Original Article

Diagnostic Accuracy of CAM-ICU and ICDSC for Detection of Early Delirium in Acute Ischemic Stroke: A Cross-sectional Study

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Abstract

Background and Objectives: Early post-stroke delirium (PSD) is difficult to diagnose and complicates recovery. We aimed to evaluate two validated delirium screening tools, focusing on patients with stroke-related higher-order cognitive deficits (HOCDs). **Methods:** We prospectively analyzed the delirium features and compared the diagnostic accuracy of the Confusion Assessment Method for ICU (CAM-ICU) and the Intensive Care Delirium Screening Checklist (ICDSC) with Diagnostic and Statistical Manual -5 (DSM-5) criteria in 164 patients with acute ischemic stroke. Early PSD was defined as delirium occurring within 72 h of admission. **Results:** Early PSD occurred in 32.3% patients, two-thirds of whom had HOCDs such as aphasia or neglect. Individual delirium features were frequent in nondelirious patients with HOCDs, inattention (Area under curve [AUC] .98, odds ratio [OR] 28.88), psychomotor changes (AUC.95, OR 10.60), and impaired arousal (AUC.95, OR 8.57) had maximum discriminating value on logistic regression analysis. When compared with DSM-5, CAM-ICU (sensitivity 81%, specificity 84%, AUC.97) had better accuracy than ICDSC (sensitivity 70%, specificity 86%, AUC.96); however, both were noninferior. In patients with HOCDs, both had markedly reduced specificities. Adding psychomotor changes to patients who were CAM-ICU positive (CAM-ICU Plus) improved its specificity. CAM-ICU Plus (sensitivity 79%, specificity 92%, AUC.98) had the best accuracy among all the tools. **Conclusions:** Early PSD is common after ischemic stroke. Available screening tools have lower specificity in patients with post-stroke cognitive deficits. CAM-ICU performed better than ICDSC. CAM ICU Plus improves the specificity of CAM ICU, which needs to be confirmed by further multicenter studies. Stroke-specific delirium screening tools are required for improving outcomes.

Keywords: Early delirium, acute ischemic stroke, screening tools, sensitivity, specificity

Introduction

Acute ischemic stroke is a neurological emergency causing significant mortality and long-term disability. Post-stroke delirium (PSD) is a common clinical problem that worsens physical and cognitive neurological impairments. A recent meta-analysis describes incidence rates of PSD ranging from 7%–66% and estimates an average incidence of 25%.[1] Patients with PSD have longer hospital stays, higher levels of physical and cognitive disability, and are five times more likely to die within the first year after stroke.[2] Despite stroke being a well-known predisposing factor for delirium, studies investigating this association, as well as stroke characteristics associated with delirium, give conflicting results.[3,4]

Delirium is an acute encephalopathy characterized by fluctuating disturbances in alertness, orientation, and cognition. In neurologically ill patients, its symptoms can be mimicked by those of structural brain damage, which also increases the risk of developing delirium.[5] Stroke-related higher-order cognitive deficits (HOCDs), such as aphasia and neglect, have been proven to precipitate delirium as well as to confound its diagnosis.[6] The Diagnostic and Statistical Manual-5 (DSM-5) criteria are considered the gold standard for diagnosis.[7] However, there is no consensus on the ideal screening instrument in stroke patients, especially those with cognitive disorders, with a meta-analysis in PSD revealing that 9 of 16 studies excluded patients with aphasia and other severe neurological deficits.[1]

A robust systematic review has concluded that the Confusion Assessment Method for ICU (CAM-ICU) is the most commonly used screening tool in neuro-intensive care settings.[8] Moreover, it has been validated in PSD, though lower specificity has been noted in patients with focal

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neurological deficits, such as aphasia.[9] The Intensive Care Delirium Screening Checklist (ICDSC) is another validated psychometric tool that has been proposed to be better for this purpose, as several test items can be scored without verbal interaction or comprehension.[10] Nonetheless, it has been shown to have lower specificity in the post-stroke setting, and the use of higher cutoff values has been suggested for aphasic patients.[11] Head-to-head comparisons between CAM-ICU and ICDSC in ischemic stroke are scarce, and available studies in other neuro-intensive care settings, such as intracranial hemorrhage and traumatic brain injury, give equivocal results.[11,12]

Early commencement of delirium screening is essential, as it has been shown that early identification and appropriate management improve outcomes in more than one-third of patients.[13] Moreover, it has been estimated that the incidence of delirium peaks within 72 h of admission, a period during which stroke-related deficits are expected to be at a maximum.[6,14] Hence, we aimed to conduct a study comparing the diagnostic performance of CAM-ICU and ICDSC against the gold-standard assessment based on DSM-5 criteria to detect early delirium in patients with acute ischemic stroke. We also aimed to characterize the delirium features and diagnostic accuracy of the screening instruments in patients with stroke-related HOCDs.

