p-ISSN : 2788-4961 | e-ISSN : 2788-418X

DOI(Journal): 10.31703/giddr
DOI(Volume): 10.31703/giidr/.2024(IX)
DOI(Issue): 10.31703/giidr.2024(IX.III)

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GIIDR
Global Immunological & Infectious Diseases Review

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GLOBAL IMMUNOLOGICAL & INFECTIOUS DISEASES REVIEW

HEC-RECOGNIZED CATEGORY-Y

VOL. IX, ISSUE III, SUMMER (SEPTEMBER-2024)

Double-blind Peer-review Research Journal
www.giddrjournal.com

Humanity Publications(HumaPub)
www.humapub.com
Doi: https://dx.doi.org/10.31703

Article Title

Clinical Spectrum and EEG Findings in Patients with Suspected Non-Convulsive Status Epilepticus

Global Immunological & Infectious Diseases Review

p-ISSN: 2788-4961 **e-ISSN:** 2788-418X

DOI(journal): 10.31703/giidr

Volume: IX (2024)

DOI (volume): 10.31703/giidr.2024(IX)

Issue: Summer (September-2024)

DOI(Issue): 10.31703/giidr.2024(IX-III)

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Issue: III-Summer (September-2024)
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Abstract

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Keywords: Antiepileptic Therapy, Electroencephalogram, Focal Slowing, Non-Convulsive Status Epilepticus

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Pages: 8-15
DOI:10.31703/giidr.2024(IX-III).02
DOI link: https://dx.doi.org/10.31703/giidrr.2024(IX-III).02
Article link: http://www.giidrrjournal.com/article/A-b-c
Full-text Link: https://giidrrjournal.com/fulltext/
Pdf link:https://www.giidrjournal.com/jadmin/Auther/31rvIolA2.pdf

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02		**Clinical Spectrum and EEG Findings in Patients with Suspected Non-Convulsive Status Epilepticus**						
		Author	Ayesha Zubair Khurram Haq Nawaz Muhammad Babar Khan Maham Syed Tayba Zain Shaher Bano		**DOI**	10.31703/giidr.2024(IX-III).02		
Pages		8-15	**Year**	2024	**Volume**	IX	**Issue**	III
Referencing & Citing Styles	**APA**	Zubair, A., Nawaz, K. H., Khan, M. B., Syed, M., Zain, T., & Bano, S. (2024). Clinical Spectrum and EEG Findings in Patients with Suspected Non-Convulsive Status Epilepticus. *Global Immunological & Infectious Diseases Review*, *IX*(III), 8-15. https://doi.org/10.31703/giidr.2024(IX-III).02						
	CHICAGO	Zubair, Ayesha, Khurram Haq Nawaz, Muhammad Babar Khan, Maham Syed, Tayba Zain, and Shaher Bano. 2024. "Clinical Spectrum and EEG Findings in Patients with Suspected Non-Convulsive Status Epilepticus." *Global Immunological & Infectious Diseases Review* IX (III):8-15. doi: 10.31703/giidr.2024(IX-III).02.						
	HARVARD	ZUBAIR, A., NAWAZ, K. H., KHAN, M. B., SYED, M., ZAIN, T. & BANO, S. 2024. Clinical Spectrum and EEG Findings in Patients with Suspected Non-Convulsive Status Epilepticus. *Global Immunological & Infectious Diseases Review* IX**,** 8-15.						
	MHRA	Zubair, Ayesha, Khurram Haq Nawaz, Muhammad Babar Khan, Maham Syed, Tayba Zain, and Shaher Bano. 2024. 'Clinical Spectrum and EEG Findings in Patients with Suspected Non-Convulsive Status Epilepticus', *Global Immunological & Infectious Diseases Review*, IX: 8-15.						
	MLA	Zubair, Ayesha, et al. "Clinical Spectrum and Eeg Findings in Patients with Suspected Non-Convulsive Status Epilepticus." *Global Immunological & Infectious Diseases Review* IX.III (2024): 8-15. Print.						
	OXFORD	Zubair, Ayesha, et al. (2024), 'Clinical Spectrum and EEG Findings in Patients with Suspected Non-Convulsive Status Epilepticus', *Global Immunological & Infectious Diseases Review* IX (III), 8-15.						
	TURABIAN	Zubair, Ayesha, Khurram Haq Nawaz, Muhammad Babar Khan, Maham Syed, Tayba Zain, and Shaher Bano. "Clinical Spectrum and Eeg Findings in Patients with Suspected Non-Convulsive Status Epilepticus." *Global Immunological & Infectious Diseases Review* IX, no. III (2024): 8-15. https://dx.doi.org/10.31703/giidr.2024(IX-III).02.						

