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Original Research Article

Cross Sectional Study of Diagnostic Contribution of Cerebral Magnetic Resonance Imaging and Cranial USG among Patients of Infantile Seizure in a Tertiary Care Centre in Western India

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Abstract

Introduction and Importance of this Study: Seizures are caused by abnormally synchronous and excessive brain activity. The causes of seizures in infancy are mostly brain structure-related, like HIE, CNS malformations, brain haemorrhage, brain infarcts, CSVT etc. These conditions are diagnosed by pediatrician by clinically but require imaging for exact diagnosis. Currently cranial US and MRI are modality for these condition for diagnosis. This study was to compare the function of MRI in determining the cause of neonatal seizures to that of C-USG in the diagnosis and management of neonatal seizures. If only C-USG had been utilized, the diagnosis could have been missed, and cerebral MRI added to the information.This study will demonstrate the role and advantages of MRI in identifying the aetiology of neonatal seizures, which will give the treating physician specific anatomical information on the neonatal convulsions, assisting in patient care and improving the efficacy and accuracy of treatment. **Results:**60 patients with seizure who are younger than 90 days have been taken. All cases were screened by USG and then considered for MRI. Out of these, almost half are cases of HIE; the second most common cases were haemorrhage; other cases are cases of CSVT; cerebral infarcts; ventriculitis; meningitis; cystic encephalomalacia; porencephalic cyst; hydranencephaly; metabolic causes and normal. In our study, MRI showed detailed findings that were missed on USG.

Conclusion: The study shows HIE as the highest aetiology, followed by hemorrhagic causes. Based on the findings of the present study, the frequency of pathologic findings in neonatal brain ultrasonography was 85% and in MRI was 96%. Thus, MRI brain scans are superior to USG scans for the evaluation of infantile seizures.

Keywords: Hemorrhagic, cystic encephalomalacia, cerebral infarcts, pediatrician

Introduction

A seizure is an excessively high level of synchronous or excessive brain activity.

They are the most common neurological issue in the nursery, and they frequently call for testing and therapy in a neonatal critical care unit.

One of the early-onset epileptic syndromes is infantile seizures (IS). They can arise in the form of an extension, flexion, or mixed group of spasms. Up to twelve times a day are possible. They may occasionally be accompanied by apnea, a sudden bout of sobbing, or eye closure. They mostly affect infants under 1 year old and, to a minor extent, young children. Developmental regression may result from them.[1]

Numerous neuroimaging characteristics have been linked to infantile spasms in the literature. Examples include hypoxia-ischemic encephalopathy, abnormalities of cortical development, meningitis, vascular insults, post-traumatic alterations in metabolism, structural lesions like corpus callosum dysgenesis, and infections like meningitis. Although an estimated frequency of 80–120 instances per 100,000 newborns per year has been proposed, the prevalence of neonatal seizures has not been completely verified. Seizures are more common in the initial week of life and occur more frequently in the newborn era or at any other period in life.[2].

The diagnosis is based on determining what caused the seizure and confirming that there was actually a seizure by detecting electrical impulses with electroencephalography (EEG). Understanding the underlying aetiology of a verified seizure is crucial since it affects treatment options and prognosis[3].

Seizures in newborns are most frequently caused by hypoxic-ischemic encephalopathy. Other causes include intraventricular haemorrhage and perinatal arterial stroke. Central Nervous System, Congenital Malformations of the Central Nervous System (Lissencephaly, Polymicrogyria, and Tuberous Sclerosis are specific conditions known to induce seizures), Inborn Metabolic Errors, Infection, and Electrolyte Abnormalities Hypoglycemia[4].

It might be challenging to identify seizure activity in a newborn since many seizures lack a clinical correlate. The only indication is frequently an altered degree of consciousness, and in a newborn, it can be challenging to determine this. Electroencephalography (EEG) is used to try and directly measure the aberrant electrical impulses in the brain in order to make a diagnosis[5]

Although imaging is not necessary to diagnose infantile spasms, it is the most crucial way to determine the cause and/or guide additional tests. Magnetic resonance imaging (MRI) of the cerebral cortex reveals an identifiable aetiology in 50–73% of cases. However, 5- 20% individuals may have anomalies that are not diagnostic.[6]

An imaging technique allows brain scientists to identify parts of the brain, such as the brainstem, cerebral cortex, cerebellum, and much more [7].

While imaging techniques and brain structure share many characteristics, a closer examination of a person's brain reveals significant individual variances. For instance, the location, size, and form of the central sulcus, among other things.[8]

The imaging technique is a diagnostic tool used to identify anatomical alterations in the brain that could lead to seizures or be linked to epilepsy. Because numerous causes of seizures might be quickly cured and long-term consequences avoided, determining the underlying cause is critical. To avoid needless radiation exposure, brain injuries such as cerebral infarction or haemorrhage can be examined using imaging techniques like magnetic resonance imaging (MRI) and cerebral ultrasonography. After a first non-febrile seizure, diagnostic imaging by

computed tomography (CT) and MRI is advised to detect structural abnormalities inside the brain. MRI is a better imaging test in general, unless cerebral haemorrhage is suspected.

Thus, present study was planned to evaluate diagnostic contribution of magnetic resonance imaging and cranial USG among patients of early infantile seizure at SMS Medical College Jaipur.

