Field Assessment Stroke Triage for Emergency Destination

A Simple and Accurate Prehospital Scale to Detect Large Vessel Occlusion Strokes

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Background and Purpose—Patients with large vessel occlusion strokes (LVOS) may be better served by direct transfer to endovascular capable centers avoiding hazardous delays between primary and comprehensive stroke centers. However, accurate stroke field triage remains challenging. We aimed to develop a simple field scale to identify LVOS.

Methods—The Field Assessment Stroke Triage for Emergency Destination (FAST-ED) scale was based on items of the National Institutes of Health Stroke Scale (NIHSS) with higher predictive value for LVOS and tested in the Screening Technology and Outcomes Project in Stroke (STOPStroke) cohort, in which patients underwent computed tomographic angiography within the first 24 hours of stroke onset. LVOS were defined by total occlusions involving the intracranial internal carotid artery, middle cerebral artery-M1, middle cerebral artery-2, or basilar arteries. Patients with partial, bihemispheric, and anterior+posterior circulation occlusions were excluded. Receiver operating characteristic curve, sensitivity, specificity, positive predictive value, and negative predictive value of FAST-ED were compared with the NIHSS, Rapid Arterial Occlusion Evaluation (RACE) scale, and Cincinnati Prehospital Stroke Severity (CPSS) scale.

Results—LVO was detected in 240 of the 727 qualifying patients (33%). FAST-ED had comparable accuracy to predict LVO to the NIHSS and higher accuracy than RACE and CPSS (area under the receiver operating characteristic curve: FAST-ED=0.81 as reference; NIHSS=0.80, P=0.28; RACE=0.77, P=0.02; and CPSS=0.75, P=0.002). A FAST-ED ≥4 had sensitivity of 0.60, specificity of 0.89, positive predictive value of 0.72, and negative predictive value of 0.82 versus RACE ≥5 of 0.55, 0.87, 0.68, and 0.79, and CPSS ≥2 of 0.56, 0.85, 0.65, and 0.78, respectively.

Conclusions—FAST-ED is a simple scale that if successfully validated in the field, it may be used by medical emergency professionals to identify LVOS in the prehospital setting enabling rapid triage of patients. **(*Stroke*. 2016;47:1997-2002. DOI: 10.1161/STROKEAHA.116.013301.)**

Key Words: cerebrovascular occlusion ■ scale ■ stroke, acute, prehospital emergency care ■ triage

Endovascular therapy reduces disability and death in patients with large vessel occlusion strokes (LVOS).[1–5] Despite this major therapeutic breakthrough discovery, the public health impact of this treatment is highly dependent on rapid identification of severe stroke symptoms by emergency medical system personnel and transport to a comprehensive stroke center with experience providing fast, effective, and safe intervention.

Although several clinical examination tools have been proposed for use in the prehospital setting, most of these tools have not been validated using arterial contrast imaging to determine the presence of LVOS.[6,7] Thus, the best prehospital strategy for identifying patients with severe stroke symptoms remains to be determined.

Considering the limited availability of comprehensive stroke centers and the time sensitivity of both intravenous tissue-type plasminogen activator and endovascular therapy,[8,9] accurate identification of patients with high probability of having an LVOS in the prehospital setting is of paramount importance.

To address this problem, we designed this study to improve the accuracy of predicting LVOS by using a new tool called the

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Field Assessment Stroke Triage for Emergency Destination (FAST-ED).

