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Stroke in young adults: A 3-month outcome analysis and predictors of mortality in Northeast India – A regional perspective

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ABSTRACT

Background: Stroke in young adults (18–50 years) is a growing public health challenge, with Northeast India reports a disproportionately high incidence (36.7% of total strokes). This study analyzes functional outcomes and mortality predictors using the modified Rankin scale in young stroke patients. **Aims and Objectives:** To study the various stroke subtypes among young adults from this country region. Second, to study the outcome of stroke at the 28th and 30th day, and further analyze the predictors of mortality. **Materials and Methods:** A prospective cohort of 128 young stroke patients (ischemic, hemorrhagic, and venous thrombosis) was assessed at discharge and 3-month follow-up. Regression analysis identified predictors of mortality and poor outcomes. **Results:** Out of 348 stroke cases, 128 (36.7%) were young patients (aged 18–55). Ischemic stroke was most common (49.2%), followed by intracerebral hemorrhage (45.3%), subarachnoid hemorrhage (3.9%), and cerebral venous thrombosis (1.6%). The study observed a total of 22 patient deaths (5.8% mortality rate). The timing of these deaths was as follows: eight patients died at discharge, nine patients passed away within the first 28 days, and five patients died by the end of three months. **Conclusion:** Targeted interventions addressing stroke severity, subtype, and complications are critical to improving outcomes in young adults.

Key words: Stroke in young; Predictor of mortality; Stroke severity; National Institutes Of Health Stroke Scale

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INTRODUCTION

Stroke in young adults now accounts for 36.7% of all strokes in Northeast India – a rate higher than the national average – signaling an urgent public health crisis.[1-3] Stroke in young leads to the loss of productive years, caregiver strain, and economic impact on society, underscoring the urgency of the matter to be addressed. In this age group, stroke prevalence ranges from 15% to 30%, with ischemic stroke as the most frequent subtype and around 31.3% reported from Northeast India.[1-3] Of these cases, 50.66% involve ischemic stroke, followed by 44.3% intracranial hemorrhage and 3.3% cerebral venous thrombosis (CVT).

Previous studies report an overall stroke survival rate of 59–67% at 12 months.[4] Stroke outcomes in younger individuals vary from older populations, influenced by factors such as better health and greater neuroplasticity. Recovery outcomes, however, still depend on variables such as stroke type, time to treatment, and access to rehabilitation. Given the data showing a high incidence of stroke among young adults in Northeast India, this

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study aims to analyze stroke outcomes using the modified Rankin scale (mRS) in this population and identify clinical predictors influencing these outcomes.

Aims and objectives

1) To study the various stroke subtypes among young adults from this country region.
2) To study the outcome of stroke at the 28th and 30th day, and further analyze the predictors of mortality.

MATERIALS AND METHODS

This prospective, hospital-based study used a stroke registry to enroll all stroke patients within 28 days. The study included young patients (aged 18–50) with both first-ever and recurrent strokes, including ischemic, hemorrhagic, venous thrombosis, and subarachnoid hemorrhage types. Transient ischemic attacks (TIA), non-vascular strokes (e.g., trauma), and other stroke mimics were excluded from the study. The study aims to know the various stroke subtypes among young adults from this country's region. Second, to study the outcome of stroke at the 28th and 30th day, and further analyze the predictors of mortality.

Data were collected from stroke patients admitted to the Neurology, Medicine, Neurosurgery, Cardiology, and Emergency departments. Patient's data were abstracted at admission, during the hospital stay, and post-discharge. Cases missed were subsequently retrieved from the Medical Records Department. This comprehensive data collection covered all relevant patients' demographic details, clinical signs and symptoms of stroke, its severity (National Institutes of Health Stroke Scale [NIHSS] score), neuro-imaging findings, stroke type and TOAST classification, territory affected, etiology, risk factors, co-morbidities, past medical history, medications, and treatments received during the hospital stay. The patient's status was followed for complications during hospitalization or interventions provided for stroke.

The mRS assessed functional outcomes, ranging from 0 (no symptoms) to 6 (death).[5] mRS status before the occurrence of stroke and on discharge was recorded. mRS outcome on 28 days and 90 days was recorded telephonically and through follow-ups at the hospital. An mRS score below 3 indicated a favorable outcome, reflecting independence in daily activities. An attempt has been made to see if some factors have caused an impact on the outcome of stroke in the young. These factors included sex, body mass index (BMI), the severity of stroke at presentation based on the NIHSS scale, time to admission from the onset of stroke, a history of intensive care unit (ICU) admission, complications developed during hospitalization (progression of current stroke in terms of expansion/extension of stroke, pneumonia, seizure, falls, recurrent stroke, urinary tract infection, decubitus ulcer, deep vein thrombosis, number of risk factors of stroke, type of stroke (ischemic or hemorrhagic), territory affected (anterior or posterior).

