Evaluation of MRI changes in Brain of newborns with Hypoxic-Ischemic Encephalopathy clinical stage I, II and III

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Abstract

Background: This study was conducted for the evaluation of MRI changes in Brain of newborns with Hypoxic-Ischemic Encephalopathy clinical stage I, II and III.

Material and methods: This descriptive, open, comparative study was conducted on 75 term newborns to evaluate various MRI changes seen in brain of term newborns with hypoxic ischemic encephalopathy within first 2 weeks as well as to evaluate if there is any stage specific MRI changes in brain of term newborns with hypoxic ischemic encephalopathy clinical stage I, II, III within first 2 weeks. The study was conducted on 75 newborns delivered at Obstetrics and Gynecological department of Rajindra Hospital, Patiala and admitted to Neonatology section of Department of Pediatrics with birth asphyxia. Three groups of newborns with each group consisting of 25 newborns of HIE clinical stage I, II and III were evaluated for MRI changes. The data was recorded on the proforma and were subjected to statistical analysis. Three groups of term newborns were evaluated for MRI changes Group-1 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage I Group-2 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage II Group-3 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage III

Results: Mean maternal age among the subjects of Group 1, Group 2 and Group 3 was found to be 28.16 years, 27.68 years and 27.12 years. Mean maternal age of all the study groups was comparable. 64 percent of the patients (16 patients) of Group 1, 56 percent of the patients (14 patients) of Group 2 and 68 percent of the patients (17 patients) of Group 3 were males while the remaining were females. Gender-wise distribution of patients of all the three study groups was comparable. Mean gestational age among the patients of Group 1, Group 2 and Group 3 was found to be 39.60 weeks, 39.28 weeks and 39.32 weeks respectively In 56 percent of the patients (14 patients) of Group 1, 68 percent of the patients (17 patients) of Group 2 and 60 percent of the patients (15 patients) of Group 3, mode of delivery was Caesarean while in the remaining cases, mode of delivery was vaginal.

Conclusion: MRI is a useful modality to assess the early changes noted in HIE. Bilateral basal ganglia and/or bilateral thalami lesions were the predominant finding in stage 3 HIE while Periventricular leukomalacia was the predominant finding in stage 2 HIE. The clinical diagnosis of birth asphyxia, along with the closely related conditions of hypoxic ischemic encephalopathy is recognized as an important cause of morbidity and mortality in newborns. Early diagnosis helps in management, prognosis and also in counselling the parents.

Keywords: brain networks, encephalopathy, MRI

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Introduction

Neonatal encephalopathy is a heterogenous syndrome characterized by signs of central nervous system dysfunction in newborn infants. NE occurs as a consequence of intracranial hemorrhage, hypoglycaemia, severe hyperbilirubinemia, various metabolic disorders and intracranial infection, among other disorders. Apgar scores at 1 min and 5 min reflect the neonate's general condition immediately after birth and are predictive of neurological outcome respectively. Several authors have reported that low Apgar scores at 5 min is a risk factor for serious morbidity and mortality.[1] Neonatal encephalopathy (NE) refers to neurological abnormalities manifesting in the neonatal period and may be caused by multiple variables, among which HIE is a key contributing factor.[1] Hypoxic ischemic encephalopathy (HIE) is one of the most serious birth complications affecting full term infants. It occurs in 1.5 to 2.5 per 1000 live births in developed countries. HIE is a brain injury that prevents adequate blood flow to the infant's brain occurring as a result of a hypoxic-ischemic event during the prenatal, intrapartum or postnatal period. By the age of 2 years, up to 60% of infants with HIE will die or have severe disabilities including mental retardation, epilepsy, and cerebral palsy.[2] HIE has tremendous detrimental effects on the developing brain and is among the leading causes of death among infants as well as major underlying cause of seizures in term infants. Neonatal HIE can also be characterized as an injury that occurs in the immature brain resulting in delayed cell death via excitotoxicity, inflammation and oxidative stress. These adverse events in the developing brain often lead to long lasting detrimental neurological defects later on in life such as mental retardation, epilepsy, cerebral palsy, learning disabilities, gross development delay, motor disabilities and other neurological handicaps.[3] Report of the National Neonatal Perinatal Database (National Neonatology Forum, India) 2002-2003 defined moderate asphyxia as slow gasping breathing or an Apgar score of 4-6 at I minute of age. Severe asphyxia was defined as no breathing or an Apgar score of 0-3 at 1 minute of age.[4] The main cause of HIE is Perinatal asphyxia which occurs due to 2 hypoxia or anoxia and hypercarbia during labour, delivery or the immediate newborn period resulting from inadequate perfusion or gas exchange through the maternal, placental, fetal or neonatal circulations.[5] Neonatal hypoxic ischemic encephalopathy is of great importance since it is the major cause and contributor to global infant mortality and morbidity. Underdeveloped countries have even reported incidences up to 26 per 1000 live births. About 20%–25% of term newborn infants die during the neonatal period and about 25% of those that survive develop permanent neurological disabilities. As reported in NNPD (2002-2003), Apgar sores of <7 was found at 1 minute in 8.4% while 2.4% had scores of <7 at 5 minutes of life of all intramural births at 18 neonatal units in India. PA was responsible for 28.8% of all neonatal deaths.

