Original Article

Magnetic Resonance Imaging pattern of congenital brain anomalies in the neurosurgery department of a teaching hospital in Nigeria: An initial experience

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Abstract

Context: Congenital brain anomalies are of diverse types however few are seen in clinical practice. They are associated with high morbidity and mortality; prompt diagnosis and management aid in mitigating some of their adverse effects. Magnetic resonance imaging (MRI) is ideal for imaging these conditions, especially in pediatric cases due to its lack of ionizing radiation and excellent soft-tissue delineation. Not much literature exists for Nigeria due to challenges with statistics and record keeping.

Aim: The aim of this study is to document the common congenital brain anomalies encountered using MRI in our environment.

Settings and Design: A 5-year retrospective study of all pediatric brain MRI conducted and reviewed in Lagos University Teaching Hospital. 73 pediatric brain MRI scans were reviewed.

Materials and Methods: Morphologic evaluation of all pediatric brain MRI conducted in the last 5 years (March 2012–February 2016) was reviewed, retrospectively, by three independent radiologists. Clinical presentations were also documented.

Statistical Analysis Used: Descriptive statistics was done using SPSS: PASW Statistics for Windows, Version 18.0

Results: Seventy-three pediatric brain MRI scans were conducted in the last 5 years with congenital brain anomalies seen in 19 (26.0%) of the cases. Their ages ranged from 3 months to 17 years with a mean age of 6.7 ± 6.1 years. There were 9 (47.4%) males and 10 (52.6%) females. The common anomalies are congenital hydrocephalus 7 (35%), of which aqueductal stenosis was 6 (32%), arteriovenous malformations 3 (16%), cerebral atrophy 3 (16%), and arachnoid cysts 2 (11%). Predominant clinical features were delayed developmental milestones, macrocephaly, seizures, headaches, and vomiting.

Conclusion: The common congenital brain anomalies in our environment are congenital hydrocephalus, aqueductal stenosis, arteriovenous malformations, cerebral atrophy and arachnoid cysts. MRI is useful in evaluating these anomalies; early diagnosis and prompt intervention can be offered to mitigate adverse effects.

Keywords: Brain, congenital anomalies, magnetic resonance imaging, Nigeria, pediatrics

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Access this article online	
Quick Response Code:	Website: www.wajradiology.org
	DOI: 10.4103/wajr.wajr_15_17

How to cite this article: Titilayo Omidiji OA, Ojo OA, Adeyomoye AO, Atalabi OM, Okwuegbuna FI. Magnetic resonance imaging pattern of congenital brain anomalies in the neurosurgery department of a teaching hospital in Nigeria: An initial experience. West Afr J Radiol 2018;25:45-51.

INTRODUCTION

Congenital malformations (CM) of the brain are diverse with many classifications documented and as many as 2000 different types described in the literatures.[1] They are commonly encountered in clinical practice;[2] however, very few types of malformations are usually seen. Challenges with statistics and record keeping exist as issues in Nigeria and the Sub-Saharan Africa; however, the prevalence of CM has been placed between 2% and 7% with geographical and racial variability.[1,3] Few specific data exists for brain malformations alone. A transfontanelle ultrasound study in Ilorin Nigeria to determine the incidence of brain congenital anomalies in African infants over a 5-year period noted that 25% of the 98 cases examined had congenital anomalies, with congenital aqueductal stenosis as the most common anomaly seen.[4] Few other literatures have documented clinical congenital neurological findings in children in the similar region using clinical and other imaging modalities except magnetic resonance imaging (MRI). A study in Kenya showed an overall incidence of central nervous system (CNS) malformations of 4.6/1000 births, with hydrocephalus being the most common anomaly. This was however by clinical examination of newborns by the clinicians.[5]

Many etiologic factors of CM exist which are broadly divided into genetic, environmental, exposure to teratogens, and certain deficiencies, especially folate and iodine, with some studies attributing its origin as multifactorial.[1,2] The causes of congenital anomalies are unknown in many cases,[6] identified risk factors include maternal age, drug intake, teratogens, radiation exposure, maternal illnesses, smoking, and alcohol consumption.[3,6-8]

Several imaging modalities have been utilized to confirm the diagnosis of congenital brain anomalies such as ultrasound, computed Tomography (CT), and MRI. MRI is not only ideal, especially for pediatric patients; it has the added advantage of being multiplanar and multiaxial with excellent soft-tissue delineation and no known biohazard effect and is, therefore, the modality of choice.[8]

This study aims to document the common congenital brain anomalies encountered using MRI in our environment.

