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Clinical Risk Factors and In-Hospital Scoring Systems for Detection of Large Vessel Occlusion in Anterior Circulation Acute Ischemic Stroke: A Comparative Study

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ABSTRACT

Background: Anterior circulation large vessel occlusion (LVO) accounts for a substantial proportion of morbidity in acute ischemic stroke and requires rapid identification to enable timely endovascular therapy. Bedside clinical scales may aid early detection, particularly where immediate vascular imaging is limited. Hence, we aimed to evaluate clinical risk factors for anterior circulation LVO and compare the diagnostic performance of the National Institutes of Health Stroke Scale (NIHSS) and the GAI_2AA (Gaze deviation, aphasia, inattention, arm weakness, atrial fibrillation) score in an in-hospital acute ischemic stroke cohort.

Methodology: This observational study included 168 consecutive adults with acute ischemic stroke admitted to a tertiary care centre between January 2025 and October 2025. All patients underwent baseline NIHSS assessment and vascular imaging with CT or MR angiography. GAI_2AA scores were derived from documented clinical findings. Diagnostic accuracy metrics and receiver operating characteristic (ROC) analyses were performed.

Results: LVO was identified in 55 patients (33%). LVO was associated with older age as well as a history of smoking and prior cerebrovascular events. At optimal cutoffs, $GAI_2AA \geq 3$ demonstrated sensitivity of 78% and specificity of 81%, outperforming NIHSS ≥ 8, which showed higher sensitivity (87%) but lower specificity (58%). GAI_2AA had superior discriminative ability (AUC 0.92 vs. 0.78). Gaze deviation was the single best discriminant (Odds ratio12.7 [95% Confidence intervals 5.8-27.8]).

Conclusions: The GAI_2AA score showed higher overall accuracy than NIHSS for predicting anterior circulation LVO and may serve as a practical, rapid bedside tool to guide triage and imaging decisions in resource-constrained environments, though prospective multicenter validation is needed before widespread adoption.

Keywords: Ischemic Stroke, Large Vessel Occlusion, GAI_2AA, NIHSS, Atrial Fibrillation

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INTRODUCTION

Acute ischemic stroke (AIS) remains a leading cause of long-term disability and mortality worldwide. Within the spectrum of AIS, occlusion of large intracranial vessels such as the internal carotid artery (ICA) and proximal segments of the middle cerebral artery (MCA) accounts for roughly one-third of ischemic strokes yet is associated with disproportionately poor functional outcomes.[1] Endovascular thrombectomy (EVT) has transformed the management of these patients, with pooled data from randomized trials showing substantial gains in functional independence even among those with large-core infarcts.[2,3]

Despite these therapeutic advances, timely identification of LVO remains a major challenge, particularly in centers without round-the-clock access to vascular imaging.[4] The NIHSS is the most widely used tool to quantify stroke severity and has been evaluated as a proxy to predict LVO, with suggested thresholds between 6 and 10 offering reasonable sensitivity.[5-7] However, NIHSS administration requires training, can be time-consuming, and includes several items that are not specific to LVO, which may reduce its diagnostic precision for large vessel occlusions.[8]

To address these limitations, several simplified scales have been developed, including the Los Angeles Motor Scale (LAMS)[9], Rapid Arterial oCclusion Evaluation (RACE)[10], and Field Assessment Stroke Triage for Emergency Destination (FAST-ED)[11]. These tools place greater emphasis on cortical signs and motor deficits thought to be more closely linked with proximal vessel occlusion.

The GAI_2AA score incorporating Gaze deviation, Aphasia, Inattention, Arm weakness, and Atrial fibrillation represent a focused approach that combines hemispheric cortical features with motor deficits and a key cardiac risk factor. [12] Initial work from a Japanese cohort suggested high predictive accuracy for LVO with a cutoff of $\geq$3 (AUC 0.90, sensitivity 88%, specificity 81%). [12] However, real-world data from diverse in-hospital populations, particularly from low- and middle-income countries, are limited, and direct comparisons with NIHSS in Indian hospital settings are lacking.

Another gap in the literature is that most LVO prediction studies have concentrated on prehospital or emergency medical service settings, whereas in-hospital populations may differ in stroke severity, comorbidity burden, and timing of presentation. [13] In addition, evidence from resource-limited environments with restricted availability of 24-hour CT angiography (CTA) is sparse, making it difficult to extrapolate existing results to such contexts.

