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Exploring the role of MRI brain in neonatal hypoxic ischemic encephalopathy evaluation

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Abstract

Background: Hypoxic Ischemic Encephalopathy (HIE) is a leading cause of perinatal mortality and neurodevelopmental disabilities. Magnetic resonance imaging (MRI) is the imaging modality of choice for the diagnosis and follow-up of infants with moderate to severe hypoxic-ischemic encephalopathy thus guiding treatment decisions and predicting neurodevelopmental outcomes. MRI provides consistent delineation particularly of involvement of specific areas of cerebral cortex, basal ganglia, thalamus and brain stem, as well as clear demonstration of the full extent of cerebral infarction.

Aims & Objectives:

1) To study neonatal Hypoxic Ischemic Encephalopathy changes using magnetic resonance imaging.

2) To correlate MRI with clinical findings.

3)To correlate MRI findings with clinical outcomes.

Methodology: The study included 30 patients referred to Department of Radiodiagnosis with clinical diagnosis/suspicious of HIE, over a period of 12 months. All patients were subjected to MRI using 1.5T Philips Achieve MRI machine.

Results: 30 patients who were clinically suspected to have neonatal hypoxic ischemic encephalopathy underwent MRI brain. Out of these thirty patients, 27 showed findings positive for hypoxic ischemic encephalopathy. Out of 27 patients, 16 patients had a central pattern of injury, 9 patients had a mixed pattern. One patient had a primarily periventricular pattern of injury and one patient had watershed territorial infarcts.

18 patients showed restricted diffusion in the PLIC, whereas 10 patients had loss of the normal signal intensity of PLIC. Two patients had restricted diffusion in the thalamus, whereas one patient out of these had T1 hyper intensity in the thalamus. Seven patients had T1

hyper intensity in the basal ganglia and three patients showed restricted diffusion in the basal ganglia.

Conclusion: MRI is superior to other imaging modalities in the evaluation of neonatal hypoxic ischemic encephalopathy. There is a strong and consistent correlation between the various MRI findings and the final clinical outcome.

Keywords: Magnetic Resonance Imaging, Hypoxic-Ischemic Encephalopathy.

Introduction

Perinatal asphyxia refers to interruption of blood flow /impaired gas exchange around labour and delivery which can result in multiorgan failure. Thus, hypoxic ischemic encephalopathy (HIE) is characterized by clinical and laboratory evidence of acute or subacute brain injury due to perinatal asphyxia.

The incidence of HIE is estimated at 1-2 per 1000 live births in developed countries and rises up to approximately 4-40 per 1000 live births in developing countries[1].Hypoxic-ischemic injury to the brain is an important cause of perinatal death and seems to be the commonest cause of permanent neurodevelopmental disability in new born infants who survive after intensive care.

Of all imaging modalities currently applied to the new born, only MRI provides consistent delineation particularly of involvement of specific areas of brain parenchyma, as well as clear demonstration of the full extent of cerebral infarction.

MRI is the imaging modality of choice for the diagnosis and follow-up of infants with moderate to severe hypoxic-ischemic encephalopathy[2-3,4]. MRI determines timing and nature of injury, patterns of injury, guide further treatment decisions and predict neurodevelopmental outcomes as well as in newly diagnosed cerebral palsy as it helps establish the cause.

Conventional MRI sequences (TIW and T2W) provide information on the status of myelination and pre-existing developmental defects of the brain. When performed after the first day (and particularly after day 4, conventional images may accurately demonstrate the injury pattern as areas of hyperintensity. Conventional images are most helpful at 7-10 days age, when the diffusion weighted imaging (DWI) findings have pseudo normalized.

DWI allows earlier identification of injury patterns in the first 24-48 hours. This MRI sequence identifies areas of oedema and hence injured areas. DWI changes peak at 3-5 days and pseudo normalizes by the end of the first week. In neonates, DWI may underestimate the extent of injury most likely because of the importance of apoptosis in the ultimate extent of neurological injury[5].

MRI is also a useful tool in the determination of prognosis. Studies indicate that infants with predominant injuries to the basal ganglia or thalamus, have an unfavourable neurological outcome when compared with infants with a white matter predominant pattern of injury.

Abnormal signals in the PLIC (posterior limb of internal capsule) have also been associated with poor neurological outcome. In a recent study, severe BGT (basal ganglia and thalamus) lesions on early MRI (performed at a median age of 10 days, range 2-42 days) were strongly associated with motor impairment at 2 years. In addition, abnormal PLIC signal was also highly correlated with inability to walk independently at 2 years with a sensitivity of 0.92 and a specificity of 0.77[6].