Manifestations of hypoxic ischemic encephalopathy (HIE) were seen in approximately 1.4% of all babies. Apart from neonatal deaths, asphyxia is responsible for lifelong neuromotor disability in a large number of children.[6] In high-income countries, neonatal encephalopathy occurs in 1 to 3 per 1000 live births; approximately 20 to 25% of the affected infants die, and 40% of the survivors have significant brain injury and lifelong disability.[7] Data from National Neonatal Perinatal database suggests that perinatal asphyxia contributes to almost 20% of neonatal deaths in India.[4] In India most of the births in developing countries occur at home, usually attended by untrained birth attendants. Failure to initiate and sustain breathing immediately after delivery has been associated with hypoxic ischaemic injury the central nervous system and the clinical manifestations of this injury have been termed as hypoxic ischaemic encephalopathy (HIE). HIE is of concern in an asphyxiated neonate because it can lead to serious long term neuromotor sequelae among survivors.[5-7]

Material and methods

This descriptive, open, comparative study was conducted on 75 term newborns to evaluate various MRI changes seen in brain of term newborns with hypoxic ischemic encephalopathy

within first 2 weeks as well as to evaluate if there is any stage specific MRI changes in brain of term newborns with hypoxic ischemic encephalopathy clinical stage I, II, III within first 2 weeks. The study was conducted on 75 newborns delivered at Obstetrics and Gynecological department of Rajindra Hospital, Patiala and admitted to Neonatology section of Department of Pediatrics with birth asphyxia. Three groups of newborns with each group consisting of 25 newborns of HIE clinical stage I, II and III were evaluated for MRI changes. The data was recorded on the proforma and were subjected to statistical analysis.

Three groups of term newborns were evaluated for MRI changes Group-1 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage I Group-2 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage II Group-3 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage III

Inclusion Criteria:

Full term babies with low Apgar score (i.e. a 5 min score of <= 7) or post- asphyxia symptoms admitted within 24h of delivery

Exclusion Criteria: Infants with gestational age< 37 weeks (as the neurological complications of prematurity may interfere with the results), presence of perinatal infection, those who did not complete the course of the follow up, all infants with obvious congenital malformations, congenital mental disorders and maternal drug addiction.