Aim and Objective

The aim of this study was to delineate etiologies and explore the diagnostic value of cerebral magnetic resonance imaging (MRI) in addition to cranial ultrasonography (cUS) in infants presenting with early infantile seizures.

Objective:-To assess and evaluate the accuracy of cerebral MRI for diagnosis of infantile seizure.

Materials and Methods

Study Type: Observational study.

Study Design: Cross sectional study.

Study Universe: All patients admitted in neonatal intensive care unit in SMS Medical College & Hospital.

Sampling Technique:Every eligible case was included in the study.

Study Population: The study was include all neonates who were suspected Neonatal seizure, who admitted in NICU SMS Hospital, Jaipur, Rajasthan.

Study Area: Department of Radiodiagnosis, SMS Hospital, Jaipur, Rajasthan.

Study Duration: Data collection for study were start after approval from the institutional research and review board, up to June 2022 or till sample size is achieved, whichever, is earlier. Then it was taken another 2 months to process the data and write the thesis.

Ethics approval

The study was approved by the Department of Radiology, SMS Medical College, Jaipur, Rajasthan, Medicine Research Ethics Committee, Rajasthan university of health sciences.

Sample Size: Sample size is calculated at 95% confidence level of (α error of 0.05) assuming incidence of HIE being 46% among all cases of Neonatal seizure as found in seed article (The aetiology of neonatal seizures and the diagnostic contribution of neonatal cerebral magnetic resonance imaging).

At the absolute allowable error of 12.5% the required sample size for the study is 60 cases.

Inclusion Criteria

1. Children from birth to 90 days of age with neonatal seizure suspected by paediatrician.
2. Parents/guardians willing to participate in the study by giving written and informed consent.

Exclusion Criteria

1. Hemodynamically unstable neonate
2. Refusal to consent.

Study Tool:

Pre-tested, pre-designed proforma were used to collect data.

Equipment:

MRI -3T Philips ingenuity MRI Scanner

USG -Hitachi preirus high frequency probe

Enrolment:

Parents of subjects who satisfy the eligibility criteria were approached for participation in the study. An Information Sheet providing the details of the study were provided and the nature of the study were also be verbally explained. Written informed consent were

obtained. Enrolment, recording of baseline information USG and MRI were done after written informed consent is obtained. Screening, assessment of eligibility criteria and obtaining consent were the responsibility of the thesis candidate.

Methodology:

1. Children who visit neonatal emergency OPD admitted in NICU with suspected Neonatal seizure from the commencement of study to June 2022 was enrolled after taking written informed consent from the parents/ guardian.
2. Cranial USG were done at our institute.
3. A brief history and examination was done at the time of MRI scan.
4. Image acquisition were done in Cranial USG in Axial an Sagittal planes with doppler findings of ACA.
5. This information was compared with USG and MRI for relevance of additional information.
6. The accuracy of prospective cerebral MRI and C-USG findings were compared with each other.

DATA COLLECTION:

- **Baseline data**

The following baseline data were recorded by the thesis candidate in a structured proforma :

1. Demographic profile
2. Vital signs and physical findings

Statistical Analysis

Data were expressed in terms of number and percent in both modalities with appropriate and necessary tabular presentation. Appropriate statistical test was used for data analysis.

P value <0.05 were taken as significant.

Observations & Results

Table 1: Distribution of Cases according to Age

Age	N	%
≤30 days	26	43.33
31-60 days	20	33.33
61-90 days	14	23.33
Total	60	100.00
Median	60	
IQR	20.5-60	
Range	2-90-	

Here, median age of infants is 60 days with majority of infants belongs to age group ≤30 days (43.33%), 33.33% are in group 31-60 days, 23.33% are of age group 61-90 days.

