ORIGINAL ARTICLE

Neuroimaging findings in pediatric patients with seizure from an institution in Enugu

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Abstract

Background: Pediatric seizures in developing countries are often poorly investigated and consequently poorly managed. Sociocultural misconceptions, financial difficulties, and lack of facilities are often blamed. This study studies the structural intracranial abnormalities associated with pediatric seizures and the proportion of these structural lesions that may benefit from surgery.

Methods: Prospective study of 311 pediatric patients referred with seizure disorders, for computed tomography and magnetic resonance imaging to the Memfys Hospital for Neurosurgery, Enugu, between 2003 and 2014. All patients had contrast studies. Angiography was done for selected cases. Demography, imaging findings, and potential benefits of surgery were analyzed using descriptive and inferential statistics.

Result: Analysis of 311 patients representing 21% of all pediatric head scans. Male to female ratio was 1.2:1.0. Definite structural lesion was identified in 53.4%. Lesions that may benefit from surgery were identified in 27.7% of all cases representing 51.8% of abnormal scan findings. Under-5 had the least scan rate of 25.1% compared with 42.4% in the adolescents. Although the older age groups had more abnormal findings, the proportion of abnormal to normal scan findings was the highest (1.7:1.0) in the under-5. Under-5 age group had more lesions that may benefit from surgery ($P = 0.001$). Intracranial tumor was diagnosed in 10.6%, vascular abnormalities (10.3%), hydrocephalus (5.8%), brain abscess (2.9%), and chronic subdural hematoma (2.6%) ($P = 0.001$).

Conclusion: Structural lesions are common and diverse in pediatric seizures. Significant proportion of these patients may benefit from surgery, and these benefits override financial and sociocultural considerations.

Key words: Convulsion, imaging, pediatrics, surgery

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Introduction

Seizures are common in the pediatric age group.[1-4] The stigmatization and sociocultural consequences still present in our society ensure that the problem is investigated as exhaustively as possible within the limits of the parents' financial abilities. The difficulty, however, is in accessing the appropriate investigation.[5]

The ability to recognize neurological disorders that indicate possible underlying pathology as basis for pediatric seizures requires thorough clinical and radiological evaluation. Relying on the descriptive ability of the possibly uninformed caregiver, for clinical diagnosis may be misleading as relatives may not recognize seizure patterns without loss of

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consciousness. Although electroencephalography (EEG) may assist in determining the nature of a seizure, it is known that the type of seizures and the pattern of EEG spikes will not distinguish seizures in patients with tumor from those without an underlying tumor.[6]

Even among medical practitioners, there seems to be a significant controversy on the need for neuroimaging investigation for pediatric patients presenting with certain clinical types of seizure. In the under-5 age group, generalized seizures often times are initially clinically diagnosed as febrile convulsions. The controversy on the imaging investigation for pediatric seizures also extends to the appropriate timing for computed tomography (CT) or magnetic resonance imaging (MRI). The concern of radiation exposure to the relatively young brain tends to delay the decision of medical experts and patient relatives to present these patients for CT imaging. This is further compounded by the currently slightly high cost of these investigations, especially MRI. Unfortunately, the use of the more affordable ultrasound scans, for investigating the brain for structural lesions is limited to infants with a patent fontanelle.

These sociocultural and clinical reasons may delay the decisions of clinicians to properly evaluate these patients, and the potential benefits of surgical interventions are possibly lost due to late scan decisions. It has been shown that up to 62.3% of abnormal CT scan findings in seizure patients may be amenable to neurosurgery intervention,[7] and seizure may be a presenting complaint in up to 17% pediatric patients who undergo surgery for an intracranial tumor.[8] When neuroimaging facilities are not utilized during the patient investigation, certain types of neurological disorders could be wrongly diagnosed, and the optimum management of such patients may be compromised. These factors also make it difficult to get a true epidemiological data.

This paper studies the structural intracranial abnormalities associated with pediatric seizures and the proportion of these structural lesions that may potentially benefit from surgery.