MATERIALS AND METHODS

Approval for the study was granted by the ethics committee of Lagos University Teaching Hospital (LUTH) where the study was done. The study was designed as a retrospective analysis of the MRIs of children in the past 5 years (March 2012–February 2016). This bidisciplinary study was conducted by the Radiodiagnosis and Neurosurgery units of the LUTH. The hospital is a tertiary center receiving referrals from Lagos state and its environs with a catchment area of over 30 million population. Patients' images were retrieved from the MRI scanning machine and the image archives of patients who were seen by the neurosurgeons within the time frame.

Study design

A structured pro forma was used to obtain the relevant data from the case note of each patient. The age, sex, clinical, and presenting features of each subject were retrieved from the pro forma and documented. Antenatal and breastfeeding histories of the mothers during index cases pregnancy were also assessed for salient information such as history of drug, alcohol, or herbal use, and prior history of congenital anomalies in previous pregnancies or in the extended family.

Inclusion and exclusion criteria

All pediatric patients (<18 years) who presented to the Neurosurgery unit and had MRI conducted in our center or came with brain MRI from other centers were assessed and those with congenital brain anomalies were documented. Patients over 18 years of age and those with infective or traumatic causes as well as those with ferromagnetic devices were excluded from the study.[8] Patients who were referred from other facilities for MRI brain scan were also excluded, as there was no access to their clinical information.

Patients had to fill a standard structured interview form to elicit the suitability for MRI imaging. Information on biodata, clinical history, and diagnosis, history of previous surgeries, injury by metallic foreign bodies, and previous reactions to contrast medium used for CT or MRI. Patients with ferromagnetic devices in place were not examined because of the possibility of dislodgement by magnetic fields.

Imaging technique

All brain MRI scans were done using standard protocols in our institution with the standard positioning for brain MRI.[9] The patients were positioned supine on the MRI table such that the median sagittal plane was equidistant to the edges of the table. A pillow was placed under the shoulders, and those requiring sedation were given IM paraldehyde 1 ml/year of life up to 5 ml or intravenous diazepam 2 mg/kg body weight. A quadrature head coil helmet was placed around the patient's head with cushions and straps to immobilize the head. Laser beam was aligned on the patient at the centering point, which was the superior

edge of the eyebrows. The table was then moved under the magnet until the patient was at the isocenter of the magnet.

An orthogonal 3-plane localizer was then obtained, consisting of axial, sagittal, and coronal views. Sagittal images were obtained on a coronal or axial localizer image. Midsagittal plane was identified using the following landmarks: corpus callosum, Sylvian aqueduct, fourth ventricle, and cervical spinal cord. Axial images were obtained on a sagittal localizer and were positioned parallel to the bicommissural line or parallel to a line linking the floor of the sella turcica to the fastigium of the fourth ventricle. Coronal images were obtained on a sagittal localizer positioned parallel to the posterior surface of the brainstem.

Imaging protocols/scan parameters

- T1-weighted sequences – TR 400–450 TE 9–15 matrix 256 × 256
- T2-weighted sequences – TR 4850 TE 118 matrix 256 × 256
- Fluid-attenuated inversion recovery sequences – TR 6000–8500 TE 89 TI 1600 matrix 256 × 256.

A slice thickness of 4 mm with 1 mm was used for all sequences done at our center. Flip angles of 90° and 180° were used for T1- and T2-weighted sequences, respectively.

Image analysis

Morphologic evaluation of the images was performed by three experienced radiologists who are coauthors for the study. The interhemispheric fissure, cortical sulcation in the cerebrum and cerebellum, cerebral cortex, ventricles, white matter, basal ganglia, internal and external capsule, thalami, corpus callosum, brain stem, cerebellum, intracranial vessels, sella and pituitary, petrous pyramids, paranasal sinuses, and orbit were assessed in terms of size, shape, position, signal characteristics, and possible space occupying lesion.

The results were presented in tabular forms.

Data analysis

The data were entered into Microsoft excel sheet and analyzed using the SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc.

The frequency of the pathologies seen was calculated and compared with those of prior studies. Correlations between the anomaly, pertinent histories, and clinical features were obtained using Chi-square test. Mean values and distribution of variables were also documented.

