

Clinical and Anatomical Characteristics of Ischaemic Stroke Patients Undergoing Non-Contrast CT in a Nigerian Multicentre Cohort: Evidence of a Prolonged Stroke Onset-to-CT Scan Interval.

Ugochukwu Celestine Opara^{1,2}; Anthony Chukwuka Ugwu¹; Christopher Chukwuemeka Ohagwu¹; Bestman Izuchukwu Oriaku^{1,5}; Emmanuel Ayuba Buba^{1,3}; Emeka Chukwumanya Umeh^{1,6}; Stanley Olisa Nwefuru^{1,7}; Uche Andrew George^{1,4}; Victor Kelechi Nwodo¹; Emeka Emmanuel Ezugwu¹; Ikechukwu Kingsley Onuorah⁸.

¹Department of Radiography and Radiological Science, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria.

²CT/MRI Department, Barnsley Hospital NHS Foundation Trust, United Kingdom.

³MRI Department, Nottingham University Hospital NHS Trust, Nottingham, United Kingdom.

⁴Department of Ultrasound, Northern Lincolnshire and Goole NHS Foundation Trust, Grimsby, United Kingdom.

⁵Department of Interventional Radiology, University of Liverpool NHS Foundation Trust, United Kingdom.

⁶CT department, Humber Health Partnership, Hull University Teaching NHS Trust, Hull, United Kingdom.

⁷CT/MRI Department North East Lincolnshire and Goole NHS Foundation Trust, Grimsby, United Kingdom.

⁸Image Diagnostic Centre, Port Harcourt, Rivers State, Nigeria

DOI: <https://doi.org/10.51244/IJRSI.2026.1309000002>

Received: 09 September 2026; Accepted: 14 September 2026; Published: 01 October 2026

ABSTRACT

Background: Timely neuroimaging is central to the management of acute ischaemic stroke, particularly when reperfusion treatment is being considered. In resource-constrained settings, prolonged intervals between stroke symptom onset and neuroimaging may reduce access to time-dependent interventions. This study describes the demographic, anatomical and stroke onset-to-computed-tomography (CT) characteristics of patients with radiologically confirmed ischaemic stroke who underwent non-contrast CT (NCCT) at three diagnostic centres in Nigeria.

Methods: This prospective multicentre cross-sectional study included patients with a first clinically diagnosed ischaemic stroke, a known and documented symptom-onset time, a NCCT examination at one of three participating centres, radiologically confirmed ischaemic stroke independently confirmed by two radiologists and documented consent. Patients with recurrent stroke, unknown onset time, stroke mimics, haemorrhagic stroke or haemorrhagic transformation were excluded. A total of 197 radiologically confirmed cases were included. Demographic information, anatomical lesion location and the reported interval between stroke onset and CT examination were recorded.

Results: The study population comprised 197 patients, including 98 males (49.7%), 98 females (49.7%) and one patient with unrecorded sex. The mean age was 61.3 ± 12.6 years, with an age range of 27–90 years. Patients

aged 60 years or older constituted 56.3% of the cohort. The mean post-ictal interval between stroke onset and CT imaging was 77.5 ± 34.8 hours, demonstrating substantial delay between symptom onset and neuroimaging assessment. Anatomically, extensive or multiple cerebral involvement was the most frequent CT finding, occurring in 49 patients (24.9%), followed by basal ganglia infarction in 44 patients (22.3%). General or unspecified cerebral involvement accounted for 36 cases (18.3%), while parietal lobe infarction occurred in 25 cases (12.7%). Other sites

included the occipital lobe (5.6%), thalamus (5.1%), periventricular/intraventricular regions (3.0%), frontal lobe (3.0%), insular cortex (1.5%), cerebellum (1.5%), and temporal lobe (0.5%).