Statistical analysis was done using Statistical Packages for the Social Sciences version 24 software where all baseline characters were noted. A regression analysis was done to see the impact of various factors on the outcome and functional dependency of stroke on discharge and at 3 months.

RESULTS

The study included 88 male and 40 female patients, showing a higher incidence of stroke cases among males with a male-to-female ratio of 2.2:1. Most patients were aged 41–50, suggesting that individuals in this age group may face a higher stroke risk. The number of younger patients (ages 18–30) was notably lower. Specifically, patients aged 18–20 represented only 2.3% of the total, whereas those aged 21–30 made up 6.3%. Young adults between 31 and 40 years accounted for 32.8% of cases, whereas the largest group, aged 41–50 years made up 58.6% of the patient population.

In our study, 128 young stroke patients (aged 18–55) were analyzed out of a total of 348 stroke cases, representing 36.7% of the patient population. Among these young stroke patients, ischemic stroke was the most prevalent subtype, accounting for approximately 49.2% (63 patients). Intracerebral hemorrhage (ICH) was the second most common, seen in 45.3% of cases (58 patients). Subarachnoid hemorrhage was notably less frequent, comprising only 3.9% (5 patients), and CVT was the rarest subtype, representing just 1.6% (2 patients).

The most common type of ischemic stroke in this patient group was an infarct in the middle cerebral artery distribution, seen in 48 patients, followed by small vessel lacunar infarcts in 43 patients. The primary causes of ischemic stroke included thrombotic and thromboembolic events, which affected 21 patients. In addition, arterial embolic causes were identified in six patients, and cardioembolic strokes were noted in another six patients. Other causes of ischemic strokes included central nervous system vasculitis and Moya-Moya disease, each observed in two patients. Infective causes accounted for strokes in five patients, whereas polycythemia was found in two patients. In 20 cases, the etiology remained undetermined, making up 31%.

For patients with ICH, hypertensive hemorrhages were the most frequent, affecting 50 patients. Two patients experienced hemorrhage due to arteriovenous malformations, and six patients had an unknown cause of ICH. Among them, 55 patients had a supratentorial bleed, whereas only three had an infratentorial bleed (Table 1).

Many patients had high mRS scores, reflecting considerable functional impairment at discharge. Specifically, 31 patients (24%) had a score of mRS 4, and 35 patients (27%) had a score of mRS 5, whereas eight patients (6%) had a fatal outcome with mRS score of 6. Only 54 patients (42%) achieved a favorable mRS score of <3. By the 3-month follow-up, 87 patients (68%) had improved to a favorable mRS score of 3 or less. However, 24 patients continued to experience severe disability with mRS scores ranging from 4 to 6. A total of 22 patients died during the study period, with eight deaths occurring at discharge, nine by the 28-day follow-up, and five additional deaths by 3 months, representing an overall mortality rate of 5.8% (as illustrated in Figure 1), with two patients lost to follow-up.

A statistically significant association was noted between the stroke severity and type of stroke (hemorrhagic stroke) with poor outcomes. The stroke severity variable, as measured by NIHHS, is highly significant (P=0.000), suggesting that stroke severity is a strong predictor of the outcome. Further, the functional status at discharge (mRS), those who develop complications during the hospital stay, an ICU stay, and the presence of multiple risk factors of stroke in a patient were also associated with poor outcomes. Surgical interventions (e.g., external ventricular drainage, hemicraniectomy) were associated with lower survival rates, though the sample sizes are small (P=0.004). Other variables such as duration of hospital stays, BMI, days from stroke onset to admission, sex, ICH score, and territory affected are not statistically significant in affecting the outcome of stroke in the young, as depicted in Tables 2 and 3.

