Correlation of Alberta Stroke Program Early Computed Tomography Score on CT and Volume on Diffusion Weighted MRI with National Institutes of Health Stroke Scale

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Introduction

Stroke is the third largest killer in the world. The disability caused by a stroke is the worst of all in majority of those who survive the acute phase. There are approximately 7,50,000 new or recurrent cases of stroke annually in United States(1). The estimated adjusted prevalence rate for stroke in India varies between 84-262/100,000 in rural to 334-424/100,000 in urban population centers. Also, based on recent population studies the incidence rate in India is approximately 119-145/100,000(2). Eighty to ninety percent of these events are ischemic strokes. This becomes all the more important in India, where 20% of strokes occur in patients of < 40 yrs of age (2). In cerebral infarction, occlusions of large vessels are responsible for 40-50% of the cases, followed by small vessel lacunar infarcts (25%). The aim of our study was to correlate the Alberta Stroke Program Early Computed tomography score (ASPECTS) and volume on diffusion weighted imaging in MRI with National Institutes of Health Stroke Scale (NIHSS). Also, we planned to analyze which variable correlated better with NIHSS. Many studies have correlated ASPECT and NIHSS and volume of infarct as seen on Diffusion Weighted Imaging (DWI) on MRI and NIHSS; however, both the parameters have not been correlated in same group patients at the same time. India is a developing country; with meager resources thus the availability of MRI is limited to big cities only. Therefore, it was planned to compare the outcome of stoke, as judged by the NIHSS scores, using both ASPECTS and infarct volume on DWI MR.

Methods

We undertook this prospective study in which 32 consecutive patients, suffering from acute ischemic stroke, who fit into inclusion criteria, underwent clinical evaluation with NIHSS score and investigation using plain non-enhanced CT and diffusion weighted imaging on MRI. The MRI and CT were performed within 1 hour of each other in every case.

INCLUSION CRITERIA
- Patients aged >18 years.
- Patients with middle cerebral artery stroke.

EXCLUSION CRITERIA
- If Ischemic stroke was of more than 48 hours
- If the stroke was in posterior circulation

The clinical neurological status of all the patients was evaluated using NIHSS (3). This was performed by the on call neurologist. The CT images were analyzed using the Alberta Stroke Program Early Computed tomography score (ASPECTS) prospectively (4) (Illustration 1).

On diffusion weighted images infarcts appear as areas of restriction. The volume of these infarcts on diffusion weighted imaging on MRI was measured. After acquiring the diffusion weighted images, the area of the infarcted parenchyma was measured using commercially available soft ware. The area of each slice was then multiplied by the slice thickness to give the volume of infarct in that particular slice. All the volumes obtained from each slice in a study were subsequently summated to arrive at the final volume of the total infarct.

Finally, a comparison of the Alberta Stroke Program Early Computed tomography score and of volume of infarct on diffusion weighted MRI was done to determine which of these two methods correlate better with the score on National Institutes of Health Stroke Scale.

Results

Out of thirty two patients who were recruited in this study five patients were unconscious at the time of presentation. Headache was prominent symptom in 6 out of 32 cases. Left MCA was involved in 17 patients and right MCA in 15.

Out of 32 patients, 21 (65.62%) were males and 11 (34.37%) were females. The age ranged from 30 to 78
years with mean age of 55.81±13.41 yrs. 11 patients (34.37%) were of < 50 yrs of age and 10 (31.25%) were in the 5th decade

**ASPECTS**
The ASPECTS values ranged from 0-10 with mean of 7±2.38. 11 cases (34.37%) had ASPECT score of < 7.

**Infarct Volume**
The infarct volume as calculated on DWI MRI in 32 cases ranged from 3.2 to 445 cm$^3$, with mean of 58.60±96.47 cm$^3$.

**NIHSS Score**
The neurological status of all the patients at the time of presentation was evaluated and NIHSS Scores were calculated. The NIHSS score in all the patients ranged from 5 to 22 with a mean of 8.92±3.855. 10 out of 32 (31.25%) had a score of 10 or more.

**Inter-relation of ASPECT, NIHSS and Infarct Volume on DWI MRI**

Multivariate analysis was performed using Pearson correlation. Volume of infarct as measured on DWI MRI had a positive correlation with NIHSS score and the correlation was statistically significant (Illustration 2). Infarct volume on DWI had inverse correlation with ASPECT. NIHSS scores had also inverse correlation with ASPECT values, where as NIHSS score had a positive correlation with infarct volume. The correlation of all the three was statistically very significant.

Illustration 3 shows a multiple regression analysis correlating infarct volume on DWI with ASPECTS as constant. It revealed significant R value (0.675), adjusted R square value (0.644) and significant F change (0.000). This suggests that one can predict the degree of infarct volume by knowing the ASPECTS. If unconsciousness is added as a constant to ASPECT score the R value increased to 0.718, adjusted R square to 0.699, further increasing the accurate infarct size prediction.

Illustration 4 shows a multiple regression table correlating NIHSS as constant with infarct volume. The R value was 0.699 with R square value being 0.489, adjusted R square of 0.472 and significant F change (0.000). The predictability of volume of infarct with NIHSS score was very good.

Illustration 5 shows a multiple regression table correlating NIHSS (as constant) with ASPECT. The R value was .664, R square of .441, adjusted R square of .422 and a significant F change suggesting a very strong correlation and predictability between NIHSS and ASPECTS.