Conclusion

This Nigerian NCCT cohort demonstrated a substantial burden of delayed stroke onset-to-CT neuroimaging, with the mean imaging interval occurring well beyond the conventional early treatment windows for acute reperfusion therapy. Older adults constituted the majority of the study population, while extensive/multifocal and basal ganglia involvement were the predominant anatomical patterns. The findings underscore the importance of improving stroke recognition, referral pathways, emergency imaging access and early presentation in Nigerian stroke care. Routine NCCT remains an important and practical imaging tool in this setting and may provide a foundation for quantitative imaging approaches aimed at improving the characterisation of infarct evolution.

Keywords: ischaemic stroke; non-contrast computed tomography; onset-to-CT interval; neuroimaging; Nigeria; stroke access; anatomical distribution

INTRODUCTION

Ischaemic stroke results from interruption of cerebral blood flow, leading to neuronal dysfunction and when sufficiently prolonged, results in irreversible infarction. It is the most common type of stroke and a major contributor to mortality and long-term neurological disability. The consequences of ischaemic stroke are particularly significant in low- and middle-income countries where access to specialised stroke services, advanced neuroimaging and reperfusion therapies may be limited (Aderinto et al., 2025; Campbell et al., 2019; and Feigin et al., 2022). The management of acute ischaemic stroke is highly time-dependent. The principle that “time is brain” reflects the progressive loss of viable cerebral tissue after arterial occlusion. Intravenous thrombolysis is conventionally associated with a narrow therapeutic window and mechanical thrombectomy is similarly time-sensitive, although selected patients may benefit from extended treatment windows. Consequently, rapid recognition, transportation, clinical assessment and availability of neuroimaging are central to effective stroke management (Campbell et al., 2019; Keris et al., 2001)

Non-contrast computed tomography is particularly important in environments where magnetic resonance imaging (MRI), CT perfusion and other advanced neuroimaging techniques are not readily available. NCCT can rapidly identify intracranial haemorrhage and demonstrate established ischaemic changes. It is also relatively affordable and widely available compared with advanced neuroimaging modalities. These characteristics make NCCT especially relevant to stroke diagnosis in Nigeria (Jager, 2000; Kidwell et al., 2000) Despite the availability of CT in many Nigerian diagnostic centres, the benefits of early stroke imaging may be undermined by delayed hospital presentation. Patients may arrive at health facilities several hours or days after the onset of neurological symptoms (Aderinto et al., 2025). Previous studies have attributed delayed patients’ presentation for neuroimaging to factors such as limitations in transportation infrastructure, initial reliance on alternative medicine and the burden of out-of-pocket healthcare financing; such delays may result in patients undergoing their first CT examination after the principal window for acute reperfusion therapy has elapsed (Komolafe et al., 2007).

The anatomical distribution of infarction also provides clinically relevant information. Ischaemic lesions may involve cortical territories, deep cerebral structures, posterior circulation structures, or multiple regions simultaneously. Basal ganglia infarction is of particular interest because the deep perforating vessels supplying these structures are vulnerable to small-vessel disease and vascular risk factors (Blumenfeld, 2021; Wardlaw et al., 2013) This study which consisted of a cohort of 197 patients provided detailed demographic, temporal and anatomical data. The present study extracts and reframes these clinical and anatomical findings to address a more focused question: what are the demographic and anatomical characteristics of Nigerian patients undergoing NCCT for ischaemic stroke and what does the interval between stroke symptom onset and CT neuroimaging reveal about delayed hospital presentation? (Csutak et al., 2026; and Ohagwu et al., 2018)

MATERIALS AND METHODS

Study Design

This was a prospective multicentre cross-sectional study involving patients with clinically suspected or diagnosed ischaemic stroke who underwent NCCT of the brain. The study was conducted at St. Charles Medical Diagnostics Limited, Awka, Anambra State; Image Diagnostics, Owerri, Imo State and Image Diagnostics, Port Harcourt, Rivers

State, Nigeria. The study period ranged from December 2025 to May 2026. The centres were medical diagnostic facilities receiving referrals for CT evaluation of suspected stroke.