In this study, we focused exclusively on anterior circulation LVO, excluding posterior circulation strokes because they exhibit different clinical patterns, are less common, and have distinct prognostic and therapeutic profiles. [14] Posterior circulation strokes often present with brainstem features such as vertigo, ataxia, or cranial nerve involvement, and scales optimised for anterior LVO may perform poorly in this group. Endovascular outcomes also differ, with higher recanalization and better functional results typically reported for anterior LVOs. [15]

Against this background, our primary aim was to identify clinical risk factors for anterior circulation LVO and to compare the diagnostic performance of NIHSS and GAI_2AA scores in an in-hospital cohort with acute ischemic stroke. We hypothesized that GAI_2AA would provide at least comparable, if not superior, predictive accuracy while being simpler to apply at the bedside for early triage and CTA prioritization.

MATERIALS AND METHODS

Study design and setting: This was a cross-sectional study comparing two in-hospital stroke scales for early detection of large vessel occlusion. The study conducted in the Department of Neurology at a tertiary care academic hospital in India. The study period spanned from January 2025 to October 2025. All consecutive patients admitted with a diagnosis of acute ischemic stroke (AIS) were screened for eligibility. The Institutional Ethics Committee approved the protocol (IEC NO: 01/19/2025/MCTH, dated 13/01/2025), and informed consent was obtained.

Study population: Patients were eligible if they were 18 years or older, had AIS confirmed on neuroimaging, presented within 24 hours of symptom onset, had a complete neurological examination including an admission NIHSS score, and underwent CTA or MR angiography (MRA) within 24 hours of admission.

Exclusion criteria included: (1) hemorrhagic stroke or stroke mimics (e.g., seizure, migraine, metabolic encephalopathy), (2) incomplete neurological examination or missing NIHSS component data, (3) absence of vascular imaging, and (4) prior disability (modified Rankin Scale score $\geq$3) limiting baseline functional assessment.

Data collection: Demographic and clinical data were collected using a structured proforma. Variables included age, sex, vascular risk factors (hypertension, diabetes mellitus, dyslipidemia, atrial fibrillation, smoking, prior stroke or transient ischemic attack), and baseline blood pressure and glucose levels. Time from symptom onset to hospital arrival, stroke subtype according to the TOAST classification, and imaging findings were also recorded.

The NIHSS score was documented at presentation by neurology residents trained in its use. GAI_2AA scores were then retrospectively reconstructed from the documented NIHSS subscores, acknowledging that such retrospective derivation may introduce misclassification, particularly for more subjective items like neglect or gaze deviation. Interobserver agreement was evaluated in a subgroup of 30 patients.

GAI_2AA scoring system: The GAI_2AA scale includes five

components derived from the neurological examination: Gaze deviation, aphasia, or inattention/neglect (any one present): 2 points; Arm weakness (any arm motor deficit): 1 point; and Atrial fibrillation (documented history or ECG evidence): 1 point

The total possible score ranges from 0 to 4, with cortical signs assigned double weight compared to motor weakness or atrial fibrillation, reflecting their stronger association with proximal occlusion. A cutoff of ≥3 has been suggested by previous work as optimal for LVO prediction. [12]

Imaging and definition of LVO: All patients underwent either CTA or MRA within 24 hours of admission, according to institutional stroke protocol. Anterior circulation large vessel occlusion (LVO) was defined as complete or near-complete occlusion of the intracranial internal carotid artery (ICA) or M1/M2 segment of the middle cerebral artery (MCA).

Outcome measures: The primary outcome was the diagnostic performance of the NIHSS and GAI_2AA scores in identifying LVO. Secondary outcomes included identification of clinical and demographic predictors of LVO. To minimize observer bias, data extraction and scale calculation were performed independently by two investigators blinded to angiographic results. Disagreements were resolved through discussion.

For each scale, the following parameters were calculated: sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, and area under the receiver operating characteristic (ROC) curve (AUC). The optimal cutoff scores for predicting LVO were determined using Youden's index.

Statistical analysis: NIHSS cutoffs of ≥6 and ≥8 were selected based on prior validation studies demonstrating optimal balance between sensitivity and specificity for LVO detection. Demeestere et al. (2017) validated NIHSS-8 cutoff of ≥8 with sensitivity 81% and specificity 75% for LVO prediction. [5] Similarly, systematic reviews analysing the accuracy of prediction instruments for diagnosing large vessel occlusion reported that NIHSS thresholds between 6 and 10 provide reasonable diagnostic accuracy across multiple cohorts. [7]

Given potential collinearity between NIHSS and GAI_2AA (both derived from overlapping neurological features), multivariate logistic regression models were interpreted cautiously. Separate models were constructed for each scale to avoid multicollinearity, and variance inflation factors were assessed to ensure model stability.

