# Less is more - The Finnish Prehospital Stroke Scale prospective validation

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*Objectives:* The current bifurcation of the acute stroke care pathway requires prehospital separation of strokes caused by large vessel occlusion. The first four binary items of the Finnish Prehospital Stroke Scale (FPSS) identify stroke in general, while the fifth binary item alone identifies stroke due to large vessel occlusion. The straightforward design is both easy for paramedics and statistically beneficial. We implemented FPSS based Western Finland Stroke Triage Plan, including medical districts of a comprehensive stroke center and four primary stroke centers. *Patients and Methods:* The prospective study population was consecutive recanalization candidates transported to the comprehensive stroke center within the first six months of implementing the stroke triage plan. Cohort 1 consisted of n=302 thrombolysis- or endovascular treatment candidates transported from the comprehensive stroke center hospital district. Cohort 2 comprised ten endovascular treatment candidates transferred directly to the comprehensive stroke center from the medical districts of four primary stroke centers. *Results:* In Cohort 1, FPSS sensitivity for large vessel occlusion was 0.66, specificity 0.94, positive predictive value 0.70, and negative predictive value 0.93. Of the ten Cohort 2 patients, nine had large vessel occlusion, and one had an intracerebral hemorrhage. *Conclusions:* FPSS is straightforward enough to be implemented in primary care services to identify candidates for endovascular treatment and thrombolysis. When used by paramedics, it predicted two-thirds of large vessel occlusions with the highest specificity and positive predictive value reported to date.

**KEYWORDS:** stroke—triage—paramedics—large vessel occlusion



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## INTRODUCTION

Stroke triage is the logistics of achieving the shortest possible delay from symptom onset to recanalization (OTR), determining a favorable prognosis[1]. Today's triage is more demanding than ever, as the anatomical location of the thrombus determines the geographical location of the center capable of recanalization. About 30% of ischemic strokes are large vessel occlusions (LVO)[2]. Bypassing the nearest stroke center and transferring the LVO patient directly to a comprehensive stroke center (CSC) capable of endovascular treatment (EVT) often shortens the OTR significantly[3]. As mobile stroke units are not widely used, prehospital LVO identification is based on paramedics' clinical algorithms called LVO scores[4,5].

In a prehospital setting, the score must be simple. When the incidence rate of LVO of 25/100 000/year is related to the number of paramedics serving the CSC population in t his study, an individual paramedic encounters an LVO patient on average every 19 months[6]. In about ten minutes, paramedics must identify and correct life-threatening conditions other than stroke and gather critical information from an unstable patient or confused bystanders. In this rare, brief, and intensive encounter, the score must answer the question, "Is the patient having a stroke - and if so, is it a LVO stroke?"

For triage, the score must be accurate[7,8]. The LVO scores published so far are typically sensitive, i.e., they detect LVO well. In contrast, insufficient specificity is a common problem, i.e., only a small proportion of cases identified as LVOs are indeed LVOs. This is reflected in a low positive predictive value (PPV), reported, for example, in two Dutch prospective observational studies[9,10]. PPVs of eight LVO scores in the first study ranged from 0.3 to 0.4, and seven in the second study from 0.21 to 0.32. Thus, the probability of false LVO predictions per score in the first study varied from 60-70% and in the second study from 68-79%, implying the likelihoods of unjustified mothership path transfers[11]. The challenge is to get good sensitivity to go hand in hand with specificity so that the PPV is likely, clearly above 0.5[12,13].

