Centrally Guided Identification of Patients With Large Vessel Occlusion: Lessons From Trauma Systems

Toby I. Gropen, MD, Melissa Gazi, MPH, Michael Minor, BBA, NRP, Abimbola Fadairo, MD, MPH, and Joe Acker, EMT-P, MPH

Objective: Improve prehospital identification of acute ischemic stroke patients with large vessel occlusion (LVO) by using a trauma system-based emergency communication center (ECC) to guide the emergency medical service (EMS). *Methods:* We trained 24 ECC paramedics in the Emergency Medical Stroke Assessment (EMSA). ECC-guided EMS in performance of the EMSA on patients with suspected stroke. During the second half of the study, we provided focused feedback to ECC after reviewing recorded ECC-EMS interactions. We compared the sensitivity, specificity, and area under the receiver operator characteristics curve (AUC) and 95% confidence interval of ECC-guided EMSA to the NIH Stroke Scale (NIHSS) for predicting a discharge diagnosis of LVO. *Results:* We enrolled 569 patients from September 2016 through February 2018. Of 463 patients analyzed, 236 (51%) had a discharge diagnosis of stroke and 227 (49%) had a nonstroke diagnosis. There were 45 (19%) stroke patients with LVO. For predicting LVO, there was no significant difference between the EMSA AUC = .68 (.59-.77) and the NIHSS AUC = .73 (.65-.81). An EMSA score greater than or equal to 4 had sensitivity = 75.6 (60.5-87.1) and specificity = 62.4 (57.6-67.1) for LVO. During the first 9 months of the study, the EMSA AUC = .61 (.44-.77) compared to an AUC = .74 (.64-.84) during the second 9 months. *Conclusions:*ECC-guided prehospital EMSA is feasible, has similar ability to predict LVO compared to the NIHSS, and has sustained performance over time.

Key Words: Acute stroke—emergency medical services—systems of care—thrombectomy

Introduction

Like those of alteplase, the benefits of mechanical thrombectomy (MT) for patients with acute ischemic stroke (AIS) due to proximal large vessel occlusion (LVO) are time dependent.[1] Identifying patients with LVO and transporting them to hospitals that provide MT is a challenge to our existing acute stroke system of care, which generally transports stroke patients to the nearest stroke center. Unfortunately, interfacility transfer of LVO patients to a hospital that provides MT often results in delayed or missed opportunities for treatment.[2,3] Accordingly, one goal of our acute stroke system of care should be to optimize paramedic identification and triage of AIS patients with LVO.

Brief prehospital stroke severity scales based on the NIH Stroke Scale (NIHSS)[4] have been developed to help emergency medical service (EMS) providers identify AIS patients with LVO who may benefit from MT.[5-12] Although clinical scales used to identify patients with LVO are subject to false positives in patients with stroke mimics as well as false negatives in patients with mild deficits,[13] there are opportunities to improve prehospital stroke recognition and triage. The ability of EMS to assess and screen for stroke is hampered by limited stroke-specific training, infrequent exposure of individual EMS providers to stroke, and limited feedback of performance.[14,15] We sought to

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Address correspondence to Toby I Gropen, MD, FAHA, Division of Cerebrovascular Disease, The University of Alabama at Birmingham, RWUH M226, 619 19th St S, Birmingham, AL 35249-3280. E-mail: tgropen@uabmc.edu.

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improve the ability of EMS providers to identify stroke patients with LVO by developing and demonstrating the feasibility and validity of a model of prehospital stroke assessment that leverages existing trauma system emergency communication centers (ECCs) to assist EMS providers in the field.

Methods

Standard Protocol Approvals, Registrations, and Patient Consents

The study was approved by the University of Alabama at Birmingham (UAB) Institutional Review Board. The need for patient consent was waived.

The Alabama Stroke System

Birmingham Regional EMS System (BREMSS) implemented a 7-county regional stroke system in north central Alabama in 2000, using the existing infrastructure of the BREMSS Trauma System to identify and route stroke system patients. In 2017, the Alabama Department of Public Health Office of Emergency Medical Services developed a statewide stroke emergency care system. At the heart of the system is the Alabama Trauma Communications Center (ATCC), operated by BREMSS, where 24 paramedic-trained communicators field calls from EMS providers and maintain up-to-the-minute status of hospitals and resources 24/7 across the state. EMS providers in Alabama enter all patients with suspected stroke into the Alabama Stroke System by calling the ATCC via cell phone or radio system for voice communications. The ATCC, like other ECCs, is not involved with initial emergency medical dispatch, but rather assists EMS providers in routing the patient to the correct stroke system hospital depending on hospital-resource availability and sending out a prenotification to the receiving hospital. Hospitals have the ability to continually update their stroke patient resource availability through the computer system. All interactions between ATCC and EMS are recorded, allowing review of audio files of their interaction and facilitating quality improvement. Prior to the initiation of the present study, all EMS providers in BREMSS assessed suspected stroke patients using the Face, Arm, and Speech Test (FAST).[16]

Patient Population

The study included patients who suspected of having stroke evaluated by 3 large EMS organizations that provide most of the EMS transports in BREMSS and who were transported to UAB. We excluded patients who were responsive only to pain or who were unresponsive based on the Alert, responds to Voice, responds to Pain and Unresponsive (AVPU) Scale.[17]