Methods

Study design

This is a cross-sectional (diagnostic accuracy) study evaluating two delirium screening instruments, the CAM-ICU and the ICDSC, in patients with acute ischemic stroke. Data were collected prospectively. Approval was obtained from the Institutional Research Committee and the Institutional Ethics Committee (HEC NO: 01/19/2025/MCT, dated 13/01/2025). Written informed consent was obtained from all patients.

Population and setting

The study was conducted in the Stroke Unit at the Department of Neurology, Government Medical College, Thiruvananthapuram. Our hospital is a large tertiary-care, referral, and teaching hospital serving both urban and rural populations across multiple districts in the southern part of India. The stroke unit admits more than 800 patients with acute ischemic and hemorrhagic stroke annually. The study was conducted over a period of 6 months, from January to June 2025. All acute stroke patients admitted to the stroke unit were assessed, and adult patients aged 18 years or above, presenting within 24 h of stroke onset and with a sufficient level of arousal for further testing, were included. Patients with hemorrhagic stroke and transient ischemic attacks were excluded. As specified in CAM-ICU, patients required a Richmond Agitation-Sedation Scale (RASS) of ≥−3 for further assessment.[15] Patients who had RASS <-3 were reassessed after 24 h and were included if their score had improved. Patients who remained comatose throughout the hospital stay were excluded.

Socio-demographic and clinical variables, including age, sex, vascular risk factors, comorbidities, clinical features, radiological characteristics, stroke causes, and treatment details, were recorded on a standard data collection form.

Sample size

The sample size was estimated for sensitivity using the formula:

$n = Z_{\alpha/2}^2 \times Se\ (1\text{-}Se)/d^2 \times P$ where Se = expected sensitivity, d = precision, and P = prevalence of delirium as per previous studies.

The sample size was calculated for both ICDSC and CAM-ICU using the expected sensitivity based on previous studies (78% and 84%, respectively),[16] and the higher number was used as the final sample size. Hence, using Type 1 error(α) of 5% ($Z\alpha_{/2} = 1.96$), Se = 78%, d = 10%, and P = 39% as per previous studies in ischemic stroke,[6] the sample size was calculated as 164 patients.

Delirium assessment and outcome measures

Early PSD was defined as delirium occurring within 72 h of admission. Trained neurology residents conducted the assessments for PSD using the screening tools CAM-ICU and ICDSC. The diagnosis of delirium according to DSM-5 criteria was established by a team consisting of a neurology resident and a consultant neurologist, either DS or RP, who were blinded to the results of the screening tests. To minimize observer and incorporation bias, the residents underwent structured training and used uniform case-record forms with explicit operational definitions for each criterion. The screening test assessors were blinded to the results of DSM-5. The order of application of CAM-ICU and ICDSC was alternated across patients to reduce order effects. The screening tests and the DSM-5 assessments were completed within a comparable time frame (2–4 h) to minimise temporal variation in delirium status. A bedside cognitive examination, focusing on tests of attention, orientation, language, and memory, chart review, and interviews with nurses and family members were also conducted.

Brief and specific cognitive assessments were done to limit fatigue in acutely ill patients with attentional constraints. Bedside cognitive examinations included forward and backward digit span (attention), Vigilance A test (sustained attention), and orientation to time, place, and person. Language assessments included observation of fluency and grammatical structure of spontaneous speech, comprehension, repetition, naming, reading, and writing. Aphasia was classified as nonfluent (motor), fluent (sensory), and global based on standard definitions. Memory was tested using the three-word recall test and by testing recall of autobiographical and semantic information. The clock drawing test was used to assess global executive and visuospatial dysfunction. The tests were tailored according to the clinical situation, with necessary adaptations for patients with aphasia and motor weakness. Information obtained from informal assessments of

cognitive function during the course of clinical examination, such as the ability to focus, sustain, and shift attention, aided decision-making when neurological deficits precluded formal testing. Data regarding the cognitive assessment procedures and interpretations are available in the supplementary files.

The first delirium assessment was done within 24 h of admission, and the second was done 24 to 36 h later. The National Institutes of Health Stroke Scale (NIHSS) was assessed along with delirium assessments to identify focal neurological deficits. Language function and extinction/inattention were assessed as part of the NIHSS.

Delirium was considered present using a screening test if either one of the two assessments was positive, taking into account its fluctuating nature. The definitive diagnosis of delirium was established using criteria from the DSM of Mental Disorders, Fifth Edition (DSM-5). Stroke-related HOCDs were defined as the presence of aphasia, neglect, or short-term memory loss secondary to the stroke. Short-term memory was clinically defined as recall of information (e.g. three items) after a delay of about 2 min, and short-term memory loss was operationally defined as non-recall of all three items of the three-word recall test, even with cueing, after normal registration.[17] Short-term memory loss was considered stroke-related if there was neuroimaging evidence of acute infarcts in anatomically plausible regions, such as the left medial/occipitotemporal, basifrontal, or medial thalamic regions,[18] to differentiate the focal deficit from diffuse memory dysfunction. Diffuse cognitive abnormalities, such as executive dysfunction, visuospatial deficits, and memory impairment, were not included under HOCDs, as they are difficult to distinguish from pre-existing cognitive dysfunction and confusional states.