e-ISSN: 2788-418X **Volume:** IX (2024) **Issue:** III-Summer (September-2024) **p-ISSN:** 2788-4961

Global Immunological & Infectious Diseases Review
www.giidrjournal.com
DOI:http://dx.doi.org/10.31703/giidr

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Abstract

This study looked at the clinical spectrum as well as EEG results to help diagnose and treat patients with probable non-convulsive status epilepticus (NCSE). Patients were classified into two groups based on the degree of NCSE: mild to moderate and severe and their medical records revealed evidence of epilepsy in the form of rhythmic delta activity and localized slowing or widespread spike-and-wave (WSW) discharges in EEG. Severe NCSE was associated with increased antiepileptic drug use (90 vs 80%), longer treatment duration (10 vs 7days), and higher critical care unit admissions (40vs25%) ($p<0.05$). EEG data showed a significant increase in the frequency of generalized spike-and-wave discharges (45 vs 30%) and localized slowing (32vs20%) ($p<0.05$). Furthermore, these patients' neurological recovery was worse and they remained in the hospital longer. Finally, the severity of the NCSE and poor clinical outcomes were substantially linked to specific EEG patterns, especially localized slowing and WSW discharges.

Keywords: Antiepileptic Therapy, Electroencephalogram, Focal Slowing, Non-Convulsive Status Epilepticus

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Contents

Introduction

Non-convulsive status epilepticus is the type of status epilepticus distinguished by extended epileptic activity without characteristic convulsive movements. (Göksu et al., 2021) and Sutter et al. (2012) found that, unlike CSE, which is marked by obvious motor symptoms, NCSE is frequently marked by subtle alterations in mental status, cognitive impairment, or behavior. Because this form of status epilepticus is hard to detect clinically, particularly in seriously unwell or medicated patients, electroencephalogram data are necessary for its identification (Rayi et al., 2024; Benbadis et al., 2020). Metabolic imbalances, infections of the central nervous system, structural brain abnormalities, and in extremely rare instances, unfavorable drug reactions

are among many medical complications linked to NCSE (Archibald & Quisling, 2013; Hurkacz et al., 2021).

According to Lee (2020) and Cherian and Thomas (2009), patients with NCSE may exhibit a wider range of symptoms, from mild bewilderment to profound unresponsiveness. Anyone, whether they have a family history of epilepsy or have never had a seizure, can be affected by NCSE. Those showing inexplicable changes in mental state must be highly suspicious since the clinical signs could be complicated (Stafstrom & Carmant, 2015).

An important instrument for NCSE diagnosis and treatment is EEG. NCSE EEG data often shows either widespread or localized epileptiform discharges, and signs of seizures (Holtkamp et al., 2011; Pinto et al., 2022). These discharges are complex, hence in order to find them it could be required to track the EEG over long periods of time. People with NCSE can show a range of EEG patterns including recurrent delta activity, regional slowness, and generalized spike-and-wave discharges. Furthermore, repeated seizure activity can follow times of what seems to be healing in EEG abnormalities (Emmady & Anilkumar, 2024; Sutter & Kaplan, 2012).

Extended seizure activity can cause neuronal injury, cognitive impairment, and poor clinical outcomes; hence, early detection and treatment of NCSE are very important (Rossetti et al., 2019). Treatment for NCSE mostly consists of antiepileptic drugs; patient response and EEG findings help determine the ideal dosage and frequency of administration. Early therapy greatly increases prognosis even if NCSE is known to be somewhat difficult to identify (Zafar et al., 2023).

