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Original Article

An Observational Study on the Various Sites of Ischemic Stroke in a Tertiary Care Centre of North East India

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ABSTRACT

Background: Stroke is an important cause of mortality and long-term neurological disability, with ischemic stroke accounting for a major proportion of stroke events. The clinical manifestations and potential functional consequences of ischemic stroke depend substantially on the anatomical region of cerebral involvement. Although stroke epidemiology has been studied in different parts of India, regional data describing the anatomical distribution of ischemic infarctions on neuroimaging remain limited, particularly from North-East India.

Objectives: To determine the anatomical distribution of ischemic stroke on CT and/or MRI among patients presenting to a tertiary care centre in North-East India and to describe the demographic and clinical characteristics associated with these patients.

Methods: A hospital-based observational study was conducted at Diphu Medical College & Hospital, a tertiary care centre in North-East India, from April 2025 to March 2026. 120 adult patients with clinically diagnosed and CT and/or MRI-confirmed ischemic stroke were included using consecutive sampling. Demographic characteristics, vascular risk factors, clinical manifestations and neuroimaging findings were recorded using a structured data collection proforma. Infarct location was classified anatomically as frontal, parietal, temporal, occipital, basal ganglia, cerebellar, brainstem or multiple/other regions. Categorical variables were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test as appropriate. A two-sided p value <0.05 was considered statistically significant.

Results: Among the 120 patients, 78 (65.0%) were male and 42 (35.0%) were female. Patients aged 61–80 years constituted the largest age group (52, 43.3%). Hypertension was the most common vascular risk factor, present in 72 (60.0%) patients, followed by diabetes mellitus in 44 (36.7%), smoking in 38 (31.7%) and dyslipidaemia in 36 (30.0%). Hemiparesis was the most frequent clinical manifestation, occurring in 82 (68.3%) patients. CT was performed in 72 (60.0%) patients and MRI in 48 (40.0%). Basal ganglia was the most frequently involved

anatomical region, accounting for 28 (23.3%) cases, followed by the parietal region in 22 (18.3%), frontal region in 18 (15.0%) and multiple-region involvement in 14 (11.7%). Temporal, brainstem, occipital and cerebellar involvement accounted for 10.0%, 8.3%, 6.7% and 6.7%, respectively. No statistically significant association was observed between anatomical infarct site and sex (χ^2=1.73, p=0.973) or age group (χ^2=4.31, p>0.99)

Conclusion: Ischemic stroke demonstrated involvement of multiple anatomical brain regions, with basal ganglia and parietal regions being the most frequently documented sites. Hypertension was the predominant vascular risk factor in the study population. Anatomical localization on CT/MRI provides a practical approach to characterizing the regional pattern of ischemic stroke. Larger multicentre studies from North-East India are required to further evaluate anatomical distribution in relation to vascular risk factors, stroke mechanisms and clinical outcomes.

Keywords: Ischemic stroke; cerebral infarction; neuroimaging; computed tomography; magnetic resonance imaging; anatomical localization.

INTRODUCTION

Stroke is a major cause of mortality, long-term disability and loss of functional independence worldwide. The global burden of stroke has remained substantial despite advances in prevention and acute treatment, with ischemic stroke accounting for a major proportion of all stroke events. The Global Burden of Disease Study has demonstrated a persistent and considerable burden of stroke across different regions, with substantial variations in incidence, mortality and disability according to demographic and geographical characteristics.[1] Ischemic stroke occurs when cerebral blood flow is interrupted by arterial occlusion, resulting in neuronal dysfunction and, if sufficiently prolonged, irreversible infarction. The clinical manifestations depend on the location and extent of cerebral tissue involved and may range from focal motor and sensory deficits to disturbances of language, vision, coordination and consciousness.

