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CT Brain Imaging and Seizure Etiology in Sudanese Adults: A Clinical Correlation Study

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L A P R E S S E M É D I C A L E

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Author Contribution

[1]H. S " *She* " conceptualized the study, designed the research framework, and supervised the overall project. She also contributed to manuscript writing and final revisions.

O. E" *He"* conducted the literature review, developed the methodology, and participated in data collection and analysis. He also assisted in drafting the manuscript.

W. A " *He*" , was responsible for statistical analysis, data interpretation, and visualization. He also contributed to the discussion and review of findings.

M. I" ***She*** coordinated research activities, managed resources, and ensured adherence to ethical guidelines. She also assisted in manuscript editing.

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I. M.: ***She*** provided technical support, assisted with data processing, and contributed to the final review of the manuscript.

Abstract

Purpose: *Adult seizure is one of the more frequented clinical scenarios. Neuroimaging can help to determine whether a seizure in a patient is the result of a structural abnormality of the brain or its surroundings. This study has been undertaken to evaluate the role of CT scan of the brain in adult patients presenting with seizures in El-Moalem Medical City, thus aiding in management. This study also highlights the common CT abnormalities in patients presenting with seizures.* **Materials and Methods:** *This retrospective study was conducted in the radiology department of the aforementioned site from October 2018 to April 2019. Patients aged 18 years or more who were referred to for CT scans of the head with history of seizures were included in our study with a total of 93 patients.* **Results***: One-third of our participants were >60 years old. 53.8 % of them were males and 46.2 % were female. Focal seizures were seen in only 6.5 % of patients whereas generalized seizures were seen in 93.5 % of patients. Abnormal CT scan findings were found in 48.4% of patients with seizure. CT scan was abnormal in 84% of patients with focal seizure. 46% of patients with generalized seizures had abnormal CT scans. Cerebral infarction was the commonest abnormality detected on CT scan, followed by tumors, and hemorrhage.* **Conclusion:** *CT scan showed its diagnostic efficacy in near half of the cases in the assessment of seizures in adults. Cerebrovascular causes dominated the etiologies found.*

Keywords: *Cerebral infarction, Cerebrovascular, Focal seizures, CT scan.*

NTRODUCTION

The term "seizure" refers to a transient occurrence of signs and/or symptoms due to abnormally excessive neuronal activity of the cerebral cortex that manifests as motor, behavioral and autonomic symptoms, with or without altered level of consciousness [1]. Seizures can be due to metabolic, infectious, drugs or structural CNS abnormalities like stroke. It is termed epileptic when it is associated with brain dysfunction, and those tend to recur [1]. The causative factors are often not evident by history and clinical examination alone. Hence, diagnostic tools like serum [1].

CT uses ionizing radiation and can generate excellent hard-tissue imaging contrast with moderately good soft-tissue resolution biochemistry, electroencephalogram (EEG), and computed tomography (CT) scans are employed. Epileptogenic lesions identified on imaging include stroke, posttraumatic sequelae, neoplastic, mesial temporal sclerosis, malformation of cortical development, cavernoma and other vascular malformations. It is commonly ordered in patients presenting with new-onset seizures to an emergency department [2]. It is generally available quickly and is used to exclude acute neurologic problems that require immediate attention and urgent intervention [3]. A CT scan can help identify treatable lesions, and if the patient can undergo the scan particular treatment can be initiated [4]. CT also detects hemorrhages, infarcts, structural malformations, large tumors, cerebral atrophy, calcified lesions and post traumatic sequelae [5]. The technique is preferred in the perioperative state because it can rapidly detect recent hemorrhage, hydrocephalus and major structural changes [1]. CT has several advantages, including lower cost, scan speed, ready accessibility, and easy use, which provide a relatively reliable imaging modality for most patients [1]. It is also an alternative to MRI for patients who cannot undergo MRI because of cardiac pacemakers, severe claustrophobia, and patients with ferromagnetic objects in the body (e.g., aneurysm clips) [6].

