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Research Article

COMPARATIVE STUDY OF NON CONTRAST CT AND DIFFUSION WEIGHTED MR IMAGING IN DIAGNOSTIC EVALUATION OF HYPERACUTE ISCHEMIC STROKE

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Abstract

Background: Early and accurate diagnosis of acute ischemic stroke is essential for appropriate management and improved clinical outcomes. Non-contrast computed tomography (NCCT) is widely used as the initial imaging modality; however, its sensitivity in the early detection of ischemic changes is limited. Diffusion-weighted magnetic resonance imaging (DW-MRI) has emerged as a more sensitive technique for detecting acute cerebral ischemia.

Aim: To document and compare the diagnostic performance of Diffusion-weighted MR imaging with Non contrast CT in the diagnosis of hyper acute ischemic stroke.

Materials and Methods: This hospital-based cross sectional study was conducted over a period of 3 months in the Department of Radio-diagnosis, SVRRGGH, Titupati Andhra pradesh. A total of 50 patients with clinical suspicion of acute stroke were included. All patients underwent NCCT and MRI, including diffusion-weighted imaging. Imaging findings were correlated with final clinical diagnosis. Diagnostic performance of NCCT and DW-MRI was evaluated using sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy.

Results: Among the 50 patients, males constituted 58% and females 42%, with a mean age of 61.6 ± 11.45 years. NCCT demonstrated ischemic changes in 56% of patients, with hypoattenuating brain parenchyma being the most common finding, while 44% showed normal findings. DW-MRI detected ischemic lesions in 95.6% of patients. DW-MRI showed a sensitivity

of 95.6%, specificity of 100%, and diagnostic accuracy of 96%, compared to NCCT sensitivity of 56.5%, specificity of 50%and accuracy of 56%.

Conclusion: DW-MRI is significantly superior to NCCT in the diagnosis of acute ischemic stroke and should be considered whenever available, particularly in CT-negative cases with strong clinical suspicion.

Keywords: Acute ischemic stroke; Diffusion-weighted imaging; Non-contrast CT; MRI; Diagnostic accuracy

INTRODUCTION

Cerebrovascular disease represents a major source of global mortality, with over 6 million deaths documented annually, and is the second leading cause of death in all income groups worldwide, exceeded only by ischemic heart disease. In addition to being a leading source of mortality, cerebrovascular disease is also a significant cause of morbidity. As many as 50 % of stroke survivors do not regain functional independence, and 20 % require institutional care 3 months after stroke onset .[1,2,]

The National clinical guidelines for stroke from the Royal College of Physicians firmly recommend neuroimaging for all patients with clinical symptoms of stroke. Within 24 hours of the stroke event, appropriate and early neuroimaging is essential for patient care and has proved to be cost effective.[28]

More than 80% of strokes stem from ischemic damage to the brain due to the acute reduction of the blood supply. It was calculated that 1.8 million neurons are lost every minute that appropriate treatment is not given (‘time is brain’). For these reasons, ‘stroke imaging’ is crucial and has to be performed in a fast and efficient manner.[6,27.]

The imaging examination also serves to exclude other pathologies that may resemble stroke clinically, known as the “stroke mimics”. Such pathologies include, but are not limited to spinal stroke, hemorrhagic neoplasms, encephalitis, multiple sclerosis, post ictal (Todd’s) paresis, some types of migraine, intoxications, hypertensive encephalopathy, hyper- or hypoglycemia, as well as psychiatricdiseases.[1]

Strokes are either ischemic or haemorrhagic. Because the management of these subtypes is so different, the clinical distinction between the subtypes is one of the most important and urgent steps in stroke management. This distinction has been revolutionised by the introduction of CT and MRI. Although CT has been the workhorse of stroke diagnosis during the past 20 years, MRI is now as useful as, if not more so than, CT.[27.]

NCCT remains the mainstay of emergency imaging of stroke in order to exclude intracranial haemorrhage. NCCT may also identify other intracranial pathologies that mimic stroke such as tumour or encephalitis.[12]

The early CT signs of ischemia are often difficult to identify in the first few hours after stroke onset**.** There is also considerable inter-observer variability.[13]

NCCT is relatively insensitive for the detection of acute small cortical or subcortical infarctions, especially in the posterior fossa.[8]

STROKE MRI

Since its first use in clinical practice in 1984, MRI has created a significant shift in the management of neurological disorders. MRI is very helpful for acute ischemic stroke in the clinical setting and for therapeutic decision making with regard to the use of thrombolysis.

