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Original Research Article

# ROLE OF TRANSCRANIAL ULTRASOUND AND COLOR DOPPLER IN EVALUATION OF NEONATES WITH PERINATAL ASPHYXIA

**Dr. Prachi Shukla[1] (Assistant Professor), Dr. Vivek Yonati[2] (Associate Professor), Dr. Mengpi Jamoh[3] (PG resident) & Dr. Ashish Sahoo[4] (PG Resident)**

Department of Radio diagnosis, M.G.M Medical College & M.Y Hospital, Indore, Madhya Pradesh, India[1,2,3&4]

Corresponding Author: Dr. Mengpi Jamoh

**ABSTRACT**

BACKGROUND: Perinatal asphyxia is a lack of blood flow or gas exchange to or from the foetus just before, during, or after birth. Perinatal asphyxia can have serious systemic and neurologic consequences like cerebral palsy, mental retardation, irreversible neurologic damage, and/or epilepsy. Ultrasound is a simple tool that can be used readily anytime at bedside. USG helps in identifying intracranial lesions like haemorrhages, periventricular leukomalacia, brain edema. Doppler parameters of anterior and middle cerebral artery like PSV, EDV, PI and RI helps in evaluating the cerebral blood flow velocity and vascular resistance. METHODS : This prospective observational study was done on 120 neonates referred to the Radiodiagnosis department with suspected hypoxic ischemic brain injury. Cranial ultrasound was done at <= 36 hours and at >= 72 hours along with the doppler study in all neonates. RESULT: Abnormal ultrasound findings were common in preterm neonates compared to term neonates. Germinal matrix haemorrhage and periventricular leukomalacia were the most common sonographic findings in preterm neonates and that of term neonates was cerebral edema. With increase in severity of clinical grades of HIE, there was decrease in the mean RI values of ACA and MCA. CONCLUSION: Transcranial ultrasound can be used as a valuable diagnostic tool for the management of hypoxic ischemic brain injury. Thus, by performing transcranial ultrasound and colour doppler at 36 hours, early diagnosis and intervention can be achieved. This can help reduce ominous complications and decrease morbidity and mortality.

**KEYWORDS:** Transcranial ultrasonography, Color doppler sonography, Hypoxic ischaemic encephalopathy (HIE).

## 1. INTRODUCTION

Perinatal asphyxia is a lack of blood flow or gas exchange to or from the foetus just before, during, or after birth. Due to decreased blood flow and/or oxygen to a foetus or infant during the peripartum period, perinatal asphyxia can have serious systemic and neurologic consequences (1).

One of the main causes of perinatal and early neonatal mortality in developing countries, perinatal asphyxia accounts for one-fourth of the three million neonatal deaths globally and nearly half of the 2.6 million stillbirths in the third trimester (2,3). Despite the rapid advances in neonatal intensive care unit (NICU), the mortality and incidence of adverse neurodevelopmental outcomes like Cerebral Palsy have remained unchanged because of the lack of early diagnosis.

Ultrasound is a quick and simple tool that can be used at bedside. USG can identify many intracranial lesions like intracranial hemorrhages, periventricular leukomalacia, changes in echogenicity of brain parenchyma, calcifications, ischemia, and brain abscess with the optimal technique and viewpoint. Transcranial Doppler Ultrasonography is noninvasive technique that can detect altered cerebral hemodynamics during hypoxic brain injury. Peak systolic velocity (PSV), end diastolic velocity (EDV) and Pourcelot's resistive index (RI) counts obtained from anterior and middle cerebral arteries. It allows assessment of intracranial vessels for better care of neonates with neurologic insults (4).

Therefore, present study was conducted to detect the presence of brain injury and abnormalities via transcranial ultrasound in asphyxiated neonates and to study the pattern of brain injury in preterm and term asphyxiated neonates. Also, to measure the brain perfusion with dynamic colour doppler sonography of anterior and middle cerebral arteries and to find its correlation with clinical grades of HIE.

