Original Article

Pediatric Education and Research
Volume 7 Number 3, July - September 2019
DOI: https://dx.doi.org/10.21088/per.2321.1644.7319.6

Correlation of EEG, CT, and MRI Brain with Neurological Outcome at 12 Months in Term Newborns with Hypoxic Ischemic Encephalopathy

Sharda C Aher[1], Suhas Ghule[2], Sunil Mhaske[3]

[1]Resident, Dept. of Pediatric [2]Associate Professor, Dept. of Radiology [3]Professor and Dean, Dept. of Pediatric, Padmashree Dr.Vithalrao Vikhe Patil Foundation's College, Vilad Ghat, MIDC, Ahmednagar, Maharashtra 414111, India.

How to cite this article:
Sharda C Aher, Suhas Ghule, Sunil Mhaske. Correlation of EEG, CT, and MRI Brain with Neurological Outcome at 12 Months in Term Newborns with Hypoxic Ischemic Encephalopathy. Pediatr Edu Res. 2019;7(3):113–117.

Abstract

Objective: To study the correlation between electroencephalograms (EEG), computed tomography (CT), and magnetic resonance imaging (MRI) brain with neurological result at 12 months in term neonates with hypoxic ischemic encephalopathy. *Design:* Prospective observational study. *Materials and Methods:* :The study has been conducted between August 2017 and August 2018. Termneonates with perinatal asphyxia and hypoxic ischemic encephalopathy were the subjects. All babies were managed as per standard protocol in a tertiary health care hospital in NICU (Neonatal Intensive Care Unit). EEG was done as soon as the baby was stable and CT brain within 7 days. MRI was done at 3 months. Neurodevelopmental assessment was done at 1 year. *Results:* Out four babies died of total 31, four babies died. 15 babies showed normal neurodevelopmental results at the age of 1 year. EEG results were normal in six babies and all of them had a normal neurodevelopment. Thirteen of the 14 babies with burst suppression pattern were abnormal. CT brain reports were normal in 14 babies and all of them had normal neurodevelopment while 11 of the 12 babies with cerebral edema had abnormal outcome. Of the 16 babies with normal MRI, 14 were normal, while all six babies showing abnormal signals in the cortex and thalamus had unfavorable outcome. *Conclusions:* Term newborn babies with hypoxic ischemic encephalopathy (HIE) and showing normal EEG & CT Brain results is associated with good neurological outcome. Babies showing Burst suppression pattern in EEG & bleeds & or hypodensities in the CT and involvement of basal ganglia/thalamus in the MRI are predictors of unfavourableunfavorable outcome.

Introduction

With the advancement in understanding of the pathogenesis of hypoxic ischemic encephalopathy (HIE), it is still the most anxious and worrisome neurological disease of the newborn. The reported incidence of HIE vary from one to four per 1,000 live births. Hypoxic–ischemic encephalopathy (HIE) is an important cause of permanent damage to CNS tissues that may result in neonatal deaths or manifest later as cerebral palsy or developmental delay. Approximately 20–30% of infants with HIE die in the neonatal period, and 33–50% of survivors suffer from permanent neurodevelopmental abnormalities (cerebral palsy, mental retardation)[1] HIE is the foremost concern as it leads to CNS dysfunction and has the potential to cause long term neurological sequelae among the survivors. An early assessment of severity of HIE would help proper parent counseling and early institution of stimulation therapy for better development of the infant. In this study, an attempt has been made to associate the electroencephalogram (EEG) and CT brain done in the newborn period and MRI brain done at 3 months of age with the neurological outcome at 1 year in terms of asphyxiated newborns.

Corresponding Author: Sharda C Aher, Resident, Dept. of Pediatric, Padmashree Dr.Vithalrao Vikhe Patil Foundation's College, Vilad Ghat, MIDC, Ahmednagar, Maharashtra 414111, India.

