Research Paper

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Study of co-relation of CT Scan Perfusion Changes in Acute Ischemic Stroke with Modified Rankin Score in 50 patients of Stroke over a period of 3 years.

Medical Science

KEYWORDS :

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A stroke is defined as an abrupt onset of a neurologic deficit that is attributable to disruption of blood flow to a focal region of the brain due to a vascular cause.

Stroke can be classified into two major categories: Ischemic stroke (80-85%) and Hemorrhagic stroke (15-20%). C.V stroke is one of the most important causes of death and disability. It is the third most common cause of death worldwide. Age adjusted prevalence rate of stroke in India is around 270 cases per 100,000 population[1]. Estimated stroke related death is 1.2 % of the total deaths. Since long, CT scanning has been a versatile tool in diagnosis and assessment of damage to nervous tissue by stroke. Recent advancement in the field of neuroimaging has come up with Multi Detector Computed Tomography for evaluation of ischemic cerebral penumbra. This newer but readily available technology provides important information in evaluation of cerebral stroke patients like viability of brain parenchyma, status and patency of cerebral vessels and most importantly presence of penumbra.

The **modified Rankin Scale** (mRS) is a commonly used scale for measuring the degree of disability or dependence in the daily activities of people who have suffered a stroke or other causes of neurological disability. It has become the most widely used clinical outcome measure for stroke clinical trials.

Score Description

0 - No symptoms at all
1- No significant disability despite symptoms; able to carry out all usual duties and activities
2- Slight disability; unable to carry out all previous activities, but able to look after own affairs without assistance
3 - Moderate disability; requiring some help, but able to walk without assistance
4- Moderately severe disability; unable to walk without assistance and unable to attend to own bodily needs without assistance
5- Severe disability; bedridden, incontinent and requiring constant nursing care and attention
6- Dead

The scale was originally introduced in 1957 by Dr. John Rankin of Stobhill Hospital, Glasgow, Scotland,[1] and then modified to its currently accepted form by Prof. C. Warlow's group at Western General Hospital in Edinburgh for use in the UK-TIA study in the late 1980s.[2] The first publication of the current modified Rankin Scale was in 1988 by van Swieten, *et al.*, who also published the first interobserver agreement analysis of the modified Rankin Scale.

Perfusion Computed Tomography is a relatively new technique that allows rapid quantitative and qualitative evaluation of cerebral perfusion. The technique requires the use of commercially available softwares employing complex algorithms to produce perfusion maps.

CEREBRAL BLOOD FLOW (CBF) : It is the most important parameter of all. It measures the amount of blood flowing in a particular region and is denoted as mL/100gm brain/min. Normal values are between 50 to 80mL.

CEREBRAL BLOOD VOLUME (CBV) : It is defined as percentage of blood vessels in a specific amount of brain tissue. CBV alters according to the phenomenon of autoregulation.

MEAN TRANSIT TIME (MTT) AND TIME TO PEAK (TTP) : MTT is the time between arterial inflow and venous outflow, whereas TTP is the time taken by the contrast to achieve maximum intensity.

	NORMAL	ABNORMAL
CBF	> 50 - 60 ml/100gm/min	Oligemia 30 - 60 ml/100gm/min Penumbra 20 - 30 ml /100gm/min Infarction < 10 ml/100gm/min
CBV	3.5 ml/100gm/min	Penumbra > 2.5 ml Infarct < 2.5 ml
MTT	1.9 - 5 sec	> 6.2 sec
CBF ratio	CBF in infarct/ CBF in mirror area.	0.35 to 0.46 - perform well with fibrinolytic Rx ; 0.2 to 0.35 - more than 5% will develop infarct after fibrinolytic Rx ; < 0.2 - No fibrinolytic Rx
CBV ratio	Not specific	< 0.7 abnormal ; < 0.55 critical

	CBV	CBF	TTP
Normal	Normal	Normal	Normal
Compensating arterial stenosis	Normal	Normal	Prolonged
Restorable oligemic region	> 80%	> 60mL	Prolonged
Risky tissue	> 60%	> 30mL	Prolonged
Irreversible infarct tissue	< 40%	< 30mL	Prolonged

A study was conducted at Canada in 1999-2001, undertaking 100 patients with acute neurological insult and comparing diffusion imaging of CT vs MRI. It concluded that among patients with moderate to severe acute ischemic stroke, the ability of CT to detect signs of early infarction were comparable to MRI. However, CT being accessible, versatile and fast, was considered the preferred modality in patients presenting to the emergency department with acute neurological deficits.

Comparision with MRI

	CT	MRI
Availability	Good, getting better	Fair
Examination time	5 – 10 min	20 – 30 min
Imaging volume for perfusion study	2 – 4 cm	Entire brain
Ability to exclude hemorrhage	Excellent	Good, but may require expert interpretation
Ability to detect early irreversible infarction	Good	Excellent
Radiation Risk	Yes	No
Contrast Toxicity	More	Less

Hence forth the following study is undertaken to highlight the importance of and as well as co- relate the severity of CT perfusion changes along with severity of Modified Rankin Score as the score has been used world wide and a study highlighting the importance of the score with the actual perfusion changes of brain parenchyma in stroke as recorded by CT scan has never been undertaken before.

