

# The Role of Quantitative Electroencephalography in Neurocritical Care: A Cross Sectional Study

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## ABSTRACT

**Background:** Neurocritical patients often present with complex neurological conditions requiring continuous monitoring and rapid intervention to prevent secondary brain injury. Clinical and Imaging assessments might fail to detect evolving cerebral dysfunction in real time. Quantitative EEG (QEEG) offers transformative approach by providing objective, real time metrics for cerebral monitoring to identify subclinical seizures and predicting patients outcomes.[1] **Methods:** A Cross-sectional design including 30 patients with Encephalopathy who met the inclusion criteria such as Post ROSC, Meningoencephalitis, Non-Hemorrhagic Stroke and Uremic Encephalopathy. **Results:** Descriptive analysis revealed that 70% of the total samples showed a decrement in Beta Absolute Power. In The Group Post ROSC 25% of total samples showed Burst suppression. Hypocoherence Pattern were found in the Group Post ROSC and Meningoencephalitis 75% and 80% respectively. Asymmetry Amplitude was found in all Non-Hemorrhagic Stroke group. **Discussion:** This study demonstrates pattern of QEEG in Critical Care Unit patients with Encephalopathy. Low Beta absolute power may indicate cortical dysfunction in patients with altered mental status regardless of the etiology.[2] As Diffuse injury existed, it induced neural disruptions that may be found in hypocoherence pattern of QEEG that may lead to cognitive impairment in the future. [3] Burst suppression in the background pattern was associated with poor outcome, in this research it was found in Post ROSC group. [4] The asymmetry amplitude could indicate lateralization as most of these patterns found in Non-Hemorrhagic Stroke.[5].

**Keywords:** Quantitative Electroencephalography, Post ROSC, Encephalopathy, Neurocritical.

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## INTRODUCTION

Quantitative EEG uses mathematical principles and computational techniques to graphically display information derived from raw EEG. These graphical displays are often referred to as "trends" and the use of qEEG is usually called "trending." Trend qEEG can be incorporated into a vendor's own EEG review software or displayed using a separate qEEG software package.

Using qEEG trends together with raw EEG review conveys several advantages. First, by compressing the timescale, it is possible to visualize extended periods of EEG data on a single screen. Typically, one "screen" of raw EEG contains 10-15 seconds of information, whereas one screen of qEEG data can cover hours, or even days, of recording. This time-compressed view is useful when quickly screening for seizures as well as when evaluating background features (e.g., state change/variability, symmetry, and amplitude, among others). Secondly, a variety of different qEEG trends can be displayed simultaneously as a "panel", which allows concurrent visualization of various aspects of the EEG tracing (Figure 9.1), and the choice of trends that make up the panel can be tailored to the clinical problem. Finally,

trends can be displayed at the bedside and can be interpreted by non-neurophysiologists after brief training.

## METHODS

The research method used was retrospective cross sectional conducted at the Intensive Care Unit (ICU) Dr. Kariadi Hospital Semarang, This study aims to look at the profile of Encephalopathy patients treated at Dr. Kariadi Hospital Semarang. The inclusion criteria were All Neurology Patient treated in ICU April 2024 - May 2024, age  $\geq 18$  years old and GCS score  $\leq 8$ . We performed onsite EEG recording to these patients. The EEG data was the baseline data before converting it into QEEG analysis.

EEG was recorded using a Nihon Kohden Neurofax EEG-1200 system (19-channel, 10-20 system, linked-ears reference, 250 Hz sampling, 0.5-70 Hz band-pass, 50 Hz notch filter), and a minimum of 20 minutes of artifact-free resting-state EEG was selected by an experienced neurophysiologist. Integrated commercial software performed QEEG spectral analysis; artifact-free epochs underwent Fourier Transform for frequency domain power analysis ( $\mu V^2$  vs Hz). Standard frequency bands were Delta

(0.1–<4 Hz), Theta (4–<8 Hz), Alpha (8–13 Hz), and Beta (>13–30 Hz). Calculated QEEG metrics were Absolute Power per band, Coherence (Hypocoherence, with alpha band focus for meningoencephalitis), Amplitude Asymmetry (RMS difference >2:1), Burst Suppression (ACNS criteria), and Power Ratios (DAR, DTABR) for Non-Hemorrhagic Stroke. EEG patterns were described as "Abnormal I (Intermittent Slowing)" or "Abnormal II (Continuous Slowing)," and data visualized via topographic maps and spectrograms .

**RESULTS**

During the sampling period from April 2024 to May 2024, a total of 30 patients with decreased consciousness meeting the inclusion criteria were enrolled in this study. The patients were distributed across four encephalopathy groups: Post ROSC (n=8), Meningoencephalitis (n=10), Non-Hemorrhagic Stroke (n=7), and Uremic Encephalopathy (n=5). The age distribution of the total cohort revealed that 12 patients (40%) were below 48 years old, while 18 patients (60%) were 48 years old or older. The median age for the entire cohort was 52 years (IQR 41-63 years). Further demographic and baseline clinical characteristics for each patient group are summarized in Table 1.