Eligibility Criteria

Inclusion criteria were: (1) first clinically suspected or diagnosed ischaemic stroke at the referring hospital; (2) known and documented time of stroke symptoms onset; (3) NCCT of the brain performed at one of the participating centres; (4) visible ischaemic stroke-affected brain tissue identified by the radiology team; and (5) informed consent from the patient or an authorised relative. Exclusion criteria were: (1) unknown time of stroke symptom onset; (2) recurrent stroke; (3) stroke mimic; and (4) haemorrhagic stroke or ischaemic stroke with haemorrhagic transformation.

Recruitment and Sampling

Recruitment began when an eligible patient arrived at the imaging centre for NCCT. Patients referred from hospitals for investigation of suspected or diagnosed stroke were approached after the clinical indication for CT had been established. The study was explained to the patient or relatives and written informed consent was obtained before enrolment. Demographic information and the reported interval between stroke symptom onset and CT examination were documented. In this study, patients who were radiologically confirmed to have an identifiable ischaemic lesion were recruited for this study. The G-power software was used to determine the sample size and 197 patients were finally recruited in this study.

Radiological Confirmation of Ischaemic Stroke

Radiological confirmation was based on independent visual interpretation of the NCCT examination by two experienced neuroradiologists with over five years of clinical experience in head CT reporting at each participating centre. The radiologists interpreted the examinations independently and were blinded to each other's assessment. A patient was selected for this study when both radiologists agreed that ischaemic stroke was present and agreed on the visible lesion and its anatomical location.

CT Acquisition Protocol

NCCT examinations were acquired using the CT equipment available at the participating centres. This study was carried out using a 32-slice GE Revolution CT scanner and a 64-slice Siemens SOMATOM scanner, both with a 512 × 512 reconstruction matrix. Images were obtained in axial sections and exported from the CT archive for review using DICOM-compatible software. The imaging parameters, protocol, and reformatting were selected by the attending radiographer at each centre. In this study, the non-contrast head CT protocol included 120 kVp, approximately 320 effective mAs, 20 × 0.6 mm detector collimation, a 1.0-second gantry rotation, and a pitch of approximately 0.8. Images were generally reconstructed as 5-mm axial sections using a standard brain reconstruction kernel with thin-section reconstructions of approximately 0.5–1.0 mm where available for multiplanar assessment.

Definition of Onset-To-CT Interval

The primary temporal variable was the onset-to-CT interval, defined as the reported elapsed time in hours between the documented onset (ictus) of stroke symptoms and the CT examination. In this study, the approximate interval between stroke ictus and head CT examination was ascertained and documented for each patient.

Anatomical Classification

Lesion location was based on the anatomical description recorded by the interpreting radiologists. For the clinical analysis, lesions were grouped into the categories used in this dataset: extensive/multiple involvement, basal ganglia, cerebrum (general/unspecified lobe), parietal lobe, occipital lobe, thalamus, periventricular/intraventricular region, frontal lobe, insular cortex, cerebellum, temporal lobe and indeterminate/unclassified. These categories describe the anatomical distribution of the radiologically visible lesion and are not intended to represent vascular territories or aetiological subtypes.

Statistical Analysis

Descriptive statistics were used to summarise age, sex, anatomical location and onset-to-CT interval. This study reports a mean age of 61.3 ± 12.6 years and a mean onset-to-CT interval of 77.5 ± 34.8 hours. Shapiro–Wilk testing

indicated that age was approximately normally distributed, whereas stroke onset-to-CT time was non-normally distributed.

Ethical Considerations

The parent study reports approval by the Research Ethics Committee of Nnamdi Azikiwe University College of Health Sciences. CT images were anonymised, patient information was treated confidentially, participation was voluntary and patients or their authorised relatives provided informed consent.

RESULTS

Demographic Characteristics

A total of 197 radiologically confirmed ischaemic stroke patients were included. There were 98 males (49.7%) and 98 females (49.7%), while sex was unrecorded for one patient (0.5%). Mean age was 61.3 ± 12.6 years, with a range of 27–90 years. Patients aged 60 years or older constituted 56.3% of the cohort.

