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Prehospital identification of acute ischaemic stroke with large vessel occlusion: a retrospective study from western Norway

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ABSTRACT

Background In 2019, the emergency medical services (EMS) covering the western Norway Regional Health Authority area implemented its version of the prehospital clinical criteria G-FAST (Gaze deviation, Facial palsy, Arm weakness, Visual loss, Speech disturbance) to detect acute ischaemic stroke (AIS) with large vessel occlusion (LVO). For patients with gaze deviation and at least one other G-FAST symptom, a primary stroke centre (PSC) may be bypassed and the patient taken directly to a comprehensive stroke centre (CSC) for rapid endovascular treatment (EVT) evaluation. The study aim was to investigate the efficacy of the G-FAST criteria for LVO patient selection and direct transfer to a CSC.

Methods This retrospective study included patients with code-red emergency medical communication centre (EMCC) stroke suspicion ambulance dispatch between August to December 2020. Stroke suspicion was defined as having at least one G-FAST symptom at EMS arrival. We obtained patient data from dispatches from EMCCs, EMS records and local EVT registries. Clinical features, CT images, and reperfusion treatment were recorded. The test characteristics for gaze deviation plus one other G-FAST symptom in detecting LVO were determined.

Results Among 643 patients, 59 were diagnosed with LVO at hospital arrival. In this group, seven fulfilled the G-FAST criteria for direct transport to a CSC at EMS arrival on scene, resulting in a sensitivity of 12% (95% CI 5% to 23%). The specificity was 99.66% (95% CI 98.77% to 99.96%), the positive predictive value 78%, and the negative predictive value 92%. EVT was performed in 64% (38/59) of LVO cases. Median time from PSC arrival to start of EVT at a CSC was 163 min.

Conclusion The use of local G-FAST prehospital criteria by EMS personnel to identify patients with AIS with LVO is not suitable for selection of patients with LVO for direct transfer to a CSC.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Prehospital clinical criteria for the detection of patients with suspected large vessel occlusion (LVO) are widely used and implemented by the emergency medical services (EMS) in densely populated areas.
⇒ Direct transport to a stroke centre offering endovascular treatment is expected to reduce time from symptom onset to vessel reperfusion.
⇒ However, very few studies have validated gaze deviation in combination with one other Gaze deviation, Facial palsy, Arm weakness, Visual loss, Speech disturbance symptom as a predictor for LVO in the EMS, or the use of such clinical criteria in a rural area with low population density.

WHAT THIS STUDY ADDS

⇒ In this retrospective registry-based study in a rural area in Norway, the combination of gaze deviation and facial paralysis, arm weakness, visual loss or speech disturbance is not a suitable marker for LVO stroke in the EMS.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The study highlights the need to improve current practice in our health region and may contribute to developing more optimal clinical criteria for LVO stroke identification.

BACKGROUND

Stroke is one of the leading causes of death and disability.[1] For patients who suffer acute ischaemic stroke (AIS) with large vessel occlusion (LVO), the risk of disability and death is particularly high.[1 2] Endovascular treatment (EVT) is the gold standard therapy for LVO stroke, with a number needed to treat as low as 2.6.[3] Rapid patient triage, diagnosis and treatment are crucial for a favourable patient outcome, as the effect of EVT decreases dramatically over time.[4 5] Patients with suspected stroke are usually transported to the nearest hospital for initial diagnosis and rapid administration of intravenous thrombolysis in eligible cases. Most hospitals offer treatment with intravenous thrombolysis and are defined as primary stroke centres (PSCs). In case of LVO, intravenous thrombolysis alone frequently is not effective as reperfusion therapy. These patients need LVO-specific EVT, offered at regional hospitals defined as comprehensive stroke centres (CSCs). Patients with LVO admitted to a PSC are therefore transferred to the nearest CSC.