Characteristic	Post ROSC (n=8)	Meningoencephalitis (n=10)	Non-Hemorrhagic Stroke (n=7)	Uremic Encephalopathy (n=5)	Total Cohort (N=30)
Median Age (years, IQR)	5 (45-65)	47 (38-56)	60 (52-68)	58 (49-67)	2 (41-63)
Sex (Male, n (%))	5 (62.5%)	6 (60.0%)	4 (57.1%)	3 (60.0%)	8 (60.0%)
Median GCS on Admission (IQR)	6 (3-8)	9 (7-11)	8 (5-10)	10 (8-12)	8 (5-11)
Mechanical Ventilation (n (%))	7 (87.5%)	3 (30.0%)	2(28.6%)	1 (20.0%)	3 (43.3%)
In-Hospital Mortality (n (%))	3 (37.5%)	1 (10.0%)	1 (14.3%)	0 (0.0%)	5 (16.7%)

Across the entire cohort of 30 patients, a prominent QEEG abnormality was a decrement in Beta Absolute Power, which was observed in 21 out of 30 patients (70%). In the 8 patients with Post ROSC encephalopathy, a low voltage EEG picture was observed in 6 patients (75%), while continuous deceleration waves (Abnormal II) were present in 2 patients (25%). A decrease in Beta Absolute Power was

universal, found in all 8 patients (100%), and a decrease in Alpha Absolute Power was observed in 6 patients (75%). Burst suppression was identified in 2 patients (25%), one of whom had a poor outcome and died on day 10 post-ROSC. Hypocoherence patterns, predominantly in slower frequency bands, were found in 6 patients (75%).

Among the 10 patients with meningoencephalitis, intermittent deceleration (Abnormal I) was seen in 6 patients (60%), and continuous deceleration waves (Abnormal II) were present in 4 patients (40%). A decrease in Alpha Absolute Power was noted in 8 patients (80%), and a decrease in Beta Absolute Power was observed in 6 patients (60%). An increase in Theta Absolute Power was found in 8 patients (80%). Hypocoherence, particularly in the alpha band, was identified in 8 patients (80%).

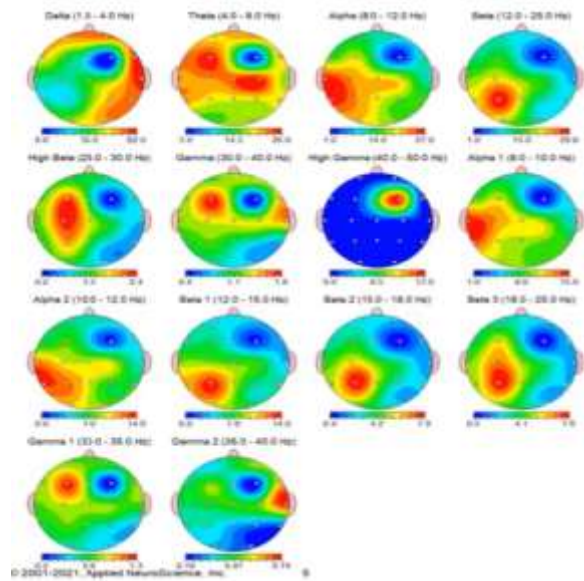
For the 7 patients with Non-Hemorrhagic Stroke, amplitude asymmetry was a consistent finding, observed in all 7 patients (100%). This typically manifested as reduced amplitude over the affected hemisphere or, conversely, increased slow-wave activity leading to apparent higher amplitude focally. A decrease in Beta Absolute Power in the affected hemisphere was observed in 5 patients (71.4%), while an increase in Delta Absolute Power in the affected hemisphere was seen in 6 patients (85.7%). The mean Delta/Alpha Ratio (DAR) in the affected hemisphere was 4.2±1.1, compared to 1.5±0.6 in the unaffected hemisphere. The mean Delta-Theta/Alpha-Beta Ratio (DTABR) in the affected hemisphere was 3.8±0.9, compared to 1.3±0.5 in the unaffected hemisphere.

In the 5 patients with uremic encephalopathy, intermittent deceleration (Abnormal I) was observed in 2 patients (40%), and continuous deceleration waves (Abnormal II) were seen in 2 patients (40%). A low voltage EEG picture was present in 1 patient (20%). A decrease in Beta Absolute Power was noted in 4 out of 5 patients (80%).

A summary of these key QEEG findings across the different conditions is presented in Table 2.

