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PREVALENCE OF KEY STROKE TYPES AND PHASES OF PRESENTATION AT A TERTIARY CARE HOSPITAL - IMPLICATION FOR EFFECTIVE MANAGEMENT

KEY WORDS: MRI, Stroke, Prevalence, Time of Onset

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ABSTRACT

Stroke requires early diagnosis for effective management, especially in developing countries like India. This study was undertaken to categorize stroke types and phases. We conducted a single-center retrospective study with convenience sampling in which MRI brain scans and reports were taken from PACS in the Radiology department at a tertiary care hospital in Pune, India. The sample consisted of 606 confirmed stroke patients whose MRI was taken between January and December 2022. Data extracted from patient records included the type & the phase of stroke, presenting symptoms at hospital admission, and demographic variables (i.e. age, gender). Descriptive statistics along with chi-square analysis was conducted to assess associations between types & phases of stroke with studied categorical variables. Our data revealed ischemic stroke (41.5%) and transient ischemic attack (TIA) (32.36%) as predominant stroke types. Males exhibited higher stroke incidence than females, with notable gender-based differences in stroke phases. Only 14.31% of patients received MRI scans within the early hyperacute stroke phase. TIA patients were scanned predominantly in the early hyperacute phase, contrasting with micro-hemorrhagic stroke patients scanned in the chronic phase. Age and gender were associated with stroke types (gender: $p = 0.03$; age; $p = 0.00002$) and phases (gender: $p = 0.035$; age; $p = 0.001$). Types and phases of stroke were associated ($p = 0.0001$). These findings underscore the need for heightened awareness among local populations regarding stroke types and the golden window period of treatment, given the high occurrence of stroke, particularly TIA, in younger age groups.

INTRODUCTION

Stroke remains one of the leading causes of death in most Western countries and Low-and-Middle Income countries (LMIC) like India (1,2,3). Stroke is caused due to brain damage resulting from a loss of blood flow to a portion or region of the brain. It can be divided into two major categories dependent on the cause: Ischemic stroke (caused by a blockage of an artery and, in a rare instance, vein) and hemorrhagic stroke (caused due to bleeding). Few studies have focused on studying the prevalence of stroke and its subcategories in India, particularly in western India (i.e., Pune region). In this study, we investigated the prevalence of the following subtypes of stroke based on MRI imaging classification: thrombotic, lacunar, embolic, ischemic stroke with hemorrhagic transformations, Transient Ischemic Attack (TIA), Micro hemorrhages, Hemorrhagic Venous Stroke, Non-Hemorrhagic Venous Stroke, Wake-up Stroke, and Silent Brain Infarcts.

It is well-known that early detection of & intervention in stroke, particularly ischemic stroke caused due to a blockade, leads to better management & quicker recoverability with minimum brain damage (4,5,6). However, little evidence is provided at actuals of the number of stroke suspected individuals presenting at hospitals in India within the different phases of stroke: Early Hyperacute, Late Hyperacute, Acute, Subacute, and chronic (classified based on the time gap between the initial occurrence of symptoms and MRI stroke imaging protocols).

Given the reports showing an increasing trend demonstrating an overall rise in the number of stroke cases pan India, further investigation is warranted to understand the subtypes of stroke and time of presentation (i.e., when are individuals reaching hospital for a stroke diagnostic protocol) for effective management at hospitals/stroke units across India. Our aims in this study were to study 1. The prevalence of each subtype of stroke, and 2. MRI-based imaging method to ascertain the different phases of stroke (time interval from stroke onset to MRI imaging). Understanding this information could guide patient awareness and appropriate intervention & mitigation strategies in the current local context.

Aim

1. The prevalence of each subtype of stroke.
2. MRI-based imaging method to ascertain the different phases of stroke (time interval from stroke onset to MRI imaging).

