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Relationship of Alberta Stroke Program Early CT Score (ASPECTS) with the outcome of ischemic stroke and the neurocognitive stroke biomarkers

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Abstract

Background: Reliable and acceptable biomarkers are needed to anticipate the outcome and cognitive impairment following ischemic stroke. The goal of this research is to examine the association of ASPECTS with cognitive decline, biomarkers of stroke, and acute ischemic stroke outcomes. This study included 120 patients with ischemic stroke in the middle cerebral artery region. The initial NIHSS, non-contrast CT brain assessed by ASPECTS, and the biomarkers of cognitive decline such as ESR, CRP, S100B, MMP9, and glutamate were investigated. The Montreal Cognitive Assessment and modified Rankin scale (mRS) were evaluated after 3 months. Correlations between ASPECTS, MoCA, biomarkers of cognitive impairment, and mRS were done by Spearman correlation.

Results: The incidence of cognitive impairment in our patients was 25.8%. Stroke biomarkers (ESR, CRP, S100B, MMP9, and glutamate) were significantly increased in cognitively disabled individuals with significantly lower mean MoCA scores than in cognitively intact patients. There was a strong direct correlation linking the initial ASPECTS and total MoCA test score after 3 months follow-up. Cases with unfavorable outcomes were older, more incidence of hypertension, and had higher average initial NIHSS ($P < 0.05$). While the average ASPECTS scores for the favorable outcome group of patients were significantly higher and there was a significant negative correlation between the initial ASPECTS and modified Rankin Scale score.

Conclusions: ASPECTS is a reliable scale to identify the extent of acute ischemic injury and could participate in assessing the outcome. ASPECTS and particular neurocognitive stroke biomarkers will enable the early detection of post-stroke cognitive impairment.

Trial registration Registration of Clinical Trial Research: ClinicalTrials.gov ID: NCT04235920

Keywords: Stroke, ASPECTS, mRS, NIHSS, MoCA, Neurocognitive stroke biomarkers

Background

Strokes are known to be the third most frequent cause of death after cardiac and neoplastic disorders [1]. Moreover, stroke is a significant cause of mortality and morbidity all around the world. The effect of ischemic injury is so rapid because of the very few reserves of glucose inside the brain, the key energy material [2]. So far, the CT brain is considered to have been the examination of

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choice for diagnosing patients with acute ischemic stroke (AIS). With regard to adequate assessment in patients with acute ischemic stroke, brain CT is an easy, effective, appropriate and affordable tool [3]. The availability of the non-contrast CT brain to the initial evaluation makes it an effective neuroimaging marker to evaluate acute care outcomes [4, 5].

In order to assess the magnitude of early ischemic alterations in the brain, the Alberta Stroke Program Early Computed Tomography Score (ASPECTS) has been widely used [6], and was confirmed to anticipate neurological outcomes [7]. In specific, stroke cases with higher ASPECTS treated with thrombolytic therapy have better outcomes [8–10].

In AIS patients, the incidence of cognitive dysfunction is around 25% following 3 months of follow-up [11]. The measurement of cognitive functions by traditional neuropsychological methods after acute stroke is very controversial due to several factors that cause false interpretation of study results, such as the nature of medical status, apathy, depression, and anxiety disorders [12]. In order to predict the nature of its course and the effectiveness of treatment, reliable and acceptable biomarkers are therefore needed to anticipate the occurrence of post-stroke cognitive impairment [13, 14]. The purpose of our research is to examine the association of ASPECTS with cognitive decline, biomarkers of stroke, and acute ischemic stroke outcomes.

Methods

Study design and participants

This research was a prospective cross-sectional study that included 120 patients presented with AIS referred to the neurology department in the time from October 2019 and March 2020. One hundred and twenty patients were involved in this research, diagnosed with the first occurrence of acute MCA territorial ischemic infarction during 2 days from the initial symptoms and signs. AIS was identified as a quickly evolving neurological dysfunction with a recognized apparent onset, and an early brain CT with no ICH evidence. The exclusion criteria included infarction of the anterior or posterior cerebral arteries, venous sinuses infarctions, or prior strokes. Also patients with severe dysphasia or aphasia were excluded.