All cases of birth asphyxia who landed into hypoxic ischaemic encephalopathy were evaluated in detail clinically for signs and symptoms of birth asphyxia and were graded into three groups i.e. HIE-I, HIE-II, HIE-III as per Sarnat and Sarnat's Staging System. Full history was obtained and general physical and systemic examination on the predesigned and pretested proforma including information regarding name and age of mother, maternal registration, baby registration, father's name, address parents, income and education status, date and time of birth gender, identification of baby, detail antenatal of history and investigation of mother, type of delivery, type of first cry of baby, mode of resuscitation and establishment of regular aspiration, apgar score at 1, 5, 10 and 20 minutes, physical examination of baby in the form of vitals anthropometry, presence of cyanosis, anemia, jaundice respiratory system examination, type of breathing or any signs of respiratory distress, cardiac examination for normal/abnormal sounds, CNS examination for alertness, primitive neonatal reflexes, all cranial nerves, posture, tone, reflexes, touch, pain and temperature was recorded at a time of birth on pre-designed proforma for all babies.

Statistical analysis

All the results were compiled in Microsoft excel sheet and were analysed by SPSS software. Chi-square test and independent t test were used for assessment of level of significance. P-value

Results

The study was conducted on 75 newborns delivered at Obstetrics and Gynecological department of Rajindra Hospital, Patiala and admitted to Neonatology section of Department of Pediatrics with birth asphyxia. Three groups of newborns with each group consisting of 25 newborns of HIE clinical stage I, II and III were evaluated for MRI changes. Group-1 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage I Group-2 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stageII Group-3 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage III Following results were obtained:

Table 1: Distribution of patients according to maternal age

Maternal age (years)	Group 1		Group 2		Group 3	
	N	%	N	%	N	%
Less than 25	5	20	7	28	8	32
25 to 30	11	44	10	40	8	32
More than 30	9	36	8	32	9	36
Total	25	100	25	100	25	100
Mean (years)	28.16		27.68		27.12	

Mean maternal age among the subjects of Group 1, Group 2 and Group 3 was found to be 28.16 years, 27.68 years and 27.12 years. Mean maternal age of all the study groups was comparable.

Table 2: Distribution of neonates according to gender

Gender	Group 1		Group 2		Group 3	
	N	%	N	%	N	%
Males	16	64	14	56	17	68
Females	9	36	11	44	8	32
Total	25	100	25	100	25	100

64 percent of the patients (16 patients) of Group 1, 56 percent of the patients (14 patients) of Group 2 and 68 percent of the patients (17 patients) of Group 3 were males while the remaining were females. Gender-wise distribution of patients of all the three study groups was comparable.

Table 3: Distribution of neonates according to gestational age

Gestational age (weeks)	Group 1		Group 2		Group 3	
	n	%	n	%	N	%
37 weeks	3	12	5	20	5	20
38 weeks	5	20	4	16	5	20
39 weeks	4	16	4	16	3	12
40 weeks	4	16	6	24	4	16
41 weeks	5	20	3	12	5	20
42 weeks	4	16	3	12	3	12
Total	25	100	25	100	25	100
Mean gestational age (weeks)	39.60		39.28		39.32	

Mean gestational age among the patients of Group 1, Group 2 and Group 3 was found to be 39.60 weeks, 39.28 weeks and 39.32 weeks respectively.

Table 4: Distribution of neonates according to type of delivery

Type of delivery	Group 1		Group 2		Group 3	
	N	%	N	%	N	%
Caesarean	14	56	17	68	15	60
Vaginal	11	44	8	32	10	40
Total	25	100	25	100	25	100

In 56 percent of the patients (14 patients) of Group 1, 68 percent of the patients (17 patients) of Group 2 and 60 percent of the patients (15 patients) of Group 3, mode of delivery was Caesarean while in the remaining cases, mode of delivery was vaginal.

Table 5: Distribution of patients according to maternal parity

Maternal parity	Group 1		Group 2		Group 3	
	N	%	N	%	N	%
Primi	13	52	14	66	14	56
Gravid 2	8	32	6	24	7	28
Gravid 3	4	16	5	20	4	16
Total	25	100	25	100	25	100

Maternal parity in 52 percent of the patients (13 patients) of Group 1,66 percent of the patients (14 patients) of Group 2 and 56 percent of the patients (14 patients) of Group 3 was Primi gravid. Maternal parity in 32 percent of the patients (8 patients) of Group 1, 24 percent of the patients (6 patients) of Group 2 and 28 percent of the patients (7 patients) of Group 3 was Gravid 2.

