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ORIGINAL ARTICLE

Accuracy of Alberta stroke program early computed tomography score (aspects) as a predictor of outcomes in acute ischemic stroke patients.

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ABSTRACT… Objective: To evaluate the diagnostic accuracy of ASPECTS in determining the outcomes (good versus poor) among AIS patients by taking Modified Rankin Score (MRS) as gold standard. **Study Design:** Validation study. **Setting:** Department of Radiology, Shifa International Hospital, Islamabad. **Period:** July 2025 to November 2025. **Methods:** A total of 646 patients aged 18–65 years with middle cerebral artery territory acute ischemic stroke who underwent NCCT within two days of symptom onset were included using consecutive sampling. ASPECTS was calculated on NCCT and categorized as good (8–10) or poor (0–7). Functional outcome was assessed at discharge using the modified Rankin Scale, classified as good (0–3) or poor (4–6). DA parameters including sensitivity, specificity, PPV, NPV, and receiver operating characteristic (ROC) curve analysis were calculated using SPSS version 25. **Results:** Out of 646 patients, 53.3% had good ASPECTS scores, while 63.3% achieved good functional outcomes. Using an ASPECTS cutoff of ≥8, sensitivity was 73.1%, specificity 81.0%, PPV 86.9%, and NPV 63.6%. The overall diagnostic accuracy was 76.0%. The area under the ROC curve was 0.79, indicating good discriminative ability of ASPECTS in predicting functional outcomes. **Conclusion:** ASPECTS is a reliable and clinically useful imaging tool for early prediction of functional outcomes in acute ischemic stroke. Its good diagnostic accuracy, ease of application, and reliance on widely available NCCT make it particularly valuable for early stroke assessment, especially in resource-limited settings.

Key words: Acute Ischemic Stroke, ASPECTS, Diagnostic Accuracy, Modified Rankin Scale, Non-contrast CT.

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INTRODUCTION

Acute ischemic stroke (AIS), also known as a cerebrovascular accident, is the second leading cause of death in the world and ranks third on the list of the most common causes of disability by prevalence. Ischemic strokes account for approximately 80 % of all strokes, almost all of which are brought on by cerebral ischemia brought on by arterial blockage.[1] The increasing incidence of AIS globally is attributed to risk factors such as smoking, hypertension diabetes mellitus and other factors.[2] Stroke is becoming more common in the developing nations, like Pakistan, posing a significant threat to public health. Reports suggests that the 30-day death rate for AIS is over 15%, highlighting the need for earlier screening and treatment.[3] A 1.2% prevalence of stroke was reported in the study focusing on the Khyber Pakhtunkhwa province of Pakistan.[4]

For the diagnosis and treatment of AIS, imaging methods are essential to predict accurate results. Because of its affordability and quick availability, non-contrast computed tomography (NCCT) is still the gold standard for the initial assessment of strokes. A 10-point grading system called the Alberta Stroke Program Early Computed Tomography Score (ASPECTS) was created to identify early ischemia alterations on NCCT and support clinical decision-making.[5] The incorporation of ASPECTS into the guidelines of American Heart Association (AHA) has been done as a selection criterion for endovascular treatment. This follows the recommendation of patients with an ASPECT score of ≥6 are eligible for thrombectomy if they present within 6 hours of symptom onset.[6]

One of the major advantages of ASPECTS is its ability to facilitate rapid triage of AIS patients without the need for advanced imaging techniques such as

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magnetic resonance imaging (MRI).[7] Additionally, it plays a crucial role in detecting hyperacute infarcts and predicting functional outcomes in stroke patients. Studies have shown that patients with higher ASPECTS scores tend to have better neurological outcomes and lower mortality rates compared to those with poor scores.[8] ASPECTS achieved a sensitivity of 73% and specificity of 81% in detecting early ischemic changes keeping modified rankin scale as gold standard. Prevalence of good outcomes was found to be 63.3% and prevalence of bad outcomes was found to be 33.7%.[1] However, it has certain limitations, including its restriction to anterior circulation strokes, potential interobserver variability, and challenges in detecting subtle early ischemic changes on NCCT. Variability in lesion volume despite identical ASPECTS scores can also influence treatment decisions, potentially leading to inappropriate patient exclusion from thrombectomy.[9]