Roy and Pandit (2011) data indicate that a CT scan is more likely to be abnormal in patients with focal seizures than in patients with generalized seizures [2]. A head CT is indicated on an emergency basis for any partial seizure or suspected intracranial process (trauma, past history of malignancy or immunocompromised, or anticoagulation, new focal neurologic examination, age > 40 y) [7]. The principal aim of the study was to determine whether computed tomography (CT) scans of the brain are useful in detecting structural brain abnormalities in adult Sudanese patients with seizures. The study objectives estimate the prevalence of abnormalities such as cerebral infarctions, tumors and hemorrhages and to determine the associations between different types of seizures (focal and generalized) and these abnormalities to help the diagnosis and management of seizures in this population.

Pathophysiology of seizures

Abnormal, excessive neuronal discharges in the brain, especially in the cerebral cortex, cause seizures. Seizures occur when the hyperactive neuronal activity seen in the other two disorders (hypoxic/ischemic, genetic) is triggered by reduced GABAergic inhibition or increased glutamatergic excitation [8]. Balestrini et al. (2021) highlighted various factors that provoke seizures, including metabolic disturbances, infections, toxins, or structural brain abnormalities, e.g., tumors, strokes, or injuries [9]. Chronic conditions such as epilepsy involve lasting atrophy of brain circuitry; for instance, hippocampal sclerosis and mesial temporal sclerosis are associated with focal seizure [10]. Goodman and Szaflarski's (2021) findings emphasize the importance of neuroimaging in understanding seizure pathophysiology and provide insights for developing treatment [11]. Hyper excitability is caused by an imbalance of glutamate and GABA neurotransmitter systems. However, the role of catecholaminergic neurotransmitter systems and opioid peptides in epileptogenesis was also identified [12]. Epileptic seizures result from paroxysmal, uncontrolled discharges of electricity from the brain that arise predominantly from the cerebral cortex. It is not surprising that involvement of the cortex by various pathologies is often associated with seizures [13].

MATERIALS AND METHODS

Study Design

This study used a retrospective cross-sectional design as data were collected from records of patients who came with seizures to a hospital within the stipulated time. It was a retrospective study, which means analysing medical records and imaging reports that evaluated it at one point without following the patients over a span. The study was limited to patients who used the hospital as the setting of hospital-based medical care. The study was conducted between September 2018 and April 2019; CT feed collection and analysis was possible for adult patients who were inptive with seizures, providing a unique overview over the time frame.

Acquisition of CT Brain

The study employed a 128 slice Toshiba scanner with continuous helical scanning to produce a 3D volume of data. With multiple applications, this technique provides multiplanar reconstructions with thick slices or thin slices using different algorithms. Diagnostic flexibility is increased with the axial plane being able to be adjusted to any desired position, independent of the patient head alignment during the scan [14].

Study Population and Size

Almoalem Medical City is a big hospital located in Khartoum. It has a well-equipped radiology department, a modern CT unit, trained technicians, and competent radiologists. All adult patients presented to El-Moalem Medical City in the study period. The sample size was n= 93 (total coverage, convenience-based), and all patients who had presented consented to participate.

Inclusion and Exclusion Criteria

Patients presenting with seizures and having CT brain scans with available images at the time of research were included in the study. So that the study would be limited to adult patients with seizures and appropriate imaging for analysis. Specific exclusion criteria included patients younger than 18 years since the study was interested in evaluating adult seizure cases. This criteria, therefore, kept a targeted demographic to direct results to adult patients and not from pediatric seizure patterns.

Data Collection Methods

CT brain images and reports were stored electronically in the computer in 2 backup and master Excel sheet as hard copy and data collection sheet.

Study Variables

In this study, type of seizure (focal or generalized), CT modality and CT findings are the dependent variables. The dependent variables are gender, age were used. The variables help us correlate demographics with seizure-related brain abnormalities as illustrated in Table 1 below,

Table 1: Research Variables

Dependent	Independent
Type of seizure	Gender
CT modality	Age
CT finding	

Data Analysis

Collected data was analyzed using version 18 of SPSS and were interpreted in tables, graphs, and charts as illustrated in Table 2.

