Los Angeles Motor Scale to Identify Large Vessel Occlusion
Prehospital Validation and Comparison With Other Screens

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Background and Purpose—Prehospital scales have been developed to identify patients with acute cerebral ischemia (ACI) because of large vessel occlusion (LVO) for direct routing to Comprehensive Stroke Centers (CSCs), but few have been validated in the prehospital setting, and their impact on routing of patients with intracranial hemorrhage has not been delineated. The purpose of this study was to validate the Los Angeles Motor Scale (LAMS) for LVO and CSC-appropriate (LVO ACI and intracranial hemorrhage patients) recognition and compare the LAMS to other scales.

Methods—The performance of the LAMS, administered prehospital by paramedics to consecutive ambulance trial patients, was assessed in identifying (1) LVOs among all patients with ACI and (2) CSC-appropriate patients among all suspected strokes. Additionally, the LAMS administered postarrival was compared concurrently with 6 other scales proposed for paramedic use and the full National Institutes of Health Stroke Scale.

Results—Among 94 patients, age was 70 (±13) and 49% female. Final diagnoses were ACI in 76% (because of LVO in 48% and non-LVO in 28%), intracranial hemorrhage in 19%, and neurovascular mimic in 5%. The LAMS administered by paramedics in the field performed moderately well in identifying LVO among patients with ACI (C statistic, 0.79; accuracy, 0.72) and CSC-appropriate among all suspected stroke transports (C statistic, 0.80; accuracy, 0.72). When concurrently performed in the emergency department postarrival, the LAMS showed comparable or better accuracy versus the 7 comparator scales, for LVO among ACI (accuracies LAMS, 0.70; other scales, 0.62–0.68) and CSC-appropriate (accuracies LAMS, 0.73; other scales, 0.56–0.73).

Conclusions—The LAMS performed in the field by paramedics identifies LVO and CSC-appropriate patients with good accuracy. The LAMS performs comparably or better than more extended prehospital scales and the full National Institutes of Health Stroke Scale. **(*Stroke*. 2018;49:565-572. DOI: 10.1161/STROKEAHA.117.019228.)**

Key Words: ambulances ■ brain ischemia ■ cerebral hemorrhage ■ thrombectomy ■ triage

National guidance in the United States for regional systems of acute stroke care has recommended a 2 tier system comprised of disseminated Primary Stroke Centers and Acute Stroke Ready Hospitals able to provide intravenous fibrinolysis and organized supportive care and Comprehensive Stroke Centers (CSCs) able to provide endovascular interventions for acute cerebral ischemia (ACI) and advanced neurosurgical and neurointensive care for patients with intracranial hemorrhage (ICH).[1,2] The desirability of routing select ambulance patients directly to CSCs for faster definitive care has been intensified by the demonstration of dramatic, but time-dependent, benefit of endovascular thrombectomy for acute ischemic stroke because of large vessel occlusion (LVO).[3] Accordingly, there is an urgent need to develop and validate LVO-recognition scales for paramedic use in the field, to identify patients who would benefit from direct routing to a nearby CSC, diverting past an even nearer Primary Stroke Center.[2,4,5]

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In response to this imperative, several scale thresholds and scale instruments have been developed for paramedic use to identify LVO in the field. The first approach developed was a scale threshold for the Los Angeles Motor Scale (LAMS).[6] A 3-item, 0- to 10-point motor stroke-deficit scale, the LAMS had initially been developed for the general purpose of characterizing stroke deficit severity in the field.[7] For this application, it performs well, showing excellent concurrent, predictive, and divergent validity when administered by paramedics in the field in a recent large validation study.[8] After development, similarly to the National Institutes of Health Stroke Scale (NIHSS), the LAMS was analyzed to identify a score threshold associated with an LVO. In a derivation study in consecutive patients examined in the emergency department (ED) by physicians, a LAMS threshold ≥4 predicted LVO with good accuracy.[6] However, this threshold requires validation in patients actually examined prehospital by paramedics. It is also important to analyze how LVO-recognition scales categorize, for direct CSC versus Primary Stroke Center routing, prehospital stroke patients whose focal deficits are because of acute ICH rather than ischemic stroke.

Compared with other, generally later-developed, LVO identification instruments,[9–14] the LAMS is briefer (3 items), easier to implement (all straightforward motor items), and more efficient (LAMS is obtained automatically when the Los Angeles Prehospital Stroke Screen is performed for stroke recognition). If the LAMS performs comparably or better than other scales developed for LVO recognition, it could more easily be integrated into paramedic practice. We undertook a field validation study of the LAMS for LVO recognition and for CSC-appropriate (LVO AIS and ICH patients) recognition, and analyzed the comparative performance of the LAMS with 6 other, later-proposed prehospital the full NIHSS.