In 1868, Jean Louis Prévost reported that horizontal conjugate eye deviation (CED), opposite to severe hemiparesis, predicts a widespread hemisphere stroke[14]. Later, Singer proved the "Prévost's sign" high association with anterior circulation LVO and severe hemiparesis[15]. Of the items of the National Institutes of Health Stroke Scale (NIHSS), "Best Gaze" incorporating CED best predicts LVO[16-19]. However, as the "Best Gaze" discards the CED direction and contains a one-eye deviation, NIHSS-based cohorts do not capture the accuracy of the Prévost's sign in LVO prediction. (https://www.stroke.nih.gov/documents/NIH_Stroke_Scale_508C.pdf, last accessed Jul 24, 2022). Following the discoveries of Prévost and Singer, the Finnish Prehospital Stroke Scale (FPSS) is built on two assumptions. First, the CED away from the limb paresis sufficiently identifies the LVO. Secondly, as limb paresis in this context is practically a severe hemiparesis[15], it is not necessary to prove motor severity. So, FPSS predicts the EVT candidate based solely on "Gaze," CED away from any unilateral limb weakness. In the absence of the Gaze, the rest binary items, Face, Extremity, Speech, or Vision, are released to identify the IVT candidate[19], Table 1.

The purpose of this prospective study was to compare the applicability and statistical performance of the FPSS with those LVO scores that have been first implemented in emergency care and, after that, prospectively evaluated, M-DIRECT[20], FACE$_2$AD[21], RACE[22,23], FAST PLUS Test[24] and LAMS[25]. We excluded one score because most ischemic strokes in its study cohort were classified as LVO, making the results non-comparable[26].

## PATIENTS AND METHODS

The ethics committee of Tampere University Hospital approved this study (ETL R18010).

### *Training of paramedics*

The study period was from Jan 1 to Jun 30, 2018. The previous year, paramedics attended two 45-minute training sessions on using FPSS. Since 2004, paramedics have used the first four FPSS items to identify IVT candidates. Only Gaze, the conjugate horizontal eye deviation opposite limb weakness, was new. Forced Gaze, often accompanied by turning the head in the same direction, is an easily detectable symptom. Partial Gaze is verified by asking the patient (or encouraging the aphasic patient) to

**Table 1.** *The Finnish Prehospital Stroke Scale (FPSS)*

| | | points |
|---|---|---|
| Face | Facial droop | 1 |
| Extremity | Weakness in one or more extremities, including grip | 1 |
| Speech | Difficulty in producing or understanding speech, slurred speech, or mute | 1 |
| Vision | Field cut, blindness, or double vision | 1 |
| Gaze | Forced or partial gaze or head deviation opposite to arm or leg weakness | 4 |
| Total score | 1-8 | |

1-4 = IVT candidate, intravenous thrombolysis candidate
5-8 = EVT candidate, endovascular treatment candidate

follow a horizontally moving object (e.g., a pen or penlight). In this case, Gaze is positive if the patient cannot move eyes across the midline to the side of limb paresis. The training included a 2.5-minute video on performing the FPSS (https://dreambroker.com/channel/f1rltzde/if5ncljy), last accessed Jun 4, 2022). Paramedics were provided with a form that included the FPSS (Figure 1), instructions for its use, the phone numbers of on-call physicians involved in the triage plan, and a link to the above training video.

### *Patients*

The study population was consecutive recanalization candidates transported to the CSC (Tampere University Hospital) during the study period as either IVT or EVT candidates, according to the FPSS. The time window was 6 hours from symptom onset or unknown. Patients formed two cohorts according to the transport route.

Cohort 1 comprised patients of the CSC hospital district with a population of 535 000 served by 460 paramedics. After examining the patient and determining the FPSS, paramedics issued a pre-notification to the CSC neurologist on call (neurologist or physician specializing in neurology), who reviewed the patient's digital medical record for contraindications to recanalization therapy (e.g., severe dementia, significantly reduced life expectancy due to malignant disease). If there were no contraindications, the CSC on-call neurologist confirmed the transport code as a candidate for IVT or EVT, according to the FPSS. Of the n=319 patients initially transported, we excluded 17 patients because they did not undergo computed tomography angiography (CTA) due to, for example, severe renal impairment or contrast agent allergy and concomitant large irreversible infarction, where the harm to the patient would have outweighed the benefits. The final cohort size was n=302.