Ethical concern

Verbal, informed consent was obtained from the study participants. Written consent was obtained from the head department of radiology at El-Moalem Medical City to gain access to the data needed for this study. Ethical clearance was obtained from the Sudanese Medical Specialization Board.

RESULTS

Demographic Data

In **Figure 1**, the demographic data reveal that among the 93 participants suggest that male represented a slightly greater percentage of the population than female. Specifically, 54% of the participants were male, while 46% were female, resulting in a male-to-female ratio of approximately 1.2:1. This slightly prevalence indicates that there is a possibly greater occurrence or reporting of seizures in male patients than in female patients in this sample. The distribution between the genders is almost equal, so the findings can be generalized to male and female populations. The small gender gap suggests that gender may not play a large role in the prevalence of seizures in this group, and leads to the need to consider other factors when assessing the likelihood of CT brain findings and seizures diagnosis (**Figure 1**).

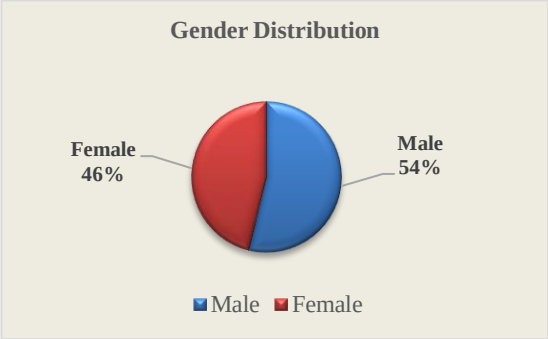

Figure 1: Distribution of the study participants by gender (n = 93)

The age distribution of the study participants is shown by different age groups (**Figure 2**). The over 60+ age represents the largest proportion of participants with over 30% of the sample. Elderly people were most likely to have been represented in this study. About 30% of the population is in the 18-30 age group, clearly showing the participation of the younger cohort as well. Each of these remaining age groups show a lower percentage at 10-15%. The distribution of this study's seizures implicated older adults (61+) as a higher prevalence group potentially attributable to age related neurological changes or coexisting health conditions. Major representation by younger adults (18-30) reflects the widespread age range of individuals affected by such seizures (**Figure 2**).

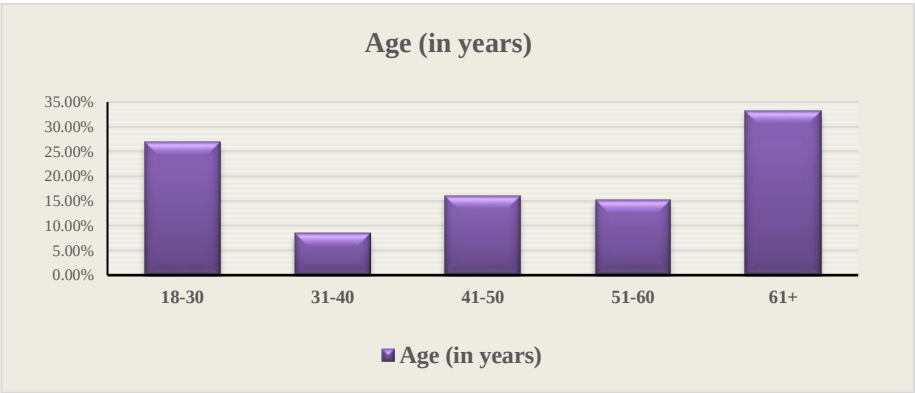

Figure 2: Distribution of participants by age (n = 93)

Gender and Age Group Significance

In **Figure 3**, the relationship between CT and gender of seizure patients is presented. The majority of 'normal' CT scans is found among the 93 participants nearly half of the male and approaching half of the female participants had no abnormalities as shown in figure 3. The second most common abnormality is infarction which accounts for approximately 10% of males and 7% of females. Less frequent are other abnormalities hemorrhage (3% in males, 2% in females), tumors (4% in both genders), hydrocephalus (1% in both genders) and structural malformations (around 2% in both females and males) as shown in

Figure 3. The prevalence of calcified lesions, posttraumatic contusions and gliosis is rare, with each occurring less than 2% of the time in both men and women. The analysis of the results of the Chi-square test reveals no statistically significant difference in the gender (p-value ≯ 0.732) and within age groups (p-value ≯ 0.111). This implies that gender and age are not important in relation to the prevalence and type of CT abnormalities in seizure patients in terms of the distribution of structural abnormalities found in this study (**Figure 3**).

