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ORIGINAL ARTICLE

Prehospital identification of large vessel occlusion using the FAST-ED score

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Abstract

Objectives: The prehospital identification of stroke patients with large vessel occlusion (LVO) enables appropriate hospital selection and reduces the onset-to-treatment time. The aim of this study was to investigate whether the Field Assessment Stroke Triage for Emergency Destination (FAST-ED) scale could be reconstructed from existing prehospital patient reports and to compare its performance with neurologist's clinical judgement using the same prehospital data.

Materials & Methods: All patients transported by ambulance using stroke code on a six-month period were registered for the study. The prehospital patient reports were retrospectively evaluated using the FAST-ED scale by two investigators. The performance of FAST-ED score (≥4 points) in LVO identification was compared to neurologist's clinical judgement ('LVO or not'). The presence of LVO was verified using computed tomography angiography imaging.

Results: A total of 610 FAST-ED scores were obtained. The FAST-ED had a sensitivity of 57.8%, specificity of 87.2%, positive predictive value (PPV) of 37.3%, negative predictive value (NPV) of 93.4% and area under curve (AUC) of 0.724. Interclass correlation coefficient for both raters over the entire range of FAST-ED was 0.92 (0.88–0.94). The neurologist's clinical judgement raised sensitivity to 79.4%, NPV to 97.1% and PPV to 45.0% with an AUC of 0.837 ($p < .05$).

Conclusions: The existing patient report data could be feasibly used to reconstruct FAST-ED scores to identify LVO. The binary FAST-ED score had a moderate sensitivity and good specificity for prehospital LVO identification. However, the FAST-ED was surpassed by neurologist's clinical judgement which further increased the sensitivity of identification.

KEYWORDS
EMS, large vessel occlusion, stroke

Presented in part among the best abstracts at the Emergency Medical Services 2019 Congress in Madrid, Spain, 26-28th April 2019.

1 | INTRODUCTION

Endovascular thrombectomy (EVT) is a highly effective treatment for acute ischaemic stroke patients with large vessel occlusion (LVO)—conventionally up to 6 hours from symptom onset. A carefully selected subset of patients can benefit from the treatment up to 24 hours.[1] The prehospital identification of LVO holds significant potential to decrease the onset-to-treatment time: the ambulance crews can select the correct transport destination and alert the in-hospital endovascular team via prenotification. [2]

Most emergency medical service (EMS) systems currently rely on stroke recognition tools to identify stroke symptoms.[3] However, LVO identification is a more complicated task since the ambulance crews are required to assess a wider array of neurological symptoms and their severity. A number of prehospital LVO scales and algorithms have been developed for this purpose,[4-9] but only few of them have been thoroughly validated using prehospital data.[5,8,10]

The Field Assessment Stroke Triage for Emergency Destination (FAST-ED) is a prehospital LVO scale that is based on the National Institutes of Health Stroke Scale (NIHSS).[6,10-14] It complements the widely adopted Face Arm Speech Test (FAST) recognition tool[15] by including the assessment of eye deviation, neglect and motor symptom severity.

This study aimed to investigate whether the FAST-ED scale could be reconstructed from existing prehospital patient reports and to compare its performance with neurologist's judgement using the same prehospital data. Our hypothesis was that the identification could be further improved based on the neurologist's assessment.

2 | METHODS

2.1 | Study setting

Helsinki University Hospital (HUH) is the largest academic hospital in Finland and the only comprehensive stroke centre (CSC) in the capital region covering directly a population of 1,600,000 and a population of 800,000 in the surrounding regions with four primary stroke centres (PSCs) (Kouvola, Kotka, Lahti and Lappeenranta). The study setting, EMS system, emergency department (ED) process and principles of data collection have been described in detail previously.[16-19] Currently, all suspected stroke patients are screened during the emergency call processing and the prehospital examination using the FAST identification tool.[15] Prehospital LVO scales are not currently used in the EMS system, and the ambulance crews have not received training in their use.