Table 1: Patient information

Patient information	Frequency	Percent
Sex		
Male	88	68.7
Female	40	31.5
NIHSS		
No stroke symptoms	6	4.7
Minor stroke	27	21.3
Moderate stroke	74	58.3
Moderate to severe stroke	10	7.9
Severe stroke	10	7.9
ICU transfer	15	11.8
Territory affected		
None (SAH)	2	1.6
Supratentorial	55	42.9
Infratentorial	3	2.3
Complications in hospital stay		
Decubitus ulcer	1	0.8
Fall	1	0.8
Pneumonia	11	8.7
Pneumonia, decubitus ulcer	2	1.6
Progression of current stroke, Pneumonia	1	0.8
Seizures	1	0.8
Stroke type		
Venous	2	1.6
Ischemic stroke	63	49.2
Intracerebral hemorrhage	58	45.3
Subarachnoid hemorrhage	5	3.9
Surgical intervention		
External ventricular drainage	2	1.6
Hemicraniectomy	1	0.8
External ventricular drainage for hydrocephalus	1	0.8

NIHSS: National Institutes of Health Stroke Scale, ICU: Intensive care unit

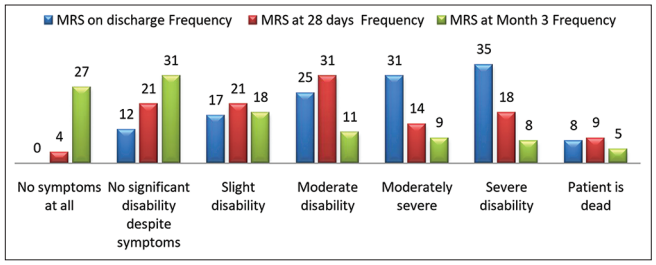

Figure 1: Outcome of stroke in young (modified Rankin scale on discharge, 28 days, and 3 months after discharge)

DISCUSSION

Stroke among young adults, defined as individuals aged 18–50, is relatively uncommon but constitutes a growing proportion of all stroke cases, making it a significant health concern.[6] In the U.S., the incidence of stroke in this age group rose from 17/100,000 in 1993 to 28/100,000 by 2015.[7] Stroke in children and young adults causes significant disability and societal costs. Advances have improved care for large vessel occlusions and rare stroke causes such as genetic treatment of monogenic causes of stroke, hydroxyurea in sickle cell anemia, and easy access to hyperacute therapies.[8]

In India, the stroke rate for individuals under 45 is estimated at 0.1–0.3/1,000 person-years, a figure expected to increase in the coming years.[9] Stroke among young adults accounts for 15–30% of all cases, with studies from Northeast India reporting a rate of 31.3% – similar to recent findings of the present study but showing an increasing trend, now at 36.7%.[3] While global young stroke rates rise by 1.5% annually, Northeast India's 36.7% incidence demands region-specific prevention strategies.

Ischemic stroke is more common than hemorrhagic stroke among young adults, often resulting from large artery disease, cardio-embolism, atherosclerosis, and

