Section: Miscellaneous

Original Research Article

CAN CLINICAL SCORES SUBSTITUTE CT SCAN IN RURAL SETTINGS FOR DIFFERENTIATING ISCHEMIC FROM HAEMORRHAGIC STROKE

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ABSTRACT

Background: Timely differentiation between ischemic and intracerebral haemorrhagic stroke is essential because acute management differs substantially between subtypes. Although non-contrast computed tomography (CT) is the reference standard, access remains limited in many low-resource settings. We evaluated the diagnostic performance of the Siriraj Stroke Score (SSS), Allen (Guy's Hospital) Stroke Score (ASS), and Greek Stroke Score (GSS) for bedside stroke subtype classification. **Materials and Methods:** We conducted a prospective observational study of 200 consecutive adults presenting within 48 hours of acute stroke onset to a tertiary care hospital in southern India. SSS, ASS, and GSS were calculated using their original published algorithms. Stroke subtype assigned by each scoring system was compared with the reference diagnosis established by non-contrast CT. Diagnostic performance and inter-score agreement (Cohen's κ) were assessed. **Results:** CT identified 140 ischemic strokes and 60 intracerebral haemorrhages. SSS demonstrated the highest diagnostic performance, correctly classifying 80.0% of ischemic and 70.0% of haemorrhagic strokes. ASS correctly classified 70.0% of ischemic and 63.3% of haemorrhagic strokes. GSS showed poor performance for haemorrhagic stroke (16.7%) and classified 61.4% of ischemic strokes correctly, with a high proportion of indeterminate results. Agreement was good between SSS and ASS (κ=0.619) and moderate between SSS and GSS and between ASS and GSS (κ=0.337). **Conclusion:** None of the evaluated clinical scores demonstrated sufficient diagnostic accuracy to reliably distinguish ischemic from intracerebral haemorrhagic stroke without neuroimaging. Although SSS outperformed ASS and GSS, its accuracy remained inadequate to support treatment decisions. These findings reinforce the importance of improving access to CT-based diagnosis in resource-limited settings.

INTRODUCTION

Stroke remains a leading cause of mortality and long-term disability worldwide, imposing a substantial clinical and socioeconomic burden. The Global Burden of Disease (GBD) 2019 study identified stroke as the second leading cause of death and the third leading cause of disability-adjusted life years globally, with the greatest increases in incidence and mortality occurring in low- and middle-income countries (LMICs). India has experienced a marked rise in stroke burden over the past two decades, driven by population ageing, increasing prevalence of vascular risk factors, and inequities in access to timely stroke care.[1,2]

Acute stroke comprises two major subtypes ischemic stroke and intracerebral haemorrhage (ICH), two entities requiring fundamentally different therapeutic approaches. Early differentiation is essential because reperfusion therapies and antiplatelet agents benefit selected patients with ischemic stroke but may be harmful in ICH, whereas prompt recognition of haemorrhagic stroke enables blood pressure optimization, reversal of anticoagulation, neurosurgical evaluation, and intensive monitoring.[3,4] Current international guidelines recommend non-contrast computed tomography

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(NCCT) as the first-line imaging modality because of its rapid acquisition, widespread availability, and high sensitivity for detecting acute intracranial haemorrhage.[3-5] Although magnetic resonance imaging offers greater sensitivity for detecting early ischemic lesions, its limited availability, higher cost, and longer acquisition time restrict its use in emergency settings, particularly in resource-constrained regions.[5]

Despite advances in stroke systems of care, timely access to neuroimaging remains challenging in many LMICs, including rural India, where delays in imaging may postpone definitive diagnosis and treatment.[6] Consequently, simple bedside clinical tools capable of predicting stroke subtype continue to be of interest in settings where immediate neuroimaging is unavailable.