India has experienced a considerable burden of cerebrovascular disease, with epidemiological studies demonstrating substantial geographical and temporal variation in stroke incidence and prevalence.[2,3] Systematic reviews have reported that stroke incidence in India has increased over time, while the available evidence remains heterogeneous because of differences in study methodology, population characteristics and case ascertainment.[2] The increasing burden of vascular risk factors, including hypertension, diabetes mellitus, dyslipidaemia, smoking and other cardiovascular risk factors, further emphasizes the importance of understanding the clinical and anatomical characteristics of stroke in Indian populations. However, much of the available Indian literature has originated from selected urban populations and established stroke centres, and data from several geographically distinct regions remain comparatively limited.[2,3]

The anatomical distribution of cerebral infarction is clinically important because different regions of the brain subserve distinct neurological functions. Infarction involving the frontal, parietal, temporal or occipital lobes may produce different combinations of motor, sensory, behavioural, language and visual abnormalities, while lesions involving the basal ganglia, cerebellum or brainstem may present with characteristic extrapyramidal, cerebellar or cranial nerve and long-tract manifestations. Consequently, identification of the precise anatomical site of infarction provides important information for correlating neuroimaging findings with clinical presentation and may contribute to a better understanding of the pattern of ischemic stroke in a particular population.

Neuroimaging is central to the diagnosis and characterization of acute ischemic stroke. Non-contrast computed tomography (CT) is widely used during the initial assessment because it is rapidly available and is effective for excluding intracranial haemorrhage and identifying early ischemic changes.[4,5] Magnetic resonance imaging (MRI), particularly diffusion-weighted imaging, has greater sensitivity for detecting early ischemic lesions and can provide detailed information regarding the location and extent of cerebral infarction.[6,7] Contemporary stroke guidelines emphasize rapid brain imaging as an essential component of the initial evaluation of suspected acute ischemic stroke, with CT or MRI selected according to clinical circumstances, availability and institutional workflow.[8] Beyond establishing the diagnosis, these modalities permit systematic localization of infarcted tissue within specific anatomical brain regions.

Although substantial research has examined stroke epidemiology, risk factors, vascular territories and clinical outcomes, comparatively less information is available regarding the anatomical distribution of ischemic infarctions identified on CT or MRI among patients attending tertiary care hospitals in North-East India. Local characterization of infarct sites may provide useful epidemiological information and facilitate correlation between neuroimaging findings and clinical

manifestations. Diphu Medical College & Hospital serves as a tertiary care institution for patients from the surrounding region, providing an appropriate setting to characterize the distribution of ischemic stroke according to anatomical brain regions.

Therefore, the present study was undertaken to describe the various anatomical sites of ischemic stroke identified on CT and/or MRI among patients presenting to a tertiary care centre in North-East India.

METHODOLOGY

Study Design: The present study was conducted as a hospital-based observational study.

Study Setting: The study was conducted in the Department of Medicine, Diphu Medical College & Hospital, a tertiary care teaching hospital in North-East India.

Study Duration: The study was conducted over a period of 12 months, from April 2025 to March 2026.

Study Population: The study population comprised adult patients presenting to Diphu Medical College & Hospital with a clinical diagnosis of ischemic stroke during the study period and having CT and/or MRI brain imaging demonstrating an ischemic infarction. The anatomical location of the infarct was determined from the radiological findings documented in the CT/MRI report and, where available, correlated with the imaging findings.

Inclusion Criteria

Patients fulfilling all of the following criteria were eligible for inclusion:

1. Patients aged 18 years or older.
2. Patients presenting with clinical features suggestive of stroke and diagnosed with ischemic stroke.
3. Patients with ischemic infarction demonstrated on CT and/or MRI of the brain.
4. Patients presenting during the defined study period.
5. Patients for whom adequate demographic, clinical and neuroimaging information was available.

Exclusion Criteria

The following patients were excluded:

1. Patients with intracerebral, subarachnoid or other intracranial haemorrhage on neuroimaging.
2. Patients with stroke mimics in whom cerebral infarction was not demonstrated on CT/MRI.
3. Patients with an inadequate or unavailable neuroimaging study/report that did not permit identification of the anatomical site of infarction.
4. Patients with incomplete essential clinical or demographic information.
5. Patients younger than 18 years.

Sample Size: As the principal objective was to estimate the distribution of ischemic stroke according to anatomical brain region, the sample size was estimated using the single-proportion formula:

$$n = \frac{Z_{\frac{\alpha}{2}}^2 pq}{d^2}$$

where n is the required sample size, ($Z_{\frac{\alpha}{2}}$) is the standard normal deviate corresponding to a 95% confidence level (1.96), p is the anticipated proportion, q is (1-p), and d is the desired absolute precision. In the study setting, a prevalence of 50% was assumed, as this provides the maximum sample size. With 95% confidence and an absolute precision of 10%, the initial sample size was calculated as:

$$n = \frac{(1.96)^2(0.50)(0.50)}{(0.1)^2}$$

n=96

Considering the 20% possibility of exclusions due to incomplete clinical or imaging information, the final study sample was taken as approximately 120 participants.

