International Journal of Medicine Research
www.medicinesjournal.com
ISSN: 2455-7404
Received: 07-10-2021, Accepted: 22-10-2021, Published: 08-11-2021
Volume 6, Issue 4, 2021, Page No. 08-13

Analysis of clinical features, EEG & neuroimaging studies in childhood epilepsy

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Abstract
Background: Epilepsy is the most common childhood neurologic disorder. About 50% of all cases of epilepsy start in childhood, nearly 90% of the people with epilepsy are found in developing regions.
Objectives: To analyze the clinical features and neuroimaging studies among epileptic children.
Patients and Methods: One hundred epileptic children were included in the study. They were evaluated to determine the clinical features, developmental assessment and the significance of neuroimaging studies.
Results: Among 100 children included in the study, the sex distribution was nearly equal, the most prevalent age group was below 3years (50%), the tonic-clonic epileptic seizure was the commonest type (56%), the EEG study was positive in 96% of patients, CT scan had been done for significant number of children in the study (86%) while only 4% had MRI. The most prevalent CT change was variable degree of brain atrophy (46.5%) followed by calcifications (5.7%) then hydrocephaly (2.3%)
Conclusion: Most patients with epilepsy present below 3 years of age, the most common type of epilepsy was tonic-clonic epilepsy, EEG mostly abnormal. CT scan imaging used more than MRI in the evaluation of the possible pathology causing epilepsy & the most common finding was brain atrophy, then calcifications and hydrocephaly.

Keywords: epilepsy, seizures, neuroimaging

Introduction

Epilepsy is the most common childhood neurologic disorder, affecting 0.5% to 1.0% of children younger than age 16 years [1] and as many as 6% of all children experience febrile seizures before the age of 6 years [2]. Nearly 90% of the people with epilepsy are found in developing regions [3], and approximately 50% of all cases of epilepsy start in childhood [4]

Definition: from the Ancient Greek (epilēpsía)-"to seize" [5] When a patient has had two or more seizures that were not the result of a general medical condition or fever, the patient is said to have epilepsy [6], it results from an abnormal and excessive discharge of a set of neurons in the brain [5]

Classification of Seizures

To understand the treatment of epilepsy, the physician must know the difference between partial (focal) seizures and primary generalized seizures. The difference is important both for the purpose of understanding the nature of the seizures and because several medications indicated for partial seizures do not control or may even worsen primary generalized seizures [7]. The classification system for epileptic seizures currently in use is based on both clinical and EEG features. It divides seizures into two major categories, generalized and partial (table1) [8]

Table 1: International Classification of Epileptic Seizures

- Partial Seizures
  - Simple partial (consciousness retained)
    - Motor
    - Sensory
    - Autonomic
    - Psychic
  - Complex partial (consciousness impaired)
  - Simple partial, followed by impaired consciousness
    - Consciousness impaired at onset
  - Partial seizures with secondary generalization
- Generalized Seizures
  - Absences
    - Typical
    - Atypical
  - Generalized tonic-clonic
    - Tonic
    - Clonic
    - Myoclonic
    - Atonic
  - Infantile spasms
  - Unclassified Seizures

Generalized seizures are those in which the clinical features indicate the involvement of both cerebral hemispheres from the start. Consciousness usually is impaired and, when motor involvement is present, it is bilateral and relatively symmetric from the beginning. Conversely, partial seizures are characterized by clinical features suggesting that only a limited or functional area of one cerebral hemisphere is involved. They begin focally, although they may become generalized. Partial seizures are divided further into those with elementary or simple symptomatology and those with complex symptomatology. In children, elementary partial seizures most commonly are focal motor or focal sensory phenomena, and consciousness is preserved unless secondary generalization occurs. Complex partial seizures usually have their origin in temporal or frontal lobe structures, and the clinical features encompass a spectrum of complex phenomena, including behavioral automatisms, alterations of perception, hallucinations, changes in affect and memory, and ideational distortions [4] Epileptic syndromes have been defined by the commission on Classification and Terminology of the International League against Epilepsy as: A complex of signs and symptoms that define a unique epilepsy condition. This must involve more than just the seizure type; thus, frontal lobe seizures per se, for instance, do not constitute a syndrome [9]

Diagnosis

The diagnosis of epilepsy and classification of specific seizure types are essential to determining a prognosis and choosing an appropriate treatment. The investigation of a child experiencing seizures begins with a medical history and physical examination. Although significant technologic advances have been made in electrophysiology and neuroimaging, the diagnosis of seizures and epilepsy remains largely clinical [9]

History and physical examination

The first diagnostic step is to determine if the clinical presentation is compatible with seizures or with other paroxysmal phenomena. Although this distinction often is easy to make clinically, certain conditions (especially syncope, pseudo seizures, and tics) can be confused with seizures. [9] No single clinical symptom can reliably discriminate between a seizure and a nonepileptic event [12].