2.2 | The electronic prehospital patient reporting

The electronic prehospital patient reporting (EPR) system (Merlot Medi, CGI Inc; Montreal, Quebec, Canada) is used by the regional EMS on laptop computers with both traditional keyboard and touch screen options (Panasonic Toughbook CF20 10.1", Panasonic corp. Osaka, Japan). In addition to fields on the patient's medical history and background, it includes an interactive template of neurological symptoms and findings. In suspected acute stroke, it is obligatory to answer questions regarding the presence of facial droop, arm weakness, difficulty of speech and time of symptom onset as per the FAST algorithm. In addition, other neurological key findings such as leg weakness, eye deviation, pupil status, headache and seizures are included in the template. Additional information such as the presence of neglect and assessment of symptom severity can be described using free text in a separate field. This is also used to provide a short description of the events that led to the situation. Selected hospitals are equipped with Merlot Medi terminals which can be used to access the EPR when the patient is en route to the hospital. The final prehospital patient report is transferred to the patient's hospital records as a PDF file and can also be printed out in paper format.

2.3 | The prehospital stroke protocol

If the patient has one or more FAST-symptoms and the symptoms have started less than nine hours ago, the ambulance crew aims for rapid transport to HUH ED using the stroke code ('recanalization candidate') with a telephone prenotification. Patients with high degree of disability, dependence or known terminal illness are transported to municipal hospitals instead. If the patient's condition is atypical, the crews can consult the EMS physician or the stroke neurologist for advice on hospital selection and urgency of transport who can both access the patient's EPR during the telephone call. At the hospital ED, a stroke team meets the patient directly on arrival according to the 'Helsinki stroke protocol'.[16,17] In the capital region, the patient is transported directly to HUH, bypassing the nearest EDs (Figure 1). In the surrounding areas, the nearest regional PSC is the primary transport destination. Secondary transport is arranged to HUH only if the patient is expected to benefit from EVT based on CTA imaging. Arranging secondary transport is not part of the EMS operation in this region.

2.4 | The study protocol

The study protocol was approved by the relevant authorities at HUH. Additional ethics review board approval was not required due to the retrospective register-based nature of the study. All prehospital patient reports over a six-month period from January to June 2018 were retrieved from the EPR system. The sample was screened for patients transported to HUH ED using the stroke code and high priority ('candidates for recanalization'). Secondary transport from other hospitals was not included. Two investigators, a prehospital EMS physician (T.P.) and a neurologist (D.S.), both well aware of the prehospital chain of care and frequently consulted by ambulance crews regarding suspected acute stroke evaluated the patients'