Materials and Methods

We analyzed data prospectively gathered in the FAST-MAG (Field Administration of Stroke Therapy-Magnesium) phase 3 randomized trial, which studied prehospital initiation of magnesium versus placebo for likely stroke patients presenting within 2 hours from last known well (LKW) time.[15] Any query about the data supporting the findings of this study can be requested from the FAST-MAG Trial Publication Committee through the corresponding author. The detailed methods of the FAST-MAG trial have been published previously.[16,17] For this study, data were analyzed from consecutive patients transported to UCLA Medical Center, the only FAST-MAG receiving hospital site with a standing clinical policy throughout the study period (2004–2012) of obtaining vessel imaging immediately on patient arrival, using magnetic resonance angiography (MRA) or computed tomography angiography (CTA).

The study was approved by the prehospital and hospital Institutional Review Boards. Patients were enrolled using explicit written informed consent (preponderance of enrollments) or exception from explicit informed consent in emergency research circumstances (when patient not competent and no legally authorized representative on scene). Patients with likely stroke, indicated by a positive modified Los Angeles Prehospital Stroke Screen, and within 2 hours of LKW, were enrolled in the trial. Paramedics performed the LAMS and the Glasgow Coma Scale (GCS) at time of enrollment in the field in all patients. After hospital arrival, study research coordinators performed the NIHSS and concurrently performed repeat LAMS and GCS assessments.

At the individual patient level, study entry criteria were (1) transport by UCLA Medical Center by emergency medical services (EMS) for likely stroke, (2) enrollment in FAST-MAG, and (3) MRA or CTA obtained within 6 hours of ED arrival and before intravenous tPA or endovascular thrombectomy. Among final diagnosis patients with ACI, the first vessel imaging study, MRA or CTA, was independently analyzed by 2 vascular neurologists blinded to other data, assessing if a vessel occlusion was present and which arterial segment was involved. Discordant ratings were settled by joint scan review. Occluded arterial segments were placed into categories of extra LVOs (XLVOs), LVOs, and medium vessel occlusions (MVOs). The lead occlusion site analysis was of LVOs, defined as arteries potentially accessible by current endovascular thrombectomy technology. Accordingly, LVO occlusions included occlusions of the intracranial internal carotid artery, the middle cerebral artery M1 or M2 segments, the vertebral artery, the basilar artery, the posterior cerebral artery P1 segment and the anterior cerebral artery A1 segment. XLVO occlusions were the subset of LVO occlusions that are largest, most proximal, and most easily accessed: the ICA, M1 middle cerebral artery, vertebral artery, and basilar artery. Patients were considered to have MVOs if occlusions were in the arterial segments inaccessible to endovascular approach: middle cerebral artery M3 or M4, posterior cerebral artery P2 or higher, and anterior cerebral artery A2 or higher. Patients were placed in the category of CSC-appropriate if they had either LVO AIS or ICH.

In the field validation portion of the current study, the performance of the LAMS administered by paramedics in the prehospital setting (PH LAMS) was assessed in identifying (1) LVOs among all patients with ACI and (2) CSC-appropriate patients among all suspected stroke patients. As a negative control, the predictive value of the prehospital GCS (PH GCS) administered by paramedics was also assessed.

In the scale comparison portion of the current study, the predictive value of 8 scales performed by study nurse coordinators in the ED was assessed in identifying (1) LVOs among all patients with ACI and (2)CSC-appropriate patients among all suspected stroke patients. The more extended examination interval in the ED permitted the full NIHSS to be performed, in addition to repeat LAMS and GCS assessments, and individual NIHSS item scores were used to populate multiple LVO assessment scales. The 8 scales for LVO recognition assessed in the ED included 6 developed for prehospital and 2 for ED use. The prehospital scales were (1) LAMS[6]; (2) Cincinnati Stroke Triage Assessment Tool (C-STAT; formerly CPSSS)[10]; (3) Field Assessment Stroke Triage for Emergency Destination[13]; (4) Prehospital Acute Stroke Severity scale[11]; (5) Rapid Arterial Occlusion Evaluation (RACE) scale[12]; and (6) Vision-Aphasia-Neglect (VAN) scale.[14] The ED scales were (1) 3-item Stroke scale (3i-SS)[9] and (2) full NIHSS. For the prehospital scales and the 3i-SS, the cut point evaluated for predicting LVO presence was that recommended by each scale publication, and the same cut point was used to identify all CSC-appropriate patients. For the NIHSS, 2 recommended cut points were analyzed, ≥10 and ≥7.[18,19] For the GCS, the cut point was selected using the Youden Index.[20]