Methodology:

Study design & population studied:

This was a retrospective study utilizing a convenience based sampling technique. We analyzed 723 scans (from PACS system- taken between January to December 2022) from 606 stroke-diagnosed & confirmed patients. Out of 1500 stroke confirmed scans, 723 scans fit the inclusion/Exclusion criteria consisting of: 1) Scans of patients who were above 18 years of age who showed signs and symptoms of stroke & who were confirmed as stroke patients with MRI stroke protocol, 2) Scans without motion artifacts, 3) Scans were excluded if a follow-up scan were called on for potential differential diagnosis (epilepsy protocol, brain contrast, spectroscopy, perfusion, etc.). The study was conducted at the Imaging department of Tertiary care hospital in Pune, Maharashtra.

Stroke Screening MRI Imaging Protocol:

MRI Brain scans (standardized stroke screening MRI protocols) were performed on Phillips MRI Ingenia 3T scanner (sequences were used: DWI, SWI, and FLAIR: DWI- FOV 230 mm, Slice Thickness 2 mm, TE 87, TR 3275, Matrix 176* 170, Scan time 1 min 45 seconds; SWI- FOV 230 mm, Slice Thickness 1 mm, TE 7.2, TR 31, Matrix 352* 290 Scan time 1 min 30 seconds; FLAIR- FOV 230 mm, Slice Thickness 2 mm, TE 120, TR 11000, Matrix 336* 163 Scan time 2 min 45 seconds). These sequences were taken following the acquisition of a localizer in all three orientations (Sagittal, Coronal, and Axial planes).

Classification of stroke into types and phases:

Stroke was classified into various types according to the underlying stereotypic MRI observed pathophysiology, which are clinically assigned to these types: ischemic stroke,

hemorrhagic stroke, lacunar stroke, embolic stroke, infarcts with hemorrhagic transformation and non-hemorrhagic venous stroke, hemorrhage, and hemorrhagic venous stroke (Fig. 1). The phases of stroke were classified into the following categories: hyperacute (early & late), acute, subacute, and chronic phases based on the correlating parameters acquired in MRI imaging sequences (Supplementary Figure 2). For determining the phases of stroke, 531 stroke patients with only one determinable type of presenting stroke were chosen for the stroke by phase analysis (classification into early & late hyperacute, acute, subacute, & chronic) to avoid misinterpretation.

Statistical Analysis

The data extracted from the images and reports which were entered into standardized Microsoft Excel Worksheets. Descriptive analysis was used for calculating the occurrence of the types and phases of stroke. Associations were made using the Chi-square test (for this analysis, stroke was categorized into the four major types & phases of stroke). Significance was considered at $p < 0.05$ with a confidence level of 95%.

Standard protocol approval and permissions:

This study was approved by Institutional Ethics Committee (IEC) of Symbiosis International (Deemed University) (SIU).

RESULTS

In terms of demographics, the mean age of study participants was 55.21 ± 5.65 (mean ± SD) with a range of 18-93 years. The study participants consisted mainly of males {381 (63%) males and 225 (37%) females}.

Categorization & prevalence of types of Stroke

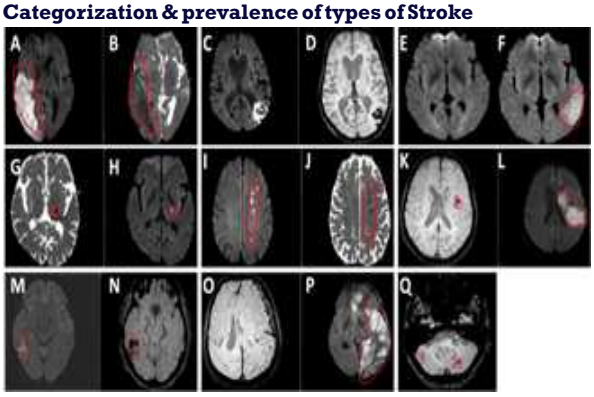

Fig. 1: Categorization of different types of stroke differentiated through MRI sequences:

A) Ischemic/Non-Hemorrhagic stroke seen as hyper intense (bright) on the diffusion-weighted image (DWI) B) Ischemic/Non-Hemorrhagic stroke seen as hypo intense (dark) on apparent diffusion coefficient (ADC) C) Hemorrhagic stroke seen as hyper intense on the DWI D) Hemorrhagic stroke seen as an area of blooming seen on gradient or susceptibility weighted image (SWI) E) DWI images showing TIA (Transient Ischemic Attack); Initial MRI showed no infarcts when a patient came with symptoms of stroke lasting from 90 minutes. F) DWI images showing TIA (Follow-up MRI done after 12 hours showed infarction on the left side, suggesting that the patient had a mini stroke). G) DWI images showing lacunar stroke, which are small subcortical infarcts (<15 mm). H) ADC images showing lacunar stroke are subcortical infarcts small (<15 mm). I) DWI and J) ADC images showing embolic infarction. Multiple foci of restricted diffusion are scattered on the left side of the brain parenchyma. K) Infarcts with hemorrhagic transformation: A large non-hemorrhagic infarct seen on DWI is seen getting converted/transformed into a hemorrhage, which can be seen on SWI (L). M, N) Venous infarction with hemorrhage-blooming on SWI indicates hemorrhage. O, P) Venous infarction without hemorrhage- no blooming on SWI is seen. Q) Micro hemorrhages seen on SWI sequence as small circular lesions.

Table 1: The prevalence of different types of strokes

Types Of Stroke	No. of Cases	Percentage
Ischemic/Non-Hemorrhagic Stroke	300	41.50 %
Transient Ischemic Attack (Tia)	234	32.36 %
Lacunar Stroke	67	9.27 %
Micro hemorrhages	41	5.67 %
Hemorrhagic Stroke	35	4.84 %
Infarcts with Hemorrhagic Transformation	21	2.90 %
Embolic Stroke	18	2.49 %
Hemorrhagic Venous Stroke	5	0.69 %
Non-Hemorrhagic Venous Stroke	2	0.28 %
Wake-Up Stroke	0	0 %
Silent Brain Infarcts	0	0 %
Total no. of types of stroke	723	

The prevalence of ischemic stroke (41.5%) was the highest, which was followed by the transient ischemic attack (TIA) (32.36%). The prevalence of hemorrhagic stroke was present to a much lower extent in the study population (4.84%) than ischemic stroke and TIA. Lacunar stroke (9.27%), embolic stroke (2.49%), and infarcts with hemorrhagic transformation (2.90%) were present to a lower extent along with micro-hemorrhages (5.67%) and venous stroke- with hemorrhage (0.69%) and without hemorrhage (0.28%) (Table1). Interestingly, there were no Wake-up Stroke and Silent Brain infarct cases in the study sample (Table 1).

Stroke type distribution by gender and age.

