# Cranial computed tomography imaging of patients with stroke in a tertiary facility

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**Abstract Background:** Neuroimaging plays an important role in stroke management by providing information to accurately triage patients, expedite clinical decision with regard to treatment, and in improving outcomes in patients presenting with stroke. The aim of this study is to determine the spectrum of computed tomography (CT) findings in patients with stroke with respect to the type of lesion, location, and possible risk factors.

**Materials and Methods:** This was a retrospective study with data compiled from medical files and cranial CT scan images of 148 patients clinically diagnosed with stroke conducted over a period of 36 months from the Department of Radiology, University of Abuja Teaching Hospital.

**Results:** There were 148 patients with complete data who were clinically diagnosed with stroke. From cranial CT findings, 56.1% of patients studied had cerebral infarct, 41.2% hemorrhage, and 2.7% normal findings. The gender distribution of cranial CT findings was not statistically significant (P = 0.09 for males and P = 0.07 for females). The parietal lobe was the most affected site for hemorrhage and infarcts accounting for 31.1% and 49.4%, respectively. The cerebellum was the least affected site. The two most commonly documented risk factors identified in this study were hypertension and diabetes mellitus accounting for 61.9%.

**Conclusion:** Cerebral infarct was the most common computed tomographic finding among patients with stroke, and the parietal lobe was the most common location for infarct and hemorrhage. Hypertension was a major risk factor for stroke. CT is an important imaging modality for diagnosis, differentiating infarct from hemorrhage in stroke management.

Keywords: Abuja, computed tomography, Nigeria, stroke

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# INTRODUCTION

Stroke is a clinical term that describes a sudden loss of neurologic function persisting for more than 24 h that is caused by an interruption of the blood supply to the brain. Stroke is a major public health problem and the

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third leading cause of death worldwide, with several degrees of reversible and irreversible disability among survivors.<sup>[1,2]</sup> According to the WHO, the burden of stroke has been projected to increase for developing countries, especially Sub-Saharan Africa due to increased risk for cardiovascular disease.<sup>[3,4]</sup> The prevalence of stroke in

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Nigeria is 1.14/1000, whereas the 30-day case fatality rate is as high as 40%.<sup>[4]</sup>

The diagnosis and classification of stroke was based on clinical judgment, with the advent of radioimaging techniques in stroke being visualized using either computed tomography (CT) or magnetic resonance imaging (MRI). CT has greatly influenced the diagnosis and management of stroke and added significantly to our understanding of pathophysiology of stroke. The main role of imaging in stroke is to differentiate an intracranial hemorrhage from an infarct, to define the ischemic region, to distinguish between infarct core and penumbra, to depict the vessel status, and to rule out other pathologic processes that can present with stroke-like symptoms.

CT has become the predominant imaging modality for initial evaluation of patients with suspected stroke, and in the United States, noncontrast CT is the primary imaging modality for the initial evaluation of patients with suspected stroke.<sup>[5]</sup> Furthermore, the use of CT especially in acute stroke is further enhanced by the advent of additional CT techniques which include CT perfusion imaging and CT angiography. The combination of these techniques with noncontrast CT has greatly improved the detection and diagnosis of acute infarction.<sup>[6,7]</sup>

The increasing availability of CT scanners in Nigeria has made neuroimaging an option in the management of patients with stroke. There is a paucity of data in our environment, Abuja, on the patterns of utilization of CT in patients diagnosed with stroke. This study aimed at determining the pattern of CT findings in patients with stroke with respect to the type of lesion, location, and possible risk factors.

# MATERIALS AND METHODS

This was a retrospective study with data compiled from medical files and cranial CT scan images conducted over a period of 36 months from February 2015 to January 2018.

The study was conducted at the Department of Radiology, University of Abuja Teaching Hospital, Gwagwalada. The hospital is a tertiary facility located in the suburban area of Abuja and serves as a referral center to people of Abuja and other neighboring states.

One hundred and forty-eight patients with complete research information, who were clinically diagnosed with stroke and had a cranial CT imaging done in the units, were retrieved for this study. Images from CT were reviewed and recorded in relation to the type of lesion (hemorrhage or infarct), location of hemorrhage or infarct, and sidedness (right or left hemisphere).

The age, sex, duration of onset of symptoms, and possible risk factors were retrieved from patient's medical files as defined by the managing physician. From the medical files, patients with blood pressure above 140/90 mmHg and normotensive on antihypertensive medications were considered hypertensive, whereas known or recently diagnosed diabetics with normal or elevated blood sugar level were considered diabetics. Those with heart disease and HIV seropositive were considered as risk factor. Those with documented elevated serum cholesterol and managed for sickle cell anemia were grouped as hypercholesterolemia and sickle cell disease, respectively. Existence of one verifiable risk factor in patients was documented as "single risk factor," while the presence of two risk factors in patients was referred to as "two risk factors." The absence of any risk factor is considered as "unknown."