Development of the Emergency Medical Stroke Assessment (EMSA) and Training

The derivation of the EMSA has been previously reported.[12] The EMSA was adapted from the NIHSS and includes gaze preference, facial asymmetry, asymmetrical arm and leg drift, and abnormal speech or language. The 24 ATCC personnel were provided initial training from May to July 2016. Training included a $7^1/_2$-minute EMSA video,[18] an 18-minute video on stroke signs and symptoms, mimics, and the concept of "last known well,"[19] a 20-question examination, and survey. The training program was also available via internet links to providers from the three participating EMS organizations. EMSA cards with instructions on performance of each item but without scores assigned to test items (Fig 1) were provided to ATCC personnel and EMS providers.

Key Operational Characteristics of ECC-guided EMSA

Key operational characteristics of the model included focused experience, item-specific prenotification page of the prehospital assessment, and focused feedback. The model enabled the 24 communicators to gain significant experience guiding performance of the scale to compensate for the limited experience of individual EMS providers. The communicators were instructed to ask EMS providers from the 3 participating EMS services for the results of each EMSA item on every patient entered into the Alabama Stroke System who were alert or responsive to voice. The communicators, as needed, guided EMS providers on performance of EMSA items as scripted per the EMSA card (Fig 1) and probed further in order to determine whether each item was normal or abnormal. ATCC communicators recorded and sent a prenotification page including specific EMSA item results rather than a summary score. This served to reinforce specific scale items, improved completeness and accuracy of data collection, and provided a more detailed prenotification to the UAB Emergency Department (ED) and stroke team. Starting in May 2017, we initiated ongoing focused feedback to ATCC communicators. In this process, a vascular neurologist (T.I.G.) reviewed all recorded ATCC-EMS interactions on stroke system patients evaluated with EMSA and provided specific feedback to each communicator to improve their guidance skills. Best practices were shared with the entire ATCC staff. For example, ATCC was instructed to help EMS evaluate patients who were unable to follow commands by instructing EMS to assess gaze by response of the patient to having their name called on one side and then the other, facial droop by noting asymmetric grimace to pain, and arm and leg weakness by holding up limbs and letting go.

Data Collection and Definition of Reference Standard

Prespecified data included patient demographics; prehospital data including the EMSA, FAST, Glasgow Coma