Due to the escalating burden of AIS in Pakistan, stroke management through evidence-based approach becomes necessary. Even though ASPECTS has been widely used in clinical settings, there are no studies focusing on its predictive nature for stroke outcomes in Pakistan. This study aims to examine the prognostic ability of ASPECTS in determining outcomes among AIS patients in a local population.

METHODS

This validation study was conducted in the Department of Radiology, Shifa International Hospital, Islamabad, over a period of Five months (July to November'25) following approval of the synopsis by the CPSP and the Institutional Review Board (Ref No: IRB # 087-25, Dated: 26-June-2025). Consecutive sampling technique was employed. A total sample size of 646 patients was calculated using an online diagnostic test sample size calculator for sensitivity and specificity, assuming a sensitivity of 0.73, specificity of 0.81, prevalence of good outcome as 63.3%, precision of 0.05, and a confidence level of 95%.[1]

Patients of both genders aged between 18 and 65 years who presented to Shifa International Hospital, Islamabad, and underwent non-contrast computed tomography (NCCT) of the brain within two days of onset of AIS involving the middle cerebral artery (MCA) territory were included in the study. Patients with firearm or other penetrating injuries, significant extra-cranial injuries, history of alcohol intake, recent brain surgery or brain tumor, recurrent stroke, psychiatric illness, or dementia were excluded.

It was determined that a localized neurological impairment of sudden onset that lasted for more than twenty-four hours constituted the operational definition of an acute ischemic stroke. This deficit was caused by cerebral infarction that was caused by arterial blockage. The diagnosis was confirmed on NCCT based on early ischemic changes including hypodensity suggestive of cytotoxic edema, loss of gray–white matter differentiation, cortical swelling, and sulcal effacement.

All included patients underwent NCCT brain imaging in the Radiology Department using a TOSHIBA Aquilion RXL 16-slice CT scanner. Imaging was performed in the supine position following a standard non-contrast brain protocol. Early ischemic changes were assessed using the ASPECTS, which is a standardized 10-point scoring system applied to the MCA territory. The MCA territory was divided into ten regions evaluated on two axial CT sections, one at the level of the basal ganglia and the other at the level of the thalamus. A score of 10 indicated no ischemic changes, while a score of 0 represented complete infarction of the MCA territory. For the purpose of this study, ASPECTS scores of 8–10 were categorized as good, whereas scores of 0–7 were categorized as poor.

Outcome assessment was performed using the Modified Rankin Scale (MRS), a seven-point scale ranging from 0 to 6, which was used to evaluate functional disability at the time of discharge. Scores of 0 to 3 were classified as good outcomes, while scores of 4 to 6 were categorized as poor outcomes, as detailed in Annexure I. Patients were followed during their hospital stay until discharge or expiry, and outcome data were recorded accordingly.

Study participants were recruited from the Radiology Department after meeting the inclusion criteria. The procedure and benefits of the study were explained to the attendants of eligible patients, and written

informed consent was obtained prior to enrollment (Annexure II & III). Demographic information including age and gender, along with clinical details, CT scan findings, and outcome measures, were recorded on a specially designed proforma (Annexure IV). Assessment of CT images was performed independently by the principal investigator and a consultant radiologist, both of whom were adequately trained prior to commencement of the study.

After review from board at Shifa International Hospital, Islamabad, data collection was started. Patient confidentiality was maintained by anonymizing all collected data, which were securely stored. The study posed no additional risk to participants, as CT imaging was part of routine clinical evaluation. Participants retained the right to withdraw from the study at any stage without any consequences.

