Research Article

Cuestiones de Fisioterapia

Medicine

Imaging Spectrum of Stroke in Young Adults: A Retrospective Study

Dr. Praveen*

Assistant Professor, Department of Radiology, JR Medical College and Hospital, Villupuram Tk, Tamilnadu, India.

Abstract

Background: Stroke in young adults differs from stroke in older populations in terms of underlying causes, clinical characteristics, and neuroimaging findings. Young stroke is associated with substantial long-term disability and socioeconomic burden, making accurate diagnosis and aetiological evaluation essential. Neuroimaging plays a pivotal role in identifying stroke subtype, vascular involvement, and underlying mechanisms.

Objectives: To describe the imaging spectrum of stroke in young adults and to evaluate the distribution of stroke subtypes, underlying aetiologies, vascular territories, and characteristic neuroimaging features.

Methods: This retrospective observational study was conducted in the Department of Radiodiagnosis and included 130 young adults aged 18–45 years with a confirmed diagnosis of acute stroke. Neuroimaging studies, including computed tomography (CT), magnetic resonance imaging (MRI), CT angiography, MR angiography, and venographic examinations, were reviewed. Stroke subtype, vascular territory, presumed aetiology, and characteristic imaging findings were recorded and analysed descriptively.

Results: The mean age of participants was 36 ± 7 years, and 58% were male. Ischaemic stroke was the predominant subtype, occurring in 88 patients (68%), followed by haemorrhagic stroke in 31 patients (24%) and cerebral venous sinus thrombosis (CVST) in 11 patients (8%). Among ischaemic strokes, arterial dissection, cardioembolic disorders, and vasculitic or other uncommon causes were prominent, with a notable proportion remaining cryptogenic. Characteristic imaging findings included diffusion-restricted infarcts and arterial occlusions in ischaemic stroke, parenchymal haematomas with associated vascular abnormalities in haemorrhagic stroke, and venous sinus filling defects with venous infarction in CVST.

Conclusion: Stroke in young adults exhibits a distinctive and heterogeneous imaging profile, characterised by a predominance of ischaemic stroke and a relatively high frequency of dissection, cardioembolic causes, and CVST. Comprehensive neuroimaging, including arterial and venous vascular assessment, is essential for accurate diagnosis, aetiological classification, and optimisation of secondary prevention strategies.

Keywords: *Young adult stroke; Ischaemic stroke; Intracerebral haemorrhage; Cerebral venous sinus thrombosis; Neuroimaging; Magnetic resonance imaging.*

Introduction

Stroke is traditionally considered a disease of older adults; however, a significant proportion of cases occur in young adults, where the underlying causes, clinical characteristics, and imaging findings often differ substantially from those observed in older populations. Stroke affecting individuals between 18 and 45 years of age has important personal, social, and economic consequences because it occurs during the most productive years of life, frequently resulting in long-term disability, loss of employment, and reduced quality of life (1). Consequently, early recognition of the underlying mechanism and accurate diagnosis are essential for optimizing management and preventing recurrent cerebrovascular events (2).

The aetiological spectrum of stroke in young adults is notably broader than that seen in older patients. In addition to conventional vascular risk factors such as hypertension, diabetes mellitus, and atherosclerosis, young adults are more likely to experience stroke secondary to arterial dissection, cardioembolic disorders including patent foramen ovale, vasculitis, inherited and acquired thrombophilic states, substance abuse, and cerebral venous sinus thrombosis (CVST). Despite comprehensive diagnostic evaluation, a substantial proportion of young strokes remain cryptogenic, highlighting the complexity of this population (3).

Neuroimaging plays a pivotal role in the evaluation of young stroke. Computed tomography (CT), magnetic resonance imaging (MRI), diffusion-weighted imaging, CT and MR angiography, and venography facilitate accurate classification of stroke subtype, identification of vascular territories involved, and detection of underlying causes (4). Understanding the local imaging spectrum may improve diagnostic pathways and resource allocation.

