DOI 10.1007/s11055-021-01105-2
Neuroscience and Behavioral Physiology, Vol. 51, No. 5, June, 2021

Electroencephalography in the Acute Phase of Stroke

M. V. Sinkin,[1,2] I. L. Kaimovsky,[2,3] I. G. Komoltsev,[3,4] I. S. Trifonov,[2] A. A. Shtekleyn,[5] M. E. Tsygankova,[6] and A. B. Guekht[4,7]

Translated from Zhurnal Nevrologii i Psikhiatrii imeni S. S. Korsakova, Vol. 120, No. 8, Iss. 2, Stroke, pp. 10–16, August, 2020. Original article received April 27, 2020. Accepted June 4, 2020.

Objective. To determine the frequency of nonconvulsive status epilepticus (NCSE), epileptiform activity, and rhythmic and periodic patterns in patients with acute cerebrovascular accidents (aCVA). **Materials and methods.** The informativeness of the EEG was studied in 86 patients hospitalized in the neurology section of the Department of Resuscitation and Intensive Therapy of a level 3 medical center with diagnoses of aCVA. The criterion for starting recordings was an epileptic seizure or clinical suspicion of NCSE. The content of biomarkers of the ictal-interictal continuum and the diagnostic value of the EEG were evaluated in relation to prognoses for survival and recovery of consciousness. **Results.** Pathological changes in the EEG were seen in 84% of patients. Most patients lacked a dominant occipital rhythm (DOR) (66% of patients) and many showed hemispheric slowing (42%). Slowing of the background rhythm to below the θ range was seen in 41% of patients. EEG reactivity was absent in 20% of patients. Individual epileptiform graphical elements were recorded in 36% of patients, while rhythmic and periodic patterns were recorded in 26%. Significant predictors of unfavorable outcomes were the absence of DOR, areactivity, and decreases in the amplitude and generalized slowing of the background EEG to below the θ range. Our data did not find any link between recording of epileptiform graphic elements or their rhythmic and periodic patterns on the one hand and an increased probability of death on the other. **Conclusions.** The most informative EEG indicators for prognosticating survival and recovery of consciousness were the amplitude, the dominant frequency of the background recording, and reactivity in response to external stimulation. Recording of sporadic epileptiform graphic elements and rhythmic and periodic patterns in patients with aCVA was not always linked with unfavorable prognoses.

Keywords: stroke, intracranial hemorrhage, ischemic stroke, electroencephalograph, EEG monitoring, electrographic epileptic seizures.

The morbidity of acute cerebrovascular accidents (aCVA) in the Russian Federation is three cases per 1000 people, and it takes the leading position among all diseases in mortality and long-term disability [1]. The complications of aCVA include acute epileptic seizures, in some cases converting into status epilepticus. In subclinical cases, these conditions can be diagnosed only by electroencephalography (EEG) [2, 3].

Symptomatic and subclinical epileptic seizures degrade the prognosis and course of the main disease, though their frequency and influence on mortality and disability in mixed populations of patients with aCVA remain to be established [4–6].

The aim of the present work was to determine the frequency of nonconvulsive status epilepticus (NCSE), epileptiform activity, and rhythmic and periodic patterns (RPP) in patients with aCVA undergoing treatment in the Department of Resuscitation of the Regional Vascular Center and their

[1] Sklifosovskii Research Institute of Emergency Medicine, Moscow, Russia; e-mail: mvsinkin@gmail.com.
[2] Evdokimov Moscow State Medical and Dental University, Russian Ministry of Health, Moscow, Russia.
[3] Buyanov City Clinical Hospital, Moscow Health Department, Moscow, Russia.
[4] Solov'ev Scientific and Applied Psychoneurology Center, Moscow Health Department, Moscow, Russia.
[5] Peoples' Friendship University of Russia, Moscow, Russia.
[6] Federal Brain and Neurotechnology Center, Russian Federal Medical Biological Agency, Moscow, Russia.
[7] Pirogov Russian National Research Medical University, Russian Ministry of Health, Moscow, Russia.