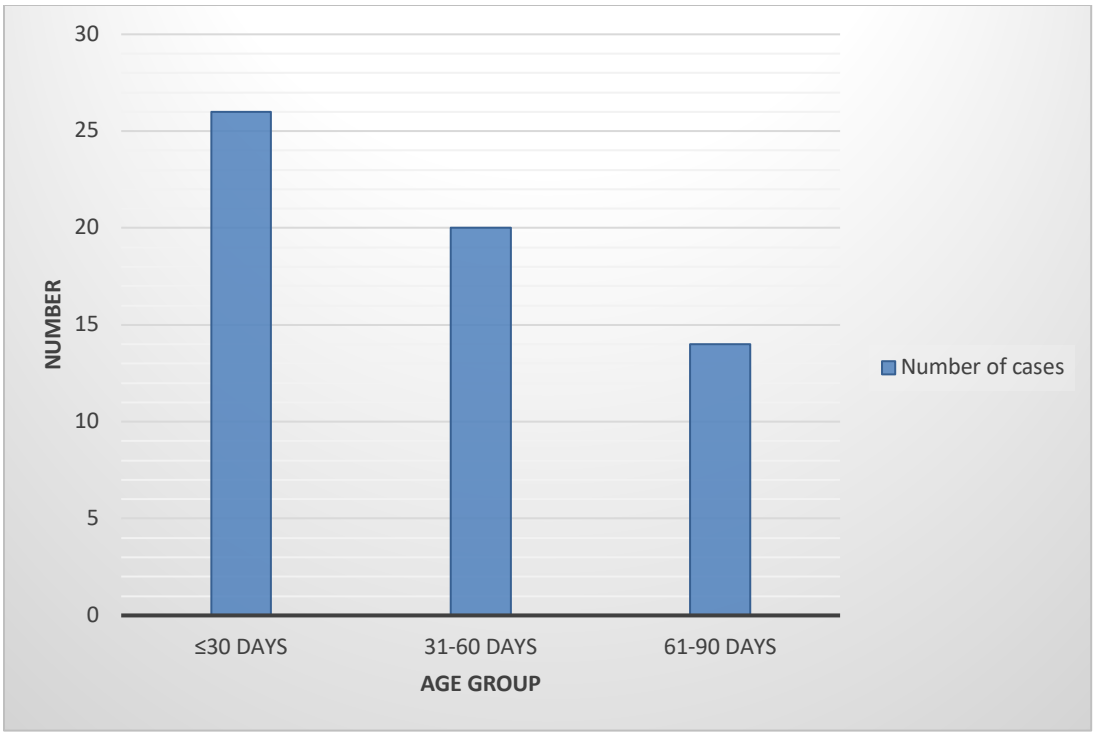


Figure 1

Table 2: Distribution of cases according to gender

Sex	N	%
Male	35	58.33
Female	25	41.67
Total	**60**	**100.00**

There are 58.33% male infants and 41.67% female infants.

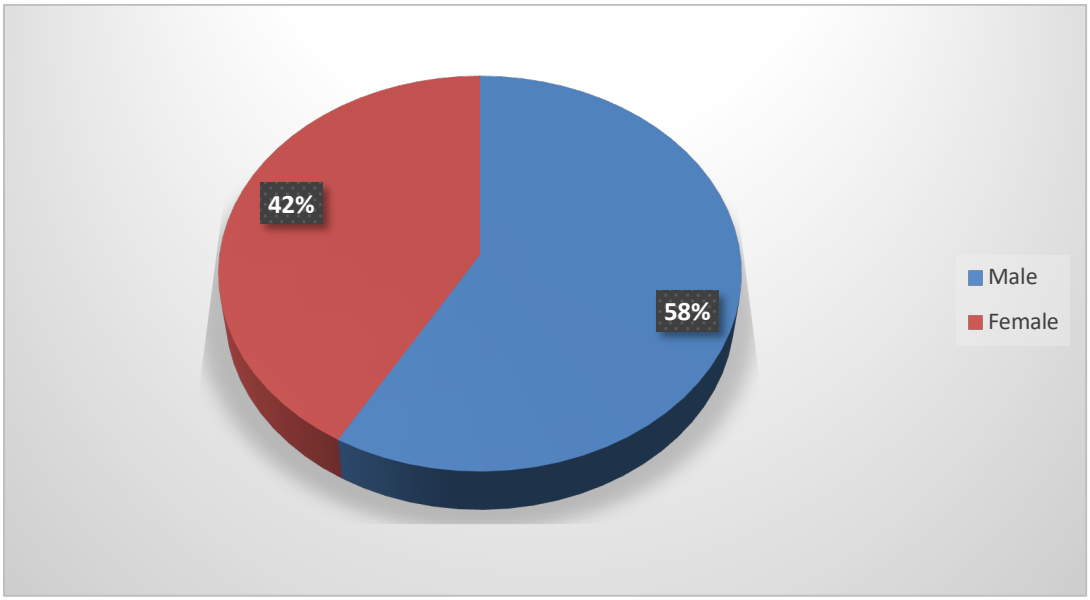


Figure 2

Table 3: Distribution of cases according to underlying cause of seizure

Diagnosis	N	%
Cystic encephalomalacia	1	1.67
Hydranencephaly with hydrocephalus	1	1.67
Meningitis	1	1.67
Metabolic	1	1.67
Ventriculitis meningitis	1	1.67
Normal	2	3.33
Porencephalic cyst	2	3.33
Ventriculitis	3	5
Infarcts	4	6.67
Venous sinus thrombosis	4	6.67
Haemorrhage	9	15
HIE	31	51.67
Total	**60**	**100**

Here, we found that hypoxic ischemic encephalopathy (51.67%) is the most common cause of seizure followed by 15% haemorrhagic cause, 6.67% each has infarcts and venous sinus thrombosis, 5% has ventriculitis, 3.33% has porencephalic cyst, and 1.67% each has cystic encephalomalacia, hydranencephaly with hydrocephalus, meningitis, metabolic and Ventriculitis meningitis.

