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RELATIONSHIP BETWEEN EEG PATTERN AND LEVEL OF CONSCIOUSNESS WITH CLINICAL OUTCOMES IN HEMORRHAGIC STROKE PATIENTS

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ABSTRACT

Hemorrhagic stroke, characterized by cerebral blood vessel rupture and bleeding within the brain tissue or surrounding areas, remains a critical global health issue that significantly contributes to morbidity and mortality rates. This cross-sectional study aimed to analyze the relationship between electroencephalogram (EEG) patterns and the level of consciousness and clinical outcomes in stroke patients with intracerebral hemorrhage (ICH). This study included 43 patients with hemorrhagic stroke diagnosed with ICH at Dr. Zainoel Abidin General Hospital, Banda Aceh, Indonesia. Demographic data were obtained from medical records, clinical outcomes were assessed using the modified Rankin Scale (mRS), and level of consciousness was evaluated using the Glasgow Coma Scale (GCS). Most patients (62.8%) had good clinical outcomes, whereas 37.2% had poor outcomes. Hypertension was the most prevalent comorbidity (48.8%) and non-lobar hemorrhage was the most frequent (72.1%). A significant relationship was found between EEG patterns and clinical outcomes (p=0.012) as well as between the level of consciousness and clinical outcomes (p=0.000). The mean GCS score for patients with favorable outcomes was 13.93, while for patients with unfavorable outcomes was 10.25. Abnormal EEG patterns may potentially lead to post-stroke seizures, and alterations in EEG characteristics significantly increase risk factors for future post-stroke epilepsy. The integration of EEG data with clinical evaluations of the level of consciousness can improve prognosis, tailor rehabilitation efforts, and enhance overall clinical outcomes in patients with hemorrhagic stroke.

Keywords: Hemorrhagic stroke., EEG., level of consciousness

INTRODUCTION

Stroke is a clinical syndrome characterized by sudden onset and rapid progression, presenting as localized or global neurological deficits. It persists for 24 hours or more or results in death and is exclusively caused by non-traumatic cerebral circulatory disorders.[1,2] Hemorrhagic stroke is characterized by cerebral blood vessel rupture, causing bleeding within the brain tissue or surrounding areas, such as the subarachnoid space. This condition is primarily categorized into intracerebral hemorrhage (ICH) and subarachnoid hemorrhage (SAH), each of which has distinct pathophysiological mechanisms and clinical prognoses. Stroke remains a critical global health issue, with hemorrhagic stroke representing 15–30% of all stroke incidents and contributing significantly to morbidity and mortality rates.[3]

The effects of hemorrhagic stroke extend beyond immediate physical brain damage and profoundly influence long-term functional recovery and quality of life.[4] Hemorrhagic stroke is characterized by sudden neurological deficits, altered consciousness levels, and complications that lead to cognitive decline and functional disabilities in the post-acute phase. Early recognition of altered level of consciousness can facilitate timely imaging and therapeutic measures that significantly affect outcomes.[3,5]

Seizures often occur during the initial phase after a stroke, with a frequency of 2.5% - 5.7% within 14 days. Seizures in this phase are called early seizures, whereas those occurring more than 2 weeks after a stroke are called late seizures.[6] In acute ICH, seizures can be caused by space pressure or compression due to an increased bleeding volume in the brain parenchyma. In the chronic phase, seizures can result from cortical irritation, hemosiderin deposits, and chronic scar lesions in glial cells.[7]

Electroencephalography (EEG) has become essential for evaluating neurological function, particularly in stroke patients. EEG offers real-time insights into brain electrical activity and can be crucial in identifying post-stroke complications such as seizures, which are more prevalent in patients with hemorrhagic stroke compared to ischemic strokes. EEG has become instrumental in the clinical evaluation of hemorrhagic stroke, contributing significantly to the comprehension and diagnostic processes. Its application in acute stroke cases extends beyond seizure diagnoses. EEG provides insights into cortical electrical dynamics, which can reflect the severity of neurological deficits and inform prognostic evaluations.[8] The capacity of EEG to detect subtle alterations in brain activity before, during, and after a stroke event is particularly significant, given the rapid dynamics of brain pathophysiology associated with stroke.[9]