Table 2: Association between patient characteristics and mortality

Patient characteristics	Death (%)	Alive (%)	Chi-square	P-value
Sex				
Male	4 (4.6)	83 (95.4)	2.599	0.107
Female	5 (12.5)	35 (87.5)		
ICH score				
ICH score (0)	1 (5.6)	17 (94.4)	5.631	0.131
ICH score (1)	0 (0)	11 (100)		
ICH score (2)	1 (5.6)	17 (94.4)		
ICH score (3)	2 (28.6)	5 (71.4)		
BMI				
Underweight	0 (0)	6 (100)	0.589	0.745
Normal weight	8 (7.2)	103 (92.8)		
Overweight	1 (10)	9 (90)		
Number of days from stroke to admission				
Very early admission	6 (7.3)	76 (92.7)	1.390	0.708
Early admission	3 (9.7)	28 (90.3)		
Moderate delay	0 (0)	10 (100)		
Late admission	0 (0)	4 (100)		
NIHHS symptom score				
No stroke symptoms	0 (0)	6 (100)	19.034	0.001
Minor stroke	1 (3.7)	26 (96.3)		
Moderate stroke	2 (2.7)	72 (97.3)		
Moderate to severe stroke	3 (30)	7 (70)		
Severe stroke	3 (30)	7 (70)		
Patient in ICU				
ICU	6 (5.4)	106 (94.6)	4.308	0.038
ICU	3 (20)	12 (80)		
Types of strokes				
Venous	0 (0)	2 (100)	13.012	0.005
Ischemic stroke	2 (3.2)	61 (96.8)		
Intracerebral hemorrhage	5 (8.6)	53 (91.4)		
Subarachnoid hemorrhage	2 (50)	2 (50)		
Territory affected				
None	1 (50)	1 (50)	5.874	0.053
Supratentorial	8 (6.6)	114 (93.4)		
Infratentorial	0 (0)	3 (100)		
Complications during hospital stay				
None	5 (4.6)	104 (95.4)	40.878	0.000
Progression of current stroke, pneumonia	0 (0)	2 (100)		
Pneumonia	1 (10)	9 (90)		
Seizures	2 (100)	0 (0)		
Fall	0 (0)	1 (100)		
Pneumonia, decubitus ulcer	0 (0)	2 (100)		
Decubitus ulcer	1 (100)	0 (0)		
Functional status at discharge (MRS)				
No significant disability despite symptoms	0 (0)	12 (100)	26.495	0.000
Slight disability	0 (0)	17 (100)		
Moderate disability	0 (0)	25 (100)		
Moderately severe	0 (0)	31 (100)		
Severe disability	9 (26.5)	25 (73.5)		
Patient is dead	0 (0)	8 (100)		
Number of risk factors				
Risk factor (0)	0 (0)	4 (100)	32.077	0.000
Risk factor (1)	2 (8.3)	22 (91.7)		
Risk factor (2)	1 (2)	48 (98)		
Risk factor (3)	0 (0)	26 (100)		
Risk factor (4)	1 (8.3)	11 (91.7)		
Risk factor (5)	4 (50)	4 (50)		
Risk factor (6)	1 (50)	1 (50)		
Risk factor (8)	0 (0)	1 (100)		
Surgical intervention				
No	8 (6.5)	115 (93.5)	13.403	0.004
External ventricular drainage	0 (0)	2 (100)		
Hemi-craniectomy	0 (0)	1 (100)		
External ventricular drainage for hydrocephalus	1 (100)	0 (0)		

NIHSS: National Institutes of Health Stroke Scale, ICU: Intensive care unit, ICH: Intracerebral hemorrhage, BMI: Body mass index

Table 3: Likelihood ratio tests (evaluating the significance of various patient characteristics and clinical factors on an outcome)

Parameters	-2 Log likelihood of reduced model	Chi-square	Significant
Intercept	58.434	0.000	
Duration of hospital stay	68.862	10.428	0.108
BMI	65.021	6.587	0.361
Number of days from stroke onset to admission to the reporting institute	60.442	2.009	0.919
Sex	69.781	11.347	0.078
ICH score	71.732	13.299	0.774
NIHSS	1157.984	1099.551	0.000
ICU	63.801	5.367	0.498
Type of stroke	58.434	0.000	
Territory affected	58.996	0.562	0.997
Complications during hospital stay	67.817	9.383	0.997
Functional status at discharge (MRS)	75.438	17.004	0.973

NIHSS: National Institutes of Health Stroke Scale, ICU: Intensive care unit, ICH: Intracerebral hemorrhage, BMI: Body mass index

other specific etiologies but a larger proportion remains cryptogenic (of unknown origin).[9,10] Traditional risk factors such as hypertension, diabetes, tobacco use, and alcohol consumption are also well-documented among stroke in young.[11-13] In our study, 93 patients had hypertension, 20 had diabetes, 12 had a history of stroke or TIA, 70 used tobacco, 50 consumed alcohol, and one had a history of drug abuse.

The etiology of stroke significantly impacts outcomes. Young adults frequently experience ischemic strokes linked to atypical mechanisms, such as cervical artery dissection or congenital heart defects, which can lead to more favorable outcomes due to effective acute interventions. Conversely, those with strokes tied to high-risk factors – such as hypertension, smoking, or genetic clotting disorders – often face a higher likelihood of long-term impairments.[14] In our study, patients with multiple risks were also associated with poorer outcomes, emphasizing the importance of comprehensive risk management for better recovery.

Although higher BMI is a recognized risk factor and is generally linked to worse stroke outcomes, in our study, patients with higher BMI initially showed poorer outcomes at discharge. However, this trend reversed by the 3-month follow-up, with these patients demonstrating better functional outcomes (P = 0.019, statistically significant). This finding suggests a need for further research to understand the long-term impacts of BMI on stroke recovery.