Delirium screening tools

CAM-ICU

The 4 item CAM-ICU is adapted from the Confusion Assessment Method to be used in critically ill, nonverbal, or intubated patients.[15] It requires the presence of inattention combined with a change in baseline level of consciousness, coupled with either disorganized thinking or impaired arousal at the time of examination, for a diagnosis of delirium. However, patients who are unable to follow commands may be scored positive for inattention and disorganized thinking by default, as the method of testing requires verbal comprehension.

ICDSC

The ICDSC is a checklist of eight delirium features developed for use in the Intensive Care Unit (ICU), with a score of 4 or more points indicative of delirium and scores of 1–3 classified as sub-syndromal delirium.[19] The items are scored through a combination of direct bedside examination and a review of symptoms from the previous 24 h. Hence, aphasic patients or those with significant neurologic deficits may be able to score on at least four of the components, thereby earning a positive rating.

The screening tools were translated into the local vernacular, Malayalam, by two independent translators and were back-translated into English. The translated questionnaires were then critically reviewed and validated. The questionnaires were first face-validated in 10 patients, and minor adjustments were made. The final translations were pilot-tested and validated in 20 patients with acute stroke. Two well-trained residents independently assessed delirium using the Malayalam versions of CAM-ICU and ICDSC. One of the two consultant neurologists, DS or RP, independently assessed the patients for DSM-5 criteria. All assessments were completed within a 4-h time frame. Both instruments demonstrated good internal consistency, with Cronbach's alpha values of 0.81 and 0.91 for CAM-ICU and ICDSC, respectively. Inter-rater reliability was substantial, with Cohen's K values of 0.78 and 0.73 for CAM-ICU and ICDSC, respectively. Validity was determined based on sensitivity, specificity, and positive and negative predictive values. Sensitivity was 88% and 75%, specificity was 83% and 92%, positive predictive value was 78% and 86%, and negative predictive value was 91% and 85% for CAM-ICU and ICDSC, respectively.

Statistical analysis

Standard descriptive statistics were used to report demographic and clinical characteristics, with means and standard deviation used for normally distributed data and nonnormal data described with median and interquartile range (IQR). The prevalence of individual delirium features were reported as proportions and percentages. The Chi-square test or Fisher's exact test were used to compare categorical variables, and t tests or Mann–Whitney U tests were used for continuous variables. The performance of CAM-ICU as well as ICDSC were compared with the reference-standard DSM-5 diagnosis, including measurements of sensitivity, specificity, negative predictive value, and positive predictive value using two-by two tables. The Mcnemar test was used to compare CAM-ICU and ICDSC with DSM-5 criteria. The agreement between the screening tests and DSM-5 was additionally assessed using Cohen's Kappa (κ) coefficients. An area under the receiver operating characteristic curve (AUROC) analysis was also performed.

The ability of individual delirium characteristics to improve diagnostic validity was evaluated by logistic regression analyses, and the effect of adding additional items (i.e. nonverbal items such as abnormal psychomotor activity and altered sleep–wake cycle) to improve the accuracy of the 4-item CAM diagnostic algorithm was analyzed by comparison with DSM-5. Statistical analysis was performed using SPSS version 23.

Results

A total of 304 patients were assessed for inclusion in the study, of whom 96 had hemorrhagic stroke, 15 patients had TIA, 23 had stroke onset more than 24 h prior to admission, and 6 patients were comatose throughout their stay. The final study cohort included 164 patients. The mean age was 64 ± 13 years, and the median NIHSS was 9 (IQR 5–13). Fifty-three patients (32.3%) developed early delirium based

on reference-standard diagnosis by DSM-5 criteria, of whom 34 patients (64%) had stroke-related HOCDs. Delirium was present on the first screening in 69% of patients. Demographic and clinical characteristics of patients with and without delirium are shown in Table 1. Delirium was significantly associated with increased age (odds ratio [OR] 1.12 [Confidence Interval [CI] 1.07–1.17] per year, $P < .001$) and stroke severity (OR 1. 25[CI1.16–1.35] per point increase, $P < .001$). Delirium was also significantly associated with the presence of aphasia (OR 3.96 [CI 1.89–8.31]), hemi-neglect (OR 3[1-48–6.07]), hemianopia (OR 3.26[CI 1.38–7.59]), and cortical location of infarcts (OR 2.23[CI 1.15–4.35]).

There were three patients with post-stroke seizures, all of whom had delirium. Each had only a single seizure, and there were no clinical features of nonconvulsive status epilepticus (NCSE), such as chewing movements, facial twitching, or oral automatisms.

Stroke-related HOCDs occurred in 64 (39%) patients, 34 (53%) of whom developed delirium. HOCDs included aphasia (n = 41, 25%), hemi-neglect (n = 48, 29%; 15 severe and 33 minor), and short-term memory loss (n = 2). Twenty-seven patients with aphasia also had minor neglect as per NIHSS scoring. Among the 41 patients with aphasia, nine had fluent aphasia, 11 had nonfluent aphasia, and 21 had global aphasia. In these 41 patients, 23 had severe comprehension defects rendering memory untestable, six patients with motor aphasia were tested by picking out three previously named objects from pictures, and 12 patients with mild aphasia were able to perform the three-word recall test verbally. Ten out of the 19 tested patients had memory impairment, but none fulfilled the criteria for stroke-related short-term memory loss.