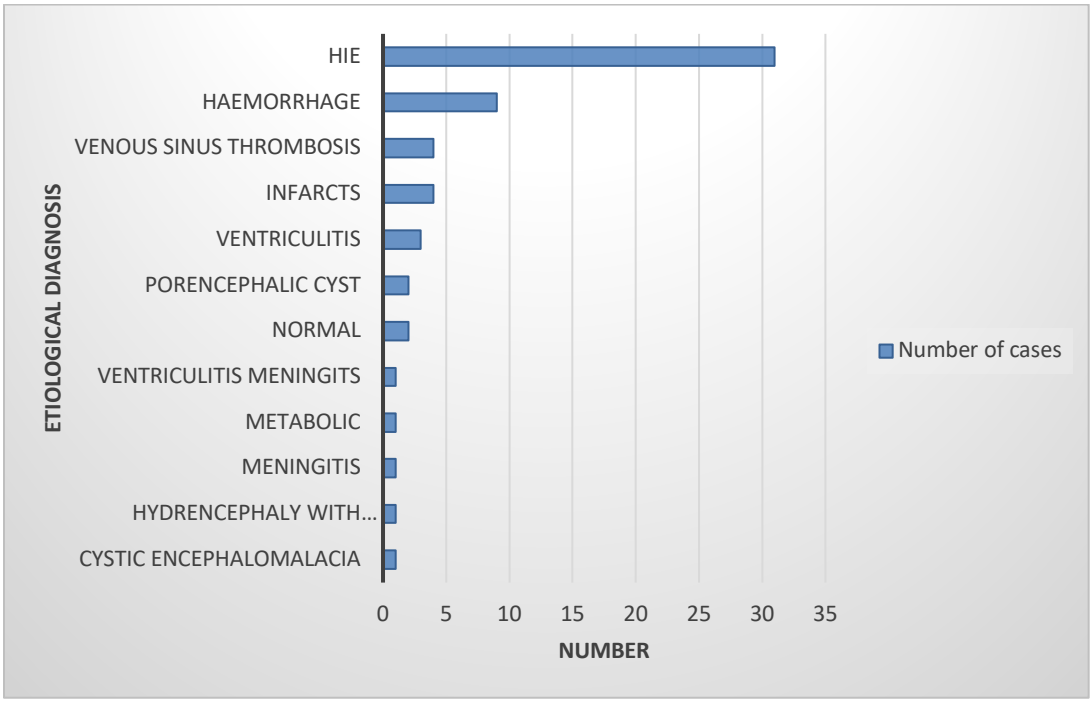
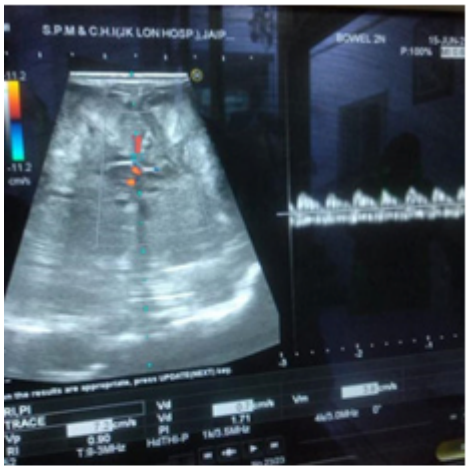


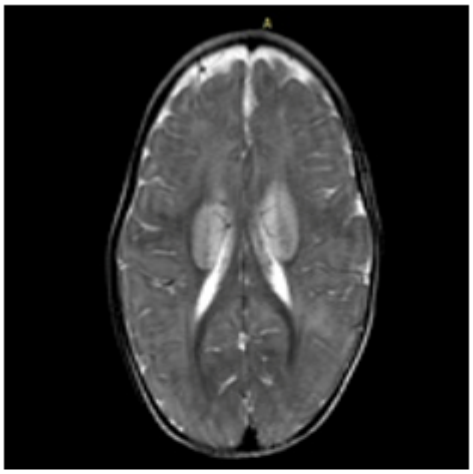
Figure 3

Here, HIE is present in 31 infants, out of them 27 has normal T1 sequence followed by 3 infants has hyperintensities in bilateral thalami and 1 infant has hyperintensities with DWI restriction and PLIC sign. T2 hyperintensities in bilateral thalami was found in 20 infants followed by 10 infants and 1 infant has T2 hyperintensities in bilateral thalami and putamen and perirolandic area and periventricular areas respectively. DWI restriction found in 19 infants followed by 10 infants has no restriction, 1 infants each has DWI sequence Hypointense and T2 shine through respectively. Fall in ADC value found in 19 infants and GRE sequence Normal in all of them.

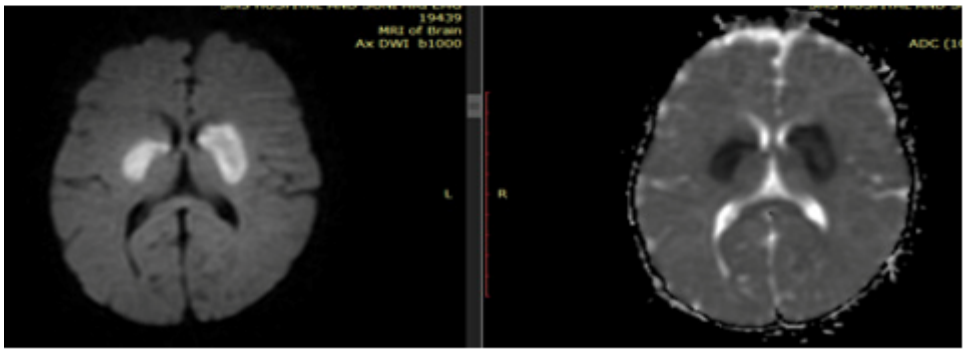
A 9 days female neonate with history significant for premature rupture of membranes for 22 hours and history of posturing movement, apnea, desaturations and refractory seizures