On admission

Clinical assessment

A history of vascular risk factors for all cases had been collected. Full general and neurological studies were performed. To measure the intensity of the stroke and the initial morbidity, early GCS and NIHSS were estimated. NIHSS was categorized into three categories: mild (0–5), moderate (6–15), and extreme (≥ 16) [15].

Neuroimaging evaluation

Every patient performs CT imaging by means of (16-Multi-slice GE, optima 520, China). For all cases, the initial non-contrast CT brain was performed after the onset and after 7 days. Images produced captured in the axial cut, 5-mm segments starting from the base up to the vertex, were used by all patients. The criteria for imaging were the following: 120 kVp, 320 mA, FOV of 195 mm, and table speed of 15 mm/rotation.

Laboratory investigations

Within 24 h of the onset of the stroke, blood samples were obtained for all patients. Basic laboratory tests such as full blood count, serum lipids, clotting pattern, liver and kidney functions, and fasting and postprandial glucose levels were performed. Also, biomarkers of cognitive decline such as ESR, S100B, MMP9, CRP and glutamate were assessed.

Image analysis

Image review was carried out by two neuroradiologists separately for evaluation of CT brain. For all patients, ASPECTS scoring was determined. CT brain images were analyzed for markings of parenchymal hypoattenuation, lack of grey and white matter distinction, and obscure sulci. ASPECTS offers accurate techniques for ischemic stroke assessment by using the "M1, M2, M3, M4, M5, M6, I: insula, IC: internal capsule, L: lentiform, and C: caudate" ten-point score, all representing one point (Fig. 1). A score of ten indicates a CT scan that is normal. To every affected region of the CT brain, one point is reduced. Therefore, a value of 0 indicates extensive ischemia in the MCA area [16].

Functional outcome in cases of stroke

In the following 3 months, functional outcome of stroke in each patient was assessed by the modified Rankin Scale. MRS is a widely used scale to assess impairment which can be used in patients with stroke as a prognostic tool and graded into seven outcomes ranging from no symptoms (0 scores) up to death (6 scores) [17].

Assessment of cognition

Montreal Cognitive Assessment (MoCA) Arabic form was utilized for the evaluation of cognitive functions of the studied participants [18]. This scale measures different domains of cognition and is a 30-point exam with a value of 25 or less is regarded as impaired cognitive functions [19]. Cases were grouped according to the MoCA score into two categories. The 1st group reported a cognitive disability test with a MoCA value