Methods

This is a prospective study of 311 pediatric patients referred with seizure disorders, for CT and MRI to the Memfys Hospital for Neurosurgery (MHN), Enugu, between 2003 and 2014. MHN was the only referral center for CT and MRI in the South-East zone during most part of this study. The pediatric age range was defined as <18 years. Patients had referred for surgical management with already established radiological diagnosis before the referrals were excluded. All pediatric patients referred for head scan were assessed, but only patients specifically referred for seizures were included in this study. Our protocol for these patients is to obtain scans with contrast and in selected cases to include angiography. The study was limited by the fact that referral originated from different sources, and it was impossible to determine the patients that may have benefited but were not referred. Demography, imaging findings, and potential benefits of surgery were analyzed using descriptive and inferential statistics with the Statistical Package for Social Sciences (version 17 SPSS Inc., Chicago, IL, USA) software. Ethical approval was obtained from Memfys Hospital Ethics Committee before the study was embarked on.

Result

A total of 311 patients representing 21.2% of all pediatric head scans were recruited. CT scan was used for diagnosis in 157 patients, whereas MRI was used in 154 patients. Twelve patients underwent MRI scan following an inconclusive initial CT scan. In those cases, the MRI findings were used for the study instead of the CT scan findings. Further, CT angiography (CTA) and MR angiography (MRA) were done in eight and three cases, respectively, for suspected vascular malformation, and arteriovenous malformation was confirmed in five cases.

The male to female ratio was 1.2:1.0 [Table 1]. Intracranial tumor was diagnosed in 10.6%, 10.3% had vascular abnormalities, 5.8% had hydrocephalus, 2.9% had brain abscess, and 2.6% had chronic subdural hematoma (CSH) ($P = 0.001$) [Tables 2 and 3]. Brain

Table 1: Demography

Age	Male	Female	Total	Percentage
0-5	44	34	78	25.1
6-10	47	38	85	27.3
11-15	50	43	93	29.9
16-18	29	26	55	17.7
Total	170	141	311	100

Male: female=1.2:1.0

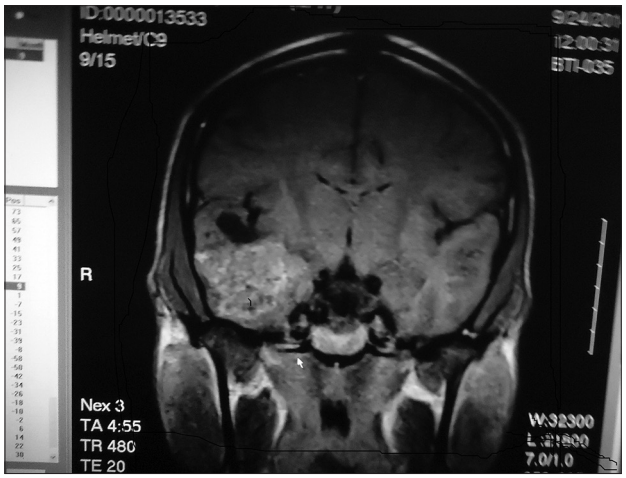

Figure 1: Postcontrast coronal brain magnetic resonance imaging of an 11-year-old patient who presented with seizure. Lesion showed poor contrast enhancement. Postoperative histology was infiltrating fibrillary astrocytoma WHO grade 2

Table 2: Structural abnormalities detected on neuroimaging

Abnormal findings	0-5.0 *n* (%)	5.1-11.0 *n* (%)	11.1-18 *n* (%)	Total		
				Total	Percentage of abnormal (*n*=166)	Percentage of total (*n*=311)
Tumor*	13 (7.9)	8 (4.8)	12 (7.2)	33	19.9	10.6
Vascular*,†	12 (7.2)	14 (8.5)	6 (3.6)	32	19.3	10.3
Atrophy	6 (3.6)	4 (2.4)	9 (5.4)	19	11.4	6.1
Hydrocephalus*	7 (4.2)	10 (6.0)	1 (0.6)	18	10.9	5.8
Encephalomalacia	1 (0.6)	2 (1.2)	8 (4.8)	11	6.7	3.5
Abscess*	4 (2.4)	-	5 (3.1)	9	5.4	2.9
CSH*	2 (1.2)	4 (2.4)	2 (1.2)	8	4.8	2.6
Cavum septum pellucidum	-	-	5 (3.1)	5	3.0	1.6
Contusion	1 (0.6)	3 (1.8)	1 (0.6)	5	3.0	1.6
Encephalitis/meningitis	3 (1.8)	2 (1.2)	-	5	3.0	1.6
Calcification	-	2 (1.2)	1 (0.6)	3	1.8	1.0
Craniostenosis*	-	1 (0.6)	1 (0.6)	2	1.2	0.6
Depressed skull fracture*	-	-	1 (0.6)	1	0.6	0.3
Multiple lesions	1 (0.6)	2 (1.2)	12 (7.2)	15	9.0	4.8
Total	50 (30.1)	52 (31.3)	64 (38.6)	166	100	100