Subjects and Methods

The FAST-ED scale (*F*acial Palsy [scored 0–1], *A*rm weakness [0–2], Speech changes [0–2], *T*ime [documentation for decision making but no points], *E*ye deviation [0–2], and *D*enial/neglect [0–2]) was designed based on items of the National Institutes of Health Stroke Scale (NIHSS) with higher predictive value for LVOS. In addition, time was included considering its importance in the prehospital decision algorithm. For the current analysis, the FAST-ED score was derived from the NIHSS score assessed by certified research personnel at hospital admission and is shown in Table 1.[10]

The scale was tested on data from 741 consecutive patients enrolled in a prospective cohort study at 2 university-based hospitals, the Screening Technology and Outcomes Project in Stroke (STOPStroke), in which admission noncontrast computed tomography scans and computed tomographic angiography (CTA) were obtained in all patients suspected of having ischemic stroke (stroke, transient ischemic attack, or stroke mimics) in the first 24 hours of symptom onset. Patients were excluded if iodinated contrast agent administration was contraindicated (ie, history of contrast agent allergy, pregnancy, congestive heart failure, and increased creatinine level) or if there was evidence of intracranial hemorrhage on noncontrast computed tomography. The STOPStroke study received institutional review board approval at both participating institutions and was Health Insurance Portability and Accountability Act compliant.

Table 1. The FAST-ED Scale and Its Correspondence to the NIHSS

Item	FAST-ED Score	NIHSS Score Source
Facial palsy		
Normal or minor paralysis	0	0–1
Partial or complete paralysis	1	2–3
Arm weakness		
No drift	0	0
Drift or some effort against gravity	1	1–2
No effort against gravity or no movement	2	3–4
Speech changes		
Absent	0	0
Mild to moderate	1	1
Severe, global aphasia, or mute	2	2–3
Eye deviation		
Absent	0	0
Partial	1	1
Forced deviation	2	2
Denial/Neglect		
Absent	0	0
Extinction to bilateral simultaneous stimulation in only 1 sensory modality	1	1
Does not recognize own hand or orients only to one side of the body	2	2

FAST-ED indicates Field Assessment Stroke Triage for Emergency Destination; and NIHSS, National Institutes of Health Stroke Scale.

For this study, patients with unilateral acute complete symptomatic occlusion of the intracranial internal carotid artery (intracranial ICA), M1 and M2 segments of the middle cerebral artery (MCA) and basilar artery were selected and compared with patients without a proximal intracranial occlusion. Patients with symptomatic bilateral and anterior+posterior circulation occlusions were excluded from the analysis. Our prespecified hypothesis was that the FAST-ED would have similar or higher accuracy than other preexisting scales.

Image Protocol and Review

The STOPStroke noncontrast computed tomography and CTA protocol is described elsewhere.[11] Image review was independently performed on a picture archiving and communication system workstation (Impax; AGFA Technical Imaging Systems, Richfield Park, NJ) by a board-certified neuroradiologist and a clinical neurologist experienced in stroke imaging interpretation. Disagreements in readings were resolved by consensus. Reviewers were blinded to follow-up clinical and imaging findings but had information in regard to the patients' age, sex, and presenting clinical symptoms. Neither of the reviewers had participated in the selection of the patients. For every image, vessels were graded for the presence or absence of total occlusion according to a 5-point level of certainty score (score 5, definitely present; score 4, probably present; score 3, equivocal; score 2, probably absent; and score 1, definitely absent). Those subjects with equivocal scores were excluded from the analysis. The site of intracranial occlusion was defined as the most proximal site of occlusion (intracranial ICA, MCA-M1, MCA-M2, and basilar). Functional outcomes were assessed with the use of the modified Rankin scale (mRS) at 6 months.

Statistical Analysis

Continuous variables are reported as mean±SD or as median±interquartile range (IQR). Categorical variables were reported as proportions.