Aim: To describe the imaging spectrum of stroke in young adults.

Primary Objective: To determine the distribution of stroke subtypes, including ischaemic stroke, haemorrhagic stroke, and cerebral venous sinus thrombosis, among young adults.

Secondary Objectives: (i) To describe the underlying aetiologies and vascular territories involved in ischaemic stroke; and (ii) to characterise the major neuroimaging features associated with each stroke subtype.

This study was designed as a descriptive investigation to characterise the distribution of stroke subtypes, aetiologies, and imaging patterns in young adults presenting with stroke.

MATERIALS AND METHODS

This study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for observational research.

Study Design and Setting

A retrospective observational study was performed in the Department of Radiodiagnosis. The study reviewed neuroimaging records of young adults diagnosed with stroke during the study period. Clinical and imaging data were retrieved from hospital records and radiology archives for analysis.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee ([IEC approval number and date]). Owing to the retrospective nature of the study and the use of anonymized patient data, the requirement for informed consent was waived. All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Study Population

Patients aged 18–45 years with a confirmed clinical and radiological diagnosis of acute stroke were eligible for inclusion. Stroke diagnoses were established based on characteristic findings on neuroimaging and clinical presentation. Patients with stroke mimics, incomplete imaging records, poor-quality or non-diagnostic studies, and insufficient clinical information were excluded from the analysis.

Imaging Assessment

All available imaging studies, including computed tomography (CT), magnetic resonance imaging (MRI) with diffusion-weighted and susceptibility-weighted sequences, CT angiography, MR angiography, and venographic examinations, were reviewed. Stroke subtype, vascular territory involved, presumed aetiology, and characteristic imaging findings were documented. Imaging interpretation was independently performed by two experienced radiologists, and discrepancies were resolved through consensus review.

Sample Size and Statistical Analysis

All eligible cases identified during the study period were included. A sample size of approximately 130 patients was considered adequate to estimate the expected prevalence of major stroke subtypes with acceptable precision. Statistical analyses were performed using SPSS version [] or R version []. Categorical variables were summarised as frequencies and percentages, whereas continuous variables were expressed as mean ± standard deviation or median with interquartile range. Comparisons between subgroups were performed using the chi-square test where appropriate, and a two-tailed p-value <0.05 was considered statistically significant.

RESULTS

Cohort and subtypes

Of 130 young adults with stroke, mean age was 36 ± 7 years; 58% (75/130) were male. Ischaemic stroke predominated, followed by haemorrhagic stroke and CVST (Figure 1, Table 1).

Table 1: Stroke subtype distribution.

Subtype	n (%)
Ischaemic	88 (68)
Haemorrhagic	31 (24)
Cerebral venous sinus thrombosis	11 (8)

A total of 130 young adults with stroke were included in the study. Ischaemic stroke was the predominant subtype, accounting for 88 cases (68%), making it the most common form of cerebrovascular disease in this age group. Haemorrhagic stroke was identified in 31 patients (24%), representing approximately one-quarter of all cases. Cerebral venous sinus thrombosis (CVST) was the least common subtype, observed in 11 patients (8%). The findings demonstrate that while arterial ischaemic events constitute the majority of strokes among young adults, a substantial proportion of patients present with haemorrhagic stroke or venous thrombosis. This distribution highlights the heterogeneous nature of stroke in younger populations and underscores the importance of comprehensive neuroimaging to accurately classify stroke subtype and guide further diagnostic evaluation and management.

Aetiology and territory

Among ischaemic strokes, dissection, cardioembolism, and vasculitic/other causes were prominent, with a notable undetermined proportion (Figure 2). Common imaging features by subtype are summarised in Table 2.

Table 2: Representative imaging features by stroke subtype.