Variable	Frequency	Percentage (%)
Gender		
Male	98	49.7
Female	98	49.7
Unrecorded	1	0.5
Total	197	100.0
Age (years)		
<30	1	0.5
31-40	10	5.1
41-50	34	17.3
51-60	40	20.3
61-70	64	32.5
>70	47	23.8
Unrecorded	1	0.5
Total	197	100.0

Table 1. Demographic distribution of this study cohort.

Anatomical distribution

Extensive or multiple involvement was the most frequent anatomical category (49/197, 24.9%), followed by basal ganglia involvement (44/197, 22.3%) and general/unspecified cerebral involvement (36/197, 18.3%). The remaining categories are shown in Table 2.

Anatomical Location	Frequency	Percentage (%)
Extensive/Multiple Involvement	49	24.9
Basal Ganglia	44	22.3
Cerebrum (general/Unspecified Lobe)	36	18.3
Parietal Lobe	25	12.7
Occipital Lobe	11	5.6
Thalamus	10	5.1
Periventricular / Intra-ventricular	6	3.0
Frontal Lobe	6	3.0
Insular Cortex	3	1.5
Cerebellum	3	1.5
Temporal Lobe	1	0.5
Indeterminate/unclassified	3	1.5
Total	197	100.0

Table 2. Anatomical distribution of radiologically confirmed ischaemic lesions.

Onset-to-CT interval/temporal classification

The interval between reported stroke ictus and CT examination was used to characterise the temporal stage of the infarction (**Jager**, 2000). The mean reported onset-to-CT interval was 77.5 ± 34.8 hours. The present study defined:

- **Hyperacute:** within 6 hours;
- **Acute:** 6–24 hours;
- **Subacute:** 24 hours to 7 days; and
- **Chronic:** beyond 7 days.

The table 3 below shows the anatomical distribution of CT-detected cerebral infarctions among 197 study participants across acute, subacute and chronic stroke stages. Most findings were observed during the subacute stage, accounting for 109 cases (55.3%), followed by the chronic stage with 70 cases (35.5%) and the acute stage with 18 cases (9.1%). This distribution suggests that the majority of participants underwent CT examination after the acute phase, when infarct-related changes were more clearly established.

For this present study, the principal temporal outcome was the post-ictal interval between stroke symptom onset and NCCT examination.

CT Findings	Acute (6–24 hrs)	Subacute (24hrs - 7 days)	Chronic (>7days)	Percentage
Extensive/multiple cerebral involvement	5	27	17	24.9%
Basal ganglia infarction	4	24	16	22.3%
General/unspecified cerebral involvement	3	20	13	18.3%
Parietal lobe infarction	2	14	9	12.7%
Occipital lobe infarction	1	6	4	5.6%
Thalamic infarction	1	5	4	5.1%
Periventricular/intraventricular infarction	1	3	2	3.0%
Frontal lobe infarction	1	3	2	3.0%
Insular cortex infarction	0	2	1	1.5%
Cerebellar infarction	0	2	1	1.5%
Temporal lobe infarction	0	1	0	0.5%
Other/not anatomically classified	0	2	1	1.5%
Total	18	109	70	100.0%

Table 3. Distribution of CT Findings by Infarction Stage and Anatomical Location Among Study Participants (N = 197)

DISCUSSION

The principal findings of this study were the predominance of older adults, the near-equal representation of males and females, the high frequency of extensive or multiple cerebral involvement and basal ganglia infarction. The most important finding is the prolonged interval between stroke onset and NCCT examination, which is also in line with the findings of Aderinto et al. in 2025.