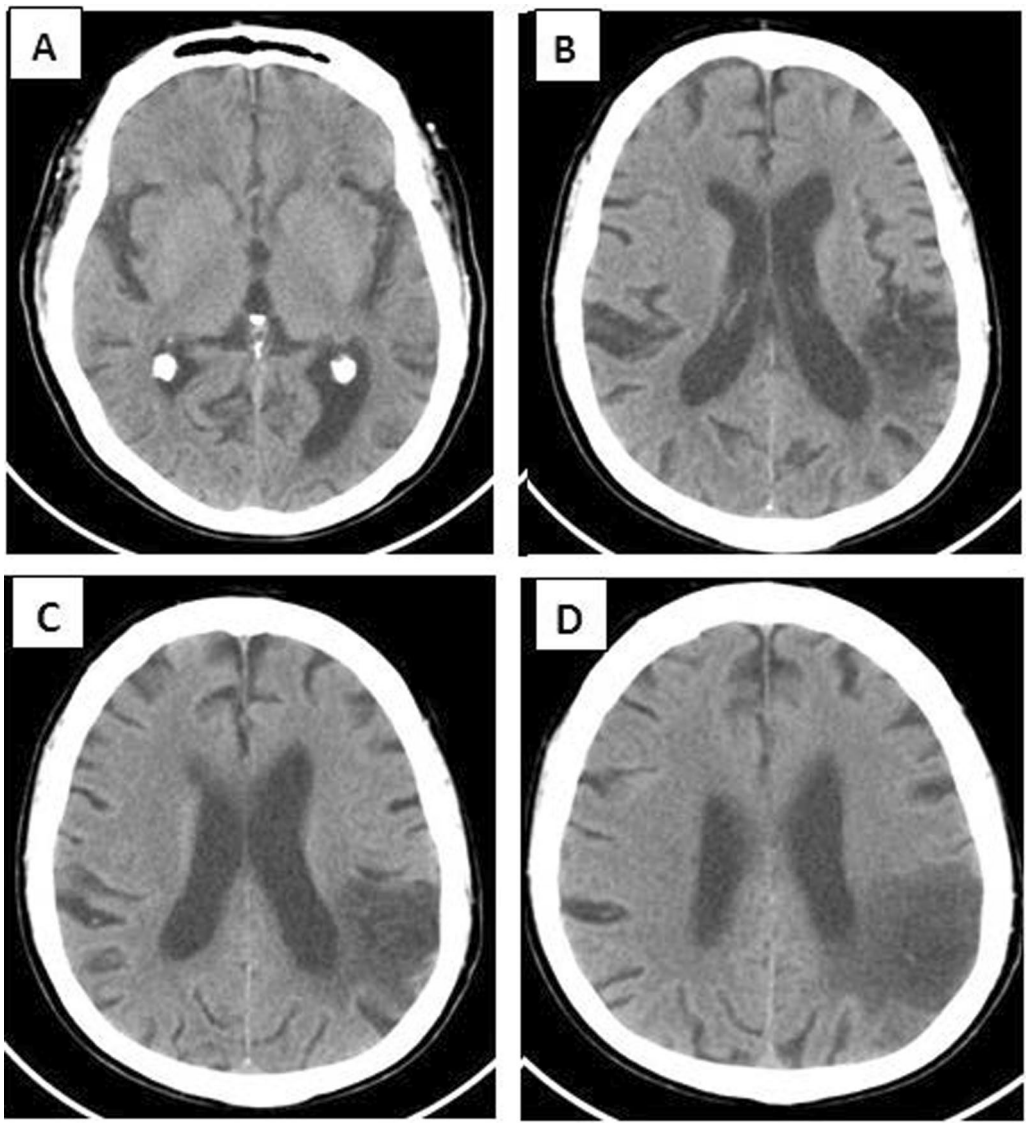

Fig. 1 **A**–**D** Sequential axial non-contrast CT images of the brain reveal a hypodense area of infarction at the left temporoparietal region (M5 and M6 regions); ASPECTS = 8

of 25 or less, and the 2nd group reported normal cognitive functions with a MoCA score over 25.

Statistical analysis

Data analysis was conducted using the Statistical Package of Social Science (SPSS) by IBM, Chicago, IL, USA, version 20, 2013 for Windows. Descriptive data were represented using numbers and percentages. Categorical variables were compared by the Chi-square test. Continuous variables have been shown as mean ± SD for parametric data and median for non-parametric data.

Spearman correlation was carried out for correlation between ASPECTS, stroke severity (initial NIHSS) domains of MoCA test, and biomarkers of cognitive impairment. Multivariate logistic regression analysis was carried out for the independent variables of cognitive impairment such as age, ASPECTS, initial INHSS, HTN and the biomarkers of cognitive decline such as ESR, CRP, S100B, MMP9, and glutamate were investigated. The collected data were analyzed using the SPSS Prism created.

Results

Clinical characters, initial NIHSS, and ASPECTS of ischemic stroke patients

One hundred and twenty patients were included in our research study, 63 males (52.5%) and 57 females (47.5%) with an average age of 62.68 ± 12.4. The frequent risk

Table 1 Clinical characters, initial NIHSS, and ASPECTS of ischemic stroke patients

Variable	All patients
Number	120
Age (Y)	62.68 ± 12.4
Male *N* (%)	63 (52.5%)
Hypertension *N* (%)	80 (66.7%)
DM *N* (%)	31 (25.8%)
Smoking *N* (%)	46 (38.3%)
Hyperlipidemia *N* (%)	18 (15%)
AF *N* (%)	20 (16.7%)
IHD *N* (%)	13 (10.8%)
Initial NIHSS (mean ± SD)	13.4 ± 6.9
ASPECTS (Mean ± SD)	7.11 ± 2.43

factors for ischemic stroke were hypertension (66.7%), smoking (38.3%), DM (25.8%), AF (16.7%), hyperlipidemia (15%), and ischemic heart disease (10.8%). The average initial stroke severity as determined by NIHSS was 13.4 ± 6.9 and the mean ASPECTS value was 7.11 ± 2.43 (Table 1).