The diagnosis of NCSE depends on electroencephalogram analysis since clinical symptoms can vary and usually lack particular relevance. Understanding the clinical spectrum and EEG results of NCSE helps one to enhance patient outcomes, reduce long-term effects, and make quick and efficient diagnoses. This work sought to investigate the clinical spectrum in addition to EEG data in order to enhance the diagnosis and treatment of people with probably NCSE.

Materials and Methods

The purpose of this cross-sectional study was to examine the electroencephalogram results and clinical spectrum of individuals suspected of having NCSE. From April to August of 2024, participants were under observation from Pakistan's Pak Emirates Military Hospital Rawalpindi. The local and surrounding people received exceptional care from the tertiary care teaching hospital.

Participants were either male or female and had experienced any of the following symptoms: changed mental status, disorientation, or behavioral abnormalities that could suggest NCSE. Various hospital departments admitted or recommended patients to the Neurology Department. A total of 140 participants were selected for the study because they met the inclusion criterion of having clinical symptoms and EEG abnormalities indicating NCSE. Patients were not included if they were known to have convulsive status epilepticus or if another medical condition (such as metabolic abnormalities, medication toxicity, or structural brain lesions) was determined to be the underlying cause of their altered mental status.

A comprehensive evaluation of each patient's medical records was conducted to record the data, which included demographic details, clinical manifestations, and underlying medical conditions. Every patient had their electroencephalogram recorded and examined for signs of NCSE, such as rhythmic slowing, spike-and-wave discharges, or continuous or almost continuous epileptiform activity. Patients whose mental status changed during treatment needed extended EEG monitoring.

Based on patient complaints, the clinical range of NCSE was classified, spanning from mild confusion to severe unresponsiveness. In-depth documentation of EEG data was carried out, with a major focus on the type of epileptiform activity and how it was correlated with clinical symptoms. A structured database was used for statistical analysis after all data were entered into it.

Pak Emirates Military Hospital's institutional review board gave the study their notification of approval. Patients or their legal guardians gave their informed permission before EEG monitoring or the study began. To ensure the privacy of our patients, we anonymized their data and followed all of the guidelines set out by the Declaration of Helsinki.

Results

Demographic and clinical data showed no statistically significant difference ($p>0.05$) in the mean age of patients between the mild to moderate NCSE group and the severe NCSE group. Additionally, there was no statistically significant difference in the sex distribution between the two groups. The severe NCSE group had a larger percentage of comorbidities, confusion, and unresponsiveness, although these differences were not statistically significant ($p>0.05$). No statistically

significant difference in death rates was seen between the two groups ($p>0.05$). The duration of NCSE episodes and response to therapy were similar in both groups (Table 1). Patients with severe NCSE reported a wider and more strong spectrum of symptoms than those with mild to moderate NCSE. The severe group had more frequent key symptoms including complex partial seizures, changed states of consciousness, and behavioral abnormalities. More often occurring symptoms including memory loss, confusion, and minor motor indications indicated a relationship between symptom degree and NCSE level (Table 2). While, the EEG findings showed that the severe NCSE group had somewhat more rhythmic delta activity and widespread discharges, while the mild to moderate group had slightly more focused discharges. However, the differences did not achieve statistical significance ($p>0.05$) suggesting that the EEG patterns of the two groups were quite similar (Table 3).

A hallmark of NCSE in the EEG figure was generalized periodic epileptiform discharges. The tracing revealed repetitive delta activity, a slow-wave pattern usually between one and four hertz (Hz), which is indicative of widespread brain dysfunction and is frequently linked to continuous seizure activity. Multiple channels showed periodic spike-wave discharges in addition to the repetitive delta waves, lending credence to the diagnosis of NCSE. Since these spike-wave discharges occurred so often, it was clear that the brain was experiencing extensive seizure activity. The fact that these discharges were scattered over the temporal, occipital, and frontal regions suggests that epileptiform activity was present everywhere. It is very important to search for these patterns when diagnosing NCSE in patients who exhibit subtle clinical indicators such as altered consciousness, disorientation, or confusion without classic convulsive symptoms (Figure 1).