For all scales, predictive performance over full scale range was evaluated by calculating the C statistic, and predictive performance for suggested scale cut points was evaluated by calculation of sensitivity, specificity, positive predictive value, negative predictive value, overall accuracy, and positive and negative likelihood ratios. For the C statistic, scale performance was considered excellent for values between 0.9 and 1, good between 0.8 and 0.9, fair between 0.7 and 0.8, poor between 0.6 and 0.7, and failed between 0.5 and 0.6.[21]

Results

Among the 94 study patients, mean age was 70±13, 49% were female, median prehospital LAMS 4.0 (interquartile range [IQR], 3.0–5.0), and median ED NIHSS 9 (IQR, 2–18). Final stroke subtype diagnosis was ACI in 76%, ICH in 19%, and neurovascular mimic in 5%. The mode of first vessel imaging was MRA in 82% and CTA in 18%. The time interval from LKW to paramedic LAMS examination in the field was

median 23.5 minutes (IQR, 14.0–39.3). Additional time intervals were LKW to ED arrival 62 minutes (IQR, 48.8–87.3); LKW to first vessel imaging 100.5 minutes (IQR, 83.3–128.3); and LKW to study nurse ED examination 160 minutes (IQR, 122.3–195.0). Transports were by 29 ambulances from 4 EMS provider agencies.

Among patients with ACI, vessel occlusion locations are shown in Table 1. LVOs were present in 45/71 (63%), including XLVOs in 36/71 (51%), MVOs were present in 5/71 (7%), and no occlusion was observed in 21/71 (30%). Considering LVO ACI patients (n=45) and ICH patients (n=18), CSC-appropriate patients accounted for 63/94 (67%) of transports.

The demographic and clinical features of patients are shown in Table 2. Severity of focal deficits was the only feature consistently distinguishing LVO and CSC-appropriate patients from all other suspected stroke patients. Both the prehospital LAMS and ED NIHSS were higher in the target patients (Table 2; Figure 1A and 1B; Figure IA and IB in the online-only Data Supplement).

The LAMS performed by paramedics in the field showed fair performance as a continuous scale in predicting the presence of LVO among cerebral ischemia patients (C statistic=0.79), and good performance in identifying CSC-appropriate patients among all suspected stroke transports (C statistic=0.80). The prehospital LAMS score cutoff at ≥4 showed good binary performance (Table 3), both in identifying LVOs among cerebral ischemia patients (sensitivity, 0.76; specificity, 0.65; and accuracy, 0.72) and in identifying CSC-appropriate patients among all suspected stroke transports (sensitivity, 0.73; specificity, 0.71; and accuracy, 0.72). Prehospital LAMS performance was similar for identifying XLVOs (Table I in the online-only Data Supplement).

In contrast, the GCS performed by paramedics in the field showed poor performance as a continuous scale in identifying LVOs among those with cerebral ischemia (C statistic=0.61) and failed performance in identifying CSC-appropriate patients among all suspected stroke transports (C statistic=0.56).The best prehospital GCS threshold of ≤14 also performed poorly in identifying LVOs among cerebral ischemia patients (sensitivity, 0.4; specificity, 0.84; and accuracy, 0.56) and CSC-appropriate patients among all suspected stroke transports (sensitivity, 0.32; specificity, 0.81; and accuracy, 0.47).

Table 1. Final Diagnoses Among Enrolled Patients

	n	Percent
Acute cerebral ischemia	71/94	76%
No vessel occlusion	21/94	22%
Large vessel occlusion	45/94	48%
Internal carotid artery	13/94	14%
M1	21/94	22%
M2	9/94	10%
Vertebral artery	1/94	1%
Basilar artery	1/94	1%
P1 posterior cerebral artery	0/94	0%
A1 anterior cerebral artery	0/94	0%
Medium vessel occlusion	5/94	5%
M3–4	2/94	2%
P2 posterior cerebral artery	3/94	3%
A2 anterior cerebral artery	0/94	0%
Intracranial hemorrhage	18/94	19%
Cardiovascular disease mimic	5/94	5%

The comparative performance of the 8 scales administered by study nurse coordinators in the ED is shown in Figure 2 and Table 4. For identifying LVOs among those with cerebral ischemia, all thresholded scales showed fair to moderate performance (accuracies ranging from 0.62–0.70). The 4 highest accuracy point estimates were for the LAMS (0.70), the C-STAT (0.68), the Prehospital Acute Stroke Severity scale (0.68), and the full NIHSS cutoff at ≥7 (0.68) and the 2 lowest point estimates were for the 3i-SS (0.62) and the VAN (0.63). For identifying CSC-appropriate patients among all suspected stroke transports, the scales showed performance ranging from poor to moderate (accuracies ranging from 0.56–0.73). The 4 highest accuracy point estimates were for the LAMS (0.73) and the full NIHSS cutoff at ≥7 (0.73), RACE (0.66), and VAN (0.66) and the two lowest point estimates were for the 3i-SS (0.56) and the C-STAT (0.62). Similar results were seen for identifying XLVOs (Table II in the online-only Data Supplement).