Prehospital stroke scales have been developed for LVO identification by the emergency medical service (EMS), to expedite patients routing directly to a CSC and reducing symptom onset-to-groin time.[6] Most prehospital stroke scales are simplified variations of common stroke symptom examinations based on the National Institutes of Health Stroke Scale (NIHSS).[7 8] In 2019, the EMS in western

Norway implemented the Gaze deviation, Facial palsy, Arm weakness, Visual loss, Speech disturbance (G-FAST) prehospital criteria, assessing the presence of gaze deviation, facial palsy, arm weakness, visual loss and speech disturbance. The combination of gaze deviation and at least one other G-FAST symptom indicates suspicion for LVO, qualifying for direct patient routing to a CSC by ambulance or air ambulance, as long as transport time is not prolonged by more than 30 min compared with PSC admission.[9] Evidence is limited for the use of gaze deviation, combined with at least one other G-FAST symptom, as the criteria for prehospital identification of LVO. Thus, the aim of this study was to investigate the efficacy of the G-FAST criteria for LVO patient selection and direct transfer to a CSC.

METHODS

Study design

This retrospective study used patient data from a registry of all code-red stroke dispatches from the emergency medical communication centres (EMCCs) in western Norway between August and December 2020. The first author (NL) abstracted the data independently.

Included patients received an information letter with the possibility to decline study participation before the start.

Setting

The western Norway health region covers Vestland and Rogaland counties, an area of 43 000 km^2 with approximately 1.1 million inhabitants, eight PSCs providing intravenous thrombolysis, and two CSCs providing both intravenous thrombolysis and EVT. Transport distances between PSCs and CSCs are in general large (median 120 km, range 1–278 km), except from the city of Bergen, where one PSC is located close (1 km) to a CSC.

Four EMCCs dispatch 92 ambulances and five physician-staffed air ambulances. Nurses and ambulance coordinators in the EMCCs are responsible for medical evaluation and advice, along with dispatch and coordination of ambulances. Two paramedics with a bachelor's degree in paramedicine or nursing or a certificate of completed apprenticeship in ambulance service skills constitute the ambulance personnel.

Participants

We included patients over 18 years seen between August and December 2020 who were transported to a western Norwegian hospital with at least one G-FAST symptom, and where assessments of G-FAST were documented in an EMS on-scene report. Waver of consent was approved by the Regional Ethics Committee, but the participants received an information letter where they were given the possibility to actively decline study participation.

G-FAST prehospital criteria

The G-FAST criteria were introduced in 2019 to enable the potential for prehospital bypass of PSC for stroke patients with suspected LVO, facilitating direct transfer to a CSC. Patients with both gaze deviation and at least one other G-FAST symptom fulfil the prehospital criteria for LVO suspicion. Bypass of a PSC for patients with LVO suspicion is recommended if transport time is not prolonged by more than 30 min.

These criteria were introduced by the western Norway health authority and developed in cooperation among regional stroke neurologists and EMS physicians. They were presented at the regional EMS forum and then implemented in the medical operation manual. All EMS personnel received hands-on mandatory training in G-FAST examination at annual courses.

Prehospital procedures and definitions

A G-FAST prehospital clinical examination was routinely performed at on-scene ambulance arrival. Assessment of G-FAST by EMS included examination of gaze deviation, facial palsy, arm weakness, visual loss and speech disturbance. Only presence or absence of these symptoms were evaluated, no scoring of the severity of each symptom was performed.

Prehospital clinical examination by EMS personnel was compared with NIHSS examination performed in the ED by a physician.

In-hospital procedures and definitions

ED clinical findings, NIHSS score at initial hospital arrival, neuroimaging, reperfusion treatment data and patient diagnoses were abstracted from in-hospital medical records. For patients with LVO undergoing EVT, the NIHSS score at initial hospital arrival, door-to-groin time and intravenous thrombolysis treatment were collected from local EVT registries.

Immediately after ED admission, a non-enhanced CT, perfusion CT and CT angiography were performed, as indicated. MRI was used as the primary imaging tool for patients with unknown onset stroke or wake-up stroke.