Table 6: Mean Apgar score at 1 min

APGAR score	Group 1		Group 2		Group 3	
	N	%	N	%	N	%
0 to 3	4	16	20	80	25	25
4 and 5	18	72	5	20	0	0
≥6	3	12	0	0	0	0
Total	25	100	25	100	25	100
Mean	4.32		2.56		2.04	
SD	1.31		1.21		0.61	

Mean Apgar score among the patients of Group 1, Group 2 and Group3 at 1 minute was found to be 4.32, 2.56, and 2.04 respectively.

Table 7: Mean Apgar score at 5 min

APGAR score	Group 1		Group 2		Group 3	
	N	%	N	%	N	%
0 to 3	0	0	0	0	1	4
4 and 5	11	44	16	64	24	96
≥6	14	56	9	36	0	0
Total	25	100	25	100	25	100
Mean	5.48		5.16		4.48	
SD	0.65		0.80		0.71	

Mean Apgar score among the patients of Group 1, Group 2 and Group3 at 5 minute was found to be 5.48, 5.16, and 4.48 respectively.

Table 8: Mean Apgar score at 10 min

APGAR score	Group 1		Group 2		Group 3	
	N	%	N	%	N	%
0 to 3	0	0	0	0	0	0
4 and 5	9	36	13	52	23	92
≥6	16	64	12	48	2	8
Total	25	100	25	100	25	100
Mean	5.64		5.43		4.68	
SD	0.49		0.70		0.62	

Mean Apgar score among the patients of Group 1, Group 2 and Group 3 at 10 minute was found to be 5.64, 5.43, and 4.68 respectively.

Table 9: Mean Apgar score at 20 min

APGAR score	Group 1		Group 2		Group 3	
	N	%	N	%	N	%
0 to 3	0	0	0	0	0	0
4 and 5	5	20	11	44	21	84
≥6	20	80	14	56	4	16
Total	25	100	25	100	25	100
Mean	5.84		5.53		4.84	
SD	0.37		0.64		0.68	

Mean Apgar score among the patients of Group 1, Group 2 and Group 3 at 20 minute was found to be 5.84, 5.53, and 4.84 respectively.

Table 10: Comparison of Mean Apgar score at 1 min

Mean Apgar score at 1 min	t-statistics	p- value
Group 1 Vs Group 2	-4.935	0.0001
Group 2 Vs Group 3	1.919	0.0610
Group 3 Vs Group 1	7.889	0.0000

Mean Apgar score at 1 minute was significantly lower among patientsof Group 3 in comparison to patients of Group 2. Mean Apgar score at 1 minute was significantly lower among patients of Group 2 in comparison to patients of Group 1. However; non-significant results were obtained while comparing the mean Apgar score at 1 minute among patients of Group 2 and Group 3.

Table 11: Comparison of Mean Apgar score at 5 min

Mean Apgar score at 5 min	t-statistics	p- value
Group 1 Vs Group 2	-1.552	0.1271
Group 2 Vs Group 3	3.179	0.0026
Group 3 Vs Group 1	5.194	0.0001

Mean Apgar score at 5 minute was significantly lower among patientsof Group 3 in comparison to patients of Group 2 and Group 1. However; non- significant results were obtained while comparing the mean Apgar score at 5 minute among patients of Group 2 and Group 1.

Table 12: Comparison of Mean Apgar score at 10 min

Mean Apgar score at 10 min	t-statistics	p- value
Group 1 Vs Group 2	-1.625	0.3501
Group 2 Vs Group 3	5.963	0.0001
Group 3 Vs Group 1	-6.074	0.0020

Mean Apgar score at 10 minute was significantly lower among patients of Group 3 in comparison to patients of Group 2 and Group 1. However; non- significant results were obtained while comparing the mean Apgar score at 10 minute among patients of Group 2 and Group 1.