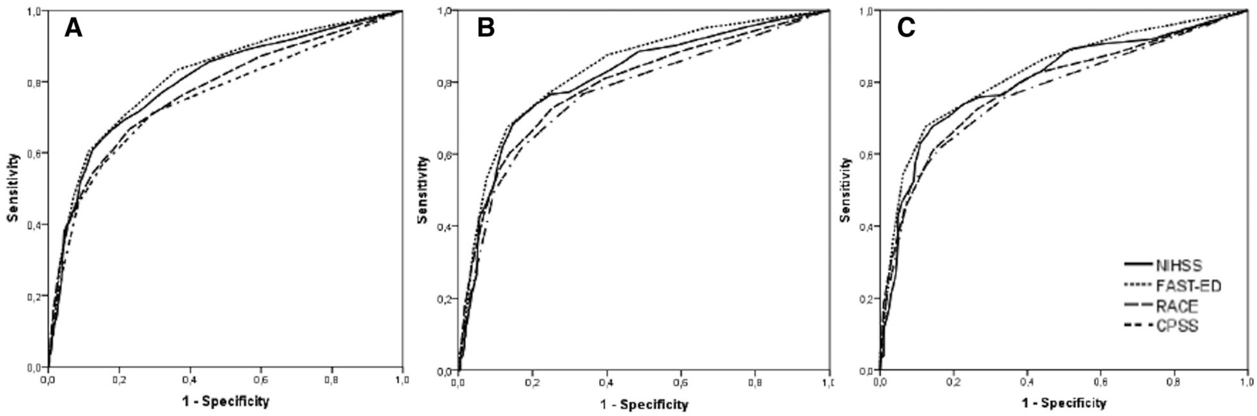
The Spearman test was used to test the linear correlation of the NIHSS and the FAST-ED scores. Receiver operating characteristics (ROC) curve analysis was used as the primary analysis to test whether the FAST-ED had higher discrimination ability than other similar previous published scales (the Rapid Arterial Occlusion Evaluation [RACE] Scale, the Cincinnati Prehospital Stroke Severity [CPSS] scale, and the NIHSS).[12,13] The areas under the curve were compared with the FAST-ED as the reference.[14] Calibration of FAST-ED was assessed graphically and by the use of the Hosmer and Lemeshow test.[15] Given the potential influence of time to presentation on NIHSS, sensitivity analyses were performed including only those patients who underwent CTA within 12 hours from symptom onset and again in those patients who underwent CTA within 6 hours from symptom onset. Partial occlusions on conventional angiography are generally classified as total occlusion on CTA.[16] However, as some patients were still classified as partial occlusion on CTA, we also performed a sensitivity analysis including those patients with partial occlusion on CTA.

Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy were calculated using several different thresholds of the FAST-ED. The Youden Index was used to evaluate the optimal threshold of the FAST-ED scale.[17] Prespecified published thresholds of the other scales and a cutoff of 6 and 10 points in the NIHSS were used for comparison.[10,18]

The distribution of the FAST-ED was also compared according to the mRS at 6 months (dichotomized as good, mRS score of ≤2 and poor outcome, mRS score of >2). The Kruskal–Wallis test was used to compare the distribution of the FAST-ED scores according to the most proximal site of occlusion (intracranial ICA, MCA-M1, MCA-M2, and basilar). A 2-sided *P* value of <0.05 was considered significant. All statistical analysis was performed using SPSS software (version 20.0).

Results

Seven hundred twenty-seven qualifying patients were selected. The mean age was 68.1±15.4 years, median baseline NIHSS



SCALE	AUC	SE	p*	AUC	SE	p*	AUC	SE	p*
NIHSS	0,799	0,018	0.28	0.811	0.021	0.17	0.806	0.025	0.26
FAST ED	0,813	0,018	reference	0.834	0.019	Reference	0.827	0.023	Reference
RACE	0,771	0,020	0.02	0.791	0.022	0.03	0.787	0.025	0.08
CPSS	0,752	0,021	0.002	0.769	0.023	0.001	0.772	0.026	0.02

* all individual curves presented a p value < 0.001

Figure 1. A, Receiver operating characteristic curves comparing the discrimination of Field Assessment Stroke Triage for Emergency Destination (FAST-ED), National Institutes of Health Stroke Scale (NIHSS), Rapid Arterial Occlusion Evaluation (RACE), and Cincinnati Prehospital Stroke Severity (CPSS) scales for the detection of large vessel occlusion strokes (all subjects). **B**, Subjects who performed computed tomographic angiography (CTA) of ≤12 hours from symptom onset. **C**, Subjects who performed CTA of ≤6 hours from symptom onset. AUC indicates area under the curve. All individual curves presented a *P* value <0.001.

was 5 (IQR, 2–12), and 52% were males. LVO was detected in 240 (33%) subjects. Fifty-three (7.3%) subjects had occlusion of the intracranial ICA, 98 (13.5%) of the MCA-M1, 74 (10.2%) of the MCA-M2, and 15 (2.1%) of the basilar artery. As expected, the FAST-ED had a strong correlation with NIHSS (r=0.92; P<0.001).