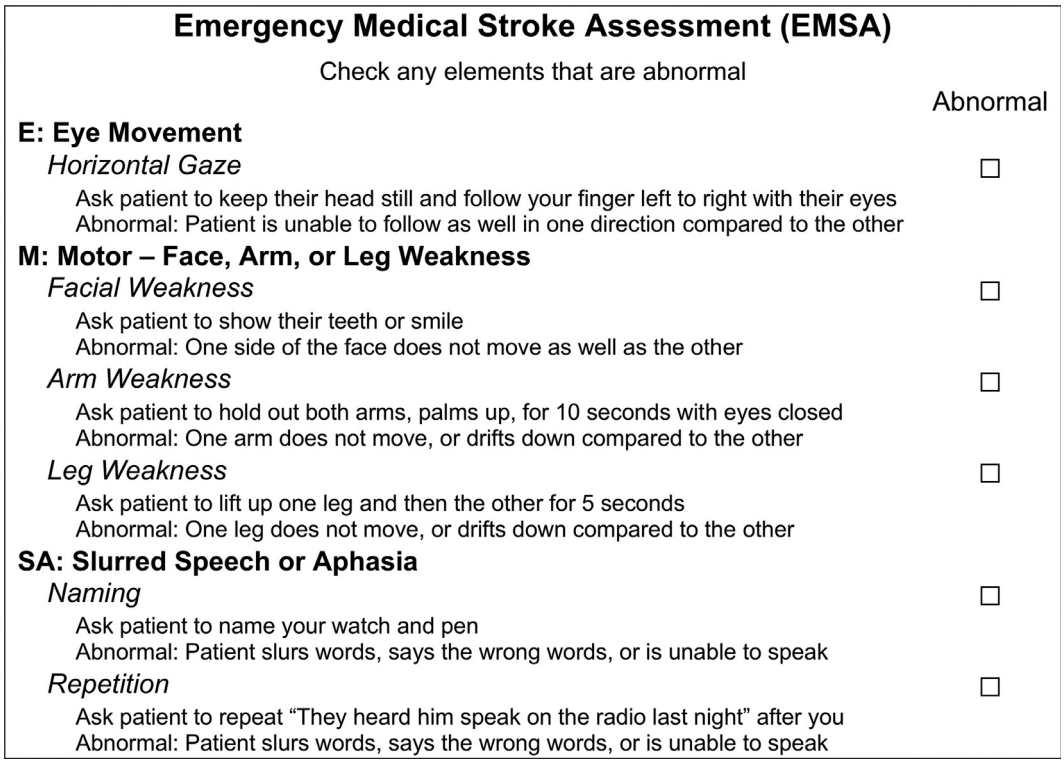

Figure 1. *Emergency Medical Stroke Assessment.*

Scale,[20] and the AVPU Scale[17]; ED data including the initial hospital NIHSS performed by certified physicians generally as part of the code stroke process, results of vascular imaging with CT angiography (CTA), MR angiography (MRA) or conventional angiography, treatment with alteplase or MT; and discharge data including discharge diagnosis (AIS, intracerebral hemorrhage (ICH), transient ischemic attack (TIA), subarachnoid hemorrhage, or nonstroke-related diagnosis), and ischemic stroke subtype (TOAST classification).[21] LVO was defined as AIS or TIA referable to occlusion of the internal carotid artery, middle cerebral artery stem (M1), or basilar artery. Patients without acute focal cerebral ischemia (including patients with ICH and nonstroke patients), were considered non-LVO. For patients with AIS or TIA, determination of LVO status was based on results of vascular imaging. The vascular neurologist conducted a review of vascular imaging data of all AIS and TIA patients blinded to prehospital data, and confirmed accuracy of discharge diagnosis, presence or absence of LVO, and location of LVO. For determination of presence and location of LVO, CTA was preferred over MRA or carotid ultrasound and transcranial Doppler (TCD) since CTA is performed at UAB as part of the code stroke process on presentation to the ED, and has higher sensitivity, positive predictive value, and inter-rater reliability compared to MRA or TCD.[22] To evaluate inter-rater agreement, a sample of recordings from EMS were reviewed separately by the ATCC and the vascular neurologist and assigned scores to each patient according to the deficit stated by the EMS provider.

Statistical Analysis

Study recruitment was guided by an estimated 15% prevalence of LVO in patients hospitalized with AIS. We planned to recruit 60 patients with LVO. We derived the sensitivity, specificity, negative likelihood ratio (LR−), and positive LR+ and 95% confidence interval (CI) for various cut points of ATCC-guided EMSA for predicting a discharge diagnosis of LVO for patients with suspected stroke who were transported to UAB. Patients missing EMSA were excluded from this analysis as were AIS or TIA patients without vascular imaging. For patients who had both EMSA and NIHSS, we determined area under the receiver operator characteristics curve (AUC) and 95% CI of ATCC-guided EMSA and the NIHSS for predicting a discharge diagnosis of LVO. In exploratory analyses, we compared test performance before initiation of focused feedback to the ATCC communicators (the first 9 months of the study) to performance after initiation of focused feedback (the second 9 months). To determine inter-rater reliability, we utilized the Kappa statistic with a significance level of .05, where the higher the kappa value, the stronger the agreement between raters. All analysis was done in Statistical Analysis Software (SAS) 9.4.

Results

We trained 24 ATCC communicators and a total of 891 EMS providers, including 866 during the initial training period, and 25 thereafter. The ATCC communicators guided an average of 19 (463/24) EMSAs per provider compared to an average of .5 (463/891) EMSAs for each EMS provider trained. The accrual of patients into the study is shown in Figure 2. There were 656 stroke system entries from September 1, 2016 through February 28, 2018. Based on the AVPU scale, patients who only responded to pain (n = 44), who were unresponsive (n = 36), or who had no documented AVPU (n = 7) were excluded, yielding an eligible population of 569. We excluded 101 patients (18%) who did not have an EMSA, and 5 patients with AIS or TIA because of absent vascular imaging. Both the diagnostic test and disease status were measured in 81% (463/569) of participants. Of 463 patients analyzed, 236 (51%) had a discharge diagnosis of stroke, including 173 (73%) AIS, 36 (15%) ICH, and 27 (11%) TIA. Table 1 shows the imaging method for LVO. Of the 200 patients with AIS or TIA, 170

Table 1. *Imaging method for LVO*

	CTA	MRA	CUS/TCD	Total
LVO	37	8	0	45
Non-LVO AIS	110	17	1	128
TIA	23	4	0	27
ICH	19	11	0	30
Nonstroke	119	30	0	149
Total	308	70	1	379

A total of 84 patients did not undergo vascular imaging because they experienced ICH (n = 6) or had a clear nonstroke diagnosis (n = 78). AIS, acute ischemic stroke; CTA, computerized tomographic angiography; CUS, carotid ultrasound; ICH, intracerebral hemorrhage; MRA, magnetic resonance angiography; LVO, large vessel occlusion; TCD, transcranial Doppler.