Cognitive impairment in ischemic stroke patients

Of the ischemic stroke patients, 31 patients (25.8%) had diminished cognition, while 89 patients (74.2%) had preserved cognition. The average MoCA scores for cognitively disabled patients were considerably lower (21.72 ± 2.93 vs 26.02 ± 3.21, $P < 0.001$) than for cognitively intact patients. The mainly affected sub-items of MoCA were lower executive functions ($P = 0.005$), lower attention ($P = 0.04$), lower language ($P = 0.03$), and lower memory ($P = 0.02$). There were no significant differences between both groups of patients regarding educational level ($P = 0.9$). Patients with diminished cognitive ability were older ($P = 0.001$) and had no substantial difference in sex ($P = 0.76$). Also, the average ASPECTS score in the cognitively disabled group of patients was significantly lower (5.46 ± 3.84 vs 8.32 ± 1.33 and $P = 0.004$) than for the cognitively intact group of patients (Table 2).

Stroke biomarkers of cognitive impairment

In cognitively affected patients, there has been a substantial rise in stroke biomarkers (including ESR, CRP, S100B, MMP9, and glutamate) relative to cognitively preserved patients (Table 2). Significant inverse relations have been observed regarding ASPECTS and cognitive impairment biomarkers (except for glutamate) ($P < 0.05$) (Table 3).

Table 2 Biomarkers of cognitive impairment and MoCA test scores in patients with cognitive impairment compared with patients with preserved cognition

	Impaired cognition	Preserved cognition	*P* value
Number	31 (25.8%)	89 (74.2%)	
Age (Y)	66.87 ± 8.21	61.56 ± 6.87	$P = 0.001$
Gender (male)	17 (54.8%)	46 (51.7%)	$P = 0.76$
Education			
Illiterate	5 (16.1%)	14 (15.7%)	$P = 0.9$
Primary school	9 (29%)	22 (24.7%)	
Secondary school	6 (19.4%)	20 (22.5%)	
Tertiary school	5 (16.1%)	16 (18%)	
University education	6 (19.4%)	17 (19.1%)	
Biomarkers of cognitive impairment			
ESR	32.9 ± 28.5	18.7 ± 16.8	$P < 0.001$
CRP	7.1 ± 2.29	3.94 ± 1.1	$P < 0.01$
S100B	136 ± 39.24	95 ± 29.2	$P < 0.01$
MMP 9 ng/ml	417.5 ± 122	212.6 ± 79.8	$P < 0.01$
Glutamate nmol/l	1.412 ± 0.492	0.971 ± 0.374	$P < 0.01$
MoCA test scores			
Visual–spatial ability	3.17 ± 1.11	3.47 ± 1.08	$P = 0.39$
Naming	2.32 ± 0.57	2.42 ± 0.77	$P = 0.51$
Executive functions	2.42 ± 1.07	3.53 ± 0.96	$P = 0.005$*
Attention	4.34 ± 1.23	5.69 ± 1.34	$P = 0.04$ *
Language	3.41 ± 1.2	4.37 ± 1.34	$P = 0.03$*
Memory	3.08 ± 1.27	3.75 ± 1.43	$P = 0.02$*
Orientation	5.69 ± 0.3	6.09 ± 0.38	$P = 0.12$
Total MoCA score	21.72 ± 2.93	26.02 ± 3.21	$P < 0.001$
ASPECTS	5.46 ± 3.84	8.32 ± 1.33	$P = 0.004$

Correlation between MoCA, ASPECTS, and neurocognitive stroke biomarkers

In cognitively impaired patients, the aspects of language, attention, memory, and executive functions were significantly affected. But on the other hand, in cognitively disabled patients, the domains of visual–spatial ability, naming, and orientation were non-significantly reduced. Table 3 demonstrates significant inverse correlations linking mRS scores and MoCA test domains (executive functions, attention, memory, and language), as well as ASPECTS ($P < 0.001$ and $P = 0.002$, respectively). In addition, there was a significant inverse correlation linking values of MoCA test domains and most of the biomarkers of strokes ($P < 0.05$). Also, there were significant direct correlations linking ASPECTS and neurocognitive test domains ($P < 0.05$).