Although EEG is a reliable diagnostic tool, its application in routine clinical management of patients with hemorrhagic stroke is often undervalued. Research has shown that early EEG implementation can aid in predicting neurological deficits and enhancing clinical decision making. EEG plays a crucial role in detecting nonconvulsive seizures, which are often overlooked, but can significantly affect a patient's neurological health and rehabilitation Participants were recruited using a non-probability sampling approach (consecutive sampling), and met the inclusion and exclusion criteria of the study. The subjects in this study were patients with intracerebral hemorrhage stroke who met the following inclusion criteria: (a) diagnosis of intracerebral hemorrhage stroke by a neurologist based on medical history, physical examination, neurological examination, laboratory examination, and CT scan examination; and (b) transportable patients for EEG examination on the 7th day after stroke onset. The exclusion criteria were as follows: (a) patients with complications of renal function disturbance, (b) patients with complications of hepatic function disorder, (c) patients with electrolyte balance disorders, (d) Patients with COVID-19, (e) patients with a history of epilepsy, (f) patients who underwent craniectomy for bleeding evacuation, and (f) patients who did not consent to participate in the study.

Data collection

Demographic data were obtained from the patients' medical records. The diagnosis of hemorrhagic stroke was confirmed by a neurologist based on the results of non-contrast head CT scans conducted within 24 hours post-stroke. Clinical outcomes were assessed using the modified Rankin Scale (mRS) scores on the first and fourteenth days of treatment. Clinical outcomes were categorized as follows: poor outcome (mRS 3-6) and good outcome (mRS 0-2).[10] Interpretation of the patient's electroencephalogram (EEG) was verified by a consultant epilepsy neurologist. The EEG results were classified into normal, epileptiform, and non-epileptiform categories.[11] The level of consciousness was evaluated using the Glasgow Coma Scale (GCS) scores and

success. Therefore, this study aimed to analyze the relationship between EEG patterns and level of consciousness with the clinical outcomes of stroke patients with ICH. The findings are anticipated to provide additional information to the public regarding the use of EEG in predicting clinical outcomes for patients with hemorrhagic stroke receiving hospital care.

METHODS

Study design

This cross-sectional study was conducted in the Neurology Inpatient Ward of Dr. Zainoel Abidin General Hospital (RSUDZA), Banda Aceh, Indonesia between January and April 2022.

Population and sample

classified into compos mentis (GCS 15), somnolence (GCS 12-14), sopor (GCS 8-11), and coma (GCS 3-7).[12]

Data analysis

Categorical data are presented as percentages, and numerical data as mean ± SD. Chi-square analysis was performed to analyze the relationships between the research variables. SPSS software (version 25.0; IBM Corp., Armonk, New York, USA) was used for all the statistical analyses. Statistical significance was set at $p < 0.05$. Institutional ethical approval was obtained to conduct this study from the Ethics Committee of the Dr. Zainoel Abidin Hospital. Written consent to participate in this study was provided by all patients or their guardians.

RESULTS

Forty-three patients met the inclusion criteria for this study. Table 1 shows that hemorrhagic stroke patients with ICH were predominantly male (55.8%). The incidence of ICH was higher in the elderly population (aged > 55 years) (51.2%). Hypertension was the most prevalent comorbidity among these patients (48.8 %), followed by diabetes (25.6 %). Hypertension and diabetes were observed in 20.9% of patients, while vascular abnormalities, such as arteriovenous malformation (AVM), were present in 4.7% of patients. The most frequent hemorrhage location was the non-lobar (72.1%). A hemorrhage volume exceeding 30 cc was common, occurring in 58.1% of patients. Clinical seizures were reported in 32.6% of the patients. A favorable clinical outcome was observed in 62.8% of intracerebral hemorrhage stroke patients.