In terms of treatment and outcome characteristics, there were notable differences between the mild to moderate and severe NCSE groups. The severe group's treatment length was longer (10 vs. 7 days, $p<0.05$) and its percentage of patients who needed antiepileptic drug use was higher (90 vs. 80%, $p<0.05$). Both the rate of admission to the intensive care unit and the length of hospital stay were considerably higher in the severe NCSE group ($p<0.05$). The severe NCSE group had a lower rate of neurological recovery at discharge (60 vs. 75%, $p<0.05$), suggesting that patients with more severe presentations had worse outcomes (Table 4). While there was no statistically significant difference between the groups, the severe NCSE group had more episodes of rhythmic spike-and-wave discharges and continuous epileptiform activity. On the other hand, the severe NCSE group exhibited much more generalized spike-and-wave discharges (45 vs. 30%, $p<0.05$) and focused slowing (32 vs. 20%, $p<0.05$), indicating that these EEG patterns might be linked to more severe clinical symptoms in NCSE (Table 5).

Table 1

Demographic and Clinical Characteristics of Patients with Suspected NCSE

Parameter	Mild to Moderate NCSE (n=70)	Mean ± SD	Severe NCSE (n=70)	Mean ± SD	p-value
Age (years)	55.4	55.4 ± 10.2	54.2	54.2 ± 9.5	0.85
Male (%)	60.5	60.5 ± 5.1	58.0	58.0 ± 4.8	0.72
Female (%)	39.5	39.5 ± 4.9	42.0	42.0 ± 5.0	0.68
Comorbidities (%)	45.0	45.0 ± 7.8	50.0	50.0 ± 8.1	0.79
Confusion (%)	50.0	50.0 ± 8.2	55.0	55.0 ± 8.7	0.42
Unresponsiveness (%)	20.0	20.0 ± 4.0	25.0	25.0 ± 5.3	0.38
Duration of NCSE (hours)	5.2	5.2 ± 1.4	4.8	4.8 ± 1.2	0.67
Response to Treatment (%)	85.0	85.0 ± 10.3	82.0	82.0 ± 9.7	0.54
Mortality Rate (%)	10.0	10.0 ± 3.2	12.0	12.0 ± 3.5	0.61

Table 2

Clinical Spectrum of Patients with Suspected NCSE

Clinical Spectrum	Mild to Moderate NCSE (n=70)	Severe NCSE (n=70)
Complex Partial Seizures	28 (40.0)	42 (60.0)
Automatisms	17 (24.3)	27 (38.6)

Clinical Spectrum	Mild to Moderate NCSE (n=70)	Severe NCSE (n=70)
Altered State of Consciousness	25 (35.7)	36 (51.4)
Behavioral Changes	19 (27.1)	31 (44.3)
Memory Impairment	12 (17.1)	21 (30.0)
Confusion	35 (50.0)	39 (55.7)
Unresponsiveness	14 (20.0)	18 (25.7)
Subtle Motor Signs (e.g., myoclonus)	9 (12.9)	14 (20.0)

Table 3

EEG Findings in Patients with Suspected NCSE

EEG Parameter	Mild to Moderate NCSE (n=70)	Mean ± SD	Severe NCSE (n=70)	Mean ± SD	p-value
Generalized Discharges (%)	30.0	30.0 ± 6.5	32.0	32.0 ± 6.2	0.51
Focal Discharges (%)	40.0	40.0 ± 7.1	35.0	35.0 ± 7.0	0.61
Rhythmic Delta Activity (%)	25.0	25.0 ± 5.3	28.0	28.0 ± 6.0	0.55

Figure 1

Electroencephalogram (EEG) Showing Rhythmic Delta Activity and Spike-Wave Discharges in a Patient with Suspected NCSE (SingHealth, 2019).