*Structural lesions with potential benefit from neurosurgical intervention; †Seventeen cases were diagnosed with ischemic process, five with AVM, three with cavernoma, seven with SICH of unknown etiology. χ^2=25.639, *P*=0.001<0.05, significant. CSH=Chronic subdural hematoma; AVM=Arteriovenous malformation; SICH=Severe intracerebral hemorrhage

Table 3: Summary of findings analyzed by age

Findings	Age (years)						Total	
	0-5.0		5.1-11.0		11.1-18.0			
	n	Percentage of 311	*n*	Percentage of 311	*n*	Percentage of 311	*n*	Percentage of 311
Normal	28	9.0	49	15.8	68	21.9	145	46.6
Structural abnormality	50	16.1	52	16.7	64	20.5	166	53.4
Total	78	25.1	101	32.5	132	42.4	311	100.0

Analysis of cases that may potentially benefit from surgery

Age group	0-5.0	5.1-11.0	11-18.0	Total
Number of patients with potential benefit from surgery	31	25	30	86
Percentage of potential surgery benefit out of total in each age subgroup	39.7	24.8	22.7	27.7
Percentage of potential surgery benefit from structural abnormality scans in each age subgroup	62.0	48.1	46.8	51.8

Potential surgery=Tumor 33 + vascular 15 + hydrocephalus 18 + abscess 9 + hematoma 8 + craniosynostoses 2 + depressed skull fracture 1=86 (Table 2). χ^2=2.994, *P*=0.224<0.05, insignificant

Table 4: Clinical types of seizure and findings

	n (%)
Seizure type (*n*=311)	
Primary generalized	226 (72.7)
Partial	58 (18.6)
Unknown	27 (8.7)
Sub-group analysis of partial seizures (*n*=58)	
Tumor	12 (20.7)
Vascular	8 (13.8)
CSH	3 (5.2)
Brain abscess	3 (5.2)
Others*	8 (13.8)
No abnormality detected	24 (41.3)
Total	58 (100.0)

*Others: Contusion, calcification, depressed skull fracture, encephalomalacia, intracranial abscess, multiple. CSH=Chronic subdural hematoma

atrophy (6.1%), ischemic processes (5.5%), and encephalomalacia (3.5%) were the most common nonsurgery structural lesions [Table 2]. In the under-5 age range, intracranial tumor and vascular pathologies accounted for most of the structural abnormalities. In patients aged between 5 and 11 years, vascular lesion and hydrocephalus were the more common findings followed by intracranial tumors. Among the adolescents, intracranial tumors, brain atrophy, and encephalomalacia were the most common lesions identified [Table 2] (P = 0.001). No mesial temporal sclerosis was diagnosed among the patients that had MRI.

In 46.6% of the patients, the imaging study was normal, but a definite structural lesion was identified in 53.4%. A lesion that may potentially benefit from surgery was identified in

