IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 19, Issue 11 Ser.3 (November. 2020), PP 41-51
www.iosrjournals.org

Importance of Multimodal MRI as the Single Diagnostic Investigation in the Initial Assessment of Patients with Hyperacute Ischemic/Hemorrhagic Stroke

Dr. Anjali Dathan
Associate Professor, Government Medical College, Palakkad, Dr. Amritha Menon, Consultant Radiologist, Pulse Scans, Palakkad

Abstract
Introduction
CT was the first line of investigation in suspected stroke patients due to its ubiquity and sensitivity for detection of blood – but its limitations are a relative lack of sensitivity for the detection of early ischemia and low specificity in determining appropriateness for intervention with thrombolysis. So now MRI has emerged as a standard initial imaging modality in acute stroke. Diffusion weighted MR imaging is more sensitive for the detection of hyperacute ischemia. Diffusion perfusion mismatch indicates penumbra. Gradient echo MR sequences help in detecting hemorrhages. MR angiography and MR spectroscopy help to assess status of neck and intracranial vessels respectively. MR Spectroscopy provides information regarding abundance of metabolites. In this study we studied the feasibility of multimodal MRI for the initial evaluation of stroke.
Materials And Methods
This is a prospective study conducted at KG Hospital and Post Graduate Medical Institute, Coimbatore between June 2007 to June 2009. 350 patients who were clinically suspected to have stroke were analysed based on the MRI findings.
Results
Of the 350 patients subjected to MRI of the brain, 79.43% had infarction, 11.14 % had intracerebral bleed, 2.85% had subarachnoid Hemorrhage. 4.28% had Cerebral venous thrombosis, 2.28% had tumours, 0.58% had subdural hematoma and 0.28% had cerebral abscess.
It was observed that the mean age of stroke was 50 – 59 years. Sex ratio showed a clear male preponderance. It was observed that both infarction and intracerebral hemorrhage were most commonly encountered in the age group between 50 – 59 years.
The commonest Territory involved was the middle cerebral artery (L>R) and accounted for 37.41%, this was followed by anterior cerebral, posterior cerebral artery involvement, lacunar, hemorrhagic and multiple infarcts. It was observed that diffusion weighted imaging added sensitivity and specificity to the standard MR evaluation. DWI makes a significant contribution in the acute and even subacute timeframe. So multimodal MRI has carved a niche as feasible, cost effective and time saving initial exclusive modality of choice in stroke.
Conclusion
Multimodal MRI may be considered the single most important diagnostic investigation in the initial assessment of patients with hyperacute ischemia/hemorrhagic stroke.
Keywords
- ***MRI***
- ***HYPERACUTE ISCHEMIC STROKE***
- ***HEMORRHAGIC STROKE***

Date of Submission: 28-10-2020 Date of Acceptance: 12-11-2020

I. Introduction

MRI is the most sensitive and specific imaging technique for diagnosing cerebral infarction.

During the hyper acute (<6 hrs) and acute (<1 week) stages of cerebral ischemia, loss of normal vascular flow voids represents the earliest possible MRI finding using conventional spin echo sequences.

On T_2W, FLAIR and PD weighted images, increased signal is demonstrated in 80% of MRI scan within the first 24 hours. Morphological changes in brain parenchyma caused by tissue swelling may be seen as early as 6 hrs after the onsetof ischemia. On $T_1W_1T_2$, FLAIR and PD weighted images. PD weighted and FLAIR images are often superior in detecting lesions near a ventricle or subarachnoid space because similar signal intensity may occur within the lesions on T_2W images.

During the subacute stage, (1 to 4 weeks) of cerebral ischemia, mass effect and oedemastabilise during the second week. Hyperintensity on T2W regress/disappear – 'Fogging'.

The chronic stage (>4 weeks) begins when the integrity of blood brain barrier is restored, oedema has resolved and most of resorption of necrotic tissue is complete. This leads to glial scarring, encephalomalacic cysts, shrunken gyri, enlarged sulci and adjacent ventricular dilatation.

Diffusion weighted imaging is very important in assessment of hyperacute stroke by showing cerebral ischemia early. (ie., within the first few hours) and with a high degree of specificity. The sensitivity and specificity of DWI for acute strokes are greater than 95%. Typically infarcts less than 6 hours old will be detectable on DWI but not T_2 MR image.

Moseley et al[1] in 1990, were the first to observe hyperintensity in the ischemic territory within minutes of vascular occlusion when DWI was done in animal models.The observe hyper intercity in the ischemic territory within minutes of vascular occlusion when DWI was done in animal models. The signal contrast between the ischemic and normal side is so much that it was called the 'light bulb sign' for acute stroke.

Rima et al[2] (2003) concluded that abnormal signal intensity is found on DW images and ADC maps in all stroke patients presenting within 24 hours of onset of ictus and in upto 94% of patients studied within 14 days of stroke and stressed on inclusion of DWI in routine MR imaging protocols of stroke patients.

In perfusion weighted imaging the area of decreased CBV, decreased CBF on prolonged MTT in the ischemic region represent both the infarct core as well as reversible surrounding ischemic tissue at risk (penumbra) whereas the area of abnormal diffusion represents only the irreversibly ischemic infarct core (umbra). The mismatch between area of perfusion abnormality and area of diffusion abnormality represents salvageable ischemic tissue at risk for infarction. In subacute infarction, the presence of luxury perfusion, characterized by increased CBV, surrounding the infarct core can be evaluated.