(A) Transcranial ultra sonography



(B)T2 WI Image



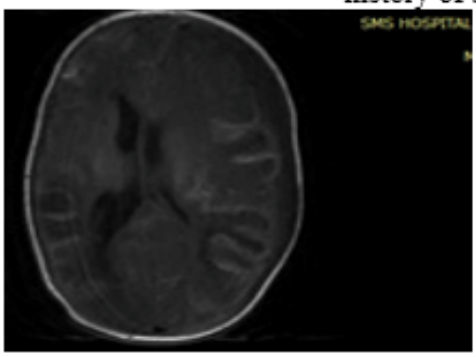
(C) DWI & (D) ADC

(A)Trans cranial USG showing Echogenecity in Bilateral Gangliothalamic Region with Increased RI value of Anterior Cerebral Artery.
(B,C,D) MRI Images showing T2 Hyperintesity in Bilateral Gangliothalamic Regions with Corresponding Diffusion Restriction on DWI Images s/o HIE changes

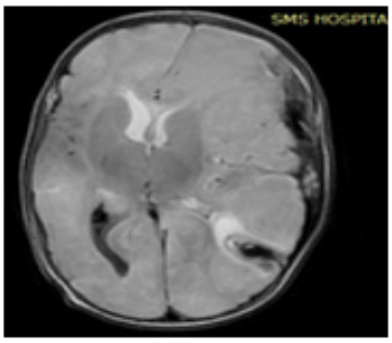
Out of 9 Haemorrhagic cases 7 has T1 sequence hypointense followed by 2 has hyperintense. T2 sequence hypointense in all 9 cases, DWI sequence restriction found in 2 infants, fall in ADC value found in 1 infant, and Blooming GRE sequence found in 8 infants.

A 1 Month male infant was presented with history of seizure since 5 days

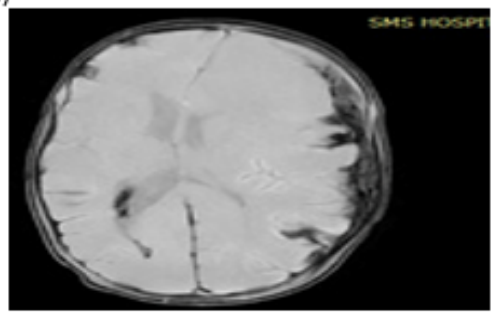
A 1 Month male infant was presented with history of seizure since 5 days



(A)

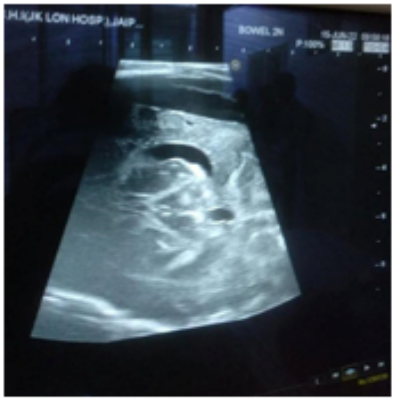


(B)

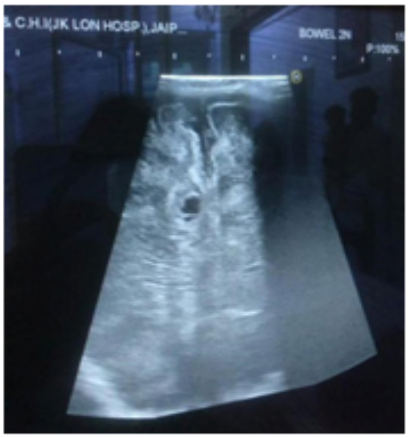


(C)

Image (A) to (C) : T1/T2 weighted images showing hypointensity with GRE images showing blooming along left fronto-parieto-temporal convexity and midline shift toward right side - Sub dural haemorrhage



(D)

