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FAST-ED scale for prehospital triage of large vessel occlusion: results in the field

Escala FAST-ED para a triagem pré-hospitalar de oclusão de grande vaso: resultados de campo

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Abstract

Background Acute ischemic stroke (AIS) is an extremely time-sensitive condition. The field triage of stroke patients should consider a careful balance between the best destination for the timely delivery of intravenous and/or endovascular reperfusion therapies. The Field Assessment Stroke Triage for Emergency Destination (FAST-ED) scale has been shown to have an accuracy comparable to that of the National Institutes of Health Stroke Scale (NIHSS). However, it has not been tested in the field.

Objective To evaluate the accuracy of the FAST-ED scale in the detection of AIS due to large vessel occlusion (LVO) in the prehospital setting.

Methods A cross-sectional study of consecutive prospective data collected from February 2017 to May 2019 in the city of Porto Alegre, state of Rio Grande do Sul, Southern Brazil, correlating the prehospital FAST-ED scale scores with the hospital diagnosis of LVO. Area under the curve (AUC), sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated.

Results In total, 74 patients were included in the analysis. As compared with the diagnosis of LVO upon hospital discharge, the prehospital FAST-ED scale applied by paramedics had a sensitivity of 80%, a specificity of 47.7%, a PPV of 51.1%, an NPV of

Keywords
- Stroke
- Triage
- Emergency Medical Services
- Thrombectomy
- Mobile Applications

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77.8%, and an AUC of 0.68 (95% confidence interval [95%CI]: 0.55–0.80). Among the patients with a final diagnosis of AIS, the accuracy was higher, with an AUC of 0.75 (95%CI: 0.60–0.89), a sensitivity of 80%, a specificity of 60%, a PPV of 80%, and an NPV of 60%.
Conclusions In the present study, the FAST-ED scale, which was applied by paramedics in the field, demonstrated moderate accuracy but high sensitivity and NPV, which are essential attributes for a triage scale. While larger studies are still needed, these findings further support the use of the FAST-ED in stroke triage.

Resumo

Antecedentes O acidente vascular cerebral isquêmico (AVCI) é uma doença altamente dependente do tempo. A triagem de pacientes com AVCI na cena deve considerar um equilíbrio cuidadoso entre o melhor destino para a administração rápida de terapias de reperfusão intravenosas e/ou endovasculares. Já foi demonstrado que a escala de Avaliação de campo de triagem de AVC para destino de emergência (Field Assessment Stroke Triage for Emergency Destination, FAST-ED, em inglês) tem precisão comparável à da Escala de AVC dos Institutos Nacionais de Saúde dos Estados Unidos (National Institutes of Health Stroke Scale, NIHSS, em inglês). Entretanto, a FAST-ED não foi testada em campo.
Objetivo Avaliar a acurácia da escala FAST-ED na detecção de AVCI por oclusão de grande vaso (OGV) no contexto pré-hospitalar.
Métodos Estudo transversal de dados prospectivos consecutivos, coletados de fevereiro de 2017 a maio de 2019, em Porto Alegre, Rio Grande do Sul, Brasil, em que se correlacionam a pontuação pré-hospitalar na escala FAST-ED e o diagnóstico hospitalar de OGV. A área sob a curva (ASC), a sensibilidade, a especificidade, o valor preditivo positivo (VPP), e o valor preditivo negativo (VPN) foram calculados.
Resultados Ao todo, 74 pacientes foram incluídos na análise. Comparada ao diagnóstico de OGV na alta hospitalar, a escala FAST-ED aplicada em campo por profissionais do pré-hospitalar teve sensibilidade de 80%, especificidade de 47,7%, VPP de 51,1%, VPN de 77,8%, e ASC de 0,68 (intervalo de confiança de 95% [IC95%]: 0,55–0,80). Entre pacientes com diagnóstico final de AVCI, a precisão foi mais alta, com ASC de 0,75 (IC95%: 0,60–0,89), sensibilidade de 80%, especificidade de 60%, VPP de 80%, e VPN de 60%.
Conclusões Neste estudo, a escala FAST-ED, aplicada por profissionais do pré-hospitalar em campo, demonstrou precisão moderada, com alta sensibilidade e VPN, atributos essenciais para uma escala de triagem. Embora estudos com amostras maiores ainda sejam necessários, estes achados apoiam o uso da FAST-ED na triagem de AVCI.

