

POSITIVE PREDICTIVE VALUE OF TRANSCRANIAL ULTRASOUND IN EVALUATION OF HYPOXIC-ISCHEMIC ENCEPHALOPATHY KEEPING MRI AS A GOLD STANDARD

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Abstract: *The retrospective study was conducted in the Department of Radiology, Combined Military Hospital, from January 2023 to June 2023 to compare the diagnostic accuracy of TUCS and MRI to assess HIE and evaluate the pros and cons of both imaging modalities. A total of 50 neonates were included in the study. All patients underwent physical examination, and detailed history was recorded. MRI and TCUS were performed on all patients. Results showed that 33 of 50 patients were diffusion restricted. Thirty-two cases were TCUS positive, and 18 were TCUS negative. Correlated to DWI, its sensitivity was 88.3%, specificity 100%, positive predictive value (PPV) 100%, negative predictive value (NPV) 79%, and diagnostic accuracy 91.7%. Among 48 MRS-positive patients, 41 were TCUS-positive, and 9 were negative. Correlated to MRS, its sensitivity was 89.5%, specificity 100%, PPV 100%, NPV 28.7%, and diagnostic accuracy 90%. TCUS is a simple imaging modality with good sensitivity for periventricular leukomalacia and hemorrhage. However, it is less sensitive and detection of lesions of the brainstem and cerebral convexity. MRI has higher specificity and sensitivity for detecting injury caused by HIE. It provides soft tissue contrast and information about the site and extent of injury.*

Keywords: Hypoxic Ischemic Encephalopathy, Transcranial Ultrasound, Magnetic Resonance Imaging

Introduction

Hypoxic ischemic encephalopathy (HIE) is a common cause of encephalopathy in newborn infants (Parmentier et al., 2022). It is characterized by acidosis, hypotonia, seizure, multi-organ dysfunction, and coma. It has a mortality rate of 20% to 50%. Among those who survive, have a 25% incidence of permanent brain damage, including seizures, mental retardation, and cerebral palsy (Venkatakrishna et al., 2023). Early diagnosis of cerebral injury is important in intervention and disease prognosis. Infant survival can be increased, and morbidity can be reduced if therapeutic hypothermia is given within 6 h of neonatal asphyxia (Aker et al., 2020; Liu et al., 2020). The essential aim of neuroimaging is to provide information about the pattern, site, extent, severity, and time of injury and the neurological outcomes of it (Hagan et al., 2023). Ultrasound is the preferred imaging modality for neonates as its pain-free, non-ionizing, and widely available. Transcranial ultrasound (TCUS) is a simple technique and is sensitive to hydrocephalus, hemorrhage, and periventricular leukomalacia (PVL) (Gotardo et al., 2019). Evaluation of resistive index (RI) and Doppler interrogation provides valuable information regarding cerebral perfusion. Nevertheless, TCUS is not quite

accurate for detecting structural abnormalities in the brainstem and cortex and is also non-specific about parenchymal abnormalities like cerebral edema and PVL (Benninger et al., 2021).

Magnetic resonance imaging (MRI) has the highest sensitivity and specificity for evaluating HIE. It can provide information about site, extent, and soft tissue differentiation. MR spectroscopy (MRS) and diffusion-weighted MR imaging (DWI) provide further information that is helpful for therapeutic intervention (Liu et al., 2019). However, MRI is unsuitable for screening and cannot be used for hemodynamically unstable infants as it is time-consuming and requires sedation. This aims to compare the diagnostic accuracy of TUCS and MRI to assess HIE and evaluate the pros and cons of both imaging modalities.

Methodology

The retrospective study was conducted in the Department of Radiology, Combined Military Hospital, from January 2023 to June 2023. The study included neonates diagnosed with neonatal encephalopathy, suspected cases of perinatal cerebral injury, neonates with neurological abnormalities 48

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hours post-birth, and those with fetal distress. Hemodynamically unstable cases in whom MRI was contraindicated were excluded. A total of 50 neonates were included in the study. Informed consent of the parents was taken. The ethical board of the hospital approved the study.

All patients underwent physical examination, and detailed history was recorded. MRI and TCUS were performed on all patients. TCUS was performed in a warm environment. Images of mastoid fontanelle, temporosquamous fontanelle, anterior fontanelle (AF) and posterior fontanelle (PF). MRI scan was done in sagittal, coronal, and axial planes. 3D Spoiled Gradient Recalled (SPGR), apparent diffusion coefficient mapping (ADC Map), diffusion-weighted imaging (DWI), susceptibility-weighted imaging (SWI), Post Gadolinium T1WI, Proton density (PD), Fluid attenuation inversion recovery (FLAIR), T1WI and T2WI sequences were used. Babies were wrapped in a warm cloth and placed in the supine position. Intravenous Propofol (bolus dose 2 to 5mg/kg) was used for sedation. Atropine (0.02 mg/kg) was used to prevent oropharyngeal secretion. SPSS version 23.0 was used for data analysis. Fisher Exact test and Chi-square test were done. MedCalc's evaluation calculator was used for evaluating sensitivity and specificity.