QEEG Parameter	Post ROSC (n=8)	Meningoencephalitis (n=10)	Non-Hemorrhagic Stroke (n=7)	Uremic Encephalopathy (n=5)
Decreased Beta Abs. Power (%)	100%	60%	71.4% (affected hemisphere)	80%
Decreased Alpha Abs. Power (%)	75%	80%	N/A (focus on asymmetry/ratios)	N/A
Increased Theta Abs. Power (%)	N/A	80%	N/A	N/A
Increased Delta Abs. Power (%)	N/A	N/A	85.7% (affected hemisphere)	N/A

<b>Burst Suppression (%)</b>	25%	0%	0%	0%
<b>Hypocoherence (%)</b>	75%	80% (alpha band)	N/A	N/A
<b>Amplitude Asymmetry (%)</b>	N/A	N/A	100%	N/A
<b>Elevated DAR (affected hemi.)</b>	N/A	N/A	Yes (mean 4.2)	N/A
<b>Elevated DTABR (affected hemi.)</b>	N/A	N/A	Yes (mean 3.8)	N/A

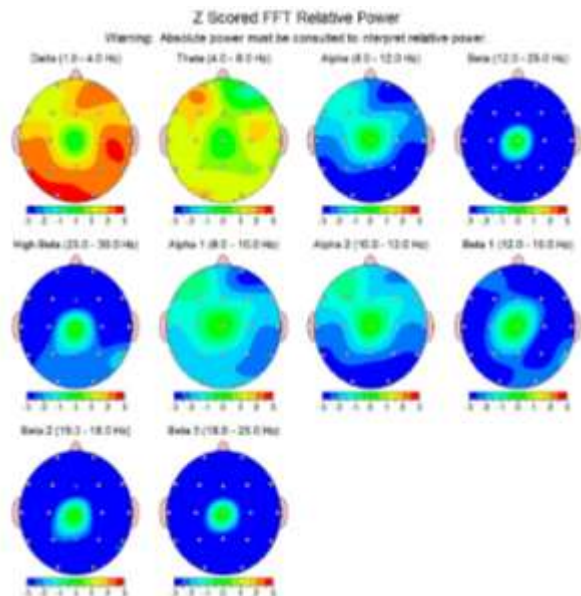


**DISCUSSION**

This study characterized QEEG patterns in encephalopathy from Post ROSC, meningoencephalitis, non-hemorrhagic stroke, and uremic encephalopathy, comparing findings with existing literature to understand pathophysiology and QEEG's clinical utility. A common finding across 70% of patients was decreased Beta Absolute Power, indicating widespread cortical dysfunction. Distinct profiles included: Post-ROSC: reduced alpha/beta power, 25% burst suppression (linked to poor outcome), and 75% hypocoherence. Meningoencephalitis: decreased alpha (80%)/beta (60%) power, increased theta power (80%), and 80% alpha-band hypocoherence. Non-hemorrhagic stroke: universal amplitude asymmetry, increased delta power, and elevated DAR/DTABR in the affected hemisphere. Uremic encephalopathy: 80% decreased beta power and generalized slowing.

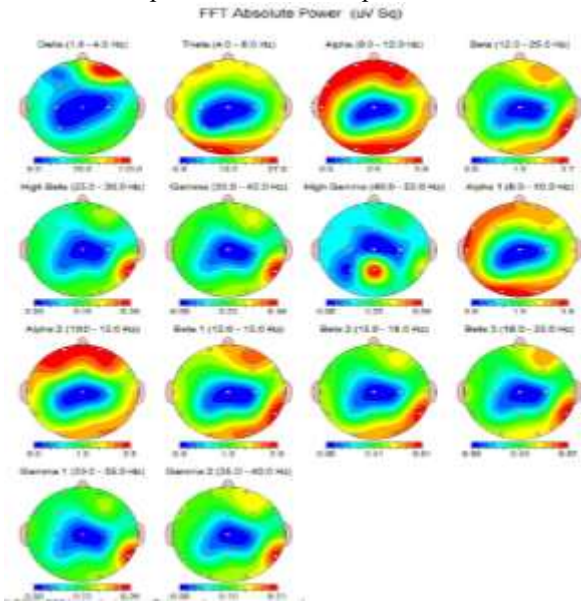
These QEEG abnormalities reflect diverse cerebral injuries. Reduced beta power, prevalent in 70% of patients, indicates diffuse cortical dysfunction or altered mental status, as beta activity is linked to cortical arousal and cognitive processing. Hypocoherence, prominent in Post ROSC and meningoencephalitis, signifies disrupted functional connectivity due to diffuse brain injury (e.g., anoxia, inflammation), potentially leading to cognitive impairment. Post-ROSC findings (decreased alpha/beta power, 25% burst suppression, 75% hypocoherence) align with severe anoxic-ischemic injury. Burst suppression, per ACNS criteria, is an ominous sign linked to high mortality, as seen in one patient. Literature confirms early burst suppression predicts poor outcomes. Tjepkema-Cloostermans et al. (2019) found RPPs from suppressed backgrounds also predicted poor outcomes, contrasting with RPPs from continuous backgrounds in patients with better recovery potential. CNV recovery time is also critical for prognosis. The observed hypocoherence further indicates widespread network disruption. These findings are concordant with literature highlighting burst suppression and RPP characteristics as key prognosticators.