Astrup et al[3] as early as 1981 described the penumbra as a dynamic entity that exists within a narrow range of perfusion pressures and ascribed the duration of delay in recanalisation as being inverselyrelated to the size of the penumbra.

The most common patternin acute stroke is a PWI lesion that is larger than the DWI lesion seen in approximately 70% of patients within the Ist 6 hours after stroke onset (PWI > DWI mismatch). These patients may respond favourably to thrombolytic therapy even when it is administrated beyond 3 hours after onset.

The second pattern is DWI lesion that is similar in size to PWI lesion. Such lesions are unlikely to benefit from thrombolytic therapy.

The third pattern is an early DWI lesion that is larger than PWI lesion (PWI <DWI mismatch). They may have partial or complete spontaneous recanalisation. They also have little or no benefit from thrombolytic therapy.

MR spectroscopy offers unique metabolic information. Ischemic brain reveals a higher concentration of lactate which is usually too low to be detected in normal brain.

Magnetic Resonance Angiography (MRA) enables the non invasiveevaluation of vascular patency. MRA can be used to display major cerebral vascular anatomic details in strokes as well as provide functional information about flow dynamics Circle of Willis.

Schellinger at el[4] (2005) transformed the CT characteristics of the 'arterial hyperdense medial sign[1] to MRI and defined an 'early MR imaging vessel sign in hyperacute stroke.

Chen et al[5] (2008) stated that diffusion tensor imaging has emerged as a promising tool to study ischemic stroke. This study shows that DT can be used to investigate ischemic stroke and assess ischemic stroke induced damage.

Rohit R Das et al[6] documented the prevalence and documented the prevalence and risk factors associated with silent cerebral infarction the Framingham off spring study. Their results support current guidelines emphasizing early detection and treatment of stroke risk factors.

II. Materials and Methods

This is a study conducted at K. G. Hospital and post graduate Medical Institute, Coimbatore, between June 2007 to June 2009.

Inclusion Criteria

Patients clinically diagnosed as having stroke and admitted to K G Hospital and some cases referred from outside (for MRI). Almost all the cases underwent anacute stroke protocol MRI within 48 hours of the episode. Exclusion Criteria: - Patients less than 20 years and more than 90 years old, patients who had general contradictions to MRI, critically ill and those who were claustrophobic were excluded.

MRI Protocol

This comprised of T2W, T1W, FLAIR, DWI, GRE and MRA. The total imaging was done with 1.5 T whole body MRI Machine.

Detailed clinical history and data such as age, sex, past history of hypertension, diabetes mellitus, ischemic heart disease, TIAs or stroke were given impatience.

Statistical Analysis

Date collected was coded and tabulated using SPSS statistical package, descriptive and deferential statistics were computed.

III. Results

350 patients clinically suspected of stroke were submitted for MRI scan : - Of these 278 (79.43%) had cerebral infarction and 39 (11.14%) had intracerebral hemorrhage. According to the Mumbai stroke registry[7] 80.2% (366 out of 407) had ischemic stroke and 17.7% (81 out of 407) had hemorrhagic stroke which is similar to our study. U.S. stroke registries – NINDS[8] – Stroke Data Bank (SDB) , Oxfordshire community stroke project (OCSP)[9] have shown that ischemic stroke was 3 to 4 times as frequent as hemorrhagic stroke, according for 70% to 80% of all strokes.

Our study showed 79.43% of infarction, 2.86% of subarachnoid hemorrhage, 11.14% of intracerebral hemorrhage, 4.28% of cerebral venous thrombosis, 0.58% of subdural hemorrhage and 0.28% of cerebral abscess.

Age

The maximum incidence of stroke was found to be between 50 – 59 years. 114 patients presented with stroke in the 5th decade. Regarding cerebral hemorrhage, the maximum incidence was found to be between 50 – 59 years in men and 60 – 69 in women in our series. This is similar to a study by Harrison et al[10]. Amongst males as in infarction, maximum cases were between 50 – 59 years (33.3%) but in females, the maximum number of cases was in younger population. The age of occurrence of stroke in our population is lower than the average age in western countries (70 in men, 75 in women) – Feigin et al[11].

Risk Factors

The two commonest risk factors are Hypertension and diabetes mellitus in patients who developed strokes.

Hypertension

156 (44.57%) patients in our study had history of hypertension.124 (79.48%) patients with Hypertension showed infarction. 30 (20.52%) patients with hypertension showed cerebral hemorrhage. In our study population, 80% of patients who showed hemorrhage and 44.77% of patients' who showed infarction were found to be hypertensive – Corresponding to studies by Moulin et al[12] and Cairu Li et al[13] and the Lausanne stroke Registry[14]. This study corroborates the well established association between hypertension and stroke and emphasises, the importance of adequate hypertension control in significantly lowering risk of stroke.

Diabetes Mellitus

Out of 350 patients, 20% (70) were known diabetes, 82.6% (58) had infection and 17.4% (12) had cerebral hemorrhage. Kuller LH et al[15]. Study showed stroke was 2.5 – 4 times more common in diabetics .Most of our diabetic patients who developed hemorrhage were also hypertensive suggesting a multi factorial risk etiology.

Ischemic Stroke – Out of 350 cases, we observed 278 (79.43%) cases with infarction. The percentage of infarcts reported in NEMESIS[16] series was 72.5% Stroke data bank and Oxfordshire community stroke project is 81%. Our study results are comparable with various above mentioned studies.