## 2. MATERIALS AND METHODS

### Study design

A hospital based and prospective study, was conducted in the Department of Radio-diagnosis, of a tertiary care hospital in Indore, Madhya Pradesh, India after getting approval from the Institutional Scientific and Ethical Committee. The duration of the study was from March 2021 to August 2022.

Inclusion criteria was clinically diagnosed case of perinatal asphyxia with APGAR score at 1 min < 3 and at 5 minutes < 6 while exclusion criteria were neonates with major or multiple minor developmental malformations, chromosomal anomalies, congenital brain infections.

### Study protocol

All the patients were subjected to clinical examination and were classified according to the Sarnat and Sarnat grading of HIE (Table 1) into Stage 1, 2 and 3 (5).

Each neonate was examined in supine position and quiet state with convex and linear array transducer portable ultrasound system. Routine coronal and sagittal examinations were done through the anterior and posterior fontanelle. Presence of periventricular leukomalacia, germinal matrix haemorrhage/ intraventricular hemorrhage, cerebral edema, dilated ventricle, changes in ehogenicity of brain parenchyma were considered as abnormal transcranial ultrasound findings. Color doppler evaluation of anterior cerebral artery and middle cerebral artery were performed through anterior fontanelle and temporal bone respectively. PSV, EDV and RI values of both the arteries were measured. For ACA and MCA, normal range RI was taken as $0.67 \pm 0.06$ and $0.68 \pm 0.07$ resectively (6).

A review transcranial ultrasound and colour doppler were repeated at >=72 hours to study the delayed brain structural and haemodynamic abnormalities.

### Statistical analysis

Data was tabulated in Microsoft Excel Sheet and SPSS software was used to analyse the data. Mean and standard deviation of the quantitative variables were calculated.

Association among the study groups was assessed with the help of Pearson chi-Square test. P value < 0.05 was considered statistically significant.

TABLE 1: SARNAT AND SARNAT STAGES OF HIE (5)

| Assesment | Stage 1 | Stage 2 | Stage 3 |
|---|---|---|---|
| Alertness | Hyperalert | Lethargic | Stuporous |
| Suck reflex | Weak or absent | Weak or absent | Absent |
| Moro reflex | Strong | Weak | Absent |
| Muscle tone | Normal | Hypotonia | Flaccid |
| Autonomic function | Generalized sympathetic | Generalised parasympathetic | Absent |
| Pupils | Mydriasis | Miosis | Variable |
| Seizures | None | Common | Variable |
| EEG | Normal | Early- low voltage theta and delta | Early periodic pattern with isopotential phases<br>Late-isopotential |
| Duration | <24 hours | 2-14 days | Hours to weeks |

## 3. RESULTS

The study included 120 neonates with perinatal asphyxia. 71 (59.2%) patients were preterm and 49 (40.8%) patients were term. Unfortunately, 9 (8.3%) preterm neonates and 7 (54.5%) term neonates were deceased during the hospital stay. 11 cases of mild HIE were discharged. So, 27 cases were lost on follow up.
In the first scan, done at <= 36 hours, abnormal cranial ultrasound findings were found in 43 (60.6%) preterm neonates which suggest that abnormal cranial ultrasound findings were significantly (P value = 0.04*) higher in preterm neonates.

Table 2 : DISTRIBUTION OF PRETERM NEONATES ACCORDING TO TRANSCRANIAL USG FINDINGS AT <= 36 HOURS AND AT >=72 HOURS

| Transcranial ultrasound findings | At <= 36 Hours | | At >= 72 Hours | |
|---|---|---|---|---|
| | No. of patients | Percentage% | No. of patients | Percentage% |
| Germinal matrix haemorrhage (GMH) | 19 | 26.8% | 13 | 21% |
| Periventricular Leukomalacia (PVL) | 17 | 23.9% | 22 | 35.5% |
| Dilated Ventricle | 2 | 2.8% | 2 | 3.2% |
| PVL + GMH | 2 | 2.8% | 2 | 3.2% |
| GMH + Cerebral edema | 2 | 2.8% | 0 | 0% |
| GMH + Dilated ventricle | 1 | 1.4% | 1 | 1.6% |

