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Original Article

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Clinico-Radiological Correlation Using Transcranial Ultrasonography (USG) In Term Asphyxiated Neonates

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ABSTRACT

Background: Perinatal asphyxia is a significant cause of neonatal morbidity and mortality, particularly in low-resource settings. Hypoxic-ischemic encephalopathy (HIE) resulting from asphyxia may lead to long-term neurological disabilities. Early and accurate assessment of brain injury is essential for timely intervention and prognosis. Transcranial ultrasonography (USG) is a bedside, non-invasive imaging modality that can provide valuable information about the extent of cerebral involvement.

Methods: This hospital-based prospective observational study was conducted in the Department of Pediatrics, SCB Medical College & SVPPGIP, Cuttack, from August 2023 to August 2024. Fifty term neonates diagnosed with HIE were included. Clinical staging was performed using the Sarnat and Sarnat classification. Transcranial USG was carried out through the anterior fontanelle to assess cerebral edema, echogenicity changes, hemorrhage, cystic changes, and ventricular abnormalities. Data were analyzed to determine the correlation between clinical severity and USG findings.

Results: Among 50 neonates, 44% were clinically categorized as Stage I, 34% as Stage II, and 22% as Stage III. Transcranial USG showed abnormalities in 72% of cases, with cerebral edema and cystic changes being the most common findings. A statistically significant correlation was observed between clinical HIE stage and USG staging ($p<0.001$), indicating increasing radiological severity with higher clinical stage.

Conclusion: Transcranial USG demonstrates a strong correlation with clinical severity of HIE and serves as a useful, accessible bedside tool for early assessment and prognostication in term asphyxiated neonates.

Key-words: Perinatal Asphyxia, Term neonate, Hypoxic-ischemic encephalopathy, Transcranial Ultrasonography, Sarnat and Sarnat classification

INTRODUCTION

One of the leading causes of infant illness and mortality, especially in underdeveloped nations, is still perinatal hypoxia. The disruption of gas exchange prior to, during, or following delivery causes hypoxaemia and acidosis, making it a critical condition.

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Nearly 1-2 per 1,000 live births are affected by perinatal asphyxia in high-resource settings; in low-resource settings, the prevalence is higher because of insufficient prenatal care and delivery facilities. This disorder is closely associated with hypoxic-ischemic encephalopathy (HIE), a significant cause of long-term neurodevelopmental impairments, including epilepsy, cerebral palsy, and cognitive impairment.

Initiating therapeutic procedures and forecasting results depend on early diagnosis and grading of HIE. Despite being essential, clinical examination may be arbitrary and inadequate in offering thorough details about the severity of brain damage. Given this, neuroimaging has become a vital tool for evaluating brain damage in asphyxiated term newborns. Transcranial ultrasonography (USG) is unique

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among the existing modalities since it is non-invasive, portable, affordable, and can be done at the patient's bedside [1–3].

Transcranial USG enables visualization of the neonatal brain through the open fontanelles, providing real-time imaging of intracranial structures. It has been widely used to detect abnormalities such as intraventricular hemorrhage, periventricular leukomalacia, and cerebral edema [4–6]. When correlated with clinical findings, transcranial USG can serve as a valuable tool to predict the extent of brain damage and the prognosis of affected infants [4–7].

This study aims to evaluate the clinico-radiological correlation in terms of asphyxiated infants using transcranial USG of the brain. By correlating clinical features and imaging findings, this research intends to contribute to the understanding of the pathophysiological mechanisms of perinatal asphyxia and aid in the development of effective diagnostic and prognostic strategies. Early identification of brain injury through such integrated approaches may pave the way for timely interventions, improving outcomes and reducing the burden of long-term neurodevelopmental disabilities.

MATERIALS AND METHODS

Study Design and Setting- This was a hospital-based prospective observational study conducted in the Department of Pediatrics, SVPPGIP, and SCB Medical College, Cuttack, Odisha, from August 2023 to August 2024.

Study Population- Term neonates diagnosed with hypoxic-ischemic encephalopathy (HIE) admitted to the neonatal intensive care unit during the study period were included.

Inclusion Criteria

- Term neonates (gestational age ≥ 37 weeks).
- Diagnosed cases of HIE Stage II and Stage III according to Sarnat and Sarnat classification.