Table 1: Demographic and clinical characteristics of patients

	Delirium (n=53)	No delirium (n=111)	*P* value
Demographics			
Age in years, mean± SD	70.7±12.6	60.6±13.8	<.001*
Male gender	29 (55)	76 (68)	.08
Diabetes	30 (57)	59 (53)	.67
Hypertension	35 (66)	70 (63)	.71
Previous stroke	8 (15)	9 (8)	.16
Atrial fibrillation	2 (4)	5 (5)	.82
Coronary artery disease	14 (26)	26 (23)	.67
Smoking	18 (34)	41 (37)	.71
Alcoholism	19 (36)	37 (33)	.75
Clinical Characteristics			
NIHSS (median, IQR)	15 (11,18)	7 (3,11)	<.001*
Aphasia	23 (43)	18 (16)	<.001*
Hemineglect	24 (45)	24 (22)	.002*
Hemianopia	15 (28)	12 (11)	.004*
Stroke cause			
Large artery disease	25 (47)	41 (37)	.21
Cardioembolic	6 (11)	13 (12)	.94
Small vessel disease	11 (21)	37 (33)	.09
Other determined etiology	3 (6)	3 (3)	.34
Undetermined etiology	8 (15)	24 (22)	.32
Location of infarcts			
Cortical	32 (60)	45 (41)	.02*
Subcortical	17 (32)	49 (44)	.08
Brainstem/cerebellar	4 (8)	17 (15)	.16

Numbers in parentheses are percentages. *Statistically significant at $P<.05$. IQR: interquartile range, NIHSS: National Institutes of Health Stroke Scale, SD: standard deviation

Characteristics of delirium

In delirious patients, inattention (impaired vigilance, 95%) was the most common feature, followed by impaired arousal (82%) and psychomotor changes (81%). The motor phenotype of delirium was mixed in 28 patients (53%), hypoactive in 15 (28%), and hyperactive in 10 (19%) patients. Individual delirium features of inattention and disorientation were common among stroke patients even without delirium, especially in patients with stroke-related HOCDs [Figure 1]. On logistic regression analysis, inattention (AUC.98, OR 28.88), psychomotor changes (AUC.95, OR 10.60), and impaired arousal (AUC.95, OR 8.57) were identified to have maximum discriminating value for a diagnosis of delirium based on DSM-5 in patients with HOCDs [Table 2]. The presence of delusions or hallucinations had good discriminatory value but was infrequently present, whereas disorientation and inappropriate speech or mood had poor discriminatory value.

Performance of screening tests in diagnosis of delirium

When applied to the entire study cohort, both instruments did not differ significantly from DSM-5 and are suitable as screening tools to detect early PSD. However, CAM-ICU had better accuracy than ICSDC. It had moderately good sensitivity with good specificity (AUROC 0.97), whereas sensitivity for ICDSC at the standard cut-off of ≥4 was lower at 68%, with good specificity (AUROC 0.96). Furthermore, CAM-ICU had substantial agreement with DSM 5 (Cohens κ 64), while ICDSC had good agreement (Cohens κ 53).

However, when applied to patients with HOCDs, the specificity of both instruments was markedly reduced, with a mild reduction in sensitivity. [Table 3]. When the ICDSC cutoff was

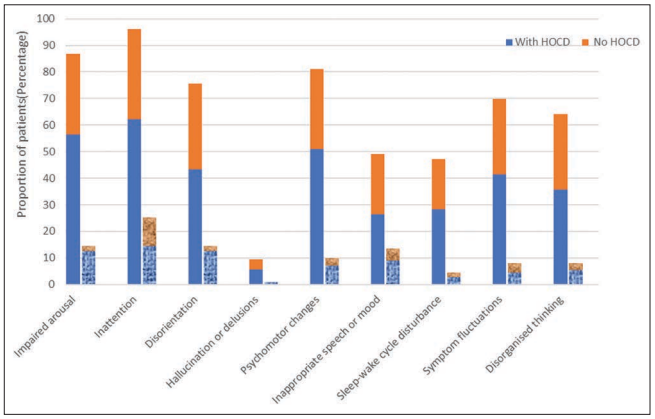

Figure 1: Frequency of individual delirium characteristics in patients with delirium (solid colors) and without delirium (textured colors)

Table 2: Logistic regression of delirium characteristics in patients with higher-order cognitive deficits (HOCDs)