Ethical consideration

The safety of MRI is an important consideration and as yet no basic hazard has been identified. The National Radiological Protection Board in the UK medicine and healthcare regulatory agency (MHRA) and the Food and Drug Administration in the USA have published guidelines for the medical use of MRI which were followed.[10]

The procedure was explained to the child and the parents/caregivers. Signed informed consent was obtained from parents of the study subjects. The study was at no additional cost to the parents/caregivers.

Children who were diagnosed with congenital anomalies had the benefit of prompt intervention.

RESULTS

A total of 73 pediatric brain MRI scans were conducted in the 5-year period.

Congenital brain anomalies were seen in 19 (26.0%) of the cases. Their age distribution ranged from 3 months to 17 years with a mean age of 6.7 + 6.1 years. There were 9 (47.4%) males and 10 (52.6%) females [Table 1].

The clinical features seen predominantly were delayed developmental milestones 7 (36.8%), macrocephaly 6 (31.6%), seizures 6 (31.6%), headache, mental retardation, and vomiting 4 (21%) with delayed developmental milestones being the most common presenting complaint [Table 1].

Table 2 shows the frequency of congenital cerebral anomalies in this study. The most common anomalies are congenital hydrocephalus 7 (35%) of which 6 (86%) were due to aqueductal stenosis, arteriovenous malformations 3 (16%), cerebral atrophy 3 (16%), and arachnoid cysts 2 (11%).

Aqueductal stenosis

Aqueductal stenosis was seen in 6 cases with their ages ranging from 3 months to 14 years. A male preponderance was noted (M:F 2:1). Macrocephaly and delayed developmental milestones were the common clinical findings in aqueductal stenosis. On MRI imaging, marked thinning of the cortical mantle was noted with marked dilatation of the lateral and third ventricle and normal-sized fourth ventricles. Dilatation was severe in all the cases seen with cortical mantle measuring <1 cm in width.

Arteriovenous malformation

Arteriovenous malformations were seen in 3 (16%) cases; solitary in two cases and multiple in 1 case, seen in ages

Table 1: Congenital anomalies and their clinical findings

Sex	Clinical finding	Age (years)	Anomaly
Male	Macrocephaly, vomiting	0.25	Aqueductal stenosis
Male	Macrocephaly, delayed developmental milestone	0.25	Aqueductal stenosis
Male	Macrocephaly, vomiting	0.5	Aqueductal stenosis
Female	Macrocephaly, delayed developmental milestone	1	Aqueductal stenosis
Male	Delayed developmental milestone	2	Dandy–Walker malformation
Female	Seizures	2	AVM
Female	Macrocephaly, vomiting	2	Aqueductal stenosis
Female	Delayed developmental milestone	3	Cerebral atrophy
Female	Delayed developmental milestone	4	Schizencephaly
Female	Macrocephaly, headache, seizures	5	Hydrocephalus
Male	Delayed developmental milestones	6	Cerebral atrophy
Male	Seizures	7	Heterotopia
Male	Delayed developmental milestones	7	Cerebral atrophy
Female	Seizures	10	AVM
Female	Headache	13	Arachnoid cyst
Male	Headache vomiting, poor school performance	14	Aqueductal stenosis
Male	Seizures	17	Tuberous sclerosis
Female	Seizures	17	AVM
Female	Headache	17	Arachnoid cyst

Mean age: 6.7±6.1 years. AVM – Arteriovenous malformation

Table 2: Frequency distribution of congenital malformations

Diagnosis	Frequency (%)
Aqueductal stenosis	6 (32)
Cerebral atrophy	3 (16)
AVM	3 (16)
Arachnoid cyst	2 (11)
Heterotopia	1 (5)
Communicating hydrocephalus	1 (5)
Schizencephaly	1 (5)
Dandy–Walker	1 (5)
Tuberous sclerosis	1 (5)
Total	19 (100)

AVM – Arteriovenous malformation

3, 10, and 17 years, all in females. They all presented with seizures. On MRI imaging, multiple tortuous dilated flow void structures of varying sizes were noted on all imaging sequences [Figure 1].

Cerebral atrophy

Cerebral atrophy was seen in 3 (16%) of cases, ages 3–7 years, more in males (M:F = 2:1). The three patients presented with delayed developmental milestones. The atrophy was generalized but worse in the frontal lobes [Figure 2].