Subtype	Representative imaging features
Ischaemic	DWI restriction in a vascular territory; vessel occlusion/stenosis on angiography; arterial wall haematoma in dissection
Haemorrhagic	Parenchymal haematoma; underlying vascular malformation/aneurysm on angiography; lobar versus deep location
CVST	Venous sinus filling defect on venography; venous infarction/haemorrhage not respecting arterial territories

Distinct neuroimaging patterns were observed across the different stroke subtypes. Ischaemic strokes typically demonstrated diffusion-weighted imaging (DWI) restriction within a defined arterial vascular territory, often accompanied by vessel occlusion or significant stenosis on angiographic studies. In cases of arterial dissection, characteristic findings included mural haematoma and vessel wall irregularity. Haemorrhagic strokes were characterised by intraparenchymal haematomas, with imaging enabling differentiation between lobar and deep haemorrhages and identification of underlying vascular abnormalities such as aneurysms or arteriovenous malformations. Cerebral venous sinus thrombosis (CVST) showed venous sinus filling defects on CT or MR venography, frequently associated with venous infarction and haemorrhagic lesions that did not conform to arterial vascular territories. These imaging features were instrumental in establishing stroke subtype and suggesting the underlying aetiology.

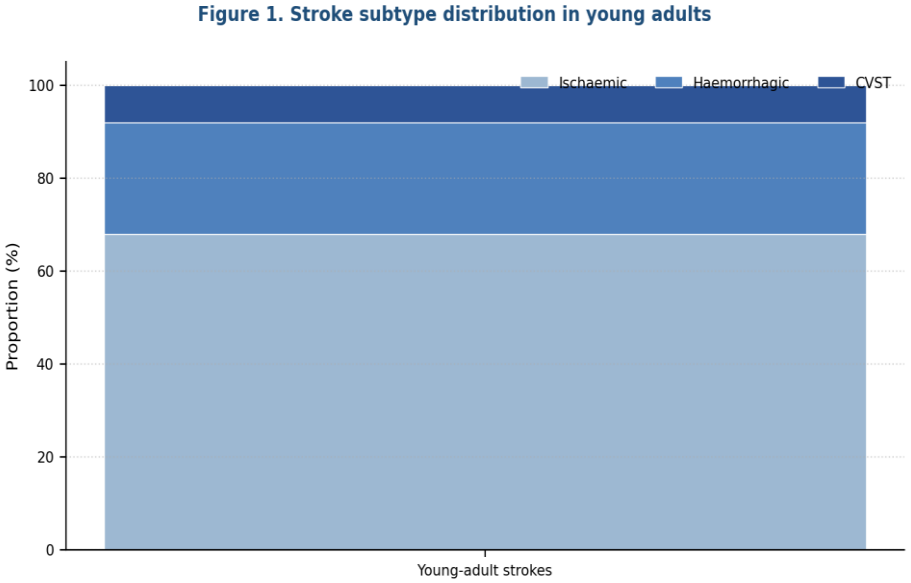

Figure 1: Stroke subtype distribution in young adults.