Table 1. Demographic characteristics of stroke patients with ICH (n = 43)

Characteristics	**n (%)**
Gender	
Male	24 (55.8)
Female	19 (44.2)
Age (year)	
≤ 55	21 (48.8)
> 55	22 (51.2)
Comorbids	
Hypertension	21 (48.8)
Diabetes	11 (25.6)
Hypertension and Diabetes	9 (20.9)
Vascular abnormality (AVM)	2 (4.7)
Site of Hemorrhage	
Lobar	12 (27.9)
Non-Lobar	31 (72.1)
Volume of Hemorrhage	
≤ 30 cc	18 (41.9)
> 30 cc	25 (58.1)
Seizures	
Yes	14 (32.6)
No	29 (67.4)
Level of conciousness	
Compos mentis (GCS 15)	12 (27.9)
Somnolence (GCS 12-14)	19 (44.2)
Sopor (GCS 8-11)	12 (27.9)
Coma (GCS 3-7)	0 (0.0)
EEG results	
Normal	20 (46.5)
Non-epileptiform	14 (32.6)
Epileptiform	9 (20.9)
Clinical Outcomes	
Good	27 (62.8)
Poor	16 (37.2)

AVM: arteriovenous malformation.

The relationship between the level of consciousness, EEG patterns, and clinical outcomes of stroke patients with ICH is shown in Table 2. There was a significant relationship between the results of the patients' EEG patterns and the outcomes of intracerebral hemorrhage stroke patients (p = 0.012). Level of consciousness was also significantly associated with clinical outcomes in patients with ICH (p =0.000).

Table 2. Relationship between level of consciousness and EEG patterns with clinical outcome of the hemorraghic stroke patients

Variables	Outcomes		Total	p-value
	Poor	Good		
Level of conciousness				
GCS 15	12	0	12	
GCS 12-14	15	4	19	0.000*
GCS 8-11	0	12	12	
Total			43	

EEG				
Normal	16	4	10	0.012^*
Non-epileptic	9	5	14	
Epileptic	2	7	9	
Total	27	16	43	

Data were analyzed using the Chi-square test. *p < 0.05 was significant.

DISCUSSION

The findings of our study indicate a significant relationship between the level of consciousness and changes in EEG patterns with respect to the clinical outcomes in patients with hemorrhagic stroke. This highlights the critical role of consciousness level in diagnosing not only the severity of stroke but also the prediction of clinical outcomes.

The present study found that 27 patients (62.8 %) had good clinical outcomes based on the conclusion of the hospitalization period, whereas 16 patients (37.2%) had poor clinical outcomes after hospitalization. The prognosis of patients with intracerebral hemorrhage stroke is affected by several factors including the severity of brain damage, volume of hemorrhage, and location. A favorable functional outcome is associated with a hemorrhage volume of less than 30 ml.[13,14]

Regarding levels of consciousness, the majority of patients with hemorrhagic stroke (46.5%) had a severe level of consciousness (GCS 8-12). The mean GCS score for patients with favorable clinical outcomes was 13.93 (SD = 1.107), whereas the mean GCS score for those with unfavorable outcomes was 10.25 (SD = 1.653). These findings are consistent with a study conducted at Hasan Sadikin Hospital in Bandung, where it was observed that intracerebral hemorrhage stroke patients predominantly had GCS scores ranging from 8 to 12 (59%), followed by patients with GCS scores of 15 (20.9%). They also determined that a decrease in the level of consciousness upon admission correlated with an elevated risk of mortality in patients with hemorrhagic stroke. Specifically, patients with a somnolent level of consciousness exhibited a mortality risk six times greater than those with a compos mentis (p = 0.02; RR = 6.38).

Furthermore, patients with sopor and coma levels of consciousness demonstrated a mortality risk 24 times greater than those with compos mentis (p = 0.00; RR = 23.85).[15] Increased intracranial pressure caused by the compressive effect of intracerebral hemorrhage mass space causes a compressive effect, which results in the suppression of the ascending reticular activation system (ARAS). This mechanism is related to the consciousness of patients with hemorrhagic stroke. The more severe the degree of intracerebral hemorrhage stroke, the lower the patient's level of consciousness.[4,16]