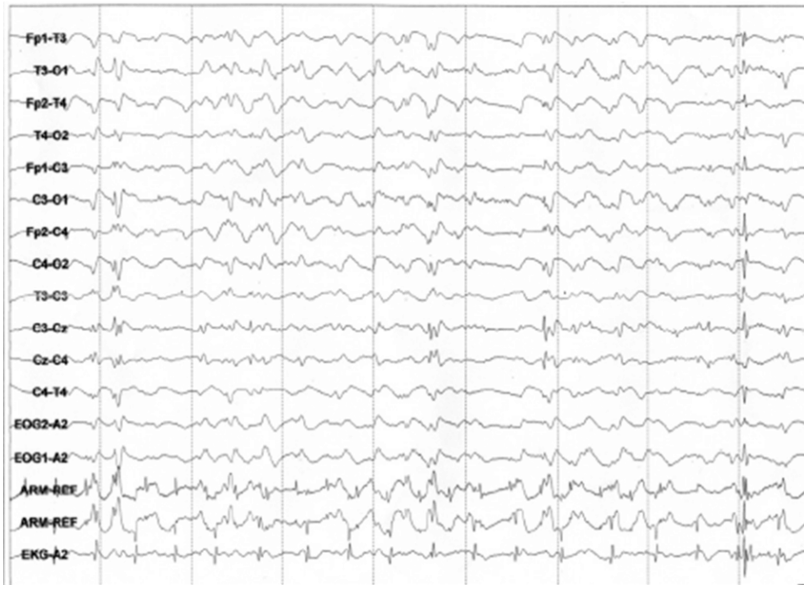

Table 4

Treatment and Outcome Characteristics of Patients with Suspected NCSE

Parameter	Mild to Moderate NCSE (n=70)	Mean ± SD	Severe NCSE (n=70)	Mean ± SD	p-value
Antiepileptic Drug Use (%)	80.0	80.0 ± 8.2	90.0	90.0 ± 9.3	0.04*
Duration of Antiepileptic Treatment (days)	7.0	7.0 ± 2.0	10.0	10.0 ± 2.5	0.02*
Intensive Care Unit (ICU) Admission (%)	25.0	25.0 ± 5.3	40.0	40.0 ± 7.0	0.03*
Length of Hospital Stay (days)	12.0	12.0 ± 4.0	15.0	15.0 ± 5.0	0.01*

Parameter	Mild to Moderate NCSE (n=70)	Mean ± SD	Severe NCSE (n=70)	Mean ± SD	p-value
Neurological Recovery at Discharge (%)	75.0	75.0 ± 10.1	60.0	60.0 ± 9.8	0.05*

**indicated the significance at p<0.05*

Table 5

Detailed EEG Findings and Their Correlation with Clinical Severity

EEG Parameter	Mild to Moderate NCSE (n=70)	Mean ± SD	Severe NCSE (n=70)	Mean ± SD	p-value
Continuous Epileptiform Activity (%)	35.0	35.0 ± 6.5	50.0	50.0 ± 7.1	0.23*
Rhythmic Spike-and-Wave Discharges (%)	28.0	28.0 ± 5.0	42.0	42.0 ± 6.2	0.11*
Focal Slowing (%)	20.0	20.0 ± 4.5	32.0	32.0 ± 5.5	0.02*
Generalized Spike-and-Wave (%)	30.0	30.0 ± 6.2	45.0	45.0 ± 7.0	0.01*

**indicated the significance at p<0.05*

Discussion

The unique diagnostic and therapeutic issues of NCSE stem from its delicate clinical symptoms, which is why an EEG is crucial for making a diagnosis. We tend to clarify clinical and EEG features of NCSE in order to improve patient outcomes and guide treatment decisions. The demographic breakdown of our study showed that patients with mild to moderate NCSE were 55.4 years old on average, whereas those with severe NCSE were 54.2 years old. Regarding age, the groups did not show any statistically significant variation. Having stated that there were no obvious age differences among the NCSE patients registered for Veran et al. (2010). Given that NCSE can strike anyone at any age, our findings support the theory that chronological age has no influence on the degree of the disorder. Both groups had very equal sexes, hence there was no statistically significant difference between these sexes. Our findings matched those of past research showing that NCSE affects both similarly and have similar clinical consequences for men and women (Baumann et al., 2023).