Figure 2. Aetiology and vascular territory of ischaemic stroke in young adults

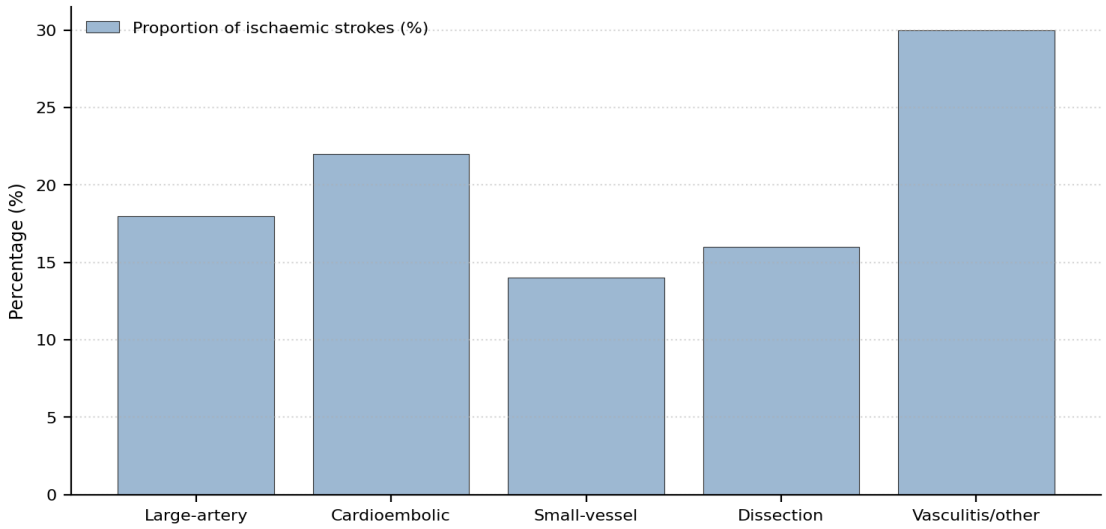

Figure 2: Aetiology and vascular territory of ischaemic stroke in young adults.

DISCUSSION

In this retrospective study, stroke in young adults demonstrated a distinctive neuroimaging spectrum that differed considerably from the patterns typically observed in older populations (5). Ischaemic stroke constituted the majority of cases, accounting for more than two-thirds of all strokes, while haemorrhagic stroke and cerebral venous sinus thrombosis (CVST) together represented a substantial minority (6). Beyond differences in subtype distribution, the underlying aetiological profile of ischaemic stroke was notable for the prominence of arterial dissection, cardioembolic mechanisms, and vasculitic or other uncommon causes, which are encountered less frequently in older patients where atherosclerotic and small-vessel disease predominate (7). These findings reinforce the concept that stroke in young adults represents a heterogeneous clinical entity requiring a broader diagnostic perspective and a more comprehensive imaging approach (8).

The observed imaging patterns reflect the unique pathophysiological mechanisms that contribute to cerebrovascular disease in younger individuals (9). Arterial dissections were identified through characteristic vessel-wall abnormalities and mural haematomas, while cardioembolic strokes frequently demonstrated territorial infarcts involving large cerebral arteries. Similarly, cases of CVST exhibited venous sinus filling defects and venous infarctions that did not conform to conventional arterial territories (10). Such findings underscore the value of advanced neuroimaging techniques, including diffusion-weighted MRI, susceptibility-weighted imaging, CT and MR angiography, vessel-wall imaging, and venographic studies. Reliance on routine non-contrast imaging alone may fail to identify important vascular abnormalities, potentially delaying diagnosis and appropriate secondary prevention strategies.

A noteworthy observation was the persistence of a substantial proportion of cryptogenic strokes despite extensive imaging and clinical evaluation. This finding is consistent with previous studies and highlights the ongoing challenges in establishing definitive aetiological diagnoses in young adults (11). The cryptogenic category may encompass occult cardioembolic sources, inherited thrombophilic disorders, transient vascular abnormalities, or mechanisms that remain inadequately understood. Continued refinement of diagnostic protocols, including advanced cardiac evaluation, prolonged rhythm monitoring, and genetic or coagulation studies, may improve diagnostic yield in this population (12).

The present study has several strengths. Neuroimaging findings were systematically reviewed across multiple modalities, including CT, MRI, angiographic, and venographic examinations. Independent assessment by experienced radiologists with consensus review enhanced diagnostic consistency and allowed detailed characterisation of subtype-specific imaging features. Furthermore, the study provides valuable insight into the local epidemiology and imaging characteristics of young stroke, which may assist clinicians in developing targeted diagnostic pathways.

However, certain limitations should be acknowledged. The retrospective design may be associated with selection, referral, and verification biases. As a single-centre study, the findings may not be fully generalisable to other populations. Additionally, aetiological classification depended on the completeness of available investigations, and some patients lacked comprehensive vascular, cardiac, or laboratory evaluations. Consequently, a proportion of cases remained undetermined despite extensive review.