MATERIAL AND METHODS

After approval from the institutional ethics committee, this prospective study of co-relation of CT Perfusion scan of Brain with modified rankin score was carried out at Smt. N.H.L Municipal

Medical College. This study was done along with the help of radiology department in our institute.

All indoor patients admitted in our unit of a large teaching hospital during the period of June 2012 to April 2015 who presented with symptoms and signs of stroke within 12 hours of onset, were selected for this study, after applying the inclusion and exclusion criteria.

Informed consent was taken from the patients and/or the relatives.

***INCLUSION CRITERIA* :-**

- Patients with symptoms and signs of stroke, presenting within 12 hours of onset of the symptoms.
- Patients without any past history of stroke.
- All patients who could be followed up with contrast CT 3 months after admission.

EXCLUSION CRITERIA :-

- Patients presenting after 12 hours of onset of neurological deficit.
- Patients who denied consent for the procedure.
- Patients with symptoms and signs suggestive of hemorrhage, mass lesion or any other etiology for stroke.
- Patients with altered renal function or having contrast allergy.
- Patients who could not be followed up to the final diagnosis.

METHOD OF SCANNING

Whole brain CT perfusion imaging was performed with a 64 slice row helical CT scanner (SOMATOM SENSATION, SIEMENS, Enlargen, Germany) in the head-first supine orientation.

The imaging parameters used were as follows –

	Non – contrast CT	Perfusion CT
Kvp	120	120
mA	280 - 300	380
Rotation Time	1.0 second	1.0 second
Slice collimation	0.6 mm	0.6 mm
Slice width	1 mm	1mm
Image Matrix	512 × 512	512 × 512

A standard algorithm reconstruction program was applied. From these data, values of Cerebral Blood Flow (CBF), Cerebral Blood Volume (CBV) and Mean Transit Time (MTT) in the affected area were determined and compared to those in the corresponding nonischemic contralateral area of the brain.

OBERVATIONS AND DISCUSSION

Table 1. AGE AND GENDER OF DISTRIBUTION

Age Group (years)	No. of patients	Male	Female
0 – 10	--	--	--
11 – 20	--	--	--
21 – 30	3	2	1
31 – 40	9	6	3
41 – 50	12	9	3
51 – 60	20	12	8
61 – 70	6	1	5
71 – 80	--	--	--
81 – 90	--	--	--
Total	50	30 (60%)	20 (40%)

In present study all age group of patients between 20 to 70 years were included with mean of age 52 years. The incidence of stroke was found to be more common in the age group of 41 – 60 years i.e. 64% of the total patients. The incidence of ischemic stroke was more common in male patients (60%) as compared to female patients (40%). 60% of patients in present study had left sided neurological deficit while remaining 40% had right sided deficit. We included only those patients who presented within 12 hours of onset and 48% of them presented within 6 hour.

PERFUSION CT ON ADMISSION

Perfusion CT	Number of patients	Percentage
Normal	9	18%
Infarct with penumbra	25	50%
Infarct without penumbra	16	32%
Total	50	100%

Perfusion CT Parameters	Number of patients	Percentage
↑ TTP ; ↓CBF ; ↑ CBV	25	50%
↑TTP ; ↓ CBF ; ↓ CBV	16	32%
TTP ; CBF ; CBV - Normal	9	18%
Total	50	100%

Table 3. Perfusion parameters on admission Perfusion scans

All the patients admitted with acute neurological symptoms were subjected to a perfusion CT scan on admission.

The majority of perfusion scans (25 patients, 50%) showed infarct with penumbra region. 16 patients (32%) had an infarct without penumbra. Remaining 9 patients had a normal perfusion CT. From the perfusion scans performed on admission, the values of CBV, CBF and TTP in the Region Of Interest (ROI) were analysed. Increased TTP, reduced CBF and increased CBV in ROI as compared to the normal side, suggestive of penumbra tissue (reversible), was found in 25 patients (50%). Increased TTP, reduced CBF and reduced CBV in ROI as compared to the normal side, suggestive of infarct tissue (irreversible), was found in 16 patients (32%). Normal values of TTP, CBF and CBV in ROI as compared to the normal side, suggestive of normal perfusion, were found in 9 patients (18%).

Follow up CT	Number of patients
Infarct	41
Normal	9
Total	50

Table 4. Findings on Follow up CT at 3 months

All the 50 patients were subjected to follow up contrast CT Brain at 3months of their admission. All the patients who showed perfusion defects with or without penumbra in perfusion scans on admission (total 41 patients, Table E-1), had an acute infarct on their follow up NCCT in the territory that correlated with that of abnormal perfusion scans on admission. The remaining 9 patients who had normal CT Perfusion scans on admission had a normal CT on follow up as well.