Arachnoid cyst

Arachnoid cysts were seen in 2 (11%) of the CM cases; ages 13 and 17 years, both were females. They both presented with severe headaches. On MRI, large masses with fluid signal intensity on all sequences were noted, measuring 6.3 cm × 4.4 cm and 3.5 cm × 4.4 cm in the occipital lobe and cerebellopontine angles in the first and second cases, respectively [Figure 3].

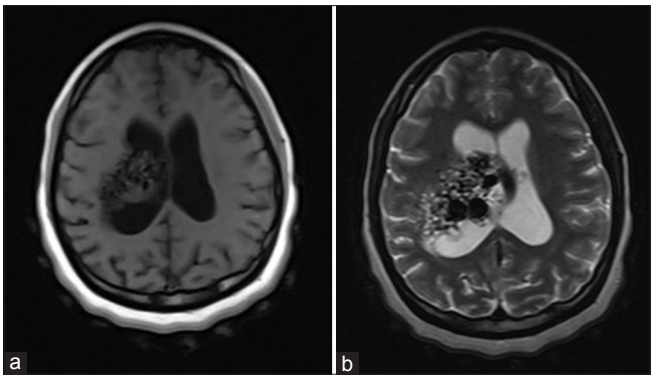

Figure 1: (a and b) Magnetic resonance imaging of the brain in a 17-year-old female with seizures. Axial T1- and T2-weighted sequences demonstrate a complex right subependymal mass with oval signal void areas due to a nidus of tortuous vessels

Schizencephaly

Schizencephaly was seen in a 4-year-old female who presented with delayed developmental milestones. On MRI, cerebrospinal fluid (CSF)-filled defects were seen in the temporoparietal lobes bilaterally communicating at the midline indicative of bilateral open-lip schizencephaly [Figure 4].

Tuberous sclerosis

Tuberous sclerosis was seen in a 17-year-old female who presented with seizures. On MRI, multiple subcortical tubers were seen in the frontal lobe with low and high signal intensity on T1- and T2-weighted sequences respectively.

Dandy–Walker syndrome

Dandy–Walker was seen in a 2-year-old male with delayed developmental milestones. There was hypoplasia of the cerebellar hemisphere, aplasia of the vermis, and a posterior fossa cyst, well delineated on the MR images.

DISCUSSION

Congenital anomalies are structural or functional anomalies that occur during intrauterine life and can be identified prenatally, at birth or present with symptoms and signs later in life.[1] Some are later seen as incidental findings and remain asymptomatic throughout life.[1] This has been studied severally in many developed centers, and we present the pattern of MRI diagnosed congenital anomalies in all the children that had brain MRI for various reasons. Studies done decades ago did not reflect the radiological diagnosis as this was pre-MRI era in our region.

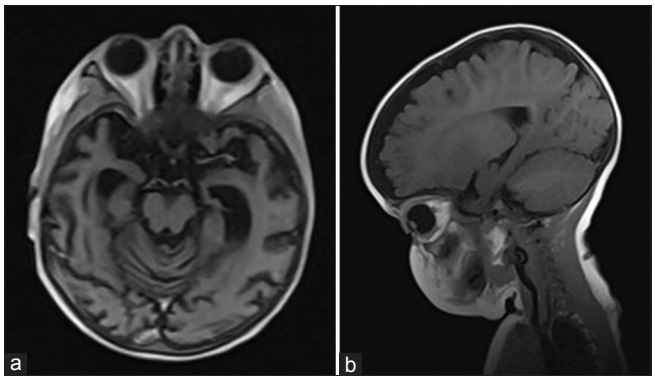

Figure 2: (a and b) T1-weighted magnetic resonance imaging axial and midsagittal brain images of a 6-year-old female. There is prominence of the subarachnoid spaces due to cerebral atrophy

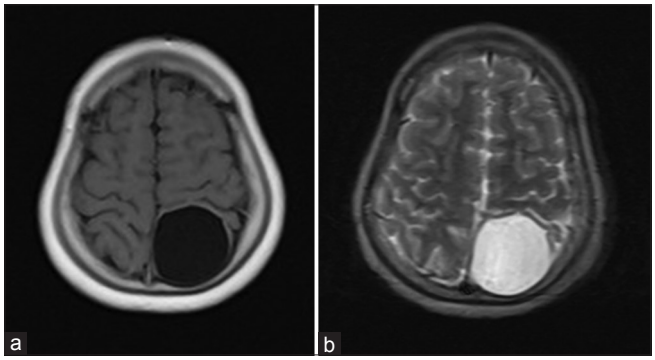

Figure 3: (a and b) Magnetic resonance imaging of the brain in a 13-year-old female with headache. Axial T1- and T2-weighted sequences demonstrate a simple cystic mass in the left occipital lobe