The history may include;

- Description of the events: aura
- Age at event onset
- Event frequency
- Precipitating factors: Fever, sleep deprivation, stress, photosensitivity, drugs
- Development: Fine motor, language, gross motor, and social skills
- General medical history: Head trauma, meningitis, stroke
- Prenatal history
- The physical examination may include:
- State of consciousness, language, social interactions
- Observation of the events (if possible); hyperventilation sometimes can provoke absence seizures
- Global development
- Dysmorphic features, limb asymmetry, neurocutaneous skin findings, organomegaly
- Head circumference
- Neurologic examination: Cranial nerves, motor strength and tone, osteotendinous reflexes, sensory and cerebellar function tests, gait [9] Home video recording home video camera recordings may reveal information not elicited by history taking and may support or refute a suspected diagnosis of epilepsy [13].

Laboratory evaluation

In approaching the laboratory evaluation, the laboratory studies are necessary to establish a baseline for future comparison, and others can help with formulating medical treatment and prognosis. Indications for laboratory studies should be based on information extracted from the history and physical examination. The investigation of a seizure depends on many factors, including the age of the patient, the type and frequency of the seizure, and the presence or absence of neurologic findings and constitutional symptoms. If specific disease entities such as hypocalcemia, hypoglycemia, or other metabolic, toxic, or degenerative disorders are valid considerations, additional studies relevant to the particular entity are, of course, appropriate [4, 8].

Electroencephalography (EEG)

The invention of the electroencephalogram in 1929 had a profound impact on the diagnosis and classification of the epilepsies [11].

The EEG is a useful adjunct to the history and physical examination in establishing the diagnosis of epilepsy, but a routine interictal (between seizures) EEG will show an epileptiform abnormality in only approximately 60% of patients [10]. The sensitivity of interictal EEG recordings is too low to be a reliable diagnostic test for epilepsy [14]. but The sensitivity of the EEG can be increased to more than 80% if the EEG is repeated, if the patient is sleep deprived before the EEG, or if the patient is monitored for 24 to 72 hours [7]. Thus; If a first standard inter-ictal EEG is normal, there is evidence that a second recording increases the yield of diagnostically helpful abnormalities [15].

A routine EEG always should be recorded during wake fulness and sleep and, in older children, during hyperventilation and photic stimulation. Seizure discharges are more likely to be recorded in infants and children than in adolescents or adults [8]. The EEG may or may not normalize following initiation of antiepileptic drug (AED) therapy. In most cases, if the patient's seizures are controlled by the AED, it does not matter that the EEG remains abnormal. The treatment of certain conditions, such as infantile spasms, is expected to normalize the EEG [7]. Patients who are taking an anticonvulsant and who are scheduled for a routine EEG should not have the medication decreased or discontinued before the study, because status epilepticus may result [8].

A routine EEG is recorded using electrodes, usually 20 in number, affixed in a standard pattern to the patient's scalp by a conductive gel. The duration of a standard EEG recording is 30 minutes [7] (or 1 hour) [4] for adults, but it may be less for young children.

Prolonged EEG monitoring with simultaneous closed-circuit video recording is reserved for complicated cases of protracted and unresponsive seizures. It provides an invaluable method for recording ictal seizure events that are rarely obtained during routine EEG studies [8].

Neuroimaging

Routine skull radiography seldom is indicated or helpful except when overt bony pathology is detected by physical examination. High-resolution ultrasound is a useful

technique in the investigation of premature infants and term neonates with seizures [4]. Patients are investigated thoroughly to identify any structural abnormalities that may act as epileptogenic foci [18]. Depending on the circumstances, first line investigations include computed tomography (CT) and magnetic resonance imaging (MRI), Additional techniques are available in specific circumstances including single positron emission CT, diffusion imaging, MR spectroscopy, perfusion imaging and functional MRI [19].