Data were entered and analyzed using the Statistical Package for Social Sciences (SPSS) version 25. Qualitative variables included gender and comorbidities such as diabetes mellitus, hypertension, smoking status, and ischemic heart disease, while quantitative variables included age, Glasgow Coma Scale (GCS) score, Modified Rankin Scale score, ASPECTS score, and total duration of hospital stay.

Qualitative variables were presented as frequencies and percentages, whereas quantitative variables were expressed as mean ± standard deviation for normally distributed data or median with interquartile range for non-normally distributed data. Diagnostic accuracy of ASPECTS was evaluated using receiver operating characteristic (ROC) curve analysis, taking MRS as the gold standard. A 2 × 2 contingency table was constructed to calculate sensitivity, specificity, PPV, and NPV.

RESULTS

A total of 646 patients with acute ischemic stroke were included in the study. The clinical characteristics and vascular risk factors of the patients are presented in Table-I. Diabetes mellitus was present in 105 (16.3%) patients, while 127 (19.7%) had hypertension. A history of smoking was noted in 240 (37.2%) patients. Ischemic heart disease was observed in 69 (10.7%) patients, whereas the majority 577 (89.3%) had no documented ischemic cardiac disease.

The distribution of ASPECTS categories and functional outcomes is shown in Table-II. Based on ASPECTS, 344 (53.3%) patients were classified as having good scores (8–10), while 302 (46.7%) had poor scores (0–7). Functional outcome assessment using the modified Rankin Score revealed that 409 (63.3%) patients achieved a good functional outcome (MRS 0–3), whereas 237 (36.7%) had a poor outcome (MRS 4–6).

The diagnostic performance of ASPECTS in predicting functional outcome is illustrated in the 2×2 contingency table (Table-III). Among patients with good ASPECTS scores, 299 (86.9%) achieved a good functional outcome (true positives), while 45 (13.1%) had a poor outcome (false positives). Conversely, among patients with poor ASPECTS scores, 192 (63.6%) had a poor outcome (true negatives) and 110 (36.4%) achieved a good outcome (false negatives).

The derived diagnostic accuracy parameters are summarized in Table-IV. Using an ASPECTS cutoff of ≥8, the sensitivity was 73.1% and specificity 81.0%. The PPV was 86.9%, while the NPV was 63.6%. The overall diagnostic accuracy was 76.0%. The positive likelihood ratio and negative likelihood ratio were 3.85 and 0.33, respectively, indicating good discriminative ability of ASPECTS.

The descriptive statistics of continuous variables are presented in Table-V. The mean age of the patients was 52.83 ± 8.76 years. The mean onset-to-CT time was 1.05 ± 0.67 days. The mean Glasgow Coma Scale score at presentation was 12.79 ± 2.15, while the mean modified Rankin Score was 2.73 ± 1.77. The average duration of hospital stay was 5.49 ± 2.80 days.

Values are presented as number (row percentage). TP = true positive; FP = false positive; TN = true negative; FN = false negative. ASPECTS ≥8 was considered a positive test result. Good functional outcome was defined as modified Rankin Score (MRS) 0–3.

TABLE-I

Clinical and risk factor profile of patients (N = 646)

Variable	Category	Frequency (n)	Percentage (%)
Diabetes Mellitus	Yes	105	16.3
	No	541	83.7
Hypertension	Yes	127	19.7
	No	519	80.3
Smoking	Yes	240	37.2
	No	406	62.8
Ischemic Heart Disease	Yes	69	10.7
	No	577	89.3

TABLE-II

Aspects classification and functional outcome (N = 646)

Variable	Category	Frequency (n)	Percentage (%)
ASPECTS Category	Good (8–10)	344	53.3
	Poor (0–7)	302	46.7
Functional Outcome (MRS)	Good (0–3)	409	63.3
	Poor (4–6)	237	36.7