The accurate diagnosis of hypoxic-ischemic injury in the neonate requires knowledge of the normal appearance of

the brain at that age on MRI and the patterns of hypoxic ischemic injury.

Materials and Method

This study on "**Exploring the role of MRI brain in neonatal hypoxic ischemic encephalopathy evaluation"** has been carried out in the Department of Radio-diagnosis, Mahadevappa Rampure Medical College, Kalaburagi. A total number of 30neonates with clinical diagnosis/suspicion of HIE of either sex referred to the Department of Radiodiagnosis over a period of 12 months i.e. between 1st November 2022 to 31st October 2023 were included in this study.

The study protocol was approved by the ethical committee. All the guardians of neonates were explained of the procedure and informed consent was taken from them.

MRI was performed by using Philips Achieva 1.5 Tesla MRI machine. The standard brain imaging sequences including T1W(axial), T2W (axial, coronal), DWI (axial), Flair (axial) and GRE(axial) sequences were acquired.

Inclusion Criteria

- Clinically diagnosed /suspicious of hypoxic ischemic encephalopathy.
- Patients born with perinatal asphyxia, antenatal insults and/or prolonged labor.
- Hemodynamically stable term and preterm neonates.

Exclusion Criteria

- Contraindications to MRI such as prosthesis, heart valve prosthesis, artificial/prosthetic limb, surgical staples, clips or metallic sutures and claustrophobia.
- Critically ill patients who may not tolerate prolonged examination duration.

Results

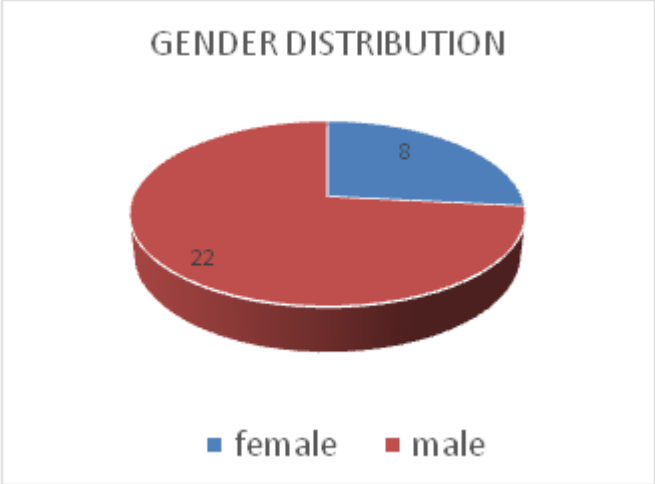
In the present study of HIE in neonates in 30 patients during the study period, following are the results:

1. Distribution of study subjects according to gender

Table 1: showing distribution of gender in study subjects.

Sex	Frequency	Percent
Female	8	26
Male	22	74
Total	30	100

Chart 1: Pie chart showing distribution of gender in study subjects

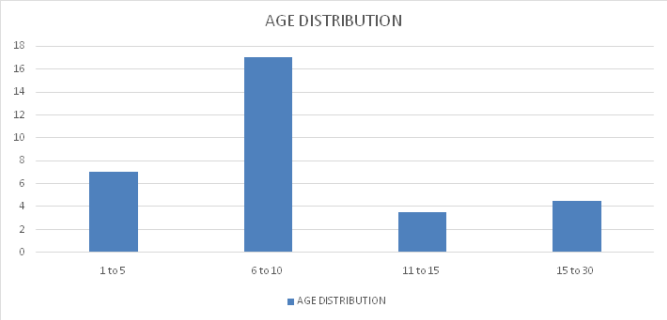


2. Age wise distribution of study subjects

Table 2: showing age wise distribution of study subjects

Age(days)	Frequency	Percent
1-5	7	23.4 %
6-10	17	56.6%
11-15	5	16.7%
16-30	1	3.3%
Total	30	100 %

Chart 2: Age wise distribution of study subjects.