Discussion

This study provides prospective validation of the LAMS performed by paramedics in the field as a useful tool to identify individuals with LVOs among all patients with ACI; and to identify both types of CSC-appropriate patients, those with symptoms because of LVO ACI or acute ICH, among all suspected stroke transports. A LAMS score of 4 or higher doubled, and a LAMS score of 0 to 3 halved, the likelihood that a patient was among the target group. In addition, this study provides perspective on the comparative performance of the LAMS and other scales for LVO recognition, when performed concurrently shortly after ED arrival. The LAMS was comparable or superior to 6 alternative, more complicated scales that have been suggested for prehospital or ED use, and comparable to the full NIHSS.

This field validation study confirms and extends the findings of the initial derivation study of the LAMS for LVO recognition.[6] Whereas the derivation study was based on patients examined by physicians in the ED, the current study confirms that the LAMS has value in identifying LVOs among all cerebral ischemia patients when actually performed by paramedics in the field, and also demonstrates scale value in identifying all CSC-appropriate patients (LVO AIS plus ICH) among all stroke transports. Though the LAMS showed fair performance, comparable or superior to other proposed scales and the full NIHSS, the accuracy of the LAMS for LVO recognition was less in the current study than in the derivation study, likely for several reasons. The derivation study included not only 911 EMS-transported patients, but also patients arriving by private vehicle, who are likely to have mild deficits and

Table 2. Patient Characteristics

Characteristic	All Patients	ACI Because of LVO	ACI Because of Non-LVO	ICH	CVD Mimics	*P* Value LVO vs Other	*P* Value CSC-Appropriate vs Other
n	94	45	26	18	5	…	…
Age, mean (SD)	69.6 (12.9)	70.7 (11.5)	69.5 (14.0)	65.1 (13.1)	78.0 (16.8)	0.61	0.60
Sex female, n (%)	46 (48.9)	23 (51.1)	12 (46.2)	8 (44.4)	3 (60.0)	0.69	0.94
Race, n (%)							
Asian	4 (4.3)	2 (4.4)	2 (7.7)	0 (0.0)	0 (0.0)	0.49	0.98
Black	21 (22.3)	12 (26.7)	5 (19.2)	4 (27.2)	0 (0.0)	0.49	0.98
White	68 (72.3)	31 (68.9)	18 (69.2)	14 (77.8)	5 (100)	0.49	0.98
Other	1(1.1)	0(0.0)	1(3.8)	0(0.0)	0 (0.0)	0.49	0.98
Ethnicity–Hispanic, n (%t)	12 (12.8)	3 (6.7)	3 (11.5)	5 (27.8)	1 (20.0)	0.47	0.98
Prehospital LAMS							
Mean (SD)	3.7 (1.3)	4.1 (1.2)	2.8 (1.3)	4.1 (1.1)	2.4 (0.9)	0.001	<0.001
Median (IQR)	4.0 (3.0–5.0)	5 (3.5–5)	3 (1.5–4)	4.5 (3.0–5.0)	3.0 (1.5–3.0)	0.001	<0.001
Prehospital GCS							
Mean (SD)	14.2 (1.6)	13.8 (1.8)	14.4 (1.7)	14.7 (1.0)	14.4 (0.9)	0.16	0.32
Median (IQR)	15.0 (14.0–15.0)	15 (13–15)	15 (15–15)	15.0 (15.0–15.0)	15.0 (13.5–15.0)	0.05	0.01
ED NIHSS							
Mean (SD)	11.1 (9.4)	13.5 (10.1)	6.1 (7.9)	13.7 (5.5)	6.8 (11.3)	0.002	<0.001
Median (IQR)	9.0 (2–18)	14 (4.5–21.5)	3 (1–8)	12.5 (9.0–18.3)	2.0 (1.5–14.5)	0.001	0.03
Prestroke modified Rankin Scale, median (IQR)	0.0 (0.0–0.0)	0 (0.0)	0 (0.0)	0.0 (0.0–0.0)	0.0 (0.0–0.0)	0.48	0.86
Hypertension, n (%)	65 (69.1)	33 (73.3)	19 (73.1)	9 (50.0)	4 (80.0)	0.98	0.45
Diabetes mellitus, n (%)	18 (19.1)	9 (20.0)	5 (19.2)	2 (11.1)	2 (40.0)	0.94	0.55
Hyperlipidemia, n (%)	44 (46.8)	26 (57.8)	14 (53.8)	0 (0.0)	4 (80.0)	0.75	0.13
Atrial fibrillation, n (%)	26 (27.7)	15 (33.3)	9 (34.6)	1 (5.6)	1 (20.0)	0.91	0.48
Smoking, n (%)	17 (18.1)	9 (20.0)	7 (26.9)	3 (16.7)	1 (20.0)	0.63	0.73
Prior ischemic stroke, n (%)	10 (10.6)	5 (11.1)	4 (15.4)	0 (0.0)	1 (20.0)	0.60	0.27
Prior TIA, n(%)	8 (8.5)	2 (4.4)	2 (7.7)	2 (11.1)	2 (40.0)	0.57	0.28
Any alcohol use, n(%)	39 (41.5)	22 (48.9)	8 (30.8)	8 (44.4)	1 (20.0)	0.14	0.86