Palavras-chave
- Acidente Vascular Cerebral
- Triagem
- Serviços Médicos de Emergência
- Trombectomia
- Aplicativos Móveis

INTRODUCTION

Acute ischemic stroke (AIS) is an extremely time-sensitive condition, and its optimal management depends on the referral of the patient to a hospital with adequate staff and structure.[2,3] After studies found evidence of the benefit of mechanical thrombectomy (MT) for the treatment of AIS with large vessel occlusion (LVO),[4–8] it is no longer only necessary to identify AIS in the prehospital setting, but it has become critical to further categorize the events as potential LVOs to define the best destination for the timely delivery of intravenous and/or endovascular reperfusion therapies.[9]

In this setting, many different prehospital stroke scales have been proposed.[10] Amongst them, the Rapid Arterial Occlusion Evaluation (RACE),[11] the Cincinnati Prehospital Stroke Severity Scale (CPSSS),[12] and the Field Assessment Stroke Triage for Emergency Destination (FAST-ED)[13] have been compared with the National Institutes of Health Stroke Scale (NIHSS) regarding the accuracy in the detection of LVO in AIS patients. A previous study[13] demonstrated that the FAST-ED scale had an accuracy comparable to that of the NIHSS, and higher accuracy than that of the CPSSS and RACE in the detection of LVO.

The FAST-ED scale was the basis for the development of the JoinTriage app (formerly FAST-ED app),[14] a smartphone application intended to deliver the scale in a handheld device, enabling a quicker recognition of the LVO patient in the field. Patients with a score below 4 points are labeled as "low probability of LVO", and should preferably be directed to the nearest hospital, be it a primary stroke center (PSC) or a comprehensive stroke center (CSC); and patients with a score of 4 or more points are labeled as "high probability of LVO", and should preferably be directed to an CSC, depending on the distance and the possibility of "drip-and-ship" or "mothership" regional protocols. The scale has shown good agreement among physicians with different levels of experience,[15]

as well as between emergency medical services (EMS) personnel and emergency physicians.[16]

However, the FAST-ED scale has not been previously tested by prehospital healthcare professionals in the field. The present study aims to evaluate the accuracy of the FAST-ED scale in the JoinTriage app in the prehospital setting, in the regional stroke network of the city of Porto Alegre, state of Rio Grande do Sul, Southern Brazil.

METHODS

A pragmatic, cross-sectional study that compared the prehospital diagnosis of LVO by the FAST-ED scale to the final diagnosis upon hospital discharge. The FAST-ED scale was prospectively applied to patients with suspected AIS evaluated by the local EMS, called Serviço de Atendimento Móvel de Urgência (SAMU), in the city and metropolitan area of Porto Alegre, from February 2017 to May 2019. The city's stroke network provides care to $\sim$ 1.5 million inhabitants,[17] and had, at the time of the study, 1 public CSC and 3 PSCs. The app was available in 22 ambulances and at the dispatch center. The paramedics assessed the patients according to the SAMU stroke protocol and decided, on their discretion, whether or not to apply the FAST-ED scale within six hours of symptom onset. The inclusion criteria were patients assessed through the FAST-ED scale by the EMS staff, and availability of the data in the patient's medical records. All patients consecutively assessed were included in the analysis. Hospital emergency physicians and neurologists were unblinded to the score of the pre-hospital scale, but radiologists were blinded.

The JoinTriage App – FAST-ED Scale

The JoinTriage app contains the FAST-ED scale, which was designed to present a series of clinical questions to the healthcare professional to help estimate the probability of LVO in the prehospital setting (►**Table 1**). Scores are not assigned to questions 1 to 4 in the app, and they can be used in some scenarios as criteria to select the patient's destination – which was not the case of the present study. The FAST-ED App and its development has been detailed elsewhere.[14]

Patients with a score of 4 or more points were preferably referred to the local CSC (Hospital de Clínicas de Porto Alegre, HCPA), whereas patients with a score below 4 points were referred either to the HCPA, to one of the two local PSCs (Hospital Nossa Senhora da Conceição – HNSC – and Hospital Santa Casa de Misericórdia de Porto Alegre, HSCMPA) (►**Figure 1**). This cutoff point was used according to the findings of the FAST-ED validation study.[13] The diagnostic evaluation and clinical management followed institutional guidelines.