The most common cranial ultrasound finding in preterm asphyxiated neonates was germinal matrix haemorrhage (GMH) followed by periventricular leukomalacia (PVL). The follow up scan was done at >= 72 hours in 93 patients. Abnormal cranial ultrasound findings were found in 40 (64.5%) preterm neonates. The most common cranial ultrasound finding in preterm asphyxiated neonates at >= 72 hours was periventricular leukomalacia (PVL) followed by germinal matrix haemorrhage (GMH).

Table 3 : DISTRIBUTION OF TERM NEONATES ACCORDING TO TRANSCRANIAL USG FINDINGS AT <= 36 HOURS AND AT >= 72 HOURS

| | At <= 36 hours | | At >= 72 hours | |
|---|---|---|---|---|
| Transcranial ultrasound findings | No. of term neonates | Percentage % | No. of term neonates | Percentage % |
| Cerbral edema | 18 | 36.7% | 11 | 35.4% |
| Intracerebral haemorrhage | 3 | 6.1% | 2 | 6.5% |
| Focal cerebral infarct | 1 | 2% | 1 | 3.2% |
| Cerebral edema + intracerebral haemorrhage | 2 | 4% | 1 | 3.2% |
| IVH + dilated ventricle | 3 | 6% | 1 | 3.2% |

In the first scan, done at <= 36 hours, 22 (44.9%) term neonates had normal transcranial ultrasound findings. While abnormal cranial ultrasound findings were found in 27 (55.1%) term neonates. Cerebral edema was the most common finding in term neonates in both scans done at <= 36 hours and >= 72 hours, seen in 20 (40.8%) and 11 (35.4%) term neonates respectively.

Table 4: COMPARISON OF RESISTIVE INDEX OF ANTERIOR CEREBRAL ARTERY AND MIDDLE CEREBRAL ARTERY AT < 36 HOURS WITH SARNAT AND SARNAT GRADING OF HIE IN NEONATES.

| RI At <36 hours | Sarnat and Sarnat grading of HIE | | | | | |
|---|---|---|---|---|---|---|
| | HIE 1 | | HIE 2 | | HIE 3 | |
| | ACA | MCA | ACA | MCA | ACA | MCA |
| DECREASED | 0 | 0 | 38 | 36 | 25 | 22 |
| NORMAL | 50 | 50 | 4 | 6 | 0 | 2 |
| INCREASED | 0 | 0 | 0 | 0 | 3 | 4 |
| Mean ± SD | 0.72 ± 0.05 | 0.70 ± 0.04 | 0.58 ± 0.14 | 0.56 ± 0.15 | 0.49 ± 0.05 | 0.46 ± 0.17 |

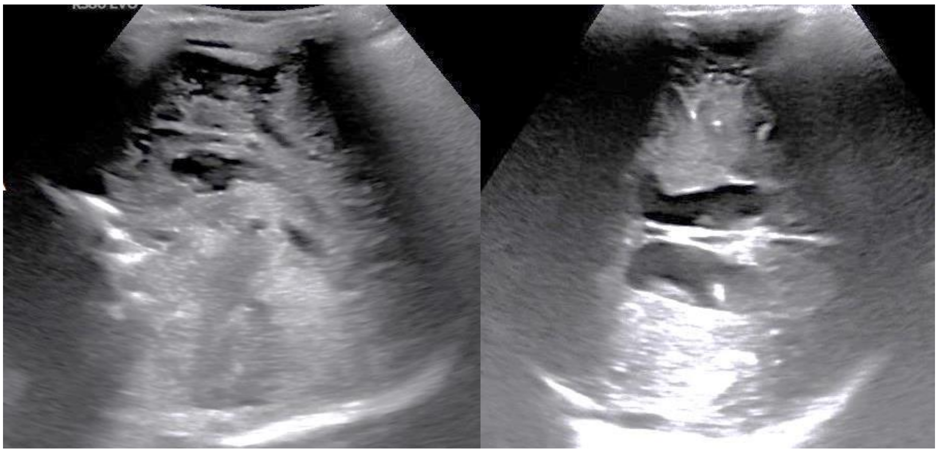
Table 5: COMPARISON OF RESISTIVE INDEX OF ANTERIOR CEREBRAL ARTERY AND MIDDLE CEREBRAL ARTERY AT >= 72 HOURS WITH SARNAT AND SARNAT GRADING OF HIE IN NEONATES

