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Новый День в Медицине

NDM



TIBBIYOTDA YANGI KUN

Ilmiy referativ, marifiy-ma'naviy jurnal



AVICENNA-MED.UZ



ISSN 2181-712X.
EISSN 2181-2187

1 (87) 2026

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ТИББИЁТДА ЯНГИ КУН НОВЫЙ ДЕНЬ В МЕДИЦИНЕ NEW DAY IN MEDICINE

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Научно-реферативный,
духовно-просветительский журнал*

УЧРЕДИТЕЛИ:

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МЕДИЦИНСКИЙ ИНСТИТУТ
ООО «ТИББИЁТДА ЯНГИ КУН»**

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А.В. Вишневского является генеральным
научно-практическим
консультантом редакции

Журнал был включен в список журнальных
изданий, рецензируемых Высшей
Аттестационной Комиссией
Республики Узбекистан
(Протокол № 201/03 от 30.12.2013 г.)

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2026 *январь*

CORRELATION BETWEEN EEG ABNORMALITIES AND NEUROLOGICAL COMPLICATIONS IN PATIENTS WITH BRAIN TUMORS

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✓ Resume

Electroencephalography (EEG) plays a critical role in assessing functional brain disturbances associated with intracranial tumors. The present study investigates the correlation between various EEG abnormalities and postoperative neurological complications in 100 patients with histologically confirmed brain tumors. Preoperative and postoperative EEG recordings were analyzed in relation to clinical outcomes, including seizure activity, motor deficits, visual disturbances, and cognitive decline. Specific EEG patterns, particularly epileptiform discharges and reduced alpha reactivity, demonstrated strong prognostic value. Epileptiform discharges were significantly associated with postoperative seizure risk, while impaired alpha reactivity correlated with visual deficits and poorer cognitive outcomes. Theta–delta predominance and diffuse slowing were also linked to motor and cognitive impairments, highlighting the differential prognostic significance of distinct EEG abnormalities. These findings underscore the utility of EEG not only as a diagnostic tool but also as a biomarker for predicting postoperative neurological complications. Incorporating EEG parameters into perioperative risk assessment may contribute to personalized patient management and improved rehabilitation strategies. The study emphasizes the need for integrated electrophysiological monitoring in the neurosurgical care pathway for brain tumor patients.

Keywords: Electroencephalography (EEG); Brain Tumors; Neurological Complications; Postoperative Seizures; Alpha Reactivity; Epileptiform Discharges; Cognitive Decline; Motor Impairment; Prognostic Biomarker.

КОРРЕЛЯЦИЯ МЕЖДУ ЭЭГ-АНОМАЛИЯМИ И НЕВРОЛОГИЧЕСКИМИ ОСЛОЖНЕНИЯМИ У ПАЦИЕНТОВ С ОПУХОЛЯМИ ГОЛОВНОГО МОЗГА

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✓ Резюме

Электрэнцефалография (ЭЭГ) играет ключевую роль в оценке функциональных нарушений головного мозга, связанных с внутричерепными опухолями. В настоящем исследовании изучается корреляция между различными ЭЭГ-аномалиями и послеоперационными неврологическими осложнениями у 100 пациентов с гистологически подтвержденными опухолями головного мозга. Были проанализированы до- и послеоперационные записи ЭЭГ в связи с клиническими исходами, включая судорожную активность, двигательные дефициты, зрительные нарушения и когнитивное снижение. Конкретные паттерны ЭЭГ, в частности эпилептиформные разряды и сниженная альфа-реактивность, продемонстрировали высокую прогностическую ценность. Эпилептиформные разряды были значимо связаны с риском послеоперационных судорог, в то время как нарушенная альфа-реактивность коррелировала со зрительными дефицитами и худшими когнитивными исходами. Тета-дельта доминирование и диффузное замедление также были связаны с двигательными и когнитивными нарушениями, что подчеркивает

различное прогностическое значение отдельных ЭЭГ-аномалий. Эти данные подчеркивают полезность ЭЭГ не только в качестве диагностического инструмента, но и в качестве биомаркера для прогнозирования послеоперационных неврологических осложнений. Включение параметров ЭЭГ в периоперационную оценку риска может способствовать персонализированному ведению пациентов и улучшению реабилитационных стратегий. Исследование подчеркивает необходимость интегрированного электрофизиологического мониторинга в нейрохирургическом пути лечения пациентов с опухолями головного мозга.

Ключевые слова: Электроэнцефалография (ЭЭГ); Опухоли головного мозга; Неврологические осложнения; Послеоперационные судороги; Альфа-реактивность; Эпилептиформные разряды; Когнитивное снижение; Двигательные нарушения; Прогностический биомаркер.