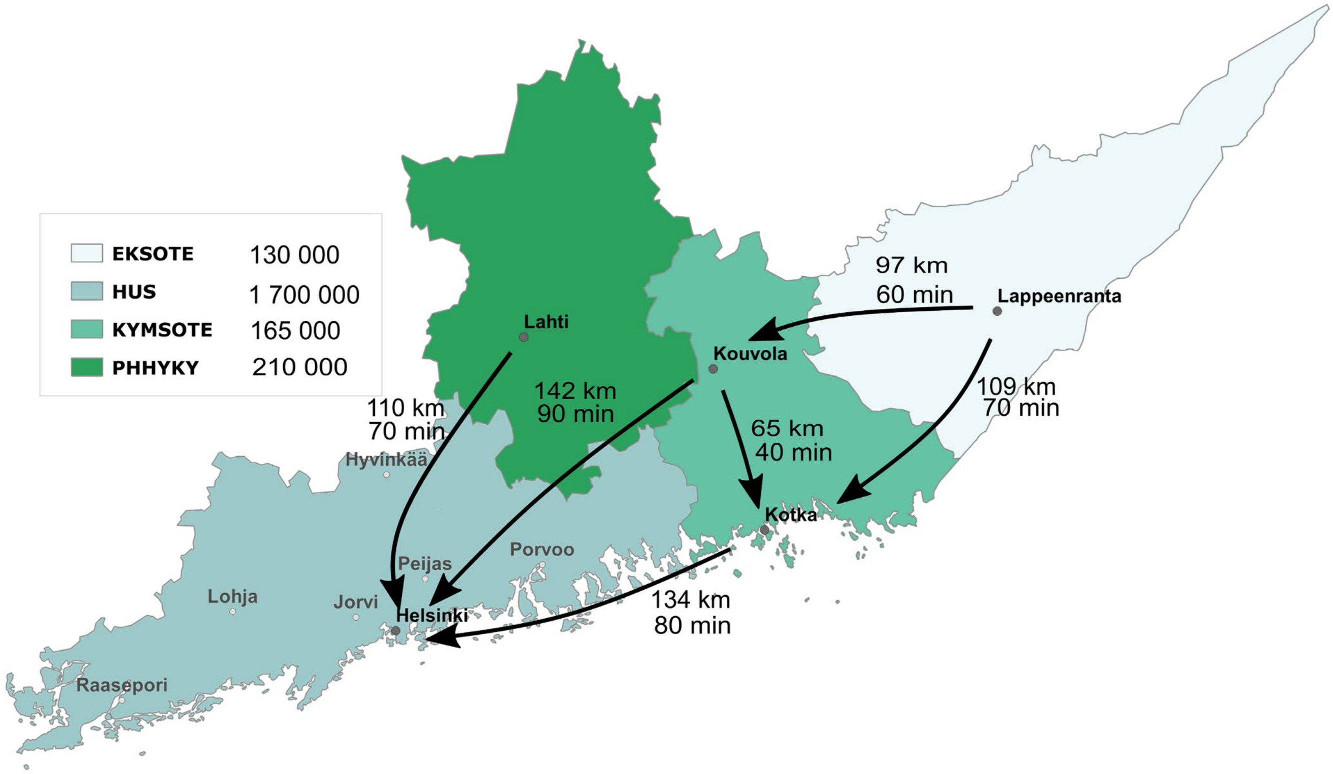

FIGURE 1 Helsinki University Hospital area and the neighbouring healthcare districts with own primary stroke centres (Kouvola, Kotka, Lahti, Lappeenranta). Transport times (minutes) between hospitals are estimations based on the distance and the use of 'lights and sirens'. EKSOTE, South Karelia Social and Health Care District; HUS, Helsinki University Hospital; KYMSOTE, Kymi Social and Health Care District; PHHYKY, Päijät-Häme Social and Health Care District

prehospital reports by using the FAST-ED scale.[6] During the evaluation, the investigators had no access to other patient information.

The FAST-ED consists five items (facial droop, arm weakness, speech disturbance, eye deviation and denial/neglect) which give between zero and two points each. The maximum score is nine points. The investigators calculated the patients' FAST-ED scores based on the symptom descriptions provided by paramedics or emergency medical technicians in the prehospital patient report. Denial/neglect was scored in the prehospital patient report only if an ambulance crew member had suspected that the patient has a deficit in awareness of one side of his body. A sub-cohort of 101 patients was evaluated by both investigators in order to obtain the interclass correlation between the two raters. The previously published cut-off of ≥4 points was used as the denominator of suspected LVO.[6] After the evaluation of FAST-ED scores, the patients reviewed by the neurologist (D.S.) were further categorized as either 'LVO' or 'no LVO' using overall clinical judgement based on all available data in the prehospital patient report. During the evaluation, the neurologist did not have access to any other patient records. The performance of the binary FAST-ED score was compared to the neurologist's clinical judgement. The presence of LVO was evaluated independently by a neuroradiologist (P.V.) in a blinded manner using the computed tomography angiography (CTA) imaging data taken at admission. In this study, LVO was defined as the occlusion of internal carotid artery (ICA), the first (M1) or the second (M2) segment of the middle cerebral artery. For practical reasons, the occlusions of the basilar artery (BA) were also included since this is a very small patient group benefiting from EVT. In addition to CTA imaging data, the patients' final diagnosis was separately retrieved from the hospital records by a member of the study group (J.K).

To compare FAST-ED scores by both raters, interclass correlation coefficient (average measures) for the whole range of FAST-ED scale was calculated. Further calculations included accuracy, sensitivity, specificity, negative predictive value (NPV), and positive predictive value (PPV) for FAST-ED and LVO-prediction. The ability of the FAST-ED scale or neurologist's own judgement to correctly identify LVO was calculated with c-statistics (receiver operating characteristic-area under curve, ROC-AUCs). The statistical analysis was conducted using the SPSS 25 statistical package. The comparison of AUC was done according to previously published methodology.[20] Significance was set at $p < .05$.