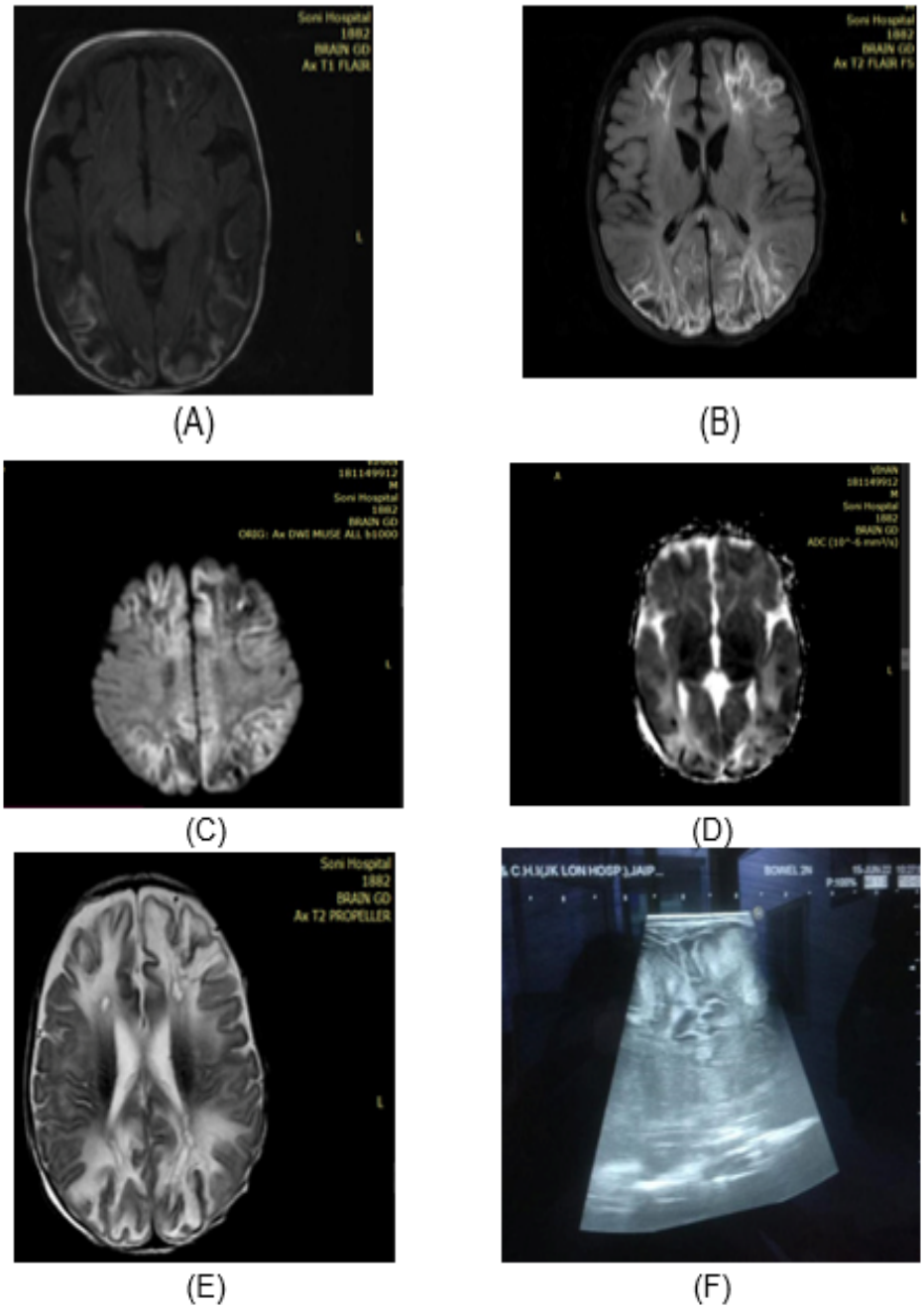


(E)

Image (D) & (E) : Transcranial USG showing hypoechoic collection with echoes noted in left sub dural space.

Out of 4 Infarcts cases 1 has T1 sequence hypointense and 3 has hyperintense. T2 sequence hypointense and hyperintense in 2 cases each, DWI sequence restriction found in 3 infants 1 infant has no restriction, fall in ADC value found in 2 infants, and Blooming GRE sequence found in 1 infant.

A full term baby delivered by Caesarean section due to antepartum hemorrhage.she had convulsion, no history of maternal fever no prolonged rupture of membrane.



Areas of T1 hyperintensity with diffusion restriction and mild post contrast enhancement are seen involving water shed areas of bilateral cerebral hemispheres. trascranial USG showing hyperechoic areas of brain parenchyma on bilateral cerebral hemisphere.s/o cerebral infract

Table 4: Cohen's Kappa coefficient used to estimate interrater reliability

		MRI	
		Abnormal	**Normal**
USG	Abnormal	51 (87.9)	0
	Normal	7 (12.1)	2 (100)
Kappa= 0.327 and p value=0.001(Significant)			
Kappa < 0: No agreement			
Kappa between 0.00 and 0.20: Slight agreement			
Kappa between 0.21 and 0.40: Fair agreement			
Kappa between 0.41 and 0.60: Moderate agreement			
Kappa between 0.61 and 0.80: Substantial agreement			
Kappa between 0.81 and 1.00: Almost perfect agreement			

Out of 58 cases who showed abnormalities in MRI, most of them 51(87.9%) were also abnormal in USG and two cases who were normal in MRI, were also found normal in USG . there was fair agreement between USG and MRI findings using Cohen's Kappa analysis and this agreement was found to be statistically significant (p value<0.05)

*Fisher's exact test – p value=0.020 (Significant)

Discussion

The identification of imaging characteristics linked with infantile seizures may aid in the identification of patients at increased risk of developing this severe epileptic encephalopathy. We present the clinical and imaging characteristics of newborns with diverse seizure aetiologies. Cranial MRI has been used to determine the cause of infantile seizures. Despite the fact that no unique pathologic engagement common for infantile convulsions has been discovered in cranial MRI, the diagnostic availability of causative lesions that additionally give therapeutic alternatives and prognosis considerations allows cranial MRI to maintain its ultimate importance in this condition.

In our study we found median age of infants is 60 days with majority of infants belongs to age group ≤30 days (43.33%), 33.33% were in group 31-60 days, 23.33% were of age group 61-90 days. There were 58.33% male infants and 41.67% female infants.

