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The Field Assessment Stroke Triage for Emergency Destination (FAST-ED): a Simple and Accurate Pre-Hospital Scale to Detect Large Vessel Occlusion Strokes

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Abstract

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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 FAST-ED scale was based on items of the NIHSS with higher predictive value for LVOS and tested in the STOPStroke cohort, in which patients underwent CT angiography within the first 24 hours of stroke onset. LVOS were defined by total occlusions involving the intracranial-ICA, MCA-M1, MCA-2, or basilar arteries. Patients with partial, bi-hemispheric, and/or anterior + posterior circulation occlusions were excluded. Receiver operating characteristic (ROC) curve, sensitivity, specificity, positive (PPV) and negative predictive values (NPV) of FAST-ED were compared with the NIHSS, Rapid Arterial oCclusion Evaluation (RACE) scale and Cincinnati Prehospital Stroke Severity Scale (CPSSS).

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 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). A FAST-ED 4 had sensitivity of 0.60, specificity 0.89, PPV 0.72, and NPV 0.82 versus RACE 5 of 0.55, 0.87, 0.68, 0.79 and CPSS 2 of 0.56, 0.85, 0.65, 0.78, respectively.

Conclusions—FAST-ED is a simple scale that if successfully validated in the field may be used by medical emergency professionals to identify LVOS in the pre-hospital setting enabling rapid triage of patients.

INTRODUCTION

Endovascular therapy (ET) 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 (EMS) personnel and transport to a comprehensive stroke center (CSC) with experience providing fast, effective and safe intervention.

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

Considering the limited availability of CSCs and the time sensitivity of both intravenous t-PA and endovascular therapy,[8, 9] accurate identification of patients with high probability of having a LVOS in the pre-hospital setting is of paramount importance.

To address this problem, we designed the present study to improve the accuracy of predicting LVOS by using a new tool called the 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), **S**peech 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 NIHSS with higher predictive value for LVOS. In addition, time was included considering its importance in the pre-hospital 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 two university-based hospitals, the Screening Technology and Outcomes Project in Stroke (STOPStroke), in which admission non-enhanced CT scans (NCCT) and computed tomography 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 (i.e., history of contrast agent allergy, pregnancy, congestive heart failure, increased creatinine level) or if there was evidence of intracranial hemorrhage on NCCT. The STOPStroke study received institutional review board approval at both participating institutions and was Health Insurance Portability and Accountability Act compliant.

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

Image Protocol and Review

The STOPStroke NCCT and CT angiographic 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 five point level of certainty score (score 5, definitely present; score 4, probably present; score 3, equivocal; score 2, probably absent; 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 ± standard deviation (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 Curve (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 (RACE: The Rapid Arterial Occlusion Evaluation Scale; CPSS: The Cincinnati Prehospital Stroke Severity Scale) and the NIHSS.[12, 13] The areas under the curve (AUC) were compared with the FAST-ED as the reference.[14] Calibration of FAST-ED was assessed graphically and by 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, since 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 (PPV) and negative predictive values (NPV) and accuracy were calculated using several different thresholds of the FAST-ED. The Youden's Index (YI) was used to evaluate the optimal threshold of the FAST-ED scale[17]. Pre-specified published thresholds of the other scales and a cut-off 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 2, and poor outcome – mRS > 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 two-sided p-value < 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 was 5 (IQR 2-12) and 52% were males. LVO was detected in 240 (33%). 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 BA. 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 AUC 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; 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%; 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 4 while a FAST-ED <2 was specifically associated with a low likelihood of LVO. There was a steady increase in the frequency of poor outcome (6-month mRS >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%; 9 – 100%). (**Figure 2**).

