Original Article

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Correlation of Motor and Functional Recovery with Neuroimaging in Ischaemic Stroke: An Observational Study

Physical Medicine and Rehabilitation Section

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ABSTRACT

Introduction: Stroke is a leading cause of long-term disability worldwide. Neuroimaging plays a critical role in diagnosing and planning the treatment of stroke. Early prognostic markers help in predicting the prognosis after stroke.

Aim: To correlate the motor recovery and functional outcome with Computed Tomography (CT) brain findings using Alberta Stroke Programme Early Computed Tomography Score (ASPECTS) in patients with ischaemic stroke.

Materials and Methods: This observational cross-sectional study was conducted in Department of Physical Medicine and Rehabilitation at Vardhman Mahavir Medical College and Safdarjung Hospital (tertiary care centre), New Delhi, India from October 2016 to March 2018. A total of 45 patients diagnosed with Middle Cerebral Artery (MCA) territory Ischaemic Stroke were included. Motor and functional assessment were done using Fugl-Meyer Assessment (FMA), and Barthel Index (BI). FMA and BI were correlated with the radiological assessment using ASPECTS on Non Contrast Computed Tomography (NCCT) of head.

Results: The mean age of the study population was 60.98±8.61 years. The mean BI score was 70.34±25.2, and FMA score was 61.56±32.8. The mean ASPECTS was 7.5, with 26 patients having ASPECTS 8-10 and 19 with ASPECTS 0-7. Patients with higher ASPECTS (8-10) had moderate to no dependence in Activities of Daily Living (ADL) and mild to no motor impairment respectively (p-value <0.0001). Patients having lower ASPECTS (0-7) had severe dependency in ADL and motor impairment (p-value <0.0001).

Conclusion: Alberta stroke programme early computed tomography score has a significant correlation with motor and functional recovery and is a strong predictor of outcome after ischaemic stroke. The higher the score on ASPECTS, the better will be the motor and functional outcome. The computed tomography findings of brain will help in stroke rehabilitation by enabling to set realistic goals at an early (acute) stage poststroke.

Keywords: Alberta stroke programme early computed tomography score, Barthel index, Brain, Fugl-meyer assessment, Non contrast computed tomography, Rehabilitation

INTRODUCTION

Stroke represents a major source of global mortality and is the second leading cause of death worldwide [1]. Stroke accounts for the largest proportion of total Disability Adjusted Life Years (DALYs) (47.3%) among all neurological disorders worldwide [2]. Functional and motor impairment are major complications poststroke. Only a small proportion of stroke survivors (≈14%) achieve full recovery; whereas, 25-50% require some assistance and approximately half experience long-term dependency in activities of daily living [3]. Rehabilitation following stroke is essential to overcome the disabilities and enable the patient to function independently at physical, social, and community levels [4].

Computed Tomography (CT) is the imaging technique of choice for the initial assessment of suspected stroke as it is readily available, effective, and affordable. The CT brain is an effective neuroimaging marker to evaluate acute care outcomes and permits rapid assessment of patients with acute stroke [5-7]. For quantifying the ischaemic changes on CT within the territory of the Middle Cerebral Artery (MCA) the Alberta Stroke Programme Early Computed Tomography Score (ASPECTS) was developed [8]. It is extensively used in clinical practice to assess the magnitude of early ischaemic changes on brain imaging for acute stroke management [9]. ASPECTS has shown good correlation with BI, modified Rankin Scale, National Institute of Health Stroke Scale, Glasgow Coma Scale and Functional Independence Measure in acute ischaemic stroke patients. Higher ASPECTS is significantly associated with better functional outcomes, and reduced mortality and is an independent predictor of long-term functional independence poststroke [6,10-18]. Prediction of the outcome at an early stage after stroke is important for setting treatment goals, aiding in rehabilitation management, and anticipating possible consequences. The aim of the present study was to correlate motor recovery and functional outcome, six months after ischaemic stroke with CT brain findings at stroke onset using ASPECTS.

MATERIALS AND METHODS

This observational cross-sectional study was conducted in Department of Physical Medicine and Rehabilitation at Vardhman Mahavir Medical College and Safdarjung Hospital (tertiary care centre), New Delhi, India from October 2016 to March 2018. This study was approved by the Institutional Ethics Committee (IEC/VMMC/SJH/Thesis/October/2016).

Inclusion criteria: All patients diagnosed with middle cerebral artery ischaemic stroke with a minimum poststroke duration of six months with Non Contrast Computed Tomography (NCCT) head done after 24 hours of stroke onset were enrolled in the study after obtaining written informed consent.

Exclusion criteria: Patients with haemorrhagic stroke and recurrent stroke were excluded from the study.