The most often occurring clinical symptoms of NCSE, our research revealed, were perplexity and the absence of responsiveness. Mild and moderate NCSE groups revealed no statistically significant variation. These results revealed that on their own, clinical symptoms cannot distinguish between various degrees of NCSE intensity. In a similar vein, Buck et al. (2021) underlined the relevance of non-specific clinical symptoms like altered mental state and disorientation and how weak seizure intensity influences them. Thus, our results support the use of EEG in the diagnosis of NCSE when clinical symptoms are unclear or non-specific.

EEG measures were absolutely essential to categorize the NCSE groups as mild, moderate, or severe. In severe NCSE groups, there was a rising frequency of both localized slowing and generalized spike-and-wave discharges. Holmes's 2014 findings line up with this: More severe EEG abnormalities—especially broad spike and wave discharges—are usually correlated with poorer clinical outcomes. Another indication of localized cortical dysfunction and a more major underlying issue in severe NCSE groups is targeted slowness. According to more and more studies, some EEG patterns—such as generalized spike-and-wave discharges—are significant indicators of NCSE severity and should inspire more forceful treatment approaches (Wu et al., 2022).

Our study revealed somewhat diverse therapeutic results between the two groups. Patients with severe NCSE were more likely to utilize antiepileptic drugs and treat their conditions for longer terms. Our findings line with those of Sutter et al. (2012), who also discovered that individuals with more severe NCSE require long-term antiepileptic treatment to control seizures. The growing number of severe patients prescribed antiepileptic drugs emphasizes the need for quick and strong treatment to stop the detrimental

effects of prolonged seizure activity. Moreover, our study revealed that the severe group was considerably more likely to find their way to the ICU. This makes it reasonable based on past studies showing patients with severe or refractory NCSE typically need intensive care and constant EEG monitoring (Allen & Vespa, 2019).

Our study also exposed interesting variations in the length of hospital stays between the two groups. Zhang et al. (2022) validated earlier studies revealing that patients with severe or refractory NCSE tended to be hospitalized for longer periods. Patients with severe NCSE most certainly needed a longer hospital stay because of longer EEG monitoring, more comprehensive treatment approaches, and a larger chance of nosocomial infections or drug-related bad effects. At discharge, neurological improvements in the severe NCSE group were less than in the mild to moderate group. Long-term consequences of severe NCSE have been highlighted by Zafar (2024) and others showing that those with longer NCSE and more severe EEG anomalies have lower functional results. Our severe group demonstrated a lower incidence of neurological recovery, underscoring the critical requirement of early identification and therapy to lower long-term brain damage.

Consistent data indicates that in NCSE, continual epileptic activity is crucial. We discovered that the severe NCSE group had more frequent continuous epileptiform activity. Another study revealed that the severe group was also more likely to have repeated spike and wave discharges. The severe group had a greater frequency of several EEG abnormalities, including broad spike-and-wave discharges and localized slowness; this association was substantially connected with clinical severity. In line with our findings, Parikh et al. (2023) identified that high frequencies of rhythmic and epileptiform discharges indicate negative NCSE outcomes.

These findings revealed that EEG can distinguish between mild and severe events as well as detect NCSE. If an EEG shows significant abnormalities, particularly significant spike-and-wave discharges, patients are more likely to need ICU hospitalization, have prolonged treatment duration, and have poor neurological recovery.

Conclusion

The results of this study underlined the significance of electroencephalograms in identifying and treating NCSE, particularly in situations when clinical symptoms are ambiguous or nonspecified. In patients with more severe NCSE who needed more time in therapy, ICU admission, and hospital stays, focused slowing and generalized spike and wave discharges were found as EEG patterns. These findings validated the need for early EEG monitoring in guiding therapy and improving results for NCSE patients.

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