Better performance of FAST-ED according to the Youden's Index could be shown at two distinct thresholds 3 (YI = 0.490) and 4 (YI = 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, PPV of 0.62 and 0.72, and NPV of 0.84 and 0.82 versus RACE 5, 0.55, 0.87, 0.68, 0.79 and CPSS 2, 0.56, 0.85, 0.65, 0.78, NIHSS 6 0.76, 0.70, 0.55, 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 4 when compared with those with scores < 4. Moreover, the proportion of LVO in those subjects with FAST-ED 4 was mostly due to an increase in the frequency of more proximal occlusions such as MCA-M1 and intracranial ICA occlusions (**Figure 3**).

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 to 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 IV tPA and endovascular treatment thus avoiding unnecessary and costly delays.

Other scales have also been developed to predict LVOS in the pre-hospital 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]. As compared to FAST-ED, RACE gives a higher weight to motor symptoms. Specifically, a patient can be assessed one extra point for facial weakness and up to 2 extra points for leg weakness that would not be computed in FAST-ED. While 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 one point for gaze deviation (versus up to 2 points in the FAST-ED scale). Gaze deviation is a typical sign of cortical (or brainstem) dysfunction and as such is a powerful discriminator of LVOS. While 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 the some patients may have concomitant neglect and aphasia as well as that some left-handed patients might have right hemisphere dominance.

The CPSS scale is a simple scale easily implemented in the pre-hospital setting. However, it fails to recognize the important 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 three distinct groups for the likelihood of LVOS: score 0-1: <15%, 2-3: ~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 from PSC 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 <4 had a high prevalence of MCA-M2 occlusion as compared to those with score 4 who had a higher proportion of MCA-M1 and intracranial ICA-occlusions. As MCA-M2 occlusions have higher rates of recanalization with IV tPA, a lower threshold should be used to triage patients with scores <4 to the closest stroke center (e.g. PSC or CSC).

Our study has limitations. Only a limited number of patients with basilar occlusions were included in the present 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 amongst EMS personnel. However, we believe that it will not be difficult to teach EMS personnel about FAST-ED as they are already familiar with the Cincinnati Stroke Scale (FAST) and we just have added two items to it. Indeed, the FAST-ED scale is a simpler than the RACE scale (6-items) which has been validated in the pre-hospital setting[13]. We have not compared FAST-ED to all existing pre-hospital scales. We could not compare it to

LAMS as we did not have data on grip strength. Even though we believe LAMS would probably have an inferior performance as 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 to 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 appears to be too complex and time-consuming to be used by EMS personnel.

In conclusion, given the time-sensitivity 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 might be useful for medical emergency professionals to accurately identify LVOS in the pre-hospital setting enabling rapid triage of patients to primary versus endovascular capable stroke centers.

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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

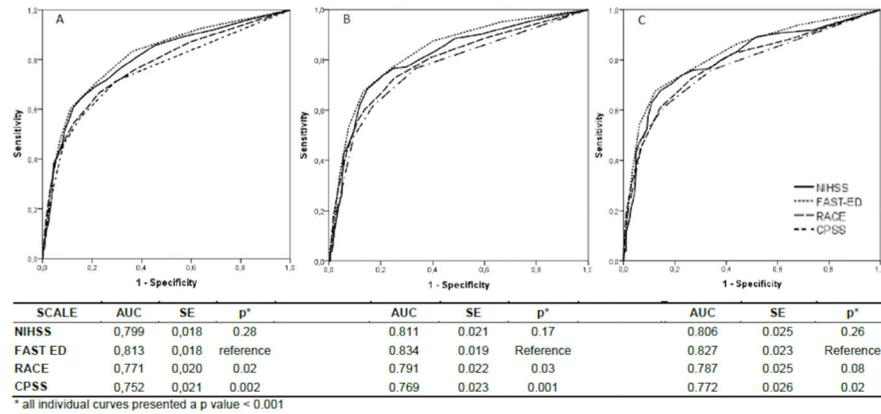* all individual curves presented a p value < 0.001

Figure 1.