Exclusion Criteria

- Preterm neonates (gestational age<37 weeks).
- Neonates with metabolic disorders (e.g., hypoglycemia, inborn errors of metabolism).
- Neonates with hyperbilirubinemia leading to kernicterus.
- Neonates with congenital or structural CNS anomalies.
- Cases in which parental consent was not provided.

Sample Size- A total of 50 term neonates fulfilling the inclusion criteria were enrolled.

Clinical Assessment- Clinical staging of HIE was performed using Sarnat and Sarnat criteria, based on level of consciousness, tone, reflexes, seizures, and autonomic function.

Ultrasonography Technique- Transcranial ultra-sonography was performed using a high-frequency (5–7.5 MHz) sector probe through the anterior fontanelle. Brain structures were assessed for edema, ventricular changes, echogenicity, cystic lesions, and hemorrhage. USG HIE staging was documented.

Statistical Analysis- Demographic, clinical, and imaging data were entered in Microsoft Excel and analyzed using SPSS software. Chi-square test was applied, and $p<0.05$ was considered statistically significant.

RESULTS

The study included a total of 50 term neonates diagnosed with neonatal asphyxia. The mean age of the participants at the time of assessment was 3.28 days with a standard deviation of 1.85 days, and the age ranged from 0 to 6 days. In terms of gender distribution, 33 (66.0%) of the neonates were female, while 17 (34.0%) were male (Table 1).

Table 1: Socio-demographic profile of the study participants

Characteristics	Overall (N=50)
Age (Days)	
Mean (SD)	3.28 (1.85)
Range	0.00 - 6.00
Gender	
Female	33 (66.0%)
Male	17 (34.0%)

Fig. 1 illustrates the sex distribution among the term asphyxiated neonates included in the study. Out of a total of 50 neonates, 33 (66%) were female and 17 (34%) were male, indicating a female predominance in the study population.

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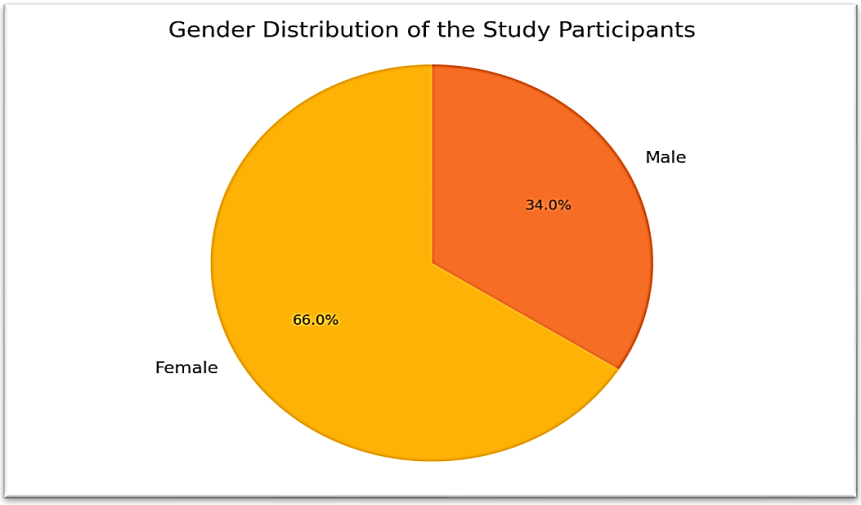

Fig. 1: Sex distribution of the study participants

The mean birth weight of the neonates was 3.06 kg with a standard deviation of 0.49 kg, and the birth weight ranged from 1.98 kg to 4.33 kg. The mean gestational age was 38.66 weeks with a standard deviation of 1.47 weeks, ranging from 37 to 41 weeks. The mean Apgar score at 1 minute was 4.22 ± 2.91, with scores ranging from 0 to 9. At 5 minutes, the mean Apgar score was slightly lower at 3.88 ± 2.63, with a range of 0 to 8 (Table 2).