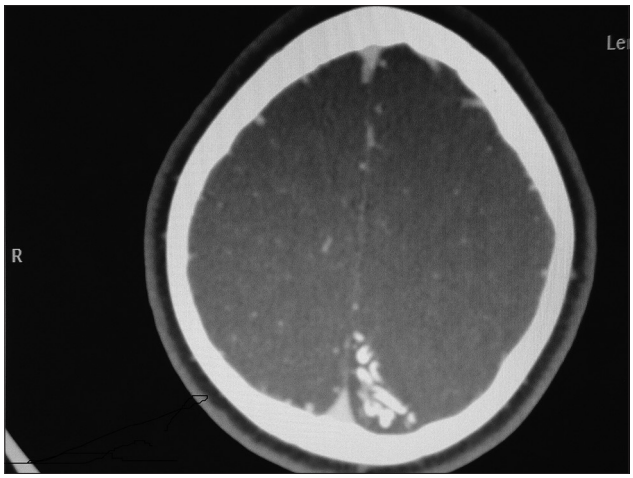

Figure 2: A noncontrast brain computed tomography scan of an 8-year-old boy who was investigated for seizures. Postoperative histology revealed dystrophic calcification on a background of encephalomalacia probably related to a previous head injury

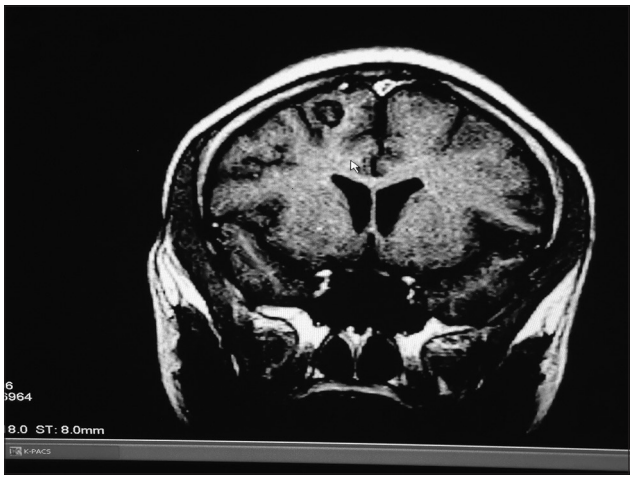

Figure 3: T1-weighted images coronal image of a 14-year-old boy who presented with seizures. Magnetic resonance imaging revealed a cavernoma in the right superior frontal gyrus

Figure 4: Postcontrast computed tomography scan of a 10-year-old girl which showed a ring enhancing lesion in the right frontal lobe with significant mass effect. The intraoperative finding confirmed an intracranial abscess

27.7% of all the cases, and 51.8% of all cases with abnormal scan findings ($P = 0.224$). Figures 1-4 shows neuroimaging findings of lesions that may potentially benefit from surgery. The under-5 had the least scan rate of 25.1% compared with 42.4% scan rate in the adolescents. Although the older age group had more abnormal findings, the proportion of abnormal to normal scan findings was the highest in the under-5 age group, 1.7:1.0. Similarly, the under-5 age group has more lesions that may potentially benefit from surgery [Table 3].

Subgroup analysis of the clinical type of seizure revealed that 226 (72.7%) patients had generalized seizure, 58 (18.6%) patients had partial seizure, and the seizure type in 27 (8.7%) cases was unknown [Table 4]. Among the patients presenting with partial seizures, intracranial tumors, vascular-related pathologies, abscess, and CSH were the common findings [Table 4].

Discussion

In this study, seizures account for over 21% of pediatric patients referred for neuroimaging, although the prevalence of seizures in the pediatric population in Nigeria is estimated at 0.5–3.7%.[9] The study revealed that the proportion of pediatric patients referred for imaging investigations increased steadily with age and that marginally more male children were referred for imaging investigations. The trend to invest more in the health of males, both for children and adults, has been established in published works in this sub-region and other developing countries.[1,2,4,7,10,11] The finding from this study of 1.2:1.0 as opposed to 1.8:1.0[12] may be an indication that this practice is slowly reversing toward the trend seen in more developed countries.[13,14] This and the improvement in the overall scan rate over the years may be related to increasing literacy and increasing social awareness of the need for social equity for the sexes.