* A - ROC curves comparing the discrimination of FAST-ED, NIHSS, RACE and CPSS scales for the detection of LVOS (all subjects); B – Subjects who performed CTA   12 hours from symptom onset; C – Subjects who performed CTA   6 hours from symptom onset.

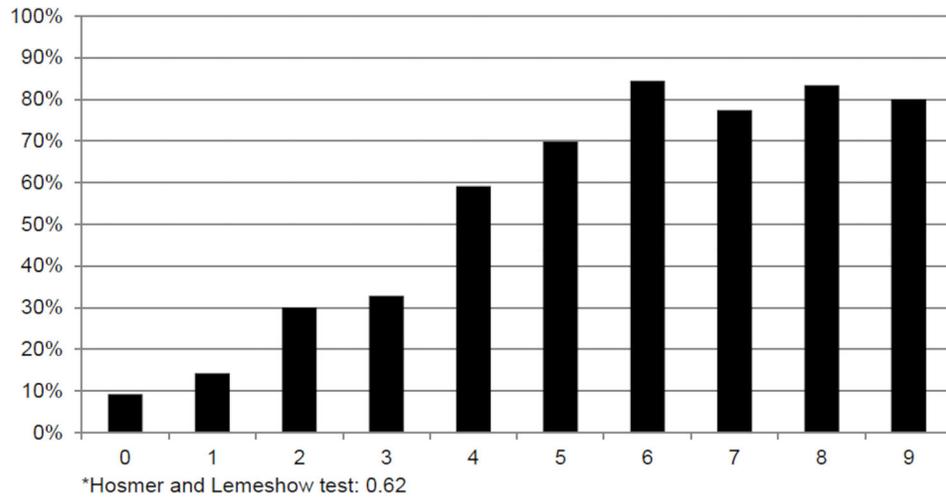* all individual curves presented a p value < 0.001

Figure 2.
Proportion of patients with LVOS according to the FAST-ED scale*.

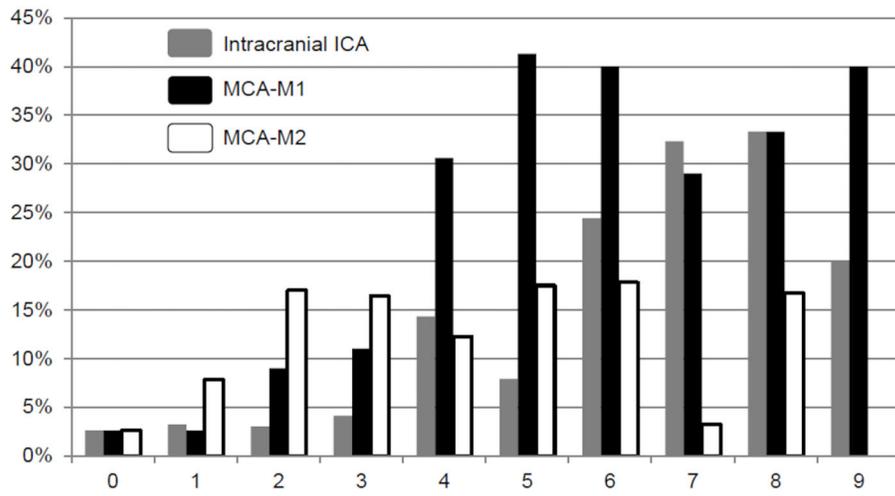*Hosmer and Lemeshow test: 0.62

Figure 3.
Proportion of patients with LVOS according to the FAST-ED scale and most proximal site of occlusion.

▨ Intracranial ICA

■ MCA-M1

☐ MCA-M2

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 one sensory modality	1	1
Does not recognize own hand or orients only to one side of the body	2	2

Table 2

Sensitivity, specificity, positive and negative predictive values 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

Table 3

Comparison of thresholds of the FAST-ED, RACE, CPSS and NIHSS according to sensitivity, specificity, positive and negative predictive values 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