Delirium Characteristics	Delirium (n=34)	No Delirium (n=30)	Odds ratio (95% CI)	*P* value	AUC
Impaired arousal	30 (88)	14 (47)	8.57 (2.41–30.40)	<.001*	.95
Inattention (Impaired vigilance)	33 (97)	16 (53)	28.88 (3.48–239.31)	.002*	.98
Disorientation	23 (68)	14 (47)	2.09 (.75–5.76)	.15	.84
Hallucinations or delusions	3 (9)	1 (3)	2.8 (.28–28.53)	.38	.97
Psychomotor changes	27 (79)	8 (27)	10.60 (3.32–33.84)	<.001*	0.95
Inappropriate speech or mood	14 (41)	10 (33)	1.4 (.50–3.87)	.51	.80
Sleep wake cycle disturbances	15 (44)	3 (10)	7.1 (1.8–28.0)	.01*	.94
Symptom fluctuation	22 (75)	5 (17)	9.1 (2.79–30.14)	<.001*	.94
Disorganised thinking	19 (56)	6 (20)	5.06 (1.65–15.56)	.01*	.91

Numbers in parentheses are percentages. *statistically significant at *P*<.05. AUC: area under curve, CI: confidence interval

Table 3: Diagnostic performance of screening tools in early post-stroke delirium

	Sensitivity	Specificity	PPV	NPV	*P* value (Stastistical significance vs DSM 5)
All patients					
CAM-ICU	81.13	83.78	70.49	90.29	.19
ICDSC 4	69.81	85.58	69.81	85.59	.86
ICDSC 5	54.71	90.99	74.35	82.79	.11
CAM- ICU plus	79.24	91.89	82.35	90.27	1.0
Patients with HOCD					
CAM ICU	73.53	56.67	645.78	65.38	.52
ICDSC 4	64.71	66.67	68.75	62.50	.83
ICDSC 5	50.0	80.1	73.91	58.53	.04*
CAM-ICU plus	70.59	80.0	80.0	70.59	.45

*Statistically significant (worse) at *P*<.05 on McNemar test for paired binary observations. CAM-ICU: Confusion Assessment Method for ICU, DSM: Diagnostic and Statistical Manual, HOCD: higher-order cognitive deficit, ICDSC: Intensive Care Delirium Screening Checklist, PPV: positive predictive value, NPV: negative predictive value

raised to ≥5, improved specificity was obtained at the cost of significantly reduced sensitivity, and its performance differed significantly from DSM-5.

We then analyzed the diagnostic utility of adding nonverbal delirium features to the CAM-ICU. We chose the presence of psychomotor changes (agitation or retardation) as the additional point, as it can be scored by direct observation without verbal interaction. It had the highest OR in our study for discriminating between patients with and without delirium among patients with HOCDs. Moreover, it is a core feature of other delirium screening tests, such as the Nursing Delirium Screening Scale and the Observational Scale of Level of Arousal. The new scale, CAM- ICU Plus, was considered positive if patients who were CAM-ICU positive also had the additional presence of psychomotor changes.

In patients with HOCDs, CAM-ICU Plus demonstrated higher accuracy with increased specificity (80%), offset only by a mild reduction in sensitivity (74%). CAM-ICU Plus was then applied to the entire study cohort during the analysis, as it is difficult to have different screening tests for different subgroups. CAM-ICU Plus showed substantial agreement with DSM-5 (Cohens κ 71) and did not differ significantly from it on the Mcnemar test.

In patients with hypoactive delirium with psychomotor retardation (n = 15), CAM-ICU had lower sensitivity (60%) with good specificity (94%). CAM-ICU Plus did not improve the accuracy in these patients due to the nature of its scoring; however, the presence of psychomotor retardation was significantly associated with false-negative CAM-ICU results (OR 16[2.88–88.73], *P* < .001), identifying a subgroup where further testing would be beneficial.

The ROC graphs presented in Figure 2 depict the sensitivity and false-positive rates of ICDSC, CAM-ICU, and CAM-ICU Plus in the entire study cohort.

Discussion

Delirium occurred in nearly one-third of patients in the immediate aftermath of an ischemic stroke, with more than two-thirds having onset within 24 h of admission. Previous studies on early delirium have shown rates ranging from 13%–38%, depending on the time frame and type of stroke.[5,6,20,21]A large study in a mixed cohort of predominantly ischemic stroke found an incidence rate of 25%, almost three-quarters of whom developed delirium on the first day.[5] Another study found an incidence rate of 38% within 72 h in a cohort of ischemic stroke and TIA patients, 14% of whom developed delirium on the first day.[6] The incidence of early-onset delirium in first-ever ischemic stroke has been reported to be lower, at 13%–16%.[20,21] Risk factors for delirium identified in our study included increased age,