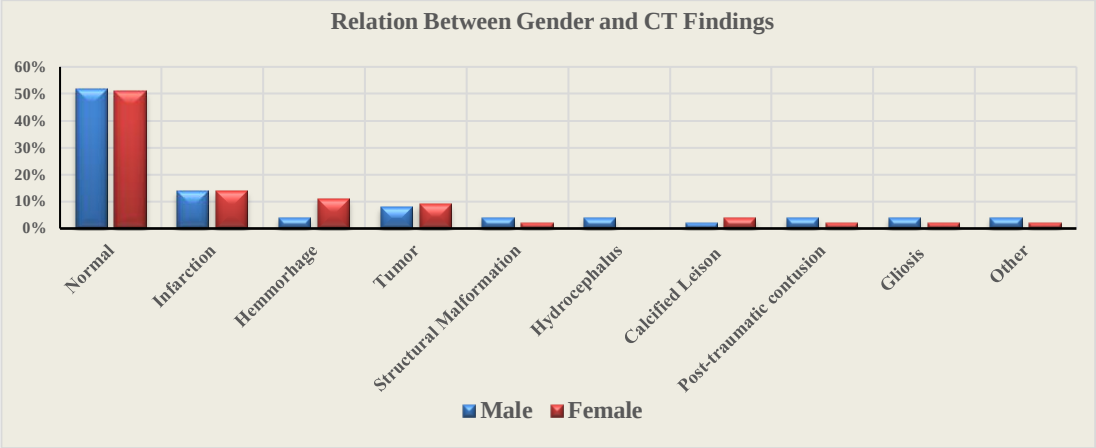

Figure 3: Relation between Gender and CT findings (n = 93) (insignificant, P value = 0.732)

In the **Table 2**, CT findings among patients with seizures different age groups are shown. Most patients of all age groups had normal CT findings, with the greatest number in the 18–30 group (64%) and the smallest in the 41–50 group (33.3%). In contrast, tumors were most common in the (41–50) and (51–60) groups about 20 and 21.4%, respectively, and infarction was most common in the 61+ group (25.8%). Older age groups over 50 had more hemorrhages, including subdural and subarachnoid. While, younger patients were more likely to have posttraumatic contusions at 8% in the 18–30 year age group (**Table 2**). These findings suggest that older age groups are more likely to have pathological findings on CT i.e. infarctions and tumors.

Table 2: Age and CT findings

CT Findings		Age										Total	
		18-30		31-40		41-50		51-60		61+			
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Normal		16	64	5	62.5	5	33.3	7	50	15	48.4	48	51.6
Infarction		2	8	0	0	3	20	0	0	8	25.8	13	14
Hemorrhage	Epidural	0	0	0	0	0	0	0	0	0	0	0	0
	Subdural	0	0	0	0	1	6.7	0	0	2	6.5	3	3.2
	Subarachnoid	0	0	0	0	0	0	1	7.1	1	3.2	2	2.2
	Intra-cerebral	0	0	1	12.5	0	0	0	0	1	3.2	2	2.2
Tumor (SOL)		0	0	1	12.5	3	20	3	21.4	1	3.2	8	8.6

Gross structural malformation		2	8	0	0	0	0	1	7.1	0	0	3	3.2
Hydrocephalus		1	4	0	0	1	6.7	0	0	0	0	2	2.2
Calcified lesion		1	4	0	0	0	0	1	7.1	1	3.2	3	3.2
Post - traumatic sequlae (contusion)		2	8	1	12.5	0	0	0	0	0	0	3	3.2
Gliosis		0	0	0	0	0	0	1	7.1	2	6.5	3	3.2
Others	Meningitis	1	4	0	0	0	0	0	0	0	0	1	1.1
	Diffuse brain edema	0	0	0	0	2	13.3	0	0	0	0	2	2.2

Type of Seizures

The study population is represented by the distribution of seizure types, as shown in **Figure 4**. In the the majority of participants, general seizures were the most common (93.5%), and focal seizures were the minority (6.5%). The results showed that generalized seizures mainly involved both sides of the brain. These symptoms could be more widespread in this population, as the underlying cause could be an infection, metabolic problem, or genetic issue. The prevalence of focal seizures arising in one particular spot within the brain is lower in this patient group. There may be fewer cases of localized brain injury, such as tumors or localized trauma (**Figure 4**).