Table 2: Perinatal characteristics of the study participants

Characteristics	**Overall (N=50)**
Birth Weight (kg)	
Mean (SD)	3.06 (0.49)
Range	1.98 - 4.33
Gestational Age (Days)	
Mean (SD)	38.66 (1.47)
Range	37.00 - 41.00
APGAR Score (1 min)	
Mean (SD)	4.22 (2.91)
Range	0.00 - 9.00
APGAR Score (5 min)	
Mean (SD)	3.88 (2.63)
Range	0.00 - 8.00

Among the 50 asphyxiated term neonates included in the study, clinical staging based on the Sarnat classification revealed that 22 (44.0%) were classified as Stage I, 17 (34.0%) as Stage II, and 11 (22.0%) as Stage III. Seizures were observed in 17 (34.0%) of the neonates, while the remaining 33 (66.0%) did not have any seizures. Regarding muscle tone, 15 (30.0%) of the infants exhibited hypertonia, 16 (32.0%) showed hypotonia, and 19 (38.0%) had normal tone. Feeding difficulty was reported in 17 (34.0%) of the neonates, while 33 (66.0%) had no issues with feeding (Table 3).

Table 3: Clinical profile of the asphyxiated term infants

Characteristics	Overall (N=50)
HIE Clinical Staging	
Stage I	22 (44.0%)
Stage II	17 (34.0%)

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Stage III	11 (22.0%)
Seizure	
No	33 (66.0%)
Yes	17 (34.0%)
Tone Abnormality	
Hypertonia	
Hypotonia	16 (32.0%)
Normal	19 (38.0%)
Feeding Difficulty	
No	33 (66.0%)
Yes	17 (34.0%)

Fig. 2 shows the distribution of the study participants according to the Sarnat and Sarnat clinical staging of hypoxic-ischemic encephalopathy (HIE). Out of 50 neonates, 22 (44%) were classified as Stage I, 17 (34%) as Stage II, and 11 (22%) as Stage III, indicating that the majority presented with mild to moderate encephalopathy.

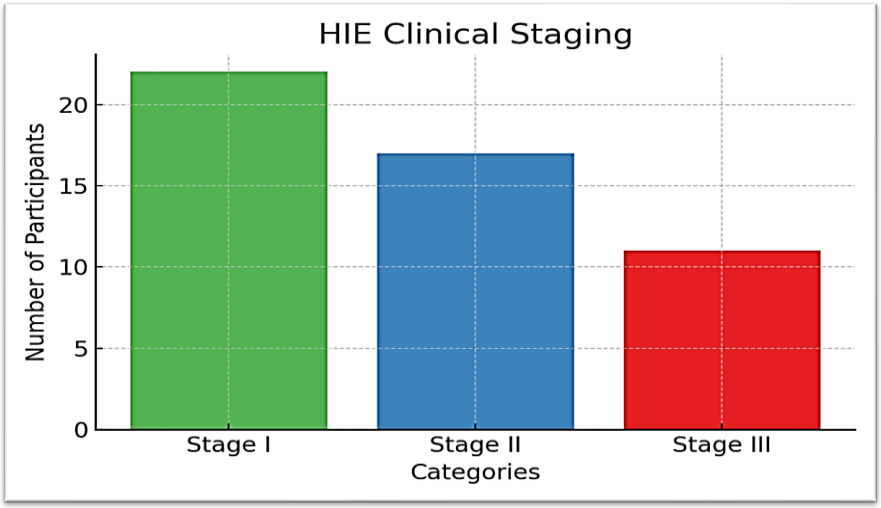

Fig. 2: HIE staging among the study participants

Fig. 3 represents the proportion of neonates who developed seizures during the course of clinical assessment. Seizures were present in 17 (34%) neonates, whereas 33 (66%) did not exhibit seizure activity, reflecting that seizure occurrence increased with higher severity of HIE.