Sampling Technique: A consecutive sampling technique was used. All eligible patients with imaging-confirmed ischemic stroke presenting to Diphu Medical College & Hospital during the study period were assessed for inclusion. Patients fulfilling the predefined eligibility criteria were enrolled consecutively until the required sample size was achieved.

Data Collection Tools and Procedure: Data were collected using a structured data collection proforma. Demographic characteristics, including age and sex, were recorded along with relevant clinical information such as presenting symptoms, neurological manifestations, history of hypertension, diabetes mellitus, dyslipidaemia, smoking, alcohol use and other relevant vascular risk factors, where available. Details of neuroimaging investigations were recorded, including the imaging modality used (CT and/or MRI), side of involvement and anatomical region of cerebral infarction. For the purpose of the study, the anatomical site was categorized as frontal, parietal, temporal, occipital, basal ganglia, cerebellar, brainstem, and multiple/other regions according to the documented CT/MRI findings. Where infarction involved more than one predefined anatomical region, it was recorded as multiple-region involvement. Relevant clinical and imaging findings were entered into a structured database for statistical analysis.

Study Variables: The principal dependent variable was the anatomical site of ischemic infarction on CT/MRI, categorized according to the affected brain region. Secondary variables included age, sex, clinical presentation and selected vascular risk factors such as hypertension, diabetes mellitus, dyslipidaemia, smoking and alcohol use, where documented. Imaging-related variables included the modality used, side of cerebral involvement and presence of single or multiple anatomical regions involved. These variables were assessed to describe the overall pattern of ischemic stroke and to examine associations between patient characteristics and infarct location.

Statistical Analysis: The collected data were entered into a computerized database and analyzed using appropriate statistical software. Continuous variables were summarized using mean ± standard deviation when normally distributed and median with interquartile range when distributions were non-normal. Categorical variables were presented as frequencies and percentages. Normality of continuous variables was assessed using appropriate graphical and statistical methods. For comparison of categorical variables between anatomical-site groups, the Chi-square test was used when its assumptions were satisfied, while Fisher's exact test was used when expected cell frequencies were small. For comparison of continuous variables between two groups, an independent-samples *t* test was used for normally distributed data and the Mann–Whitney U test for non-normally distributed data. For comparisons involving more than two groups, one-way analysis of variance (ANOVA) or the Kruskal–Wallis test was used according to data distribution and statistical assumptions. Where clinically and statistically appropriate, measures of association with 95% confidence intervals were reported. A two-sided p value <0.05 was considered statistically significant.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee of Diphu Medical College & Hospital. Patient confidentiality was maintained throughout the study, and identifying information was not included in the analysis or reporting of findings. The collected data were used only for the stated research purpose and were securely maintained. Informed consent was obtained from participants where required by the Institutional Ethics Committee and study procedures. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and applicable institutional and national requirements.

RESULTS

A total of 120 patients with imaging-confirmed ischemic stroke were included in the analysis. The study population comprised 78 (65.0%) males and 42 (35.0%) females. The largest proportion of patients belonged to the 61–80-year age group (52, 43.3%), followed by 41–60 years (38, 31.7%). Patients aged >80 years constituted 15.0% of the study population, while 10.0% were aged 18–40 years.

Table 1. Sociodemographic characteristics of patients with ischemic stroke (n=120)

Characteristic		Frequency (n)	Percentage (%)
Sex	Male	78	65.0
	Female	42	35.0
Age group (years)	18–40	12	10.0
	41–60	38	31.7
	61–80	52	43.3
	>80	18	15.0
	Total	**120**	**100.0**

Hypertension was the most frequently documented vascular risk factor, being present in 72 (60.0%) patients. Diabetes mellitus was present in 44 (36.7%), while dyslipidaemia was documented in 36 (30.0%). A history of smoking was reported in 38 (31.7%) patients and alcohol use in 30 (25.0%). Among the recorded clinical manifestations, hemiparesis was the most common presentation, followed by facial weakness, speech disturbance and sensory deficits.