**Discussion and conclusions:**

In the developing world stroke causes around 3 million deaths (5). India needs to be prepared to handle this catastrophic illness and strategies need to be planned to reduce the mortality and disability by timely monitoring. There are very few centers in India that have resources for stroke management (6). MRI is only available in big cities. Natural history of stroke varies, however, there are effective interventions, which can prevent progression of pathophysiological process of stroke (6)(7)(8). CT scan is available in majority of cities in India, hence may be of great use at many places. Hacke et al (9) demonstrated the utility of identifying ischemic changes on early CT in the diagnosis of early stroke. Hence the present study was planned to find out the possibility of predicting the clinical outcome by using ASPECT score or DWI MRI.

In the present study the ASPECTS score ranged from 0-10 with a mean of 7±2.38. By using Pearson correlation, the data of ASPECTS obtained in this study was compared with infarct volume as seen on DWI MRI (Illustration 2). There was strong inverse correlation of ASPECT score with infarct volume. In fact one could confidently predict the infarct volume by knowing the value of ASPECTS. Hill et al (10) demonstrated that patients who were functionally independent at 90 days had higher 24 hour ASPECTS as they had smaller infarcts. The deceased patients at day 90 had lower 24 hr ASPECTS by a median of 3 points due to large infarcts. Dzialowsky et al (11) also made similar observations.

NIHSS score, which was designed by group of stroke research neurologists to document the severity of neurological deficit in acute cases of stroke,(3) has withstood the test of time. Muir et al (12) after comparing NIHSS, Canadian Neurological scale, Middle Cerebral artery neurological scale, and Scandanavian Stroke Scale concluded that baseline NIHSS best predicted the 3 month outcome after stroke.

Our study also correlated NIHSS with ASPECTS. The results suggest a very strong correlation and predictability between NIHSS and ASPECTS i.e. recovery after stroke can be predicted by a low NIHSS in patients, who in turn have high reading on ASPECTS.

With the regular use of DWI technique on MRI, the volume of infarct can be accurately predicted. Baird et al(13) reported that volume of infarct calculated on DWI MRI within 48 hrs of ischemic stroke onset was
an independent predictor of outcome. Similar results were obtained by Thjis et al (14). In the present study, on applying the Pearson correlation test, a positive correlation was found between infarct volume on DWI MRI and NIHSS. This data is consistent with earlier reports (14)(13). However, Hand et al (15) and Wardlaw et al (16) did not find DWI as a fantastic tool as independent Predictor factor. Johnston et al (17) analyzed large acute stroke data base and concluded that in addition to other clinical variables, baseline NIHSS score and baseline DWI were also correlated in both the development datasets. Jonston(17)also evaluated combined clinical and imaging information on early stroke outcome measures and concluded that, NIHSS score measured at about one week after an acute ischemic stroke, was highly predictive of the outcome. Tong et al (6)and Lovbald et al (18) also found a significant correlation between lesion size on DWI MRI within 6.5 hrs of onset of symptoms and NIHSS; concluding thereby that baseline NIHSS score can predict outcome. In our study, the predictability of volume of infarct from NIHSS score was also very good (adjusted $R^2$.472, $p=0.00$). Thus infarct volume on DWI has direct correlation with outcome. The correlation of NIHSS score and infrarct volume on DWI was slightly more as compared to correlation between NIHSS score and ASPECT score (Adjusted $R^2$.422, Sig F change .000).

The NIHSS score is not determined by ASPECTS alone but by specific anatomic site involved, the deficit due to ‘stunned’ region , periembra and the actual infarct tissue (19). The actual significance of ASPECTS and NIHSS correlation is important as reversal of periembra and stunned areas has been found under controlled conditions and after early interventions(10). CT and DWI on MRI are comparable for detecting and qualifying signs of cerebral ischemia in acute disabling stroke , when they are of good quality and are assessed systematically using ASPECTS, as was done in the present study. However this does not imply that the two modalities are equivalent. ASPECTS values were lower for DWI on MRI, implying that the DWI is more sensitive than CT at detecting ischemic tissue changes. Barber et al (4)found positive correlation between CT ASPECTS and DWI. They concluded that "among patients with moderate to severe stroke, the ability of CT to detect signs of early cerebral infarction is comparable with DWI. The decision about which imaging to use in acute stroke, will depend upon feasibility and availability of modality." Thulborn (20) also mentioned that early clinical decisions do not require the use of MRI. The MRI in our set up has got a secondary role in emergency stroke management.

The present work has confirmed the earlier reported positive relations of infarct volume on DWI MRI and the outcome of stroke. The capability of the ASPECT score to predict outcome as judged by NIHSS score has also been validated. Initial NIHSS score has been shown to best predict the 3 months outcome in stroke in earlier studies (21). In addition, it has also added a significant contribution by finding that the sensitivity of ASPECTS (on CT) is only slightly less than that of infarct volume (as seen on DWI MRI) in predicting the stroke outcome. Hence it can be recommended that even at places, where there is no MRI available, judicious use of CT scan by using ASPECTS can help in predicting the stroke outcome and the stroke management may be adequately planned.

The present study is only a pilot study and a larger study comparing the infarct volume on DWI, ASPECT score and correlating these parameters with the outcome (as seen by NIHSS) is warranted to further strengthen the observations. Another limitation of our study is that the numbers of patients with large volume infarcts are less. It is possible that the relationship between ASPECTS and volume on DWI MRI can be delineated better if a larger sample of this subgroup were to be evaluated.
Illustrations

Illustration 1

ASPECTS study form and MCA variants.(22)

Illustration: 2 Pearson Correlation showing relation of infarct volume and NIHSS score with each other

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Illustration 3

Illustration: 3 Multiple regression table correlating infarct volume, ASPECTS and unconsciousness

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Illustration 4

Illustration: 4 Multiple regression Table showing correlation of NIHSS score and Infarct volume

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Illustration 5

Illustration: 5 Multiple regression table showing correlation of NIHSS and ASPECTS

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