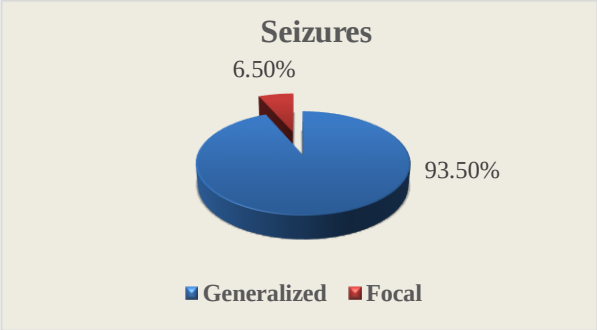

Figure 4: Distribution of participants according to the type of seizure

Contrast Findings

In this study, contrast was administered to only 16.1% of participants. In contrast, tumor (space-occupying lesions, or SOL) findings were significantly higher in the 53.3% of cases that received contrast, as shown in **Table 3**. The contrast group had 20% infarcts and 6.7% normal findings. Most findings were normal (51.6%) without comparison and 14% less infarction, and 3.8% of the cases had no contrast and subdural hemorrhages. In addition, without contrast, cases of hydrocephalus, intra-cerebral hemorrhage, and calcified lesions also occur in 2–3% of cases. The finding shows that contrast-enhancing CT significantly affects the positivity of tumors (SOL). Still, non-contrast scans often demonstrate normal findings or infarctions (reducing SOL), indicating why contrast is very useful in some cases (**Table 3**).

Table 3: Contrast and CT findings

CT findings		Contrast				Total	
		Given		Not			
		Freq.	%	Freq.	%	Freq.	%
Normal		1	6.7	47	1	48	51.6
Infarction		3	20	10	3	13	14
Hemorrhage	**Epidural**	0	0	0	0	0	0
	Subdural	0	0	3	3.8	3	3.2
	Subarachnoid	1	6.7	1	1.3	2	2.2
	Intra-cerebral	0	0	2	2.6	2	2.2
Tumor (SOL)		8	53.3	0	0	8	8.6
Gross structural malformation		0	0	3	3.8	3	3.2
Hydrocephalus		0	0	2	2.6	2	2.2
Calcified lesion		1	6.7	2	2.6	3	3.2
Post - traumatic sequlae (contusion)		0	0	3	3.8	3	3.2
Gliosis		0	0	3	3.8	3	3.2
Other	**Meningitis**	1	6.7	0	0	1	1.1
	Diffuse brain edema	0	0	2		2	2.2

CT Brain Findings

Table 4 shows the distribution of CT findings among 48 participants (51.6%) who had normal CT scan results, which indicates that no obvious pathology was detected. For infarctions, the finding was (14%) which considered significant. The hemorrhages were typed, and subdural hemorrhages were identified in 3 participants (3.2%), subarachnoid hemorrhages in 2 participants (2.2%), and intra-cerebral hemorrhage in the other 2 participants (2.2%) there were no epidural hemorrhages. While, 8 participants had tumors (SOLs), which accounted for 8.6% of abnormalities and ranked second only to infarctions in this sample of patients as shown in **Table 4**. Gross structural malformations, hydrocephalus, calcified lesions, posttraumatic sequelae (contusion) and gliosis were present in 3 subjects (3.2%). Meningitis was diagnosed in 1 person (1.1%) and diffuse brain edema in 2 persons (2.2%). The results reveal that normal scans are most common, but a considerable number of participants had such lesions as infarctions and tumors. However, other ailments for instance non-clinical hemorrhages and structural opportunities were sparse but that was not a rare incidence. These figures show that the majority of scans are negative, yet severe pathologies are identified in a substantial number of patients (**Table 4**).