Computed tomographic examinations were carried out using the Toshiba Activion 16-slice CT scanners. A range of 120–140 kvp and 150–300 mAs were used, and images were acquired in the axial plane at 2.5 mm from the base of the skull to the vertex. Low-osmolar intravenous contrast medium iopamidol 40 ml in adult and 1 ml/kg in children was given in the absence of hemorrhage.

# **Ethical approval**

Ethical clearance was obtained from the Ethics Committee of University of Abuja Teaching Hospital, Gwagwalada.

## Statistical analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) for Windows version 20.0 (IBM<sup>®</sup>, Chicago, Illinois, USA) and statistical test of association was carried out using Chi-square and P = 0.05 was considered statistically significant.

# RESULTS

From the available data from February 2015 to January 2018, 148 patients out of 163 patients clinically diagnosed with stroke had all the necessary intact verifiable clinical and radioimaging data and hence met the study requirements. The mean age of the patients was  $54 \pm 13.6$  years with age range of 15–86 years. A higher proportion of patients were in the age group of 41–50 years representing 27.0% of the patients clinically diagnosed of stroke and with reviewed CT images, closely followed by the age group of 51–60 years representing 23.6%, whereas the lowest proportion of stroke patients investigated with CT scan was in the age group of 21–30 years representing

2.0%. There were 99 (66.9%) males and 49 (33.1%) females with a male: female ratio of 2.3:1. The mean age of male was  $54 \pm 16.6$  years and female was  $54 \pm 13.6$  years.

From the CT scan films examined over a 36-month period, 83 (56.1%) patients studied had cerebral infarct, 61 (41.2%) had hemorrhage, and 4 (2.7%) had normal findings in the brain.

From the cranial CT images of male patients, 63.9% had hemorrhage and 67.5% had infarct, whereas among the female patients, 36.1% had hemorrhage and 32.5% had infarct. This relationship between gender of the patients studied and cranial CT findings was not statistically significant [P = 0.09 for males and P = 0.07 for females; Table 1].

In terms of the location of the lesion on examination of the CT scan films, parietal lobe was the most affected site for hemorrhage [Figure 1] and infarcts [Figure 2] accounting for 31.1% and 49.4%, respectively. The cerebellar hemisphere was the least affected site for hemorrhage and infarcts [Figure 3] accounting for 4.9% and 2.4%, respectively [Table 2]. On further radiological examination, 89 (60.1%) patients who were cranial CT reviewed had lesions (infarct and hemorrhage) in the left cerebral hemisphere, 38 (25.7%) had lesions in the right hemisphere, and in 17 (11.5%) infarct and hemorrhage were seen in both hemispheres. There was a positive correlation between the location of cranial CT lesion and the type of lesion, and the differences observed were statistically significant (confidence interval [CI] = 2.47-28.67, P = 0.004,  $\chi^2 = 23.136$ , df = 1,  $r_s = 0.719$ ).

Among the patients who met the inclusion criteria, 55.4% of patients whose records were analyzed in the study had one risk factor whereas 42.6% had two risk factors and 2.0% of patients were without risk factors (unknown) [Table 3]. The top three identified and verified single risk factors among patients who had CT scan done for clinically diagnosed stroke in the unit over the period were hypertension (50.0%), diabetes mellitus (DM; 28.0%), and hypercholesterolemia (7.3%). The two most commonly documented risk factors identified in this study were hypertension and DM accounting for 61.9% [Table 3].

The most common risk factor for stroke in male and female patients was hypertension representing 54 (71.1%) and 22 (28.9%), respectively [Table 4]. There was no association between gender of the verified patients and associated risk factor (odds ratio [OR] =11.472, 95% CI = 2.657–47.972, P = 0.43).

## Table 1: Gender and type of stroke

Gender	Frequency (%)	Frequen	Р	
		Hemorrhage	Infarct	
Males	99 (66.9)	39 (63.9)	56 (67.5)	0.09
Females Total	49 (33.1) 148 (100.0)	22 (36.1) 61 (100.0)	27 (32.5) 83 (100.0)	0.07

#### Table 2: Location of infarct and hemorrhage

Location	Type of stroke, frequency (%)				
	Hemorrhage	Infarct			
Parietal	19 (31.1)	41 (49.4)			
Frontal	12 (19.7)	12 (14.5)			
Thalamus	9 (14.8)	11 (13.3)			
Brainstem	6 (9.8)	8 (9.6)			
Temporal	4 (6.6)	5 (6.0)			
Occipital	2 (3.3)	4 (4.8)			
Cerebellar	3 (4.9)	2 (2.4)			
Intraventricular	4 (6.6)	0			
Subarachnoid	2 (3.3)	0			
Total	61 (100.0)	83 (100.0)			