Next, we wanted to understand how the different types of stroke were distributed by gender and age. In terms of percentage, more males were affected by Ischemic/Non-Hemorrhagic stroke (Males: 59.3 % (280/472); Females: 50.99 % (128/251)) while more females suffered from Transient Ischemic attacks than males (Males: 26.9 % (127/472); Females: 42.62 % (107/251)) (Table 2). Micro-hemorrhages (Male: 7.20 % (34/472); Females: 2.78 % (7/251)) and Hemorrhagic stroke (Male: 6.56 % (31/472); Females: 3.58 % (9/251)) in terms of percentage was more frequent in males than females. Gender was significantly associated with types of stroke (Chi-square = 22.8, df = 3, $P < 0.05$). When segregated according to types of stroke present with respect to age categories, 68, 330, and 325 were the total counts of stroke in the young (18-30), middle (31-60), and old age patients (60 and above) respectively (total 723 types of stroke in 606 patients). The percentage of Ischemic/Non-Hemorrhagic stroke increased with age (18-30 age: 19/68 (27.94 %); 31-60 age: 175/330 (53.03%); and >60 age: 214/325 (65.84 %)). Transient Ischemic Attack (TIA) had an opposite trend as compared to Ischemic/Non-Hemorrhagic stroke with highest incidence in the young age group, followed by a lower incidence in both the middle age, and was lowest in the old age group (18-30 age: 42/68 (61.76%); 31-60 age: 128/330 (38.78%); and >60 age: 64/325 (19.69%)). The frequency of occurrence of hemorrhagic stroke remained approximately constant throughout the age groups studied (18-30 age: 4/68 (5.88%); 31-60 age: 18/330 (5.45%); and >60 age: 18/325 (5.53%)). The percentage of micro-hemorrhages increased from middle-age to old-age groups (18-30 age: 3/68 (4.41%); 31-60 age: 9/330 (2.72%); and >60 age: 29/325 (8.92%)). Association analysis revealed that the age groups were significantly associated with the type of stroke (Chi-square = 65.36, df = 6, $P < 0.001$) (Table 2).

Classification of stroke according to phase

The phases of stroke were classified as hyperacute (early & late), acute, subacute, and chronic (Fig.2) based on the radiologist's report, and this classification, based on imaging criteria, is depicted in Fig 2.

Table 2: Distribution of types of stroke with age and gender

Factor	Category	Non Hemorrhagic Stroke	Hemorrhagic Stroke	TIA	Micro Hemorrhage	P-value
Gender	Male	280	31	127	34	0.03
	Female	128	9	107	7	
Age	Young 18-30 years	19	4	42	3	0.00002
	Middle age 31-60 years	175	18	128	9	
	Old age 61 years & above	214	18	64	29	

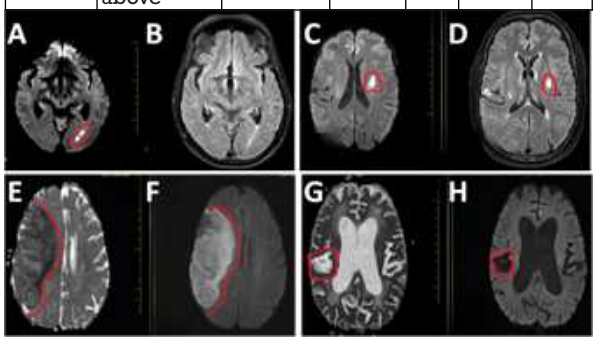

Fig. 2: Phases of Stroke as seen on MRI images:

A, B) Hyper-acute stroke: Infarcts are seen hyperintense in DWI but are not seen in FLAIR sequence (B) (period: up to 24 hours) C, D) Acute Stroke: Infarcts are seen as hyperintense (bright) both on DWI and FLAIR sequence (D) (24 hours – 1 week) E, F) Sub-acute Stroke: Intensity of infarction in DWI is reduced indicating that it has become subacute (F) (up to 3 months) G, H) Chronic stroke: The area of gliosis (dead brain tissue) is seen in the DWI image(H) as hypointense (dark) and hyperintense (bright) on the ADC image (G).

Based on our phase of stroke classification, only 76 patients (14.31%) had their MRI stroke protocol screening done to confirm stroke in the early hyperacute phase (i.e., less than four hours from symptom onset). 31.29% of patients had MRI scans done in the late hyperacute phase (i.e., 4 to 24 hours), and approximately 38.6% had MRI scans done in the acute phase (i.e., 24 hours to 1 week). 2.25% had their MRI scans done in the subacute phase (i.e., 1-week to 3-month period), and 14.12% of patients had their MRIs done in the chronic phase (i.e., 6 months or more) (Table 3).

Table 3: Percentage of stroke-suspected patients getting their stroke screening MRI protocol in different phases.