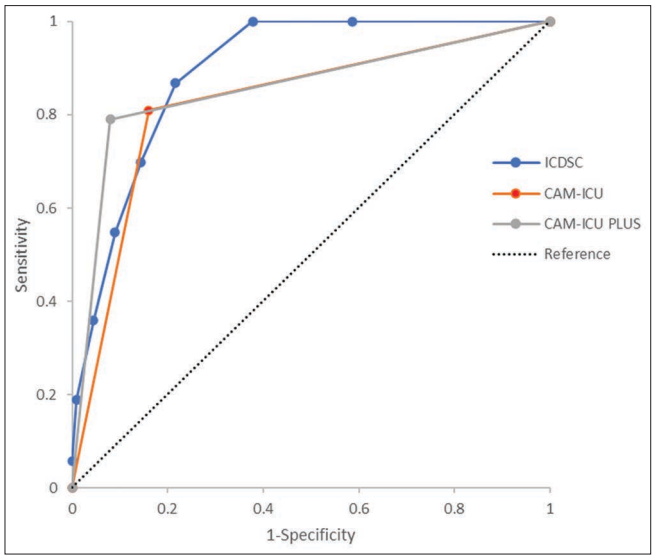

Figure 2: Receiver operating characteristic (ROC) curves for the CAM-ICU (binary), CAM-ICU Plus (binary), and ICDSC (ordinal). AUROC: CAM-ICU plus-.983, CAM-ICU-.969, ICDSC (ordinal)-.923. AUROC: area under the receiver operating characteristic curve, CAM-ICU: Confusion Assessment Method for ICU, ICDSC: Intensive Care Delirium Screening Checklist

moderate-to-severe stroke, presence of cortical infarcts, and clinical feature of aphasia, hemi-neglect, and hemianopia, which is in accordance with previous studies.[22]

Inattention, a defining feature of delirium, was highly prevalent in post-stroke patients without delirium and often co-occurred with aphasia. Sustained, selective, and divided attentional impairments have been described in stroke survivors, with deficits in divided attention and alertness predominating in patients with aphasia, whereas patients with neglect have deficits in both phasic and sustained attention.[23] This may be a direct impact of the stroke on attentional mechanisms and confounds delirium assessments, as it has been shown that false-positive screening tool results are more common in patients with minor neglect.[6] Other core features of delirium, such as alteration of consciousness and disorientation, were also common in stroke patients with HOCDs. While some of these are undoubtedly due to the direct impact of the stroke, differentiation from subsyndromal delirium is essential, as it has also been associated with poorer outcomes.[24]

Screening tests for delirium

When applied to the entire study cohort, both CAM-ICU and ICDSC did not differ significantly from the gold standard for diagnosing delirium. However, the sensitivity and specificity of both instruments were lower in patients with HOCDs. This is in accordance with previous studies, which have established the utility of CAM-ICU and ICDSC in the detection of PSD, while noting reduced accuracy in patients with cognitive deficits.[9-11]

In a recent influential study of several delirium screening tools in ischemic stroke, CAM has been reported to be the only screening test noninferior to DSM-5.[6] A systematic review of delirium screening tools in acute stroke identified only four well-designed studies that reported their accuracy and was unable to select the optimal screening test.[25]

Notably, we found that CAM-ICU performed better than ICDSC, with higher sensitivity and similar specificity even in patients with stroke-related HOCDs. It has previously been demonstrated that CAM-ICU is a better predictor of outcome in critically ill patients.[26] There are few head-to-head comparison studies between the two in neuro-intensive care settings, with some reporting ICSDC to have better accuracy in patients with aphasia.[11,12,27] However, one of these was in patients with intracerebral hemorrhage and included only 60 patients, with over half having intraventricular hemorrhage.[11] Another was a pilot study conducted over a period of 1 month in 123 neuro-critically ill patients, 54% of whom had ischemic stroke, finding similar accuracy for the two instruments in the entire cohort, while ICDSC performed better in patients with aphasia.[28] In contrast, a study evaluating ICDSC in post-stroke aphasia found a specificity of only 55% and suggested increasing the cutoff to ≥5.[27]

We attribute the higher sensitivity of CAM-ICU to its psychometric properties, which detect the core impairment in delirium, that is, in attention and cognition, when scored by examination at the bedside in a single discrete assessment, whereas the ICDSC requires information gained over previous 24 h from chart review, as well as nurses' and caretakers' interviews, leading to the possibility of under-reporting of symptoms, especially in a resource poor setting. Studies from resource-poor settings have described reduced prevalence of ICDSC delirium features, indicating regional variations, and have proposed lowering the cut-off values.[29] Intriguingly, we also noted that higher ICDSC cut-offs resulted in reduced sensitivities, predominantly in patients with HOCDs, suggesting that there is blunting of multiple delirium features in patients with cognitive deficits.

Strategies used to improve the test performance of screening tools included raising the ICDSC cutoff to 5, which resulted in higher specificity in a group of patients with post-stroke aphasia at the cost of markedly reduced sensitivity in nonaphasic patients.[27] Judicious use of CAM ICU has been attempted, unfortunately resulting in drastically reduced sensitivities.[11] It has been suggested that including motor manifestations that are not affected by cognitive deficits could improve delirium testing accuracy in patients with HOCDs.[30] Psychomotor changes have been reported as a good discriminant between delirious and nondelirious patients in PSD and have the additional advantage of never being rated untestable while being present in the vast majority of patients.[11] They are also part of the recently described Fluctuating Mental Status Examination, which is designed specifically for use in neuro-critical care settings.[31]

Hence, we tested a modification of the CAM-ICU incorporating psychomotor changes, the CAM-ICU Plus, which increased

the specificity of CAM-ICU in PSD and had the highest accuracy of all screening tools (AUROC.983), making it a suitable screening tool. Moreover, the presence of psychomotor changes, specifically psychomotor retardation, is a valuable clue to the presence of subtle delirium in CAM-ICU–negative patients, warranting repeated testing and careful clinical examination. However, the single-centre nature of our study limits generalizability, and further larger studies are needed to confirm our results.