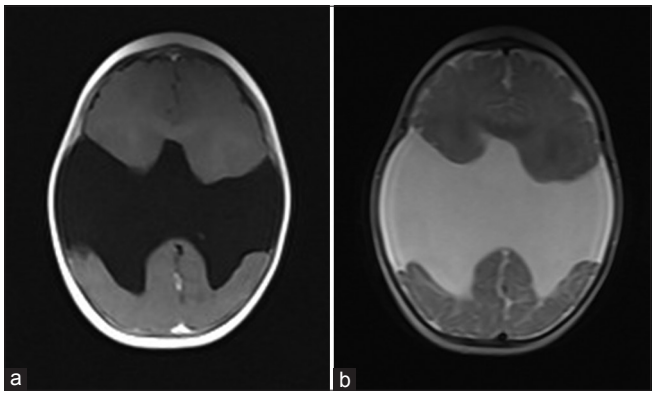

Figure 4: (a and b) Axial T1- and T2-weighted magnetic resonance imaging images of a 4-year-old demonstrates bilateral cleft communicating with the subarachnoid spaces and lined by heterotopic gray matter. The characteristic batwing appearance is noted

The incidence of brain malformation in our study was 26%, similar to that of Nzeh *et al*.'s study on brain malformations in infants.

Embryologically, the brain develops in 4 stages.[11] Stage I involves dorsal induction with formation and closure of the neural tube, and this takes place between 3rd and 5th week of embryological life. Failure of this stage results in neural tube defects. Neural tube defect is commonly seen in developing region such as our country and its repair and complications form the majority of pediatric neurosurgery service. The diagnosis is usually clinical except in the occulta type that X-ray may help. MRI scan is not necessary for diagnosis.[11] Stage 2 involves ventral induction with formation of the brain segments and face at 5–10 weeks. Failure of this results in holoprosencephaly, Dandy–Walker malformation, and facial anomalies to mention a few.[11] Diagnosis is made with clinical suspicion and MRI scan of the brain. Only one case of Dandy–Walker malformation was seen in this study and presented at 2 years of age with delayed developmental milestones. The presentation may be earlier in life, and in many cases, the diagnosis is made within the first few weeks of life with hydrocephalus.[11] Even though our patient was diagnosed with Dandy–Walker at 2 years of age, the clinical history was earlier, and the delay was due to difficulties to raise funds for appropriate investigation and management. Some patients may remain asymptomatic for life and diagnosis may be picked as incidental findings.[11] It is an anomaly in which there is cystic dilatation of the fourth ventricle, hypoplasia of the cerebellar vermis, enlarged posterior fossa, and hydrocephalus which is seen in 75%–90% of cases. Variants of these presentations are seen in many cases and few will have all the malformations for the syndrome. These features were all present in the only case seen in this study.[2] Stage 3 involves migration and histogenesis at 2–5 months of gestation with the failure of migration resulting in heterotopias, agyria-pachygyria, polymicrogyria, schizencephaly, corpus callosal agenesis, while the failure of histogenesis results in aqueductal stenosis, arachnoid cysts, megalencephaly, phakomatoses, congenital vascular malformations, and neoplasms.[11,12] Schizencephaly is a rare cortical malformation that manifests as a gray matter-lined cleft extending from the ependyma to the pia mater with clinical presentations of seizures and delayed developmental milestones, as seen as the only case in this study.[11] Schizencephaly can be bilateral and morphologically has 2 types– the open lip in which the cleft walls are separated and filled with CSF; closed lip in which the cleft walls are in apposition. It involves the posterior frontal or parietal lobes (70%), and when large, clefts can extend to involve the temporal or occipital lobes. In this study, it was an open-lip type that was seen, giving a batwing appearance and involved the temporoparietal lobes. Heterotopic gray matter was seen lining the CSF cleft.

