodes 9 hearth presence of low amplitude waves from acute anterior frontal leads to background recording, recording with the closing of the eyes, the sample with hyperventilation and background recording after hyperventilation (Figure 2-7).

All six of the selected contact observations using the international 10-20 system and our proposed EEG systems using only registered electrodes 9 Peak-hearth presence of acute waves due photostimulation 3-, 8-, 15-, 24- and 25 Hz with further bilaterally synchronous flares and complexes sharp waves lasting up to 0.8 seconds (Figure 8-13).

Thus, the registered readings from “10-20” system were compared with the covers 9EEG system indications (Figure 2-13). In the analysis of the results obtained using the two systems were identified almost the same bioelectric patterns: flattening of the EEG rhythms, disorganization-rhythm zonal differences smoothness, reduced activation reaction bilaterally synchronous flash sharp wave complexes of low amplitude waves and Peak-acute.

Moreover, in all the selected contact 6 observations using the international 10-20 system and our proposed EEG systems using only registered electrodes 9 Peak-hearth presence of acute waves due photostimulation 3-, 8-, 15-, 24- and 25 Hz with subsequent bilateral synchronous flashes and complexes of sharp waves lasting up to 0.8 sec.

Consequently, with a view to preserving signal quality and the corresponding visualization frontal localization patterns in the traditional recording system, and the system 9EEG with fewer electrodes, the data logical promote the results presented previously [3, 8]. Of course, our scientific work is in no way a plagiarism of the scientific research of Andrey J, Antti K 2014 [8], as colleagues offer a more rapid diagnosis of wireless electroencephalographic system with minimal preparation time for use in emergency situations in patients with neurological disorders, and the most important difference of our work – in obtaining the most qualitative and reliable answer for solving General clinical problems and diagnostics of neurological, medical and other biological problems by registering patterns of frontal localization using the proposed new original innovative approach in the system of electroencephalography.

Interpretation of the data presented demonstrates the possibility of detecting and analyzing the frontal localization patterns made in contact provided 9EEG system and obviously conclusively verifies maximum simplification technically electroencephalographic procedure.

Based on the above, the results of studies with sensors 9 on the figure are represented equally informative, as with 20 sensors. Results of the study are primarily applied nature of scientific novelty and scientific originality of employing new for electroencephalography circuit diagram of 9 electrodes for simplification and greater availability of registration and analysis of bioelectric patterns frontal localization without loss of information, which implies a simplification and greater availability of
clinical interpretation of EEG data in the provision of diagnostic and/or therapeutic medical care or medical services electroencephalograph under various conditions.

Our proposed wiring diagram of the EEG is partly declarative character and, of course, is expected to further the conduct of scientific research with the use of this innovative system with 9 electrodes in search of further modernization of the traditional EEG registration system in order to minimize the technical and technological means and the amount of travel time without loss of information and while maintaining the quality of research.

Figure 10. Recording of the EEG at 8Hz photostimulation in the “10-20” system.

Figure 11. Recording of the EEG at photostimulation 8 Hz “9EEG” system.

Figure 12. EEG photostimulation at 15 Hz in the “10-20” system.

Figure 13. EEG photostimulation at 15 Hz “9EEG” system.
5. Conclusion
In this way, 9EEG system represented by minimizing amount of travel time and means determines upgrading conventional EEG recording system for simplification and greater availability of recording and analyzing patterns and frontal localization implies simplification and greater availability providing diagnostic and therapeutic medical care or medical electroencephalography services in different conditions.

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References
[1] Belyaev O and Samygin D 2016 Guidelines for carrying out of routine eeg of neurophysiology expert board of russian league against epilepsy. *Epilepsia and Paroxzmal Conditions* [Epilepsiya i parokszimal'nyye sostoyaniya – in Russian] 8(4) 99–108
[2] Nazarova M, Blagoveschenskiy E, Nikulin V and Mitina M 2017 Transcranial magnetic stimulation with electroencephalography: methodology, applications for research and clinic. *Neuromuscular Diseases* 7(4) 20–32 [https://doi.org/10.17650/2222-8721-2017-7-4-20-32]
[3] Kozhevnikov I, Gribanov A, Pankow M and Startceva L 2017 Neurophysiological correlates of depressive disorders. *Mental Ecology* [Ekologiya Cheloveka – in Russian] 12 26–32
[4] Zvozdochkina N 2014 *Study of brain electrical activity* (Kazan: Kazan University) p. 59
[5] Gnezditsky V 2004 Contact EEG task and clinical electroencephalography (Moscow: MEDpress) p. 624
[6] Farzan F, Vernet M and Shafi M 2016 Characterizing and modulating brain circuitry through transcranial magnetic stimulation combined with electroencephalography. *Frontiers in Neural Circuits* 10 30–35 [https://doi.org/10.3389/fncir.2016.00073]
[7] Cavaleri R, Schabrun S and Chipchase L 2017 The number of stimuli required to reliably assess corticomotor excitability and primary motor cortical representations using transcranial magnetic stimulation (TMS): a systematic review and meta-analysis. *Systematic Reviews* 6(1) 2046–4053 [https://doi.org/10.1186/s13643-017-0440-8]
[8] Jakab A, Kulkas A, Salpavaara T, Kauppinen P, Verho J, Heikkila H and Jantti V 2014 Novel wireless electroencephalography system with a minimal preparation time for use in emergencies and prehospital care. *BioMedical Engineering OnLine* 13(60) 1475–925X [https://doi.org/10.1186/1475-925X-13-60]
[9] Tugolukov E, Neprokin A, Gorbunov A and Nechaev V 2016 A method of improving the quality of mathematical modeling of unsteady temperature fields. *Transactions TSTU*. 4 596–601 doi:10.17277/vestnik.2016.04.pp.596-601
[10] Gorbunov A, Egorov A and Egorov S, RU Patent No. 168584 (February 9, 2017)