MRI has been shown to have diagnostic superiority over CT with comparable specificity (98% CT vs 97% MRI) for acute ischemic stroke, but MRI has much higher sensitivity (26% CT vs 83% MRI).There is also lower inter-rater variability with MRI in the diagnosis of acute stroke in first few hours as compared to conventional CT.[30]

However conventional MRI is less sensitive than DWI imaging in hyperacute stroke, the latter being an essential part of MR stroke imaging protocols. MRI is particularly useful for ischemic lesions, vessel occlusions, and pathology in the posterior circulation.[30]

The major drawback of CT is the high radiation dose, while MRI is a more complicated examination.[1]

AIM

- To document and compare the diagnostic performance of Diffusion-weighted MR imaging with Non contrast CT in the diagnosis of hyper acute ischemic stroke.

OBJECTIVES

- To determine the location and territory of blood vessel involved.
- To study the age and gender incidence in hyper acute ischemic stroke.

NEED FOR THE STUDY:

- Early diagnosis of hyper acute ischemic stroke and to plan management .
- Early diagnosis of posterior circulation cerebral infarcts (PCCI) .

MATERIALS AND METHODS

STUDY DESIGN: A Cross sectional comparative study

STUDY PERIOD: The study was conducted for a period of 3months after approval from the Institutional Ethical Committee

INCLUSION CRITERIA:

All patients with clinical diagnosis of acute stroke, referred from Emergency department and department of general medicine to department of Radiodiagnosis in SVRRGGH,Tirupati. MR and CT scans are obtained within 6 hours of ictus in patients with a clinical diagnosis of acute stroke.

EXCLUSION CRITERIA:

Children**,** Pregnant women**,** Patients with pacemakers, metallic implants, aneurismal clips, prosthetic valves, with intracranial bleed, Dural venous sinus thrombosis, Critically ill ICU patients and Claustrophobia

METHOD OF STUDY & DATA COLLECTION

Equipment:
The evaluation of cases in the department of Radiodiagnosis, S.V Medical College, Tirupati.using Philips Ingenia1.5 Tesla MRI machine and GE revolution 16 slice CT machine.
Procedure:
No specific patient preparation is required prior to the study.
MRI protocol:
A head coil is used.Axial diffusion weighted images of the brain AxialT1W, T2W, FLAIR,SWI images of the brain were obtained. ADC images are reconstructed from the diffusion weighted images. B value of 0 and 1000 s/mm2 are used for diffusion weighted imaging
Duration of MRI brain study:20 min.
Various parameters of MRI include:

	TE	TR	TI

T1W	10	415	
T2W	120	4290	
FLAIR	92	9000	2500
DWI	102	4500	

CT protocol:

Patient Position:

Patient should be supine with the head on the head rest, arms by the sides and the chin should be as far down as comfortably possible.

Plane of Section at10 – 25 degree to Reids line or parallel to orbito-meatal Line

Scan parameters:slice thickness:4.8mm,1.2 mm.Window width:80,window level :35

RESULTS

The study group includes a sample of 50 patients who came to the department of radiodiagnosis with acute stroke symptoms. Non contrast CT and diffusion-weighted MRI including the conventional MRI were done in all the patients and the image findings were studied. The association between NCCT and DWMRI findings was calculated using McNemar's Test. Diagnostic accuracy, sensitivity, specificity, positive predictive value and negative predictive value of DWMRI and NECT in acute stroke patients were calculated using diagnostic statistics. $P<0.05$ was considered significant.

Table 1. Distribution of patients according to the sex

Sex	Distribution (n=50)	
	Number	Percentage
Male	29	58.00
Female	21	42.00
Total	50	100.00

Table 2. Distribution of patients according to the age group

Age group (Years)	Distribution (n=50)	
	Number	Percentage
45 to 50	13	26.00
51 to 60	16	32.00
61 to 70	11	22.00
71 to 80	7	14.00
81 to 85	3	6.00
Total	50	100.00

Table 3. Distribution of patients according to the CT findings

Findings	Distribution (n=50)	
	Number	Percentage
Hypo attenuating brain parenchyma	22	44.00
Loss of grey matter- white matter differentiation	16	32.00
Vanishing basal ganglia	7	14.00
Insular ribon sign	6	12.00
Hyperdense artery sign	3	6.00

Multiple presentations hence total not shown.