Our study has several other limitations. The screening instruments were applied consecutively by the same examiner, which may lead to some subjectivity. However, intensive training in the application of the instruments, alternation in the sequence of testing, and strict adherence to the study protocol minimized this bias. We may have missed some cases, as screening was done twice in the first 3 days due to resource constraints, and more frequent examinations may have revealed a few additional cases. As only brief bedside cognitive tests could be done in acutely ill patients, the spectrum of neuropsychological deficits in patients with HOCDs, such as aphasia, could not be fully characterized. We used the easier three-word recall test rather than the more difficult five-word recall test, which is used in the Montreal Cognitive Assessment, to facilitate testing in patients with attentional restrictions. However, the three-word recall test is prone to ceiling effects, which may have led us to miss a few cases of acute stroke-related memory loss. We may also have missed some cases of mild HOCDs, which are evident only on detailed neuropsychological assessment. Continuous electroencephalogram (EEG) monitoring to rule out NCSE, which can mimic delirium, was not done; however, no patient had clinical features to suggest NCSE. We did not collect information on non-stroke-related etiologies for delirium, such as infections and medications.

Conclusions

Early PSD occurs in one-third of patients with acute ischemic stroke, being more common in those with HOCDs due to the stroke. Both CAM-ICU and ICDSC were suitable as screening tools, with CAM-ICU performing better than ICDSC in detecting PSD. CAM-ICU Plus improves the specificity of CAM-ICU in patients with stroke-related cognitive deficits, which needs to be confirmed by further multicenter studies. It remains challenging to detect PSD and requires the development of screening tools tailored for stroke patients.

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Nil.

Author contributions

DS: conceptualization; methodology; writing- original draft (lead), writing- review and editing. RP: project administration; conceptualization (supporting); methodology (supporting); writing- review and editing. JC: supervision; writing- review and editing. NSS: investigation; writing -original draft (supporting). AA: investigation; writing- original draft (supporting). TGJ: visualization; investigation. NM: visualization; investigation. AMM: data curation; investigation. NEF: data curation; formal analysis.

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Conflicts of interest

There are no conflicts of interest.

Data availability statement

The data generated and/or analyzed in this study will be made available by the corresponding author upon reasonable request.

References

1. Shaw RC, Walker G, Elliott E, Quinn TJ. Occurrence rate of delirium in acute stroke settings: Systematic review and meta-analysis. Stroke 2019;50:3028-36.
2. Shi Q, Presutti R, Selchen D, Saposnik G. Delirium in acute stroke: A systematic review and meta-analysis. Stroke 2012;43:645-9.
3. Zhang GB, Li HY, Yu WJ, Ying YZ, Zheng D, Zhang XK, et al. Occurrence and risk factors for post-stroke delirium: A systematic review and meta-analysis. Asian J Psychiatr 2024;99:104132.
4. Siokas V, Fleischmann R, Feil K, Liampas I, Kowarik MC, Bai Y, et al. The role of vascular risk factors in post-stroke delirium: A systematic review and meta-analysis. J Clin Med 2022;11:5835.
5. Pasinska P, Kowalska K, Klimiec E, Szyper-Maciejowska A, Wilk A, Klimkowicz-Mrowiec A. Frequency and predictors of post-stroke delirium in PRospective Observational POLIsh Study (PROPOLIS). J Neurol 2018;265:863-70.
6. Fleischmann R, Warwas S, Andrasch T, Kunz R, Witt C, Mengel A, et al. Course and recognition of poststroke delirium: A prospective noninferiority trial of delirium screening tools. Stroke 2021;52:471-8.
7. American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders: DSM-5. Fifth Edition. Arlington, VA, American Psychiatric Association; 2013.
8. Patel MB, Bednarik J, Lee P, Shehabi Y, Salluh JI, Slooter AJ, et al. Delirium monitoring in neurocritically ill patients: A systematic review. Crit Care Med 2018;46:1832-41.
9. Mitasova A, Kostalova M, Bednarik J, Michalcakova R, Kasparek T, Balabanova P, et al. Poststroke delirium incidence and outcomes: Validation of the confusion assessment method for the intensive care unit (CAM-ICU). Crit Care Med 2012;40:484–90.
10. Larsen LK, Frøkjær VG, Nielsen JS, Skrobik Y, Winkler Y, Møller K, et al. Delirium assessment in neuro-critically ill patients: A validation study. Acta Anaesthesiol Scand 2019;63:352-9.
11. Reznik ME, Drake J, Margolis SA, Moody S, Murray K, Costa S, et al. Deconstructing poststroke delirium in a prospective cohort of patients with intracerebral hemorrhage. Crit Care Med 2020;48:111-8.
12. Frenette AJ, Bebawi ER, Deslauriers LC, Tessier AA, Perreault MM, Delisle MS, et al. Validation and comparison of CAM-ICU and ICDSC in mild and moderate traumatic brain injury patients. Intensive Care Med 2016;42:122-3.
13. Nydahl P, Baumgarte F, Berg D, Bergjan M, Borzikowsky C, Franke C, et al. Delirium on stroke units: A prospective, multicentric quality-improvement project. J Neurol 2022;269:3735-44.
14. Nydahl P, Bartoszek G, Binder A, Paschen L, Margraf NG, Witt K, et al. Prevalence for delirium in stroke patients: A prospective controlled study. Brain Behav 2017;7:e00748.
15. Ely EW, Inouye SK, Bernard GR, Gordon S, Francis J, May L, et al. Delirium in mechanically ventilated patients: Validity and reliability of the confusion assessment method for the intensive care unit (CAM-ICU). JAMA 2001;286:2703–10.
16. Barman A, Pradhan D, Bhattacharyya P, Dey S, Bhattacharjee A, Tesia SS, et al. Diagnostic accuracy of delirium assessment methods in critical care patients. J Crit Care 2018;44:82–6.