Table 4: Distribution of participants by CT findings

CT Findings		Frequency	Percentage
Normal		48	51.6
Infarction		13	14
Hemorrhage	**Epidural**	0	0
	Subdural	3	3.2
	Subarachnoid	2	2.2
	Intra-cerebral	2	2.2
Tumor (SOL)		8	8.6
Gross structural malformation		3	3.2
Hydrocephalus		2	2.2
Calcified lesion		3	3.2
Post - traumatic sequlae (contusion)		3	3.2
Gliosis		3	3.2
Others	**Meningitis**	1	1.1
	Diffuse brain edema	2	2.2

Types of seizures were found to be significantly associated with CT findings with a p-value of 0.002 (Figure 5). CT findings of focal versus generalized seizures are compared, as presented in **Figure 5**. More than 50% of participants with generalized seizures had normal CT, compared with only about 10% with focal seizures, who had normal findings on CT. Infarctions were most common in focal seizure patients (about 35%). About 15% of people had focal seizures, and these tumors were more common, with less than 5% in people whose seizures were generalized. For both seizure types, smaller proportions of hemorrhages and structural malformations were observed in **figure 5.** Relative to both groups, including hydrocephalus, calcified lesions, posttraumatic contusions, gliosis, and diffuse brain edema were rare. A statistically significant association between seizure type and CT findings was demonstrated with p-value of 0.002, focal seizures with an increased risk of having pathological findings, like infarctions and tumors, and generalized seizures with increased probability of normal CT findings (**Figure 5**).

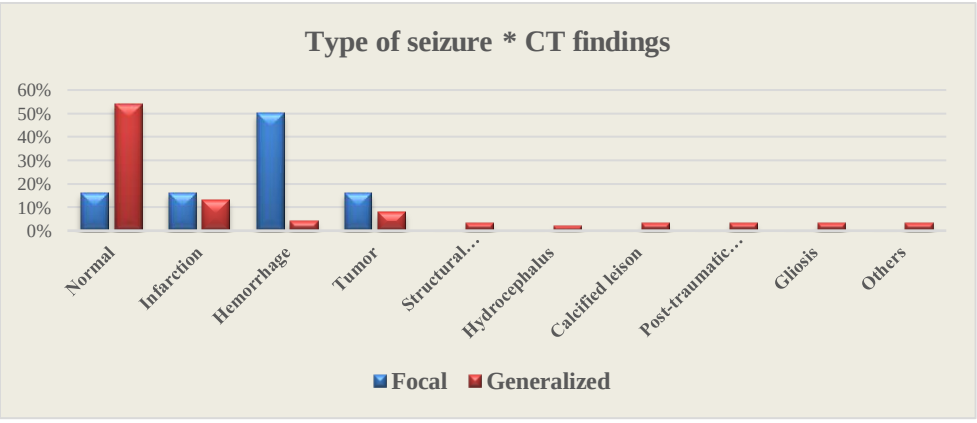

*Figure5: Type of seizure * CT findings (n = 93) P value = 0.002*

DISCUSSION

These findings emphasize that gender differences in seizure prevalence, age, and comorbidities make a significant difference in the development of seizures and CT abnormalities, particularly in older patients, consistent with existing research on age-related neurological factors. The majority of patients participating in this study (93.5%) had a generalized seizure. In comparison, only a small proportion of them (6.5%) reported focal seizures lower than the findings of a similar study [4]. The findings show male predominance, which may indicate a higher incidence of seizures amongst the male population. Despite almost equal gender distribution, no gender differences in seizure prevalence are apparent. This is consistent with Hophing et al. (2022) study, which found only minor gender differences in seizure occurrence and concluded that seizure risk factors predominantly depend on age, neurologic health, and related physiologic factors, not on gender [15]. The demographic data reveal a seemingly predisposing of participants in the age category 61 and over suggesting that age might be a predisposing factor for seizures due to changes in neurological disorders or other related conditions. According to Blank et al (2021), older adults have a higher rate of seizures due to several accumulated health conditions [16].