Here, we found that hypoxic ischemic encephalopathy (51.67%) is the most common cause of seizure followed by 15% haemorrhagic cause, 6.67% each has infarcts and venous sinus thrombosis, 5% has ventriculitis, 3.33% has porencephalic cyst, and 1.67% each has cystic encephalomalacia, hydranencephaly with hydrocephalus, meningitis, metabolic and ventriculitis meningitis. This result was consistent with earlier study Leth *et al* [9] who found that most common cause of neonatal seizures was hypoxic problems (35%), 26% haemorrhagic, 16% metabolic disorders and unknown in 23% (16).

Another study which is in favour of this result was Tekgul *et al*[11] where hypoxia was the most frequent cause of seizures (40%) and cerebral infarction the second most common cause (18%).

In our study, HIE was present in 31 infants; out of them, 27 had a normal T1 sequence, followed by 3 infants with hyperintensities in bilateral thalami and 1 infant with hyperintensities with DWI restriction and PLIC sign. T2 hyperintensities in bilateral

thalami were found in 20 infants, followed by 10 infants, and 1 infant had T2 hyperintensities in bilateral thalami, putamen, perirolandic area, and periventricular areas, respectively. DWI restriction was found in 19 infants, followed by 10 infants with no restriction and 1 infant with a DWI sequence. Hypointense and T2 shine through, respectively. A fall in ADC value was found in 19 infants, and the GRE sequence was normal in all of them. Similar to our study.Rorke *et al* [12] on MRI show that HIE in early infants exhibits primarily white matter injury. Johnson *et al* [13,14] study in 1983, and 1987 found that adding DWI to conventional MR imaging improves sensitivity for acute parasagittal lesions that are hypointense on T1-weighted images, hyperintense on T2-weighted images, and hyperintense on DWI. Barkovich AJ [23] showed conventional MR is the technique of choice for diagnosis. In HIE, hypointense foci in the basal ganglia show on T1-weighted sequences, corresponding to hyperintense lesions on T2 imaging. Approximately two to three days after injury, regions of hypointensity on T1 become hyperintense. Finally, lesions on T2 develop a hypointense look six to ten days after damage. These modifications are characteristic, whether they occur in the thalamus, perirolandic cortex, hippocampal formation, or dorsal mesencephalic regions. Shafi *et al*.[15] found that newborns with HIE showed separated cortical and subcortical, PLIC, and basal ganglion and thalamus (BGT) patterns..Weeke *et al*.[16] observed that the BGT pattern of injury is typically seen following an acute sentinel event; however, the occurrence of an acute sentinel incident could have been lower in the cohort of babies in the current investigation.

Out of 9 hemorrhagic cases, seven have hypointense T1 sequences and two have hyperintense T1 sequences. The T2 sequence is hypointense in all 9 cases, with hyperintensity found in bilateral lateral ventricles and bilateral thalami and putamen (1 case each), followed by hypointense T1 and T2 sequences in bilateral lateral ventricles in 4 infants, with hypointensity found in the bilateral parieto-occipital area, bilateral subarachnoid space, and right hemisphere with prominent intralesional venous channels. In addition, DWI sequence restriction was discovered in two newborns, a decrease in ADC value was discovered in one infant, and a blooming GRE sequence was discovered in eight infants. Shafi *et al* [15] reported Three (43%) infants had bilateral intraparenchymal bleeding. The frontal and parietal lobes were the most commonly affected. Three of the five neonates with intraventricular haemorrhage (IVH) had grade II IVH, whereas the other two had grade III IVH with communicating-type hydrocephalus. Subdural haemorrhage, extradural haemorrhage, posterior fossa haemorrhage, punctuate haemorrhages, and cystic alterations have all been determined by MRI.

We had 4 infarct cases, and 1 had T1 sequence hypointense and 3 had hyperintense. T2 sequence hypointense and hyperintense in 2 cases each; DWI sequence restriction found in 3 infants; 1 infant has no restriction; fall in ADC value found in 2 infants; and blooming GRE sequence found in 1 infant. Barkovich *et al* [17] study showed that After two to three days, infarcts are clearly visible on T1- and T2-weighted images as regions exhibiting a lack of grey-to-white matter distinction. Connelly *et al* [18] reports that DWI changes emerge before any abnormalities may be seen on conventional MR. Robertson *et al* [19] reported that DWI reveals hyperintensity with reduced apparent diffusion coefficients (ADC) as early as twenty minutes after an acute infarction. Preliminary data reveal that DWI is the most efficient approach for detecting acute infarcts.

Out of 4 cases of venous sinus thrombosis in our study, 1 has the T1 sequence as iso-hyperintense and 3 are hypointense. T2 sequence is hypointense in all 4 cases; DWI sequence has no restriction found in all 4 cases; and ADC and GRE sequence are normal in all of them. Saposanik *et al* [20] study showed that usually, Acute CVT (between 1 and 5 days) is typically isointense on T1-weighted MR images and hypointense on T2-weighted MRI because of deoxyhemoglobin, while subacute CVT (between 6 and 15 days) is hyperintense on both T1- and T2-weighted MR images due to methemoglobin, and chronic CVT (more than 15 days) is isointense on T1-weighted images.According to Idbaih *et al* [21] to diagnose CVT, T2*-weighted sequences of MRI were 90% sensitive, but T1-weighted sequences were only 70% sensitive.