ACI indicates acute cerebral ischemia; CSC, Comprehensive Stroke Center; CVD, cardiovascular disease; ED, emergency department; GCS, Glasgow Coma Scale; ICH, intracranial hemorrhage; IQR, interquartile range; LAMS, Los Angeles Motor Scale; LVO, large vessel occlusion; NIHSS, National Institutes of Health Stroke Scale; and TIA, transient ischemic attack.

non-LVO strokes, and patients arriving by interfacility transport, who are likely to have severe deficits and LVO strokes. All scales are likely to perform better in such broad cohorts than in a pure 911 EMS-transported patient population, with less representation of mild deficit, non-LVO and severe deficit, LVO extremes. In addition, the derivation study, performed in the era before current mechanical endovascular technology, evaluated scale performance in identifying LVOs and MVOs combined, rather than just LVOs.

Notably in the current study, the LAMS performed prehospital by paramedics had higher sensitivity, though lower specificity, for LVO than the LAMS performed after arrival in the ED. This pattern likely reflects the frequent occurrence of spontaneous improvement in neurological deficits among patients with ACI very early after onset,[22,23] and may reflect in some cases actual spontaneous lysis of an LVO between the time of paramedic assessment and ED arrival.[24]

The comparative performance in this study of the prehospital scales for LVO recognition largely accords with prior investigations. In the largest prior comparative study, analyzing scales performed by physicians in the ED in patients receiving intravenous tPA, the LAMS, C-STAT, Prehospital Acute Stroke Severity scale, and RACE all performed comparably in LVO recognition, whereas the 3i-SS had less sensitivity and greater specificity.[11] In another study of consecutive stroke alert patients examined by physicians in the ED, the LAMS, Field Assessment Stroke Triage for Emergency Destination, Prehospital Acute Stroke Severity scale, and RACE all performed comparably in LVO recognition, whereas the C-STAT had a lower C statistic.[25] Our study