E-mail: drshado23@gmail.com

Received on 25.06.2019, **Accepted on** 16.08.2019

Materials and Methods

This was a prospective observational study conducted from August 2017 to August 2018 at the tertiary health care hospital in NICU. The study population included term newborns with perinatal asphyxia and HIE admitted to the newborn intensive care unit.

Definition of HIE

Perinatal asphyxia was defined as when there is presence of two or more of following:[2]

(a) Signs of fetal distress as indicated by one or more of the following: Fetal bradycardia (≤100 beats/min), thick meconium staining of liquor, abnormal cardiotocography recordings, arterial cord ph <6.7 or base deficit >25 mmol/L.

(b) Apgar score <5 at 5 min of life.

(c) Need for >10 min of positive pressure ventilation before occurrence of sustained respiration.

(d) A sentinel hypoxic or ischemic event occurring immediately before or during labor and delivery: ruptured uterus, severe abruption placentae, umbilical cord prolapse, maternal hypotension and collapse.

(e) Fetal HR monitor patterns: Category I pattern (normal) converting to Category III (sinusoidal pattern or absent variability with recurrent late decelerations, recurrent variable decelerations, or bradycardia) is suggestive of hypoxic-ischemic event.

Inclusion Criteria

All term newborn completed 37 weeks of gestation born who went under peripartum hypoxic insult.

Exclusion Criteria

I. All newborn babies who were born with gestational age ≤ 36 + 6 or had

II. Major congenital anomalies/inborn error of metabolism

II. Low Apgar score as a result of maternal sedation

New born babies who fulfilled the inclusion criteria were admitted to the neonatal intensive care unit (NICU) and included in the study. The study was approved by the institutional ethics committee. Informed written consent was obtained from the parents.

Details regarding the mother's medical history, antenatal illnesses, mode of delivery, duration of labor, and drugs administered were obtained. The neonates were classified into one of the three stages of Sarnat and Sarnat classification for HIE.[3] The babies were all managed as per the standard management protocol of the neonatal unit which did not include hypothermia.

All babies had an EEG recorded during the first 72 hours of their life or as soon as the baby was secure. EEG recording was done using recorders and medi-care system (RMS) recorder and the electrodes were placed according to 10:10 system which is the internationally recommended system for infants. The EEG was reported by a single trained neurologist, who was blinded to the clinical status of the baby. The different patterns in EEG were classified into normal continuous activity, secluded temporal spikes, transient discontinuous activity, and permanent discontinuous activity/ suppression burst.[4] The CT scan was done between 72 hours of life and the 7th day, as the clinical condition of baby was improved. The findings were accepted as normal/cerebral edema and other changes such as intracranial or extra cranial bleeds, and areas of hypodensities.

Magnetic resonance imaging (MRI) was done at 10–12 weeks of age under sedation. The MRI findings were classified according to basal ganglia/ watershed pattern as described in a study by Barkovich *et al*.[5]

Classification for MRI score

Normal- 0

Abnormal signal in basal ganglia/thalamus- 1

Abnormal signal in cortex- 2

Abnormal signal in areas of cortex and basal nuclei- 3

Abnormal signal in the entire cortex and basal nuclei- 4.

The CT and MRI scans were reported by qualified radiologists who were blinded to the clinical details. The babies were followed-up at 3, 6, and 12 months of age. Parents were told to report in between, if there were any unusual abrupt neurological deterioration or seizures. During the follow-up period, seizure recurrences

and developmental milestones were noted and neurological examination carried out.

At 12 months of age, a complete neurological evaluation was done by a pediatrician and developmental assessment was done by the authors. Developmental screening was done by two authors separately, using Denver Developmental Screening Test II (DDST II). While doing DDST II the items intersected by and just adjacent to the age line were tested. The items were denoted as '*p*' for pass, 'F' for failed, 'No' for no opportunity, and 'R' for refused to cooperate or attempt. The interpretation of the individual items was made as follows:

a. *Advanced:* Child passes item that falls completely to the right of the age line
b. *Normal:* Child passes, fails, or refuses item on which the age line falls between the 25th and 75th percentile
c. *Caution:* Child fails or refuses item on which the age line falls between the 75th and 90th percentile
d. *Delayed:* Child fails or refuses item that falls completely to the left of the age line
e. *No opportunity:* Child has had no chance to perform the item (taken only for report items).