The FAST-ED scale had comparable accuracy to predict LVO to the more complex NIHSS and higher accuracy than RACE and CPSS (area under the ROC curve: FAST-ED=0.81 as reference; NIHSS=0.80, P=0.28; RACE=0.77, P=0.02; and CPSS=0.75, P=0.002; Figure 1A). A similar pattern was seen when the analysis was repeated for those patients who underwent CTA within 12 hours (n=393; area under the ROC curve: FAST-ED 0.83 as reference; NIHSS=0.81, P=0.17; RACE=0.79, P=0.03; and CPSS=0.769, P=0.001; Figure 1B) and within 6 hours from symptom onset (n=360; area under the ROC curve: FAST-ED=0.83 as reference; NIHSS=0.81, P=0.26; RACE=0.79, P=0.08; and 0.77, P=0.02; Figure 1C).

Ninety-four patients had partial occlusions on CTA. A similar pattern was observed when those patients were included with FAST-ED having a similar area under the curve when compared with the NIHSS but larger when compared with RACE and CPSS (area under the ROC curve: FAST-ED=0.79 as reference; NIHSS=0.77, P=0.24; RACE=0.74, P=0.003; and CPSS=0.73, P<0.001).

Good calibration of the FAST-ED scale for the prediction of LVOS was observed (0–9.3%, 1–14.3%, 2–30.0%, 3–32.9%, 4–59.2%, 5–69.8%, 6–84.4%, 7–77.4%, 8–83.3%, 9–80.0%, and Hosmer and Lemeshow test P value=0.62; Figure 2). An important increase in the frequency of LVO was detected for those patients with FAST-ED score of ≥4, whereas a FAST-ED score of <2 was specifically associated with a low likelihood

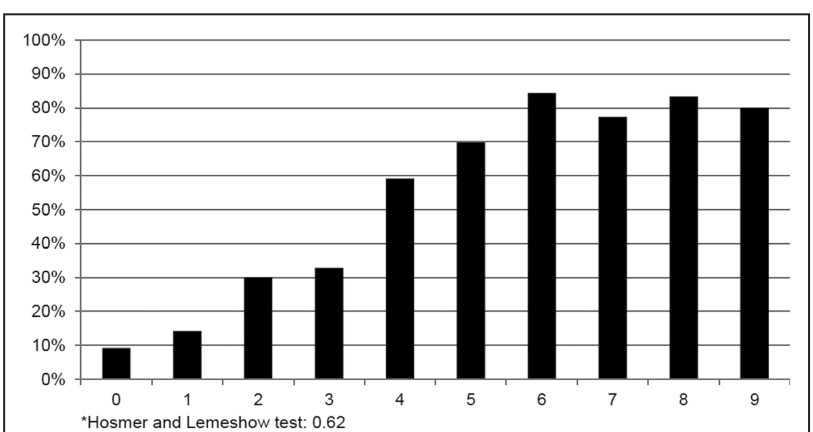


Figure 2. Proportion of patients with large vessel occlusion strokes according to the Field Assessment Stroke Triage for Emergency Destination (FAST-ED) scale. Hosmer and Lemeshow test: 0.62.