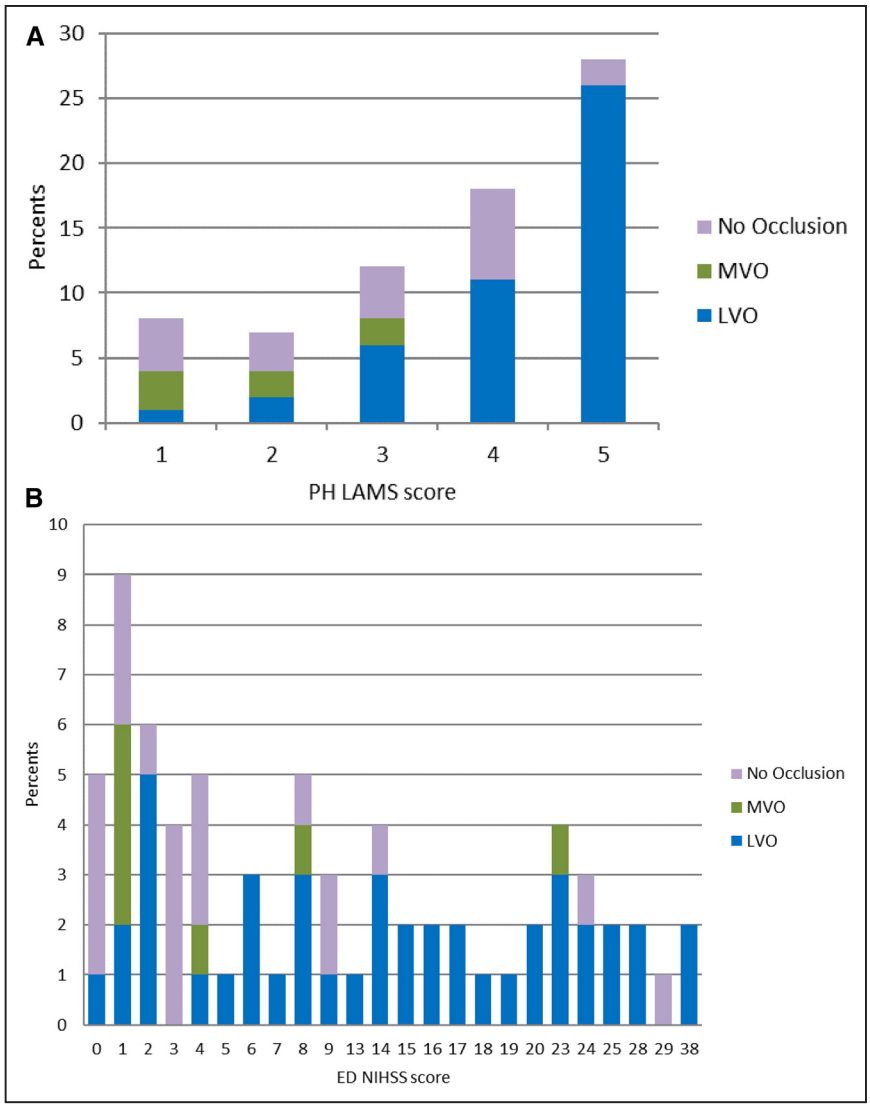

Figure 1. Deficit severity scores of acute cerebral ischemia patients with large vessel occlusions (LVO), medium vessel occlusions (MVO), and no visualized occlusion, on (**A**) the Los Angeles Motor Scale (LAMS) performed in the field by paramedics and (**B**) the full National Institutes of Health Stroke Scale (NIHSS) performed in the emergency department (ED) after hospital arrival.

similarly shows the LAMS performing comparably or better than other proposed scales.

Few prior studies have analyzed actual performance of an LVO-recognition scale when applied by paramedics in the field. In one study, the RACE was evaluated among patients transported by paramedics, but the scale was completed in only 40% of transports, and 18% of patients with completed scales were interfacility transfers rather than direct field responses.[12] In addition, CTA, MRA, or catheter angiography were obtained only when there was clinical suspicion of LVO, and were performed in only 23% of patients. In this selected population, the prehospital RACE performed with comparable accuracy to the prehospital LAMS in the current study (0.72 versus 0.72). In the current study, after ED arrival, the RACE showed lesser accuracy than the concurrently performed LAMS (0.65 versus 0.70). In another study, the C-STAT was performed by paramedics among patients transported during a 6 month period to one stroke center, but C-STAT values were incomplete in 23%, hospital evaluation information missing in 7%, and performance was not assessed in the 7% of patients with subsequent improvement.[26] Among the remaining 17 patients, the prehospital C-STAT performed with comparable accuracy to the prehospital LAMS in the current study (0.71 versus 0.72). In the current study, after ED arrival, the C-STAT showed comparable accuracy to the concurrently performed LAMS (0.68 versus 0.70).

It should not be surprising that, in an acute EMS-transported population, the LAMS, a pure motor assessment, performs

Table 3. Performance of Prehospital Los Angeles Motor Scale score ≥4 in Identifying LVO and CSC-Appropriate Patients

	LVO Among All Cerebral Ischemia	CSC Among All Suspected Stroke Transports
Sensitivity	0.76	0.73
Specificity	0.65	0.71
Positive predictive value	0.79	0.84
Negative predictive value	0.61	0.56
Accuracy	0.72	0.72
Positive likelihood ratio	2.18	2.51
Negative likelihood ratio	0.37	0.38

CSC indicates Comprehensive Stroke Center; and LVO, large vessel occlusion.