DDST II test interpretation was done as

I. *Normal:* Child with no delays and a maximum of 1 caution
II. *Suspect:* Two or more cautions and or one or more delays
III. *Untestable:* Refusal scores on 1 or more items completely to the left to age line or; more than one item intersected by the age line in the 75–90th percentile area. These children were rescreened again.

Infants with a normal neurological examination and normal DDST II were considered as normal neurodevelopmental outcome and those who had an abnormal neurological examination and/or untestable DDST II were taken as poor neurodevelopmental outcome. Those with suspect DDST II had a re-evaluation after 2 weeks.

Results

There were 50 newborns with birth asphyxia admitted during the study period. Out of them 3 had inborn errors of metabolism and were not incorporated. 7 were excluded due to major congenital anomalies. 10 were preterm and so not included. Among the remaining 30, there was 22 males and seven females. One was lost to follow-up. Four infants (13.3%) died. While 18 babies had birth weights between 2.5 and 3 kg, three were over 3.5 kg, and one weighed less than 2.5 kg. Seven were born normally, while 11 were instrumental, and 18 were born by lower segment caesarian section (LSCS). While nine babies had Sarnatstage 1, nine were in stage 3. EEG showed normal continuous activity in six (19.4%), isolated temporal spikes in four (12.9%), transient discontinuous activity in seven (22.6%), and permanent discontinuous activity in 14 (45.2%).

The CT brain was normal in 14 (45.2%), in 12 (38.7%) there was cerebral edema, and in five (16.1%) there were bleeds or hypodensities.

The MRI was normal in 16 (61.5%). There were abnormal signals in basal ganglia in two (7.7%) in the cerebral cortex and scattered signal abnormalities in both cortex and basal ganglia in six (23.1%). MRI could not be done in the four babies who died.

Neurological examination at 12 months was normal in 17, while there were neurological deficits in nine babies. DDST II was normal in 15, while in 11 it was suspect.

The correlation of neurological outcome with EEG is shown in Table 1, with CT brain in Table 2 and with MRI in Table 3. The value of the three modalities in predicting an abnormal outcome is shown in Tables 1-3.

Table 1: Correlation of electroencephalogram with neurodevelopmental outcome

EEG pattern	Normal outcome		Abnormal outcome	
	No.	%	No.	%
Normal continuous activity	6	40.0	0	0.0
Isolated temporal spikes	4	26.7	0	0.0
Transient discontinuous activity	5	33.3	2	13.3
Permanent discontinuous activity/ suppression burst	0	0.0	13	86.7
Total	15	100.0	15	100.0

Table 2: Correlation of computed tomography scan with neurodevelopmental outcome

CT brain	Normal outcome		Abnormal Outcome	
	No.	%	No.	%
No abnormality	14	93.3	0	0.0
Edema	1	6.7	12	80
Others	0	0.0	36	20
Total	15	100.0	15	100.0

Table 3: Correlation of magnetic resonance imaging scan with neurodevelopmental outcome

MRI brain	Normal outcome		Abnormal outcome	
	No.	%	No.	%
Normal	14	93.3	2	18.2
Abnormal signal in basal ganglia or thalamus	0	0.0	2	18.2
Abnormal signal in cortex	1	6.7	1	9.1
Abnormal signal in cortex and basal nuclei (basal ganglia or thalami)	0	0.0	6	54.5
Abnormal signal in entire cortex and basal nuclei	0	0.0	0	0.0
Total	15	100.0	11	100.0