Table 4. Distribution of patients according to the blood vessel territory involved based on CT

Blood vessel territory involved	Distribution (n=50)	
	Number	Percentage
MCA	11	22
VBC except PCA	4	8
MCA + PCA	5	10
SVD	2	4
PCA	2	4
ACA	2	4
Watershed ACA-MCA, MCA-PCA	1	2
PCA+VBC	1	2
Normal findings	22	44
Total	50	100

MCA-middle cerebral artery,ACA-anterior cerebral artery,PCA-posterior cerebral artery,VBC –vertebrobasilar circulation,SVD- small vessel disease.

Table 5. Distribution of patients according to the affected area based on CT

Affected area	Distribution (n=50)	
	Number	Percentage
FPR	10	20
FPOR	4	8
Cerebellum	4	8
BG+IC	2	4
FR+CC	1	2
BG	1	2
Watershed region of FPR, OPR.	1	2
MB	1	2
OR	1	2
PR	1	2
OR+Pons	1	2
OR+TR	1	2
Normal findings	22	44

,FPR -,frontoparietal region, FPOR frontoparietal and occipital region ,BG basal ganglia,IC –internal capsule,FR – frontal region,CC- corpus callosum,OPR.occipitoparietal region,

Table 6. Distribution of patients according to the diagnosis based on CT

Diagnosis	Distribution (n=50)	
	Number	Percentage
Acute ischemic infarct	23	46
Acute lacunar ischemic infarct	4	8
Watershed acute ischemic infarct	1	2
Normal findings	22	44
Total	50	100

Table 7. Distribution of patients according to the blood vessel territory involved based on MRI

Blood vessel territory involved	Distribution (n=50)	
	Number	Percentage
MCA	11	22
VBC except PCA	10	20
PCA	7	14
SVD	6	12
MCA + PCA	4	8
ACA	3	6
PCA+VBC	2	4
Watershed ACA-MCA,MCA-PCA	1	2
No territory involved	6	12
Total	50	100.00

MCA-middle cerebral artery,ACA-anterior cerebral artery,PCA-posterior cerebral artery,VBC –vertebrobasilar circulation,SVD- small vessel disease,

Table 8. Distribution of patients according to the affected area based on MRI

Affected area	Distribution (n=50)	
	Number	Percentage
FPR	10	20
Multiple locations	7	14
BG+IC	6	12
Cerebellum	5	10
Thalamus	3	6
Medulla	3	6
FPOR	4	8
MB	2	4
FR +CC	2	4
PR	1	2
OR	1	2
BG	1	2
Pons	1	2

Watershed region of FPR and OPR	1	2
Normal	3	6
Total	50	100.00

FPR -,frontoparietal region, FPOR frontoparietal and occipital region ,BG basal ganglia,IC –internal capsule,FR – frontal region,CC- corpus callosum,OPR.occipitoparietal region,

Table 9. Distribution of patients according to the diagnosis based on DW-MRI

Diagnosis	**Distribution (n=50)**	
	Number	**Percentage**
Acute ischemic infarct/s	35	70
Acute lacunar ischemic infarcts	7	14
Watershed Acute ischemic infarct	1	2
Acute ischemic infarct and lacunar infarct	1	2
No infarct	6	12
Total	50	100.00

Table10. Distribution of patients based on MRI findings in acute ischemic stroke cases.

Findings	**Distribution (n=46)**	
	Number	**Percentage**
DWI/ADC presence of true restricted diffusion	44	95.6
T2/ FLAIR hyperintensities	38	82.60

Table11. Comparison of acute ischemic stroke diagnosis based on NCCT AND DW MRI

	Acute ischemic stroke		**p value**
	Positive	**Negative**	
DW-MRI	44	6	0.0003*
NC-CT	28	22	

P value <0.05 is considered significant.