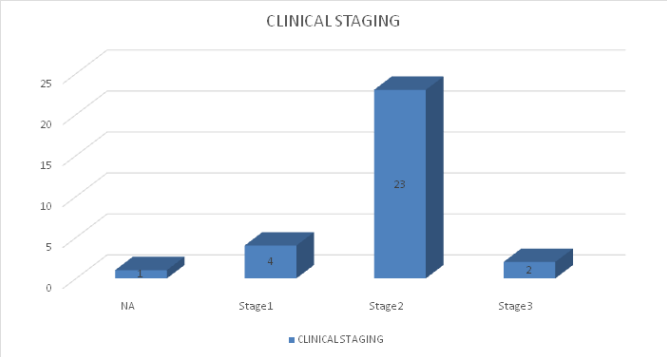


3. Distribution based on clinical staging of neonates

Table 3: Showing distribution based on clinical staging of neonates

Clinical stage	Frequency	Percent
NA	1	3.5
Stage 1	4	13.6
Stage 2	23	76.6
Stage 3	2	6.6
Total	30	100

Chart 3: Column chart showing distribution of neonates based on clinical stage of HIE



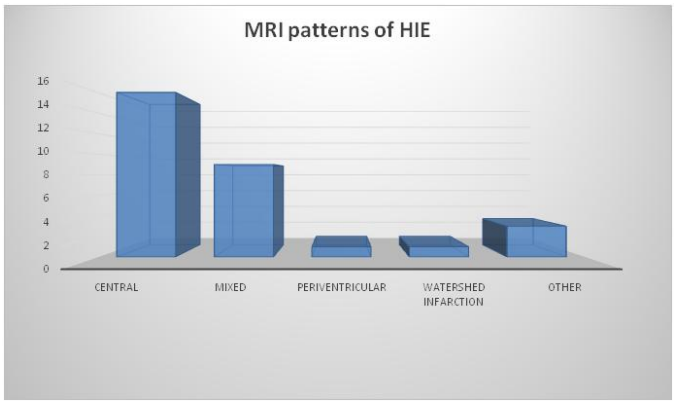
The largest proportion of neonates included in the study were Stage 2 HIE, as it was difficult to obtain MRI for highly unstable neonates of stage 3 who were on ventilator support.

4. Distribution based on MRI pattern of injury

Table 4: Showing distribution of neonates based on the MRI pattern of injury to brain

MRI pattern	Number	Percent
Central	16	53.3
Mixed	9	30
Peri ventricular	1	3.3
Watershed infarction	1	3.3
Other	3	10

Chart 4: column chart showing distribution of neonates based on the MRI pattern of injury to brain

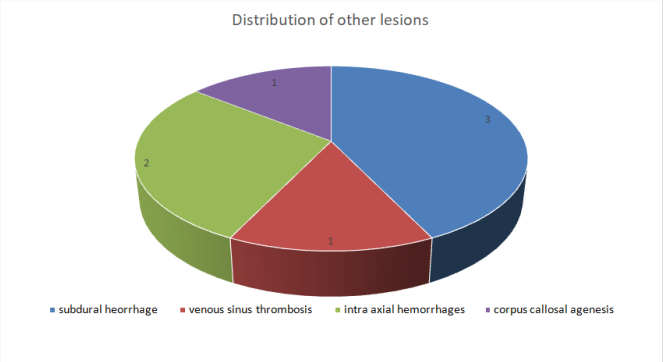


5. Distribution of other lesions

Table 5: Showing distribution of other lesions in MRI brain

Other significant MRI findings	Number
Subdural hemorrhage	3
Venous sinus thrombosis	1
Intra axial hemorrhages	2
Corpus callosal agenesis	1

Chart 5: Pie chart showing distribution of other lesions in MRI brain

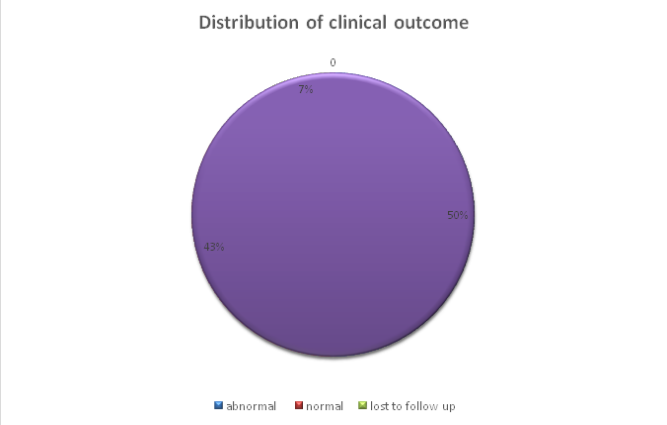


6. Distribution of clinical outcome

Table 6: Showing distribution of clinical outcomes of neonates

Outcome	Number	Percent
Abnormal	15	50
Normal	13	43
Lost to follow up	2	7
Total	30	100

Chart 6:Chart showing distribution of clinical outcome



Out the examined patients, close to half had abnormal outcomes at six months.the rest had normal oucomes at 6 months or were lost to follow up.