Table 13: Comparison of Mean Apgar score at 20 min

Mean Apgar score at 20 min	t-statistics	p- value
Group 1 Vs Group 2	-1.412	0.0950

Group 2 Vs Group 3	5.887	0.0013
Group 3 Vs Group 1	-5.006	0.0028

Mean Apgar score at 20 minute was significantly lower among patients of Group 3 in comparison to patients of Group 2 and Group 1. However; non- significant results were obtained while comparing the mean Apgar score at 20 minutes among patients of Group 2 and Group 1.

Discussion

Hypoxic-ischemic injury (HII) of the neonatal brain and subsequent clinical hypoxic-ischemic encephalopathy (HIE) affects 1–3 per 1,000 live births in developed countries and is responsible for a significant burden of morbidity and mortality in the pediatric population.[8]

Insufficient cerebral blood flow (ischemia) and decreased oxygenation in the blood (hypoxia) lead to loss of normal cerebral autoregulation. This results in diffuse brain injury and thereby causes hypoxic–ischemic encephalopathy (HIE). The clinical diagnosis of HIE is based on evidence of fetal distress, low umbilical cord pH of <7.1 (acidosis), a poor Apgar score (0– 3) at 5 min, necessity for resuscitation, abnormal neurology (seizure, coma, hypotonia), and multiorgan dysfunction. Even when all the criteria for HIE are fulfilled, it may be due to a pre-existing neurological condition predisposing to an abnormal delivery and HII.[9]

Neuroimaging modalities such as ultrasound (US), computed tomography (CT), and magnetic resonance imaging (MRI) help in identification and characterization of the accurate location, extent, and severity of the brain injury. Newer imaging techniques such as diffusion- weighted imaging (DWI) and magnetic resonance spectroscopy (MRS) being more sensitive to diagnose acute brain injury have a potential role in early diagnosis and timely intervention. The treatment is primarily supportive, aimed at correction of underlying cause. The role of neuroprotective interventions to limit the extent of brain injury caused by hypoxia-ischemia is under investigation. The prognosis of HIE depends on the severity of injury and gestational age of the infant.[10-12]

Hence; the present study was undertaken for identifying if there is any stage specific MRI changes in term newborns with hypoxic ischemic encephalopathy stage I, stage II and stage III.

The study was conducted on 75 newborns delivered at Obstetrics and Gynecological department of Rajindra Hospital, Patiala and admitted to Neonatology section of Department of Pediatrics with birth asphyxia. Three groups of newborns with each group consisting of 25 newborns of HIE clinical stage I, II and III were evaluated for MRI changes.

Group-1 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage I

Group-2 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage II

Group-3 consisted of 25 newborns, delivered with perinatal asphyxia and having HIE stage III

In the present study, mean maternal age among the subjects of Group 1, Group 2 and Group 3 was found to be 28.16 years, 27.68 years and 27.12 years. Mean maternal age of all the study groups was comparable.

In the present study, 64 percent of the patients (16 patients) of Group 1, 56 percent of the patients (14 patients) of Group 2 and 68 percent of the patients (17 patients) of Group 3 were males while the remaining were females. Gender-wise distribution of patients of all the three study groups was comparable. Our results were in concordance with the results obtained byJose O et al who also reported similar findings in their study. They reported that out of 30 babies with HIE, 19 were males and 11 females, which correspond to 63.3% of male and the rest female babies. According to a study by Zaneli SA, Stanley DP et al, there was no gender predilection. Male gender being a risk factor for HIE has also been reported by others.[13,14,15]

In the present study, Mean gestational age among the patients of Group 1, Group 2 and Group 3 was found to be 39.60

weeks, 39.28 weeks and 39.32 weeks respectively. In 56 percent of the patients (14 patients) of Group 1, 68 percent of the patients (17 patients) of Group 2 and 60 percent of the patients (15 patients) of Group 3, mode of delivery was Caesarean while in the remaining cases, mode of delivery was vaginal.

