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Original Research Article

Neuroimaging in paediatric emergencies

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ABSTRACT

Background: Neonatal and Pediatric population comprise up to 20% of emergencies and it is very important to choose appropriate imaging modality to diagnose early and treat accurately. These Pediatric emergencies require different approach to diagnose and manage compared to the adult population. This article will focus on the neuroimaging for evaluation and diagnosis that has more common and specific occurrence in paediatric population.
Methods: Cases were selected based on inclusion and exclusion criteria and a single centre study was done using the scanners, imaging software and medical records from March 2021 to August 2022.
Results: 36 non-traumatic cases were further subgrouped based on the etiological factors; of which 13 cases (36.1%) had findings consistent with congenital abnormalities. The proportion of children with Hypoxic ischemic encephalopathy, Stroke, Infections and Neoplastic were 10 cases (27.7%), 9 cases (25%), 5 cases (13.8%), 4 cases (11.1%) and 4 cases (11.1%) respectively.
Conclusions: Neuroimaging is the key in pediatric emergencies. The advancement in newer modalities of technology should be put into use more as a combined approach in diagnosis, management and prognostication as well as for early intervention to improve functional and psychological outcome.

Keywords: Paediatric emergencies, Paediatric neuroimaging, MRI brain

INTRODUCTION

Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) are important imaging tools in the evaluation and diagnosis of infants and children requiring emergency medical care. speed, accuracy, accessibility and feasibility made CT the most commonly used advanced imaging modality in the emergency situations. [1]

Technological advances in MRI including the development of rapid protocols, increased availability has led to greater feasibility of MRI for children in emergencies. Neuroimaging in pediatric emergency is most often indicated in evaluation of the child who has altered sensorium, comatose or obtunded; has a change in neurologic status; presenting in status epilepticus; or suffering the neurologic consequences of a traumatic, infectious/inflammatory, vascular, or metabolic abnormality. The multiplanar capability of MR to show superior anatomic detail and tissue contrast without the harmful effects of ionizing radiation makes it the imaging modality of choice for evaluating the neuraxis in children of all ages presenting with acute neurologic symptoms in the emergency department. MRI is superior to CT in evaluating the posterior fossa and in detecting early cerebral edema and microhemorrhages. Further, MRI can provide functional and physiologic information about the brain that cannot be generated by other modalities.

Table 1: Paediatric central nervous system emergencies: brain.[2]

Acute hydrocephalus
Trauma
Accidental
Nonaccidental
Non-traumatic vascular events
Arterial ischemic stroke
Venous thrombosis
Embolic stroke
Vasculitis
Dissection
Migraine
Hypoxic-ischemic injury
Strangulation
Cardiorespiratory insufficiency
Near-drowning
Electrolyte and hormonal imbalances
Hypoglycemia
Hyponatremia
Hypocalcemia
First-time seizure and status epilepticus
Infection
Congenital
Acquired
Complications and sequelae
Demyelination
Acute disseminated encephalomyelitis (ADEM)
Multiple sclerosis (MS)
Metabolic disease (acute presentation)
Iatrogenic, toxic and drug-related injury
L-asparaginase
Cyclosporine
Methotrexate
Recreational drugs
Carbon monoxide
Neoplastic disease (acute presentation)
Encephalopathy in hematologic and oncologic disease
Posterior reversible encephalopathy (PRES)
Posttransplant lymphoproliferative disorder (PTLD)

Advanced MR imaging sequences, including susceptibility-weighted imaging (SWI), diffusion-weighted and diffusion-tensor imaging (DWI and DTI), magnetic resonance spectroscopy (MRS), and perfusion imaging, including arterial spin labeling (ASL), are being increasingly incorporated into acute pediatric neuroimaging protocols. The differential diagnoses in the child considered for emergent neuroimaging can be roughly divided into the following groups, as shown in (Table 1). These groups are specific to the pediatric patient, the imaging features of the suspected or known condition, and the diagnostic algorithms that are selected in performing the examination.

Table 2: Advantages and disadvantages of CT head.

Advantages	Disadvantages
Ease of availability	Exposure to imaging radiation
Lesser cost compared to MRI	Early changes in stroke are missed
Shorter imaging time	Limited resolution in patients with white matter lesions, infections, inflammation, neurometabolic disorders and tumours.
Lesser need for sedation	-
No contraindications in patients with metallic implants	-
Good resolution in skull fractures, calcification and bleed	-

METHODS

Study design, location and duration

Combined Prospective and Retrospective hospital based study was conducted at Rajarajeswari Medical College and Hospital, Bengaluru for a period of 18 months (March 2021 to August 2022).