TABLE. 1. Description of Background EEG Activity

Section	Value variants			
Symmetry of activity	Symmetrical	Minor slowing, 0.5–1 Hz frequency	Marked slowing, >50% amplitude, >1 Hz frequency	–
Breach effect	Present	Absent	Unclear	
Dominant occipital rhythm (DOR)	Preserved (frequency, Hz)		–	
Frontotemporal gradient	Preserved		Inverted	
EEG variability			Undeterminable	
EEG reactivity		Only SI patterns	Absent	Unclear
Wave amplitude	Normal, >20 μV	Decreased, 10–20 μV	Suppressed, <10 μV	BCS, <2 μV
Components of sleep phase II	Preserved, normal	Preserved, altered	Absent	
Continuity of activity	Continuous	Close to continuous, <10% of epochs decreased/ suppressed	Discontinuous, 10–49% reduced/suppressed	Burst-suppression, >50% decreased/ suppressed

SI – stimulus-induced patterns arising on testing EEG reactivity; BCS – bioelectrical cerebral silence.

influence on the probability of unfavorable outcomes – deaths or progression to vegetative state. Further aims were to assess other indicators of background bioelectrical activity and identify those with prognostic value.

Materials and Methods. A retrospective analysis of EEG results and their links with disease outcomes was run in 86 patients (52 men, median age 60 years, and 34 women, median age 72 years) hospitalized for aCVA in the Intensive Care Unit (ICU) for neurological patients, Buyanov City Clinical Hospital, Moscow Health Department, in 2014–2018. Studies included patients undergoing standard or long-term EEG recordings for the clinical signs of the frontal forms of epileptic seizures or suspected NCSE. Among the subjects, 61 cases (70.9%) were admitted to the ICU with ischemic stroke (IS) and 21 (24.4%) with nontraumatic intracranial hemorrhage (ICH), including those with ruptures into the ventricles, and four (4.7%) with subarachnoid hemorrhages (SAH) without formation of hematomas. Treatment results were evaluated in terms of the number of lethal outcomes in the cohort throughout the whole of the hospitalization period or transfer of the patient to the ward.

All patients underwent EEG recordings following the recommendations of the Neurophysiology Expert Committee of the Russian League against Epilepsy using 19 electrodes positioned on the scalp [7]. The median recording duration was 154.5 min (lower quartile 15 min, upper quartile 270 min). Short-term EEG was used for detection of electrographic signs confirming the clinical hypothesis, while monitoring studies were undertaken in cases with ambiguous pictures and the need to monitor antiepileptic treatment.

Classification and analysis of the electrographic picture were run using a scheme proposed by the Clinical Neurophysiology Group of the Department of Emergency Neurosurgery, Sklifosovskii Research Institute of Emergency Medicine. This consisted of four sections containing descriptions of background activity, occasional epileptiform graphical elements, RPP, and electrographic seizures. The structure of the classification of background activity is shown in Table 1.

The reactivity of the background rhythm was evaluated in responses to passive opening of the eyes, addressing the patient by name, loud handclaps, and pain stimulation. When interrupted and suppressed EEG recordings or recordings with "spike-suppression" patterns were obtained, the possibility of deep medication-induced sedation was considered. EEG data gathered during use of this treatment were excluded from analysis.

Occasional epileptiform graphic elements were classified according to their morphology: spikes, spike-waves, polyspikes, polyspike-waves, spike runs, sharp waves (SW), sharp wave–slow wave complexes (SWSW), and runs of SWSW complexes.

RPP were described using the classification of the American Clinical Neurophysiology Society [8]. This consisted of two obligatory main terms reflecting the location and morphology of discharges in patterns supplemented where required with one or several "modifier" words. These provide a more precise classification of patterns, while morphology modifiers "+ (plus)" increased the probability that a pattern was ictal in nature (Table 2) [9]. As the location, morphology, and RPP modifiers could have different prognostic significance, we classified them separately with assessment of their occurrence in groups with unfavorable and favorable prognoses for survival.

Diagnoses of NCSE were made in compliance with clinical and electrographic (Salzburg) criteria recommended by the International League against Epilepsy [10].