Epilepsy causes great parental worry. It is not surprising, therefore, that a computed tomography brain scan is often requested for parental reassurance in the face of marked and continuing anxiety [20].

CT has relatively low sensitivity for many of the cortical abnormalities that cause epilepsy in the younger age groups. Due to this lack of sensitivity and the radiation exposure, CT should not be used routinely in children and young adults [19]. Thus, CT should not be ordered unless MRI is unavailable to prevent unnecessary radiation exposure [17] CT is useful when MRI is unavailable or contraindicated and also is preferable for acutely ill patients because patient accessibility and acquisition time are limiting factors for MR scanning [21].

Urgent imaging is usually not required for patients with an epileptic seizure alone [22].

The following are the main indications:

- Partial seizures (in all children), except those with benign partial epilepsy
- Abnormal neurological signs
- Persistent and localized slow wave changes (delta focus) and/or spike or sharp wave foci, either or both of which may indicate the presence of a local structural lesion [20].
- Manifestation of a sudden change in seizure pattern, in neurological examination, or in the EEG (any or all of which may indicate the presence of a progressive lesion) [20].
- Patients with refractory seizures, even of many years' duration, should be considered as candidates for imaging, particularly MRI if available, because of the possible presence of a potentially resect able epileptogenic lesion [20].
- Preoperative MRI has a prognostic value in characterizing the chance of postoperative seizure control [21].

The International League Against Epilepsy has published recommendations on cranial imaging in epilepsy: Most children with epilepsy should have an elective MRI brain scan. Children with the following epilepsy syndromes (which are following a typical course) do not need brain imaging:

- Idiopathic (primary) generalized epilepsies (e.g. childhood absence epilepsy, juvenile myoclonic epilepsy or juvenile absence epilepsy)
- benign childhood epilepsy with centrotemporal spikes (benign Rolandic epilepsy) [23].

MRI findings that account for a focal or secondarily generalized seizure include tumor, abscess, arteriovenous malformation, cortical malformation, recent or remote infarct, and hemorrhage. Uncommon congenital brain malformations that often cause focal seizures include lissencephaly, hemi-megalencephaly, polymicrogyria and schizencephaly [7].

In most cases, MRI reveals no abnormality. Although a normal MRI study is reassuring, patients and parents must be informed that this is no guarantee that more seizures will not occur [7].

Aim of the study

The study was carried out to evaluate a sample of epileptic patients.

The objectives of the study to determine: -

- The main types of epilepsy in children of the study group.
- Electroencephalography results in epilepsy
- The significance of neuroimaging in epilepsy

Patient and method

A total of 100 epileptic children included in our study, they were visiting the neurology clinic at the central child teaching hospital in Baghdad between 1st January 2010 31st December 2010. The information taken either directly from the patients and their relatives and/or from the outpatient file information. Review of case records were done and the requested data were: age, sex, perinatal history, history of trauma or central nervous system infection, development, seizure type, electroencephalography (EEG) result, neuroimaging result, family history of epilepsy or febrile convulsion.

First step; The patients were divided according to their sex, then divided according to their age into 5 groups (below 3 years, 3-6 years, 6-9 years, 9-12 years & above 12 years).

The perinatal history taken to find the possible events occur that may lead to development of epilepsy, this history includes {difficult labor, birth asphyxia, respiratory distress syndrome (RDS), prolonged neonatal jaundice, hypoglycemia, and neonatal seizure}.

Developmental assessment has been done for the patients aged less than 6 years, then the patients were divided into 2 groups (normal development, delayed development). The patients regarded to had developmental delay if had developmental quotient (DQ) {the developmental age divided by chronologic age times 100} less than 70% [24].

The electroencephalography (EEG) results were taken for the patients and we depend on the report of the electro encephalo grapher, the patients were divided into 3 groups (patients with positive EEG result, patients with negative EEG result, and patients not had EEG yet; so, their diagnosis were clinical only). Neuroimaging results {either Computerized Tomography (CT) scan or Magnetic Resonance Imaging (MRI)} were taken in the history. The results were taken from radiologist report. Some patients had no neuroimaging at the time of the study, so they were not included in this result.

Results

Age & sex

The total female patients were 53 (53%) while male patients were 47 (47%) & the female to male distribution was about 1.2:1(table 2).