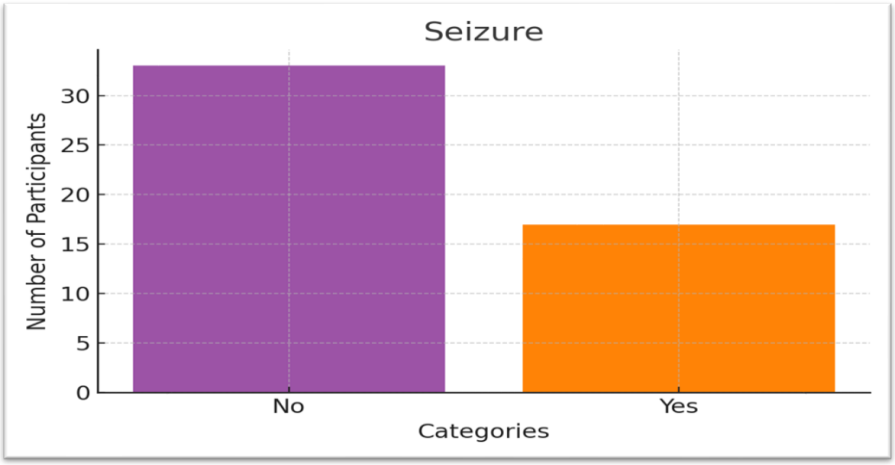

Fig. 3: Prevalence of seizure among the study participants

Fig. 4 depicts muscle tone findings in the neonates included in the study. Hypertonia was observed in 15 (30%) neonates, hypotonia in 16 (32%), while 19 (38%) had normal tone. Tone abnormalities were more frequently associated with increasing HIE severity.

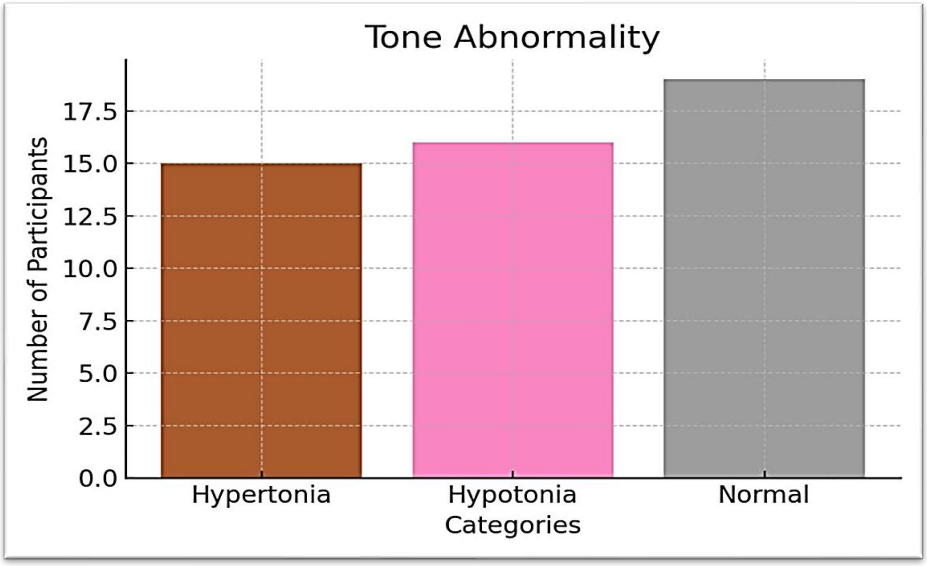

Fig. 4: Tone abnormality among the study participants

Transcranial ultrasonography revealed a range of findings among the 50 asphyxiated term neonates. Fourteen neonates (28.0%) had normal USG scans. Cerebral edema was observed in 10 cases (20.0%), while cystic changes were noted in 8 infants (16.0%). Hyperintensities were seen in 3 neonates (6.0%), and hyperintensities localized to the deep white matter were found in 5 cases (10.0%). Increased echogenicity was present in 4 neonates (8.0%), and intracerebral hemorrhage was detected in another 4 cases (8.0%). Ventriculomegaly was observed in 2 neonates (4.0%) (Table 4).

Table 4: Transcranial USG findings of the study participants

Characteristics	Overall (N=50)
Transcranial USG findings	
Normal	14 (28.0%)
Cerebral oedema	10 (20.0%)
Cystic Changes	8 (16.0%)
Hyperintensities	3 (6.0%)
Hyperintensities in deep white matter	5 (10.0%)
Increased Echogenicity	4 (8.0%)
Intracerebral hemorrhage	4 (8.0%)
Ventriculomegaly	2 (4.0%)
HIE USG Staging	
Stage I	17 (34.0%)
Stage II	21 (42.0%)
Stage III	12 (24.0%)

A statistically significant association was observed between clinical staging and transcranial USG staging of hypoxic-ischemic encephalopathy (HIE) among the study participants ($p<0.001$). Among the 22 neonates clinically staged as HIE Stage I, 12 (54.5%) had Stage I changes on USG, 6 (27.3%) had Stage II changes, and 4 (18.2%) showed findings consistent with Stage III. Of the 17 neonates clinically staged as HIE Stage II, the majority—13 (76.5%)—demonstrated Stage II findings on USG, while 4 (23.5%) had Stage I findings and none had Stage III changes (Table 5).