Table 2. Sensitivity, Specificity, PPV and NPV, and accuracy of the FAST-ED Scale

FAST-ED	Sensitivity	Specificity	PPV	NPV	Accuracy	Youden Index
≥1	0.92	0.37	0.42	0.91	0.55	0.29
≥2	0.83	0.64	0.53	0.89	0.70	0.47
≥3	0.71	0.78	0.62	0.84	0.76	0.49
≥4	0.61	0.89	0.72	0.82	0.79	0.49
≥5	0.48	0.93	0.76	0.78	0.78	0.41
≥6	0.30	0.97	0.82	0.74	0.75	0.27
≥7	0.14	0.98	0.79	0.70	0.70	0.12
≥8	0.04	1.00	0.82	0.68	0.68	0.03
≥9	0.17	1.00	0.80	0.67	0.67	0.17

FAST-ED indicates Field Assessment Stroke Triage for Emergency Destination; NPV, negative predictive value; and PPV, positive predictive value.

of LVO. There was a steady increase in the frequency of poor outcome (6-month mRS score of >2) with higher FAST-ED scores (0–11.8%, 1–25.7%, 2–41.6%, 3–42.2%, 4–52.4%, 5–60.3%, 6–85.7%, 7–85.7%, 8%–100%, and 9% to 100%; Figure 2).

Better performance of FAST-ED according to the Youden Index could be shown at 2 distinct thresholds of ≥3 (Youden Index=0.490) and ≥4 (Youden Index=0.491; Table 2). A threshold of ≥3 and ≥4 in the FAST-ED for LVO had a sensitivity of 0.71 and 0.60, specificity of 0.78 and 0.89, positive predictive value of 0.62 and 0.72, and negative predictive value of 0.84 and 0.82 versus RACE ≥5, 0.55, 0.87, 0.68, and 0.79 and CPSS ≥2, 0.56, 0.85, 0.65, and 0.78, NIHSS ≥6 0.76, 0.70, 0.55, and 0.85 and NIHSS ≥10 0.64, 0.85, 0.68, and 0.83, respectively (Table 3).

The median NIHSS was 14.5 (IQR, 6.2–19.7), 14 (IQR, 9.7–17), 8 (IQR, 4–15.5), and 17 (IQR, 14–32) for intracranial ICA, MCA-M1, MCA-M2, and basilar occlusion, respectively (P=0.003). The median FAST-ED score was 5 (IQR, 2.2–6.7), 5 (IQR, 3–6), 3 (IQR, 2–5), and 5 (IQR, 1–7) for intracranial ICA, MCA-M1, MCA-M2, and basilar occlusion, respectively (P<0.001). As previously noted, an important increase in the frequency of large vessel occlusion was observed for those subjects with FAST-ED score of ≥4 when compared with those with the scores of <4. Moreover, the proportion of LVO in those subjects with FAST-ED of ≥4 was mostly because of an increase in the frequency of more proximal occlusions such as MCA-M1 and intracranial ICA occlusions (Figure 3).

Table 3. Comparison of Thresholds of the FAST-ED, RACE, CPSS, and NIHSS According to Sensitivity, Specificity, PPV and NPV, and Accuracy

	FAST-ED ≥3	FAST-ED ≥4	RACE ≥5	CPSS ≥2	NIHSS ≥6	NIHSS ≥10
Sensitivity	0.71	0.61	0.55	0.56	0.76	0.64
Specificity	0.78	0.89	0.87	0.85	0.70	0.85
PPV	0.62	0.72	0.68	0.65	0.55	0.68
NPV	0.84	0.82	0.79	0.78	0.85	0.83
Accuracy	0.76	0.79	0.77	0.75	0.72	0.78

CPSS indicates Cincinnati Prehospital Stroke Severity Scale; FAST-ED, Field Assessment Stroke Triage for Emergency Destination; NIHSS, National Institutes of Health Stroke Scale; NPV, negative predictive value; PPV, positive predictive value; and RACE, Rapid Arterial Occlusion Evaluation.