Definition of large vessel occlusion

For the purpose of the present study, patients were considered as having AIS with LVO if they presented one of the following: 1) evidence of complete occlusion of the middle cerebral artery (MCA, M1 or proximal M2 segments), internal carotid artery (ICA) or basilar artery on computed tomography angiography (CTA), and/or 2) evidence of a large territory infarction consistent with occlusion in one of the aforementioned arteries. The latter strategy was adopted because spontaneous reperfusion could have occurred prior to the imaging studies as well as due to the fact that CTA was not routinely performed for all patients in some of the PSCs. The neuroimaging was interpreted by a neuroradiologist who was blinded to the FAST-ED score of the patient.

Data collection

Data was retrieved from the registries of the JoinTriage app, the SAMU database and patient medical records in the three

Table 1 Clinical questions of the FAST-ED scale in the JoinTriage smartphone app

Question	Answers
1. Is the patient on anticoagulants?	Yes/No/Unknown
2. How old is the patient?	Older than 80 years/80 years old or younger/Age is unknown
3. Did anyone see when the symptoms started?	Yes (enter time)/No
4. What time was the patient last seen well?	Yes (enter time)/No
5. Does the patient have facial weakness?	Normal (score: 0)/Abnormal (score: 1)
6. Does the patient have arm weakness?	No weakness (score: 0)/Mild (score: 1)/Moderate/severe (score:2)
7. Check speech content and ask the patient to name 3 common items:	Normal (score: 0)/Abnormal (score: 1)
8. Ask the patient: "show me two fingers"	Normal (score: 0)/Abnormal (score: 1)
9. Does the patient have gaze deviation to the other side?	Normal (score: 0)/Gaze preference (score: 1)/Forced deviation (score: 2)
10. Ask the patient: "are you weak anywhere?" (Question only shown if answer is "normal" on items 6 and 7)	Normal (score: 0)/Abnormal (score: 1)
11. Ask the patient: "whose arm is this?" (Question only shown if answer is "normal" on items 6 and 7)	Normal (score: 0)/Abnormal (score: 1)

Abbreviation: FAST-ED, Field Assessment Stroke Triage for Emergency Destination.