Statistical analysis was run in Statistica 10 (StatSoft). Groups were compared using the nonparametric Mann–Whitney test. Proportions in groups (sex, disease outcome,

TABLE 2. RPP Classification Scheme for Patients in the ICU

Location (term 1)	**Morphology (term 2)**
Generalized (G)	Periodic discharges (PD)
with frontal	+ fast activity (+F)
occipital	+ rhythmic activity (R)
central dominance	+ fast rhythmic activity (+FR)
Lateralized (L)	Rhythmic δ activity (RDA)
unilateral	+ fast activity (+F)
bilaterally asymmetrical	+ spike-like (S)
Bilaterally independent (BiN)	+ fast and spike-like activity (+bs)
unilateral	Spike-wave (SpW)
bilaterally asymmetrical	
Multifocal (MF)	
unilateral	
bilaterally asymmetrical	
Minor modifiers	**Main modifiers**
"Quasi"	Occurrence of pattern in trace
Development of pattern	Duration of pattern recording
Triphasic morphology (for PD and RDA)	Frequency of graphical elements in pattern
Fronto-occipital gradient	Phases of discharge (for PD and SpW)
	Sharpness of shape (for PD and SpW)
	Amplitude. Absolute/relative (for PD)
	Link with external stimulation
	Evolution/fluctuation/stasis

occurrence of convulsive seizures, diagnoses) were compared using Fisher's two-way exact test. Differences were regarded as significant at $p < 0.05$. Data are presented as $S \pm SEM$.

Results. Among the patients included in the study, 46.5% (40 patients) died while in the ICU. Death rates in the IS, ICH, and SAH subgroups were 39% (24 of 61 patients), 62% (13 of 21 patients), and 75% (three of four patients) respectively. The age of hospitalized women was significantly greater than that of men (61 years vs. 69 years, $p < 0.05$).

Pathological changes on the EEG in the study cohort were seen in 72 patients (84%). Most abnormalities in brain bioelectrical activity consisted of hemispheric or regional slowing. Hemispheric slowing was seen in 42% of patients and regional in 25% (frontal in 3%, parietal in 2%, temporal in 8%, and occipital in 12%). Breach rhythms in the projection of trepanning defects were seen in 2%. Interhemisphere asymmetry in the oscillation frequency of the background frequency was noted in 75% of patients, while frequency differences were greater than 0.5 Hz – classified as marked slowing – in 40% of patients. EEG changes corresponded to the side of the stroke in 45% of patients and were contralateral in 23%; changes were not lateralized or lateralization could not be determined in 12%.

A DOR was recorded in only 34% of patients, while 5% showed DOR without any variability. Reactivity was absent in 20% of patients.

Slowing of the background rhythm to the frequency of the θ band and below was detected in 36 patients (41%).

Occasional epileptiform graphic elements were recorded in 36% of patients. The proportion of women with epileptiform graphic elements was significantly greater than the proportion of men (41% vs. 10%, $p < 0.01$). Among patients, the distribution of epileptiform graphic elements in terms of morphology was as follows: spikes were seen in three (3.5%), spike-waves in six (7%), polyspike-waves in one patient (1.2%), runs of spikes in one (1.2%), sharp waves in eight (9.3%), SWSW in 11 (12.8%), and runs of SWSW complexes in one (1.2%). In 45 patients, epileptiform graphic elements were absent and could not be distinguished from artifacts in 10 of these (see Fig. 1, *a*).