Phases of Stroke	Frequency	Percentage
Early hyperacute (4 hours)	76	14.31
Late hyperacute (24 hours)	163	31.29
Acute (1 week)	205	38.60
Subacute (3 months)	12	2.25
Chronic (>6 months)	75	14.12

Phase distribution by gender and age

Next, we wanted to understand the distribution of the phases of stroke with gender and age. Females presented with a higher percentage of early hyperacute and a lower percentage of acute stroke than males, with similar levels of late hyperacute stroke between them (Males: - early hyperacute: 11.49% (37/322), late hyperacute: 29.81% (96/322), acute: 38.81% (125/322); Females: -early hyperacute: 18.66% (39/209), late hyperacute: 32.05% (67/209), acute: 38.27% (80/209)). Females had a lower percentage of subacute (Males: 2.79% (9/322); Females: 1.43 % (3/209)) and chronic stroke (Males: 11.49% (37/322); Females: 9.56 % (20/209)). In terms of age-wise distribution in the phases of stroke, the percentage of early hyperacute stroke was highest in young age (21/60 = 35%), followed by middle age (55/247 = 22.26%), with no occurrence in old age (0%). The percentage of late hyperacute stroke declined between young and middle age (young age: 35% (21/60); middle age: 29.95 % (74/247)) and then stabilized between middle and old age (middle age: 29.95 % (74/247); old age: 30.35% (68/224)). The occurrence of acute stroke showed an increasing trend with age (18-30 age: 25 % (15/60); 31-60 age: 31.98% (79/247); and >60 age: 49.55 % (111/224)). The subacute phase was the smallest percentage in each age group (18-30 age: 1.66 % (1/60); 31-60 age: 2.83% (7/247); and >60 age: 1.78 % (4/224). The percentage of chronic stroke was low in the young age category (3.33 % (2/60)), but it increased in the middle (12.95 % (32/247)) to old age (18.30 % (41/224). There was an association between gender and phase of stroke (Chi square= 8.6, df = 3, $P < 0.05$) and with age and phase of stroke (Chi-square = 43.13, df = 6, $P < 0.001$) (Table 4).

Table 4: Phases of stroke with age and gender

Factor	Category	Hyperacute (Early & Late	Acute	Subacute	Chronic	P-value
Gender	Male	133	125	9	55	0.355
	Female	106	80	3	20	
Age	Yound 18-30 years	42	15	1	2	0.001
	Middle 31-60 years	129	79	7	32	
	Old age 61years & above	68	111	4	41	

Distribution of Type of stroke with phase

We also investigated the distribution of each stroke type in each stroke phase. After the distribution of the major categories of stroke (non-hemorrhagic, hemorrhagic, TIA, and microhemorrhages) in each phase (hyperacute, acute, subacute, and chronic), it was observed that only Non-hemorrhagic/Ischemic stroke was present in each phase with most of the cases in the acute phase (266) followed by the chronic phase (116). Interestingly, cases of TIA were present only in the hyperacute phase (234). Microhemorrhages and hemorrhagic stroke cases were most observed in the chronic phase (41 and 21 cases, respectively). Association analysis revealed that the type of stroke is significantly associated with phases of stroke (Chi-square = 829, df = 9, $P < 0.00001$) (Table 5).

Table 5: Distribution of the types of stroke in different phases of stroke

Category	Non-hemorrhagic	Hemorrhagic	TIA	Micro-hemorrhages	P-value
Hyperacute	5	0	234	0	<0.00001
Acute	266	17	0	0	
Subacute	21	2	0	0	
Chronic	116	21	0	41	