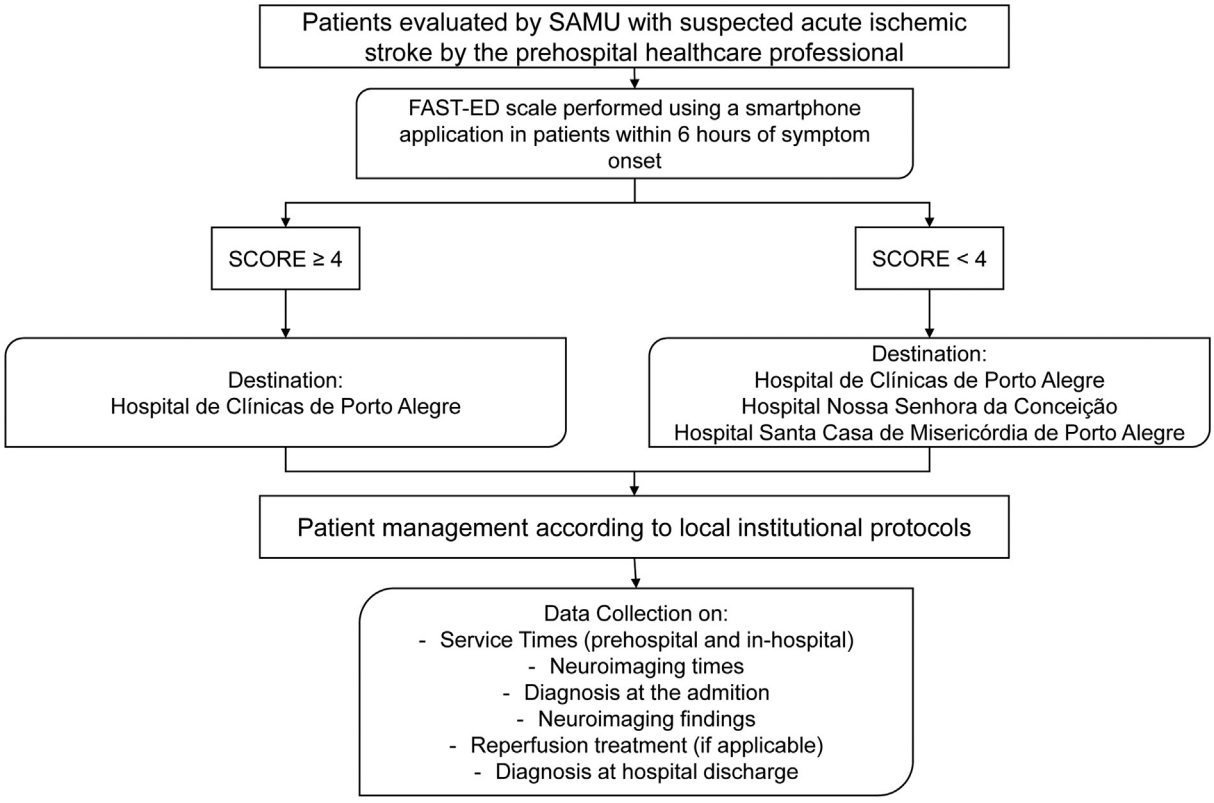


Figure 1 Abbreviations: SAMU, Serviço de AtendimentoMóvel de Urgência; FAST-ED, Field Assessment Stroke Triage for Emergency Destination. Protocol of patient referral based on the score on the FAST-ED scale. Abbreviations: SAMU, Serviço de Atendimento Móvel de Urgência; FAST-ED, Field Assessment Stroke Triage for Emergency Destination.

hospitals. We collected data on the time it took to perform certain services and procedures (symptom onset, call to the SAMU, arrival at the scene, arrival at the emergency department (ED), neurological examination, neuroimaging acquisition, intravenous thrombolysis, and groin puncture for MT), the score on the FAST-ED scale, the NIHSS score upon the admission, the diagnostic suspicion after the first medical encounter, the diagnosis after neuroimaging, and the final diagnosis at the hospital discharge. The study was registered in the local Institutional Review Board, and a consent form waiver was obtained. Authorization to collect data from the patient records was obtained from the SAMU and the three hospitals participating in the study. The access to the data was limited to members of the study staff, and measures were taken to ensure confidentiality. Given the sensitive nature of the data collected, requests to access the dataset from qualified researchers trained in human subject confidentiality protocols may be sent to the corresponding author.

Data analysis

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) and accuracy (area under the curve, AUC) were calculated comparing the pre-hospital FAST-ED score (from 0 to 7 points) as the test variable to the final diagnosis at hospital discharge (absence of LVO as negative, presence of LVO as positive) as the state variable. Nominal variables (gender, age, diagnosis and hospital of destination) were presented as frequencies and compared using the chi-squared test. The continuous variables (service and procedure times) were presented as medians with respective interquartile ranges (IQRs) and compared using the Mann-Whitney U test. Values of p below 0.05 were considered statistically significant. The Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY, United States) software, version 26.0, was used for the statistical analysis.

Ethical procedures

All procedures in the studies involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee, as well as with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The present study was approved by the Local Ethics Committee of HCPA, and the consent form was waived.

RESULTS

A total of 74 patients were included in the analysis. The median of age was of 67.5 years, and 43.2% were female patients. The median score on the NIHSS was 12 (IQR: 7–14), with no statistical differences among hospitals ($p = 0.335$). Four patients were excluded because we were not able to find the on the hospital databases (►**Figure 2**). The diagnosis at hospital discharge was of AIS in 45 (60.8%) out of the 74 patients, and 30 (66.6%) out these 45 cases of AIS were due to