Future research should focus on prospective multicentre registries incorporating standardised imaging protocols, comprehensive vascular and cardiac assessment, and long-term follow-up. Such studies would improve understanding of stroke mechanisms in young adults, enhance aetiological classification, and facilitate the development of tailored prevention and management strategies for this unique patient population.

CONCLUSION

Stroke in young adults exhibited a distinctive and heterogeneous neuroimaging spectrum, with ischaemic stroke representing the predominant subtype, while haemorrhagic stroke and cerebral venous sinus thrombosis accounted for a substantial proportion of cases. The aetiological profile differed from that typically observed in older populations, with arterial dissection, cardioembolic disorders, and vasculitic or other uncommon causes emerging as important contributors. Neuroimaging played a central role not only in confirming the diagnosis and classifying stroke subtype but also in identifying underlying vascular abnormalities and guiding aetiological evaluation. Advanced imaging modalities, including MRI with diffusion-weighted and susceptibility sequences, angiographic studies, and venography, proved particularly valuable in detecting lesions that may not be apparent on routine imaging. The persistence of a notable proportion of cryptogenic strokes highlights the complexity of stroke mechanisms in younger patients and the need for comprehensive multidisciplinary assessment. These findings support the implementation of systematic imaging protocols that incorporate both arterial and venous vascular evaluation in all young adults presenting with stroke. Such an approach may improve diagnostic accuracy, facilitate targeted secondary prevention, and ultimately reduce the burden of recurrent cerebrovascular events. Further prospective multicentre studies with standardised diagnostic work-up and long-term follow-up are required to refine aetiological classification, evaluate outcomes, and optimise management strategies for this unique and clinically important patient population.

REFERENCES

1. Smajlović D. Strokes in young adults: epidemiology and prevention. Vasc Health Risk Manag. 2015;11:157–164.
2. Ekker MS, Boot EM, Singhal AB, et al. Epidemiology, aetiology, and management of ischaemic stroke in young adults. Lancet Neurol. 2018;17(9):790–801.
3. Maaijwee NA, Rutten-Jacobs LC, Schaapsmeerders P, et al. Ischaemic stroke in young adults: risk factors and long-term consequences. Nat Rev Neurol. 2014;10(6):315–325.

4. Putaala J, Metso AJ, Metso TM, et al. Analysis of 1008 consecutive patients aged 15 to 49 with first-ever ischemic stroke: the Helsinki Young Stroke Registry. Stroke. 2009;40(4):1195–1203.
5. Bersano A, Borellini L, Motto C, et al. Cryptogenic stroke and patent foramen ovale in young patients. Cerebrovasc Dis. 2015;39(2):117–125.
6. Yesilot Barlas N, Putaala J, Waje-Andreassen U, et al. Etiology of first-ever ischaemic stroke in European young adults: the 15 cities young stroke study. Eur J Neurol. 2013;20(11):1431–1439.
7. Allen LM, Hasso AN, Handwerker J, Farid H. Sequence-specific MR imaging findings that are useful in dating ischemic stroke. Radiographics. 2012;32(5):1285–1297.
8. Adams HP, Bendixen BH, Kappelle LJ, et al. Classification of subtype of acute ischemic stroke: definitions for use in a multicenter clinical trial (TOAST). Stroke. 1993;24(1):35–41.
9. Saver JL. Cryptogenic stroke. N Engl J Med. 2016;374(21):2065–2074.
10. Schievink WI. Spontaneous dissection of the carotid and vertebral arteries. N Engl J Med. 2001;344(12):898–906.
11. Saposnik G, Barinagarrementeria F, Brown RD, et al. Diagnosis and management of cerebral venous thrombosis: AHA/ASA statement. Stroke. 2011;42(4):1158–1192.
12. Leys D, Bandu L, Henon H, et al. Clinical outcome in 287 consecutive young adults (15 to 45 years) with ischemic stroke. Neurology. 2002;59(1):26–33.