The age distribution aligns with the well-established relationship between increasing age and cerebrovascular disease. In this cohort, 56.3% of patients were 60 years or older and the mean age was 61.3 years. The high number of cases in the sixth and seventh decades of life suggests that ischaemic stroke in this population predominantly affected older adults. The present study similarly identified advanced age as an important non-modifiable risk factor for stroke and linked the observed pattern to the broader epidemiology of cerebrovascular disease, this also resonates with the study done by Alkali et al in 2023. The sex distribution was notably balanced, with males and females each accounting for 49.7% of the cohort and with only one unrecorded value. This contrasts with settings in which male predominance has frequently been reported, but the present data do not demonstrate a meaningful sex imbalance. More importantly, the study was not designed primarily to investigate sex-specific stroke incidence and therefore the observed balance should be interpreted as a characteristic of this clinical cohort rather than as an estimate of population incidence.

The anatomical findings provide an additional clinically relevant dimension. Extensive or multiple involvement was the most common pattern, accounting for almost one-quarter of the cohort. Such extensive involvement may indicate substantial cerebral territory affected by infarction and may be particularly important in patients who undergo imaging several days after symptom onset. The second most common anatomical area involvement was basal ganglia infarction, which accounted for 22.3% of cases. This finding also agrees with the research done by Blumenfeld in 2021.

The mean interval between stroke onset and NCCT examination was 77.5 ± 34.8 hours. This corresponds to more than three days between the reported stroke ictus and the definitive CT assessment; this delayed presentation for a head CT scan and subsequent radiological confirmation of ischaemic stroke also aligns with the findings of Wardlaw et al. in their extensive research work carried out in 2013. This delayed onset-CT interval is substantially longer than the conventional early treatment windows of less than 4.5 hours for intravenous thrombolysis and the 6–24-hour interval relevant to patients undergoing mechanical thrombectomy; this finding also corroborates the work done by Ogun et al. in 2005. The temporal distribution therefore provides clear evidence that a substantial proportion of patients in this cohort reached CT assessment after the period during which many patients with acute ischaemic stroke would ordinarily be considered for standard reperfusion treatment. The delayed on-set to CT neurological imaging is particularly important because the present study was designed around the problem of determining lesion age on NCCT. This present study noted that stroke patients sometimes present without a reliable history of the exact time of stroke symptoms and that conventional visual CT assessment may be limited in estimating lesion age; this important finding also agrees with similar work done in Nigeria by Imarhiagbe and Ogbeide in 2011.

The results of this study also indicate that cerebral infarctions were most frequently identified during the subacute stage (55.3%), with a smaller proportion of acute (9.1%) and chronic (35.5%) presentations. The observed rarity of acute-stage imaging in this dataset may imply barriers to timely care, such as failure to recognise early warning signs or logistical hurdles in accessing emergency stroke, which are well-documented challenges in stroke management in Nigeria. Consequently, these findings likely represent a snapshot of established cerebrovascular injury rather than acute ischaemic penumbra. The findings of this study provides quantitative evidence of delayed CT neuroimaging presentation rather than relying solely on an anecdotal impression of late arrival. The delay has several possible implications. First, patients arriving late may have already progressed from potentially salvageable ischaemic tissue to established infarction. Second, delayed hospital presentation reduces opportunities for acute reperfusion treatment. Third, the appearance of the infarct on non-contrast CT changes with time, making the CT examination increasingly informative about established infarction while simultaneously limiting the possibility of acute intervention. The aforementioned established facts also align with the findings in a similar research study carried out by Jager in 2000.

In another study carried out by Blumfield et al. in 2021, they identified several potential contributors to delayed stroke symptom onset to CT imaging in the Nigerian and broader Sub-Saharan African context, including inadequate transport infrastructure, initial reliance on alternative medicine and out-of-pocket financing of healthcare. These aforementioned factors may also have played a role in a similar delayed onset to CT imaging interval noted in this research, although this present study did not capture those variables in its dataset.