Continuous variables were summarized as mean ± standard deviation or median with interquartile range, as appropriate, and categorical variables as counts and percentages. Group comparisons between LVO and non-LVO patients used Student's t-test or the Mann-Whitney U-test for continuous variables and the χ^2 test or Fisher's exact test for categorical variables.

We performed multivariate logistic regression to identify independent predictors of LVO. ROC curves were generated to assess discriminative performance, and a p-value <0.05 was considered statistically significant. All analyses were conducted using IBM SPSS Statistics version 22.0.

RESULTS

A total of 168 patients with acute ischemic stroke were included in the final analysis. The mean age was 62.4 ± 11.8 years, and 104 (61.9%) were male. Large vessel occlusion (LVO) was identified in 55 patients (33%) based on vascular imaging. The most frequent occlusion sites were the M1 segment of the middle cerebral artery (MCA) (n = 31, 56%), followed by the intracranial internal carotid artery (ICA) (n = 17, 31%), and M2 segment (n = 7, 13%). Baseline characteristics are shown in Table 1.

Patients with LVO were significantly older (65.8 ± 10.2 years vs 60.6 ± 12.1 years, p = 0.012) and more often had a history of smoking (p = 0.021) and previous transient ischemic attack or stroke (p = 0.038). There was no significant difference in the prevalence of hypertension, diabetes, dyslipidemia, or atrial fibrillation between the two groups. Median time from symptom onset to hospital arrival similar in both groups.

Table 1: Baseline characteristics of patients with and without large vessel occlusion

Variable	Total (n=168)	LVO (n=55)	No LVO (n=113)	p value
Age, years (mean ± SD)	62.4 ± 11.8	65.8 ± 10.2	60.6 ± 12.1	0.012*
Male sex, n (%)	104 (61.9)	38 (69.1)	66 (58.4)	0.19
Hypertension, n (%)	102 (60.7)	36 (65.5)	66 (58.4)	0.38
Diabetes mellitus, n (%)	58 (34.5)	18 (32.7)	40 (35.4)	0.74
Dyslipidemia, n (%)	41 (24.4)	13 (23.6)	28 (24.8)	0.87
Atrial fibrillation, n (%)	12 (7.1)	6 (10.9)	6 (5.3)	0.18
Smoking, n (%)	54 (32.1)	26 (47.3)	28 (24.8)	0.021*
Prior stroke/TIA, n (%)	33 (19.6)	16 (29.1)	17 (15.0)	0.038*
Systolic BP (mmHg, mean ± SD)	152 ± 21	150 ± 20	153 ± 22	0.42
Onset to arrival time (h, median [IQR])	5.0 (3.4-7.9)	5.2 (3.5-8.1)	4.8 (3.2-7.6)	0.41

*Statistical significance p<0.05. TIA=Transient ischemic attack; LVO=Large vessel occlusion; SD=Standard deviation; IQR=Interquartile range. Percentages are column-wise. Comparisons performed using Student's t-test (continuous variables) or χ^2 test/Fisher's exact test (categorical variables).

NIHSS and GAI_2AA scores: Median NIHSS at presentation was significantly higher in the LVO group (13, interquartile range 10-17) compared with patients without LVO (9, interquartile range 6-12, p<0.001). GAI_2AA scores showed an even clearer separation: median 3 (IQR 2-4) in patients with LVO versus 1 (IQR 0-2) in those without LVO (p<0.001). Interrater reliability in the subgroup analysis was substantial, with a Cohen's kappa of 0.72.

Among individual GAI_2AA components, gaze deviation was the most powerful discriminator, present in 80% of LVO patients compared with 24% of patients without LVO (p<0.001; odds ratio 12.7, 95% CI 5.8-27.8). Aphasia, inattention, arm weakness, and atrial fibrillation were also more frequent in LVO, but with lower odds ratios than gaze deviation. The diagnostic value of individual items is shown in Table 2.

Diagnostic performance of NIHSS and GAI_2AA: In multivariate logistic regression, GAI_2AA ≥3 (odds ratio 6.9, 95% CI 3.1-15.2, p<0.001) and NIHSS ≥8 (odds ratio 3.2, 95% CI 1.4-7.1, p=0.005) independently predicted anterior circulation LVO.

Using optimal cut-offs determined by Youden's index, GAI_2AA ≥3 had sensitivity 78% and specificity 81%, while NIHSS ≥8 had sensitivity 87% and specificity 58%.

Table 3 depicts the diagnostic accuracy of the scoring systems.

ROC analysis (Figure 1) demonstrated that GAI_2AA had a higher area under the curve (AUC 0.92, 95% CI 0.88-0.96) compared with NIHSS (AUC 0.78, 95% CI 0.70-0.85) for detecting LVO.