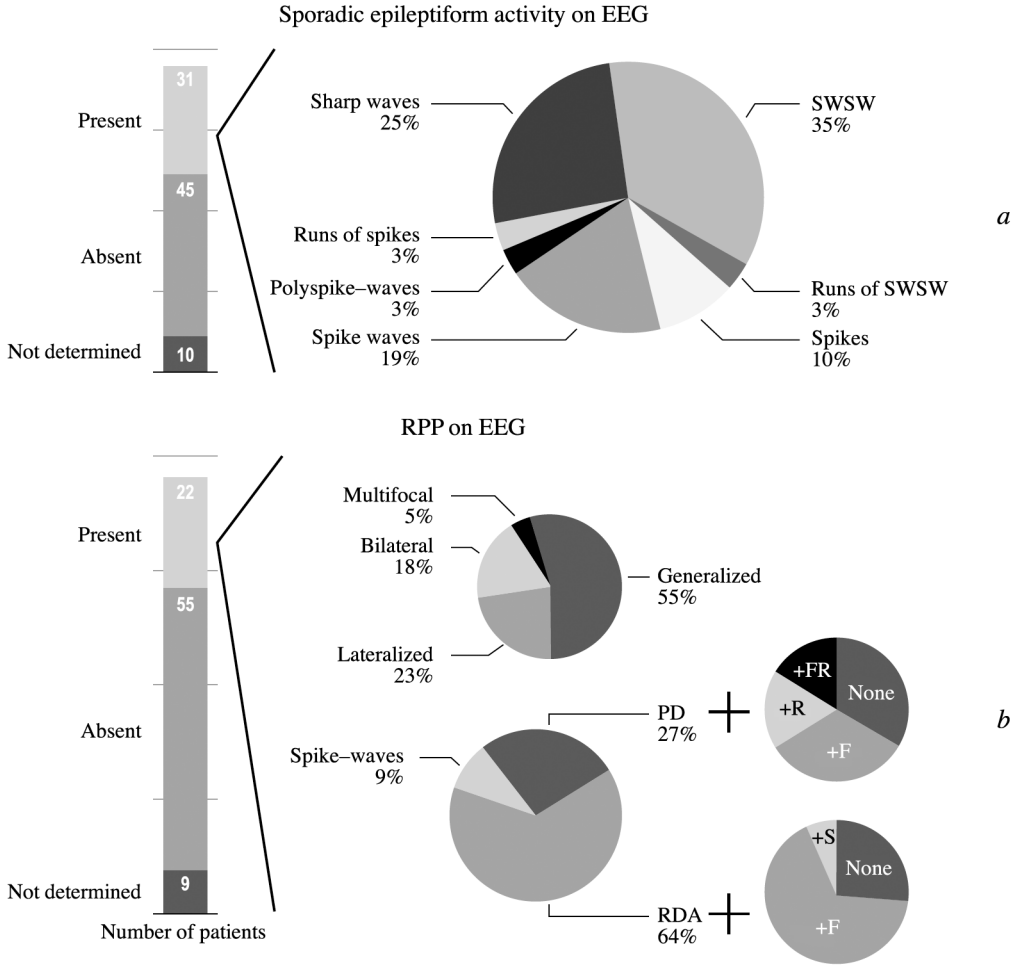

Fig. 1. Epileptiform brain activity in the study population: *a*) distribution of types of individual epileptiform elements; *b*) distribution of RPP.

RPP were recorded in 22 patients (19%): generalized in 12, lateralized in five, bilaterally and independent in four, and multifocal in one. The morphology of graphical elements of RPP consisted of spike-waves in one, periodic discharges in six, and rhythmic δ activity in 14. A detailed proportional distribution of RPP and "plus" modifiers providing evidence of a high risk that patterns were ictal is shown in Fig. 1, *b*.

An electrographic pattern of seizures with discharge frequency greater than 3 Hz was recorded in only one patient.

All these parameters were compared in patients who survived and died during the in-patient period. The proportion of patients with ICH was greater in the group of patients who died than among survivors (13 of 40 patients vs. six of 46 patients). This was not seen for IS or SAH.

The amplitude of the background EEG in patients with lethal outcomes was lower than that in survivors ($1.3 \pm \pm 0.1$ μV vs. 1.7 ± 0.1 μV, $p < 0.05$). The absence of DOR was more frequent in patients with lethal outcomes – DOR was absent in 31 of 40 dying patients ($p < 0.05$ compared with survivors, where DOR was absent in 24 of 46 patients). The proportion of patients with areactive EEG was also significantly greater in the group of patients with lethal outcomes (10 of 13 in the dying group vs. seven of 19 among survivors, $p < 0.05$; this analysis did not include 54 patients in whom EEG reactivity could not be evaluated).

Suppressed EEG with amplitude no greater than 10 μV was recorded in 10 of 40 dying patients, which was significantly greater than in the survivors group (one of 46, $p < < 0.005$). Slowing of the background rhythm frequency to the θ and δ ranges was associated with lethal outcomes (24 of 40 dying patients vs. 11 of 46 survivors, $p < 0.001$).