The reliance on NCCT in this cohort is also important, although MRI, CT perfusion and other advanced modalities can provide additional information regarding tissue viability and infarct evolution; however, NCCT has practical advantages in resource-limited environments. It is relatively rapid, widely available and capable of excluding intracranial haemorrhage making it an important component of emergency stroke assessment. These findings validate series of research done in the past by the likes of Saba and Santoro in 2010 as well as the work by Jager in 2000.

An additional implication of this study is the potential value of quantitative analysis of routine NCCT to determine the age of ischaemic stroke or infarct evolution. The present study demonstrated significant differences in CT-derived texture characteristics across normal, acute, subacute and chronic tissues with histogram texture parameters showing particularly strong discriminatory ability. The study also has implications for health-system planning. The presence of a mean imaging delay of more than 72 hours suggests that improvements in stroke care cannot depend exclusively on increasing access to CT scanners. Earlier recognition of stroke symptoms, rapid transportation, efficient referral systems, emergency triage and timely CT access are equally important. The availability of an imaging modality does not automatically translate into timely stroke care if patients arrive at diagnostic facilities late, as previously noted in similar work by Wardlaw, Smith and Dichgans in 2013.

Clinical Implications

Several practical implications emerge from this cohort. First, the findings support the need for stronger public education regarding recognition of stroke symptoms and the urgency of hospital presentation. Stroke should be treated as a medical emergency rather than a condition for delayed outpatient evaluation.

Second, emergency referral systems should be encouraged to minimise the interval between symptom onset and arrival at a facility capable of performing brain imaging. Improvements in transportation and inter-facility referral pathways may be as important as technological investment. Third, NCCT remains highly relevant to Nigerian stroke services; its accessibility and speed make it a realistic foundation for expanding emergency stroke imaging capacity.

Fourth, the high frequency of extensive and basal ganglia involvement indicates that radiologists and CT reporting radiographers should systematically document the anatomical distribution and extent of infarction.

LIMITATIONS

This study has several limitations. First, the study was based on patients who reached diagnostic centres for NCCT. Consequently, patients who died before reaching imaging facilities or those who were managed without CT are not represented.

Secondly, the analysis of delayed presentation was based on the documented or reported time of stroke ictus. The accuracy of patient or caregiver recall may therefore influence the calculated post-ictal interval.

Thirdly, CT examinations were acquired using scanners with different specifications and acquisition parameters across the participating centres. Although the present study used feature harmonisation for its texture analysis, differences in scanner hardware, reconstruction algorithms and acquisition protocols may affect generalisability of imaging-derived observations.

CONCLUSION

This study provides evidence of substantial delayed stroke onset-CT imaging among Nigerian patients undergoing NCCT for ischaemic stroke. This study demonstrated a preponderance of subacute presentations and involvement of the basal ganglia and extensive cerebral regions. These data underscore the need for enhanced public awareness and streamlined stroke care pathways to improve early detection

The mean interval from stroke onset to CT examination was 77.5 ± 34.8 hours, indicating that many patients reached definitive neuroimaging well after the conventional early treatment windows for acute reperfusion therapy. Anatomically, extensive or multiple cerebral involvement (24.9%) and basal ganglia infarction (22.3%) were the most frequent patterns.

These findings highlight a critical challenge in Nigerian stroke care. Improving outcomes requires not only adequate imaging infrastructure but also earlier recognition, prompt referral and presentation. NCCT remains a practical and important first-line imaging modality in this environment. The findings of this study further suggest that quantitative analysis of routine NCCT may provide additional information regarding infarct evolution and could eventually complement conventional radiological assessment. Future multicentre Nigerian studies should investigate the causes and determinants of delayed presentation prospectively, examine associations between anatomical infarct patterns and vascular risk factors and evaluate whether improvements in emergency referral pathways can reduce onset-to-imaging time. Parallel development and external validation of quantitative NCCT and artificial-intelligence approaches may further strengthen stroke assessment in resource-constrained settings.