Table 13: DWMRI Modality Statistics

		Acute ischemic stroke	

		Positive	**Negative**	
DW-MRI	**Restriction**	44	0	44
	No restriction	2	4	6
		46	4	50

DW MRI	**Estimate**
Sensitivity	95.6%
Specificity	100%
Accuracy	96%
Positive predictive value	100%
Negative predictive value	66%

Table 14: NCCT modality statistics

		Acute ischemic stroke		
		Positive	**Negative**	
NCCT	**Positive**	26	2	28
	Negative	20	2	22
		46	4	50

NCCT	**Estimate**
Sensitivity	56.5%
Specificity	50%
Accuracy	56%
Positive predictive value	92.8%
Negative predictive value	9.09%

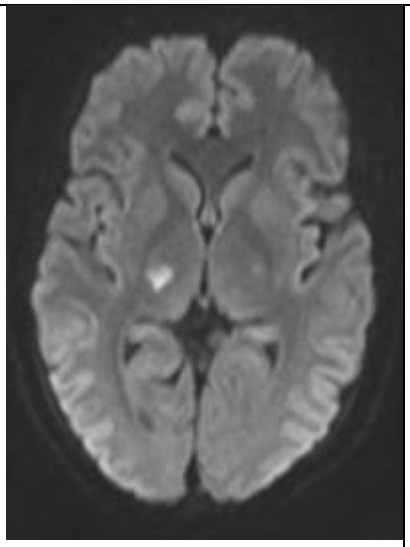
Table 15. DW MRI VS NCCT STATISTICAL ANALYSIS

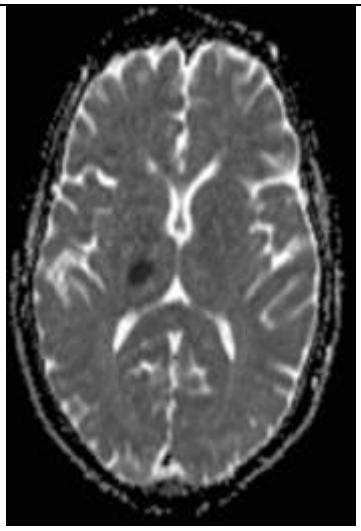
		NCCT		
		Positive	**Negative**	
DW-MRI	**Positive**	26	18	44
	Negative	2	4	6
		28	22	50
	P value	0.0003*		
	K value	0.12		
	Mc-Nemar test value	12.8		

P value <0.05 is considered significant.

CASES

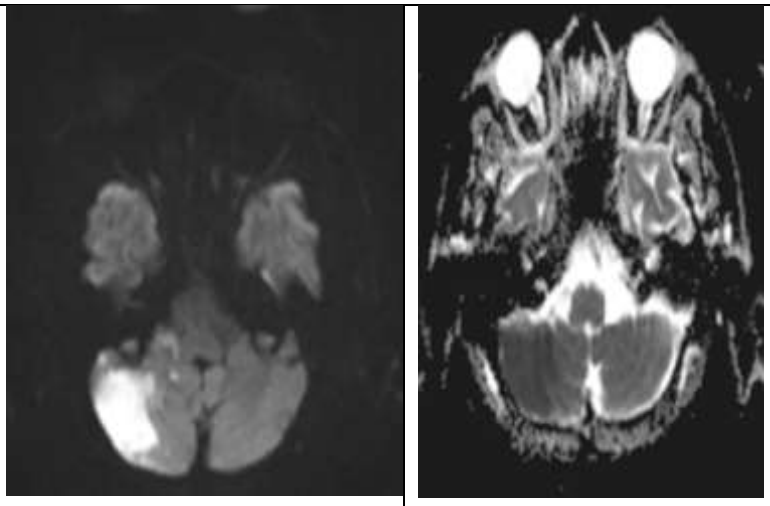
Axial NCCT in 45year old female patient with stroke symptoms reveals no significant -Abnormality.