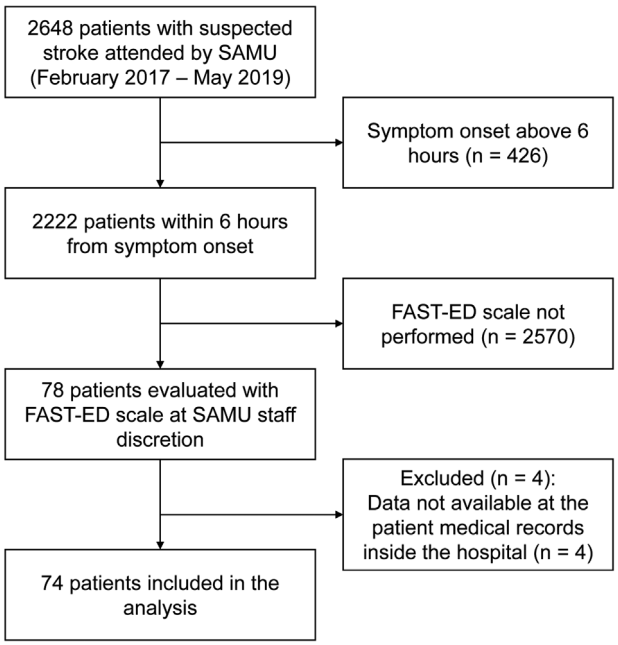


Figure 2 Study Flowchart. Abbreviations: SAMU, Serviço de Atendimento Móvel de Urgência; FAST-ED: Field Assessment Stroke Triage for Emergency Destination.

LVO. The rates of hemorrhagic stroke, transient ischemic attack (TIA), and stroke mimics were of 13.5%, 5.4%, and 20.2% respectively (►**Table 2**).

Among the 30 LVO patients, 20 presented an arterial occlusion on CTA (in the ICA in 1 patient, in the MCA-M1 in 15 patients, in the MCA-M2 in 3 patients, and in the basilar artery in 1 patient). The remaining 10 patients presented infarction in the territories of MCA-M1 (8 patients) and MCA-M2 (2 patients). More patients with a FAST-ED score of 4 or more points were referred to the CSC than to other hospitals (34 versus 5 versus 8; $p = 0.017$). The diagnosis at discharge was of AIS for 85.1% (40/47) of the patients with a FAST-ED score ≥ 4, without statistically significant difference compared with patients with a FAST-ED score < 4 (70.3%; 19/27; $p = 0.129$). The score on the FAST-ED scale (0–7 points) demonstrated moderate correlation to the NIHSS score (0–42 points) (Spearman $r = 0.58$). The median time from onset to ED arrival was of 202 (IQR: 136–260) minutes.

As compared with the diagnosis of LVO at hospital discharge, including patients with presumed LVO whose CTA was not available, the pre-hospital assessment through the FAST-ED scale by paramedics had a sensitivity of 80%, a specificity of 47.7%, a PPV of 51.1%, an NPV of 77.8%, and an AUC of 0,68 (95% confidence interval [95%CI]: 0.55–0.80). The analysis was also performed excluding patients with presumed LVO, and slightly different results were obtained: sensitivity of 80%, specificity of 47.7%, PPV of 41%, NPV of 84%, and AUC of 0,58 (95%CI: 0.45–0.70). Among the patients with a final diagnosis of AIS, the accuracy was higher, with an AUC of 0.75 (95%CI: 0.60–0.89), sensitivity of 80%, specificity of 60%, PPV of 80%, and NPV of 60% (►**Figure 3**).

Logistic regression was used to evaluate the association of the ordinal FAST-ED score with the probability of LVO among different diagnoses at discharge: all diagnoses, all types of stroke, and AIS only. The higher the FAST-ED score, the higher the probability of LVO. Among AIS patients, the probability was more expressive than among all diagnoses (►**Table 3**).