Discussion

We found that the FAST-ED has high sensitivity and high specificity for the detection of LVOS. It demonstrated a similar discrimination capacity when compared with the more complex NIHSS score and higher discrimination when compared with other scales. It can identify stroke patients with high likelihood of a proximal intracranial occlusion, especially those with intracranial ICA and MCA-M1, who are most likely to benefit from rapid triage to comprehensive stroke centers that are capable of delivering both intravenous tissue-type plasminogen activator and endovascular treatment, thus avoiding unnecessary and costly delays.

Other scales have also been developed to predict LVOS in the prehospital setting and demonstrated good sensitivity and specificity. The RACE scale has been applied in the field and shown to reasonably identify LVOS.[13] However, the RACE scale was validated in a population where most of patients were diagnosed with transcranial Doppler, which is less sensitive and specific for the detection of LVOS than CTA especially for distal MCA-M1 and M2 occlusion.[19] When compared with FAST-ED, RACE gives a higher weight to motor symptoms. Specifically, a patient can be assessed 1 extra point for facial weakness and ≤2 extra points for leg weakness that would not be computed in FAST-ED. Although motor symptoms strongly correlated with higher NIHSS scores, they are not good discriminators of non-LVOS versus LVOS as they may also occur in the setting of subcortical or lacunar strokes. Conversely, the RACE scale only computes 1 point for gaze deviation (versus ≤2 points in the FAST-ED scale). Gaze deviation is a typical sign of cortical (or brain stem) dysfunction and as such is a powerful discriminator of LVOS. Although FAST-ED tests both fluency (1 point) and comprehension (1 point), RACE only tests speech with commands and as such may miss the opportunity of diagnosing expressive aphasia, which is a highly disabling deficit and a strong discriminator of LVOS. Finally, the RACE scale restricts the evaluation of aphasia for those subjects with right weakness and neglect for those with left-sided weakness. As such, RACE ignores the fact that some patients may have concomitant neglect and aphasia and that some left-handed patients might have right hemisphere dominance.

The CPSS scale is a simple scale easily implemented in the prehospital setting. However, it fails to recognize the importance of cortical signs, such as aphasia and particularly neglect, which are highly associated with large cortical infarcts. A sensitivity of 56% and 55% for the CPSS and RACE scales seem unacceptably low for the detection of LVOS.

The FAST-ED scale has the advantage of providing 3 distinct groups for the likelihood of LVOS: score 0 to 1, <15%; 2 to 3, ≈30%; and ≥4, ≈60% or higher. This allows for better adjustments in triage process according to stroke severity/likelihood of LVOS, time from stroke onset, and distances

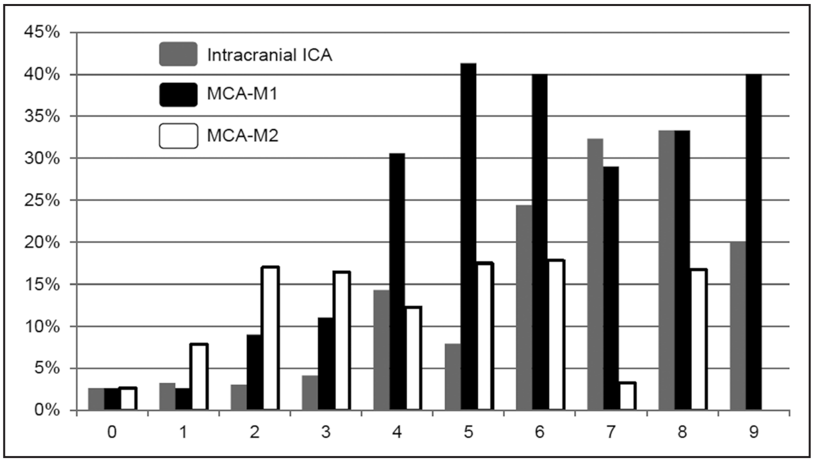


Figure 3. Proportion of patients with large vessel occlusion strokes according to the Field Assessment Stroke Triage for Emergency Destination (FAST-ED) scale and most proximal site of occlusion. ICA indicates internal carotid artery; and MCA, middle cerebral artery.

from primary stroke centers versus endovascular capable centers. Moreover, when LVOS was present, the distribution of the FAST-ED scores varied along with the site of intracranial occlusion. Those with scores of <4 had a high prevalence of MCA-M2 occlusion when compared with those with scores of ≥4 who had a higher proportion of MCA-M1 and intracranial ICA occlusions. Because MCA-M2 occlusions have higher rates of recanalization with intravenous tissue-type plasminogen activator, a lower threshold should be used to triage patients with scores of <4 to the closest stroke center (eg, primary stroke center or comprehensive stroke center).