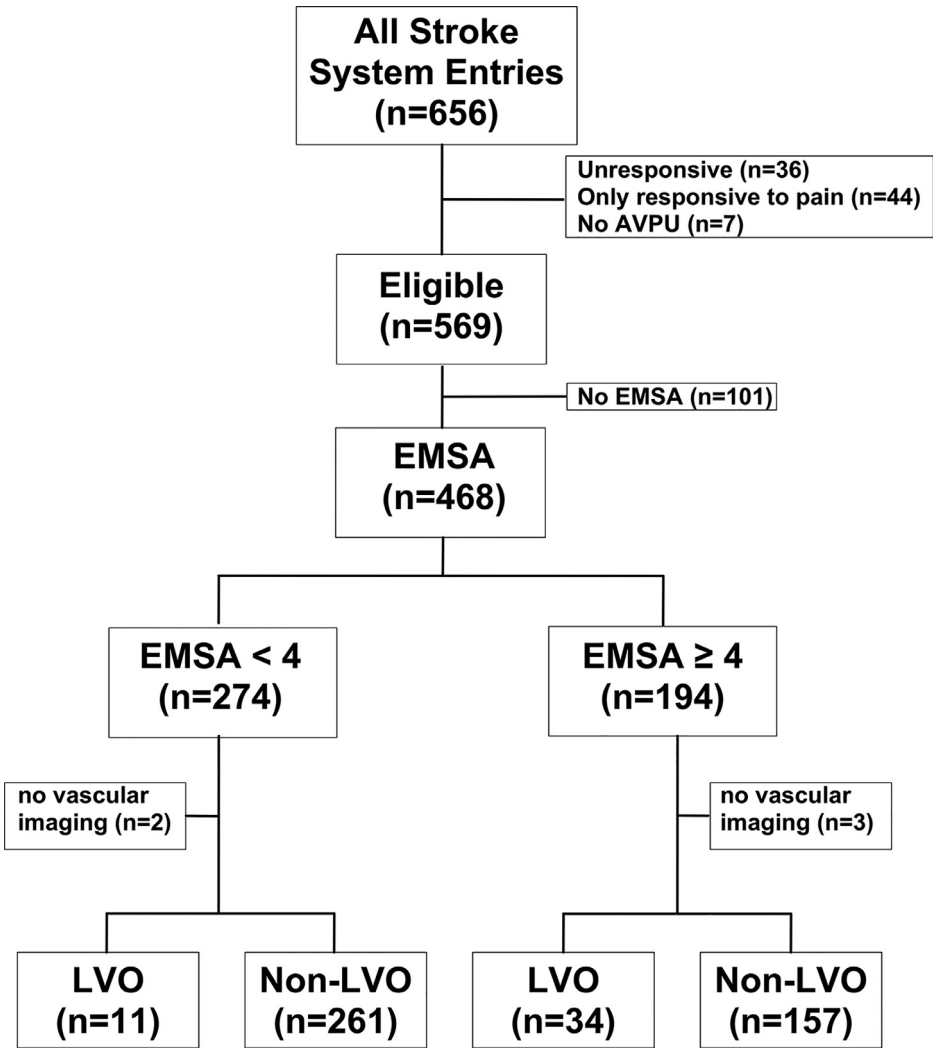

Figure 2. *Accrual of patients into the study. AVPU, Alert, responds to Voice, responds to Pain and Unresponsive Scale; EMSA, Emergency Medical Stroke Assessment; LVO, large vessel occlusion.*

underwent CTA, 29 underwent MRA, and one patient had only carotid ultrasound and TCD. Of the 45 patients with LVO, 37 underwent CTA and 8 underwent MRA.

As shown in Table 2, the study population had a mean age of 63 ± 14 years, were predominantly non-Caucasian, with a high prevalence of vascular risk factors, including 27% with a history of stroke. The median NIHSS was 7 (interquartile range = 4-12), with a typical distribution of stroke diagnoses and ischemic stroke subtypes.

Table 2. *Subject characteristics, N = 463*

Characteristic	N (%)
Demographics	
Age, years mean ± SD	63.0 ± 14.2
Female	246 (53.1)
Non-Hispanic*	446 (96.3)
Non-Caucasian*	260 (56.2)
Medical history	
Hypertension	355 (76.7)
Diabetes	161 (34.8)
Hyperlipidemia	130 (28.1)
Coronary artery disease	81 (17.6)
Congestive heart failure	42 (9.1)
Chronic kidney failure	33 (7.2)
Acute kidney injury	5 (1.1)
Atrial fibrillation	45 (9.7)
Prior stroke	127 (27.4)
Prior transient ischemic attack	22 (4.8)
Tobacco use	136 (29.6)
Alcohol abuse	44 (9.7)
AVPU	
Alert	397 (85.8)
Verbally stimulated	66 (14.2)
Initial hospital NIHSS, median (IQR)*	7 (4.0-12.0)
Discharge diagnosis	
Stroke	236 (51.0)
Acute ischemic stroke	173 (73.3)
Intracerebral hemorrhage	36 (15.3)
Transient ischemic attack	27 (11.4)
Nonstroke	227 (49.0)
Ischemic stroke subtype	
Large artery atherosclerosis	61 (35.3)
Cardioembolism	24 (13.9)
Small vessel occlusion	52 (30.1)
Other	11 (6.4)
Unknown	25 (14.5)
Large vessel occlusion location	
Middle cerebral artery stem	31 (68.9)
Internal carotid artery	12 (26.7)
Basilar artery	2 (4.4)
Revascularization	
Alteplase in AIS	37 (21.1)
Mechanical thrombectomy in LVO	21 (46.7)

*Missing: ethnicity = 16, race = 13, NIHSS = 94; AVPU, Alert, responds to Voice, responds to Pain and Unresponsive Scale; IQR, interquartile range; NIHSS, National Institute of Health Stroke Scale.

The location of LVO included 31 M1, 12 internal carotid artery, and 2 basilar arteries occlusions. Of the 45 patients with LVO, 46.7% were treated with MT.