Sample size calculation: The prevalence of stroke in the Indian population, as observed by Pandian JD et al., was 334-424 per 100000 in urban areas [19]. Taking this value as reference, the minimum required sample size with 2% margin of error and 5% level of significance was 41 patients. To reduce the margin of error total sample size taken was 45. Formula used was:

$$ME=z\times Sqrt[\{p(1-p)\}/N]$$

Where, Z is value of Z at two-sided alpha error of 5%, ME is margin of error, and p is prevalence rate.

Study Procedure

Clinical assessment was done by a rehabilitation physician using Fugl-Meyer Assessment (FMA) and Barthel Index (BI) six months poststroke.

Fugl-Meyer assessment: FMA of motor function examines the synergistic and isolated movement patterns, reflex activity, coordination, and hand grasp. A maximum score of 100 is given which includes 66 for the upper limb and 34 for the lower limb [20].

Barthel index: BI is composed of ten components that inspect ADL with a total score of 100 [21,22]. Higher score represents a higher degree of independence in the ADL.

The BI and FMA are frequently used in clinical practice as outcome measures in stroke and have excellent inter-rater reliability for administration after stroke [22-25].

FMA score was divided into three groups [26]:

- ≤55: Severe to moderately severe impairment,
- 56-79: Moderate impairment and
- >79: Mild impairment

BI score was divided into three groups [27]:

- 0-20: Total dependence,
- 21-60: Severe dependence
- >60: Moderate to slight dependence

Alberta Stroke Programme Early Computed Tomography Score (ASPECTS): Radiological assessment was done using ASPECTS in NCCT head by an expert radiologist. Based on ASPECTS patients were divided into two groups [12]:

- Better (Aspects 8-10)
- Worse (Aspects 0-7): The worse group was further subdivided into:

  ASPECTS 0-4 group and;

  ASPECTS 5-7 group.

Correlation of FMA and BI was done with the ASPECTS.

STATISTICAL ANALYSIS

Categorical variables were presented in number and percentage (%) and continuous variables were presented as mean±SD and median. Normality of data was tested by Kolmogorov-Smirnov test. Quantitative variables were compared using the Independent t-test between the two groups. Qualitative variables were correlated using the Chi-square test. A p-value <0.05 was considered statistically significant. The data was entered in the Microsoft excel spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 21.0.

RESULTS

Total 45 cases were enrolled in the study. The mean age of the patients was 60.98±8.61 years, ranging from 40-78 years, with a maximum number of patients in the age group of 60-69 years (40%) There were 29 males and 16 females. Overall, 73.33% patients had involvement of the left hemisphere, and in 75.55% dominant side was affected. Total 82.22% patients had poststroke duration between six months to two years [Table/Fig-1].

On baseline NCCT brain, ASPECTS varied from 4-9 with 26 (57.78%) patients in the better outcome group (ASPECTS: 8-10) and 19 (42.22%) in the poor outcome group (ASPECTS: 0-7) with mean ASPECTS of 7.5. At the time of assessment 32 patients had moderate to slight dependency and 13 had severe to complete dependency according to BI. Motor function according to FMA elicited mild to moderate impairment in 29 patients and severe to very severe impairment in the rest of them [Table/Fig-2]. The mean BI score was 70.34±25.2, and FMA score was 61.56±32.8.

Variables	n, %
Age (years)	
40-49	5 (11.11%)
50-59	12 (26.67%)
60-69	18 (40.00%)
70-79	10 (22.22%)
Gender	
Female	16 (35.56%)
Male	29 (64.44%)
Duration of stroke	
>2 years	8 (17.78%)
6 month-2 years	37 (82.22%)
Mean±SD (months)	13.33±9.66
Side involved	
Left	12 (26.67%)
Right	33 (73.33%)

[Table/Fig-1]: Baseline characteristics of patients (N=45).

Wheelchair was used as a means of ambulation by 8 (17.78%) patients, 20 (44.44%) were ambulating with support of assistive devices, while 17 (37.78%) were able to ambulate independently without any assistance.