| RI At >=72 hours | Sarnat and Sarnat grading of HIE | | | | | |
|---|---|---|---|---|---|---|
| | HIE 1 | | HIE 2 | | HIE 3 | |
| | ACA | MCA | ACA | MCA | ACA | MCA |
| DECREASED | 0 | 0 | 29 | 35 | 13 | 12 |
| NORMAL | 39 | 39 | 10 | 4 | 0 | 0 |
| INCREASED | 0 | 0 | 0 | 0 | 2 | 3 |
| Mean ± SD | 0.76 ± 0.05 | 0.76 ± 0.04 | 0.52 ± 0.24 | 0.63 ± 0.08 | 0.31 ± 0.25 | 0.48 ± 0.17 |

Doppler studies detected decreased mean RI of ACA and MCA in moderate and severe grades of HIE in both scans. With increase in severity of clinical grade of HIE, there was decrease in the mean RI value of ACA and MCA.

In our study at <= 36 hours, abnormal cranial ultrasound findings in preterm neonates (60.6%) were significantly higher than term neonates (55.1%) (P value =0.04*). In the follow up scan at >= 72 hours, abnormal cranial ultrasound findings in preterm neonates (64.5%) were significantly higher than term neonates (51.6%) ( P value = 0.017*).


(A)



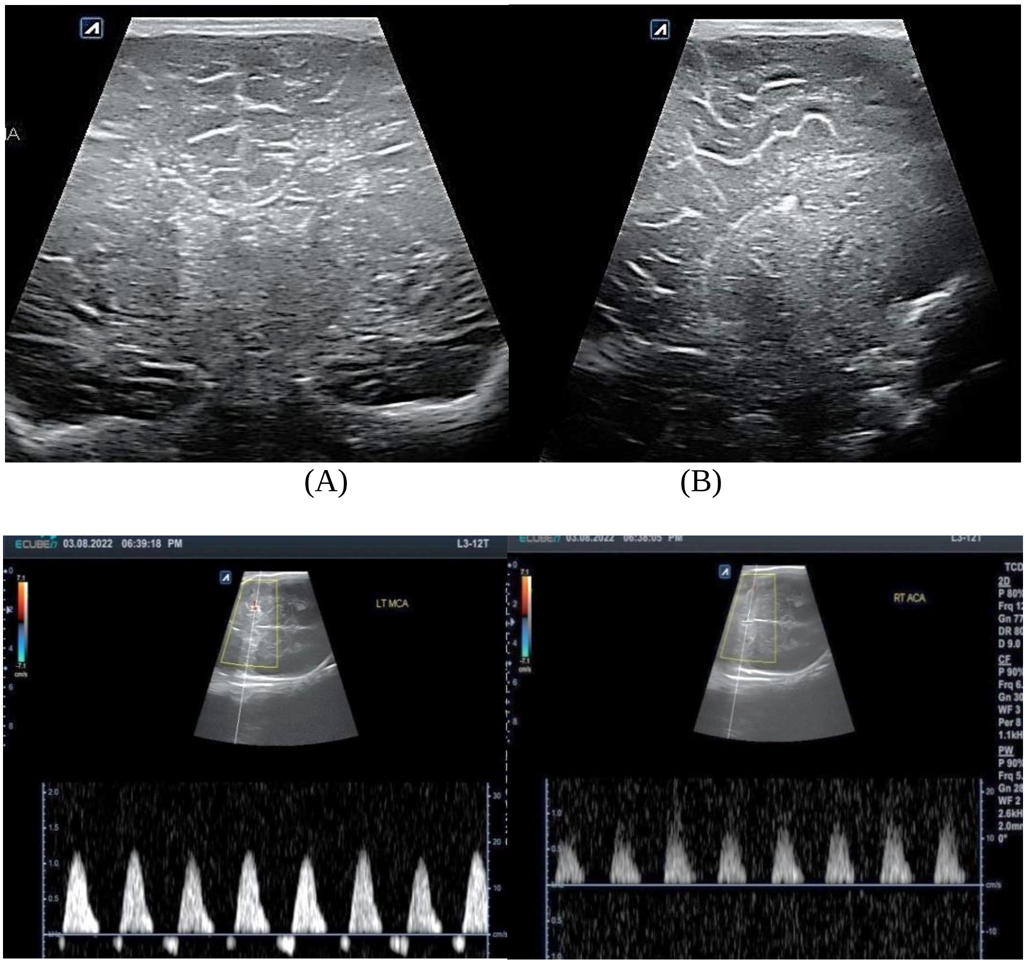
(B) (C)