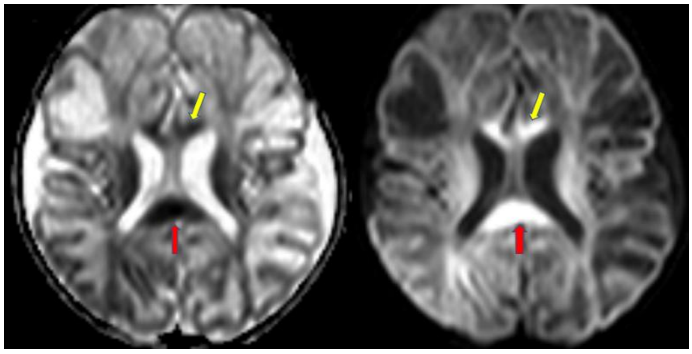


Figure 1: Axial DWI and ADC image showing diffusion restriction involving genu(yellow) and splenium (red) of corpus callosum

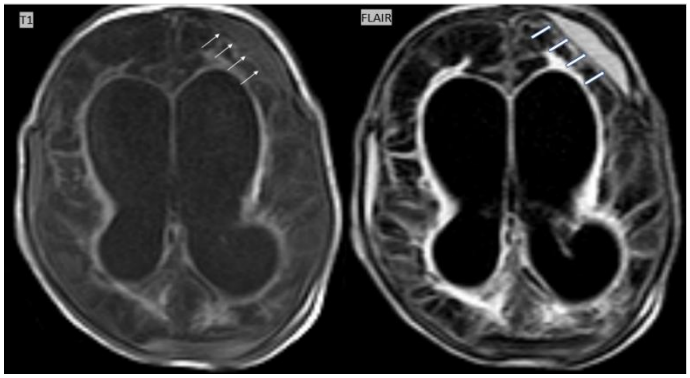


Figure 2: Axial T1 and FLAIR image shows chronic subdural hematoma in left frontal region with diffuse cystic encephalomalacic changes causing exvacuo dilation of bilateral lateral ventricles

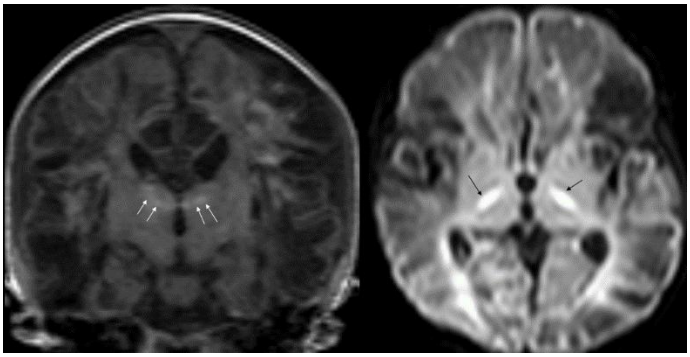


Figure 3: Coronal T1 and Axial DWI images showing T1 high signal intensity and diffusion restriction involving posterior limb of internal capsule

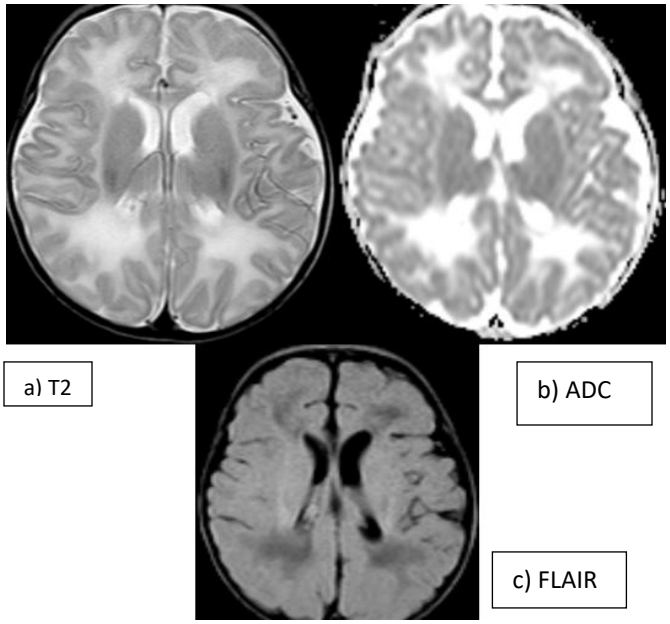


Figure 4: Axial T2 , ADC and FLAIR images showing peri-ventricular leukomalacia changes

Discussion

A total of 30 cases of HIE were evaluated using MRI brain. The MRI findings obtained in the study have been classified into T1 findings and findings on diffusion restriction based on American Journal Of Radiology guidelines and thence studied.