Globally, between 1990 and 2013, the prevalence of stroke cases, stroke-related deaths, and disability-adjusted life years has increased among adults aged 20–64. Developing countries experienced a 36.7% (95% UI, 26.3–48.5) rise in stroke-related deaths among younger adults, in contrast to declining rates in developed nations.[15] While younger stroke patients were initially thought to recover more effectively due to greater neuroplasticity and resilience, they still face significant risks, including physical disability, cognitive impairments, and recurrent strokes reported up to 15% at 10 years.[16] The prognosis remains challenging, with high mortality rates in hemorrhagic stroke and considerable long-term mortality in ischemic stroke.[7,17] In our study, functional outcomes gradually improved over time, with the majority achieving lower mRS scores by the 3-month follow-up, and a total mortality rate of around 5.8%. Identifying predictors of outcomes in young stroke patients can improve prognosis and guide personalized rehabilitation strategies.

A comparative study across India indicated higher stroke incidence rates in men, with few exceptions.[3,9] Our findings similarly show a male predominance, with a sex ratio of 2.2:1, indicating approximately 2.2 male patients for every female patient. While women tend to experience more post-stroke fatigue and emotional disturbances, which can affect recovery outcomes, lower socioeconomic status also correlates with poorer outcomes due to limited access to healthcare, lower health literacy, and greater exposure to stroke risk factors.[18] Addressing socioeconomic disparities is thus critical in the long-term care of young stroke survivors. In our study, female sex was not statistically significantly associated with poorer outcomes at the 3-month follow-up.

Stroke severity, assessed by the initial NIHSS scores, and stroke location are key predictors of patient outcomes. Higher NIHSS scores at admission reflect more severe neurological impairment and correlate with poorer functional outcomes. Lesions in the cortex or brainstem often result in significant cognitive and physical disabilities, whereas smaller, lacunar infarcts typically lead to milder deficits and better recovery.[19] Baseline NIHSS scores are a strong outcome predictor, but NIHSS scores recorded 24 h post-admission also offer valuable insights into prognosis.[20] In our study, high initial NIHSS scores, indicative of more severe strokes, were significantly associated with higher mortality and worse functional outcomes at both discharge and the 3-month follow-up (P = 0.001). This reinforces the NIHSS's role as an effective measure of stroke severity. In addition, delays in treatment are always known to be correlated with poorer outcomes, with each additional day of admission delay linked to worse outcomes which is against the present study. Ischemic strokes showed better recovery trajectories than hemorrhagic strokes. Although

the prognosis for young stroke survivors is generally better than for older adults, persistent neuro deficits are common, particularly in cases involving cerebral infarction from arterial lesions.[3] However, our study also found a significant association confirming that patients with hemorrhagic stroke have a higher mortality and a worse outcome. In a study of 65,097 young stroke patients in Taiwan, 28% died over a median 9.8-year follow-up. Survivors of the first-ever stroke had higher long-term mortality compared to other populations, so a longer time follow-up may be required to really understand the outcome.[21]

In-hospital mortality rates provide insight into the quality of stroke care. Known predictors of mortality include low Glasgow Coma scale scores and hemorrhagic stroke, with some studies highlighting hyponatremia as a mortality predictor in hemorrhagic cases.[22] Aspiration pneumonia, a common complication among stroke patients, is also a frequent cause of mortality.[23] Our study confirms that stroke severity, stroke type, ICU admission and complications during hospitalization, particularly aspiration pneumonia, the presence of multiple risk factors in a single patient, are statistically significant indicators of poor outcomes in stroke patients.

Limitations of the study

The study has several limitations, including a small sample size and regional focus, which may limit the generalizability of the findings. The retrospective design could lead to incomplete or inaccurate data, while the 3-month follow-up period may not fully capture long-term outcomes. Unaccounted confounding factors like socioeconomic status and regional lifestyle may also influence the results. Additionally, the study might not explore the underlying mechanisms of stroke in young adults or consider certain stroke subtypes. Biases in reporting and data collection, as well as cultural and regional factors specific to Northeast India, may further impact the findings and their applicability to other populations.

CONCLUSION

Stroke in young adults is a complex condition influenced by unique genetic, lifestyle, and medical factors distinct from those in older adults, with significant societal implications. The most important factors that can predict the outcome and mortality of stroke in young people are the stroke severity measured by the NIHSS scale and the stroke type. Other factors such as ICU admission and complications during hospitalization, particularly aspiration pneumonia, presence of multiple risk factors in a single patient, and female sex are also important predictors of poor outcomes. Clinicians must prioritize early NIHSS assessments and aggressive management of hemorrhagic strokes. Public health initiatives should target hypertension and tobacco among young individuals. Future studies must explore sex-specific recovery barriers and the role of socioeconomic factors in Northeast India.

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