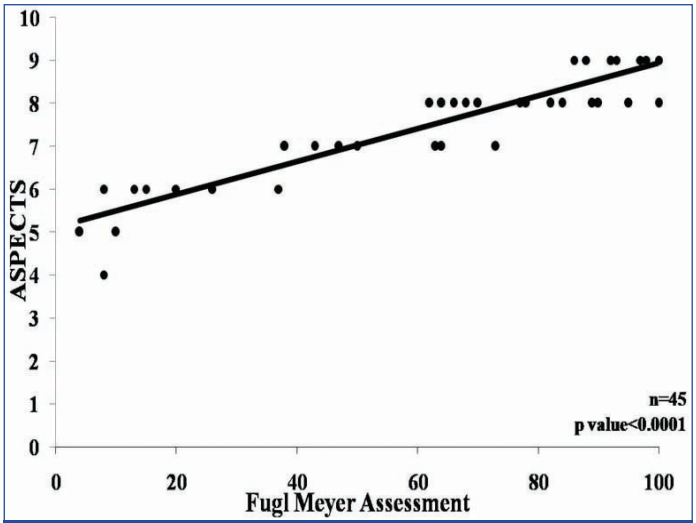
Parameters	Number of Patients
ASPECTS	
0-4 (Worse outcome)	1 (2.22%)
5-7 (Worse outcome)	18 (40.00%)
8-10 (Better outcome)	26 (57.78%)
BARTHEL INDEX	
0-20 (Total dependency)	1 (2.22%)
21-60 (Severe dependency)	12 (26.67%)
>60 (Moderate to no dependency)	32 (71.11%)
FUGL MEYER ASSESSMENT	
≤55 (Very severe to severe impairment)	16 (35.56%)
56-79 (Moderate impairment)	11 (24.44%)
>79 (Mild to no impairment)	18 (40.00%)

[Table/Fig-2]: Patient distribution according to ASPECTS, Barthel Index and Fugl Meyer Assessment (N=45).
ASPECTS: Alberta stroke programme early computed tomography score

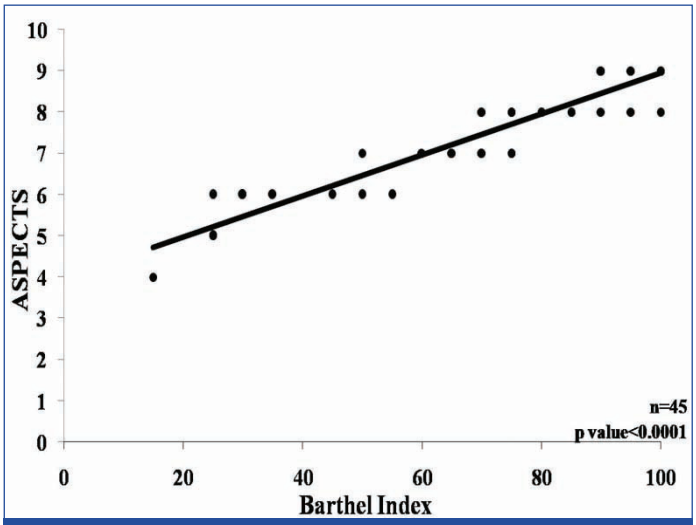
On correlating ASPECTS with BI, patients with lower ASPECTS had poor outcome according to BI and were more dependent in ADL and those with higher ASPECTS showed higher score on BI (p-value <0.0001) [Table/Fig-3]. Patients with lower ASPECTS had severe impairment whereas those in the high ASPECTS group had mild to moderate impairment according to FMA (p-value <0.0001) [Table/Fig-4]. The average ASPECTS for patients who were wheelchair bound was 5.38, whereas, for those who were independent in ambulation was 8.59, indicating that with higher ASPECTS more are chances of being independent in ambulation poststroke (p-value=0.0001) [Table/Fig-5]. There was a statistically significant difference in functional independence and motor function between the better and worse ASPECTS group [Table/Fig-6]. No significant association was found between the side involved in stroke with ASPECTS, BI and FMA [Table/Fig-7].

DISCUSSION

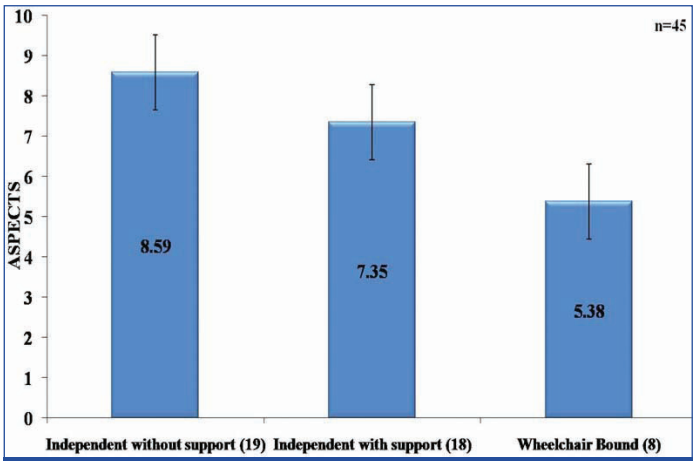
Stroke is a major global health problem and a leading cause of long-term adult disability. Imaging plays a critical role in assessment of acute stroke and assists in decision making for initiating treatment [5-7]. The extent of early ischaemic changes on neuroimaging has been found to be associated with the functional outcome. ASPECTS is a reliable method to determine the degree of early ischaemic



[Table/Fig-3]: Correlation between Barthel Index and ASPECTS (p-value <0.0001, r-value=0.96).