Cohort 2 consisted of n=10 EVT candidates transported via the mothership pathway from the hospital districts of PSCs (South Ostrobothnia Central Hospital, distance from the CSC 180 km, 193 000 inhabitants; Tavastia Central Hospital, 80, 171 000; Satakunta Central Hospital, 112, 217 000; Central Finland Central Hospital, 150, 253 000). If the FPSS predicted LVO and the transfer delay to the CSC was less than 45 minutes longer than the PSC, the PSC paramedics notified the CSC neurologist on call. After that, the procedure continued as in Cohort 1. There were no patient exclusions in Cohort 2.

Upon the arrival of the recanalization candidate, the physician performed the NIHS scoring. Patients underwent computed tomography (CT) of the brain and computed tomography angiography (CTA) of the cervical and

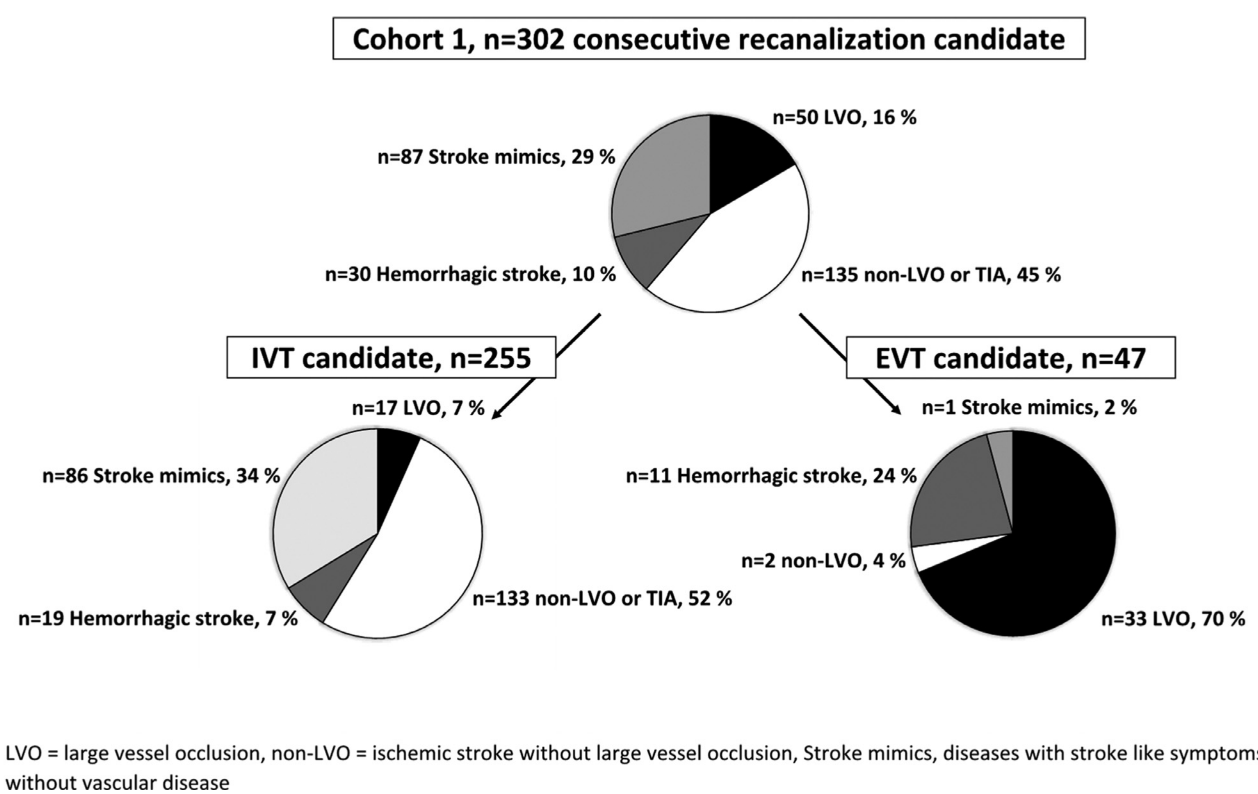


**Figure 1.** *Cohort 1 recanalization candidates and their crude diagnoses before- and after allocation by FPSS to intravenous thrombolysis (IVT) and endovascular treatment (EVT) candidates*