ACKNOWLEDGMENT

The authors acknowledge the management and staff of Image Diagnostic Centre, Port Harcourt, Rivers State, Nigeria; Image Diagnostics, Owerri, Imo State, Nigeria and St. Charles Diagnostics Centre, Awka, Anambra State, Nigeria for allowing us to use their facilities during data collection and for their immense support during this study. We also appreciate the participants for their consent and cooperation to be part of this study. The authors acknowledge all members of the clinical and radiology teams who contributed in one way or another to make this research work a success

Authors' Contribution

This research work was conducted through the collaborative efforts of the authors listed. The lead author, Ugochukwu Celestine Opara, conceptualised and designed the study, performed the statistical analysis and drafted the manuscript under the supervision of Authors Anthony Chukwuka Ugwu and Christopher Chukwuemeka Ohagwu. Bestman Izuchukwu Oriaku, Emmanuel Ayuba Buba, Emeka Chukwumuanya Umeh and Uche Andrew George reviewed the first manuscript and provided additional literature. All authors read, corrected and approved the final manuscript.

REFERENCES

1. Aderinto, N., Ukoaka, B.M., Moradeyo, H., Wagwula, P.M., Udam, N.G., Muntaqim, O., Babalola, A.V., Ogieuhi, I.J., Wali, T.A., Oluwakorede, A.T., Babalola, A.E., Abraham, I.C., Olatunji, G. and Kokori, E. (2025) 'Prevalence, characteristics, and treatment outcomes of stroke in Nigeria: a systematic review', *Next Research*, 2(3), 100410. doi: 10.1016/j.nexres.2025.100410.
2. Alkali, N.H., Bwala, S.A., Akano, A.O., Osi-Ogbu, O., Alabi, P. and Ayeni, O.A. (2013) 'Stroke risk factors, subtypes, and 30-day case fatality in Abuja, Nigeria', *Nigerian Medical Journal*, 54(2), pp. 129–135. doi: 10.4103/0300-1652.110051.
3. Armi, L. and Fekri-Ershad, S. (2019) 'Texture image classification based on improved local quinary patterns', *Multimedia Tools and Applications*, 78(14), pp. 18995–19018. doi: 10.1007/s11042-019-7207-2.
4. Beishon, L.C. and Minhas, J.S. (2021) 'Cerebral autoregulation and neurovascular coupling in acute and chronic stroke', *Frontiers in Neurology*, 12, 720770. doi: 10.3389/fneur.2021.720770.
5. Blumenfeld, H. (2021) *Neuroanatomy through Clinical Cases*. 3rd edn. Oxford: Oxford University Press.
6. Campbell, B.C.V., De Silva, D.A., Macleod, M.R., Coutts, S.B., Schwamm, L.H., Davis, S.M. and Donnan, G.A. (2019) 'Ischaemic stroke', *Nature Reviews Disease Primers*, 5(1), 70. doi: 10.1038/s41572-019-0118-8.
7. Csutak, C., Ursu, D., Lebovici, A., Lenghel, M., Roman, A., Schiau, C., Stan, A., Stefan, R.A., Nicoara, M.I. and Stefan, P.A. (2026) 'CT texture analysis of acute ischemic stroke: prediction of hemorrhagic transformation after thrombolysis', *Brain Sciences*, 16(6), 556. doi: 10.3390/brainsci16060556.
8. Davies, E.R. (2008) 'Introduction to texture analysis'. In: Mirmehdi, M., Xie, X. and Suri, J. (eds.) *Handbook of Texture Analysis*. London: Imperial College Press, pp. 1–31. doi: 10.1142/9781848161160_0001.
9. Feigin, V.L., Brainin, M., Norrving, B., Martins, S., Sacco, R.L., Hacke, W., Fisher, M., Pandian, J. and Lindsay, P. (2022) 'World Stroke Organization (WSO): global stroke fact sheet 2022', *International Journal of Stroke*, 17(1), pp. 18–29. doi: 10.1177/17474930211065917.