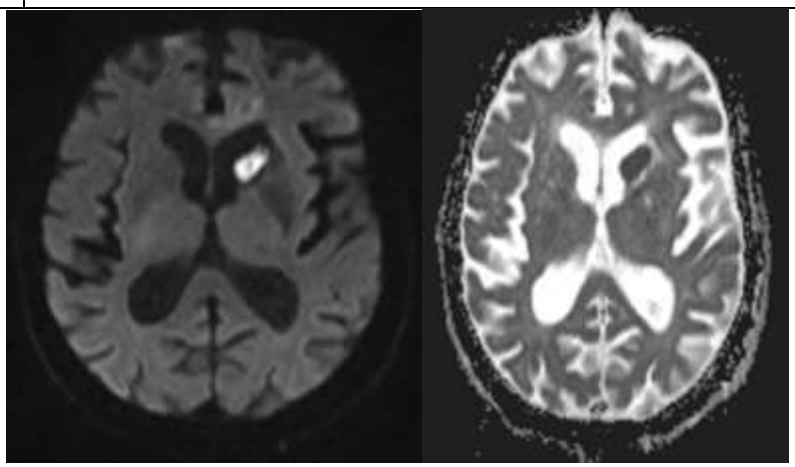
DW MRI and ADC images in the same patient shows diffusion restriction in RT thalamus suggestive of –acute ischemic infarct.

Axial NCCT in 73year old male patient with stroke symptoms reveals no significant abnormality



DW MRI and ADC images in the same patient shows diffusion restriction in RT cerebellar hemisphere suggestive of –acute ischemic infarct.

Axial NCCT in 70year old female patient with stroke symptoms reveals hypodensity in LT caudate region.



DW MRI and ADC images in the same patient shows diffusion restriction in LTcaudate region suggestive of –acute ischemic infarct.

DISCUSSION

Accurate and timely diagnosis of acute ischemic stroke is critical for initiating appropriate therapeutic interventions and improving clinical outcomes. Historically, stroke diagnosis relied on clinical assessment and scoring systems, which were limited by subjective interpretation and inability to reliably differentiate ischemic from hemorrhagic stroke. The advent of neuroimaging, particularly CT and MRI, has significantly transformed acute stroke evaluation, allowing earlier and more precise diagnosis.

The present study was designed to evaluate and to compare non contrast CT and MRI in diagnosis of hyper acute ischemic stroke.

Clinical data and images obtained in 50 consecutive patients with suspected acute stroke were examined. Results of NECT and DWI were analysed and correlated with the final neurologic discharge diagnosis. Of the 50 patients, who underwent imaging, a final diagnosis of acute ischemic stroke was made in 46 patients after full clinical evaluation and neurological imaging. The observations and results of the study were tabulated under the headings of age group, gender, types of infarct based on NCCT and DW-MRI, affected area based on NCCT and DW-MRI, territory involved based on NCCT and DW-MRI involved, comparison between DWI-MRI vs NCCT results, comparison between DWMRI vs T2/FLAIR findings.

The sex distribution pattern in the present study shows 58% males and 42% females and male to female ratio of 1.38:1.

These findings were consistent with a study by Rashid N et al.[5]who reported 55.70% of males and 44.30% of females and by Nisar S. et al.[24] reported 56.06% of the males and 43.94% females in their study.

In another study by Barber PA et al [15], on imaging of the brain in acute ischaemic stroke: comparison of computed tomography and magnetic resonance diffusion weighted imaging, it was shown that 69% were male patients and 31% were female patients.

In this study age ranged between 45 to 85 years with common age group being 51 to 60 years (32%) followed by 45 to 50 years (26%). Also the mean age and median age was noted as 61.6±11.45 years.

Study by Barber PA et al [15] (2005) 12 showed the mean age as 68±13.9 years which was slightly high compared to the present study.

Nisar S et al.[24] reported the mean age of patients was 50.38 years with standard deviation of 13.011 years. Mean age of patients was 54 years and mode age of patients was 58 years. Which is low compared to our study.

NCCT FINDINGS

In this study non contrast computed tomography(NCCT) showing signs of acute ischemia in 28 cases, and not showing signs of ischemia in 22 cases.

The common NCCT findings noted were hypo attenuating brain parenchyma (44%) followed by loss of grey matter- white matter differentiation (32%), vanishing basal ganglia (14%), insular ribbon sign (12%) and hyper dense artery sign (6%).

Hypoattenuating brain parenchyma was the most common NCCT finding in the present study. Similar trend observed by thevon kummer et al [31].