In one case of meningitis in our study, T1 sequence is normal, T2 shows hyper-intensity in CSF spaces and sulcal spaces, has DWI restriction, falls in ADC value, and GRE sequence is normal. Prager *et al* [22] studied that the unusual leptomeningeal or cranial nerve enhancement seen on post-gadolinium T1-weighted imaging can be a sign of meningitis. Parenchymal regions with enhanced signal on T2-weighted images and sporadic enhancement with post-contrast T1-weighted images are used to diagnose encephalitis.

Along with these MRI findings, we found two cases with porencephalic cysts, and in both of them, the T1 sequence is hypointense with a cystic lesion communicating with the left lateral ventricle; the T2 sequence is hyperintense with a cystic lesion communicating with the left lateral ventricle; there is no restriction in the DWI sequence; and normal ADC and GRE sequences.

In one case of metabolic aetiology, we found T1 hypointensity and T2 hyperintensity in the bilateral internal capsule, GP, thalamus, and brainstem. DWI restriction, a fall in ADC value, and a normal GRE sequence. In one case of cystic encephalomalacia, T1 shows hypo-intensity and T2 shows hyper-intensity in a cystic lesion involving white matter and cortex.

There is no DWI restriction, and the ADC and GRE sequences are normal. In one case of hydrocephalus with T1 and T2 sequences showing hypointensity in the cerebral hemisphere with dilated ventricles, DWI, ADC, and GRE sequences are normal. And, in the case of ventriculitis meningitis, we found diffuse cortical atrophy, T2 hyperintensity in the left thalamus, subcortical and deep white matter, diffuse sulcal enhancement, and meningeal enhancement on contrast.

According to cranial USG in our study, we found that out of total HIE cases 8 cases shows Bi lateral echogenic thalami, 5 cases shows Bilateral periventricular echogenicity, 2 cases each shows Bi lateral echogenic thalami, putamen, Echogenic bl thalami and periventricular area and Echogenic caudate nucleus, 1 case each shows Bilateral periventricular echogenecity, bilateral echogenic thalami and putamen, Hyperechoic bilateral thalami, Mild ventriculomegaly and Ventriculomegaly. In comparison to our results Weeke *et al* [16] found that Cranial US showed abnormalities (periventricular or thalamic hyperechogenicity, cortical highlighting, lenticulostriate vasculopathy [LSV], or choroid plexus cyst).

In last we had calculated Cohen's Kappa coefficient to estimate interrater reliability between cranial USG and MRI findings. We found that Out of 58 cases who showed abnormalities in MRI, most of them 51(87.9%) were also abnormal in USG also, and two cases who were normal in MRI, were also found normal in USG also. there was fair agreement between USG and MRI findings

using Cohen's Kappa analysis and this agreement was found to be statistically significant (Fisher's exact test – p value=0.020 (Significant)). This showed that cranial USG is can be an alternative to MRI in diagnosing infantile seizures. As, cranial ultrasound (CU) is a cost-effective, portable, non-invasive examination that does not require radiation. These features make it a valuable tool for assessing infantile brain structures.

In Nabavi and Partovi [10] study, Despite the fact that the number of ultrasound tests with positive findings was half that reported in the mentioned study, the 22% prevalence of ultrasonography results was significant. In Leth *et al* [9] study, Brain lesions were judged to be the source of 10% of newborn seizures according to brain ultrasonography findings; however, this rate increased to 68% after MRI.

Conclusion

In conclusion, neonatal seizures are a serious problem and can be caused by a variety of underlying conditions. In our cohort, HIE constituents had the highest aetiology, followed by hemorrhagic causes. Based on the findings of the present study, the frequency of pathologic findings in neonatal brain ultrasonography was 85% and in MRI was 96%. thus MRI brain scans are superior to USG scans for the evaluation of infantile seizures.

However, USG is handy, cost-effective, and portable, while MRI use involves increased cost as well as specialized equipment and personnel to ensure safety during transport and imaging.

Abbreviations: ADC-Apparent Diffusion Coefficient, ALIC-Anterior Limb of Internal Capsule, BGT -Basal Ganglia and Thallamus,CNS-Central Nervous System, CSF- Cerebro Spinal Fluid, CSVT- Cerebral Sino Venous Thrombosis, CT-Computed Tomography, C-USG- Cranial Ultrasonograpy, CVT- Cerebral Venous Thrombosis, DWI-Diffusion Weighted Imaging, EEG- Electro Encephalogram, FLAIR-Fluid Attenuated Inversion Recovery, fMRI-Functional MRI, GMH-Germinal Matrix Haemorrhage, GP-Global Pallidus, GRE- Gradient Echo, HIE- Hypoxic Ischemic Encephalopathy, ICH- Intra Cerebral Haemorrhage, IR-Inversion Recovery, IS-Infantile Spasm, IVH-Intraventricular Haemorrhage, MRI-Magnetic Resonance Imaging, NICU - Neonatal Intensive Care Unit, PAIS-Perinatal Arterial Ischemic Stroke, PLIC-Posterior Limb of Internal Capsule, PPV-Positive Predictive Value, PVL-Peri Ventricular Leukomalacia, RI-Resistive Index, SDH- Sub Dural Haemorrahge, SI-Signal Intensity, SNR-Signal to Noise Ratio, SWI- Susceptibility Weighted Image, T-Tesla, T1WI-T1 Weighted Imaging, T2WI-T2 Weighted Imaging, WMI- White Matter Injury

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