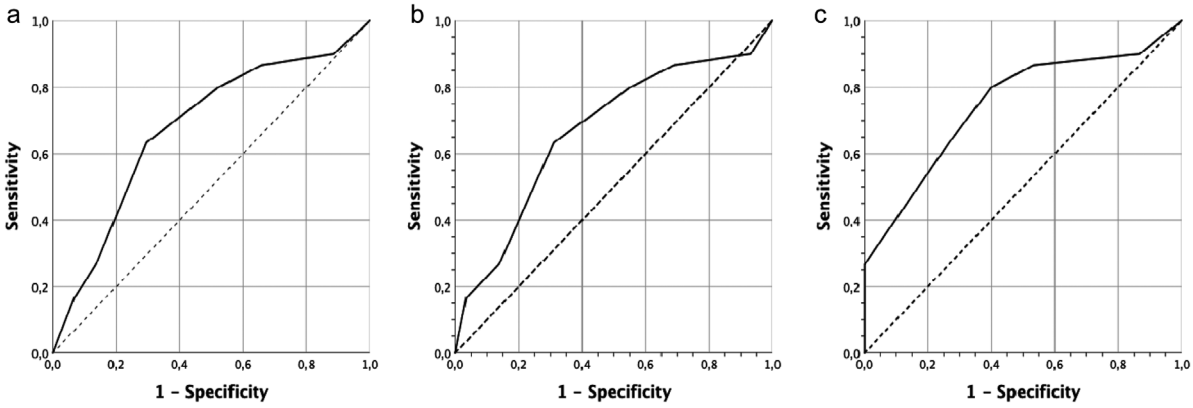
DISCUSSION

In the current study, the FAST-ED scale demonstrated lower accuracy in the detection of LVO in the prehospital setting (AUC: 0.68) as compared with the original study by Lima et al.[13] When the results were applied to patients with confirmed AIS, the accuracy was better (AUC 0.75). Lima et al.[13] found a good accuracy (AUC: 0.81) in the validation paper of the FAST-ED scale. It must be taken into account that their study was retrospective, hospital-based, and the scale was applied only to data in the medical records of patients with AIS diagnosed by neurologists. The CPSSS was also retrospectively applied by Katz et al.[12] to 303 patients with an AIS diagnosis, and an AUC of 0.67 for the detection of LVO was obtained. The present study evaluated the accuracy of the FAST-ED scale prospectively applied in the field by EMS healthcare

Table 2 Final diagnosis at discharge of the patients included in the study*

	HCPA ($n = 45$)	HNSC ($n = 14$)	HSCMPA ($n = 15$)	Total ($n = 74$)
AIS	29 (64.4%)	5 (35.7%)	11 (73.3%)	45 (60.8%)
AIS treated with tPA	11/29 (37.9%)	–	2/11 (18.2%)	13/45 (28.9%)
AIS with LVO	20/29 (68.9%)	4/5 (80%)	6/11 (54.5%)	30/45 (66.7%)
AIS with LVO treated with thrombectomy	3/20 (15%)	–	–	3/30 (10%)
Hemorrhagic stroke	6 (13.3%)	4 (28.5%)	–	10 (13.5%)
TIA	1 (2.2%)	3 (21.4%)	–	4 (5.4%)
Stroke mimics	9 (20.0%)	2 (14.3%)	4 (26.7%)	15 (20.2%)

Abbreviations: AIS, acute ischemic stroke; LVO, large vessel obstruction; HCPA, Hospital de Clínicas de Porto Alegre; HNSC, Hospital Nossa Senhora da Conceição; HSCMPA, Hospital Santa Casa de Misericórdia de Porto Alegre; TIA, transient ischemic attack; tPA, tissue Plasminogen Activator.
Note: *p-value > 0.05 for all variables. In this cohort, stroke mimics comprises: anemia (1); functional neurological deficit (1); hyperglycemia (1); sepsis (1); recrudescence of deficits (1); seizure (3); chronic neurological deficits (1); syncope (2); encephalitis (1); and undetermined etiology (3). Values expressed as absolute numbers, followed by relative percentages.



a. ALL PATIENTS		b. STROKE PATIENTS		c. AIS PATIENTS	
Sensitivity	80%	Sensitivity	80%	Sensitivity	80%
Specificity	47.7%	Specificity	44.8%	Specificity	60%
PPV	51.1%	PPV	60%	PPV	80%
NPV	77.8%	NPV	68.4%	NPV	60%
AUC (CI 95%)	0.68 (0.55-0.80)	AUC (CI 95%)	0.67 (0.53-0.81)	AUC (CI 95%)	0.75 (0.60-0.89)

Figure 3 Receiver operating characteristic (ROC) curves of patients assessed through the FAST-ED scale in the prehospital setting. A comparison was made between the probability of LVO obtained with the scale and the presence of LVO as the diagnosis at discharge. Curve "a" refers to all patients submitted to the triage. Curve "b" refers to patients whose final diagnosis was of stroke of any type. Curve "c" refers to patients whose final diagnosis was of AIS only. Abbreviations: AIS, acute ischemic stroke; FAST-ED, Field Assessment Stroke Triage for Emergency Destination; LVO, large vessel occlusion; PPV, positive predictive value; NPV, negative predictive value.

professionals, usually paramedics, which may explain some of the differences.

Pérez de la Ossa et al.[11] validated the RACE scale in a prospective study of 357 patients with suspected AIS, with the application of the scale by trained emergency technicians in the prehospital setting, and they obtained good accuracy (AUC: 0.82). In their study,[11] the final diagnosis was of AIS in 240 patients (67.2%), with 76 presenting LVO; hemorrhagic stroke in 52 (14.6%), TIA in 20 (5.6%), and other diagnoses in 45 patients (12.6%). In the present study, the cohort had a higher prevalence of LVO (40.5% versus 21.2%) and stroke mimics (19.4% versus 12.6%), which might have influenced our results.