Anterior circulation(ACA+MCA) is most commonly affected than posterior circulation (PCA +VBC) and MCA was the common vascular territory involved in the present study. Similar trend observed by Smajlović D et al[18].(2004), Kumar L, et al[22].(2016) Sinha R et al[21] (2017).

In the present study according to NCCT most common region affected was frontoparietal region(FPR) in 20% of patients followed by frontoparietooccipital(FPOR) region in 8% of patients and cerebellum in 8% of patients. Normal findings were seen in 44 % of patients. According to present study cerebral cortex (40%) was commonly affected region. Similar trend observed by the Smajlović D et al[18].

Based on NCCT findings in the present study, 46% of the patients were diagnosed to have acute ischemic stroke, 8% of the patients had acute lacunar ischemic infarct and watershed acute ischemic infarct was noted in 2% of the patients while 44% of the patients had normal findings.

MRI FINDINGS

In the present study total acute stroke patients were 50. Of the 50 patients, restricted diffusion was observed in 44 patients. DW MRI was negative in 6 patients. Of the 6 patients 2 are false negatives. Negative cases are due to small brainstem infarcts, transient ischemic attacks and stroke mimics like demyelination, metabolic disorders, tumors.

In the present study according to DW-MRI Frontoparietal region was the common area affected (20%) followed by multiple locations were noted in 14%, basal ganglia with internal capsule (12%), cerebellum (10%).

In the present study according to DW-MRI. Of the 44 patients most patients shows 22% demonstrated restricted diffusion in MCA territory, followed by 20% in vertebrobasilar circulation territory, 14% in posterior cerebral artery territory.

Based on the present study DW-MRI observations, the most common diagnosis was acute ischemic infarct/s noted in 70% of the patients followed by acute lacunar ischemic infarcts (14%), watershed Acute ischemic infarct (2%) and acute ischemic infarct and lacunar infarct (2%).

In diagnosing lacunar infarcts MRI (16%) was superior to NCCT (8%).similar trend observed by, Smajlović D et al[18]. JJ Brown et al [29].

In the present study DW MRI is superior than NCCT in diagnosing posterior fossa infarcts. Similar results also obtained from Hwang DY et al[8]and they concluded that head NCCT scans are often insensitive for detecting hyper acute and acute posterior fossa infarcts, while DWI MRI is the preferred imaging modality to exclude infarction when stroke is suspected in the posterior fossa.

In the present study Conventional T2W, fluid-attenuated inversion recovery (FLAIR) sequences were positive in 38 patients (82.6%).diffusion-weighted MRI (DWI)positive in 44 patients(95.6%).

Acute infarcts seen only on diffusion and not visualized in conventional MR imaging (T2W and FLAIR) were 6 cases. Out of the38 cases lesions also seen on conventional imaging, the extent of the lesions were better detected with diffusion imaging. The results in present study was similar to Lansberg MG et al[13].

In the present study NCCT had a sensitivity 56.5 %, specificity of 50%, positive predictive value (PPV) 92.8%,negative predictive value(NPV) 9.09%, diagnostic accuracy 56%respectively.

DWMRI had a sensitivity 95.6% and Specificity 100%, positive predictive value(PPV) 100%,negative predictive value (NPV) 66%,diagnostic accuracy 96% respectively. These results are comparable to Chalela et al[19,].Lovblad et al[14,].

The DWMRI had a higher sensitivity, specificity, accuracy rate compared to NCCT.

Diffusion-weighted imaging appeared to have a superior negative predictive value of 66% and a good positive predictive value of 100% than with a CT negative predictive value of 9.09 % and a positive predictive value of 92.8%.These results are comparable to Lovblad et al[14].,Nisar S. et al[24]., Mullins ME et al.[23], P.A.Barber et al[15].

CONCLUSION

When compared with NECT, DW MRI was more accurate for identifying hyperacute and acute infarction and more sensitive for detection of ischemia. The study concludes higher accuracy rate of diffusion-weighted MR imaging in diagnosing hyperacute and acute infarct than NECT. The present study supports the inclusion of DW MRI in the routine imaging protocol for diagnosing acute ischemic stroke. The present study concludes that diffusion-weighted imaging is a highly reliable and superior imaging method than NECT in detecting ischemia in acute stroke patients.

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