[Table/Fig-4]: Correlation between Fugl Meyer Assessment and ASPECTS (p-value <0.0001, r-value=0.93).



[Table/Fig-5]: Correlation of Ambulatory Status with ASPECTS (p-value=0.0001).

changes in stroke [8]. Very few studies have been done to assess the long-term functional outcome using BI and correlating with ASPECTS and no studies were found correlating the motor recovery using FMA and ambulatory status poststroke with ASPECTS. In the present study, motor recovery (FMA) and functional outcome (BI) in patients with a poststroke duration of more than six months were correlated with ASPECTS at stroke onset.

The mean age of the patients was 60.98±8.61 years with a male preponderance which is comparable with previous studies [2,8,12,15-17]. Although most of the patients in this study were more than 60 years of age but in the study by Zanzmera P et al., and

Parameters		ASPECTS			p-value
		0 to 4	5 to 7	8 to 10	
Barthel index	0-20	1	0	0	<0.0001
	21-60	0	12	0	
	>60	0	6	26	
Fugl-Meyer assessment	≤55	1	15	0	<0.0001
	56-79	0	3	8	
	>79	0	0	18	
Ambulatory status	Wheelchair bound	1	7	0	0.0001
	Independent with support	0	10	10	
	Independent without support	0	1	16	

[Table/Fig-6]: Correlation of ASPECTS with BI , FMA and Ambulatory Status.
ASPECTS: Alberta stroke program early computed tomography score; BI: Barthel index; FMA: Fugl-meyer assessment

Parameters	Side involved		p-value
	Left	Right	
ASPECTS	7.58	7.42	0.711
Barthel index	67.92	71.21	0.877
Fugl-Meyer assessment	56.17	63.52	0.918

[Table/Fig-7]: Correlation of side involved with ASPECTS , BI and FMA.

Prabhakar A and Kishore L, the median age of stroke patients was less than 60 years. This could be attributed to the increase in number of young adults presenting with stroke in recent years [12,17].

It was observed that higher ASPECTS (8-10) was associated with higher BI (>60) and FMA (>79) score suggesting that patients with favourable ASPECTS had less stroke severity and thus were more likely to be independent in ADL and have minimal motor impairment. There was significant positive correlation of ASPECTS with BI and FMA (p-value <0.0001) which was similar to the studies correlating ASPECTS with functional outcome [8,12-15,18,28,29].

The BI score was statistically significantly better in group with better ASPECTS (8-10) compared to worse ASPECTS (0-7) group and the mean BI score was 87.7±9.62 in patients with higher ASPECTS. This was similar to what was observed by Zanzmera P et al., who found that mean BI at three months poststroke was 84.33±13.90 [12]. Chatterjee D et al., also found good correlation between baseline ASPECTS and BI three months poststroke [18].

The average FMA score of patients with better ASPECTS (8-10) was 87.6 and those with worse ASPECTS (0-7) was 29.94. The correlation between ASPECTS and FMA score was statistically significant and interpreted that patients with better ASPECTS have better chances of recovery and less likely to have motor impairment in long-term. The patients who had a favourable ASPECTS could walk without support, whereas, those with a lower ASPECTS were either using wheelchair or were ambulating with support of assistive devices (p-value <0.0001). This implies that patients with higher ASPECTS at stroke onset have better ambulatory potential.

Hence, it can be said that 'better' ASPECTS has a significant association with better functional independence more than six months after stroke, also ASPECTS can be considered as a reliable tool for predicting the functional outcome of patients. Good prognostic value of higher ASPECTS may be explained by its association with good collateral blood flow allowing ischaemic brain tissue to survive for longer time periods and more chances of recanalisation and reperfusion which improves the outcome as observed by Hill MD et al., [14].

Limitation(s)

This study had its own limitations in the form of lack of comparison with the baseline motor and functional status.

CONCLUSION(S)

On the basis of present study, it can be concluded that ASPECTS has a good correlation with BI and FMA. Higher ASPECTS at stroke onset is associated with better functional and motor outcome in long-term. ASPECTS can be used to plan the rehabilitation interventions based on the expected recovery of the patients and set realistic goals on individual basis at an early stage to improve the functional outcome, preventing complications and help the stroke survivors to be more independent in the activities of daily living.

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