Results

Of 50 HIE patients, 19 (38%) were pre-term, and 31 (62%) were term. There were 16 (32%) female and 34 (68%) male cases. 87% of term and 10.5% pre-term had injury of the basal ganglia thalamus (central pattern). Injury of the cortex and subcortical white matter (peripheral pattern) was more frequent in preterm (58%). Germinal matrix hemorrhage (GMH) was also more frequent in pre-term (74.1%) compared to term infants (Table I). Of 50 patients, MRI identified the involvement of the thalamus in 46%, basal ganglia in 40%, cortex in 20%, brainstem in 18%, water shed zone in 8%, subcortical white matter in 28%, periventricular leukomalacia (PVL) in 10%, mixed pattern in 6% and GMH in 8% cases.

On the other hand, TCUS identified the involvement of the thalamus in 38%, basal ganglia in 30%, subcortical white matter in 22%, cortex in 16%, PVL in 6%, GMH in 6% and watershed zone in 4% cases (Table II).

33 of 50 patents were diffusion restricted. Thirty-two cases were TCUS positive, and 18 were TCUS negative. Correlated to DWI, its sensitivity was 88.3%, specificity 100%, positive predictive value (PPV) 100%, negative predictive value (NPV) 79%, and diagnostic accuracy 91.7%. Among 48 MRS-positive patients, 41 were TCUS-positive, and 9 were negative. Correlated to MRS, its sensitivity was 89.5%, specificity 100%, PPV 100%, NPV 28.7%, and diagnostic accuracy 90%.

Table I Pattern of injury in pre-term vs. term infants

Pattern	Preterm	Term
Central	2 (10.5%)	27 (87%)
Peripheral	11 (58%)	7 (22.5%)
GMH	14 (74.1%)	12 (38.7%)
PVL	6 (31.5%)	13 (42%)
Mixed pattern	7 (36.8%)	21 (68%)

Table II Comparative analysis of TCUS and MRI findings

	TCUS		MRI	
	Positive	Negative	Positive	Negative
Basal ganglia	15	35	20	30
Thalamus	19	31	23	27
Brainstem	2	48	9	41
Cortex	8	42	10	40
Subcortical white matter	11	39	14	36
Watershed zone	2	48	4	46
GMH	3	47	4	46
PVL	3	47	5	45
Mixed pattern	2	48	3	47

Discussion

In this study, we evaluated TCUS and MRI's diagnostic value for HIE assessment. Of 50 cases, 38% were pre-term, and 62% were term. A previous

study on HIE patients reported that 65.7% were term and 34.3% were pre-term (Genedi et al., 2016). Another similar study reported that 61.5% of cases were term and 38.7% were pre-term. The current study's findings align with these studies, which shows

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that HIE is more common in term than pre-term. The current study had 16 (32%) female and 34 (68%) male cases. A previous study conducted on HIE reported 62.5% males and 34.8% females in their sample (Misser et al., 2020). Another similar study reported 63.5% males and 36.8% females (Eliel Ben-David and Zharkov, 2020). According to the current study's findings, these results suggest that HIE is more prevalent in males than females. In the current study, 46% of cases had a central injury pattern, 28% had a peripheral pattern, 10% had white matter injury, and 8% had GMH injury. A previous study reported a 42.6% incidence of central injury, 10.6% white matter injury, and 5.1% GMH injury (Genedi et al., 2016); these findings are consistent with the results of the current study.

The current study's findings show that 87% of the term and 10.5% of pre-term had injury of the basal ganglia thalamus. Injury of the cortex and subcortical white matter was more frequent in preterm (58%). Germinal matrix hemorrhage (GMH) was also more frequent in pre-term (74.1%) compared to term infants. A previous study reported that 87% of term infants had a central pattern, 43.1% had a peripheral pattern, 25% had GMH, and 41% had a mixed pattern, while in preterm, 57.2% had the peripheral pattern, 76% had GMH, and 61% had the mixed pattern (Bhagat et al., 2017). Another study reported that 51% of term infants had a central pattern, and 87.1% of preterm had periventricular leukomalacia. 7.5% of preterm infants had intracranial hemorrhage (Jose and Sheena, 2017). A study reported that central injury was predominant in term while the peripheral pattern was in pre-term infants (Bersani et al., 2021). Thus, the current study's results align with the previous studies.

In the current study, correlated to MRI, the sensitivity of TCUS for GMH, watershed zone, subcortical white matter lesion, cerebral cortex, brain stem, basal ganglia, and the thalamic lesion was 100%, 50%, 71%, 64%, 37%, 60%, and 87% respectively. A previous reported that the sensitivity of TCUS for subcortical white matter, cerebral cortex, cerebellar white matter, brain stem, corpus callosum, periventricular white matter, basal ganglia, and thalamic lesion was 50%, 27%, 33%, 33%, 37.6%, 81%, 81.3%, 88.3% respectively (Aun et al., 2019). These findings and the result of the current study show that TCUS has higher sensitivity for detecting central patterns of injury compared to peripheral patterns. The limitation of this study is the small sample size. A larger study is suggested for further evaluation.

Conclusion

TCUS is a simple imaging modality with good sensitivity for periventricular leukomalacia and hemorrhage. However, its less sensitive and detection

of lesions of the brainstem and cerebral convexity. MRI has higher specificity and sensitivity for detecting injury caused by HIE. It provides soft tissue contrast and information about the site and extent of injury.

Conflict of interest

The authors declared absence of conflict of interest.

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