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Table 5: Correlation between clinical hie stage and usg findings

	Clinical HIE Staging			P-value
Staging	StageI(N=22)	StageII(N=17)	StageIII(N=11)	
USG HIE Staging				<0.001
Stage I	12 (54.5%)	4 (23.5%)	1 (9.1%)	
Stage II	6 (27.3%)	13 (76.5%)	2 (18.2%)	
Stage III	4 (18.2%)	0 (0.0%)	8 (72.7%)	

DISCUSSION

The present study assessed the clinico-radiological correlation between the severity of hypoxic-ischemic encephalopathy (HIE) and transcranial ultrasonography (USG) findings in term asphyxiated neonates. HIE continues to be a major contributor to neonatal morbidity and mortality worldwide, and early identification of neurological injury plays a crucial role in prognosis and clinical management [8].

In the present study, the mean birth weight was 3.06 kg and the mean gestational age was 38.66 weeks, which is comparable to previous studies reporting similar demographic profiles among neonates with HIE [9]. The mean Apgar scores at 1 and 5 minutes were significantly low, indicating severe perinatal compromise. Low Apgar scores have consistently been associated with increased risk of neurological injury and adverse outcomes in term neonates [10].

Clinically, 44% of neonates were categorized as HIE Stage I, 34% as Stage II, and 22% as Stage III. Seizures were seen in 34% of neonates, and tone abnormalities in 62%. Increasing severity of seizures and tone abnormalities with higher HIE stage reflects progressive neurological insult, consistent with earlier reports [11].

Transcranial USG revealed abnormalities in 72% of neonates, including cerebral edema, cystic changes, increased echogenicity, and intracranial hemorrhage. A statistically significant correlation was observed between clinical stage and USG-based staging ($p<0.001$), indicating that the severity of clinical encephalopathy closely corresponds with radiological involvement [12]. These findings highlight transcranial USG as a reliable early imaging modality for assessing brain injury in HIE.

Although MRI remains the gold standard for neuroimaging in HIE, its limited availability and feasibility in critically ill neonates restrict routine use, especially in resource-limited settings. Transcranial USG provides a practical alternative due to its bedside applicability, repeatability, and cost-effectiveness [13]. The findings suggest that integrating transcranial USG into routine neonatal assessment can improve early detection, guide clinical decision-making, and support parental counseling. Early recognition of moderate to severe USG abnormalities may help prioritize neuroprotective strategies and long-term neurodevelopmental follow-up [14].

CONCLUSIONS

This study demonstrated a strong and statistically significant correlation between clinical staging and transcranial ultrasonography (USG) findings in asphyxiated term neonates. Higher clinical stages of hypoxic-ischemic encephalopathy (HIE) were associated with more severe abnormalities on USG and poorer short-term neurodevelopmental outcomes, including delayed milestones, hypertonia, and seizures. Our findings highlight transcranial USG as a reliable, non-invasive bedside tool that complements clinical evaluation in the early diagnosis and prognostication of HIE. In settings where MRI is not readily available, cranial USG offers a practical and effective alternative for risk stratification and early intervention planning. Routine integration of clinical staging and cranial USG in the management of asphyxiated neonates can improve early identification of high-risk infants and guide neurodevelopmental follow-up strategies. Larger, longitudinal studies are warranted to further validate these findings and assess long-term outcomes.

CONTRIBUTION OF AUTHORS

Research concept- Dr. Laxminarayan Naik
Research design- Dr. Debi Prasad Jena, Dr. Pravakar Mishra
Supervision- Dr. Laxminarayan Naik
Materials- Dr. Debi Prasad Jena
Data collection- Dr. Pravakar Mishra
Data analysis and interpretation- Dr. Debi Prasad Jena,

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Literature search- Dr. Pravakar Mishra
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Critical review- Dr. Laxminarayan Naik
Article editing- Dr. Laxminarayan Naik
Final approval- Dr. Laxminarayan Naik

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