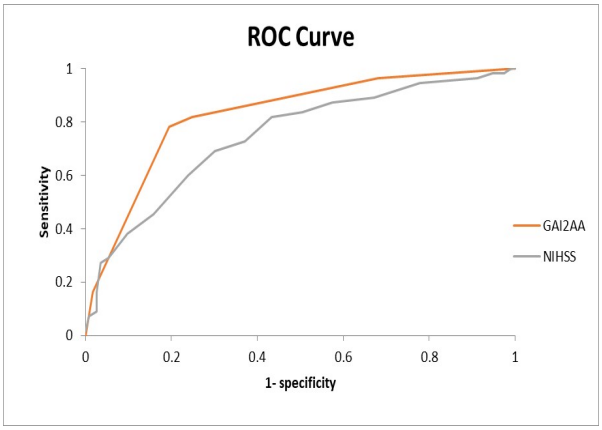

Figure 1: The ROC curves compare the discriminative performance of NIHSS and GAI_2AA for predicting LVO. GAI_2AA demonstrated the highest area under the curve (AUC = 0.92)

Table 2: Diagnostic value of individual GAI_2AA components

GAI_2AA Component	Prevalence in LVO Group (%)	Prevalence in Non-LVO Group (%)	Odds Ratio (95% CI)
Gaze Deviation	80	24	12.7 (5.8-27.8)
Aphasia	70	25	6.7 (3.5-12.9)
Inattention	65	20	6.8 (3.4-13.6)
Arm Weakness	85	40	7.6 (3.8-15.2)
Atrial fibrillation	11	5	2.2 (1.0-7.1)

CI=Confidence interval; LVO=Large vessel occlusion. Odds ratios calculated using univariate logistic regression.

Table 3: Diagnostic accuracy of scoring systems for predicting Large Vessel Occlusion

Score	Sensitivity % (95% CI)	Specificity % (95% CI)	PPV % (95% CI)	NPV % (95% CI)	Accuracy % (95% CI)
NIHSS≥6	95 (85-99)	22 (15-31)	37 (29-46)	89 (72-97)	58 (50-66)
NIHSS≥8	87 (75-95)	58 (48-67)	50 (40-60)	90 (80-96)	78 (71-84)
GAI_2AA≥3	78 (65-88)	81 (73-88)	66 (53-77)	88 (80-93)	81 (74-87)

PPV=Positive predictive value; NPV=Negative predictive value; CI=Confidence interval. Confidence intervals calculated using Wilson score method. AUC for NIHSS=0.78 (95% CI 0.70-0.85); AUC for GAI_2AA=0.92 (95% CI 0.88-0.96).

Lowering the NIHSS threshold to ≥6 improved sensitivity further (95%) but at the expense of specificity (22%), illustrating the trade-off between broad screening and precise triage.

DISCUSSION

In this in-hospital cohort of patients with AIS limited to the anterior circulation, roughly one in three had an angiographically confirmed LVO. We found that the simplified GAI_2AA score had better overall diagnostic performance than the NIHSS in predicting LVO, with particularly strong discrimination driven by gaze deviation and other cortical signs. At a cutoff of ≥3, GAI_2AA offered a balanced sensitivity and specificity profile suitable for triage decisions in busy clinical settings.

Our findings echo the original Japanese validation study, where GAI_2AA also demonstrated high accuracy with an AUC of 0.90 and similar sensitivity and specificity at the same cutoff. [12] In contrast, NIHSS, although highly sensitive at higher cutoffs, incorporates items that are less specific for LVO and may overestimate the likelihood of large vessel occlusion in patients with other stroke subtypes. This can be problematic in resource-limited settings where over-triage to advanced imaging may not be feasible.

Previous work has largely focused on prehospital scales such as LAMS, RACE, G-FAST, mG-FAST, and FAST-ED, which are intended for use by emergency medical services and have been shown to perform reasonably well in predicting LVO.[16] Our study adds to this literature by examining an in-hospital tool that emphasises similar cortical signs but is calibrated for bedside use in patients already admitted to a tertiary centre.

A large multicenter prospective study comparing 14 prehospital scales found RACE, LAMS, G-FAST, and mG-FAST demonstrated highest performance, with RACE showing AUROC values comparable to our GAI_2AA findings[16]. The FAST-ED scale, combining facial palsy, arm drift, speech abnormalities, eye deviation, and denial/neglect, demonstrated sensitivity for LVO at scores ≥3 in emergency medical service environments[10]. Our NIHSS AUC (0.78) aligns with published prehospital validations showing AUROC 0.72-0.86 depending on setting and training[16].