DISCUSSION

The following are the key findings of this study: 1. The occurrence of ischemic stroke was highest in terms of frequency in the dataset (41.5%) with a high percentage of Transient Ischemic Attack (TIA) (32.36 %), followed by Lacunar stroke (10%). 2. Only 14.31 % of stroke-confirmed patients had their brain scans; the majority had their scans in the late hyperacute phase (31.29%) and acute phase (38.6%) with ~16% falling in the subacute/chronic category, 3. Overall, the percentage of stroke in males was higher than in females, transient ischemic stroke was higher in females 4. Age groups were significantly associated with the type of stroke, with non-hemorrhagic stroke increasing with age while TIA decreases with age in terms of percentage 5. Phases of stroke were significantly associated with gender and age-females & young age groups had more of the early hyperacute

phase, which decreased with age. In contrast, chronic stroke increased with age. 6. Types of stroke were associated with stroke phases.

In keeping with other studies, non-hemorrhagic ischemic stroke was the predominant type of stroke category in this study. In a study by Ram, C. Venkata S et al., 2021 studying the types of stroke among six tertiary care hospitals across India, 56.8% of confirmed strokes were ischemic(7). (8) (9) (10) (11). Hemorrhagic stroke, which is accompanied by high mortality and morbidity, is relatively low in terms of occurrence in our study compared to other studied populations in India and the subcontinent (5% in our study versus 30.89% in Ram Narayan Kurmi et al., 2023; versus 41.6% in Muhammad Sohrab Khan et al., 2021; versus 20% in Dharam Singh Meena et al., 2022; versus 36.5% in Kolluri Susmitha et al., 2018; versus 18.6% in Ram, C. Venkata S et. al, 2021). The novelty in our population is identifying a very prominent category of stroke called 'Transient Ischemic Attack (TIA),' which amounted to 32.36% compared to other studies (1.1 % in C Venkata S Ram et al., 2021; 2.93% in South America, in Argentina). The high percentage of TIA found in our study could possibly be attributed specifically to the local population studied, and the potential high prevalence of associated stroke risk factors within the population. About 15-20% of all patients affected by stroke report a preceding TIA (12). Thus, each population must be studied separately in terms of the frequency of the types of strokes so that the proper management strategies can be resourced in that location.

Given the fact that thrombolytic therapy is beneficial in terms of reduced neurological disability and improved functional outcome if administered within the early hyperacute phase of ischemic stroke, we estimated how many patients were in the early hyperacute phase of stroke(4,6,15). Our data shows that 14.31 % had MRI scans done for stroke confirmation within the early hyperacute phase. This was lower compared to a study by (16), in which the percentage of stroke patients coming within the window period (<4.5 h) was ~20% (944 out of 4720); a study by (17), in which 44.04 % of stroke patients presented to Emergency Department (ED) within the early hyperacute phase (within 270 min; 159 out of 361); to a study by (5), in which 62% of patients presented within the hyperacute phase (680 out of 1096).

In our study, we observed a higher occurrence of stroke in males compared to females (472 males and 251 females), and that gender was significantly associated with the type of stroke. Interestingly, in terms of percentage, TIA was higher in females than males in our study. This is an important finding, given that the majority of TIA patients were in the middle-aged category. Previous data has shown that there are important gender/sex differences in stroke epidemiology and outcomes of stroke- previous data suggests that quality of life is severely affected, particularly in women post TIA besides being vulnerable to future stroke (18,19); TIA can thus serve as a possible predictive marker for future stroke(13,14,20,21). Therefore, surveillance systems should be in place to monitor young patients suffering from stroke, with a close focus on Ischemic & TIA (particularly females), so that appropriate management can be planned to reduce morbidity and increase quality of life.

CONCLUSION

Since many patients were diagnosed with ischemic stroke and transient ischemic attack (TIA) in their hyperacute stage, raising awareness about the golden window period of 4 hours for effective stroke treatment is needed. None of the elderly population had an MRI performed within four hours of their onset of symptoms but rather arrived after 24 hours or seven days when the brain is irreversibly damaged. It is necessary to raise awareness among the population so that stroke can be identified in time at its hyperacute stage, preventing irreparable brain damage.

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