Several clinical prediction models, including the Siriraj Stroke Score (SSS), Allen (Guy's Hospital) Stroke Score (ASS), and Greek Stroke Score (GSS), were developed to distinguish ischemic stroke from ICH using readily available clinical variables. Although these scores demonstrated promising performance in derivation cohorts, subsequent validation studies have reported inconsistent diagnostic accuracy across different populations. Systematic reviews have concluded that their sensitivity, specificity, and frequency of equivocal classifications are insufficient to replace neuroimaging in routine clinical practice.[7,8]

Recent advances in blood-based biomarkers, particularly glial fibrillary acidic protein (GFAP), have shown promise for early differentiation of stroke subtypes. Prospective studies, including the BE FAST India study, have demonstrated encouraging diagnostic performance for GFAP alone or in combination with biomarkers such as tau protein and neurofilament light chain. However, these assays remain unavailable in most routine and resource-limited clinical settings.[9-11]

Given the limited contemporary evidence from Indian populations and evolving stroke epidemiology, reevaluation of established clinical stroke scores remains warranted. This prospective observational study therefore assessed the diagnostic accuracy of the Siriraj, Allen, and Greek Stroke Scores for differentiating ischemic stroke from intracerebral haemorrhage in adults presenting with acute stroke to a tertiary care centre in southern India, using NCCT as the reference standard.

MATERIALS AND METHODS

This prospective, single-centre, observational diagnostic accuracy study was conducted in the Emergency Department and Department of General Medicine of a tertiary care government teaching hospital in southern India. The study evaluated the diagnostic performance of three bedside clinical stroke scores—the Siriraj Stroke Score (SSS), Allen (Guy's Hospital) Stroke Score (ASS), and Greek Stroke Score (GSS)—for differentiating ischemic stroke from intracerebral haemorrhage (ICH), using non-contrast computed tomography (NCCT) of the brain as the reference standard. The study was conducted and reported in accordance with the STARD 2015 (Standards for Reporting Diagnostic Accuracy Studies) guidelines.

The study protocol received approval from the Institutional Ethics Committee (Review Letter No. IEC-GMC-ELR/032-2026; 01 December 2025). Written informed consent was obtained from all participants or their legally authorized representatives before enrolment. The study adhered to the principles of the Declaration of Helsinki.

Consecutive adults (≥20 years) presenting within 48 hours of symptom onset with suspected acute stroke between December 2025 and June 2026 were screened. Stroke was defined according to the World Health Organization definition as a rapidly developing focal or global neurological deficit of presumed vascular origin lasting >24 hours or resulting in death. Eligible patients had a clinical diagnosis of acute stroke and underwent NCCT for confirmation of stroke subtype. Exclusion criteria included traumatic brain injury within the preceding six months, subarachnoid haemorrhage, intracranial tumours or other space-occupying lesions, current anticoagulant therapy, and incomplete clinical data precluding calculation of the stroke scores.

The SSS, ASS, and GSS (Table 1 - 3) were calculated according to their original published methods. The SSS was determined immediately after the initial clinical assessment using demographic variables, blood pressure, level of consciousness, headache, vomiting, and atherosclerotic risk factors. Because the ASS and GSS incorporate clinical findings observed during the first 24 hours after admission, these scores were calculated after completion of the first 24 hours of observation. All clinical assessments and score calculations were performed by a single experienced physician blinded to the CT findings, while NCCT images were interpreted independently by consultant radiologists blinded to the clinical scores.

NCCT served as the reference standard for stroke subtype classification. Ischemic stroke was defined by a focal hypodense lesion consistent with cerebral infarction, whereas ICH was defined by a focal hyperdense intraparenchymal haemorrhage. Patients with isolated subarachnoid haemorrhage were excluded. Baseline demographic characteristics, vascular risk factors, presenting symptoms, neurological findings, Glasgow Coma Scale score, blood pressure, laboratory investigations, and CT findings were prospectively recorded using a standardized case record form. A convenience sample of 200 consecutive eligible patients was enrolled.