Figure 1 : Preterm newborn male with HIE grade-III scanned at >72 hours. (A), (B) and (C) Coronal, axial and sagittal view of cranial ultrasound showing extensive periventricular cysts seen in frontoparietal region (PVL Grade-III)

(A)

(B)

Figure 2 : Preterm newborn male with HIE grade-III scanned at <36 hrs. (A) and (B) Coronal and sagittal view of cranial ultrasound showing germinal matrix hemorrhage extending into the ventricles (Grade-II)




(A) (B)

(C) (D)

Figure 3: Term newborn female with HIE grade-III scanned at <36 hrs. (A) and (B) Coronal and sagittal view of cranium showing cerebral edema. (C) and (D) showing reversal of end diastolic flow and absent end diastolic flow in MCA and ACA respectively.

## 4. DISCUSSION

Perinatal asphyxia is one of the leading cause of perinatal and early neonatal mortality in developing nations. Hypoxic damage can occur to most of the infant's organs (heart, lungs, liver, gut, kidneys), but brain damage is of most concern and perhaps the least likely to quickly or completely heal which can lead to catastrophic neurological sequelae (7). Therefore, early diagnosis of cerebral hypoxia is of utmost importance to initiate early treatment to avoid its complications.

In our study, most of the neonates afftected by HIE were preterm (59.2%). This may be explained by the fact that before 37 completed weeks of gestation, newborn's organs like brain, lungs are immature. There is arrest in the lineage of oligodendrocytes at the pre-oligodendrocyte stage in brain and these are particularly vulnerable to hypoxia, which act as initiators of white matter injury (9,10). Hagos et al. (11) found that preterm babies were 2.2 times more likely to develop birth asphyxia than term babies.

In the first scan, done at <= 36 hours, 28 (39.4%) preterm neonates had normal transcranial ultrasound findings. While abnormal cranial ultrasound findings were found in 43

(60.6%) preterm neonates which suggest that abnormal cranial ultrasound findings were significantly (P value = 0.04*) higher in preterm neonates.

The most common cranial ultrasound finding in preterm asphyxiated neonates was germinal matrix haemorrhage (GMH) followed by periventricular leukomalacia (PVL) seen in 26.8% and 23.9% of preterm neonates respectively. The reason for this could be that the watershed areas of brain in preterm neonate is located in the immediate periventricular region which is relatively hypovascular, therefore hypoxic-ischemic lesions are commonly seen in this location. In preterm neonate highly vascular germinal matrix is the site of haemorrhage.(12). This was in accordance with the study conducted by Niranjan et al. (13) who in his study found GMH in 11.2% of preterm neonates while Hemeda et al.(14) found PVL and GMH in 65.4% and 73.1% of her patients respectively.