17. Trzepacz PT, Mittal D, Torres R, Kanary K, Norton J, Jimerson N. Validation of the delirium rating scale-revised-98: Comparison with the delirium rating scale and the cognitive test for delirium. J Neuropsychiatry Clin Neurosci 2001;13:229-42.
18. O'Sullivan M, Li X, Galligan D, Pendlebury S. Cognitive recovery after stroke: Memory. Stroke 2023;54:44–54.
19. Bergeron N, Dubois MJ, Dumont M, Dial S, Skrobik Y. Intensive care delirium screening checklist: Evaluation of a new screening tool. Intensive Care Med 2001;27:859–64.
20. Kotfis K, Bott-Olejnik M, Szylińska A, Listewnik M, Rotter I. Characteristics, risk factors and outcome of early-onset delirium in elderly patients with first ever acute ischemic stroke-A prospective observational cohort study. Clin Interv Aging 2019;14:1771-82.
21. Qu J, Chen Y, Luo G, Zhong H, Xiao W, Yin H. Delirium in the acute phase of ischemic stroke: Incidence, risk factors, and effects on functional outcome. J Stroke Cerebrovasc Dis 2018;27:2641-7.
22. Carin-Levy G, Mead GE, Nicol K, Rush R, van Wijck F. Delirium in acute stroke: Screening tools, incidence rates and predictors: A systematic review. J Neurol 2012;259:1590-9.
23. Spaccavento S, Marinelli CV, Nardulli R, Macchitella L, Bivona U, Piccardi L, et al. Attention deficits in stroke patients: The role of lesion characteristics, time from stroke, and concomitant neuropsychological deficits. Behav Neurol 2019;2019:7835710.
24. Klimiec-Moskal E, Slowik A, Dziedzic T. Delirium and subsyndromal delirium are associated with the long-term risk of death after ischaemic stroke. Aging Clin Exp Res 2022;34:1459-62.
25. Mansutti I, Saiani L, Palese A. Detecting delirium in patients with acute stroke: A systematic review of test accuracy. BMC Neurol 2019;19:310.
26. Tomasi CD, Grandi C, Salluh J, Soares M, Giombelli VR, Cascaes S, et al. Comparison of CAM-ICU and ICDSC for the detection of delirium in critically ill patients focusing on relevant clinical outcomes. J Crit Care 2012;27:212-7.
27. Boßelmann C, Zurloh J, Stefanou MI, Stadler V, Weber Y, Lerche H, et al. Delirium screening in aphasic patients with the intensive care delirium screening checklist (ICDSC): A prospective cohort study. Front Neurol 2019;10:1198.
28. von Hofen-Hohloch J, Awissus C, Fischer MM, Michalski D, Rumpf JJ, Classen J. Delirium screening in neurocritical care and stroke unit patients: A pilot study on the influence of neurological deficits on CAM-ICU and ICDSC outcome. Neurocrit Care 2020;33:708-17.
29. George C, Nair JS, Ebenezer JA, Gangadharan A, Christudas A, Gnanaseelan LK, et al. Validation of the intensive care delirium screening checklist in nonintubated intensive care unit patients in a resource-poor medical intensive care setting in South India. J Crit Care 2011;26:138-43.
30. Thomas C, Kreisel SH, Oster P, Driessen M, Arolt V, Inouye SK. Diagnosing delirium in older hospitalized adults with dementia: Adapting the confusion assessment method to international classification of diseases, tenth revision, diagnostic criteria. J Am Geriatr Soc 2012;60:1471-7.
31. Reznik ME, Margolis SA, Andrews N, Basso C, Mintz N, Varga S, et al. Validating the fluctuating mental status evaluation in neurocritically ill patients with acute stroke. Crit Care Med 2024;52:1918-27.