EEG ANOMALIYALARI VA MIYA O'SMASI BO'LGAN BEMORLARNING NEVROLOGIK ASORATLARI O'RTASIDAGI BOG'LIQLIK

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Elektroensefalografiya (EEG) miya ichidagi o'smalar bilan bog'liq miyaning funksional buzilishlarini baholashda hal qiluvchi rol o'ynaydi. Ushbu tadqiqotda gistologik tasdiqlangan miya o'smalari bo'lgan 100 nafar bemorda turli EEG anomaliyalari va postoperativ nevrologik asoratlar o'rtasidagi bog'liqlik o'rganiladi. Operatsiyadan oldin va keyin olingan EEG yozuvlari klinik natijalar - tutqanoq faolligi, harakat nuqsonlari, ko'rish buzilishlari va kognitiv pasayish bilan bog'lab tahlil qilindi. Muayyan EEG naqshlari, xususan, epileptiform razryadlar va pasaygan alfa reaktivligi yuqori prognoz qiymatini namoyish etdi. Epileptiform razryadlar postoperativ tutqanoq xavfi bilan sezilarli darajada bog'liq bo'lsa, buzilgan alfa reaktivligi esa ko'rish nuqsonlari va yomonroq kognitiv natijalar bilan bog'liq edi. Teta-delta ustunligi va diffuz sekinlashish ham harakat va kognitiv buzilishlar bilan bog'liq bo'lib, bu alohida EEG anomaliyalarining har xil prognoz ahamiyatini ta'kidlaydi. Ushbu topilmalar EEG ning nafaqat diagnostika vositasi, balki postoperativ nevrologik asoratlarni bashorat qilish uchun biomarker sifatida foydaliligini ko'rsatadi. EEG parametrlarini perioperativ xavfni baholashga kiritish bemorlarni individual boshqarish va rehabilitatsiya strategiyalarini yaxshilashga hissa qo'shishi mumkin. Tadqiqot miya o'smasi bo'lgan bemorlarni davolashning neyroxirurgik yo'lida integratsiyalashgan elektrofiziologik monitoring zarurligini ta'kidlaydi.

Kalit so'zlar: Elektroensefalografiya (EEG); Miya o'smalari; Nevrologik asoratlar; Postoperativ tutqanoqlar; Alfa reaktivligi; Epileptiform razryadlar; Kognitiv pasayish; Harakat buzilishlari; Prognozli biomarker.

Introduction

Neurological complications remain a significant concern in patients with brain tumors undergoing surgical treatment. Seizures, motor impairments, visual disturbances, and cognitive decline represent common manifestations that negatively impact quality of life. Electroencephalography (EEG) has been widely applied for functional monitoring, but its predictive value regarding postoperative outcomes requires further clarification. Previous studies have reported associations between focal slow-wave activity and motor deficits (Boon et al., 2020), epileptiform discharges and seizures (Douw et al., 2019), as well as alpha reactivity with cognitive performance (van Dellen et al., 2018). However, the relationship between detailed EEG features and specific neurological complications after brain tumor resection remains insufficiently explored.

The objective of this study was to define the correlation between EEG abnormalities and postoperative complications in patients undergoing neurosurgical treatment for brain tumors.

Material and methods

A retrospective cohort of 100 patients (age 19–67; mean 43.3 years; 51 males, 49 females) treated surgically for supratentorial and temporal-occipital tumors was analyzed. Preoperative and postoperative EEG recordings were obtained using a standard 19-electrode 10–20 configuration, with a sampling rate of 256 Hz. EEG abnormalities evaluated included epileptiform discharges, theta–delta predominance, alpha rhythm asymmetry, reduced alpha reactivity, lateralized changes, and diffuse slowing. Neurological complications assessed included postoperative seizures, motor impairments, visual deficits, and cognitive decline. Pearson correlation analysis was performed (SPSS 25.0), and statistical significance was defined at $p < 0.05$. Ethical approval was obtained prior to study initiation.

Result and discussions

Preoperative evaluation demonstrated that seizures were present in 27% of patients overall, with a slightly higher prevalence in Group 2 (29%) compared to Group 1 (25%). Neurological deficits were detected in 41% of cases, including persistent motor weakness and visual field reductions. Importantly, baseline EEG abnormalities were significantly associated with these clinical features. Epileptiform discharges correlated with the presence of preoperative seizures ($\chi^2 = 12.47$, $p < 0.001$), while impaired alpha reactivity showed a distinct association with visual disturbances ($\chi^2 = 9.85$, $p < 0.01$).