The most common vascular territory involved was the MCA, accounting for 37.41% (104 cases) ($p < 0.01$) of all infarcts. There was greater involvement of the left MCA as also concluded by studies by H. Naesset al[17]. ACA territory involvement was noted in 13 cases with near equal involvement of right and left hemispheres. 28 patients with MCA infarction and 9 patients with ACA infarction showed involvement of ipsilateral distal ICA.

The total number of PCA territory infarcts in our study group was 30 (10.79%) with 14 cases showing right sided involvement. 9 (3.25%) had hemorrhagic infarcts, out of which 8 infarcts were in the MCA territory and 1 infarct was in the PCA territory.

Involvement of the basilar artery territory except posterior cerebral artery was noted in 25 (9.02%) cases.

Multifocal infarcts were seen in 16 (5.78%) cases. Only two cases of watershed infarction were noted. Both involve left MCA – PCA territory and were attributed to embolic etiology.

In our study, Lacunar infarcts were17.62% (49) which is also comparable with USA – stroke register (RL Sacca et al)[18] – 15.3% and North East China Stroke (X Cong et al)[19] – 15.2%.
Out of our 278 cases, 102 acute infarcts, 145 subacute infarcts and 42 chronic (most of which were noted along with acute infarcts) infarcts were noted.
Solely white matter ischemic changes were noted in 39 (14.08% cases). Most of these cases were clinically diagnosed as transient ischemic attacks. Few cases were also attributed to carotid stenosis.

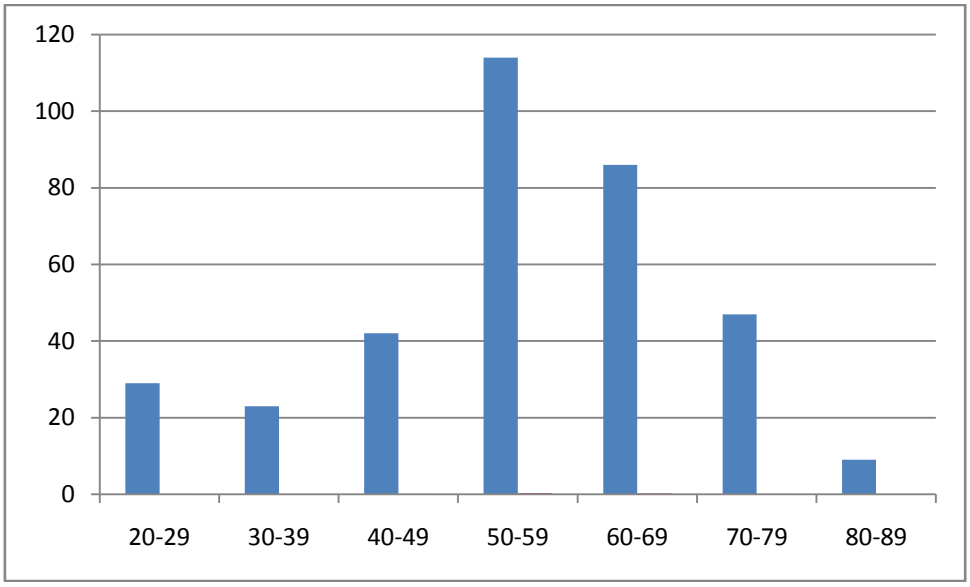
Comparison of DWI and Conventional MR Imaging in Acute Infarcts
The total number of acute infarcts is our study is 102. Both conventional T_2W and DW sequences were positive in 55 (53.9%). Acute infarcts seen only on diffusion and not visualised in conventional T_2W were 47 (46.1%) ($P< 0.01$). Out of the 57 lesions also seen on conventional imaging, the extent of the lesions were better decided with diffusion imaging. The 47 infarcts picked up only by diffusion weighted imaging presented within 6 hrs (mean of 4.25 hours) of symptom onset to our hospital.
Mark E. Mullins[20] et al in his study on 691 patients observed 97% sensitivity and 100% specificity with DW MRI ; 58% sensitivity and 100% specificity with conventional MRI and 40% sensitivity and 92% specificity with CT. Lansberg et al[21] in his study to determine yield of adding DWI to conventional MRI protocol for acute stroke observed 50 – 60% sensitivity and 49 – 69% specificity using conventional MRI as compared with DWI.
The results are consistent with our results and substantiate the superiority of DWI over conventional MR imaging.

Hemorrhagic Stroke
The percentage of hemorrhagic stroke in our study population was 11.14 %(39).
This is comparative with following studies : - NEMESIS – 14.5% ; LAUSANNE stroke registry[22] – 9.17% and Oxfordshire community study project – 10%.
Stroke Mimics
33 (9.43%) cases presented as stroke mimics. Out of which 14 patients had Cerebral Venous thrombosis, 5 patients had tumor – 2 meningioma ;2 - low grade glioma and 1 metastasis ; 2 patients showed subdural hematoma and 1 patient had cerebral abscess.
Subarachnoid Hemorrhage
10 (2.85%) cases had subarachnoid haemorrhage. Subarachnoid hemorrhage incidence in our patients is comparable with other studies – Lausanne – 0.15% and NEMESIS – 4.3%.
Cortical Venous Thrombosis
In our study we had 4.28% - more often in women with predisposing conditions such as pregnancy or use of hormonal contraceptives.
Management of Stroke – was done as per specific protocol and general measures for care of these patients.