Table 3 shows the sensitivity, specificity, LR−, and LR+ (and 95% CI) for different EMSA cutoffs for LVO for the entire 18-month study period, the first half of the study (September 2016 to May 2017), and the second half of the study (June 2017 to February 2018). An ATCC-guided EMSA with one point for each abnormal item and a cutoff of 4 yielded a good sensitivity, adequate specificity, and the lowest LR−. Overall, an EMSA score greater than or equal to 4 had sensitivity = 75.6 (60.5-87.1), specificity = 62.4 (57.6-67.1), LR− = .4 (.2-.7), and LR+ = 2.0 (1.6-2.5) for LVO. During the second 9 months of the study, an EMSA score greater than or equal to 4 had sensitivity = 84.6 (65.1-95.6), specificity = 58.3 (51.6-64.8), LR− = .3 (.1-.7), and LR+ = 2.0 (1.6-2.6) for LVO.

Of the analyzed population, 369 patients (80%) had NIHSS data available. The NIHSS was less likely to be performed on non-stroke patients resulting in 230 (62%) patients with stroke in the subgroup with both EMSA and NIHSS. The demographic characteristics, AVPU scores, discharge stroke diagnoses, and ischemic stroke subtypes were similar in the subgroup compared to the whole population. All patients with LVO had both EMSA and NIHSS data.

Figure 3 Panel A shows the distribution of prehospital EMSA for the total analyzed population, patients with LVO, and patients who were treated with MT. Of the analyzed population, 41% (191) had an ATCC-guided EMSA greater than or equal to 4, and of these patients, 18% (34) had LVO, and of these patients, 50% (17) were treated with MT. Panel B shows the distribution of NIHSS scores for all patients with NIHSS data, patients with LVO, and patients who were treated with MT. Panel B shows that patients with LVO had NIHSS scores from 1 to 29. NIHSS score greater than or equal to 6 had sensitivity = 88.9 (76.5-95.2), specificity = 41.7 (36.4-47.1), LR− = .3 (.1-.6), and LR+ = 1.5 (1.3-1.8) for LVO. An NIHSS score greater than or equal to 10 had sensitivity = 68.9 (54.3-80.5), specificity = 64.8 (59.5-69.8), LR− = .5 (.3-.7), and LR+ = 2.0 (1.5-2.5) for LVO.

Figure 4 Panel A shows the EMSA AUCs for predicting LVO for all analyzed patients for the first 9 months of the study (.61, 95% CI: .44-.77), the second 9 months (.74, 95% CI: .64-.84), and the entire 18-month study period (.69, 95% CI: .60-.78). Panels B-D include only patients who had both EMSA and NIHSS. There was no significant difference in the AUC of the EMSA compared to the NIHSS for predicting LVO during the entire study period (Panel B, [.68, 95% CI: .59-.77] versus [.73, 95% CI: .65-.81]), during the first nine months of the study (Panel C, [.61, 95% CI: .44-.77] versus [.78, 95% CI: .68-.87]), or during the second 9 months of the study (Panel D, [.73, 95% CI: .63-.83] versus [.70, 95% CI: .58-.81]). While the

Table 3. *Validity of EMSA cutoffs in LVO patients*

EMSA score	Sensitivity (95% CI)	Specificity (95% CI)	LR + (95% CI)	LR − (95% CI)
2016-2018				
≥1	88.9 (76.0-96.3)	12.0 (9.0-15.5)	1.0 (.9-1.1)	.9 (.4-2.2)
≥2	84.4 (70.5-93.5)	22.5 (18.6-26.8)	1.1 (1.0-1.2)	.7 (.3-1.4)
≥3	80.0 (65.4-90.4)	42.3 (37.6-47.2)	1.4 (1.2-1.6)	.5 (.3-.9)
≥4	75.6 (60.5-87.1)	62.4 (57.6-67.1)	2.0 (1.6-2.5)	.4 (.2-.7)
≥5	48.9 (33.7-64.2)	78.0 (73.7-81.9)	2.2 (1.6-3.1)	.7 (.5-.9)
≥6	24.4 (12.9-39.5)	93.8 (91.0-95.9)	3.3 (1.8-6.2)	.8 (.7-1.0)
Sept 2016-May 2017				
≥1	73.7 (48.8-90.9)	16.2 (11.3-22.2)	.9 (.7-1.2)	1.6 (.7-3.7)
≥2	73.7 (48.8-90.9)	27.8 (21.5-34.7)	1.0 (.8-1.4)	.9 (.4-2.1)
≥3	68.4 (43.5-87.4)	44.5 (37.3-51.9)	1.2 (.9-1.7)	.7 (.4-1.4)
≥4	63.2 (38.4-83.7)	67.0 (60.0-73.6)	1.9 (1.3-2.9)	.6 (.3-1.0)
≥5	36.8 (16.3-61.6)	79.8 (73.2-85.1)	1.8 (.9-3.5)	.8 (.6-1.1)
≥6	21.1 (6.1-45.6)	95.3 (91.2-97.8)	4.5 (1.5-13.1)	.8 (.7-1.0)
Jun 2017- Feb 2018				
≥1	100 (86.0-100)	8.3 (5.1-12.7)	1.1(1.0-1.1)	Undefined
≥2	92.3 (74.9-99.1)	18.0 (13.2-23.6)	1.1 (1.0-1.3)	.4 (.1-1.7)
≥3	88.5 (69.9-97.6)	40.4 (33.9-47.0)	1.5 (1.2-1.8)	.3 (.1-.8)
≥4	84.6 (65.1-95.6)	58.3 (51.6-64.8)	2.0 (1.6-2.6)	.3 (.1-.7)
≥5	57.7 (36.9-76.7)	76.3 (70.3-81.7)	2.5 (1.6-3.7)	.6 (.4-.9)
≥6	26.9 (11.6-47.8)	92.5 (88.3-95.6)	3.6 (1.6-7.9)	.8 (.6-1.0)