LVO was defined as an occlusion in the intracranial internal carotid artery, the middle cerebral artery (M1 or M2), the anterior cerebral artery (A1 or A2) or the basilar artery. Tandem occlusion was defined as an occlusion involving the extracranial internal and intracranial carotid arteries or the internal carotid and middle cerebral arteries.

Time intervals and definitions

Time intervals were calculated from EMCC and hospital medical records. Prehospital care time was defined as the time from EMS arrival on-scene to first ED arrival, and transfer delay as the time from initial arrival at the PSC to arrival at the CSC. Median time from PSC arrival to start of EVT was defined as the time from arrival at the initial PSC to groin puncture at the CSC. In patients with LVO, door-to-groin time was defined as the time from arrival at the CSC to start (groin puncture) of the EVT.

Clinical groups

Based on radiological results and the results of clinical investigations in the ED, patients were classified into three groups: AIS, intracerebral haemorrhage or stroke mimics. Stroke mimics were defined by presentation with stroke-like symptoms, that later were associated with a non-stroke diagnosis after diagnostic workup.

Study outcomes

The primary outcome was the sensitivity and negative predictive value of the G-FAST prehospital clinical criteria in LVO detection as performed by EMS personnel on-scene (combined presence or absence of gaze deviation and one other G-FAST symptom). Secondary outcomes were positive predictive value, specificity and transfer delay for patients with LVO who first were admitted at a PSC.

Statistics

Comparison of group proportions was performed using Pearson's χ^2 test. The Mann-Whitney U test was applied to calculate differences in non-normally distributed continuous data. The

Table 1 Patient characteristics classified by diagnosis

	Acute ischaemic stroke n=273	Intracerebral haemorrhage n=38	Stroke mimics n=323
Median age, years (IQR)	77 (67–84)	73 (64–83)	74 (58–82)
Female sex, n (%)	132 (48)	18 (47)	149 (46)
Male sex, n (%)	141 (52)	20 (53)	174 (54)
Median prehospital care time, min (IQR)	33 (25–47)	33 (26–46)	36 (27–49)
Median NIHSS score at initial hospital arrival (IQR)	4 (2–8)	8 (3–14)	1 (0–1)
Admission directly to CSC, n (%)	164 (60)	21 (55)	199 (62)

CSC, comprehensive stroke centre; NIHSS, National Institutes of Health Stroke Scale; prehospital care time, time from on-scene arrival to hospital admission.

Kruskal-Wallis test was used to calculate differences between diagnosis groups. All statistical analyses were performed using IBM SPSS Statistics V.26 (IBM, Armonk, New York, USA). Sensitivity, specificity, positive predictive value and negative predictive value were presented with 95% CIs.

Patient and public involvement

A patient representative participated in developing the study design. The representative also participated in drafting the patient information letter.

RESULTS

There were 1681 patients with code-red stroke dispatches of whom 643 fulfilled the inclusion criteria: 273 (43 %) were diagnosed with AIS, 38 (6 %) with intracerebral haemorrhage and 323 (50 %) were classified as stroke mimics (table 1 and figure 1). Patient baseline variables by diagnostic group are presented in table 1. Patients with AIS were older than patients with intracerebral haemorrhage or stroke mimics. Stroke mimics had a lower NIHSS score at ED arrival (p<0.001). There were minor differences among groups between prehospital care time (respectively 33 min, 33 min and 36 min) and in the proportion of patients admitted directly to a CSC (respectively 60%, 55% and 62%). In the AIS group, 112 patients (41%) received intravenous thrombolysis, and 59 were diagnosed with LVO (22%). Intravenous thrombolysis was given in 29 patients with LVO (49%), and 38 patients with LVO (64%) received EVT.

Patients with LVO presented with a significantly higher median NIHSS score compared to AIS patients without LVO (12 vs 3; p<0.001) (table 2). The groups did not differ in any other baseline variables. More patients diagnosed with LVO than AIS without LVO were transported directly to a CSC (71% vs 57%, p=0.049).