3 | RESULTS

The EMS responded to 61,195 calls during the study period. After initial prehospital assessment, 509 patients were transported using the stroke code as 'recanalization candidates'. The ambulance crews correctly identified stroke in 334 (65.6%) cases. Fifty-seven patients had LVO and 41 underwent EVT. The flowchart of the study population is depicted in Figure 2 and a full distribution of diagnoses as Table S1.

A total of 610 FAST-ED evaluations were registered (Figure 2). Interclass correlation coefficient for the whole range of FAST-ED scale between the two raters was 0.92 (0.88–0.94). The detailed distribution of acquired FAST-ED scores as related to the vascular occlusion status is presented in Table 1 and Figure 3A,B. The highest recorded FAST-ED score was seven points, and none of the patients received eight or nine points on the scale. Despite that some of the patients with FAST-ED score of three points did have vessel occlusions, these were mostly in M2 segment and smaller vessels.

Of all FAST-ED evaluations, 499 (81.8%) scored 0–3 points. Thirty (6.0%) of these patients still had LVO. On the other hand, 69 (62.7%) of the patients who scored ≥4 points on the FAST-ED scale did not have LVO. Nearly half of these false positives (46.4%) had intracranial haemorrhage. Overall, the FAST-ED scale had a moderate sensitivity but a good specificity for LVO identification (Table 2).

Neurologist's clinical judgement outperformed the binary FAST-ED score in overall accuracy, sensitivity, negative predictive value (NPV) and positive predictive value (PPV), while the specificity did not change (Table 2). The corresponding areas under curves (AUCs) were 0.837 and 0.724, respectively ($p < .05$).

4 | DISCUSSION

This study showed that the existing EPR data could be feasibly used to reconstruct FAST-ED scores to identify LVO without any additional training for the EMS personnel. The FAST-ED scale had an excellent interclass correlation rate, moderate sensitivity and good specificity for prehospital LVO identification which was essentially in line with earlier reports on the use of FAST-ED scale. However, the FAST-ED was surpassed by neurologist's clinical judgement which especially increased the sensitivity of identification.

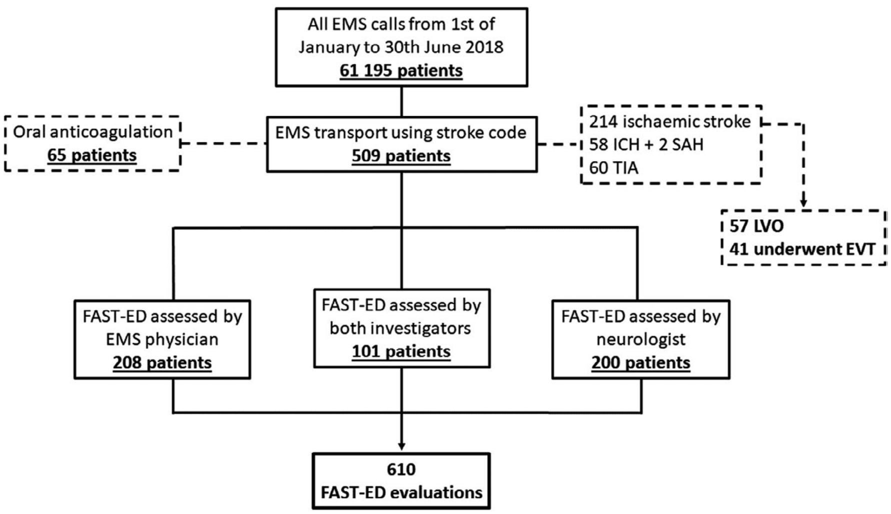

FIGURE 2 Description of the study sample. EMS, Emergency Medical Services; EVT, endovascular thrombectomy; FAST-ED, FAST-ED=Field Assessment of Stroke for Emergency Destination; ICH, intracerebral haematoma; LVO, large vessel occlusion; SAH, subarachnoid haemorrhage; TIA, transient ischaemic attack