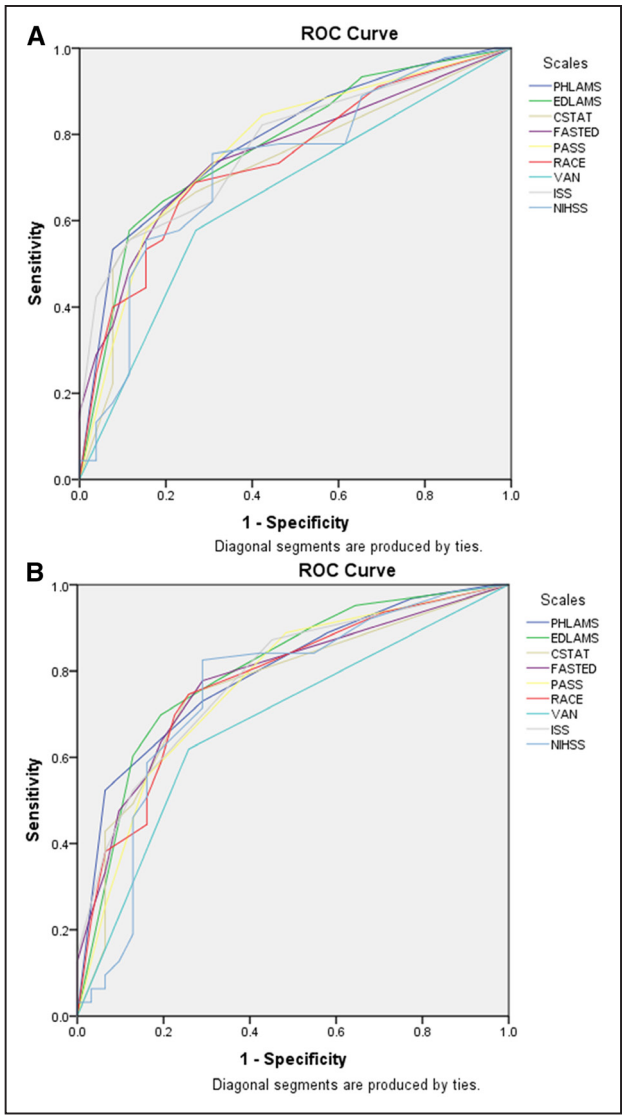

Figure 2. Comparative performance of 8 scales administered concurrently after emergency department arrival, in identifying (**A**) large vessel occlusions among all patients with acute cerebral ischemia and (**B**) Comprehensive Stroke Center-appropriate patients among all suspected stroke transports. CSTAT indicates Cincinnati Stroke Triage Assessment Tool; EDLAMS, emergency department Los Angeles Motor Scale; FASTED, Field Assessment Stroke Triage for Emergency Destination; ISS, item stroke scale; NIHSS, National Institutes of Health Stroke Scale; PASS, Prehospital Acute Stroke Severity; PHLAMS, prehospital LAMS; RACE, Rapid Arterial Occlusion Evaluation; ROC, receiver operating characteristic; and VAN, Vision-Aphasia-Neglect.

comparably in LVO identification to more complex instruments that assess cortical findings, such as aphasia, hemineglect, gaze deviation, and visual field defects. First, in acute ischemic stroke, great preponderance of patients with severe motor deficits also have cortical deficits and LVOs.[27,28] The syndrome of pure motor hemiparesis because of small deep infarcts accounts for only 7% of ischemic stroke presentations.[28] Second, some patients with small deep infarcts present with cortical signs of aphasia, neglect, gaze deviation, and visual field defect, as language, spatial attention, gaze control, and vision arise from distributed large scale neurocognitive networks in the brain that have subcortical as well as cortical nodes.[29–31] Third, presentation of ischemic stroke with isolated aphasia, neglect, and visual field deficits, sparing motor deficits, is uncommon, likely even more uncommon among early activators of the 911 EMS system, and often reflects distal, MVOs rather than proximal LVOs.[32,33] Reflecting these complexities, a detailed analysis of patterns of cortical and elementary findings on the NIHSS in 1085 acute, anterior circulation ischemic stroke patients was unable to identify any pattern of deficits that had enhanced value in detecting the presence of LVO.[34] Also of note, all of the LVO-recognition scales except the VAN have motor as well as nonmotor items, and moderate severe pure motor hemiparesis, with or without result dysarthria, will score high enough to indicate LVO presence, despite the lacunar syndrome presentation, not only on the LAMS, but also 3 of the scales (Field Assessment Stroke Triage for Emergency Destination, RACE, NIHSS).

Although the preponderance of prior studies have focused on LVO recognition, the current study additionally analyzed scale utility in identifying CSC-appropriate patients, defined as patients with either acute ischemic stroke because of LVO or acute ICH. ICH patients typically present with more severe deficits than ischemic stroke patients, and are over-represented in the EMS-transported population as they more often access the 911 system early, reflecting their more severe deficits and more frequent occurrence of headache.[16] Accordingly, LVO-recognition instruments that reflect greater deficit severity will also disproportionately select ICH patients for direct transport to CSCs. When CSCs are relatively close to the ambulance point of origin, direct transport to the comprehensive center is desirable. ICH patients benefit from the more advanced neurosurgical, neuroendovascular, and neurocritical care services available at CSCs, often in a time-urgent fashion, and interfacility transfer from a Primary Stroke Center to a CSC can be delayed in some jurisdictions.[35,36] Accordingly, in the current analysis, we included patients with ICH along with patients with LVO AIS in the CSC-appropriate category.

All of the LVO-recognition instruments tested in the current study showed only moderate, rather than high, accuracy, including the current gold standard scale of the full NIHSS. Deficits on physical examination in patients with stroke reflect not only the site of vessel occlusion, but also several additional features, including the adequacy of collateral flow, the eloquence of the particular neuroanatomic fields supplied, and preexisting deficits from prior strokes and neurological diseases. Nonetheless, although not providing definitive diagnostic information, scale performance is in a range useful for the application of determining patient routing in the field.[37]

A positive LAMS (4 or higher) more than increases the likelihood a patient harbors a CSC-appropriate lesion by 2.5-fold and a negative LAMS reduces the likelihood by nearly two-thirds.