EMSA, Emergency Medical Stroke Assessment; LR+, positive likelihood ratio; LR−, negative likelihood ratio; Proximal LVO includes ICA, M1, and BA.

NIHSS AUC decreased slightly from the first 9 months of the study to the second 9 months of the study, there was a trend to improved performance of the EMSA over time.

For evaluation of inter-rater agreement, we sampled 70 patients (15% of cohort). We observed statistically significant agreement between the raters for all EMSA components, with 63% (CI: 41%-84%, $P < .0001$) agreement in rating the gaze component, 65% (CI: 48%-83%, $P < .0001$) for the face, 58% (CI: 38%-79%, $P < .0001$) for the arm, 51% (CI: 31%-72%, $P < .0001$) for the leg, 60% (CI: 42%-78%, $P < .0001$) for naming, and 51% (CI: 33%-69%, $P < .0001$) for repetition.

Discussion

We found that our novel model of ECC-guided EMSA was feasible, had similar ability to predict LVO compared to the complex NIHSS, showed sustained performance over time, and had moderate to substantial inter-rater agreement in stroke assessment items between the paramedic staffed ECC and a vascular neurologist. Our model addresses 3 barriers to prehospital stroke care, including limited stroke-specific training of EMS, infrequent exposure of individual EMS providers to stroke, and limited feedback of performance, by focusing training, experience, and feedback on 24 ECC paramedics who became highly skilled in administration and interpretation of the EMSA.

A fundamental and unique aspect of our model was the use of real-time ECC guidance. We interpret the trend to improvement in ATCC-guided EMSA performance from the first to second halves of the study to be a consequence of improvement in ATCC guidance skills over time related to focused experience and feedback. We also suspect that real-time ECC guidance contributed to the relatively low rate (18%) of missing prehospital assessments in our study compared to 60% in the RACE scale prehospital validation study.[7] There is no directly comparable model that combines use of a prehospital severity scale with ECC guidance. Two studies have evaluated EMS medical control by physician via phone. The first study, carried out in the prethrombectomy era, found that EMS medical control reduced the proportion of code stroke patients who were ultimately ineligible for alteplase, mainly by more accurately determining the time last seen well.[23] EMS medical control by physician was also a feature of the FAST-Mag trial, but the interaction was focused on the consent process.[24] It has been observed that a major drawback of online medical control is disruption of physician activities.[15] Benefits of ECC guidance compared to physician-based medical control include the ready availability of ECC expertise at any time and the ability to route EMS to the correct stroke system hospital destination based on current hospital resource availability regardless of physician affiliation. Another benefit that is particularly relevant in rural areas is the ability of a centralized ECC to either mobilize air or ground transport directly to a hospital that can offer MT or to anticipate the potential need for interfacility transfer of patients with severe stroke who might initially require alteplase or other acute treatment at a closer stroke system hospital.