Study group

The study was conducted in children who presented to the emergency department and diagnostic imaging was done. Cases were selected based on inclusion and exclusion criteria.

Inclusion and exclusion criteria

Children of age 1 month to 14 years presenting to emergency department were included. Children in whom imaging was done for conditions other than emergencies and cases without specific findings in imaging were excluded.

Procedure

Cases were selected based on inclusion and exclusion criteria and a single centre study was done using the scanners, imaging software and medical records from March 2021 to August 2022. Cases were investigated with MRI scans of the brain via 1.5T Siemens scanner after making the child sleep or sedated. The sequences used were: Axial T1, Axial T2, Axial FLAIR, Axial DWI, Axial ADC, Axial SWI, Axial PHASE, Sagittal T1 and Coronal FLAIR. CT scan of the brain was done only when indicated on 128 slice Siemens Somatom Perspective scanner. Informed consent shall be taken from patient's parents.

RESULTS

A total of 45 cases were included in the study, of which traumatic cases were 9 and non-traumatic cases were 36 (Table 3).

Table 3: Distribution based on traumatic or non-traumatic history.

Causes	N	%
Traumatic	9	20
Non-traumatic	36	80

Table 4: Neuroimaging modality performed.

Imaging	N
CT scan	17
MRI	31

Table 5: Distribution based on etiology in non-traumatic cases.

Etiology of non-traumatic emergencies	N	%
Congenital structural malformations of brain	13	36.11
Hypoxic ischemic encephalopathy	10	27.77
Stroke	5	13.88
Infections	4	11.1
Neoplastic	4	11.1

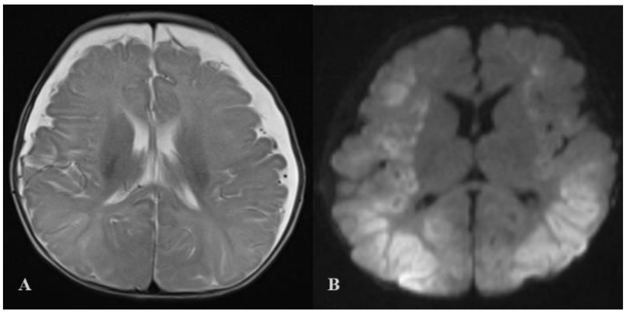

Figure 1: A 3-month-old female patient presenting with recurrent seizures and fever. A) T2W axial MR image showing subdural effusion along bilateral fronto-parieto-temporal convexities. B) DWI axial MR image showing areas of acute infarct (hyperintense) in bilateral cerebral hemispheres.

Total 31 cases underwent MRI brain imaging and 17 cases underwent CT brain imaging which guided towards diagnosis and management of these children (Table 4). 36 non-traumatic cases were further subgrouped based on the etiological factors; of which 13 cases (36.1%) had findings consistent with congenital abnormalities. The proportion of children with Hypoxic ischemic encephalopathy, Stroke, Infections and Neoplastic were 10 cases (27.7%), 9 cases (25%), 5 cases (13.8%), 4 cases (11.1%) and 4 cases (11.1%) respectively as shown in (Table 5).

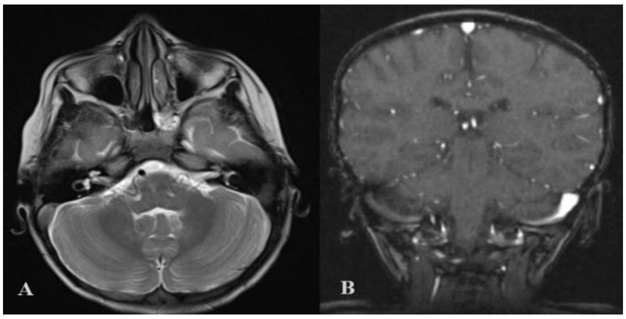

Figure 2: A 5-year-old male patient presenting with vomiting, drowsiness and neck pain. A) T2W axial MR image showing lack of flow void in the right transverse sinus, sigmoid sinus and jugular bulb. B) MRV coronal MR image showing lack of flow related enhancement (thrombosis) in the right transverse sinus, sigmoid sinus and jugular bulb.