Discussion

This study attempted to associate EEG and neuro-imaging with neurological outcome in term babies with HIE. Out of the 31 cases, six (19.4%) had normal EEG pattern and all of them had a normal outcome. This is similar to the finding by El-Ayouty *et al*., who reported that normal EEG background activity was associated with normal neurological outcome at 12 months of age.[6] It was associated with all the 14 babies who showed permanent discontinuous activity or suppression burst pattern had Sarnat stage 2 or 3 HIE. Thirteen out of these 14 cases with suppression burst pattern (one case lost to follow-up) had an abnormal outcome; which is death, neurological deficits, or suspect cases as shown by the DDST II assessment. In a study done by Caravale *et al*, showed that out of the 52 who had normal EEG, 83% had a normal outcome at 1 year, 17% had mild abnormalities and none of them had any severe abnormalities.[7] Presslan *et al*., have documented the usefulness of serial EEG in the newborn period in predicting the neurological outcome.[8] A suppression burst pattern recording obtained on any day of life is associated with a very high likelihood of an unfavorable outcome.[9] Imaging studies are usually done in all neonates with HIE. MRI is difficult to perform during the acute stage, since it takes almost an hour and needs deep sedation which is risky in asphyxiated babies. CT is easier to perform and helps in practical management by detecting intracranial hemorrhage, infarction, and cerebraledema.

Of the 30 CT scans, 14 (45.6%) were normal, 12 (40%) had cerebral edema of varying degree, and five (16.1%) had other findings (left frontoparietal and temporal lobe wedge-shaped hypodensity, white matter hypodensity, subarachanoid hemorrhage, subgaleal bleed, and thalamic hypodensity with loss of gray and white matter differentiation). All neonates with normal CT scan had normal outcome. Eleven cases with cerebral edema had abnormal outcome and four cases with other findings in CT had an abnormal outcome.

Of the 30 cases in the study, only 26 could undergo MRI brain (four deaths). 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. Of the 16 infants with normal MRI, 14 had a normal outcome. Two infants had a normal neurological assessment, but an abnormal DDST score and were labeled as suspects. El-Ayouty *et al*., in their study of 25 new borns have reported that all infants with a normal MRI in the first 4 weeks were neurologically normal at 12 months of age.[6] All the six cases which had shown abnormal signals in the cortex and thalamus had an abnormal outcome.

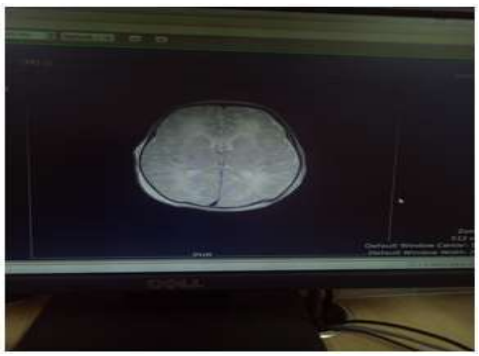

Fig. 1:

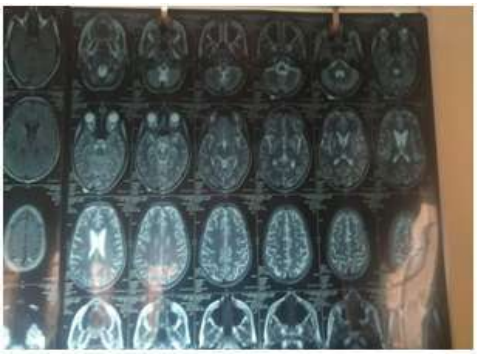

Fig. 2:

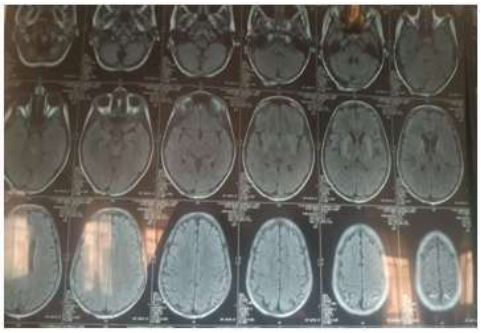

Fig. 3:

Fig. 4:

Figs. 1-4: MRI images showing cerebral oedema

Many studies have found the basal ganglia watershed score to be an excellent predictor of the neurological outcome.[10]. The result of our study is also similar, though the MRI in this study was done later than in the former. Studies based on the topographic pattern of neuronal injury have shown that term infants with predominant injury to basal ganglia and thalamus have an unfavorable neurological outcome. In our study, it was seen that all infants with lesions in the basal ganglia and/or thalamus had an abnormal outcome, which is consistent with the findings of other studies.