Congenital vascular malformations are composed of a nidus of vessels through which arteriovenous shunting occur. These malformations are characterized by a nidus forming

the transition between the feeding artery and draining vein. One-third of arteriovenous malformations (AVMs) which are diagnosed due to intracranial hemorrhage are identified before the age of 20 years of age.[13] Overall, AVMs are rare in pediatric age group but are more prone to hemorrhage than adults.[13] Fast flow generates flow voids easily seen on T2-weighted images. Complications including previous hemorrhage and adjacent edema may be evident. These features were present in the three cases seen within the period of study.

Arachnoid cysts occur from failure of histogenesis. They are relatively common, unilocular, benign, fluid-containing lesions occurring in the central nervous system, both within the intracranial compartment (most common) and spinal canal. Some studies say they contain CSF;[14-17] another says the chemical composition of arachnoid cysts differ from that of CSF.[18] They are usually located within the subarachnoid space, 50%–60% in the middle cranial fossa,[14] and 10% in the posterior cranial fossa.[15] Arachnoid cysts account for ~1% of all intracranial masses. Although the vast majority is sporadic, they are seen with increased frequency in mucopolysaccharidoses. On imaging, they are characterized as well-circumscribed cysts, with an imperceptible wall, displacing adjacent structures, and following the CSF pattern.[14] They can also have a remodeling effect on the adjacent bone. The majority of arachnoid cysts are small and asymptomatic hence patients may not be diagnosed until late teens as noted in the 17 years old. Those seen in this study were large measuring 3–6 cm in their widest diameter, presented with headaches and were in the middle and posterior cranial fossa.

Tuberous sclerosis is a neurocutaneous disorder characterized by multiple benign tumors of the embryonic ectoderm.[19] It typically presents in childhood with the Vogt triad of seizures, mental retardation, and adenoma sebaceum. Neurological findings are usually visible within the first 6 months of age and include cortical/subcortical tubers seen predominantly in the frontal lobes as low- and high-signal intensity lesions on T1- and T2-weighted sequences, respectively with 10% showing mild enhancement, and 88% having calcifications.[20] Other features are subependymal giant cell astrocytomas, white matter abnormalities, and retinal phakomas. The case seen had cortical tubers predominantly in the frontal lobes and was seen at 17 years of age likely due to late presentation. Poverty has been known to delay investigation in developing countries without appropriate health insurance.[4,5]

Cerebral atrophy and hydrocephalus occur at the stage of myelination (Stage 4).[19] Myelination is the formation of white matter from more primitive areas to more advanced areas of the brain. It occurs between 6 months and 3 years from caudad to cephalad and dorsal to ventral with failure resulting in demyelinating and metabolic diseases. It can be congenital or acquired from an infectious, ischemic, metabolic, or hereditary disorder. Congenital (*in utero*) types are Alexander's disease, adrenoleukodystrophy, metachromatic leukodystrophy, Canavan disease, while the acquired types result in cerebral atrophy, porencephaly, hydranencephaly, communicating hydrocephalus, hydrocephalus from synechiae at the aqueduct of Sylvius.[21] These diseases present with delayed developmental milestones, vomiting, and macrocephaly as seen in the cases of aqueductal stenosis and cerebral atrophy. Mental retardation is another feature which likely presented as poor school performance in one of the late presentations.[19] Hydrocephalus was the most common CNS anomaly seen in the study similar to what was found in a study done in Jos when considering the brain alone.[22]

The challenges of our study relate to late presentation of patients to tertiary centres which is due to poverty and poor access to specialist care. Ignorance is also a documented reason for delays as well as the belief to seek alternative solutions to medical problems. The sample size is also low because MRI is costly and unaffordable for patients as they have to pay out of pocket. Further studies are underway which are wider in scope.

CONCLUSION

CMs exist in our environment. The common malformations seen are aqueductal stenosis, arteriovenous malformations, cerebral atrophy, and arachnoid cysts. Other anomalies seen in less frequency are schizencephaly, tuberous sclerosis, and dandy walker malformation. CM commonly present with delayed developmental milestones and should be suspected in children with poor school performance. MRI plays a significant role in delineating these anomalies, with a significant impact on the study and understanding of the malformations and their evolution. Its incidence is likely more than has been described in this study or others; however, there is underreporting of such cases due to ignorance, poverty, cost, and inaccessibility of MRI. Advocacy for free or subsidized MRI should be done for children with suspicion of brain anomalies.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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