Table 2: Distribution of epilepsy according to the sex

Sex	Number	%
Female	53	53%
Male	47	47%
total	100	100%

The age of the patients included in our study was ranging from 3 months to 14 years. The patients were divided into 3 groups:

The patients aged less than 3 year was 50 (50%), from 3-6

years was 24 (24%), from 6-9 years was 16 (16%), from 9-12 years was 7 (7%), more than 12 years was 3 patients (3%). These results outlined also in table 3.

Table 3: Distribution of epilepsy according to the age

Age	Number	%
0-3 years	50	50%
3-6 years	24	24%
6-9 years	16	16%
9-12 years	7	7%
>12 years	3	3%

Development

Development history & milestones was determined for the patients aged less than 6 years (74 patients). Forty-nine patients (66%) had normal development; 25 patients (34%) had developmental delay (table 4).

Table 4: Patients' distribution according to their development

Development	Number	%
Normal	49	66%
developmental delay	25	34%
Total	74	100%

Previous history

Twenty-eight patients (28%) had complicated perinatal history while 72 patients (72%) had normal uneventful perinatal history. Fifteen patients (15%) had previous history of central nervous system infection (encephalitis or meningitis) before developing epilepsy, while 3 patients (3%) had previous history of head trauma before developing epilepsy. Four patients (4%) had past history of febrile convulsions before the patients regarded as epileptic patients (table 5). The incidence of epilepsy in patients with febrile convulsions is >9% when several risk factors are present, compared with an incidence of 1% in children who have febrile convulsions and no risk factors [8].

Table 5: Patients' distribution according to their previous history

Previous history	Number	%
Perinatal insult	28	28%
CNS infection	15	15%
Head trauma	3	3%
febrile convulsion	4	4%
Uneventful past history	50	50%

Type of epilepsy

The type of epilepsy was identified clinically & the distribution was: 56 patients (56%) had generalized tonic-clonic epilepsy, 10 patients (10%) had focal epilepsy, 10 patients (10%) had myoclonic epilepsy, 9 patients (9%) had tonic epilepsy, 7 patients (7%) had infantile spasm. 5 patients (5%) had atonic epilepsy, 2 patients (2%) had absence epilepsy, 1 patient (1%) had clonic epilepsy (table 6).

Table 6: Patients' distribution according to seizure type

Type of epilepsy	Number	%
Tonic-clonic	56	56%
focal	10	10%
Myoclonic	10	10%
Tonic	9	9%
Infantile spasm	7	7%
Atonic	5	5%
Absence	2	2%
Clonic	1	1%
Total	100	100%

Electro encephalo graphy (EEG)

EEG has been done for seventy-six patients (76%) & the results were recorded. Twenty-four patients (24%) not had EEG yet so their diagnosis depend on clinical base only. Seventy-three patients had EEG changes compatible with their epilepsy& 3 patients had normal EEG result (table 7).

Table 7: EEG results

EEG result	Number	%
Positive result	73	96%
Negative result	3	4%
TOTAL	76	100%

Neuroimaging

Majority of the patients which included in our study had neuroimaging study {either Computerized Tomography (CT) scan or Magnetic Resonance Imaging (MRI)}.

Regarding CT scan; 14 patients (14%) not had CT scan till the time of the study & therefore they are not put in the neuroimaging results, while 86 patients (86%) had CT scan.

Twenty-eight patients (about 33 % of the done CT scan) had normal result, while 58 patients (about 67%) had abnormal findings; these findings are summarized in table 8.

Table 8: Patient's distribution according to CT changes

CT finding	Number of patients	%
Variable degree of brain atrophy only	40	46.51%
Brain atrophy + calcifications$$	4	4.65%
Brain atrophy + hydrocephaly	2	2.32%
Brain atrophy + focal lesion (space occupying lesion)	1	1.16%
Brain atrophy + hypoxic ischemic encephalopathy signs	1	1.16%
Brain atrophy + white matter degeneration	1	1.16%
Brain atrophy + subdural effusion	1	1.16%
Brain hemiatrophy	1	1.16%
Ischemic changes	2	2.32%
Calcification (Sturge-weber syndrome)	1	1.16%
Intracranial hemorrhage	1	1.16%
subdural effusion	1	1.16%
leukodystrophy	1	1.16%
Arachnoid's cyst	1	1.16%
Normal CT scan	28	32.55%
Total	86	100%

$$ 2 patients diagnosed as Sturge-weber syndrome

Four patients only (4%) had MRI: 1 patient had normal MRI, 3 patients had abnormal results (1 patient had brain atrophy, 2 patients had hypodense cerebellar lesion).

patients with normal development & 2 patients with delayed development had no CT changes classified with the developmental state of the patients below 6 years,5 neuroimaging till the time of the study, so they not included in this result (table 9).