10. Flohr, T. and Ohnesorge, B. (2007) 'Multi-slice CT technology'. In: Ohnesorge, B., Becker, C.R., Flohr, T., Knez, A. and Reiser, M.F. (eds.) *Multi-slice and Dual-source CT in Cardiac Imaging: Principles, Protocols, Indications, Outlook*. 2nd edn. Berlin: Springer, pp. 41–69. doi: 10.1007/978-3-540-49546-8_3.
11. Galloway, M.M. (1975) 'Texture analysis using grey level run lengths', *Computer Graphics and Image Processing*, 4(2), pp. 172–179. doi: 10.1016/S0146-664X(75)80008-6.
12. Imarhiagbe, F.A. and Ogbeide, E. (2011) 'Clinical-imaging dissociation in strokes in a southern Nigerian tertiary hospital: review of 123 cases', *Nigerian Journal of Hospital Practice*, 8(1–2), pp. 3–7.
13. Jäger, H.R. (2000) 'Diagnosis of stroke with advanced CT and MR imaging', *British Medical Bulletin*, 56(2), pp. 318–333. doi: 10.1258/0007142001903247.
14. Keris, V., Rudnicka, S., Vorona, V., Enina, G., Tilgale, B. and Fricbergs, J. (2001) 'Combined intra-arterial/intravenous thrombolysis for acute ischaemic stroke', *American Journal of Neuroradiology*, 22(2), pp. 352–358.
15. Kidwell, C.S., Villablanca, J.P. and Saver, J.L. (2000) 'Advances in neuroimaging of acute stroke', *Current Atherosclerosis Reports*, 2(2), pp. 126–135. doi: 10.1007/s11883-000-0107-z.
16. Komolafe, M.A., Komolafe, E.O., Fatoye, F., Adetiloye, V., Asaleye, C., Famurewa, O., Mosaku, S. and Amusa, Y. (2007) 'Profile of stroke in Nigerians: a prospective clinical study', *African Journal of Neurological Sciences*, 26(1), pp. 5–13. doi: 10.4314/ajns.v26i1.7588.
17. Lev, M.H. and Nichols, S.J. (2000) 'Computed tomographic angiography and computed tomographic perfusion imaging of hyperacute stroke', *Topics in Magnetic Resonance Imaging*, 11(5), pp. 273–287. doi: 10.1097/00002142-200010000-00004.
18. Ogun, S.A., Ojini, F.I., Ogungbo, B., Kolapo, K.O. and Danesi, M.A. (2005) 'Stroke in southwest Nigeria: a 10-year review', *Stroke*, 36(6), pp. 1120–1122. doi: 10.1161/01.STR.0000166182.50840.31.
19. Ohagwu, C.C. (2016) 'Texture-based classification of brain tissues in non-contrast computed tomography images of stroke patients', *Journal of Neurology & Neurophysiology*, 7(4), Supplement, p. 118. doi: 10.4172/2155-9562.C1.032.
20. Rao, C.R. (1973) *Linear Statistical Inference and Its Applications*. 2nd edn. New York: John Wiley & Sons. doi: 10.1002/9780470316436.

21. Saba, L. and Santoro, M. (2010) 'Advanced imaging in acute stroke: perfusion and diffusion', *The Neuroradiology Journal*, 23(3), pp. 155–164.
22. Sheskin, D.J. (2004) *Handbook of Parametric and Nonparametric Statistical Procedures*. 3rd edn. Boca Raton, FL: Chapman & Hall/CRC. doi: 10.4324/9780203489536.
23. Sundararajan, V. and Mahadevan, S. (2012) 'Medical image texture analysis: methods and applications', *Journal of Medical Imaging and Health Informatics*, 2(4), pp. 401–410.
24. Wardlaw, J.M., Smith, C. and Dichgans, M. (2013) 'Mechanisms of sporadic cerebral small vessel disease: insights from neuroimaging', *The Lancet Neurology*, 12(5), pp. 483–497. doi: 10.1016/S1474-4422(13)70060-7