cerebral arteries. We defined LVO as a symptomatic occlusion with no antegrade flow past the occlusion site according to The Thrombolysis In Cerebral Infarction scale (TICI) 0[27]. We included occlusions of the internal carotid artery (ICA), the inner carotid artery terminus (ICA-T), the first (M1) and second (M2) segments of the middle cerebral artery, the first segment of the anterior cerebral artery (A1) and the basilar artery (BA). Ischemic strokes with arterial thrombosis more distal than LVOs were non-LVOs.

### *Determining the accuracy of the FPSS*

We correlated FPSS-based recanalization candidate transfer codes as IVT or EVT candidates with discharge diagnoses (LVO, non-LVO, hemorrhagic strokes, or stroke mimics), stroke severity (NIHSS), and LVO location.

### *Statistical analysis*

We used R (Core Team 2019, R: A language and environment for statistical computing R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/). We performed between-group statistical analyses using Pearson's Chi-square test, Fischer's exact test, or Wilcoxon's T-test, as indicated for dichotomous or continuous variables.

## RESULTS

Cohort 1, n=302 patients transported to the comprehensive stroke center from its own hospital district.

Table 2 shows patient characteristics, median NIHS scores, and discharge diagnoses. Of the ischemic strokes, 27% were LVOs. The table legends show the crude diagnoses of the stroke mimics. The table also includes n=10 mothership path patients from the four PSCs.

The FPSS sensitivity for LVO (ICA, A1, M1, M2, BA) was 0.66, specificity of 0.94, PPV of 0.70, NPV of 0.93 (CI 95%), and accuracy of 0.90. We also determined the test characteristics and clinical relevance for arterial occlusion distribution ICA, M1, or M2. Sensitivity was 0.67, specificity of 0.94, PPV of 0.70, NPV of 0.94, and accuracy of 0.90.

Table 3 presents the outcomes of the FPSS in relation to discharge diagnoses and NIHS scores. The majority of FPSS true positive LVOs were M1 thrombi. The FPSS false positives were mainly hemorrhagic strokes. There was no significant difference between the high NIHSS scores of FPSS true positive and false positive patients, but the NIHSS difference was significant between FPSS true positive and true negative patients.

Figure 1 shows the distribution of patients' diagnoses after FPSS-based prehospital separation into IVT and EVT candidates. The grand majority of EVT candidates had a LVO. Hemorrhagic strokes were second. Only a tiny proportion of EVT candidates were non-LVO- or stroke mimics.

Table 4 compares the characteristics and statistical performance of the FPSS with prospectively evaluated LVO scores. The definition of LVO and the rejection rate of cohorts vary considerably between studies. FPSS is the only one where only one item determines the EVT candidate. FPSS has superior specificity and PPV, while compared scores are more sensitive than FPSS.