Table 2. Vascular risk factors and clinical manifestations among patients with ischemic stroke (n=120)

Variable	Frequency (n)	Percentage (%)
Vascular risk factors		
Hypertension	72	60.0
Diabetes mellitus	44	36.7
Dyslipidaemia	36	30.0
Smoking	38	31.7
Alcohol use	30	25.0
Clinical manifestations		
Hemiparesis	82	68.3
Facial weakness	48	40.0
Speech disturbance	40	33.3
Sensory deficit	34	28.3
Altered sensorium	26	21.7
Visual symptoms	18	15.0
Ataxia	16	13.3

Note: Clinical manifestations and vascular risk factors were not mutually exclusive; therefore, percentages do not total 100%.

CT brain was performed in 72 (60.0%) patients, while MRI brain was performed in 48 (40.0%). Regarding the side of involvement, left-sided infarction was observed in 54 (45.0%) patients and right-sided infarction in 52 (43.3%), while bilateral involvement was observed in 14 (11.7%) patients.

Table 3. Neuroimaging characteristics of ischemic stroke (n=120)

Imaging characteristic	Frequency (n)	Percentage (%)
Imaging modality		
CT brain	72	60.0
MRI brain	48	40.0
Side of involvement		
Right-sided	52	43.3
Left-sided	54	45.0
Bilateral/multiple	14	11.7
Total	**120**	**100.0**

The anatomical distribution of ischemic infarction demonstrated that basal ganglia involvement was the most frequently observed site, occurring in 28 (23.3%) patients. Parietal involvement was identified in 22 (18.3%), followed by frontal involvement in 18 (15.0%) and multiple-region involvement in 14 (11.7%). Temporal, brainstem, occipital and cerebellar infarctions accounted for smaller proportions of the study population.

Table 4. Anatomical distribution of ischemic stroke lesions on CT/MRI (n=120)

Anatomical brain region	Frequency (n)	Percentage (%)
Basal ganglia	28	23.3
Parietal	22	18.3
Frontal	18	15.0
Multiple regions	14	11.7

Temporal	12	10.0
Brainstem	10	8.3
Occipital	8	6.7
Cerebellar	8	6.7
Total	**120**	**100.0**

The distribution of anatomical infarct sites did not demonstrate a statistically significant association with sex. Basal ganglia involvement was observed in 19 (24.4%) males and 9 (21.4%) females, while parietal involvement was observed in 15 (19.2%) males and 7 (16.7%) females. Overall, the anatomical distribution was broadly comparable between males and females (χ^2=1.73, p=0.973).

Age-group distribution also did not demonstrate a statistically significant association with anatomical site of infarction (χ^2=4.31, p>0.99). Basal ganglia and parietal involvement occurred across the major age groups, with no clear concentration of a particular anatomical site within a specific age category.

Table 5. Association of anatomical site of ischemic stroke with sex and age group

Anatomical site	Male n (%)	Female n (%)	18–40 n (%)	41–60 n (%)	61–80 n (%)	>80 n (%)
Frontal	11 (61.1)	7 (38.9)	2 (11.1)	6 (33.3)	8 (44.4)	2 (11.1)
Parietal	15 (68.2)	7 (31.8)	2 (9.1)	7 (31.8)	10 (45.5)	3 (13.6)
Temporal	7 (58.3)	5 (41.7)	1 (8.3)	4 (33.3)	5 (41.7)	2 (16.7)
Occipital	5 (62.5)	3 (37.5)	1 (12.5)	2 (25.0)	4 (50.0)	1 (12.5)
Basal ganglia	19 (67.9)	9 (32.1)	2 (7.1)	10 (35.7)	12 (42.9)	4 (14.3)
Cerebellar	4 (50.0)	4 (50.0)	1 (12.5)	2 (25.0)	4 (50.0)	1 (12.5)
Brainstem	7 (70.0)	3 (30.0)	1 (10.0)	3 (30.0)	5 (50.0)	1 (10.0)
Multiple regions	10 (71.4)	4 (28.6)	2 (14.3)	4 (28.6)	4 (28.6)	4 (28.6)
Total	**78 (65.0)**	**42 (35.0)**	**12 (10.0)**	**38 (31.7)**	**52 (43.3)**	**18 (15.0)**

Statistical analysis: Sex versus anatomical site: χ^2=1.73, p=0.973. Age group versus anatomical site: χ^2=4.31, p>0.99.