In our study the most common cranial ultrasound finding in preterm asphyxiated neonates at >= 72 hours was periventricular leukomalacia (PVL) followed by germinal matrix haemorrhage (GMH) seen in 35.5% and 21% of preterm neonates respectively.This is in accordance with the study conducted by Yasmin et. al (15) who in her study also showed that the most common lesions in preterm were Periventricular leukomalacia (29%) and Germinal matrix haemorrhage (14%).

In our study, among term neonates, cerebral edema was the most common finding in both scans, seen in 20 (40.8%) and 12 (38.7%) patients respectively. This is explained by the fact that with maturity of infant watershed zone shifts from periventricular region to a more peripheral location. In term neonate germinal matrix involutes, so hemorrhage is uncommon. This was in agreement with Yasmin et al. (15) who also showed that most common lesion in term neonates were cerebral edema (43%) on transcranial ultrasound.

Transcranial color doppler study of anterior cerebral and middle cerebral artery were done at <= 36 hours and at >= 72 hours.

In our study, we found that the mean RI gradually decreases as the severity of HIE increases. This alteration in resistive index is due to reaction to chronic as well as acute hypoxia which results in centralisation of blood flow to vital organs like brain, heart. As the autoregulatory mechanism results in secretion of vasodilators in cerebral vascular bed leading to vasodilatation and increase in blood flow in cerebrovascular circulation. Thus, cerebrovascular resistance decreases resulting in decrease in RI (16). This was in accordance with the study conducted by Shefali et al. (16) who also showed that mean resistive index of cerebral vessels decreased with increasing severity of hypoxia.

In the first scan done at <= 36 hours abnormal findings were significantly higher in preterm neonates (60.6%) compared to term neonates (55.1%), which was found to be statistically significant (P value =0.04*). Similarly at scan done at >= 72 hours, 40 (64.5%) preterm and 16 (51.6%) term neonates had abnormal ultrasound findings, which was statistically significant (P value = 0.017*).

Majority of abnormal cranial ultrasound findings were found in preterm neonates which was germinal matrix haemorrhage. In severe grade HIE patients, RI of both middle cerebral and anterior arteries were found to be decreased.

Thus, by performing transcranial ultrasound and color doppler at 36 hours after birth, early diagnosis and intervention can be achieved. This can help reduce ominous complications and help decrease morbidity and mortality.

## 5. CONCLUSION

Perinatal asphyxia results in various adaptations in the cerebral parenchyma and it's hemodynamics depending on the degree of hypoxia. Such changes can be assessed dynamically and reliably with B mode ultrasound and color doppler. Hypoxic damage can

occur to most of the infant's organs (heart, lungs, liver, gut, kidneys), but brain damage is of most concern and perhaps the least likely to quickly or completely heal. Symptoms of birth asphyxia may not be very obvious. So, as to diagnose and intervene early help of imaging through transcranial ultrasound was undertaken. In our study we found that the grey scale cranial ultrasonography is a reliable method to identify different patterns of brain injury in perinatal asphyxia. Periventricular leukomalacia and germinal matrix haemorrhage are the most common sonographic findings in preterm neonates and that of term neonates is cerebral edema. Spectral doppler imaging along with doppler indices like PSV, EDV, RI of the anterior cerebral arteries and middle cerebral arteries among HIE neonates helps in evaluating the severity of HIE.
As the severity of the HIE increases, RI value decreases. Thus, correlating the RI value with the severity of HIE helps in early initiation of treatment and preventing the adverse outcome.

In our study, we found that ultrasound can be reliably used for the changes occurring in cerebral parenchyma and cerebral haemodynamics due to asphyxia. Transcranial ultrasound being a non-invasive diagnostic technique, simultaneously efficient and readily available, thus be used as a valuable diagnostic tool for the management of hypoxic ischemic brain injury.

Therefore, by performing transcranial ultrasound and colour doppler at 36 hours, early diagnosis and intervention can be achieved. This can help reduce ominous complications and decrease morbidity and mortality.

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