TABLE 1 Distribution of Field Assessment of Stroke for Emergency Destination (FAST-ED) score and types of vessel occlusion by score category and anatomical location

Vessel occlusion category	0	1	2	3	4	5	6	7	Total†
ICA, M1 or ICA-M1	0 (0.0%)	0 (0.0%)	3 (2.1%)	5 (5.6%)	11 (22.0%)	10 (32.3%)	5 (31.3%)	5 (38.5%)	39 (6.4%)
M2	0 (0.0%)	4 (2.2%)	4 (2.8%)	8 (9.0%)	4 (8.0%)	1 (3.2%)	2 (12.5%)	2 (15.4%)	25 (4.1%)
Smaller vessels in ACA, MCA or PCA territory	3 (3.7%)	10 (5.4%)	7 (4.9%)	5 (5.6%)	2 (4.0%)	2 (6.5%)	0 (0.0%)	0 (0.0%)	29 (4.8%)
BA	0 (0.0%)	1 (0.5%)	3 (2.1%)	2 (2.2%)	1 (2.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	7 (1.2%)
No occlusion	79 (96.3%)	169 (91.8%)	126 (88.1%)	69 (77.5%)	32 (64.0%)	18 (58.1%)	9 (56.3%)	6 (46.2%)	508 (83.6%)
Total	82	184	143	89	50	31	16	13	608

Abbreviations: ACA, anterior cerebral artery; BA, basilar artery; ICA, internal carotid artery; M1, first segment of the middle cerebral artery; M2, second segment of the middle cerebral artery; MCA, middle cerebral artery; PCA, posterior cerebral artery.

†CTA data not available for two patients.