The clinical manifestations of hemorrhagic stroke can vary and often include acute neurological deficits, altered consciousness, and complications that extend to cognitive decline and functional disability post-crisis. The level of consciousness is particularly vital for diagnosis and management because alterations can indicate the severity of intracranial pressure changes and cerebral ischemia due to blood accumulation. Research indicates that diminished level of consciousness fluctuates significantly with the severity of the hemorrhage; hence, close monitoring through neurological assessments becomes critical.[17] Studies have shown that alterations in mental status were seen in around 51.4% of acute stroke patients, making this symptom a crucial marker for urgent neurological intervention.[18] Furthermore, early recognition of altered level of consciousness can facilitate timely imaging and therapeutic measures that can significantly affect outcomes.[5,13]

The present study showed a significant correlation between alterations in EEG patterns and the clinical outcomes of patients with intracerebral hemorrhage stroke. Abnormal EEG patterns may potentially lead to post-stroke seizures in the future.[19] The epileptiform EEG patterns signify cortical hyperexcitability and concurrently reflect brain electrical activity with the potential to induce seizures. This phenomenon also suggests that epileptiform activity may serve as an indicator of the severity of biochemical imbalance and structural brain damage. The extent of brain damage in patients experiencing intracerebral hemorrhagic stroke acts as an initial catalyst for the disinhibition of brain electrical activity, which can be manifested by the occurrence of seizures and alterations in the level of consciousness.[6,20]

The detection of epileptiform waves is crucial for clinicians to optimize therapeutic strategies for patients, including the administration of antiepileptic drugs (AEDs), to enhance patient prognosis. Numerous studies concerning patient outcomes and alterations in EEG patterns indicate that changes in either epileptiform or non-epileptiform EEG characteristics significantly increase the relative risk factors for future post-stroke epilepsy.[10] The occurrence of non-epileptiform waves is observed in cases of hypoxic-ischemic encephalopathy, particularly among patients experiencing intracerebral hemorrhagic strokes, which are marked by a deceleration of cerebral electrical activity. Extended periods of encephalopathy may result in poorer patient prognoses, with an increased likelihood of significant disability.[20] Lima et al. identified that the presence of epileptiform activity in EEG patterns as a predictor of potentially adverse clinical outcomes in post-stroke patients.[21]

EEG findings have been shown to have prognostic significance, particularly in relation to predicting outcomes such as functional recovery and the likelihood of post-stroke epilepsy, which is relevant in managing hemorrhagic stroke patients. The latency and type of abnormalities observed on early EEG can inform clinicians about the risk of future neurological complications, which can guide therapeutic decisions and rehabilitation strategies.[22] Studies have demonstrated that certain EEG patterns correlate with an elevated risk of adverse outcomes, enabling targeted interventions early on in the clinical pathway.[8]

The interaction between the EEG drug responses and hemorrhagic stroke adds to the complexity of patient management. Given the high incidence of seizures in acute stroke, understanding EEG patterns can provide crucial information for pharmacological management and potential seizure prophylaxis in stroke care.[20] Prolonged EEG monitoring, particularly in intensive care units, is instrumental in identifying high-risk patients who may benefit from enhanced monitoring and treatment protocols. This approach can significantly affect the long-term outcomes and survival rates.[8,23]

It is crucial to acknowledge that the interaction between consciousness, EEG alterations, and prognosis can differ markedly, depending on the type of stroke. While ischemic strokes display specific patterns, intracerebral hemorrhagic stroke may demonstrate distinct EEG changes due to the involvement of different brain structures. This differentiation is critical because of the various clinical characteristics of patients with ICH, emphasizing that certain demographic and clinical factors can significantly affect the clinical outcomes.

CONCLUSION AND RECOMMENDATIONS

This study concluded that there was a significant relationship between the level of consciousness and EEG findings and the outcome of patients with hemorrhagic stroke. The interrelated concepts of hemorrhagic stroke, level of consciousness, and the role of EEG in assessing neurological function represent a multifaceted area of study. By integrating critical EEG data with clinical evaluations of the level of consciousness, clinicians can improve prognosis, tailor rehabilitation efforts, and improve the overall clinical outcomes in patients with hemorrhagic stroke.

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