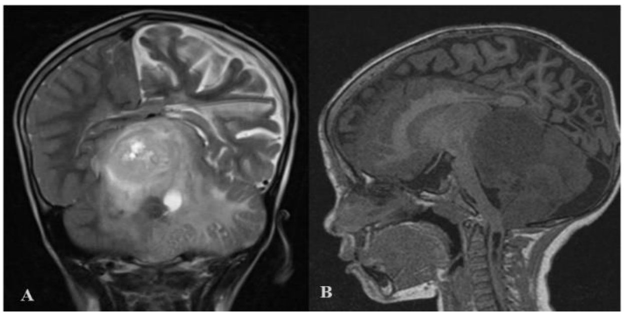

Figure 3: Known case of Neurofibromatosis type1 in a 6-year-old female patient presenting with recurrent seizures and s/p VP shunting. A) T2W coronal MR image and B) T1W sagittal MR image showing following findings-Bulky cerebellum and multiple ill-defined enhancing lesions with moderate perilesional edema and causing mass effect? gliomas. Left cerebral hemisphere appearing relatively bulky with prominence of cortical sulci and gliosis in the left occipital lobe. Prominent cisterna magna.

DISCUSSION

Non-traumatic neurological emergencies

Infections: Neuroimaging plays an important role in the diagnosis as well as in the management of neuroinfections. Magnetic resonance imaging (MRI) is proven to be superior in depicting complications like sub-dural empyema and also vascular complications particularly on FLAIR (fluid-attenuated inversion recovery) sequences. The newly advanced modality of diffusion-weighted imaging (DWI) can detect parenchymal complications of meningitis early and also helps to differentiate pyogenic abscess from ring enhancing lesions of other etiologies. In cases of suspected bacterial meningitis with altered consciousness, an immediate CT brain is recommended before lumbar puncture to rule out causes for lesions and edema that may lead to herniation.

Congenital brain anomalies can be classified as: Disorders of primary neurulation: These are mostly neural tube closure defects and early CNS anomalies occurring during 3rd and 4th gestational weeks. These include Chiari malformations, cephaloceles and myelomeningoceles. Disorders of diverticulation, cleavage, sulcation and cellular migration. These include: Holoprosencephaly, Lissencephaly, Cortical dysplasia, Heterotropia, Schizencephaly. Posterior fossa malformations include: Dandy-Walker malformations, Joubert syndrome, Rhombencephalosynapsis, disorder of histiogenesis.

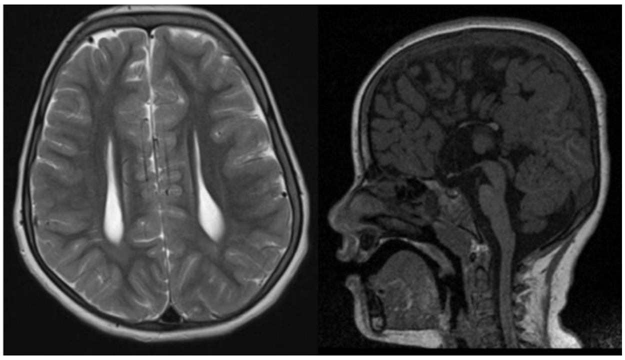

Figure 4: Dysgenesis of corpus callosum with colpocephaly in a 6-year-old female preterm born child presenting with global developmental delay. T2W axial MR image showing widely spaced parallelly oriented bodies of bilateral lateral ventricle ("racing car sign") and dilated trigones. T1W sagittal MR image showing absent genu and rostrum of corpus callosum with markedly hypoplastic body and splenium.

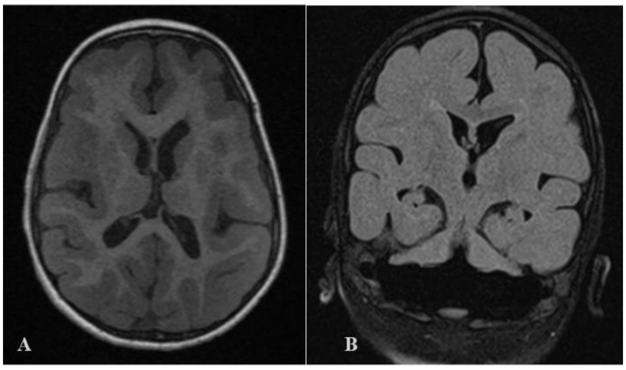

Figure 5: Pontocerebellar hypoplasia with lissencephaly-pachygyria spectrum in a four-year-old male child presenting with global developmental delay. A) T1W axial MR image showing sparse cortical sulci with wide gyri in bilateral cerebral hemispheres and thickened cerebral cortex. B) FLAIR coronal MR image showing markedly hypoplastic bilateral cerebellar hemispheres and absent caudal part of the vermis cerebelli ("dragon fly appearance"), leaving most of posterior fossa empty.