Overall, the findings demonstrated that ischemic infarctions were distributed across multiple anatomical regions of the brain, with basal ganglia and parietal regions accounting for the largest proportions. Multiple-region involvement was also observed in a subset of patients. Although the frequency of individual infarct sites varied across age groups and between sexes, these differences were not statistically significant in the present analysis.

DISCUSSION

The present study examined the anatomical distribution of ischemic stroke lesions identified on CT and/or MRI among 120 patients presenting to a tertiary care centre in North-East India. The study demonstrated involvement of multiple cerebral regions, with the basal ganglia being the most frequently affected anatomical site (23.3%), followed by the parietal region (18.3%) and frontal region (15.0%). Multiple-region infarction was observed in 11.7% of patients. Hypertension was the most frequently documented vascular risk factor, followed by diabetes mellitus, smoking and dyslipidaemia. The predominance of male patients and the relatively greater representation of older adults were also notable findings.

The demographic pattern observed in the present study is broadly consistent with the epidemiological profile reported from Indian stroke cohorts. In the Indo-US Collaborative Stroke Project, which included more than 2,000 patients with ischemic stroke from tertiary hospitals in India, 67.2% of patients were men, while hypertension, diabetes and tobacco exposure were common vascular risk factors.[1] Similarly, a systematic review and meta-analysis of Indian studies reported a male predominance among patients with stroke and identified hypertension, dyslipidaemia, diabetes, tobacco use and alcohol use among the commonly reported associated factors.[2] The male predominance in the present study, therefore, is compatible with patterns documented in other Indian clinical populations, although differences in referral patterns and population structure may influence the observed distribution.

Hypertension was identified in 60.0% of the present study population. This finding is particularly relevant because hypertension is consistently recognized as one of the major modifiable risk factors for stroke in India. The Indo-US Collaborative Stroke Project reported hypertension in 60.8% of patients with ischemic stroke, which is remarkably similar

to the proportion observed in the present study.[1] The Indian systematic review by Varkey et al. also identified hypertension as the leading intermediate risk factor among Indian patients with stroke.[2] Diabetes mellitus was present in 36.7% of the current cohort, again comparable with the 35.7% prevalence reported in the Indo-US Collaborative Stroke Project.[1] These similarities suggest that the vascular risk-factor profile observed at the study centre broadly resembles that described in other Indian tertiary-care populations.

The principal focus of this study was the anatomical localization of ischemic infarction rather than classification according to arterial vascular territory. Basal ganglia involvement was the most common finding, accounting for 23.3% of all infarctions. The predominance of basal ganglia involvement represents a descriptive finding in the present cohort; however, the study was not designed to determine the vascular mechanisms underlying this anatomical distribution. However, the present study was not designed to establish a causal relationship between hypertension and basal ganglia infarction; therefore, the observed anatomical distribution should be interpreted descriptively.

The parietal and frontal regions were the next most frequently affected sites, accounting for 18.3% and 15.0%, respectively. These findings are clinically relevant because infarction in these regions may produce combinations of motor, sensory, language, visuospatial and higher cortical dysfunction depending on the hemisphere and precise extent of involvement. The anatomical classification used in the present study provides a straightforward description of the neuroimaging pattern and may be particularly useful in settings where detailed vascular imaging or etiological classification is not uniformly available.

Previous Indian research has also demonstrated the value of recording infarction according to anatomical brain location. In a study of young Indian patients with ischemic stroke, infarcts were classified according to different brain regions, with internal capsule involvement being particularly frequent and infarctions also documented in the cerebellum, basal ganglia and midbrain.[3] Although the population and objectives of that study differ from those of the present study, it supports the feasibility and clinical relevance of describing ischemic stroke according to anatomical localization.

Multiple-region involvement was identified in 11.7% of patients. Multiple infarcts may occur through several mechanisms, including embolic phenomena, diffuse small-vessel disease or involvement of more than one vascular territory. Because the present study focused on anatomical regions rather than etiological mechanisms, the finding of multiple-region involvement should not be interpreted as evidence for any particular stroke mechanism. Further evaluation using vascular imaging, cardiac assessment and standardized etiological classification would be required to investigate these mechanisms.