TABLE-III

Diagnostic classification of aspects compared with functional outcome

ASPECTS Category	Good Outcome (MRS 0–3)	Poor Outcome (MRS 4–6)	Total
Good (8–10)	299 (TP, 86.9%)	45 (FP, 13.1%)	344 (100%)
Poor (0–7)	110 (FN, 36.4%)	192 (TN, 63.6%)	302 (100%)
Total	409 (63.3%)	237 (36.7%)	646 (100%)

DISCUSSION

In this validation study included 646 patients with acute ischemic stroke, 53.3% exhibited favourable ASPECTS scores (8–10), and 63.3% attained positive functional outcomes (modified Rankin Score 0–3). With an ASPECTS cutoff of ≥8, the sensitivity for predicting a favourable functional outcome was 73.1%, the specificity was 81.0%, the PPV was 86.9%, and the NPV was 63.6%. This means that the total DA was 76.0%. 86.9% of patients with strong ASPECTS ratings had true positives, whereas 63.6% of patients with bad ASPECTS scores had bad outcomes.

TABLE-IV

Diagnostic accuracy measures of aspects (Cut-Off > 8)

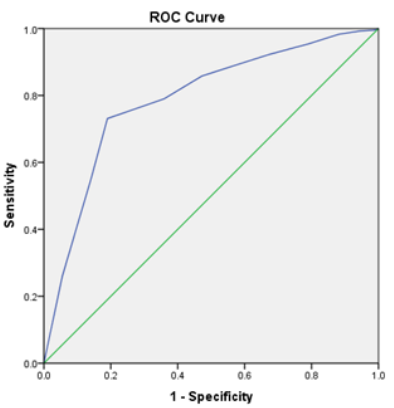
Measure	Formula	Value
Sensitivity	TP / (TP + FN)	73.1%
Specificity	TN / (TN + FP)	81.0%
Positive Predictive Value (PPV)	TP / (TP + FP)	86.9%
Negative Predictive Value (NPV)	TN / (TN + FN)	63.6%
Overall Accuracy	(TP + TN) / Total	76.0%
False Positive Rate (FPR)	FP / (FP + TN)	19.0%
False Negative Rate (FNR)	FN / (FN + TP)	26.9%
Positive Likelihood Ratio LR+)	Sensitivity / (1 – Specificity)	3.85
Negative Likelihood Ratio (LR-)	(1-Sensitivity) / Specificity	0.33

TABLE-V

Descriptive statistics of continuous variables (N = 646)

Variable	Mean ± SD	Range
Age (years)	52.83 ± 8.76	18–65
Onset to CT time (days)	1.05 ± 0.67	0–2
Glasgow Coma Scale (GCS)	12.79 ± 2.15	3–15
Modified Rankin Score (MRS)	2.73 ± 1.77	0–6
Hospital stay (days)	5.49 ± 2.80	1–21

FIGURE-1



Diagonal segments are produced by ties.

The receiver operating characteristic (ROC) are demonstrates the diagnostic performance oft& ASPECTS score forpredictinggood finicticral outcome (modified Rankin Score 0-3). The curve lies well above the reference diagonal line, indicating good discriminatory ability. The area under the curve (AUC)was 0.790, reflecting a strong capacity of ASPECTS to differentiate between patients with favorable and unfavorable outcomes. An ASPECTS cutoff value of N provided an optimal balance between sensitivity (73.1%) and specificity (81.0%).

The ROC curve's area was 0.79, which means it was good at telling the difference between groups. The average age of the patients was 52.83 ± 8.76 years, the average time from onset to CT was 1.05 ± 0.67 days, the average Glasgow Coma Scale score was 12.79 ± 2.15, and the average length of stay in the hospital was 5.49 ± 2.80 days.

The observed association between higher ASPECTS scores and improved functional outcomes is consistent with existing evidence.[10] Esmael et al[11] reported a significant inverse relationship between ASPECTS and mRS scores, demonstrating that lower ASPECTS values were associated with worse functional and cognitive outcomes at follow-up. Their findings support the role of ASPECTS as a surrogate marker of infarct burden and neurological reserve, closely aligning with the results of the present study.