Continuous variables are presented as mean ± standard deviation or median (interquartile range), as appropriate, and categorical variables as frequencies and percentages. Diagnostic performance was

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assessed by calculating sensitivity, specificity, positive and negative predictive values, likelihood ratios, diagnostic odds ratios, and overall accuracy, with 95% confidence intervals. Receiver operating characteristic curves and area under the curve (AUC) were used to evaluate discrimination, with comparisons performed using the DeLong method where appropriate. Agreement between each clinical score and NCCT diagnosis was assessed using Cohen's kappa (κ). Equivocal results were analysed separately, with sensitivity analyses performed after their exclusion. Statistical analyses were conducted using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY), with a two-sided $P<0.05$ considered statistically significant.

RESULTS

A total of 200 consecutive patients presenting with acute stroke within 48 hours of symptom onset were included. The cohort comprised 138 (69%) men and 62 (31%) women, with a male-to-female ratio of 2.2:1. The mean age was 58.1 ± 10.7 years, with the highest proportion of patients belonging to the 51–60-year age group (36%). NCCT of the brain, used as the reference standard, identified ischemic stroke in 140 patients (70%) and intracerebral haemorrhage (ICH) in 60 patients (30%).

The Siriraj Stroke Score (SSS) correctly identified 42 of 60 patients with ICH (70.0%) and 112 of 140 patients with ischemic stroke (80.0%). Misclassification occurred in ten patients with ICH (16.7%) and ten with ischemic stroke (7.1%), while equivocal results were observed in 13.3% of ICH and 12.9% of ischemic stroke cases. Overall, the SSS demonstrated the best diagnostic performance among the evaluated clinical scoring systems.

The Allen Stroke Score (ASS) correctly identified 38 of 60 patients with ICH (63.3%) and 98 of 140 patients with ischemic stroke (70.0%). Ten haemorrhagic strokes (16.7%) and fourteen ischemic strokes (10.0%) were misclassified, while 20% of cases in both groups were categorized as indeterminate.

The Greek Stroke Score (GSS) correctly classified only ten patients with ICH (16.7%) but identified 86 patients with ischemic stroke (61.4%). Although no ischemic stroke was incorrectly classified as haemorrhage, the GSS demonstrated a high proportion of equivocal results, observed in 66.7% of ICH and 38.6% of ischemic stroke cases. Diagnostic performance of all three scores compared with NCCT findings is summarized in [Figure 1].

For detection of ICH, the SSS demonstrated the highest sensitivity (84%) and specificity (92.98%), followed by the ASS (79.17% and 87.50%, respectively). The GSS showed excellent specificity (100%) but limited sensitivity (35.29%). For ischemic stroke, the GSS achieved 100% sensitivity but poor specificity (35.29%), whereas the SSS provided a more balanced diagnostic profile (sensitivity 92.98%; specificity 84.0%). The ASS demonstrated sensitivity and specificity of 87.50% and 79.17%, respectively.

Agreement between the SSS and ASS was substantial (Cohen's $\kappa=0.619$), while agreement between the SSS and GSS and between the ASS and GSS was moderate ($\kappa=0.337$ for both comparisons). Overall, the SSS demonstrated the best diagnostic performance, with fewer equivocal classifications and better concordance with CT findings. However, all three clinical scores showed clinically relevant misclassification rates, limiting their ability to replace neuroimaging for definitive stroke subtype determination.

Table 1: Siriraj score – Various parameters of score and calculation method.