Table 3: Distribution of risk	factors in the	study po	opulation
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Risk factors	Frequency (%)
Single risk factor	82 (55.4)
Hypertension	41 (50.0)
DM	23 (28.0)
Hypercholesterolemia	6 (7.3)
Sickle cell anemia	5 (6.1)
Heart disease	4 (4.9)
HIV	3 (3.7)
Two risk factors	63 (42.6)
Hypertension+DM	39 (61.9)
Hypertension+hypercholesterolemia	11 (17.5)
DM+hypercholesterolemia	13 (20.6)

DM - Diabetes mellitus; HIV - Human immunodeficiency virus

From the data of the 76 patients with clinical risk factor of hypertension complied, 40 (65.6%) had hemorrhage [Figure 4] and 34 (41.0%) had infarct on cranial CT. This was statistically significant (P = 0.000) [Table 5]. Ten (16.4%) patients with diabetes had hemorrhage, whereas 30 (36.1%) had infarct on examination of their cranial CT. The distribution of hemorrhage and infract among patients with diabetic mellitus was not statistically significant (P = 0.07) [Table 5]. Furthermore, 4 (6.6%) patients with hypercholesterolemia had hemorrhage, whereas 11 (13.3%) had infarct on review of the CT scan films. The distribution of hemorrhage and infarct among patients with hypercholesterolemia was statistically significant (P = 0.011) [Table 5].

## DISCUSSION

The peak incidence of stroke in this study was among patients in their 5<sup>th</sup> (41–50 years' age group) and 6<sup>th</sup> decades of life (51–60 years' age group) accounting for 52.4%. Similar finding was reported by Ikpeme *et al.*,<sup>[8]</sup> Watila *et al.*,<sup>[9]</sup> and Eze *et al.*<sup>[10]</sup> in their studies. Age is a

Gender	Frequency (%)	Frequency (%)						
		Hypertension	DM	Unknown	Hypercholesterolemia	SCD	Heart dx	HIV
Male	99 (66.9)	54 (71.1)	29 (69.0)	3 (100.0)	6 (40.0)	4 (80.0)	2 (50.0)	1 (33.3)
Female Total	49 (33.1) 148 (100.0)	22 (28.9) 76 (100.0)	13 (31.0) 42 (100.0)	0 3 (100.0)	9 (60.0) 15 (100.0)	1 (20.0) 5 (100.0)	2 (50.0) 4 (100.0)	2 (66.7) 3 (100.0)

Table 4: Gender with risk factors of the study population

DM – Diabetes mellitus; HIV – Human immunodeficiency virus; SCD – Sickle cell anemia

Table 5: Risk factors with type of stroke

Risk factors	Frequency (%)	Type of s frequence	Р	
		Hemorrhage	Infarct	
Hypertension	76 (51.2)	40 (65.6)	34 (41.0)	0.000
Diabetes mellitus	42 (28.4)	10 (16.4)	30 (36.1)	0.073
Unknown	3 (2.0)	0	3 (3.7)	0.299
Hypercholesterolemia	15 (10.2)	4 (6.6)	11 (13.3)	0.011
SCD	5 (3.4)	2 (3.3)	3 (3.6)	0.090
Heart disease	4 (2.8)	3 (4.9)	1 (1.2)	0.245
HIV	3 (2.1)	2 (3.3)	1 (1.2)	0.060
Total	148 (100.0)	61 (100.0)	83 (100.0)	

HIV - Human immunodeficiency virus; SCD - Sickle cell anemia

strong nonmodifiable risk factor for stroke and the risk of stroke tends to increase above 55 years of age.<sup>[3]</sup> The age of incidence of stroke is much younger in Sub-Saharan Africa and is documented to be <60 years, whereas in developed countries older people are more affected, above 70–75 years.<sup>[3]</sup>

Before the advent of CT, stroke was diagnosed based on history and physical examination by physicians and diagnosis were usually not always accurate. The use of CT is now very helpful in differentiating types of stroke, other causes of stroke, and accurate institution of therapy. The prevalence of infarct and hemorrhage recorded in this study was 56.1% and 41.2%, respectively. This is in agreement with other previous studies who reported a higher prevalence of ischemic than hemorrhagic stroke.[8,11-13] However, our study differs from what was reported by Obajimi et al.<sup>[14]</sup> The higher prevalence of infract compared to hemorrhage on cranial CT may likely be due to the fact that ischemic stroke is associated with more risk factors compared to hemorrhagic stroke where hypertension is the prevalent risk factor. In stoke management, differentiating stroke types allow for appropriate therapeutic measures, anticoagulant use is relevant for ischemic stroke but not ideal for hemorrhagic stroke as this may worsens patient's conditions. Therapy that can be instituted for ischemic stroke is endovascular mechanical embolectomy resulting in revascularization/recanalization of vessel.