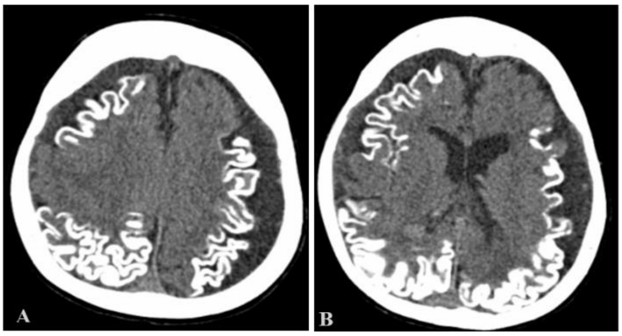

Figure 6: Struge Weber syndrome in a 9-year-old male patient presenting with recurrent seizures, glaucoma and developmental delay. MDCT brain axial images showing gyriform cortico-subcortical calcifications in bilateral cerebral hemispheres, enlarged bilateral choroid plexus, left cerebral hemiatrophy and diffuse calvarial thickening.

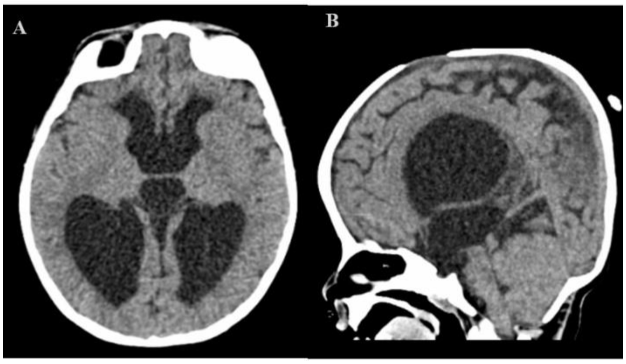

Figure 7: A 1-year-old female patient who is post-operative case of meningomyelocele with hydrocephalus. A) Axial CT image and B) sagittal CT image showing-Dilated bilateral lateral ventricles and third ventricle, with normal sized fourth ventricle – s/o obstructive hydrocephalous, diffusely atrophic bilateral cerebral parenchyma, widening of diaphragm sella, Thinning of corpus callosum.

The CT findings are mostly normal in early phases of meningitis. Contrast-enhanced CT can show beginning of meningeal enhancement, which becomes more accentuated in later stages of disease. In the diagnosis of tuberculous meningitis, MRI has been suggested as a useful tool. Visibility of the meninges on precontrast T1-weighted magnetization transfer images may be considered highly suggestive of tuberculous meningitis. As the morbidity an mortality still remains high due to the disease, it is advisable for early initiation of anti tuberculous therapy. In cases complicated with seizures and focal evolvement signs, MRI is superior to CT in demonstrating parenchymal lesions due to meningoencephalitis or vasculitic complications on FLAIR sequences. Acute inflammatory lesions, including encephalitis, cerebritis, and tuberculosis, are hyperintense. Neurocysticercosis shows hypointense lesions on DWI. Extraaxial bacterial empyema is most reliably diagnosed by MRI. CT often leaves doubt as to the nature of the lesion and its exact location. These fluid collections can be found over the convexities or interhemispherically. In relation to CSF they are mildly hyperintense and hypointense to white matter on T1WI. Whereas on T2WI, hyperintense relative to CSF and white matter that shows distinction from sterile effusions and most of the chronic hematomas.[3]

Paediatric stroke: Whenever a child presents with stroke like episode, Emergency MRI of the brain is generally required to confirm if it is a stroke or stroke mimic. In comparison to adults where CT/computed tomography angiography is most oftenly preferred first-line imaging, in children, risk of additional radiation exposure, and as computed tomography angiography requires a rapid properly timed contrast injection through a child's small intravenous line, and also due to prevalence of stroke mimics indistinguishable on CT make MRI the preferred first approach when rapidly available and feasible without sedation. Diffusion-weighted imaging (DWI) MRI, that is done in nearly 30 seconds, can quickly assess if an ischemic stroke has occurred or not.[4]