Table 3 Correlation between cognitive stroke biomarker, ASPECTS, and MoCA domains

	Executive functions	Memory	Language	Attention	ASPECTS	ESR	CRP	S100B	MMP9	Glutamate
Age										
r	−0.44	−0.37	−0.35	−0.33	−0.16	0.22	0.19	0.12	0.18	0.1
P	< 0.05	< 0.05	< 0.05	< 0.05	0.24	0.15	0.21	0.28	0.26	0.31
Modified Rankin Scale										
r	−0.81	−0.82	−0.80	−0.75	−0.73	0.63	0.53	0.49	0.55	0.45
P	< 0.001	< 0.001	< 0.001	< 0.002	0.002	0.005	0.009	0.01	0.007	0.02
Executive functions										
r	N A	0.79	0.8	0.78	0.73	−0.71	−0.61	−0.51	−0.47	−0.40
P	N A	< 0.001	< 0.001	0.001	0.002	0.004	0.006	0.009	0.01	0.04
Memory										
r	0.78	N A	0.75	0.72	0.62	−0.61	−0.60	−0.55	−0.51	−0.41
P	< 0.001	N A	< 0.001	0.003	0.006	0.006	0.005	0.007	0.009	0.04
Language										
r	0.80	0.75	N A	0.70	0.47	−0.51	−0.59	−0.50	−0.45	−0.32
P	< 0.001	< 0.001	N A	0.004	0.01	0.009	0.007	0.009	0.02	0.12
Attention										
r	0.78	0.72	0.70	N A	0.45	−0.47	−0.60	−0.49	−0.49	−0.30
P	< 0.001	0.003	0.004	N A	0.02	0.01	0.005	0.01	0.01	0.13
ASPECTS										
r	0.73	0.62	0.47	0.45	N A	−0.75	−0.51	−0.40	−0.39	−0.29
P	0.002	0.006	0.01	0.01	N A	< 0.001	0.009	0.04	0.04	0.14
ESR										
r	−0.71	−0.61	−0.51	−0.47	−0.75	N A	0.79	0.44	0.41	0.40
P	0.004	0.006	0.009	0.01	< 0.001	N A	< 0.006	0.01	0.03	0.04
CRP										
r	−0.61	−0.60	−0.60	−0.60	−0.41	0.45	N A	0.42	0.45	0.41
P	0.006	0.005	0.005	0.005	0.03	0. 01	N A	0.03	0.01	0.04
S100B										
r	−0.51	−0.55	−0.50	−0.49	−0.40	0.44	0.42	N A	0.41	0.39
P	0.009	0.007	0.009	0.01	0.04	0.01	0.03	N A	0.03	0.04
MMP9										
r	−0.47	−0.51	−0.45	−0.49	−0.39	0.41	0.45	0.43	N A	0.35
P	0.01	0.009	0.02	0.01	0.04	0.03	0.01	0.02	N A	0.11

Table 3 (continued)

	Executive functions	Memory	Language	Attention	ASPECTS	ESR	CRP	S100B	MMP9	Glutamate
Glutamate										
r	−0.40	−0.41	−0.32	−0.30	−0.29	0.40	0.41	0.39	0.35	N A
P	0.04	0.04	0.12	0.13	0.14	0.04	0.04	0.04	0.11	N A

Outcome of ischemic stroke patients

According to mRS, our cases were divided into two groups: the first one includes 82 patients (68.4%) who had favorable outcomes (mRS 0–2), while 38 patients (31.6%) had poor outcomes. Patients with poor outcomes were older ($P=0.001$), more incidence of hypertension ($P=0.001$), and had no significant difference in sex ($P=0.76$). The average initial NIHSS for the favorable outcome group of patients was considerably lower than for the poor outcome group of patients (11.23 ± 5.53 vs 17.81 ± 7.65, and $P<0.001$). While the average ASPECTS score for the favorable outcome group of patients was higher than for the unfavorable outcome group of patients (8.12 ± 1.76 vs 5.85 ± 2.47, and $P=0.001$) (Table 4).