None of the types of epileptiform activity or periodic patterns, like the presence of a history of epileptic seizures, was shown by our data to be specific for patients with lethal outcomes.

Discussion. Neurological assessment remains definitive for the diagnosis of complications and prognostication of the course of stroke, while assessment of the functional state of the brain is the basis for selecting intensive treatment tactics for patients with aCVA [11]. One frequently encountered (from 2% to 15%) neurological complication of stroke is early epileptic seizures arising in the first week of disease [12]. Despite the long history of studies of this

question, their influence on the functional outcome of aCVA remains controversial [13]. Arntz et al. [14] established that early epileptic seizures were associated with unfavorable outcomes in a cohort of young patients, though a population study reported by Serafini et al. [15] did not show any significant differences in lethality among patients experiencing poststroke epileptic seizures.

Clinical diagnosis of generalized early epileptic seizures does not present any significant difficulty, though verification of partial nonmotor (nonconvulsive) seizures may not be straightforward, especially when contact with the patient is hindered by speech disorders or mental impairments. In patients with suppressed levels of consciousness, nonconvulsive epileptic seizures and NCSE could only be diagnosed using the EEG, which recorded these in 5–48% of patients in the ICU in the state of coma regardless of its origin [16]. Such a large spread in the data is probably explained by various of the criteria used by the authors of the publications cited.

Nonconvulsive epileptic seizures lead to long-term increases in intracranial pressure, impairments to brain tissue metabolism, and atrophy of hippocampal neurons [17, 18]; unambiguous data evidencing a connection between NCSE and increased lethality have not been obtained [19]. Use of American Clinical Neurophysiology Society (ACNS) classifiers and Salzburg criteria improved the quality and standardized the diagnosis of NCSE [20], though the aim of the present work was to analyze RPP characterizing the ictal-interictal continuum, current views of which do not reflect the fact of nonconvulsive epileptic seizures and NCSE but, rather, the probability that they will arise [21].

The results obtained here did not establish a connection between sporadic epileptiform graphic elements, RPP, or electrographic epileptic seizures with increased mortality. These data are consistent with previous reports, though the relatively small cohort and diversity of our group generate the need for continuing observations and studies of separate subgroups of patients with different types of aCVA.

Another important EEG parameter reflecting the functional state of the brain is the nature of background bioelectrical activity. There is no generally recognized descriptive scheme for this activity, though our studies used the protocol of the Clinical Neurophysiology Group of the Department of Emergency Neurosurgery, Sklifosovskii Research Institute of Emergency Medicine, adapted to develop an EEG database and based on the Lüders classification [22].

In our cohort of patients, the following indicators of background brain bioelectrical activity were associated with lethal outcomes: decreased amplitude and suppression of background activity to below 10 μV, the absence of DOR, and the disappearance of EEG reactivity. These data are consistent with results from many studies showing the high prognostic value of the background EEG in patients with anoxic-ischemic encephalopathy arising as a result of cardiac arrest [23–25]. In these patients the EEG is on the list of instrumented methods for prognosticating the outcome of coma induced by secondary brain damage, though we have obtained the first confirmation of the informativeness of these signs in stroke patients [26]. This allows us to suggest with confidence that these signs are not nosologically specific and can be used for prognosticating functional outcomes in patients with any brain damage leading to loss of consciousness. This confirmation also applies to slowing of background activity accompanying the states of stupor and coma. Slowing of the dominant background frequency to below the frequency of the θ range is evidence of an increased probability of a lethal outcome. Similar results were obtained from assessment of background bioelectrical activity in patients with nontraumatic aneurysmal SAH [27].

Background EEG parameters pointing to an unfavorable prognosis in patients with anoxic-ischemic brain damage include its variance and the absence of sleep patterns [28]. In our study, mean trace duration was 152 min, which was insufficient for assessment of these signs, as this can only be done using monitoring traces lasting several hours. Further investigations should be directed to analyzing the prognostic value of long-duration EEG traces in patients with aCVA.

Another limitation of our study was the cohort including patients with the clinical features of epileptic seizures or suspected NCSE, these states initially being associated with adverse prognoses for survival [29]. The informativeness of such studies may be increased by recording bioelectrical activity in all aCVA patients admitted to the ICU, though this approach requires significant resources.