STATISTICAL ANALYSIS
I. AGE DISTRIBUTION IN STROKE

AGE (YEARS)	NO. OF CASES	IN PERCENTAGE
20-29	29	8.3%
30-39	23	6.6%
40-49	42	12%
50-59	114	32.6%
60-69	86	24.6%
70-79	47	13.4%
80-89	9	2.6%
TOTAL	278	100%

AGE DISTRIBUTION IN STROKE

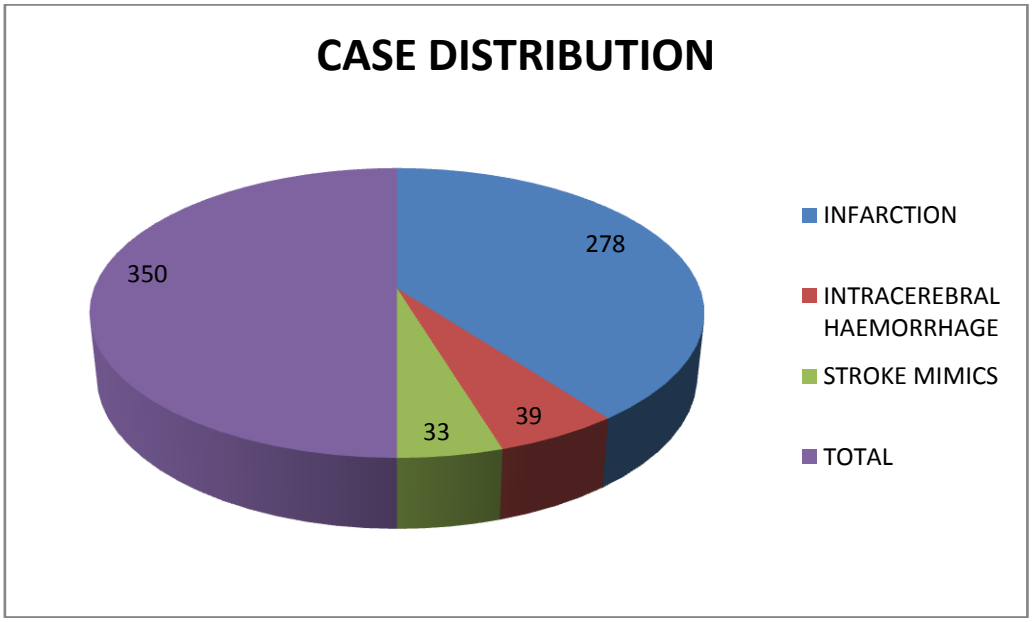


The chi square value l66.320 is significant at 0.01 levels. This shows that majority of the patients fall in the age group 50-59 years.

II. CASE DISTRIBUTION

TOTAL NO. OF CASES (N) = 350

NAME OF DISEASE	NO. OF CASES	IN PERCENTAGE
INFARCTION	278	79.43%
INTRACEREBRAL HAEMORRHAGE	39	11.14%
STROKE MIMICS	33	9.43%
TOTAL	350	100%



The most common cause of stroke is infarction followed by intracerebral hemorrhage, cortical venous thrombosis, subarachnoid hemorrhage, tumors, subdural hemorrhage, and cerebral abscess in decreasing order of frequency.

RISK FACTORS

III. A. TOTAL NO OF HYPERTENSIVES – 156(44.57%)

	No. of Cases	In Percentage
Infarction	124	79.48%
Hemorrhage	32	20.52%

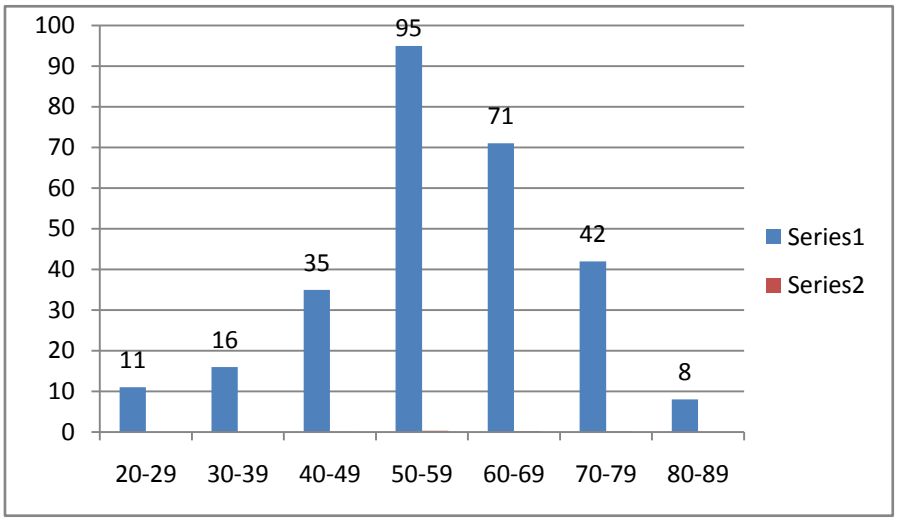
III. B TOTAL NO. OF DIABETICS – 70 (20%)