**Table 2.** *Characteristics of n=302 patients transported to CSC based on FPSS as EVT- or IVT candidates*

| Cohort 1, n = 302 patients transported from CSC hospital district to CSC | | | | | | |
|---|---|---|---|---|---|---|
| | n=185 ischemic stroke | | n=30 hemorrhagic stroke | | | Stroke mimics* |
| - | LVO | non-LVO or TIA | Deep ICH | Lobar ICH | SAH | |
| n | 50 | 135 | 20 | 6 | 4 | 87 |
| Age, median (IQR) | 77(74-80) | 79(73-85) | 70(60-78) | 79(60-87) | 71(48-73) | 59(50-71) |
| NIHSS, median (IQR) | 17(13-21) | 4(3-7) | 14(8-24) | 9(4-17) | 3(1-4) | 2(1-4) |
| OTD (min), median (IQR) | 70(55-147) | 87(56-158) | 110(51-313) | 42(17-102) | 40(24-165) | 57(51-90) |
| **Cohort 2, n=10 Mothership pathway patients transported from PSCs hospital districts directly to CSC as EVT candidates** | | | | | | |
| - | LVO | - | Deep ICH | - | - | - |
| n | 9 | - | 1 | - | - | - |
| Age, median (IQR) | 67(64-75) | - | 75 | - | - | - |
| NIHSS, median (IQR) | 18(8-20) | - | 18 | - | - | - |
| OTD (min), median (IQR) | 147(112-294) | - | 224 | - | - | - |

CSC, comprehensive stroke center; PSC, primary stroke center; FPSS, Finnish Prehospital Stroke Scale; EVT, endovascular treatment; IVT, intravenous thrombolysis; LVO, large vessel occlusion; non-LVO, ischemic stroke without large vessel occlusion; TIA, transient ischemic attack; ICH, intracerebral hemorrhage; SAH, subarachnoid hemorrhage; NIHSS, National Institutes of Health Stroke Scale; OTD, time from symptom onset to hospital arrival; *Stroke mimics, diseases with stroke-like symptoms without vascular disease: n=20 seizure, n=12 migraine, n=11 intoxication or metabolic disturbance, n=9 functional symptom, n=8 exacerbation of an old symptom, n=7 cardiovascular disorder, n=5 subdural hemorrhage, n=5 infection, n=4 musculoskeletal symptom, n=3 neurodegenerative disease, n=2 peripheral facial paresis, n=1 ocular symptom.

**Table 3.** *Cohort 1 FPSS outcomes related to diagnoses and NIHSS (n=302)*

**Table 3. Cohort 1 FPSS outcomes related to diagnoses and NIHSS (n=302)**

| FPSS | | | | NIHSS | |
|---|---|---|---|---|---|
| FPSS value | FPSS Outcome | LVO / else | n | Median (IQR) | Difference |
| FPSS 5-8 predicts LVO n=47 | True Positive FPSS correctly predicts LVO n=33 | M1 | 18 | 17 (14–22) | |
| | | M2 | 7 | | |
| | | ICA-T | 3 | | |
| | | ICA-tandem | 3 | | |
| | | ICA | 1 | | |
| | | BA | 1 | | |
| | False Positive FPSS incorrectly predicts LVO n=14 | Deep ICH | 9 | 17 (11–22) | P=0.96, NS |
| | | Lobar ICH | 2 | | |
| | | non-LVO | 2 | | |
| | | Mimics | 1 | | |
| FPSS 1-4 predicts non-LVO n=255 | False Negative FPSS misses LVO n=17 | M2 | 5 | 15 (11–22) | P=0.34, NS |
| | | M1 | 4 | | |
| | | ICA-T | 3 | | |
| | | ICA-tandem | 2 | | |
| | | ICA | 1 | | |
| | | BA | 1 | | |
| | | A1 | 1 | | |
| | True Negative FPSS correctly predicts not LVO n=238 | non-LVO | 133 | 4 (1–5) | P=0.00, S |
| | | ICH or SAH | 19 | | |
| | | Mimics | 86 | | |

FPSS, Finnish Prehospital Stroke Scale; NIHSS, National Institutes of Health Stroke Scale; LVO, large vessel occlusion; non-LVO, ischemic stroke without large vessel occlusion, M1, LVO of the first segment of the middle cerebral artery; M2, the second segment; ICA, internal carotid; ICA-T, internal carotid artery terminus; ICA-tandem, ICA and M1 or M2; BA, basilar artery; A1, the first segment of the anterior cerebral artery; non-LVO, ischemic stroke without large vessel occlusion; ICH, intracerebral hemorrhage; SAH subarachnoid hemorrhage; Mimics, stroke mimics, diseases with stroke-like symptoms without vascular disease; Difference, Wilcoxon significance tests between NIHS scores of FPSS outcomes; NS, nonsignificant; S, significant.