Conclusions. The EEG remains a highly informative method for assessing the functional state of the brain, providing for the diagnosis of nonconvulsive epileptic seizures and prognostication of disease outcome. The most informative EEG indicators for prognosticating survival and recovery of consciousness are the amplitude and dominant frequency of the background trace and reactivity in response to external stimulation. Recording of epileptiform activity and RPP is not always associated with unfavorable outcomes.

The authors have no conflicts of interests

REFERENCES

1. O. S. Starodubtseva and S. V. Begicheva, "Analysis of the incidence of stroke using information technology," *Fundament. Issled.*, **8**, No. 2, 424–427 (2012).
2. H. Meierkord and M. Holtkamp, "Non-convulsive status epilepticus in adults: clinical forms and treatment," *Lancet Neurol.*, **6**, No. 4, 329–339 (2007).
3. E. A. Baranova, T. V. Danilova, I. R. Khalitov, and M. V. Sinkin, "Nonconvulsive status epilepticus with triphasic-wave EEG patterns," *Ann. Klin. Eksperim. Nevrol.*, **14**, No. 1, 97–103 (2020).
4. V. Belcastro, S. Vidale, G. Gorgone, et al., "Non-convulsive status epilepticus after ischemic stroke: a hospital-based stroke cohort study," *J. Neurol.*, **261**, No. 11, 2136–2142 (2014), https://doi.org/10.1007/s00415-014-7471-z.
5. J. Claassen, A. Perotte, D. Albers, et al., "Nonconvulsive seizures after subarachnoid hemorrhage: Multimodal detection and out-