	No. of Cases	In Percentage
Infarction	58	82.86%
Hemorrhage	12	17.14%

IV. INFARCTS TOTAL NO. OF CASES = 278

AGE DISTRIBUTION IN INFARCTS

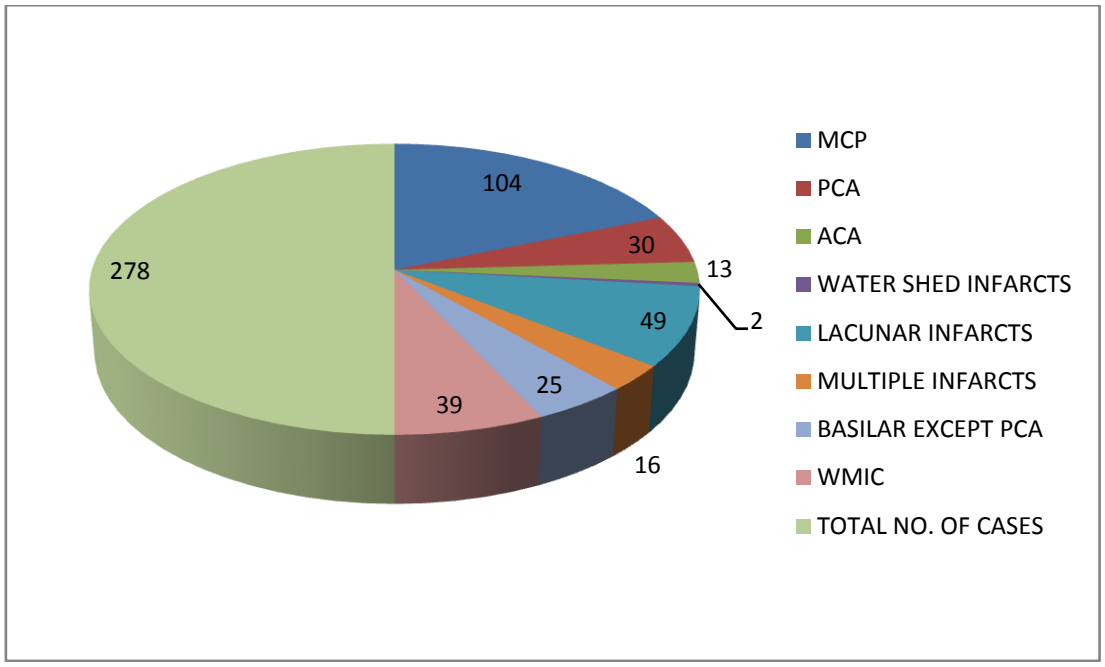
AGE (YEARS)	NO. OF CASES	IN PERCENTAGE
20-29	11	3.95%
30-39	16	5.76%
40-49	35	12.59%
50-59	95	34.20%
60-69	71	25.50%
70-79	42	15.10%
80-89	8	2.90%
TOTAL	278	100%



The chi square value l62.547 is significant at 0.01 levels. This shows that majority of the patients fall in the age group 50-59 years.

V. INFARCTS IN VASCULAR TERRITORY

VASCULAR TERRITORY	NO. OF CASES	IN PERCENTAGE
MCP	104	37.41%
PCA	30	10.79%
ACA	13	4.67%
WATER SHED INFARCTS	2	0.72%
LACUNAR INFARCTS	49	17.62%
MULTIPLE INFARCTS	16	5.78%
BASILAR EXCEPT PCA	25	9.02%
WMIC	39	14.08%
TOTAL NO. OF CASES	278	100%



From the above table, **the chi square value 202.345 at 0.01 levels reveals** that the most commonly involved vascular territory is of the middle cerebral artery.