Our study has limitations. Only a limited number of patients with basilar occlusions were included in this study, therefore, limiting our ability to draw strong conclusions about the performance of the FAST-ED in this group of patients. FAST-ED remains to be validated in an independent cohort of patients and, in particular, it still must be prospectively tested among emergency medical system personnel. However, we think that it will not be difficult to teach emergency medical system personnel about FAST-ED because they are already familiar with the Cincinnati Stroke Scale (FAST), and we just have added 2 items to it. Indeed, the FAST-ED scale is simpler than the RACE scale (6 items), which has been validated in the prehospital setting.[13] We have not compared FAST-ED with all existing prehospital scales. We could not compare it with LAMS because we did not have data on grip strength. Although we think LAMS would probably have an inferior performance because it does not include highly discriminating cortical findings, such as aphasia, neglect, and gaze deviation, it has demonstrated high accuracy to detect LVOS in a previous study.[20] Similarly, we have not made a comparison with the stroke vision, aphasia, neglect (VAN) scale. VAN has been demonstrated to perform well when applied by NIHSS certified emergency room triage nurses.[21] However, the VAN scale tests 10 different items and; therefore, it seems to be too complex and time consuming to be used by emergency medical system personnel.

In conclusion, given the time-sensitive nature of both intravenous and endovascular reperfusion therapies, fast and accurate triage of patients to hospitals, where these therapies are available is vital, to prevent delays in care, optimize outcomes, and reduce costs associated with unnecessary transfers. FAST-ED is a simple scale that if successfully validated in field, it might be useful for medical emergency professionals to accurately identify LVOS in the prehospital setting, enabling rapid triage of patients to primary versus endovascular capable stroke centers.

Disclosures

Dr Lev reports working as consultant for GE Healthcare, MLNM Pharm, MedyMatch, and D-Pharm. He also reports receiving institution research support from GE Healthcare. Dr Singhal is a deputy PI of the New England Regional Coordinating Center for the National Institutes of Health (NIH) StrokeNet. He reports receiving partial support from the following NIH grants during the conduct of the study: R01NS051412, P50NS051343, R21NS077442, R21-NS085574, and U10NS086729. He is on ACTION (A Multicenter, Double-Blind, Placebo-Controlled, Randomized, Parallel-Group Study to Evaluate the Safety and Efficacy of Intravenous Natalizumab on Reducing Infarct Volume in Acute Ischemic Stroke) trial Advisory Board sponsored by Biogen. He is the site PI of stroke clinical trial sponsored by Boehringer Ingelheim. Dr Smith is a consultant for Stryker Neurovascular, DSMB board. Dr Nogueira is the PI for Trevo-2 Trial (sponsored by Stryker Neurovascular—modest) and the DAWN (Diffusion Weighted Imaging [DWI] or Computerized Tomography Perfusion [CTP] Assessment With Clinical Mismatch in the Triage of Wake Up and Late Presenting Strokes Undergoing Neurointervention) trial (no compensation). He is on the Steering Committee of SWIFT Trial (modest) and SWIFT Prime (no compensation). He receives compensation from the STAR (Solitaire FR Thrombectomy for Acute Revascularisation) trial (Angiographic Core Lab—significant). He is also part of the Executive Committee for the Penumbra 3D separator Trial (no compensation). He is also an Editor-In-Chief of the Interventional Neurology Journal (no compensation). The other authors report no conflicts.

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