*Cohort 2*

Table 2 shows the characteristics, median NIHS scores, and discharge diagnoses of the n=10 mothership pathway EVT candidates. N=9 patients had LVO; one ICA, two ICA-T, five M1, and one M2 occlusion. One patient had a deep ICH.

**Table 4.** *FPSS compared with prospectively evaluated LVO scales*

| LVO-Score | FPSS | M-DIRECT[20] | $FACE_2AD$[21] | RACE[22] | RACE rev.[23] | FAST PLUS Test[24] | LAMS[25] |
|---|---|---|---|---|---|---|---|
| Score items | CED | motor severity, CED, aphasia, neglect, AGE, Bp | motor face, motor arm consciousness, CED, AF, Bp | motor severity, CED, agnosia, aphasia | | motor severity | motor severity |
| No of items | 5 | 6 | 6 | 6 | | 6 | 5 |
| No items predicting LVO | 1 | 6 | 6 | 6 | | 6 | 5 |
| All Items in binary form | + | - | + | - | | - | - |
| CED direction defined | + | - | - | - | | NA | NA |
| Cohort / Rejection rate | | | | | | | |
| Original cohort / Rejected subjects (n) | 319/17 | 564/23 | 787/285 | 2635/996 | 2378/556 | 899/464 | 2930/1807 |
| -rejection rate | 5 % | 4 % | 36 % | 38 % | 23 % | 52 % | 62 % |
| Study cohort after rejections (n) | 302 | 541 | 502 | 1639 | 1822 | 435 | 1123 |
| Statistical performance | | | | | | | |
| LVO definition | ICA, M1, M2, A1, BA | ICA, M1 | ICA, M1, M2, BA | ICA, M1, M2, M3, BA | ICA, M1 | ICA, M1, M2, BA | M1, BA |
| Sensitivity | 0.66 | 0.79 | 0.85 | 0.77 | 0.84 | 0.85 | 0.69 |
| Specificity | 0.94 | 0.82 | 0.80 | 0.75 | 0.60 | 0.80 | 0.85 |
| PPV | 0.70 | 0.53 | 0.39 | 0.25 | 0.35 | 0.39 | 0.29 |
| NPV | 0.93 | 0.94 | 0.97 | 0.77 | 0.94 | 0.97 | 0.97 |
| Accuracy | 0.90 | NA | NA | 0.75 | NA | 0.75 | NA |

FPSS, Finnish Prehospital Stroke Scale; LVO, large vessel occlusion; LVO scale, clinical tool for paramedics for LVO prediction; M-DIRECT, Madrid-Direct Referral to Endovascular Center; $FACE_2AD$, Field Assessment of Critical Stroke by Emergency Services for Acute Delivery to a Comprehensive Stroke Center; RACE, The Rapid Arterial oCclusion Evaluation; RACE rev., revalidation of the RACE; FAST PLUS Test, The first part is the Face Arm Speech Time -test (FAST) for stroke recognition, the second part evaluates the presence of motor severity i.e. severe arm or leg motor deficit; LAMS, Los Angeles Motor Scale; CED, conjugate horizontal eye deviation; CED direction defined, score defines CED opposite motor paresis; Consciousness, cannot say their name; AF, atrial fibrillation; Bp, blood pressure; Statistical performance, statistics reported in the original prospective studies; Original cohort, number of all patients initially included in the cohort; Rejected subjects, number patients excluded from the Original cohort due to missing data; Rejection rate, percentage of the patients rejected from the Original cohort; ICA, internal carotid artery; M1, the first segment of the medial cerebral artery; M2, the second segment of the medial cerebral artery; M3, the third segment of the medial cerebral artery; A1, the first segment of the anterior cerebral artery; BA, basilar artery; PPV, positive predictive value; NPV, negative predictive value.