VI. TOTAL NO. OF MCA TERRITORY INFARCTS = 104

SIDE OF INVOLVEMENT	NO. OF INFARCTS
RIGHT	33
LEFT	68
BILATERAL	3

VII. TOTAL NO. OF PCA TERRITORY INFARCTS = 30

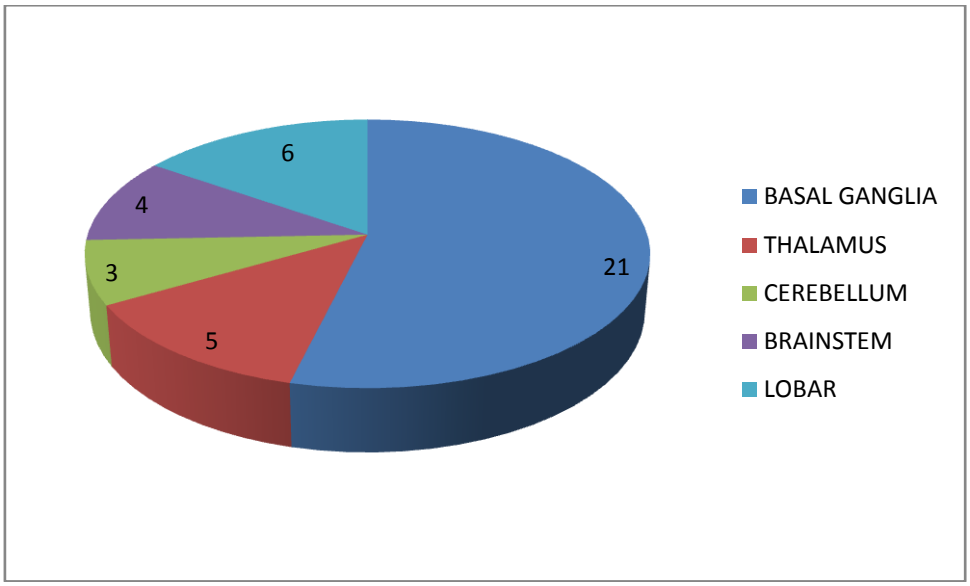
SIDE OF INVOLVEMENT	NO. OF INFARCTS
RIGHT	14
LEFT	12
BILATERAL	4

VIII TOTAL NO. OF MCA TERRITORY INFARCTS = 104

SIDE OF INVOLVEMENT	NO. OF INFARCTS
RIGHT	6
LEFT	7
BILATERAL	0

IX. INTRACEREBRAL HEMORRHAGE

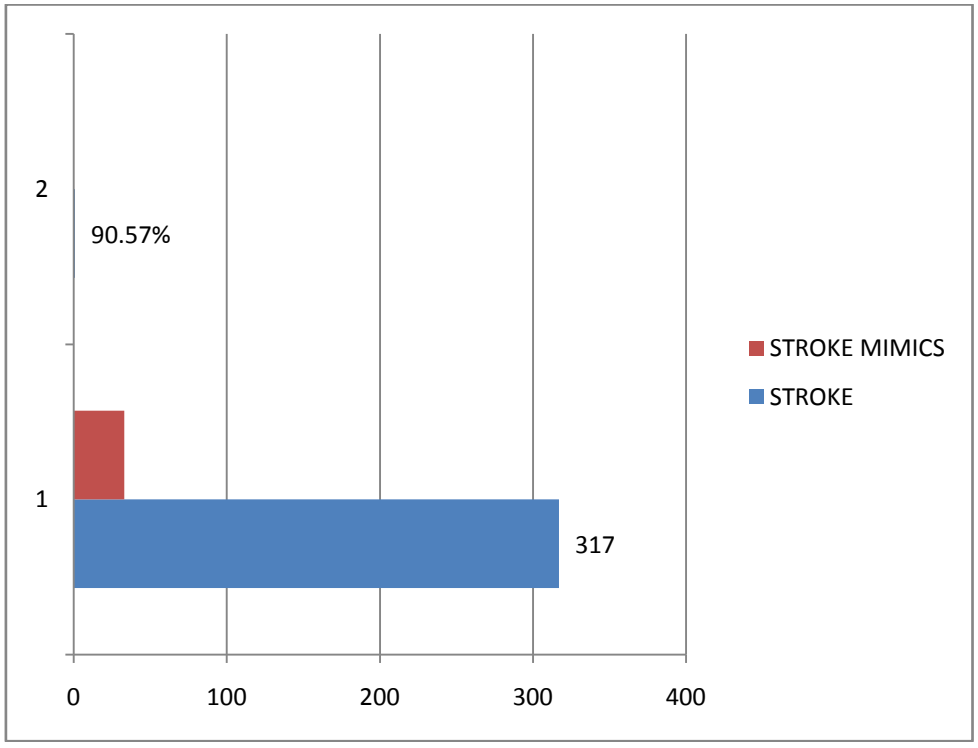
	NO. OF CASES	IN%
BASAL GANGLIA	21	53.84%
THALAMUS	5	12.83%
CEREBELLUM	3	7.69%
BRAINSTEM	4	10.26%
LOBAR	6	15.38%
TOTAL	39	100%



X2 = 21.846 (p <0.01). It can be assumed that there is greater involvement of the basal ganglia in case of intraparenchymal hemorrhage.

X. STROKE Vs STROKE MIMICS

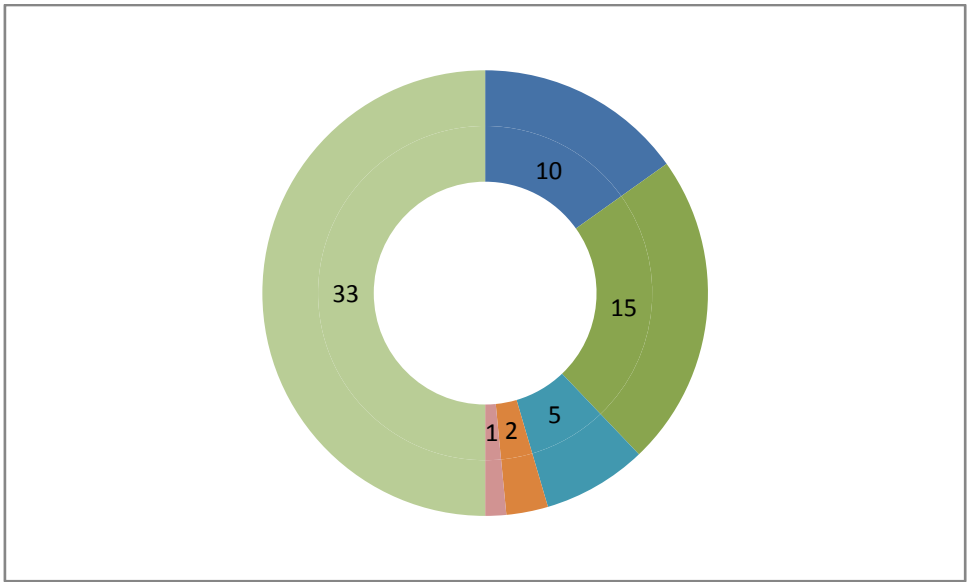
STROKE	317	90.57%
STROKE MIMICS	33	9.43%
TOTAL	350	100%



XI. STROKE MIMICS

NAME OF DISEASE	NO: OF CASES	IN PERCENTAGE
SUBARACHNOID HEMORRHAGE	10	30.30%
CORTICAL VENOUS THROMBOSIS	15	45.45%
TUMOR	5	15.15%
SUBIDURAL HEMORRHAGE	2	6.06%
ABSCESS	1	3.04%
TOTAL	33	100%

XII. Comparison between DW and conv. T_2W image in acute infarcts
Total no: of acute infarctions : 102
Conv. And diffusion positive cases : 57 (55.88%)
Conv. Negative and diffusion positive cases : 45 (44.12%)



Using simple visual analysis of DW images, we found that areas of cerebral infarction have high signal intensity and these lesions showed corresponding decreased signal on ADC maps. Creation of ADC maps negates the T2 'shine through' effect that can contribute to lesion signal hyperintensity on DW imaging.