Table 9: CT scan result compared to the development

Development	CT scan result		
	Normal (%)	Abnormal (%)	Total (%)
Normal	17(39)	27(61)	44(100)
Delayed	5(22)	18(78)	23(100)

Discussion

The female to male distribution in our study was about 1.2:1, These results are comparable to the results reported by (Willem F. M. Arts *et al*) [25] & slightly lower than the figure

reported by (Anne T. Berg. *et al*) [26] & (C M Verity *et al*) [27]. Half of our patients were aged less than 3 years, These results are comparable to the results reported by (Willem F. M. Arts *et al*) [25] & slightly lower than the figure reported by (Dominic C Heaney *et al*) [28].

About 25 patients had evidence of developmental delay. This result may be related to the fact that the risk of experiencing unprovoked seizures by age 5 years in children with developmental disability is 3%, which is approximately fourfold greater than that of the general population [4].

More than half of the patients included in the study had generalized tonic-clonic epileptic seizures, while focal epileptic seizures found in 10% of the patients. These results are comparable to the results reported by Euan M Ross *et al* [29], and (C M Verity *et al*) [27].

EEG done in 76% of our patients, 96% of them had positive results, & 4% had negative results. These results are much higher than the figure reported Euan M Ross *et al* (70% had abnormal EEG) [29]. by the explanation of this difference may be related to the fact that the interpretation of EEGs in infants and young children is difficult & should be done by an electro encephalo grapher who has had specific training and experience in interpreting EEG in young children. EEGs in many laboratories are interpreted by neurologists with little or no experience with infants and young children [4].

Eighty six percent of our patients had CT scan, but only 4% had MRI. Although; CT has poor sensitivity in detecting the common structural causes of seizure activity [19], CT remains superior in the detection of calcified lesions [11], while MRI is accepted as the more sensitive neuroimaging modality for children with seizures [30]. The use of CT scan more than MRI in our study may be explained by the shortage of MRI devices in our hospitals & it's expensive coast if done in the private radiological clinics.

Sixty seven percent of the total patients get CT scan had abnormal results, while 78% of the patients with delayed development had abnormal results. These results are comparable to the results reported by (L M Li *et al*) [31]. but higher than the figure reported by Willem F. M. Arts *et al* (abnormal CT scan found in 21%) [25] & Sujit Sharma *et al* (abnormal CT scan found in 17%) [41] & Matthew Garber (abnormal CT scan found in 19%) [33].

This increase in abnormality noticed by neuroimaging studies is expected with epileptic children with developmental delay & patients with epilepsy secondary to CNS infection & our study is showing that 25 patients had developmental delay & 15 patients had previous CNS infection.

Neuroimaging in about 10 patients had more than one lesion, consisting from brain atrophy with calcification or hydrocephaly or focal lesion. These results are comparable to the results reported by L M Li *et al* [31].

The most common abnormality identified in our study was brain atrophy (52%), &brain tissue calcification was found in 5 patients while hydrocephaly found in 2 patients; a similar results found by (Sujit Sharma *et al*) [32].

Conclusion

A study of 100 epileptic patients showing

1. Female to male ratio nearly equal with slight predominance in the female.
2. The epilepsy more common among the patients aged less than 3 years.
3. A significant number from the patients had developmental delay.
4. Generalized tonic-clonic epilepsy is the most common type of epilepsy.
5. EEG study is positive in the majority of epileptic patients.
6. CT scan used more frequently than MRI for neuroimaging.
7. Abnormalities in CT scan are noticed in a significant number of the epileptic patients, & it is more common in the patients with developmental delay.
8. Brain atrophy is the most common abnormality found among the epileptic patients.

Recommendations

1. The EEG should be done for every patient with epilepsy, & interpretation of EEGs in infants and young children must be done by an electro encephalo grapher who has had specific training and experience with this age group.
2. Neuroimaging be considered when evaluating children with new onset seizures.
3. If a neuroimaging study is obtained, MRI is the preferred modality; so, it is useful to increase the availability of MRI devices in the pediatric hospital to decrease the use of CT scan & its side effects.

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