Parameters		Score
Level of consciousness		
	Alert	0
	Drowsy, Stupor	2.5
	Coma	5
Headache within 2 hrs of onset of event		
	No	0
	Yes	2
Vomiting		
	No	0
	Yes	2
Atheroma Markers		
DM Angina Ischemic heart disease Intermittent claudication	None One or more	0 -3
Diastolic blood pressure		Value X 0.1
Constant		-12

Number Of Points = Level of Consciousness + Headache Within 2 Hrs of Onset of Event + Vomiting - Atheroma Markers + Diastolic Blood Pressure × 0.1 + Constant (-12) < -1 Ischemic +1 to -1 Equivocal > +1 Haemorrhage

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Table 2: Alle score – Variables of Allen score system and its method of calculation

Variable	Clinical Features	Score
Apoplectic Onset Loss of consciousness Headache within 2 hours Vomiting d. Neck stiffness	One or none of these	0
	Two or more	+21.9
Level of consciousness (24 hr after admission)	Alert	0
	Drowsy	+7.3
	Unconscious	+14.6
Plantar responses	Both flexor/single extensor	0
	Both extensor	+7.1
Diastolic blood pressure (24 after admission, in mm of Hg)		+ (BP x 0.17)
Atheroma markers (Angina, claudication, DM)	None	0
	One or more present	-3.7
History of hypertension	Not present	0
	Present	-4.1
Previous event Transient ischemic event	None	0
	Any no. of previous event	-6.7
Heart disease	None	0
	Aortic or mitral murmur	-4.3
	Cardiac failure	-4.3
	H/O Cardiomyopathy	-4.3
	Atrial fibrillation	-4.3
	Cardiomegaly	-4.3
	MI within 6 months	-4.3
Constant		-12.6
Number of points = Apoplectic onset + Level of consciousness + Plantar responses + (Diastolic blood pressure 24 hours after admission X 0.17) + Atheroma markers + History of hypertension + Previous events (transient Ischemic attack) + heart disease + constant (-12.6) <4 Infarction, 4-24 Equivocal, >24 Haemorrhage		

Table 3: Greek score - components and method of calculation.

Number of points = 6 * (neurological deterioration within 3 h from admission) + 4 * (vomiting) + 4 * (WBC > 12 000) + 3 * (decreased LOC).			
Either One point or Zero point shall be awarded depending on definition as given and total point shall be 17			
The cut-offs resulting in sufficiently high accuracy are - < 3 Ischemic, 3 to 11 Equivocal, > 11 Haemorrhage			
Decreased level of consciousness was defined as a score <4 points in the subscale of GCS regarding eye opening	Neurological Deterioration was defined as a decline from an initial GCS of >12 by ≥4 points and/or a new deficit, i.e., a deficit not found at presentation. Overall neurological status and GCS were assessed approximately every 3 h during the first 24 h from admission	Vomiting- At the time of onset	WBC Count - Shall be undertaken as the arrival

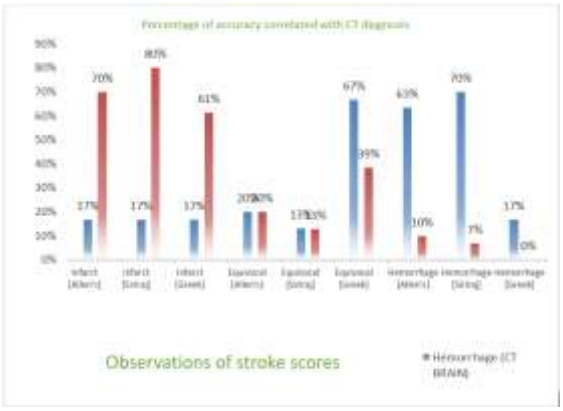

Figure 1: depicts the accuracy percentage of each scoring system for identifying infarct and hemorrhage correlated with CT diagnosis

DISCUSSION

This prospective diagnostic accuracy study evaluated three established clinical stroke scoring systems—the Siriraj Stroke Score (SSS), Allen (Guy's Hospital) Stroke Score (ASS), and Greek Stroke Score (GSS)—for differentiating ischemic stroke from intracerebral haemorrhage (ICH), using non-contrast computed tomography (NCCT) as the reference standard. The principal finding of this study was that although the SSS demonstrated superior diagnostic performance compared with the ASS and GSS, none of the evaluated clinical tools achieved sufficient accuracy to replace neuroimaging for individual patient management.[12]

In agreement with previous reports, ischemic stroke constituted the majority of cases in this cohort (70%). The mean age of 58 years is comparable with observations from Indian and African populations but lower than that reported in many high-income countries, reflecting the earlier onset of cerebrovascular disease in low- and middle-income settings. This highlights the continuing burden of premature stroke in regions where vascular risk factors are increasing and access to preventive and acute stroke services remains heterogeneous.