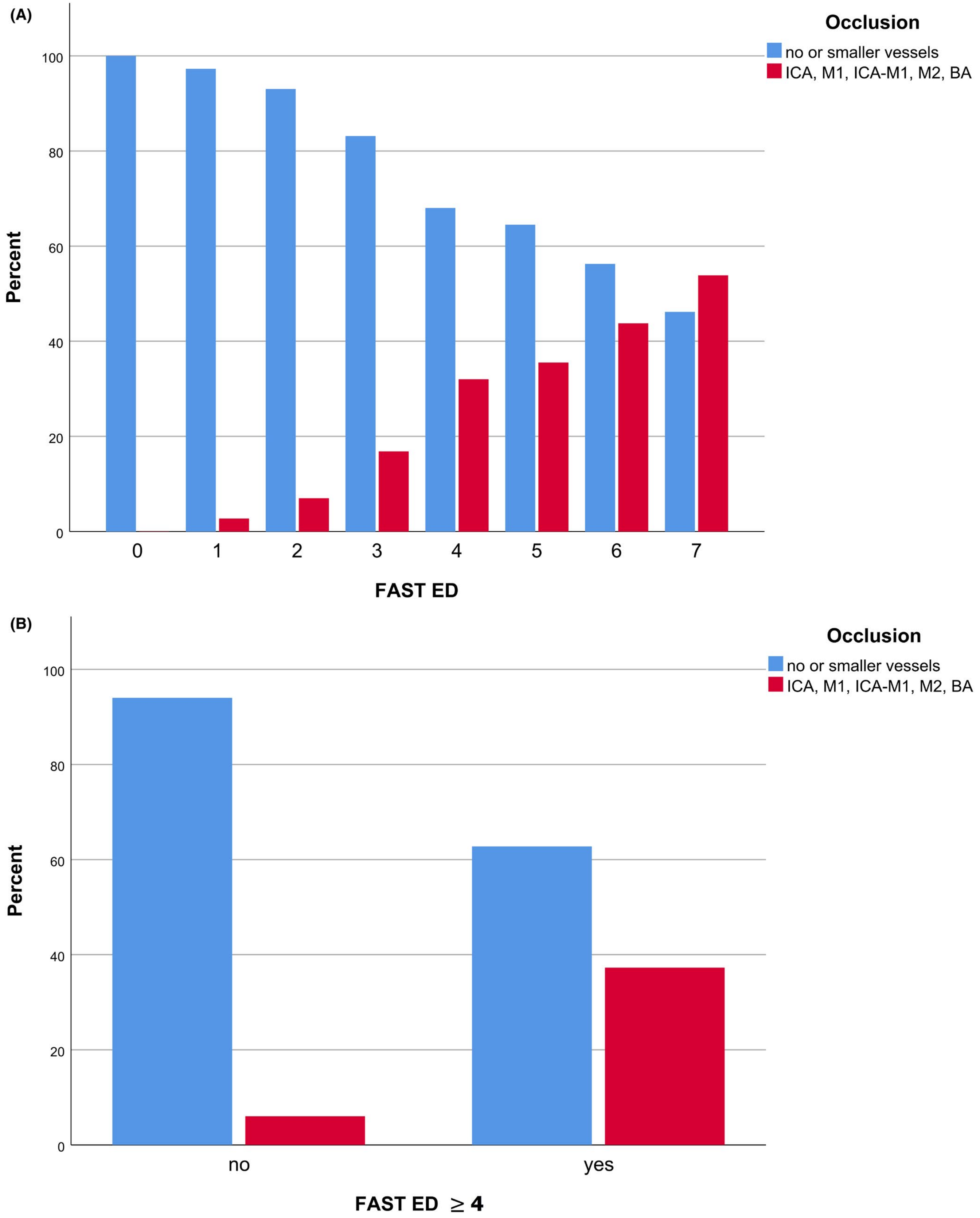

FIGURE 3 FAST-ED Score and the proportion of large vessel occlusion by score category (A) and using ≥4 points as the cut-off for positive identification (B) BA, basilar artery; ICA, internal carotid artery; M1, first segment of middle cerebral artery; M2, second segment of middle cerebral artery

TABLE 2 Comparison of Field Assessment of Stroke for Emergency Destination (FAST-ED) scale and neurologist's clinical judgement against computed tomography angiography (CTA) imaging

	n	No occlusion or smaller vessels	LVO			Accuracy	Sensitivity	Specificity	NPV	PPV	AUC for binary FAST-ED ≥4	AUC for whole range of FAST-ED
			ICA, M1, ICA-M1	M2	BA							
FAST-ED ≥4 by EMS physician	48/307†	60.5%	29.2%	10.4%	0.0%	84.7%	51.4%	89.3%	93.1%	39.6%	0.703	0.804
FAST-ED ≥4 by neurologist	62/301	64.5%	27.4%	6.5%	1.6%	82.7%	64.7%	85.0%	95.0%	35.5%	0.749	0.846
FAST-ED ≥4 by both investigators	110/610	62.7%	28.2%	8.2%	0.9%	83.7%	57.8%	87.2%	93.4%	37.3%	0.724	0.824
LVO per neurologist's clinical judgement	60/301	55.0%	30.0%	10.0%	5.0%	86.7%	79.4%	87.6%	97.1%	45.0%	0.837	N/A

Abbreviations: AUC, area under curve; BA, basilar artery; EMS, emergency medical services; ICA, internal carotid artery; M1, first segment of middle cerebral artery; M2, second segment of middle cerebral artery; EMS, emergency medical services; LVO, large vessel occlusion; NPV, negative predictive value; PPV, positive predictive value.

†CTA data not available for two patients.

In earlier reports, the prehospital LVO scales have been criticized for their high false negative and false-positive rates. It has been feared that patients whose LVO is missed by the EMS due to the use of a prehospital LVO scale do worse than their counterparts due to the disruption in the chain of care.[21-23] On the other hand, false positives, most of which consist of ICH, would unnecessarily burden the CSC when they could receive treatment at the nearest PSC. Even a long-distance transport directly from the field can have its own risks if the patient's condition begins to deteriorate. These are certain limitations which must be acknowledged when prehospital LVO scales are used. However, it is important to understand that the LVO scales should not be viewed as a substitute for neurologist's assessment or angiography imaging but as a decision-making aid for ambulance crews. For example, based on the results of this study, a FAST-ED score below four points effectively excluded over 93% of all LVO cases. This study also confirms that majority of the occlusions in patients with FAST-ED score of three points are located in M2 smaller segments.[6,11] Moreover, misclassifications by different LVO scales have not been reported to lead to excess patient harm.[23] Most recently, the preliminary results of the RACECAT-trial [24] showed that patients transported directly to a CSC for EVT did not have better outcomes compared with patients first transported to a PSC with a secondary transfer to CSC for EVT (*as presented at the ESO-WSO Stroke Congress 2020*). Naturally, this necessitates a well-functioning secondary transfer protocol in the CSC catchment area.