Correlation of ASPECTS with MoCA, and outcome after 3 months of ischemic stroke

There was a strong positive correlation between the initial ASPECTS and total MoCA test score after 3 months follow-up from the onset of ischemic stroke ($r=0.69$ and $P=0.003$) as shown in Fig. 2a. Lower values of ASPECTS were accompanied by significantly poor outcomes compared to higher values of ASPECTS in the form of a significant negative correlation between the initial ASPECTS and modified Rankin Scale score after 3 months follow-up from the onset of ischemic stroke ($r=0.39$ and $P=0.04$) as shown in Fig. 2b.

Correlation of the site of lesion with the cognitive decline (dominant or non-dominant hemisphere)

According to hemispheric dominance, patients with dominant hemisphere infarction showed significantly lower MoCA scores in comparison to patients with non-dominant hemispheric infarction (22.13 ± 4.97 vs 24 ± 3.84, $P=0.04$), as shown in Fig. 3.

The independent variables of cognitive impairment

Lastly, the logistic regression analysis revealed that older age and ESR (OR 2.51, $P<0.001$ and OR 2.33, $P<0.001$, respectively) were the independent variables related with cognitive decline, followed by NIHSS (OR 2.23, $P=0.001$). ASPECTS and HTN also were linked with cognitive decline to a lesser extent (OR 2.12, $P=0.005$ and OR 2.11, $P=0.005$, respectively). Other biomarkers of cognitive decline such as CRP, S100B, MMP9, and glutamate were less significantly associated with cognitive decline ($P<0.01$) (Table 5).

Discussion

A rapid assessment of the clinical and radiological findings is needed for acute ischemic stroke (AIS). The ability to differentiate an acute CT infarction is beneficial in verifying the interpretation of acute stroke diagnosis [20].

Risk factors of acute ischemic stroke

In the current study, hypertension (66.7%), smoking (38.3%), DM (25.8%), AF (16.7%), hyperlipidemia (15%), and ischemic heart disease were common risk factors for stroke (10.8%). The analysis of Amelia et al. 2107 and Mahdi et al. 2018 is more or less identical to these results [21, 22]. In addition, multiple reports agree with our findings on standard risk factors like hypertension, diabetes mellitus, hyperlipidemia and smoking in about 80% of stroke patients [23–25].

ASPECTS, stroke severity and the outcome of acute ischemic stroke

In our research, the ASPECTS score showed a negative relationship with the initial NIHSS that was close to the findings of David et al. 2005 reported a strong, linear, inverse relationship linking the initial NIHSS and ASPECTS; and each increase of ten points on initial NIHSS accompanied by a decrease of around 3 points on ASPECTS [26]. Additionally, Prabhakar and Kishore 2015 confirmed the ASPECT value's ability to anticipate the outcomes as measured by the NIHSS using CT scans through ASPECTS will also contribute to the prediction of the outcome of the stroke and the treatment of the stroke [27]. Subsequently, a better prognosis was correlated with patients with a score of more than seven in CT ASPECTS [28].

Our study revealed that substantial poor outcome results and higher mRS scores were correlated with older age, hypertension, high NIHSS, and decreased ASPECTS. In terms of favorable and unfavorable outcomes, sex, diabetes mellitus, dyslipidemia, IHD, and smoking did not differ significantly. Also, higher mRS, male, higher age, DM, smoking, HTN, AF, and depression were significant indicators of poor outcome in a large Swedish study of 15,959 stroke patients [29]. The much more significant factor affecting early and late outcomes is probably the severity of stroke on the clinical assessment. In general, in contrast to minor strokes accompanied by lesser initial NIHSS and higher ASPECTS, severe strokes with extreme initial NIHSS and lower ASPECTS have unfavorable outcomes [30].