Tumors: The most common childhood solid tumours are central nervous system tumours and are highly lethal. In comparison to adults, most of the childhood brain tumors are primary in origin and differ in type, location and molecular signature. Early and accurate diagnosing is challenging in children and the presentation is varied. Neuroimaging has a very important role in initial diagnosis and can be serially done to monitor the progress of pediatric brain tumors. The Conventional anatomic imaging approach of CT and MRI are useful for tumor detection but have a limited utility in differentiating tumor types and grades. Advanced MRI techniques (diffusion-weighed imaging, diffusion tensor imaging, functional MRI, arterial spin labeling perfusion imaging, MR spectroscopy, and MR elastography) can provide improved and accurate structural and functional details.[5]

Hypoxic ischemic encephalopathy: Hypoxic-ischemic encephalopathy (HIE) occurring in neonate is a devastating condition that may result in severe neurologic deficits or death. Neuroimaging modalities like neurosonogram, computed tomography and magnetic resonance imaging are valuable tools for diagnosis as well as prognostication in babies with HIE. The severity and duration of hypoxia and degree of brain maturation determines the pattern of brain injury. Mild to moderate HI injury in preterm results in periventricular leukomalacia and germinal matrix bleed, where as in full term neonates results in parasagittal watershed infarcts. Severe HI injury involves deep gray matter in both preterm and term infants. Newer and advanced imaging techniques such as diffusion-weighted imaging (DWI) and magnetic resonance spectroscopy (MRS) have been found to be more sensitive to diagnose acute brain injury have a crucial role in early diagnosis and timely intervention. CT and MRI have greater sensitivity for the detection of cortical injury and also they markedly reduce inter observer variability compared to sonography. MRI is the most sensitive and specific imaging modality for workup and prognostic purpose when a neonatal HIE is suspected. [6]

Congenital structural malformations of brain: Congenital structural brain anomalies are rare among the congenital anomalies of various other organ systems. It is important for early detection and diagnosis of these conditions because of their expected neurological deficits and detrimental outcomes. Most of the congenital structural brain anomalies can be reliably and accurately diagnosed by neuroimaging modalities (computed tomography or magnetic resonance imaging).[7,8]

Traumatic neurological emergencies: Neuroimaging after traumatic brain injury (TBI) has a classical role in identification of acute and chronic sequelae of injury, such as hemorrhages, intracranial hematomas, brain contusions, and posttraumatic complications including hydrocephalus and infections. The results of these imaging modalities are often being able to guide acute and chronic medical or surgical interventions.[9] In the past decade, magnetic resonance imaging (MRI) has become widely available. The advances like high spatial resolution, high signal and contrast to noise ratio, and the different tissue contrasts that can be generated by MRI significantly increased the diagnostic accuracy in identifying early and chronic sequelae of TBI and also to understand and counsel parents regarding prognosis.

MRI had the ability to accurately identify the exact extent and quality of brain injury as early as possible after TBI, that may help to predict the likely long-term sequelae of injury for a particular child and also to allow tailoring and monitoring of therapy. Time-sensitive interventions can be immediately initiated to limit primary and secondary brain injuries. Also, early intervention can be provided with pharmacological or behavioral interventions for specific neurocognitive sequelae. Early identification and estimation of likely functional outcome shall allow planning for and timely use of valuable resources to optimize home, school, and community reentry. Early targeted interventions would likely lead to optimal care and improved functional outcomes for the individual as well as greater efficiency in design and delivery of rehabilitation services. The value of CT in the acute setting of TBI is firmly established. In children, more recent studies of CT findings in TBI have largely been focused on identifying imaging findings that differentiate accidental from non-accidental injury in young children. Moreover, CT can provide information both about the brain as well as the skull, and frequently head CT is combined with a cervical spine CT to rule out spinal injury, especially when the history of trauma is uncertain. Multiple studies have shown the higher sensitivity of MRI compared to CT for identifying DAI.[10,11] Multiple studies are available comparing imaging findings using conventional MRI sequences with global functional outcome as well as more specific neuropsychological and psychiatric outcomes.

Limitations

Limitations were complete evaluation with genetic analysis which was required to finally diagnose few cases under suspicion of neurometabolic disorders was not able to be done due to financial constraints. A multi-centre study with inclusion of more cases would have given a wider base of causes to be assessed.

CONCLUSION

Neuroimaging is the key in pediatric emergencies. The advancement in newer modalities of technology should be put into use more as a combined approach in diagnosis, management and prognostication as well as for early intervention to improve functional and psychological outcome.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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