The development and selection of the optimal LVO recognition tool has been the subject of intense research during the past years. Many of these tools share similar NIHSS-based components but their scoring, cut-offs and performance differ. In the most recent comparison, the overall performance of the most popular scales has been similar.[10] We believe that the selection of the appropriate LVO recognition tool should be made with the local EMS and hospital systems in mind. Consecutive studies from the same regions have shown that the overall performance of the selected scale has a tendency to improve as the EMS system gains experience of using them in prehospital practice and components can be modified to better meet local demands.[5,25] When compared to other existing LVO scales, the advantage of the FAST-ED is that it is designed to complement the FAST tool which is already used in many EMS systems. The scale has been reported to correlate well with the NIHSS and to have a high discrimination regarding LVO recognition.[6] It is also well-balanced and does not give pronounced weight to any specific symptom. For example, the RACE scale[14] and the Los Angeles Motor Scale emphasize the role of motor symptoms while in the Finnish Prehospital Stroke Scale[5] the LVO identification is dependent on the presence of eye deviation. In addition, the scale has been already tested by using an app which could be easily incorporated to the EPR systems used by the EMS.[11]

An important finding in this study was that neurologist's judgement had a significantly higher sensitivity to identify LVO than the binary FAST-ED score. In many EMS and hospital systems, the ambulance crews have possibility to consult a neurologist via telephone to receive confirmation for the line of treatment, transport destination or urgency of transport. In this study setting, the neurologist is also able to see the prehospital patient report on computer screen while speaking on the phone. Since unnecessary telephone consultations have been shown to prolong the on-scene time and should be avoided,[19] a predefined FAST-ED score could be used as a cut-off for the neurologist's consultation, when direct transport to CSC instead of the PSC is considered. The neurologist can also access the patient's hospital records and provide additional information on treatment eligibility.

The strength of this study was the consecutive sample of suspected stroke patients in an EMS system with a long history and well-documented performance in acute stroke care. The EPR system ensured the high quality of data collection and low number of missing data. Limitations of the study included the FAST-ED scoring being based on prehospital reports, which were retrospectively assessed by two physician-trained investigators. Furthermore, the ambulance crews did not receive any additional training regarding LVO recognition, FAST-ED scale or patient examination, and some symptoms may therefore have been missed on examination or inadequately reported. This could lead to lower FAST-ED scores and lower sensitivity. Symptoms of BA occlusions are not typically covered by NIHSS or FAST-ED. However, we included this occlusion location in the LVO category because our approach was pragmatic with the intention to show all cases with LVO as it is in the real life seen by EMS. Furthermore, patients with BA occlusion represented only one per cent of the cohort and did not have an impact on the overall results of the study.

5 | CONCLUSION

The existing patient report data could be feasibly used to reconstruct FAST-ED scores to identify LVO without any additional training for the EMS personnel. The binary FAST-ED score had a moderate sensitivity and good specificity for prehospital LVO identification. However, the FAST-ED was surpassed by neurologist's clinical judgement which further improved the sensitivity of identification.

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CONFLICT OF INTEREST

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AUTHOR CONTRIBUTION

T.P; M.K. and D.S. researched literature and conceived the study. T.P. and M.K. collected the study data. P.V. evaluated CTA imaging results, and J.K. searched the patients' final diagnoses for the study. T.P. and D.S. were responsible for data analysis. T.P. wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

INFORMED CONSENT

Written informed consent was not required due to the register-based nature of the data.

ETHICAL APPROVAL

Ethical review board approval was not required due to the register-based and retrospective nature of the study. Guarantor: D.S.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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