The fact that more patients are referred as the age range increases is probably related to the fear of the long-term risks associated with exposure to irradiation from CT scan for the younger child but also to the tendency of clinicians to rely more on clinical judgment alone despite its limitations. The concerns for radiation risks may also account for scan rates in the under 5s being the lowest. Increasing awareness of the availability and safety of MRI service should ameliorate this concern. In addition, clinicians and the general public should understand that the potential benefit of early referral for scans may offset the feared risk of radiation exposure, and the current cost concerns. Early imaging investigation would increase diagnostic certainty, improve delay in presentation, prevent progressive brain damage, especially from lesions that would potentially benefit from surgery as well as reduce cost on the long run, as a result of wrong decision or need for medication.

MR investigation is superior to CT as it gives a better soft tissue resolution, especially if the lesion of interest is very small in size. MRI is also very useful in diagnosis of some vascular malformations such as cavernomas. It also produces images in other planes and sequences that aid lesion characterization. MRI does not expose patients to the risk of radiation, and this is very useful in pediatric age groups.

In addition, many clinicians in developing countries hold the view that there should be a higher threshold for investigating seizures in the younger age group since a significant proportion of seizures in the under-5 age range are clinically attributable to and managed as febrile convulsions. This study, however, shows that the proportion of normal findings was least in this age range and increased as the age range increased. This pattern has also been reported by Obajimi *et al*.[7] While this may be a reflection of a lower threshold for investigating seizures in the older age groups, the increased finding of structural abnormality in the under 5s argues for a change of practice and a lower threshold for neuroimaging in younger children.

This study strengthens the argument for the imaging of patients presenting with seizures in this environment irrespective of age or sex of the patient; considering that, most patients do not present to expert care until seizure has occurred more than once. MRI scans and where possible neuroultrasonography should be used preferentially in patients <5 years. The presence of neurologic deficit may increase the chance of finding an abnormality from a brain scan for seizure. However, as high as 40% of children without neurological deficit may have structural lesion identifiable on neuroimaging for seizures.[7]

As high as 53% of the imaging findings from this study revealed a structural abnormality. This is comparable to the range of 50–55% reported in other local studies.[4,7] Generally, there seems to be a high incidence of abnormal scan findings in children with seizure disorder in developing countries compared to the rate of 12–20% obtained from the developed countries.[13,14] This lower percentage of overall abnormalities does not necessarily indicate a reduced overall percentage of therapeutically important abnormalities in neurologically normal children with new-onset seizures.[15] The high percentage of abnormal scan findings in this study can be explained, at least in part by the fact that only refractory seizure cases are likely to consult the specialist clinics that usually recommend imaging investigations. In part also, this may be an indication of the higher proportional representation of the pediatric population in developing countries.

About 27.7% of all seizure patients investigated (51.8% of abnormal scan results) had findings that may potentially benefit from possible neurosurgical intervention. Among the under-5 age group, there were a very high proportion of abnormal scan findings compared to normal findings, and as much as 39.7% of the patients could potentially benefit from a neurosurgical intervention. This finding emphasizes the need to not assume seizures in this age group as "febrile convulsions," especially since clinical and EEG findings may not reliably distinguish structural from nonstructural causes of seizure.[6] This proportion of abnormal findings is significant considering the benefit of early surgical intervention. Early surgical intervention is likely to remove the primary cause of the seizure, help to achieve better seizure control, and reduce drug need and the associated side effects. The common lesions of surgical importance in this study were intracranial tumors, vascular malformations, brain abscesses, hydrocephalus, and subdural collections as found in other studies.[7,8,12-16] Interestingly, there was a high proportion of patients diagnosed with brain tumors and vascular anomalies in this study, and the frequency of some of these findings such as intracranial tumors across all the pediatric age groups was almost equal.

On the other hand, the subdural collections, contusions, and depressed skull fracture observed in the younger age group may reflect a higher incidence of child abuse in this environment than is generally reported. Although child battering and neglect may not be a commonly discussed issue in this environment, many parents leave the routine care of their children to paid or unpaid live-in nannies due to the pressure of work. Abuses inflicted in such circumstances are bound to be under-reported, and manifestations such as epilepsy leading to imaging may be the only window. Important structural findings may not be identified if such children were not properly investigated.

The cases with isolated hydrocephalus referred for imaging peaked between ages 5 and 11 instead of in the under-5 age group. These patients were referred because of onset of seizures, and this is an index of the problem of late presentation of cases for expert care. The problem of late presentation in hydrocephalic patients is, particularly, troublesome since significant brain damage and cranial deficits could occur from neglected hydrocephalus before the appropriate neurosurgical intervention is made.