CT was the imaging modality used in 60.0% of patients, whereas MRI was performed in 40.0%. This distribution reflects the complementary roles of CT and MRI in the evaluation of suspected ischemic stroke. Non-contrast CT remains an important first-line imaging modality because of its speed, accessibility and ability to exclude intracranial haemorrhage, while MRI, particularly diffusion-weighted imaging, provides greater sensitivity for detecting acute ischemic lesions.[4-6] Contemporary acute ischemic stroke recommendations emphasize rapid brain imaging as an essential component of initial evaluation, with the choice between CT and MRI influenced by availability, clinical circumstances and institutional workflow.[4] Therefore, using both modalities in the present study allowed anatomical localization across a broad range of clinical presentations.

The present study did not demonstrate a statistically significant association between sex and anatomical site of infarction. Similarly, no statistically significant association was observed between age group and anatomical infarct location. Although numerical differences were present between individual categories, the available sample size may have limited the ability to detect relatively small differences between anatomical subgroups. Furthermore, anatomical localization is influenced by multiple factors, including vascular pathology, stroke mechanism, lesion size and pre-existing cerebrovascular disease. A larger multicentre study would therefore be required to determine whether specific demographic or clinical characteristics are independently associated with particular anatomical infarct patterns.

The findings have potential relevance for clinical practice in North-East India, where region-specific data on stroke characteristics are comparatively limited. Indian stroke epidemiological studies have demonstrated substantial geographical variation in stroke burden and characteristics, and population-based registry data have emphasized the importance of generating regionally representative information.[2,7] A hospital-based description of anatomical infarct distribution can contribute to local epidemiological understanding and may provide a foundation for future studies examining relationships between imaging patterns, vascular risk factors, stroke severity and clinical outcomes.

An important strength of the present study is its simple and clinically applicable classification of infarct location based on CT/MRI findings. The inclusion of several anatomical regions permits a broad description of ischemic stroke patterns

without requiring all patients to undergo advanced vascular imaging. The study also evaluates the anatomical distribution alongside demographic characteristics and commonly documented vascular risk factors, allowing a more comprehensive description of the study population.

Several limitations should nevertheless be considered. First, the study was conducted at a single tertiary care centre, which limits the generalizability of the findings to the wider North-East Indian population. Patients reaching a tertiary referral hospital may differ systematically from patients managed at primary or secondary care facilities. Second, the observational design permits description of associations but does not establish causality. Third, CT and MRI do not provide identical sensitivity for all acute ischemic lesions, and differences in imaging availability and timing may influence detection of small or early infarcts. Fourth, classification by broad anatomical region may not capture the precise vascular territory, lesion volume or detailed cortical/subcortical anatomy. Finally, the relatively modest sample size limits the statistical power for comparisons among several anatomical categories.

Future multicentre studies involving larger patient populations could combine anatomical localization with vascular-territory classification, stroke mechanism, lesion volume, neurological severity and clinical outcomes. Such studies could also evaluate whether particular anatomical patterns are associated with specific risk-factor profiles or functional outcomes. Prospective neuroimaging-based registries may provide more detailed information regarding regional differences in ischemic stroke and could help strengthen the evidence base for stroke care in North-East India.

CONCLUSION

The present observational study found that ischemic stroke involved a broad range of anatomical brain regions on CT and MRI, with the basal ganglia being the most frequently involved site (23.3%), followed by the parietal (18.3%) and frontal (15.0%) regions. Multiple-region infarction was observed in 11.7% of patients. Hypertension was the most frequently documented vascular risk factor, followed by diabetes mellitus, dyslipidaemia and smoking. Although variations in anatomical distribution were observed across age groups and between sexes, these associations were not statistically significant. Systematic anatomical localization of ischemic infarction using CT and MRI provides useful information regarding the regional pattern of stroke in tertiary-care populations. The findings from this North-East Indian centre contribute to the limited regional information available on the anatomical distribution of ischemic stroke. Larger multicentre studies incorporating detailed vascular-territory classification, stroke mechanism, lesion characteristics and clinical outcomes are warranted to further characterize regional patterns of ischemic stroke.

DECLARATIONS

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