Gender and age of presentation

Most of the neonates included in our study belonged to the age group of 6 to 10 days. This study recognizes the limitations imposed because of this selection bias as diffusion findings have been classically known to pseudo normalize after a period of 7 days. 75% of the patients included in our study were male.

Clinical Outcome

Out of the 30 patients included in the study, 50% abnormal outcomes at 6 months follow up, 43 % had normal outcomes and 7% were lost to follow up. This study recognizes the limitations of a six- month follow up as many of the neurological sequelae of birth asphyxia are known to manifest in a delayed fashion.

MRI Findings With Clinical Outcomes

Out of 30 patients, 27 patients demonstrated findings positive for HIE. The remaining 3 MRI scans demonstrated pathology different from HIE out of which 3 showed presence of subdural haemorrhage, 1 showed evidence of venous sinus thrombosis, 2 patients showed intra-axial haemorrhages and 1 patient showed corpus callosal agenesis.

MRI findings that correlated with HIE in our patients fit into the following broad categories

A) Central, Peri Ventricular, Watershed Territory Infarcts and Mixed Findings

The largest group 53.33% demonstrated changes in the central structures which included the thalami, basal ganglia, internal capsule and the corpus callosum.

The next significant group by numbers was the patient population with mixed findings of 30%. The other groups in our study were one with periventricular changes which corresponded to 3.3% and other with watershed infarction corresponded to 3.3% .

James Barkovich et al [7] undertook a study to determine whether it was possible to detect changes of neonatal Hypoxic Ischemic Encephalopathy within the first ten days of life by using standard T1 and T2 sequences in patients with history of intrapartum or perinatal asphyxia.

The following results were obtained. Four patients had normal scans and were clinically healthy. The remaining 16 patients were divided into four groups based on the tissue structures affected.

1) Primarily deep grey matter involvement. 2) Primarily cortical injury. 3) Periventricular pattern of injury. 4) Mixed pattern of injury.

Two patients had MRI patterns that suggested prepartum injury. TI shortening was seen as early as 3 days after

injury whereas T2 shortening did not appear until 6 to 7 days after injury.

B) Lesions in the Posterior Limb of the Internal Capsule:

8 patients showed restricted diffusion in the PLIC, whereas 10 patients had loss of the normal signal intensity of PLIC.

Also, there was a stronger correlation with clinical outcome with TI lesions as compared to diffusion restriction within the posterior limb of the internal capsule 71.4% of patients with loss of the normal signal in the posterior limb of the internal capsule had abnormal outcomes at 6 months compared to 56.8% of PLIC diffusion restriction cases.

This is in partial concordance with the observations provided by Dr.Mary A Rutherford et al[8] in their studies who found that all patients with abnormal signal intensity in the Posterior limb of the Internal capsule had abnormal neurodevelopmental outcome. The higher rates of abnormal outcome in their studies may be partially due to longer follow up periods thereby possibly detecting delayed neurological outcomes.

C) Lesions within the Basal Ganglia and Thalamus Region

Two patients had restricted diffusion in the thalamus, whereas one patient out of these had T1 hyper intensity in the thalamus. Both these patients had abnormal outcome at 6 months fallow up.

Seven patients had T1 hyperintensity in the basal ganglia of which 71% had an abnormal outcome, 28% normal outcome and 14% was lost to follow up and three patients showed restricted diffusion in the basal ganglia. The clinical outcomes associated with lesions of the basal ganglia included disturbances of tone.

D) Corpus Callosal Lesions

21 patients out of 30 showed restricted diffusion in the splenium of corpus callosum, 6 neonates showed restriction in the genu and 3 patients out of 30 showed restriction in the body. All these three groups had comparable outcomes with outcomes from diffusion restriction in the genu and that in the splenium matching more closely.

Conclusion

MRI is superior to other imaging modalities in the evaluation of neonatal hypoxic ischemic encephalopathy with high sensitivity and specificity. It is set out to categorize and suitably classify the various MRI patterns of disease in these patients.

Diffusion weighted imaging adds sensitivity and provides information not seen on the other conventional sequences.

Though CT is considered the initial imaging modality because it is easily available but multiplanar MRI has carved a niche for itself as the feasible, cost effective and time saving imaging modality in hypoxic ischemic encephalopathy in the neonate with a strong and consistent correlation between the various MRI findings and the final clinical outcome.

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