	OBSERVED NO	IN PERCENTAGE
DETECTED BY DWI	102	100%
DETECTED BY T2W AND DWI	55	53.9%

From the above table, all (102) acute infarcts were detected by DWI. This is over and above the 55 infarcts detected using conventional MRI. The chi-square value 14.07 is significant at 0.01. It is evident that the number of acute infarcts detected by DWI is significantly higher than conventional MR imaging

IV. Discussion

Three hundred and fifty patients who were clinically suspected of stroke were subjected to Magnetic Resonance imaging study of the brain.

Out of these 350 patients (268 males and 82 females), 79.43% (278) of patients had infarction ; 11.14% (39) had intra cerebral bleed ; 2.85% (10) had subarachnoid haemorrhage; 4.28% (15) had cerebral venous thrombosis ; 2.28% (15) had tumors ; 0.58% (2) had subdural hematoma and 0.28% (1) had cerebral abscess.

In our study in patients presented with stroke in a Southern Indian population based in Coimbatore over a period of 1 year at our hospital ; mean age of stroke was 50 – 59 yrs. Sex ratio for cerebral infarction shows a clear male preponderance.

It was observed that both infarction and intra cerebral hemorrhage were most commonly encountered in the age group between 50 – 59 yrs.

The percentage of stroke in young (20 – 39 yrs) was 14.85% (52.) Risk factors like hypertension (44.57%) and diabetes mellitus (20%) played major role in the evolution of stroke. The incidence of cerebral hemorrhage was more than cerebral infarction in hypertensive patients.

The commonest territory involved in patients with cerebral infarction was middle cerebral artery (L > R) and accounted for 37.14%. 4.67% cases showed anterior cerebral artery involvement ; 10.79% cases showed posterior cerebral artery involvement ; 17.62% cases showed lacunar infarcts ; 3.25% cases showed hemorrhagic infarcts ; 5.78% showed multiple infarcts ; 9.43% showed involvement of vertebrobasilar and 14.08% cases showed white matter ischemic changes.

In cases of intracerebral hemorrhage (11.14%). 53.84% involved basal ganglia ; 12.82% involved thalamus, ,7.69% involved thalamus, 7.69% involved brainstem and 10.25% cerebellum and 15.38% showed lobar involvement.

The number of stroke mimics were 33 (9.43%) out of which 15 patients presented with cortical venous thrombosis ; 10 with subarachnoid hemorrhage ; 5 with tumors ; 2 with subdural hematomas and 1 with cerebral abscess.

V. Conclusion

This study is an analysis of the epidemiological trends (ages, sex) ; risk Factors (Hypertension, Diabetes Mellitus); vascular distribution of infarcts, pattern involvement of hemorrhage in a Southern Indian population in Coimbatore based on MRI findings in 350 patients clinically suspected to have stroke. This reflects the changing trends of stroke. Rapid increase in aged population and westernization of lifestyle has modified epidemiological status of stroke.

The results from our study are well comparable with other stroke surveys. Differences in pattern of stroke may be related to genetic, environmental or socio-cultural factors and to differences in the control of risk factors.

Our study observed that diffusion weighted imaging adds sensitivity and specificity to the standard MR evaluation. DWI makes an important contribution to stroke management, even in subacute timeframe. DW imaging with restricted diffusion helped in the evaluation of acute infarcts in the setting of multifocal infarcts, lacunar infarcts and white manner ischemic changes responsible for the patient's symptomatology and in distinguishing acute from subacute and chronic infarcts.

The limitation of this study is its lack of systematic follow up neuro imaging. Another constraint is a selection bias ; since not all patients clinically diagnosed as stroke routinely undergo diffusion weighted MR imaging.

Though CT is considered as the imaging modality widely available at affordable cost, multimodal MRI has carved a niche as the feasible, cost effective and time saving initial exclusive modality of choice in stroke. In conclusion, multimodal MRI may be considered the single diagnostic investigation in initial assessment of patients with hyperacute ischemic/hemorrhagic stroke.

ABBREVIATIONS

DWI - Diffusion Weighted Imaging
CBV - Cerebral Blood Volume
CBF - Cerebral Blood Flow
MTT - Mean Transit Time
PWI - Perfusian Weighted Imaging
MRA - Magnetic Resonance Angiography
DT - Diffusion Tensor Imaging
T_1W - T_1Weighted Imaging
T_2W - T_2 Weighted Imaging
FLAIR- Fluid Attenuation and Inversion Recovery
GRE - Gradient Echo
PD - Protein Density
TIA - Transient Ischemic Attack
MCA - Middle Cerebral Artery
ACA - Anterior Cerebral Artery
PCA - Posterior Cerebral Artery
SAH - Subarachnoid Hemorrhage

References

[1]. Moseley M E, Cohen Y,Mintorovitch J, et al.Early detection of regional cerebral ischemic incats comparison of diffusion and T_2 weighted MRI and spectroscopy. Magnetic Resonance Medicine 1990; 14(2); 330-346.