In the present study, Maternal parity in 52 percent of the patients (13 patients) of Group 1, 66 percent of the patients (14 patients) of Group 2 and56 percent of the patients (14 patients) of Group 3 was Primi gravid. Maternal parity in 32 percent of the patients (8 patients) of Group 1, 24 percent of the patients (6 patients) of Group 2 and 28 percent of the patients (7 patients) of Group 3 was Gravid 2. Our results were in concordance with the results obtained by Jose O et al, who also reported similar findings in their study. They also reported higher proportion of Primi Gravida mothers in their study. It may be because the first delivery is more difficult than the subsequent ones.

This points to the importance of intrapartum factors in the causation of HIE.[13] In the present study, Mean Apgar score among the patients of Group 1,

Group 2 and Group 3 at 1 minute was found to be 4.32, 2.56, and 2.04 respectively. Mean Apgar score among the patients of Group 1, Group 2 and Group 3 at 5 minute was found to be 5.48, 5.16, and 4.48 respectively. Mean Apgar score among the patients of Group 1, Group 2 and Group 3 at 10minute was found to be 5.64, 5.43, and 4.68 respectively. Mean Apgar score among the patients of Group 1, Group 2 and Group 3 at 20 minute was found to be 5.84, 5.53, and 4.84 respectively. While analysing statistically, it was observed that mean Apgar score decreased significantly with severity of HIEat different time intervals, being lowest for Grade III HIE and highest for GradeI HIE. Our results were in concordance with the results obtained by previous authors who also reported similar findings in their respective studies.

In a study conducted by Aliyu I et al, authors analysed 140 neonates. They observed that at 5 minutes, 100 percent of the neonates with Grade III HIE had Apgar score of 4 to 5, while only 60.87 percent of the patients with Grade II HIE and 39.39 percent of the patients with grade I HIE had Apgar score of 4 to 5, the results of which were found to be statistically significant. Therefore; newborns who had critically low Apgar scores were more likely to develop severe forms of HIE (Stages 2 and 3).[16]

In the present study, Significant MRI findings were found to be present in 1 patient (4 percent) of Group 1, 21 patients (84 percent) of Group 2 and 25 patients (100 percent) of Group 3 respectively. Overall, Significant MRI findings was found to be present in 62.67 percent of the patients, while significant MRI findings were found to be present in 92 percent of the patients with grade II and Grade III HIE. While comparing the frequency of MRI findings among patients of all the three study groups, significant results were obtained. Comparable results have been reported in the past literature where various authors have reported similar range of MRI changes in patients with grade II and Grade II HIE. In a study conducted by Jose O et al, authors reported that out of the 30 patients with Grade II and Grade III HIE, 27 had MRI changes seen in HIE. This comes to 90% which is comparable with study done by Rutherford et al, where the proportion was 93%.[17]

In another study conducted by Ramachandran S et al, authors reported data of term neonates with perinatal asphyxia and hypoxic ischemic encephalopathy who underwent MRI at 3 months using flair, T2, T1 and diffusion weighted sequences. Neurological assessment was done at 12 months. MRI was normal in 16 (61.5%) neonates.[18]

Term babies are more affected by MRI than preterms it may be because neonatal brain injury is difficult to diagnose in premature infants because either

obvious signs are absent or if present, are attributed to developmental immaturity. This might be the reason for occurrence of higher percentage of MRI changes in the present study.[18]

In the present study, periventricular leukomalacia was found to be present in 1 patient, 9 patients and 1 patient of Group 1, Group 2 and Group 3 respectively. Basal Ganglia and/or thalamus lesions were found to be present in 1 patient, 8 patients and 20 patients of Group 1, Group 2 and Group 3 respectively. Multicystic encephalopathy was found to be present in 3 patients and 2 patients of Group 2 and Group 3 respectively. Subcortical while matter findings were found to be present in 4 patients of Group 2 and 5 patients of Group 3 respectively. Periventricular leukomalacia was found to be present in significantly higher proportion among stage II HIE term neonates while Basal Ganglia and/or thalamus lesions were found present in significantly higher proportion among stage III HIE term neonates. Our results were comparable to the results reported in the past literature.