This study has limitations. Study entry in FAST-MAG required the presence of at least a minor motor deficit, precluding enrollment of patients with pure aphasia or pure hemineglect. This may have advantaged scales the 7 scales that used motor items and disadvantaged the VAN scale that did not. However, the frequency of isolated aphasia and

Table 4. Performance of Scales in the ED in Identifying LVO and CSC-Appropriate Patients

	LVO Among All Cerebral Ischemia Patients					CSC-Appropriate Among All Suspected Stroke Transports				
	Sensitivity	Specificity	Accuracy*	PPV	NPV	Sensitivity	Specificity	Accuracy*	PPV	NPV
ED LAMS	0.64	0.81	0.70	0.85	0.57	0.70	0.81	0.73	0.88	0.57
ED C-STAT	0.56	0.88	0.68	0.89	0.53	0.49	0.87	0.62	0.89	0.46
ED FAST-ED	0.56	0.85	0.66	0.86	0.52	0.56	0.84	0.65	0.88	0.48
ED PASS	0.58	0.85	0.68	0.87	0.54	0.56	0.84	0.65	0.88	0.48
ED RACE	0.56	0.81	0.65	0.83	0.51	0.59	0.81	0.66	0.86	0.49
ED VAN	0.58	0.73	0.63	0.79	0.50	0.62	0.74	0.66	0.83	0.49
ED 3i-SS	0.42	0.96	0.62	0.95	0.49	0.38	0.94	0.56	0.92	0.43
ED NIHSS≥7	0.67	0.69	0.68	0.79	0.55	0.75	0.73	0.73	0.84	0.58
ED NIHSS≥10	0.56	0.85	0.66	0.86	0.52	0.59	0.84	0.67	0.88	0.50

CSC indicates Comprehensive Stroke Center; C-STAT Cincinnati Stroke Triage Assessment Tool; ED, emergency department; FAST-ED, Field Assessment Stroke Triage for Emergency Destination; i-SS, item Stroke scale; LAMS, Los Angeles Motor Scale; LVO, large vessel occlusion; NIHSS, National Institutes of Health Stroke Scale; NPV, negative predictive value; PASS, Prehospital Acute Stroke Severity; PHLAMS, prehospital LAMS; PPV, positive predictive value; RACE, Rapid Arterial Occlusion Evaluation; ROC, receiver operating characteristic; and VAN, Vision-Aphasia-Neglect.

*In 2-way comparisons of accuracy values among all instruments, differences reaching nominal *P* values<0.05 favored the ED LAMS, 3i-SS, and FAST-ED over VAN, for detecting LVO among all cerebral ischemia patients; and the ED LAMS, RACE, 3i-SS, PASS, and FAST-ED over VAN for detecting CSC-appropriate among all suspected stroke patients (DeLong test). *P* values exceeded 0.05 for all other comparisons.

neglect presentations is uncommon in acute ischemic stroke, and generally reflects medium rather than LVO.[32,33] Study entry in FAST-MAG also required physician phone screen of the patient, in addition to paramedic assessment. As a result, the frequency of stroke mimics among suspected stroke transports may have been reduced in the present study. As mimic patients typically have more minor deficits and no LVO, a reduction in their numbers may have led to underestimation of the specificity of all tested scales for LVO detection. The study focused on patients encountered by paramedics within 2 hours of onset. Additional studies are needed to determine whether the relation between prehospital LVO scale scores and confirmed LVO on arrival is similar or differs in later-presenting patients. Nonetheless, the current study findings are of direct value, as one-half of all EMS-transported ischemic stroke patients in the United States are encountered by paramedics within 2 hour of onset.[38] The study sample size was moderate, and patients were transported by several ambulances from multiple EMS provider agencies, but within one geographic region to one receiving stroke center. The patients at the receiving center in this study were very similar in demographic and clinical features to patients transported to other centers in the trial.[15] Nonetheless, larger, multicenter validation studies are desirable.

We conclude that the LAMS performed in the field by paramedics shows good sensitivity and specificity in identifying LVO AIS patients among all cerebral ischemia patients and in identifying CSC-appropriate patients among all stroke transports. A positive LAMS result more than doubles the likelihood a patient is in a target category, whereas a negative result decreases by more than half the likelihood a patient is in a target category. The 3 motor-item LAMS is brief and simple for prehospital personnel to perform, and performs comparably or better than more extended prehospital scales and the full NIHSS in identifying LVO AIS and CSC-appropriate patients.

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Disclosures

None.

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