Postoperative EEG assessment (7–10 days after surgery) demonstrated a statistically significant reduction in abnormal activity across both groups. In Group 1, epileptiform discharges decreased from 0.15 ± 0.03 to 0.07 ± 0.02 ($p < 0.05$), while in Group 2, they decreased from 0.20 ± 0.04 to 0.09 ± 0.03 ($p < 0.05$). This improvement was most pronounced in patients undergoing complete tumor resection. Similarly, diffuse slowing, indicative of global cortical dysfunction, was reduced substantially in Group 1 (from 0.08 ± 0.03 to 0.04 ± 0.01), while Group 2 showed only partial improvements (0.00 increasing modestly to 0.02 ± 0.01).

Regarding visual alpha reactivity, Group 2 patients showed striking changes: preoperatively absent in nearly all cases, reactivity was restored postoperatively in 37% of individuals ($p < 0.05$). These improvements paralleled clinical recovery, with better subjective visual field perception and cognitive responsiveness during early rehabilitation.

Neurological outcomes strongly mirrored EEG dynamics. Patients who demonstrated a marked reduction in epileptiform discharges were significantly less likely to develop postoperative seizures (7%) compared to those with persistent abnormal activity (23%; $p < 0.05$). Restoration of visual alpha reactivity was closely associated with improved ophthalmological outcomes and enhanced cognitive test performance. Conversely, continued theta–delta predominance, most notable in patients with deep-seated gliomas, correlated with more persistent neurological dysfunction and limited recovery.

Table 1. Correlation between EEG abnormalities and neurological complications

EEG Parameter	Postoperative seizures	Motor impairments	Visual deficits	Cognitive decline
Epileptiform discharges	$r = 0.42$, $p < 0.001$	$r = 0.18$, $p = 0.07$	$r = 0.11$, $p = 0.21$	$r = 0.25$, $p < 0.05$
Theta–delta predominance	$r = 0.29$, $p < 0.05$	$r = 0.35$, $p < 0.01$	$r = 0.20$, $p < 0.05$	$r = 0.32$, $p < 0.01$
Alpha rhythm asymmetry	$r = 0.16$, $p = 0.11$	$r = 0.27$, $p < 0.05$	$r = 0.22$, $p < 0.05$	$r = 0.14$, $p = 0.17$
Reduced alpha reactivity	$r = 0.19$, $p = 0.08$	$r = 0.21$, $p = 0.06$	$r = 0.38$, $p < 0.01$	$r = 0.30$, $p < 0.01$
Lateralized EEG changes	$r = 0.23$, $p < 0.05$	$r = 0.29$, $p < 0.05$	$r = 0.09$, $p = 0.30$	$r = 0.18$, $p = 0.09$
Diffuse slowing	$r = 0.27$, $p < 0.05$	$r = 0.31$, $p < 0.01$	$r = 0.24$, $p < 0.05$	$r = 0.33$, $p < 0.01$

Correlation analysis confirmed these associations in quantitative terms. Epileptiform discharges remained the strongest predictor of seizure tendency ($r = 0.42$, $p < 0.001$). Reduced alpha reactivity correlated most strongly with visual deficits ($r = 0.38$, $p < 0.01$). Theta–delta predominance and diffuse slowing were consistently associated with both cognitive decline ($r = 0.32–0.33$, $p < 0.01$) and motor impairment ($r = 0.29–0.35$, $p < 0.01$). These findings highlight that each EEG abnormality carries a differential prognostic weight depending on its topography and neurophysiological basis.

Overall, the results suggest that postoperative normalization of EEG activity is not only a marker of cortical recovery but also a predictor of favorable neurological trajectories. Persistent abnormalities, on the other hand, reflect residual dysfunction and portend a heightened risk of complications.

Discussion: Our findings demonstrate that specific EEG abnormalities provide predictive information regarding postoperative neurological complications in patients with brain tumors. Epileptiform discharges were confirmed as a key predictor of postoperative seizure development, consistent with prior observations (Chen et al., 2021). Reduced alpha reactivity correlated with visual deficits, reaffirming the role of posterior alpha activity in visual cortical processing (van Dellen et al., 2018). Furthermore, diffuse slowing and theta–delta predominance correlated most strongly with cognitive decline, in line with existing evidence linking slow-wave activity to disrupted cortical connectivity (Boon et al., 2020).

Compared to prior literature, our study emphasizes the prognostic value of EEG not only in epilepsy monitoring but also in predicting a broader spectrum of neurological outcomes. The ability to identify high-risk patients preoperatively may inform surgical strategies and postoperative rehabilitation programs.

Conclusion

EEG abnormalities correlate significantly with specific neurological complications following brain tumor surgery. Epileptiform discharges predict postoperative seizures, reduced alpha reactivity is a marker for visual deficits, and diffuse slowing and theta–delta predominance forecast cognitive and motor decline. Integration of EEG parameters into perioperative risk assessment may enhance patient management and outcomes.

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Entered 20.12.2025