In a study conducted by Jose O et al, authors reported that 65% of term babies had changes in basal ganglia and/or thalamus. Out of the four babies with clinical stage 3 HIE 50% of them had bilateral basal ganglia involvement and 25% had bilateral thalami involvement. In their study, in HIE 2 cases, out of the 23 patients 27% had involvement of corpus callosam. 25% had PVL, 23% had basal ganglia or thalamus lesion. There was no MRI evidence of HIE in 11.5%. Out of 4 babies with stage 3 HIE, 50% had involvement of bilateral basal ganglia. 25% had bilateral thalami lesion and the rest showed subcortical white matter lesion.[13]

They also reported that in stage 2 HIE no stage specific change in MRI could be found. Preterm brain is highly susceptible to injury including periventricular leucomalacia, intraventricular hemorrhage/ germinal layer
hemorrhage and parenchymal hemorrhagic infarction.[13]

This is because basal ganglia and thalami are metabolically very active in the immature brain. Occasionally severe basal ganglia lesions are seen with less obvious precipitating events. This may reflect failure to recognize theseverity of asphyxia or due to individual susceptibility to damage because of previous hypoxic ischemic events or underlying metabolic or thrombotic disorders. Term infants who develop HIE following a well-defined acute hypoxic injury typically sustain bilateral lesions within the basal ganglia and thalami.[13]

In a study conducted by Ramachandran S et al, authors reported that among terms neonates with HIE, there were abnormal signals (T2WI and FLAIR hyperintensity with diffusion restriction) in basal ganglia in two neonates (7.7%) and scattered signal abnormalities in both cortex and basal ganglia in six (23.1%) neonates.[18]

Genedi EA et al conducted a study on role of magnetic resonance imaging in early identification of cerebral injuries in neonatal encephalopathy. Their study enrolled 38 neonates who presented with HIE. In their studyshowed positive findings in 33 neonates. Findings at MRI supported hypoxic- ischemic encephalopathy as an etiology in 25 neonates, other aetiologies included metabolic disorders in two, congenital neonatal infection in one, two cases of neonatal stroke, and congenital brain anomalies in two neonates and cerebral venous sinus thrombosis in one.[19]

In another study conducted by Jose A et al, authors reported that Ofthe 31 cases in their study, only 26 could undergo MRI brain (four deaths, one lost to follow-up). Among the 26 cases 16 (61.5%) had normal MRI, two (7.7%) showed abnormal signal in the basal ganglia/thalamus, and two (7.7%) showed abnormal signal in the cortex. Six (23.1%) cases showed abnormal signal in the cortex

and the basal ganglia.[20]

MRI is the most sensitive and specific imaging modality for evaluating suspected neonatal HIE. In neonatal brain imaging as compared to the adult brain, a relatively higher repetition time for both T1 (800 ms) and T2 (6500 ms) is used to optimize the signal-to-noise ratio and gray-white matter differentiation. On conventional MRI, HI injury to gray matter (cortex and deep gray matter) demonstrates characteristic T1-hyperintensity and variable T2-hyperintensity depending on duration of the imaging and pathological condition such as hemorrhage, encephalomalacia, or gliosis. White matter injury results in T1-hypointensity and T2-hyperintensity due to ischemia- induced edema or cystic encephalomalacia. Whereas, white matter injury with abnormal T1 hyperintensity and without marked T2 hypointensity denotes astrogliosis. The fluid attenuation inversion recovery (FLAIR) sequence is particularly useful for demonstrating cystic leukomalacia and gliosis. Gradient recalled echo-T2*-weighted sequence or susceptibility weighted imaging is particularly sensitive for detecting hemorrhage and distinguishing it from astrogliosis.[21,22]