## DISCUSSION

Despite the publication of dozens of LVO scores, their established use in regional stroke triage plans has not made a breakthrough. A likely reason is a dilemma between the score simplicity needed by paramedics and the accuracy required by triage.

Comparing FPSS with other scores, high sensitivity is associated with low specificity and vice versa. All are more sensitive than FPSS. However, except for M-Direct, their low specificities result in PPVs below 0.5, implying that most predicted LVOs are not LVOs. PSC bypasses based on an unlikely LVO would prevent timely IVT initiations for non-LVO patients, waste transfer resources, and congest the CSC. Moreover, in the long run, low efficiency is likely to demotivate the staff involved in the triage plan in both PSCs and CSC.

Most compared scores exploit several items, such as motor severity, aphasia, neglect, agnosia, CED, atrial fibrillation, age, or blood pressure. Although they cover a wide range of findings, they are not clearly more accurate than the simple Fast Plus Test and LAMS based solely on non-specific motor severity. The explanation is likely due to the way the items are combined. The scores add up the numerical values of the items so that different item combinations can reach a cut-off value that predicts LVO. Hence the combination follows the "OR" rule[28]. According to the OR, the combined sensitivity is higher than the sensitivities of the individual items. In contrast, the combined specificity decreases compared to the item specificities, reflected in the lower specificity and PPV of the score. Varying the cut-off value emphasizes either sensitivity or specificity but does not correct the imbalance between them.

FPSS differs from other LVO scores because only one binary symptom, Gaze, predicts LVO. Therefore, it cannot compete in sensitivity with scores that combine multiple symptoms according to the "OR" rule. As a trade-off, FPSS instead retains the high specificity of Gaze as such, followed by a superior PPV. Although the FPSS excludes motor scoring, it indirectly identified motor severity, reflected in the high NIHS scores of true and false positives. In addition, most false positives were hemorrhagic stroke patients, who may benefit from direct transport to the CSC. Consistently, only 2% of EVT candidates were non-LVOs, and 1% were stroke mimics for whom the mothership pathway is potentially harmful. The benefit of CED direction was evident in four seizure patients with no apparent jerking but an incorrect CED toward abnormal limb function, which is why paramedics did not consider them EVT candidates[29]. The diagnostic distribution of the ten mothership path patients in Cohort 2 was similar to that of Cohort 1.

Paramedics understand the FPSS with common sense: "Test face, limbs, speech and vision to find an IVT candidate and test forced and partial Gaze to find an EVT candidate." Because the result is immediately evident, paramedics' precious minutes are not wasted on calculation or filling in flow charts. Instead, they pre-notify the physician on duty, perform the mandatory scene routines, initiate transport, and often only fill in the FPSS form en route.

This study had limitations. We could not fully demonstrate the amount of training required for field implementation because, before the study period, physicians on call occasionally inquired about Gaze during pre-notifications. The comparison of prospectively estimated LVO scores is approximate due to differences in cohorts and LVO definitions. Still, the main lines can be outlined. The study's strength is the low proportion of patients rejected due to missing data, 5% in Cohort 1 and nil in Cohort 2, substantially lower than the 23-62% of five scores in comparison.

## CONCLUSIONS

FPSS solves the dilemma of simultaneous simplicity and accuracy by exploiting a single symptom, Prévost's sign, to predict LVO. As the remaining four binary symptoms are for identifying stroke in general, the FPSS quickly answers the paramedics' question, "Is the patient having a stroke - and if so, is it a LVO stroke?" In the first six months, FPSS predicted two-thirds of LVOs, with a positive predictive value in a class of its own. It is, therefore, the first score that truly picks out the LVOs from the flow of recanalization candidates. We will continue to report on the impact of the FPSS-based Western Finland Stroke Triage Plan on recanalization delays and treatment outcomes.

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