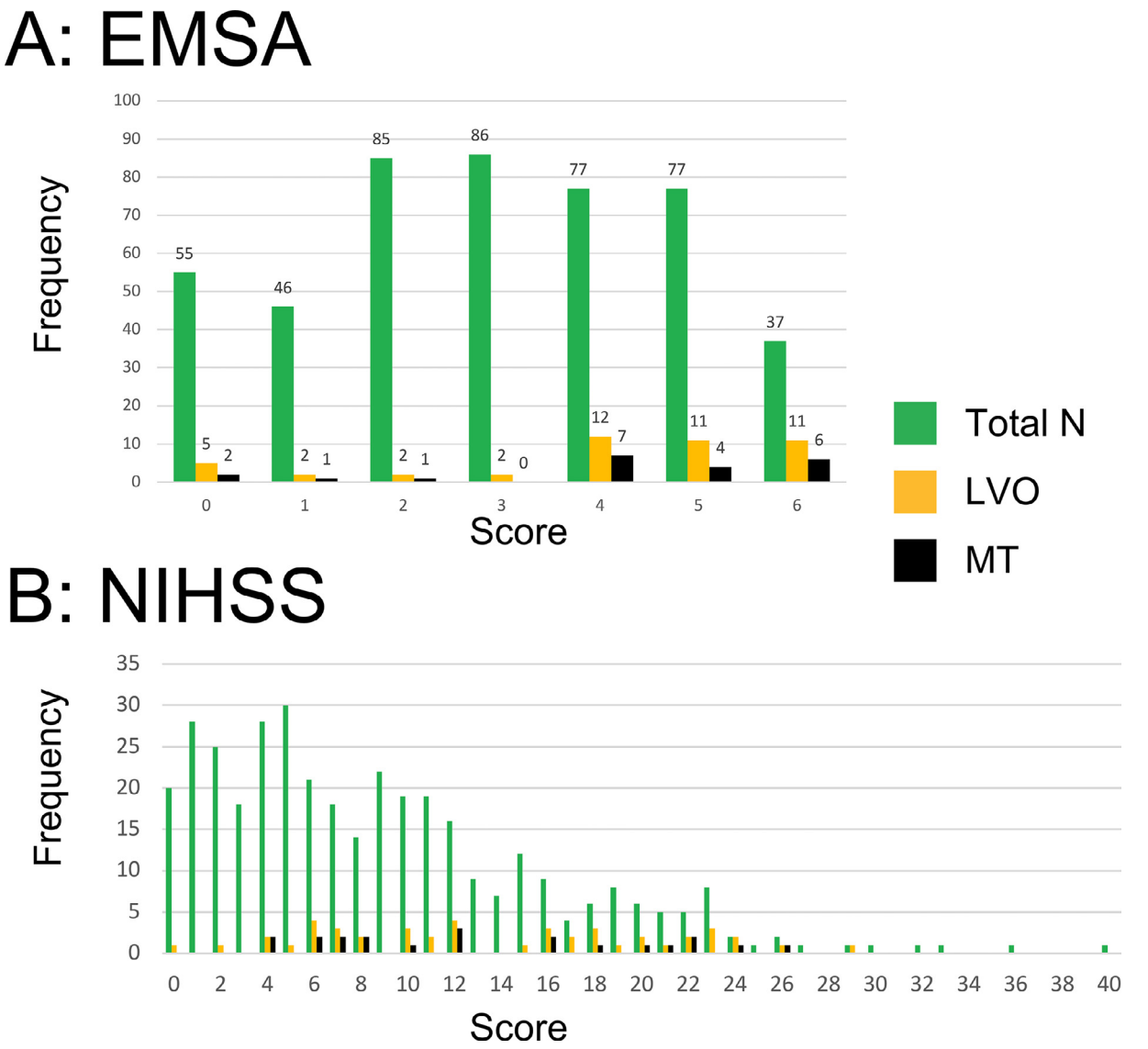

Figure 3. *Distribution of EMSA (n = 463) and NIHSS Scores (n = 369). Panel A, EMSA, Emergency Medical Stroke Assessment; Panel B, NIHSS, NIH Stroke Scale; LVO, large vessel occlusion; MT, mechanical thrombectomy.*

Thus far, only 4 stroke severity scales have been tested in the prehospital setting: the RACE, LAMS, C-STAT, and NIHSS.[7,25-27] Over the entire study period, the ability of ECC-guided EMSA to predict LVO was slightly lower than previously reported values for stroke severity scales including the NIHSS, with AUCs mostly ranging from .70 to .85.[28] We suspect that this was partly related to a large percentage of stroke mimics in our cohort, resulting in lower performance of both the EMSA and NIHSS. It is likely that this was also related to initially poor performance which improved with time and particularly after providing consistent feedback to the ECC paramedics. The inclusion of a typical population of patients with suspected stroke encountered by EMS is a strength of our study. Stroke mimics made up 49% of our cohort, similar to the 43% mimic rate recently reported in a large analysis of consecutive patients with suspected stroke encountered by EMS.[29] The RACE scale prehospital validation study reported an AUC of .82 for prediction of LVO.[7] However, this study included only 12.6% stroke mimics. In a recent study of the RACE scale in a population of 440 patients including 39% stroke mimics, the AUC for LVO was .72, similar to the performance of the simpler EMSA in our study.[30] The LAMS prehospital validation study reported an AUC for prediction of LVO of .79, but the cohort was small and selected with 71 AIS patients (that excluded mimics and ICH) and LVO in 63% of their cohort.[26] The C-STAT prehospital validation study had a cohort of 51 patients, including only 7 patients with LVO, and did not report the AUC for prediction of LVO.[25] We agree with the conclusions of recently published systematic review and a stroke systems of care policy statement from the American Heart Association that there is no clear evidence for the superiority of one scale over the others, and