Among the evaluated scores, the SSS demonstrated the most favourable balance between sensitivity and specificity for both ischemic stroke and ICH. These findings are consistent with previous validation studies and systematic reviews that have generally

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reported better performance of the SSS compared with the ASS and GSS.[13,14] However, variations in diagnostic accuracy across populations are well recognized and may be influenced by differences in stroke severity, vascular risk profiles, healthcare access, and clinical presentation.

The ASS showed moderate diagnostic performance but requires assessment of clinical variables over the first 24 hours after admission. This limits its applicability in contemporary acute stroke pathways, where therapeutic decisions regarding intravenous thrombolysis and mechanical thrombectomy frequently depend on diagnosis within the first few hours after symptom onset. In contrast, the GSS demonstrated excellent specificity for ICH but poor sensitivity and a high frequency of equivocal results, substantially limiting its utility in emergency decision-making. A key observation of this study was the proportion of indeterminate classifications across all three scoring systems. Approximately 13% of patients assessed using the SSS and nearly one-third assessed using the ASS and GSS could not be confidently categorized. Previous systematic reviews have similarly concluded that clinical stroke scores lack sufficient reliability to replace neuroimaging when treatment decisions are being considered.[15]

The limited contemporary role of bedside stroke scores should also be interpreted in the context of major advances in acute stroke care. Current guidelines recommend urgent neuroimaging before administration of thrombolytic therapy, endovascular thrombectomy, or antithrombotic treatment. Furthermore, advances including improved CT availability, mobile stroke units, tele-stroke networks, and artificial intelligence-assisted imaging interpretation have reduced diagnostic delays in many healthcare systems.[16] Nevertheless, an unmet need persists in remote and resource-limited settings where immediate neuroimaging remains unavailable. Blood-based biomarkers, particularly glial fibrillary acidic protein (GFAP), have emerged as promising adjunctive tools for distinguishing ICH from ischemic stroke, although implementation remains limited by cost, assay availability, and infrastructure constraints.[17]

The strengths of this study include its prospective design, consecutive recruitment, use of NCCT as the reference standard, and standardized assessment of three commonly used clinical scores. However, interpretation should consider the limitations of a single-centre study with a relatively small sample size, which may restrict generalizability. Potential selection bias cannot be completely excluded, and larger multicentre validation studies incorporating contemporary statistical models, biomarkers, and artificial intelligence-based approaches are required.

Future research should focus on integrating clinical prediction tools with emerging biomarkers and imaging technologies to develop accessible, accurate, and scalable diagnostic strategies for stroke subtype differentiation in resource-constrained environments.

CONCLUSION

The Siriraj Stroke Score demonstrated superior diagnostic performance compared with the Allen and Greek Stroke Scores for differentiating ischemic stroke from intracerebral haemorrhage. However, all three clinical scoring systems showed clinically important rates of misclassification and equivocal results, limiting their reliability for individual patient management. Accordingly, none of these clinical scores should be considered a substitute for non-contrast CT, which remains the reference standard for the early evaluation of patients presenting with acute stroke. In settings where immediate neuroimaging is unavailable, the Siriraj Stroke Score may provide preliminary guidance during the initial clinical assessment; however, definitive treatment decisions, particularly those involving thrombolytic or antithrombotic therapy, should never be based solely on clinical scoring systems. Further large-scale, multicentre prospective studies incorporating contemporary imaging techniques, validated blood biomarkers such as GFAP, and modern statistical prediction models are required to develop more accurate and clinically applicable diagnostic tools for resource-limited settings.

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