Although spontaneous intracerebral hemorrhage is considered quite uncommon in pediatric patients,[12] vascular malformations were significant cause of seizures in this study with over half of these being adolescents. This may reflect a trend toward increasing awareness of properly investigating suspected stroke patients among clinicians and partly the increasing utilization of the noninvasive CTA or MRA. No case of mesial temporal sclerosis was diagnosed in this study. However, it is hoped that when higher specification MRI become available, the rate of abnormal findings may increase.

Only one-quarter of seizures (25.7%) were clinically focal in this series. It has been noted in some studies that the frequency of partial seizures in pediatric age group may be as common as generalized seizures on clinical basis although most people may tend to recognize generalized seizures often.[17,18] The diagnosis of partial seizures may be quite difficult. EEG between events may be normal, and many of these patients with partial seizures may have normal clinical examination and neuroimaging investigation findings.[19] About 33% of patients have a secondary seizure focus distinct from a known tumor location.[20] It is, therefore, important as highlighted from this study to investigate partial seizures extensively, including using noninvasive angiography since vascular abnormalities and other lesions may be the underlying cause. In these circumstances, where there is a focus apart from an identified lesion, Morrell and deToledo-Morrell argue that early treatment of epilepsy may prevent development of such secondary focus.[21]

Since early scanning may reveal a diagnosis of surgical importance in about one of every four patients referred for neuroimaging, early scan decisions should be advocated after a repeat seizure event irrespective of a child's age and clinical type of seizure. In general, neurosurgical patients present late for management for a variety of reasons including delays in diagnosis and fiscal constraints.[22] Since epilepsy is still highly stigmatized, parents often get their children to initial consults when they present with seizures. The major challenge is then a delay in referral of patients for imaging investigations by the primary care centers where a significant proportion of pediatric seizure patients are still being managed based on clinical and biochemical diagnosis alone, and referrals for neuroimaging investigations reserved for cases with worsening seizure frequency. There is, therefore, a need to increase the awareness for early definitive diagnosis and treatment among pediatric healthcare workers. Unfortunately, financial challenges as a reason for delays are not as easily addressed, and require a change in health policy at governmental level. Attempts to establish a National Health Insurance Scheme has not been uniformly successful, and organized nongovernmental agency seems to offer the best support at the moment, although they still remain relatively difficult to access.

Despite these challenges, early neuroimaging investigations for pediatric patients presenting with seizure disorder should be encouraged since neuroimaging play pivotal role in management decisions, especially when considering the option of definitive treatment of the underlying cause of the seizure. Imaging provides important contributions to establishing etiology, providing prognostic information, and directing treatment in children with recently diagnosed epilepsy.[15]

The need to investigate seizures, especially first seizures, in adults because of the possibility of an underlying intracranial tumor is now well-established.[23] This should be extended to pediatric patients, especially the adolescents. Pediatric patients are dependents and in developing countries with poor social support and financial difficulties for the majority of families, a major debate is to what extent a useful but slightly expensive imaging investigation will improve the seizure management. In addition, the predisposition of the immature brain to malignant transformation following exposure to radiation must be taken into consideration. The yield in this study and the potential for early intervention improving prognosis, argues for the use of these modalities. CT scan is cheaper, and with due consideration for the possible risk of developing malignancy with repeated exposure provides excellent cost-effectiveness. Even if only CT is available, the benefits of early intervention outweigh the risk of radiation hazards, especially when due care is taken to limit exposure.

Conclusion

Neuroimaging modalities are of extreme value in the screening and definitive evaluation of seizures in children. The increasing availability of MRI scans means that all pediatric patients with unexplained multiple seizures should be investigated. Structural lesions identifiable in pediatric patients with seizures are quite common and diverse. Significant proportion of these patients may potentially benefit from neurosurgical intervention. The study is limited by its multireferral pattern and the fact that most patients did not have EEG from the referral centers.

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Conflicts of interest
There are no conflicts of interest.

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