comes," *Ann. Neurol.*, **74**, No. 1, 53–64 (2013), https://doi.org/10.1002/ana.23859.
6. M. P. Kate, G. K. Dash, and A. Radhakrishnan, "Long-term outcome and prognosis of patients with emergent periodic lateralized epileptiform discharges (ePLEDs)," *Seizure*, **21**, No. 6, 450–456 (2012), https://doi.org/10.1016/j.seizure.2012.04.011.
7. "Guidelines for Routine EEG of the Expert Neurophysiology Council of Russian Antiepilepsy League," *Epileps. Paroks. Sost.*, **8**, No. 4, 99–108 (2016).
8. M. V. Sinkin and V. V. Krylov, "Rhythmic and periodic EEG patterns. Classification and clinical significance," *Zh. Nevrol. Psikhiatr.*, **118**, No. 4 No. 2, 25–28 (2018).
9. L. Hirsch, S. M. LaRoche, N. Gaspard, et al., "American Clinical Neurophysiology Society's Standardized Critical Care EEG Terminology: 2012 version," *J. Clin. Neurophysiol.*, **30**, No. 1, 1–27 (2013), https://doi.org/10.1097/WNP.0b013e3182784729, PMID: 23377439.
10. S. Beniczky, L. J. Hirsch, P. W. Kaplan, et al., "Unified EEG terminology and criteria for nonconvulsive status epilepticus," *Epilepsia*, **54**, Suppl. 6, 28–29 (2013), https://doi.org/10.1111/epi.12270.
11. A. S. Nikitin, S. A. Burov, S. S. Petrikov, et al., "Decompressive craniotomy at patients with malignant course of massive ischemic stroke," *Neirokhirurgiya*, **3**, 23–29 (2014).
12. A. Guekht and N. M. Bornstein, "Seizures after stroke," *Handb. Clin. Neurol.*, **108**, 569–583 (2012), https://doi.org/10.1016/B978-0-444-52899-5.00016-2.
13. J. Zelano, "Poststroke epilepsy: Update and future directions," *Ther. Adv. Neurol. Disord.*, **9**, No. 5, 424–435 (2016), https://doi.org/10.1177/1756285616654423.
14. R. Arntz, N. Maaijwee, L. Rutten-Jacobs, et al., "Epilepsy after TIA or stroke in young patients impairs long-term functional outcome: the future study," *Neurology*, **81**, 1907–1913 (2013), https://doi.org/10.1212/01.wnl.0000436619.25532.f3.
15. A. Serafini, G. Gigli, G. Gregoraci, et al., "Are early seizures predictive of epilepsy after a stroke? Results of a population-based study," *Neuroepidemiology*, **45**, 50–58 (2015).
16. E. Trinka and M. Leitinger, "Which EEG patterns in coma are nonconvulsive status epilepticus?" *Epilepsy Behav.*, **49**, 203–222 (2015), https://doi.org/10.1016/j.yebeh.2015.05.005.
17. P. M. Vespa, D. L. McArthur, Y. Xu, et al., "Nonconvulsive seizures after traumatic brain injury are associated with hippocampal atrophy," *Neurology*, **75**, No. 9, 792–798 (2010), https://doi.org/10.1212/WNL.0b013e3181f07334.
18. P. M. Vespa, C. Miller, D. McArthur, et al., "Nonconvulsive electrographic seizures after traumatic brain injury result in a delayed, prolonged increase in intracranial pressure and metabolic crisis," *Crit. Care Med.*, **35**, No. 12, 2830–2836 (2007), https://doi.org/10.1097/01.CCM.0000295667.66853.BC.
19. V. V. Krylov, A. M. Teplyshova, R. Sh. Mutaeva, et al., "Posttraumatic seizures: A prospective cohort study," *Zh. Nevrol. Psikhiatr.*, **118**, No. 10, 3–8 (2018), https://doi.org/10.17116/jnevro20181181023.
20. M. O. Kinney and P. W. Kaplan, "An update on the recognition and treatment of non-convulsive status epilepticus in the intensive care unit," *Expert Rev. Neurother.*, **17**, No. 10, 987–1002 (2017), https://doi.org/10.1080/14737175.2017.1369880.
21. C. Rubinos, A. S. Reynolds, and J. Claassen, "The ictal-interictal continuum: To treat or not to treat (and how)?" *Neurocrit. Care*, **29**, No. 1, 3–8 (2018), https://doi.org/10.1007/s12028-017-0477-5.
22. H. Lüders and S. Noachtar, *Atlas and Classification of Electroencephalography*, W. B. Saunders, Philadelphia (2000).
23. A. Grippo, R. Carrai, M. Scarpino, et al., "Neurophysiological prediction of neurological good and poor outcome in post-anoxic coma," *Acta Neurol. Scand.*, **135**, No. 6, 641–648 (2017), https://doi.org/10.1111/ane.12659.
24. L. Sondag, B. J. Ruijter, M. C. Tjepkema-Cloostermans, et al., "Early EEG for outcome prediction of postanoxic coma: Prospective cohort study with cost-minimization analysis," *Crit. Care*, **21**, No. 1, 34–39 (2017), https://doi.org/10.1186/s13054-017-1693-2.
25. E. Westhall, I. Rosén, A. O. Rossetti, et al., "Electroencephalography (EEG) for neurological prognostication after cardiac arrest and targeted temperature management; rationale and study design," *BMC Neurol.*, **14**, No. 1, 159 (2014), https://doi.org/10.1186/s12883-014-0159-2.
26. E. F. M. Wijdicks, A. Hijdra, G. B. Young, et al., "Practice parameter: Prediction of outcome in comatose survivors after cardiopulmonary resuscitation (an evidence-based review). Report of the Quality Standards Subcommittee of the American Academy of Neurology," *Neurology*, **67**, No. 2, 203–210 (2006), https://doi.org/10.1212/01.wnl.0000227183.21314.cd.
27. V. V. Lebedev, N. S. Kuksova, V. V. Krylov, and M. Yu. Myatchin, "EEG informativeness in the acute period of subarachnoid hemorrhage due to ruptured arterial aneurysm," *Vopr. Neirokhir.*, **5**, 44–49 (1989).
28. R. Sutter, B. Barnes, A. Leyva, et al., "Electroencephalographic sleep elements and outcome in acute encephalopathic patients: A 4-year cohort study," *Eur. J. Neurol.*, **21**, No. 10, 1268–1275 (2014), https://doi.org/10.1111/ene.12436.
29. A. Lybeck, H. Friberg, A. Aneman, et al., "Prognostic significance of clinical seizures after cardiac arrest and target temperature management," *Resuscitation*, **114**, 146–151 (2017), https://doi.org/10.1016/j.resuscitation.2017.01.017.