[2]. K.Rima; G Rohit; P Anjali, C Veena.Role of DW MR images in early diagnosis of cerebral infarction, Indian Journal of Radiology ; 2003; Volume 13; Issue 2, Pages 213-217

[3]. Astrup J, Siesjo BK, Symon L. Thresholds in cerebral ischemia: the ischemic penumbra, Stroke 1981; 12: 723-725

[4]. Schellinger P D, Chalela J A, Kang D W et al. Diagnostic and prognostic value of early MR imaging vessels. signs in hyperacute stroke patients imaged <3hrs and treated with recombinant tissue **plasminogen** activator. American Journal of **Neuroradiology** 2005. 26; 618-624

[5]. Chen, Ziqian; Ni;,Piag; Zhang, Jing; ye, youqiang; Xiao Hui et al. Evaluating ischemic stroke with DTI Neurological research. Vol.30. Number 7 Sept 2008. Pages 720-726

[6]. Rohit R Das, MD, MDH, SudhaSeshadri, MD, DM; Alexa S. Beiser, PhD; Margaret Kelley, Hayes RN et al. Prevalence and correlates of silent cerebral infarcts in the Framingham Offspring study. Stroke 2008; 39; 2929-2935

[7]. Dolal PM, Bhattacharjee M, Variale J, Bhat P. Mumbai stroke registry - surreillance using WHO stroke instrument - challenges and opportunities J Assoc Physicians India 2008 Sept. 56:675 - 680 .

[8]. National Institute of health, National institute of neurological Disorders and stroke. Stroke: Hope through research: May 1999

[9]. Bamford J. Sandercock P, Dennis M et al. A prospective study of acute cerebrovascular disease in the community: the Oxfordshire community stroke project(1981-86) - Incidence, case fatality rates and overall out come at one year of cerebral infarction, primary intracerebral and SAH. J Neurosurg. Psychiatry 1990 tan; 53(1):16-22

[10]. Harrison M.J.G. Clinical distinction of cerebral hemorrhage and cerebral infarction Post grade. Med.J.Sept 1980. Vol.56; 629-632

[11]. Valery L. Feigin - Stroke in developing countries: can the epidemic be stopped and outcomes improved? The Lancet Neurology, Volume 6, Issue 2, Pages 94-97.

[12]. Moulin T,Tatu L, Vaillea F, Berger E Role of a Stroke databank in evaluating cerebral infarction subtypes, patterns and outcome of 1776 consecutive patients from the Besancon stroke registry (Cerebrovax Dis.200 Jul Aug; 10(4); 261-71

[13]. Cairu Li, MD,PhD; Gunnar Engstrom, MD, PhD; Bo Hedblad, MD,Phd; Goram Berglund, MD,PhD. Blood pressure control and risk of stroke - A population - based prospective cohort study - Stroke 2005; 36:725

[14]. Yamamotel, G Devuyst, J Bogusslavsky et al. The Lausanne Stroke registry: A European stroke database, GP 4-5, stroke in Asia and western countries, May 29, 2002.

[15]. Kuller LH et al In national Diabetes Data Compliled for 1984, Vol 18

[16]. Amanda G. Thrift; Helen M. Dewey, Richard A.L. Macdonellet all. Incidence of major stroke subtypes. Initial findings From the north East Melbourne stroke incidence study (NEMESIS), stroke 2001; 32; 1732.

[17]. H. Naess, U. Waje, L. Thomassen, K.Myhr. High incidence of Infarction in the left cerebral hemisphere among young adults Journal of Stroke and ccerbrovascular disease, Vol 15. Issue 6 pages 241 - 244

[18]. Dr. R.L. Sacco, MD, J.H. Ellenburg, PhD, J.P. Mohr, MD, T.K. Tatamichi, MD, D.B.Hier, M.D., T.R. Price, MD,PA Wolf, MD-Infarcts of undetermined Cause: The NINDS stroke date bank. Annals of Neurology Volume 25 Issue 4, Pages 382-390

[19]. Gian, L.Wu, J.Wang, C.Zhu et al. Stroke registry in north east china - GP4 -5, Stroke in Asia and Western Countries, May 29, 2002.

[20]. Mark E Mullins, MD, PhD, Pamela W. Schaefer, M.D, A. George Sorensen, MD, ElkanF. Halpern PhD et al- CT and conventional and Diffusion weighted MR imaging in Acute Stroke; Study in 691 patient at presentation to the emergency Department Radiology 2002; 224: 353-360

[21]. Marten GLansberg, Alex M. Norbash, Michael P Marks, Daniel C Tong D et al. Advantages of adding diffusion weighted MRI to Conventional MRI For evaluating acute stroke - Arch Neurology; Vol(57); Sept 2000

[22]. John R. Haaga; Charles F. Lanzieri; Robert C. Gilkeson, CT and MRI of the whole body, Fourth edition, 2003, Mosby. Volume 1 pages 246-282

[23]. Yee Sien Ng, MD, MRCP; Joel Stein, MD; Ming MingNing, MD,Randie M Black-Schaffer,MD,MA. Comparison of clinical characteristics and functional outcomes of Ischemic stroke in Different vascular territories . Stroke 2007:38;2309.

[24]. Anne G. Osborn, M D, FACR- Diagnostic Neuroradiology First edition, 1994, Pages 117-152.

Dr. Anjali Dathan. "Importance of Multimodal MRI as the Single Diagnostic Investigation in the Initial Assessment of Patients with Hyperacute Ischemic/Hemorrhagic Stroke." *IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)*, 19(11), 2020, pp. 41-51.