Meningoencephalitis patients showed decreased alpha/beta, increased theta, and 80% alpha-band hypocoherence, indicative of diffuse cerebral dysfunction. This generalized slowing and hypocoherence are typical in encephalitis, reflecting inflammation and neuronal disruption, with slowing often correlating with severity. The absence of highly specific patterns like Extreme Delta Brush (EDB), characteristic of severe anti-NMDAR encephalitis, or prominent periodic discharges (seen in some viral encephalitides) in our cohort may reflect etiological heterogeneity or recording timing, suggesting a more diffuse inflammatory process in most cases.

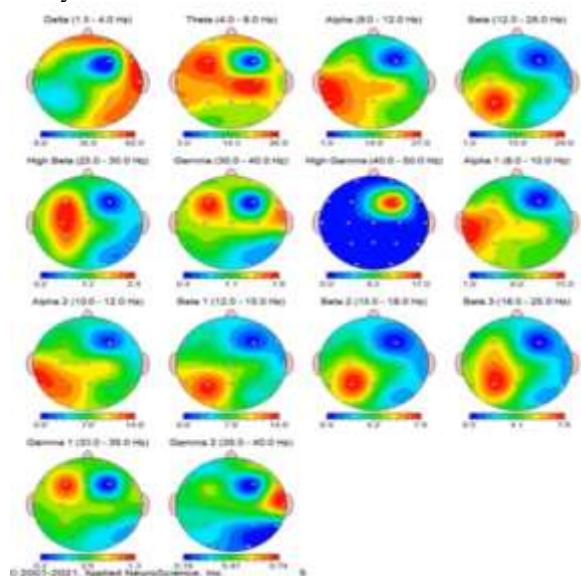


Non-hemorrhagic stroke patients universally showed amplitude asymmetry, reflecting unilateral lesions, alongside increased delta and decreased beta power in the affected hemisphere, consistent with focal slowing seen in ischemic stroke. Elevated Delta/Alpha Ratio (DAR) and Delta-Theta/Alpha-Beta Ratio (DTABR) are robust markers correlating with stroke severity and outcome, with our

cohort's mean DAR of 4.2 and DTABR of 3.8 suggesting significant ischemic burden. Higher alpha power in mild stroke indicates better function. These findings align with literature on focal slowing, asymmetry, and the prognostic value of DAR/DTABR. Furthermore, QEEG ratios like DAR/DTABR are valuable for evaluating stroke management by comparing acute phase data to post-intervention assessments, thus providing objective measures of treatment response and outcome prediction.



Uremic encephalopathy featured decreased Beta Absolute Power (80%) and generalized slowing. These findings are consistent with uremia's neurophysiological effects, where EEG typically shows loss of alpha rhythm, progressive background slowing (increased theta/delta), and sometimes triphasic waves, correlating with renal dysfunction severity. While dialysis may improve EEG abnormalities, they may not fully normalize.



This study and existing literature highlight QEEG's significant clinical implications in neurocritical care. As an objective, continuous tool, QEEG detects subtle cerebral dysfunction and subclinical seizures often missed by other

methods. It aids prognostication, with patterns like burst suppression in Post-ROSC and DAR/DTABR in stroke indicating outcomes and guiding care. QEEG also tracks therapeutic responses and can be interpreted by non-neurophysiologists, expanding continuous brain monitoring accessibility.

Study limitations include its retrospective design, small sample size with limited subgroup power, and single-center nature. The absence of a control group and formal z-scoring against normative databases impacts the precision of abnormality definitions. Analysis was confined to basic QEEG parameters, not exploring more advanced techniques. Inherent heterogeneity within diagnostic groups also warrants consideration.

Future research should involve larger, prospective, multicenter studies with standardized protocols to validate these QEEG patterns and correlate them with clinical outcomes. Investigating advanced QEEG measures (e.g., network analysis, machine learning), assessing long-term neurocognitive outcomes, standardizing QEEG interpretation, and exploring pediatric applications are also crucial.

**CONCLUSION**

QEEG is a valuable adjunct to conventional EEG and neuroimaging in the neurocritical care setting. It enables continuous, objective brain monitoring, facilitates early intervention, and supports outcome prediction. Broader adoption of QEEG, including by non-neurophysiologists, may improve care for critically ill neurological patients. Future multicenter studies and integration with advanced computational methods are warranted to further validate and expand QEEG's clinical utility

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