Table 5. IMPROVEMENT IN THE AVERAGE MODIFIED RANKIN SCORE IN PATIENTS ON REHABILITATION IN THE FORM OF PHYSIOTHERAPY

Age Group (years)	ADMISSION SCORES (AVG.)	3 MONTH SCORES (AVG.)	6 MONTH SCORES(AVG.)
0 – 10	--	--	--
11 – 20	--	--	--
21 – 30	3	2	1
31 – 40	4	3	1
41 – 50	4	3	3
51 – 60	4	4	3
61 – 70	5	4	3
71 – 80	--	--	--
81 – 90	--	--	--

All 50 patients irrespective of their age were subjected to rehabilitation in the form of limb exercises daily for 30 minutes..

Greatest improvement in admission Rankin Scores were seen in age group 20-40 years of age and these patients recovered to near normal activity with return to normal chores within 6 months.

The improvement in scores was less pronounced in >60 years of age mostly due to non adherence to physical rehabilitation. Also the greatest improvements were seen in patients who started rehabilitation within 20 days of the stroke episode.

A prospective study of role of CT Perfusion scan in acute ischemic stroke was conducted on 50 patients who presented within 12 hours with neurological manifestations. Among the 50 patients, 30 were male (60%) and 20 were female (40%) and the mean age of patients was 52 years. All the patients were clinically confirmed for stroke by neurological examination and were subjected to a non-contrast CT Brain with Perfusion scan on admission, and were followed up with a non-contrast CT Brain within 2 – 4 days of admission.

Out of 50 patients, 9 patients (18%) had a normal non-contrast CT on admission. The remaining 41 patients (82%) had an abnormal NCCT, of which 31 patients (62%) showed hypodense areas suggestive of infarct while 10 patients (20%) had an apparently normal NCCT with subtle signs of early ischemia.

The 9 patients having a normal NCCT with clinical presentation of stroke also had a normal Perfusion scan. The follow up NCCT turned out to be normal as well, with neurological complaints resolving almost completely within 2 – 4 days of admission. These patients were considered as having with Transient Ischemic Attack (TIA), with no ischemic changes on neuroimaging.

The 10 patients having apparently normal NCCT with subtle signs of early ischemia had significant perfusion defects forming a penumbra in the suspected territory. Their follow up NCCT showed development of acute infarcts, correlating with the penumbric region.

Out of the 31 patients who had hypodense areas in NCCT on admission, 15 patients showed presence of penumbra surrounding the infarct core in Perfusion scan. The penumbra size was variable, mostly dependent on the duration of symptoms. On follow up NCCT, these penumbric areas had converted into acute infarcts. The remaining 16 patients had no evidence of penumbra on perfusion scans, and their follow up NCCT were similar to that on admission.

In all, out of 41 abnormal NCCT, 25 patients showed perfusion defects with presence of penumbra. 19 out of these 25 patients had penumbra size larger than infarct core. When the duration of symptoms was considered in these 19 patients, 17 patients had arrived within the therapeutic window of 6 hours. However, 2 patients, inspite of presenting beyond the therapeutic window, showed penumbra size larger than the infarct core and had a potential therapeutic advantage.

Overall, CT Perfusion scan was accurate in 60.97% cases (25 patients out of 41) for detection of penumbra and differentiating between salvageable tissue and irreversible damage. Out of 24 patients who presented within 6 hours of symptom onset, Perfusion scan was abnormal in 20 patients (sensitivity 83.33%), as against NCCT, which was abnormal in only 12 patients (sensitivity 50%).

The detection and differentiation of penumbra from infarct core by perfusion scan has got important role in planning the management strategies of ischemic stroke.

Apart from radiation & contrast allergy risk, the drawback of CT Perfusion examination is inability to obtain sufficient information about the perfusion of the entire brain. Since it is possible to take images of only a few sections of the brain, there stays a possibility to under-estimate or even miss the abnormality. Future advancements in detector technology should address this problem. However, a clinical challenge still remains in the subset of patients with multiple bilateral infarcts, where choosing the region of interest (ROI) can be difficult.

The CT Perfusion scanning proves to be a valuable imaging tool for stroke patients, especially those arriving in the 'gray zone' of therapeutic window. It also helps to distinguish TIAs from frank ischemic stroke, particularly during the early stage of presentation. Also, it would be fair enough to consider that 'therapeutic window' is not a strict time limit, but instead is dependent on the status of tissue perfusion. This consideration can be put into practice using the CT Perfusion scanning and might be helpful in patient stratification for thrombolytic therapy, extending the advantage of this therapy to larger number of patients.

The CT Perfusion imaging method is easy to implement with the use of appropriate hardware and software. It is fairly rapid and cost effective in comparison to other imaging modalities. With increasing availability, CT Perfusion imaging is the emerging concept of radio-diagnosis. In combination with the clinical knowledge, NCCT and Angiographic studies, it has brought a revolution in diagnosis, management and prognostication of ischemic stroke.

The early the rehabilitation starts the greater is the benefit is to the patient and the greatest benefit also depends on the age when the stroke episode has occurred with near total recovery in the 20-40 years age group.

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