In terms of distribution of infract and hemorrhage based on gender, more males had infract and hemorrhage compared to females. The reason for this is not known. The male versus female for infarct was 67.5% vs. 32.5% and for hemorrhage was 63.9% vs. 36.1%. This was, however, not statistically significant. Our finding of high distribution of infracts and hemorrhage among males is in agreement with the study by Eze *et al.*<sup>[10]</sup>

Outcome from the cranial CT scan with our report of normal findings in 4 (2.7%) of our patients may align with the pathophysiology of stroke. In the early management of acute ischemic stroke, changes in the brain can be very subtle and may be missed or diagnosed as normal on noncontrast CT. MRI is considered better imaging modalities in evaluating patients with acute stroke. Diffusion-weighted image (DWI) is approximately more sensitive in detecting acute stroke than CT. DWI has a high sensitivity of 88%-100% and specificity of 86%-100% in detecting ischemia, within 30 min of occurrence.<sup>[12]</sup> Newer imaging techniques available are CT perfusion and MRI perfusion, which can predict the presence of penumbra tissue that is potentially salvageable with adequate therapy through mapping of relative cerebral blood flow, relative cerebral volume, and mean transit time.<sup>[2,12]</sup> This new imaging techniques are, however, not available in our environment.

In this study, the parietal lobe was the most common site for hemorrhage and infarct in the brain closely followed by frontal lobe. This is in agreement with other studies.<sup>[11,12,14]</sup> This region corresponds to the territory of the middle and anterior cerebral arteries. Other sites for hemorrhage were the ventricles and subarachnoid space. The least affected sites were occipital and cerebellum corresponding to territories of postcerebral and vertebrobasilar arteries. Similar finding was obtained by Kumar *et al.*<sup>[11]</sup> Left sidedness was the most common side of occurrence of stroke. Our finding was in conformity with what was obtained by Ikpeme *et al.*<sup>[8]</sup> and Kumar *et al.*<sup>[11]</sup> This may probably conform to left cerebral dominance and preponderance of right handedness among the studied population.

The traditional risk factors for stroke can be classified as modifiable and nonmodifiable risk factors. There are varieties of risk factors for the development of stroke identified in this study, but several studies have shown that hypertension is the most prevalent and strongest modifiable



**Figure 1:** Noncontrast-enhanced axial computed tomography of the brain showing intracerebral hemorrhage of the right parietal lobe with extension into the ventricles



**Figure 3:** Noncontrast-enhanced axial computed tomography of the brain showing hypodense area of infraction in the left cerebellar hemisphere

risk factor for stroke.<sup>[3,9,15]</sup> This is in agreement with our findings. Hypertension is recognized as a prevalent and independent factor for first stroke, recurrent stroke, and stroke after transient ischemic attack.<sup>[9]</sup> Diabetic mellitus is another independent risk factor for stroke, but the presence of both hypertension and diabetic mellitus increases the risk furthermore than the risk factors occurring separately.

In this study, the incidence of stroke was higher in males, with finding of male versus female being 71.1% vs. 28.9% among patients with hypertension and 69.0% vs. 31.0% among patients with diabetes, which suggests that men have more risk factor for stroke than women. This is in agreement with other studies.<sup>[8,10,11]</sup> The higher incidence in men may be due to the fact that men are more involved in social high-risk habits such as smoking and alcohol intake, which can predispose to hypertension and diabetic mellitus



Figure 2: Noncontrast-enhanced axial computed tomography image showing area of infraction (hypodense lesion) in the right parietal lobe



**Figure 4:** Noncontrast-enhanced axial computed tomography of the brain showing subarachnoid hemorrhage (hyperdensity of the falx, Sylvian fissure, and the ventricles)

which may lead to developing stroke. Furthermore, men are more involved in stressful activities, especially the social economic stress from family and work and the male gender has been established as a risk factor for stroke.

#### Limitation of the study

This was solely a hospital-based study and not a true representation of the study population.

## CONCLUSION

Infarct was the predominant CT finding in patients presenting with stroke. The parietal lobe was the most common location for infarct and hemorrhage. Most lesions (infarct and hemorrhage) were located in the left cerebral hemisphere. Hypertension was the predominant risk factor among patients with stroke. Computed tomographic imaging plays an important role in diagnoses, differentiating infarction from hemorrhage and in instituting appropriate management to patients with stroke.

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# **Conflicts of interest**

There are no conflicts of interest.

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