On a further level, therefore, this, together with a previous finding of a greater association of CT abnormalities with age than with gender, strengthens the hypothesis that age changes are crucial to epilepsy and to the detection of CT abnormalities. The findings of the study indicate that the prevalence of abnormalities such as infarctions in older patients above 60 years old, is higher. Keret et al. (2018) study on trauma-related epilepsy among young adults (18-30) who had post-traumatic contusions

indicated there is a significant role of trauma as one of the main factors of seizure etiology among young people[17]. While the study findings reveal a small gender difference in seizing patients, age and comorbid conditions are much more powerful predictors of what kind of CT abnormalities we see in seizure patients. The study reported abnormal findings in nearly half of our participants, which was comparable to the results of the regional research [6, 10].

The findings of the study indicate a higher prevalence of generalized seizures, which indicates more generalized, bilateral brain involvement seems to be the norm in these patients. Moreover, Mullen et al. (2018) study elaborated that genetic and metabolic factors are the leading causes of generalized seizures in general seizure research [18]. On the other hand, the lower rate of focal seizures may suggest fewer brain injuries, such as local tumors or trauma endemic to this population, findings that focal seizures are linked to specific sites of brain injuries or localized brain pathology.

Further, findings from this study indicate that contrast administration is most effective in the detection of tumors or space-occupying lesions, in which the incidence of such lesions is over 50% for contrast-enhanced cases. In comparison, non-contrast scans typically showed no abnormalities or infarctions, consistent with the current practice of selective contrast use for specific pathologies that non-contrast scans may not detect. Sinha et al.(2019) study points out the clinical importance of contrast in seizure evaluations, highlighting contrast's superiority in identifying abnormal structures that may participate in seizure genesis [19]. The pathologies that we highlighted in the CT exploration of seizures were dominated by infarction, which, together with hemorrhage make the majority of the CT findings in this study.

CT scan findings show large numbers of participants with normal results, with no pathology detected in half or more cases, particularly for those with generalized seizures. Moreover, hydrocephalus and diffuse brain edema were also seen, similar to the results reported by a study in India [20]. Mullen et al. (2018) finding is consistent with the fact that generalized

seizures are usually less related to visible structural abnormalities on CT [18]. However, patients with focal seizures were more likely to show pathological findings such as infarctions and tumors. Structural abnormalities, in particular hemorrhages and malformations, were rare overall but more often found in focal seizure cases, suggesting a predisposition toward pathologies in these patients. This study underscores the key importance of age related factors and comorbidities in the clinic and CT abnormalities associated with the development of seizures, especially in the setting of aging. There were minimal differences in seizure prevalence by gender, age was a predictor of abnormal CT findings, such as infarctions and tumors. Generalized seizures predominate and this is suggestive that metabolic, genetic factors may have substantial contributions in this population. However, contrast-enhanced CT scanning, the space occupying lesions were notably well detected, and based upon seizure type. It is argued that this study highlights the value of selection of diagnostic tools tailored to seizure type for more accurate detection and subsequent management of associated pathologies.

CONCLUSION

In conclusion, brain imaging plays a major role in detecting the causes of convulsive seizures. CT scan that was performed mostly without and after contrast injection showed was abnormal in almost half of the cases, been likely pathological in focal type of seizures. Generalized seizures were more common and had normal **CT findings**, however, focal seizures carried a significantly strong association with such findings as infarctions and tumors, suggesting the significance of targeted imaging. *Research findings indicate that age is a stronger predictor of CT abnormality than gender,* and that age is correlated with higher rates of pathologies likely related to age related neurological changes. Notably, contrast enhanced CT scans were good at detecting tumors and other structural abnormalities, and the use of contrast to enhance diagnostic precision in seizure patients was found to be of selective value. CT imaging routinely in seizure evaluations, and encourage additional large-scale studies to refine diagnostic protocols so that we may better diagnose seizures and develop more targeted treatment for seizure management.

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Conflict of interests: No conflict of interests is declared

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