In term neonates, mild to moderate HI injury produces parasagittal watershed zone infarcts between anterior/MCA and middle/posterior cerebral artery. Both the cortex and underlying subcortical white matter are involved. Severe HI injury results in injury to metabolically active tissues such as ventrolateral thalami, posterior putamina, hippocampi, brainstem, corticospinaltracts, and sensorimotor cortex. Basal Ganglia (BG) injury is more common than parasagittal pattern and carries the worst prognosis.. MR scan of term infants with chronic HIE may reveal cortical atrophy and thinning (ulegyria) and multicystic Encephalomalacia.[23,24]

In a previous study conducted by Rutherford MA et al, authors established whether abnormal signal intensity in the posterior limb of theinternal capsule (PLIC) on magnetic resonance imaging is an accurate predictor of neurodevelopmental outcome at 1 year of age in infants with hypoxic-ischemic encephalopathy (HIE). They have examined 73 term neonates with HIE between 1 and 17 days after birth with cranial magnetic resonance imaging and related the magnetic resonance imaging findings to neurodevelopmental outcome at 1 year of age. The absence of normal signal predicted abnormal outcome in term infants with HIE with a sensitivity of 0.90, a specificity of 1.0, a positive predictive value of 1.0, and a negative predictive value of 0.87. The test correctly predicted outcome in 93% of infants with grade II HIE, according to the Sarnat system. Applying a Bayesian approach, the predictive probability of the test (the probability that the test would predict an outcome correctly) was distributed with a mean of 0.94 and 95% confidence limits of 0.89 to 1.0. Abnormal signal intensity in the PLIC is an accurate predictor of neurodevelopmental outcome in term infants suffering HIE.[25]

Twomey E et al in another study, assessed whether MR imaging that included DWI, measured ADC values and T1- and T2-weighted sequences ultimately correlated with either neurodevelopmental outcome or with late MR imaging at 2 years of age. All infants presenting with HIE who had an MRI within 10 days of life were eligible for enrollment and subsequently underwent a full neurodevelopmental assessment at 2 years of age. All children underwent repeat MRI at this time. The patterns of injury on the early DWIand ADC maps and early T1- and T2-W studies were recorded as diffuse, central, watershed or atypical. The patterns of signal abnormality were assessed using a scoring system that yielded four separate scores [basal ganglia (BG), watershed (W), BG/W and summation (S)] for the three sets of images, a total of 12 scores in all. The appearance of the posterior limb of the

internal capsule (PLIC) on T1-W inversion recovery sequences and of the corpus callosum on all sequences was also documented. After detailed neurodevelopmental assessment at 2 years of age, infants were classified into two groups according to whether they had a favourable or unfavourable outcome. Of the 26 infants, 6 infants died before formal assessment at the age of 2 years. A further 5 infants had moderate to severe cerebral palsy in addition to severe cognitive impairment. The remaining 15 infants were categorized in the favourable outcome group. The US appearance performed well in terms of predicting final outcome (P = 0.005). The pattern of ischemia seen on early MRI was a significant predictor of outcome (P < 0.0001). Assessment of the PLIC in infants with watershed or atypical patterns of ischemia was found to be less reliable in predicting outcome. The measured ADC value in the PLIC was significantly reduced in those children who had an unfavourable outcome (P = 0.03). While early MRI performed better than cranial US, the sonography findings were useful. The pattern of ischemia on early MRI was a good predictor of prognosis.[26]

Conclusion

MRI is a useful modality to assess the early changes noted in HIE. Bilateral basal ganglia and/or bilateral thalami lesions were the predominant finding in stage 3 HIE while Periventricular leukomalacia was the predominant finding in stage 2 HIE. The clinical diagnosis of birth asphyxia, along with the closely related conditions of hypoxic ischemic encephalopathy is recognized as an important cause of morbidity and mortality in newborns. Early diagnosis helps in management, prognosis and also in counselling the parents.

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