An attempt was made to see if EEG in addition to an imaging study improves the predictive ability. In our study, combining EEG with CT brain did not result in better prediction. However, an early EEG followed by an MRI at 3 months predicts neurological outcome with the highest statistical significance. Biagioni *et al*., have reported very good correlation between EEG and MRI findings in neonatal encephalopathy and affirmed their value in predicting the neurological outcome.

Our study shows that in a term newborn with HIE, a normal EEG and/or CT scan of brain during the acute phase of illness is associated with good neurological outcome. Burst suppression pattern in the EEG and bleeds or hypodensities in the CT in the acute stage indicates a poor outcome. Involvement of the basal ganglia/thalamus in the MRI at 3 months of age also indicates a poor prognosis. EEG in the acute phase of HIE, combined with an MRI at around 3 months during follow-up is most useful in predicting the neurological outcome at 1 year. Similar studies using larger numbers of patients and follow-up for longer duration are needed to confirm the findings of our study.

Conclusion

This study attempted to correlate EEG and CT brain during the acute phase and an MRI at 3 month follow-up of term newborn babies who had HIE with their neuro-developmental outcome at 1 year. While a normal EEG and CT brain is associated with normal neurological outcome, Burst suppression pattern in EEG and bleeds/hypodensities in the CT scan were predictive of adverse outcome. While abnormal MRI at 3 months has a specificity of over 90% in predicting a normal outcome, involvement of the thalamus or basal ganglia indicates a poor outcome. Clinicians can judiciously use this data to reassure some of the anxious parents of babies with HIE who are worried about neuro-developmental outcome.

References

1. Ambalavanan N, Waldemar A. Carlo hypoxic-ischaemic encephalopathy. Nelson textbook of Paediatrics, 21st edition. Elsevierpub; 2019.
2. Onglc, Kanaheswariy, Chandranv, *et al*. The usefulness of early ultrasonography, electroencephalography, and clinical parameters in predicting adverse outcome in asphyxiated terminfants. Singaporemedj. 2009;50:705–09.
3. Sarnat HB, Sarnat MS. Neonatal encephalopathy following fetal distress. A clinical and electroencephalographic study. Archneurol. 1976;33:696–705.
4. Seltond, Andrém. Prognosis of hypoxic-ischaemic encephalopathy in full-term newborns-value of neonatal electroencephalography. Neuropediatrics. 1997;28:276–80.
5. Barkovichaj, Hajnal BL, Sola A, *et al*. Prediction of neuromotor outcome in perinatal asphyxia: Evaluation of MR scoring systems. AJNR Am J Neuroradiol. 1998;19:143–49.
6. El-ayouty M, El-mogys, Zaghlol H, *et al*. Prognosis of term infants with Hypoxic is chemic encephalopathy: A clinical, EEG and MRI study. Int J Child Neuropsychiatr. 2005;2:56–73.
7. El-ayoutym, Abdel-Hadyh, El-mogys, *et al*. A relationship between electro-encephaologography and magnetic resonance imaging findings after hypoxic-ischemic encephalopathy atterm. Amjperinataol. 2007;24:467–73.
8. Caravale B, Allemandf, Libenson MH. Factors predictive of seizures and neurologic outcome in perinatal depression. Pediatrneurol. 2013;29:18–25.
9. Presslanr M, Boylang B, Morton M. Early serial EEG in hypoxic ischemic encephalopathy. Clinneurophysiol. 2001;112:31–37.
10. Berger R, Garniery. Perinatal brain injury. J Perinat Med. 2010;28:261–85.