The diagnostic performance parameters observed in this study are comparable to previously published literature. Sensitivity and specificity values reported in international cohorts generally range between 65–80% and 75–85%, respectively. A critical review by Schröder and Thomalla[12] highlighted that ASPECTS remains a robust prognostic imaging tool when applied in the hyperacute phase, despite limitations related to lesion volume variability and interobserver interpretation. Similarly, Nagel et al[7] demonstrated that automated e-ASPECTS software performs non-inferiorly to expert neuroradiologists, reinforcing the reproducibility and clinical reliability of ASPECTS scoring.

The modified Rankin Scale was used as the reference outcome measure in this study due to its widespread acceptance in stroke research. However, variability in interobserver agreement has been a recognized limitation. A systematic review by Quinn et al[13] reported moderate inter-rater reliability for conventional mRS assessments, with significant improvement observed when structured interviews were used. Likewise, a comprehensive review by Banks and Marotta[14] confirmed that while the mRS demonstrates strong construct and convergent validity, its reliability is highly dependent on assessor training and standardized assessment methods. In the present study, outcome assessment was conducted by trained clinicians using predefined criteria, which likely minimized scoring variability.

Recent literature emphasizes the importance of patient-centered outcome assessment beyond ordinal disability scales. Delfino et al[15] introduced the concept of utility-weighted mRS, demonstrating that different mRS categories correspond to markedly different health-related quality-of-life values. These findings underscore the clinical relevance of early imaging-based predictors such as ASPECTS, as accurate early prognostication may influence not only survival but also long-term quality of life and rehabilitation strategies.

The strengths of the present study include its substantial sample size, standardized imaging protocol, and inclusion of common vascular risk factors, enhancing generalizability. Importantly, reliance on non-contrast CT makes the findings particularly applicable to resource-limited settings, where advanced imaging modalities may not be readily available. ASPECTS offers a rapid, cost-effective, and reproducible tool for early stroke triage in such environments.

Several limitations should be acknowledged. ASPECTS is limited to anterior circulation strokes and may not fully capture posterior circulation ischemia. Subtle early ischemic changes on NCCT remain susceptible to observer variability. Additionally, functional outcomes were assessed at discharge rather than at longer follow-up intervals, which may not reflect delayed neurological recovery or deterioration.

Future research should focus on integrating ASPECTS with clinical severity scores, automated imaging tools, and longer-term functional and cognitive outcomes. The incorporation of structured mRS assessments and patient-centered outcome measures may further refine prognostic models and enhance clinical applicability.

CONCLUSION

ASPECTS is a reliable and clinically valuable imaging tool for early prediction of functional outcomes in acute ischemic stroke. Its good diagnostic accuracy, ease of use, and compatibility with standardized

outcome measures support its continued use in routine clinical practice.

LIMITATION

The present study has several limitations that should be considered when interpreting the findings. First, ASPECTS is restricted to anterior circulation strokes and may not adequately represent posterior circulation ischemia, limiting the generalizability of results to all stroke subtypes. Second, subtle early ischemic changes on non-contrast CT are prone to interobserver variability, which may affect scoring accuracy despite assessments being performed by trained readers. Third, functional outcomes were assessed only at the time of discharge rather than at longer follow-up intervals, which may not capture delayed neurological recovery or deterioration. Additionally, variability in infarct volume despite identical ASPECTS scores could influence outcome prediction and treatment decisions. Finally, being a single-center study, the results may not be fully generalizable to other populations or healthcare settings.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Amna Mehboob:** Data collection, paper writing.
2	**Madiha Saeed Wahla:** Data collection.
3	**Namrah Khalid:** Literature review.
4	**Muhammad Qaisar Iqbal:** Data analysis.
5	**Nasir Khan:** Review of manuscript.
6	**Muhammad Amjad:** Discussion writing.