Cognitive impairment in acute ischemic stroke

The incidence of cognitive impairment in our patients was 25.8%. In cognitively affected patients, there has been a substantial rise in stroke biomarkers (including

Table 4 Correlation between stroke outcome according to mRS after 3 months and risk factors, initial NIHSS, and ASPECTS

Variable	Favorable outcomes	Poor outcomes	*P* value
MRS	0–2	3–6	*P* value
Number	82 (68.4%)	38 (31.6%)	
Age (years)	60.23 ± 6.74	67.6 ± 8.43	***P* = 0.001**
Male	41 (50%)	22 (57.8%)	*P* = 0.725
Hypertension	46 (56.1%)	34 (89.5%)	***P* = 0.001**
DM	20 (24.4%)	11 (28.9%)	*P* = 0.511
Smoking	32 (39%)	14 (36.8%)	*P* = 0.729
Hyperlipidemia	11 (13.4%)	7 (18.4%)	*P* = 0.654
AF	13 (15.9%)	7 (18.4%)	*P* = 0.749
IHD	8 (9.7%)	5 (13.2%)	*P* = 0.778
Initial NIHSS	11.23 ± 5.53	17.81 ± 7.65	***P* < 0.001**
ASPECTS	8.12 ± 1.76	5.85 ± 2.47	***P* = 0.001**

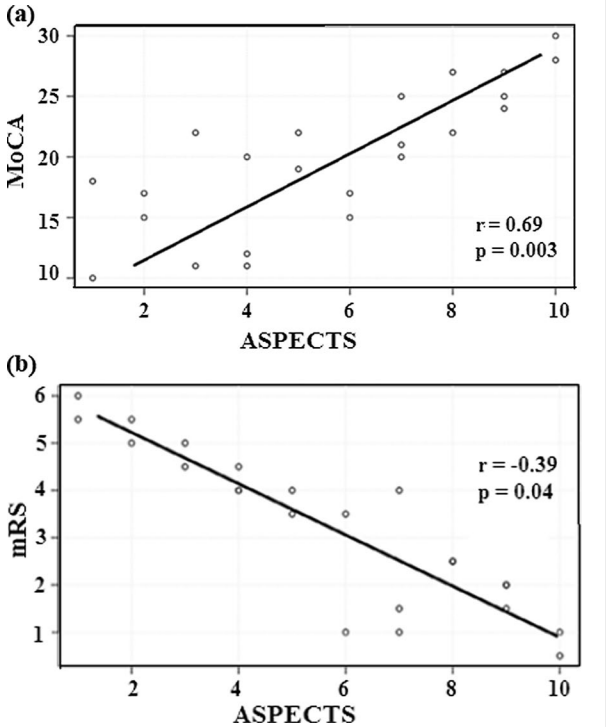

Fig. 2 **a** Correlation of ASPECTS and MoCA. **b** Correlation of ASPECTS and mRS

ESR, CRP, S100B, MMP9, and glutamate) relative to cognitively preserved patients. Significant inverse relations have been observed regarding ASPECTS and cognitive impairment biomarkers (except for glutamate). The ASPECTS may be accompanied by serum and circulating blood biomarkers that indicate and clarify the pathophysiological reaction of the brain to the ischemic injury [31, 32]. The Zhong et al. [33]s study of 558 ischemic stroke

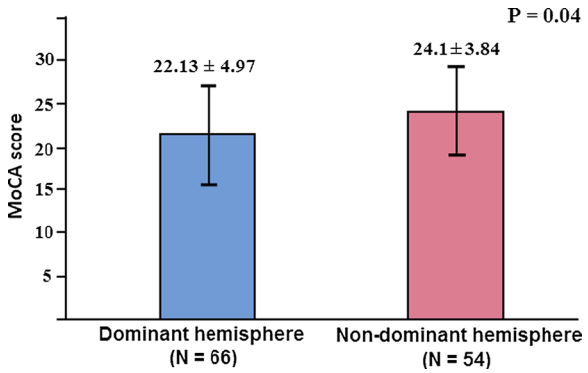

Fig. 3 Correlation of the site of lesion with the domain of cognitive decline

Table 5 Multivariate logistic regression analysis for the independent variables of cognitive impairment