Regarding all patients with suspected stroke who were assessed with the FAST-ED scale for the detection of LVO, we found a high sensitivity (80%) and a high NPV (77.8%). This means that the odds of missing an LVO patient are low. This is an important attribute for a triage scale and it remained even after the exclusion of patients with presumed LVO (infarction in a large territory without CTA available). Besides that, when the patient did not have an AIS with LVO, the other conditions in majority should have been evaluated in a tertiary hospital – such as hemorrhagic stroke. Assessment through the FAST-ED scale may also reduce the need for interhospital transfers and speed up the treatment of the patient, even though we

Table 3 Probability of large vessel occlusion (LVO) according to the score in the FAST-ED scale

FAST-ED score	All patients ($n = 74$)	Stroke patients ($n = 59$)	AIS patients ($n = 45$)
0	0.137	0.195	0.197
1	0.184	0.256	0.297
2	0.244	0.328	0.421
3	0.315	0.409	0.556
4	0.396	0.496	0.683
5	0.483	0.582	0.787
6	0.571	0.664	0.864
7	0.655	0.737	0.916

Abbreviations: AIS, acute ischemic stroke; FAST-ED, Field Assessment Stroke Triage for Emergency Destination.
Note: All patients assessed with the scale, patients whose final diagnosis at discharge was stroke of any type, and patients with a final diagnosis of AIS only.

did not find any difference in treatment times between the groups.

Our results evidence a moderate correlation between the FAST-ED and NIHSS scores upon admission, which is also conflicting with the previous literature[13] ($r = 0.578$ versus $r = 0.92$; $p < 0{,}001$). We cannot identify a single factor responsible for this, but the small sample and the difference in terms of clinical expertise of the personnel administering the scale may have played a role.

In the present study, only 10% of the patients with LVO (3 out of 30) received MT, because MT is currently not reimbursed in the public healthcare system in Brazil. Thus, the HCPA was the only hospital where this procedure was performed and, even there, only for patients randomized to the treatment arm of the "Endovascular Treatment with Stent-retriever and/or Thromboaspiration vs. Best Medical Therapy in Acute Ischemic Stroke" (RESILIENT) trial.[18]

The present study has some limitations. The number of subjects included in the analysis was low (74 subjects) and comprised only a small proportion of the number of patients eligible for EMS screening over the study period ($n = 2{,}222$), leading to a potential selection bias. However, the study aimed to provide the tool for use by the EMS staff upon their discretion. There was a lack of integration between the prehospital and intrahospital databases, which may have led to missing patient data.

In this small study evaluating the performance of the application of the FAST-ED scale by paramedics in the field for the prediction of LVO among suspected stroke patients, the scale demonstrated a moderate accuracy but high sensitivity (80%) and negative predictive value (77.8%), which are essential attributes for a triage scale. While larger studies are still needed, these preliminary findings further support the use of the FAST-ED scale in stroke triage.

Authors' Contributions

LAC: conceptualization, methodology, investigation, formal analysis, data curation, writing – first draft, project administration; ACS: methodology, investigation, writing – first draft; MSR, MDM: investigation, data curation, writing – review; RGN: conceptualization, methodology, writing – review; SCOM: conceptualization, investigation, methodology data curation, writing – review.

Conflict of Interest

LAC reports consultancy fees from Allm Inc., personal fees from Boehringer-Ingelheim and iSchemaView as a speaker, outside the submitted work; ACS reports personal fees from Boehringer Ingelheim as a speaker, outside the submitted work; MSR reports no disclosures; MDM reports no disclosures; RGN: reports personal fees from Genentech, Biogen, Prolong Pharmaceuticals, and Medtronic; serves on the Physician Advisory Board for Allm Inc, Prolong Pharmaceuticals, Viz-Al and Corindus Vascular; holds stock options in Viz-Al and Corindus Vascular Robotics; and reports personal fees from iSchemaView and Philips as a speaker, outside the submitted work; SCOM reports consultancy fees from Boehringer Ingelheim, and personal fees from Boehringer Ingelheim, Medtronic and Pfizer as a speaker, outside the submitted work.

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