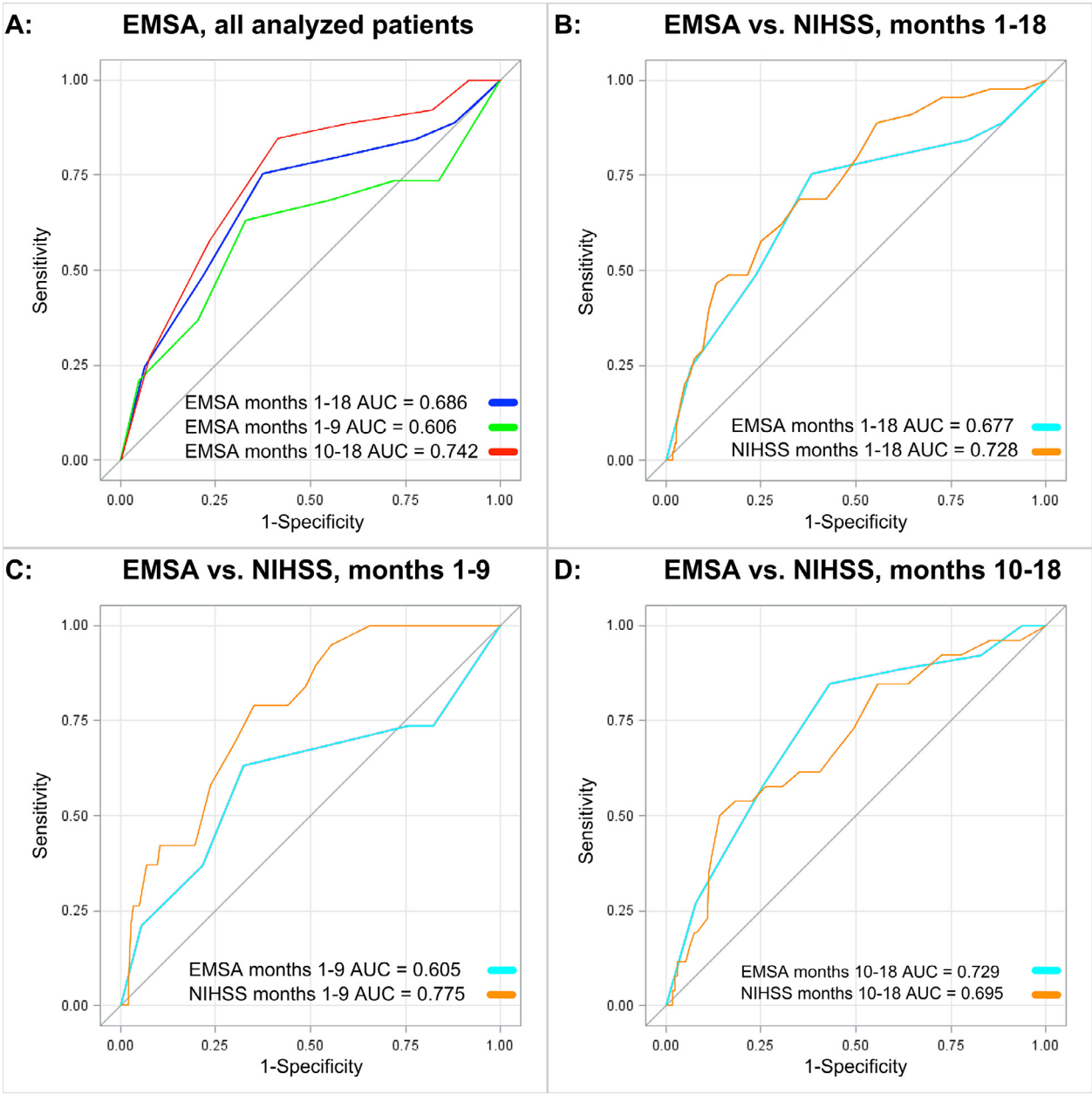

Figure 4. *Receiver operator characteristic curves for EMSA and NIHSS for prediction of discharge diagnosis of large vessel occlusion. EMSA, Emergency Medical Stroke Assessment; NIHSS, NIH Stroke Scale; Panel A, area under the curve (AUC) for EMSA for all analyzed patients (n = 463) for the first 9 months, second 9 months, and the entire study period; Panels B-D include only patients who had both EMSA and NIHSS (N= 369); Panel B, AUC for the entire study period (September 2016 to February 2018); Panel C, AUC for the first 9 months of the study (September 2016 to May 2017); Panel D, AUC for the second 9 months of the study (June 2017 to February 2018).*

there is a need for more prospectively designed studies to directly compare the accuracy of different LVO prediction instruments in the prehospital setting in representative populations.[28,31] While we tested ECC guidance of the EMSA, we suspect that the performance of other prehospital stroke scales could be improved by ECC guidance.

While this low technology model should be easy to implement with existing ECC capabilities, a potential limitation is that it relies on the report of the EMS provider rather than direct observation of the provider by the ECC. We feel that several aspects of the program served to mitigate against inaccurate reporting from the field, including use of a simple scale with dichotomous items, item-specific reporting, and scripted instructions. Nevertheless, a limitation is that independent verification of the EMSA upon ED arrival was not performed. A potential limitation is that the prehospital ATCC-guided EMSA was compared to the initial hospital NIHSS performed by physicians, and hence differences in severity assessment might be partly related to fluctuations in neurologic deficit over time or examiner expertise. The trend to improvement in ATCC-guided EMSA performance from the first

to second halves of the study may have been related in part to improved performance of the scale by EMS independent of ATCC guidance. However, almost no EMS training was undertaken after the initial training period. A potential limitation is that this study took place in the context of an already robust prehospital stroke system of care in Alabama in which EMS already entered suspected stroke patients into the stroke system by calling the ATCC. We feel it is generalizable to other prehospital systems. Similar to what happened in Alabama, the existing trauma system infrastructure including ECCs that already exist in other regions and states can serve as the basis for a more effective and integrated system of emergency stroke care.

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Conflicts of Interest

The authors warrant that they have no financial or other relationships with commercial parties that might pose a conflict of interest with regard to this manuscript.

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