The LAMS scale, focusing on motor components (facial droop, arm drift, grip strength), offers simplicity but may miss cortical signs distinctive to proximal occlusion[9]. RACE incorporates cortical signs similar to GAI_2AA (facial palsy, arm motor function, leg motor function, gaze deviation, aphasia, neglect) but uses different weighting[10]. Our findings suggest cortical sign emphasis in GAI_2AA enhances LVO detection specificity, particularly when gaze deviation is present.

From a pathophysiological standpoint, the prominence of gaze deviation as a predictor in our cohort is consistent with machine learning studies that have identified this sign, along with level of consciousness and motor deficits, as key drivers of LVO prediction based on NIHSS subitems.[17] This reinforces the concept that focused evaluation of cortical signs can meaningfully refine LVO screening.

The observed clinical risk factors older age, smoking, and prior ischemic events align with the established role of large-artery atherosclerosis and recurrent vascular events in anterior circulation LVO.[18-20] Although atrial fibrillation did not reach statistical significance in this dataset, it remains an important cardioembolic risk factor with known associations with poorer collateral flow and outcomes in LVO.[21]

Implications for Indian healthcare settings: Our hospital context, with constraints in round-the-clock access to CTA and neuroradiology support, is representative of many centers in low- and middle-income countries. In such settings, a scale that is quick to apply and reasonably accurate, like GAI_2AA, may help streamline decisions regarding urgent CTA, EVT team activation, and transfer to thrombectomy-capable centers.

The original GAI_2AA implementation demonstrated reductions in door-to-puncture time when integrated into systematic triage pathways, and similar gains may be achievable if the scale is embedded into stroke protocols in Indian hospitals.[11] A stepwise approach could involve immediate GAI_2AA scoring at presentation, prioritizing CTA for scores ≥3, early notification of interventional teams, and using telemedicine where available to support peripheral centers.

Integration of GAI_2AA into existing stroke protocols could follow a stepwise approach: (1) immediate bedside GAI_2AA assessment at presentation, (2) prioritized urgent CTA for scores ≥3, (3) simultaneous thrombectomy team activation for high-scoring patients, and (4) expedited interfacility transfer decisions in non-thrombectomy-capable centers. Combining GAI_2AA with telemedicine-based neurological consultation could further enhance resource allocation efficiency in underserved areas.

STRENGTHS AND LIMITATIONS

Strengths of this study include a well-defined in-hospital cohort, confirmation of LVO with vascular imaging within 24 hours of admission, and blinded calculation of scores to reduce observer bias. We also evaluated both clinical and scoring-system predictors, using standard statistical methods for diagnostic accuracy.

However, several limitations need to be recognized. This was a retrospective single-center study, which may limit generalizability to other populations or health systems. The GAI_2AA score was reconstructed from NIHSS sub scores rather than assessed prospectively, which may have introduced misclassification, particularly for more subjective signs. Patients without complete vascular imaging were excluded, potentially biasing the sample toward more severe strokes or those with higher clinical suspicion for LVO. Our focus on anterior circulation LVO improves specificity of the findings but limits applicability to patients with posterior circulation stroke. Finally, we did not assess functional outcomes such as 90-day modified Rankin Scale or treatment times, so the downstream impact of using GAI_2AA on clinical outcomes cannot be inferred from this dataset.

Future research should validate GAI_2AA prospectively across diverse multicenter cohorts, explore prehospital utility by emergency medical services, examine impact on clinical outcomes including treatment times and functional independence, and integrate advanced analytics such as machine learning or biomarkers to enhance prediction models.

CONCLUSION

In this retrospective single-center cohort, anterior circulation LVO was present in one-third of patients with acute ischemic stroke. The GAI_2AA score demonstrated higher diagnostic accuracy compared to NIHSS for predicting angiographically confirmed LVO, primarily driven by the strong discriminative value of cortical signs, particularly gaze deviation. GAI_2AA may represent a practical, rapid bedside tool for early LVO detection to support in-hospital triage and imaging prioritization decisions.

However, these findings require validation through prospective, multicenter studies across diverse healthcare settings before implementation can be broadly recommended. Future research should assess impact on clinical outcomes including time to treatment and functional independence.

Individual Author's Contribution: DS contributed to the study conception and design, data collection, data analysis and interpretation, and manuscript preparation. **RP** contributed to study design, data collection, and manuscript preparation.

Availability of data: The data that support the findings of this study are available from the corresponding author on reasonable request.

Declaration of Non-use of generative AI Tools: This article was prepared without the use of generative AI tools for content creation, analysis, or data generation. All findings and interpretations are based solely on the authors' independent work and expertise.

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