Variables	O R	95% CI	*P*
Age	2.51	1.91–3.24	*P* < 0.001
HTN	2.11	1.37–2.67	*P* = 0.005
NIHSS	2.23	1.62–2.84	*P* = 0.001
ASPECTS	2.12	1.42–2.73	*P* = 0.005
ESR	2.33	1.76–3.11	*P* < 0.001
CRP	1.89	1.42–2.43	*P* < 0.01
S100B	1.77	1.14–2.22	*P* < 0.01
MMP 9 ng/ml	1.65	1.03–2.12	*P* < 0.01
Glutamate nmol/l	1.79	1.21–2.31	*P* < 0.01

patients found that elevated matrix metalloproteinase-9 was associated with impairment of cortical functions. Increased MMP 9 promotes hematoencephalic barrier proteolysis and resulting in diffuse damage to the white matter of the brain [34]. Numerous researches have shown that there is a correlation regarding post-stroke cognitive impairment and C-reactive protein serum levels and ESR [35]. Excitotoxicity is a specific neuronal cell injury mechanism induced by hyperproduction of excitatory neurotransmitter [36]. Glutamate is a primary and exciting transmitter of many cognitive abilities, particularly the memory trail [37]. Leaks of neuron-specific components into liqueur and plasma are caused by acute ischemic brain damage [38]. Protein S100B is among the most researched neuro-specific biomarkers [39]. Christl et al. [40], indicated that CSF S100B could have a cognitive dysfunction diagnostic value, particularly at early phases of AD. Several logistic regression analyses revealed that the concentration of serum S100B was a statistically significant separate cognitive impairment marker [41].

Correlation of ASPECTS and cognition

A clear negative association regarding neurocognitive test scores (executive functions, attention, memory, and language) and stroke biomarkers ($P<0.05$) was observed in our results. The identification of biomarkers in blood serum, plasma and cerebrospinal fluid (CSF) could also enhance the diagnostic and prognostic reliability of post-stroke cognitive impairment [42]. Important negative associations between ASPECTS and cognitive disability biomarkers and positive significant relationships among ASPECTS and neurocognitive test domains were also found. One of the main complications following a stroke is post-stroke cognitive dysfunction, which is a subcategory of vascular cognitive impairment. Stroke has been expected to enhance cognitive impairment vulnerability by about five to eight times [43]. A large number of studies have already shown that in patients with stroke, cognitive performance can be used as a functional outcome predictor [44]. Hence, it is especially important for the diagnosis, treatment, and prognosis of post-stroke cognitive dysfunction, and has received a lot of attention among various researchers all over the world.

Correlation of the site of lesion with the cognitive decline

According to hemispheric dominance, patients with dominant hemisphere infarction showed significantly lower MoCA scores in comparison to patients with non-dominant hemispheric infarction. These findings were similar to those of Chan et al. [45] who discovered that poor performance on the MoCA test by dominant cerebral hemisphere ischemic stroke patients likely reflects the MoCA test's reliance on both receptive and expressive language abilities, as well as verbal memory capacities.

Conclusions

ASPECTS is a convenient, easy-to-use and reliable scale to identify the extent of acute ischemic injury and can participate in assessing the outcome of acute ischemic stroke. Along with the findings of neuropsychological tests, ASPECTS and particular biomarkers of cognitive impairment will enable the early detection of post-stroke cognitive impairment. Therefore, the effective use of cognitive impairment treatment and preventive drugs would be suggested.

Abbreviations

AF: Atrial fibrillation; AIS: Acute ischemic stroke; ASPECTS: Alberta Stroke Program Early CT Score; CRP: C-reactive protein; CSF: Cerebrospinal fluid; CT: *Computed tomography*; DM: Diabetes mellitus; ESR: Erythrocyte sedimentation rate; GCS: Glasgow Coma Scale; HTN: Hypertension; ICH: Intracerebral hematoma; IHD: Ischemic heart disease; MCA: Middle cerebral artery; MMP9: Matrix metalloproteinase 9; MoCA: Montreal Cognitive Assessment; mRS: Modified Rankin Scale; NIHSS: *National Institutes of Health Stroke Scale*; SPSS: Statistical Package of Social Science.

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None.

Authors' contributions

AE, ME, MA, and MF made substantial contributions to the study and participated in its design, acquisition, analysis, and interpretation of data. AA and NT participated in the analysis and interpretations of the radiological findings. SS participated in the analysis and interpretations of the study and the revisions of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated and analyzed during the current study are not publicly available due to institutional limitations, yet they are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration. Informed written consent was obtained from all individual participants included in the study. This study was approved by Mansoura Faculty of Medicine Institutional Research Board ("MFM-IRB"). Proposal Code: R.19.09.606—2019/09/04.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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