Only seven (12%) out of all patients with LVO fulfilled prehospital G-FAST criteria (table 2, figure 1), of which three were directly admitted to a CSC. The seven patients with LVO fulfilling G-FAST criteria all presented with proximal vessel occlusions in the territory of the middle cerebral artery (one internal carotid artery occlusion and six middle cerebral artery occlusions). The presence of gaze deviation and at least one FAST symptom was confirmed at ED physician examination, presented in figure 1. Two patients with a final diagnosis of stroke mimic fulfilled the G-FAST prehospital criteria and were described as false-positive for LVO stroke.

Overall, sensitivity was 12% (95 % CI 5% to 23%), and negative predictive value was 92% (95% CI 89% to 94%). Study population data used for calculation and detailed test characteristics of the G-FAST prehospital criteria are presented in tables 3 and 4.

Compared to patients transferred from a PSC, patients with LVO directly admitted to a CSC presented with higher median NIHSS (NIHSS 13 vs NIHSS 5, p<0.01). Median door-to-groin time for EVT was 67 min. Patients transferred from a PSC had shorter door-to-groin time at the CSC (33 min (IQR 25–33) vs 74 min (IQR 64–112); p=0.003). For patients with LVO initially admitted to a PSC, the median time from PSC arrival to EVT (groin puncture) at CSC was 163 min (IQR 85–200). Comparison of patients by initial hospital admission is presented in table 5.

DISCUSSION

In this retrospective study, the prehospital G-FAST criteria for direct transfer to a CSC had a low sensitivity but a high specificity for predicting LVO. Most patients with LVO did not fulfil these criteria, and only three of seven patients who fulfilled the criteria were initially admitted to a CSC. Gaze deviation detection was similar between EMS personnel and ED physicians.

Most EMS have implemented a prehospital stroke scale instead of specific clinical criteria for identifying LVO. A prehospital stroke scale assesses the severity of each stroke symptom incorporated in the scale from 0 to 3 or 0 to 2. A cut-off value score above a certain threshold qualifies for LVO suspicion and direct transport to a CSC.[6] This is contradictory to our G-FAST prehospital criteria, which has a much more stringent definition of LVO suspicion where presence of gaze deviation is a mandatory symptom. Further, we do not grade symptom severity on an ordinal scale.

At least 19 different scoring schemes have been reported, all using different types of prehospital stroke scales.[10] Most prehospital stroke scales examine the same stroke symptoms as in our prehospital criteria. In prospective and retrospective studies, these types of scales have yielded a much higher sensitivity for LVO detection compared with our prehospital criteria, ranging from 61% to 95%.[10] Thus, in a prehospital stroke scale different types of symptom combinations and quantification of symptom severity may lead to prehospital LVO suspicion. This does not apply for our G-FAST prehospital criteria, and we believe this is the reason for the low sensitivity observed in our study.

The use of a prehospital stroke scale is expected to increase sensitivity because LVO patients with other neurological deficits, not incorporated in the G-FAST clinical criteria, may be identified to a higher degree and conveyed to a CSC.

In a recently published prospective study, the sensitivity and specificity of eight different prehospital stroke scales were compared with NIHSS physician examination at ED arrival. All eight prehospital stroke scales were inferior to NIHSS-based assessment.[11] The Rapid Arterial Occlusion Evaluation Scale, a different version of the G-FAST, and Conveniently-Grasped Field Assessment Stroke Triage performed best with respective areas under the curve of 0.83, 0.80 and 0.80 compared with 0.86 for NIHSS. In contrast to the other scales, these three included both cortical and FAST symptoms, which may explain the higher diagnostic accuracy.[11 12] This specific G-FAST prehospital stroke scale differs from our local prehospital G-FAST criteria by assessing gaze deviation and arm weakness, but not visual loss.

LVO has previously been found to be related to baseline NIHSS scores of more than 8–10 in approximately 80% of patients, especially in anterior circulation strokes and shortly

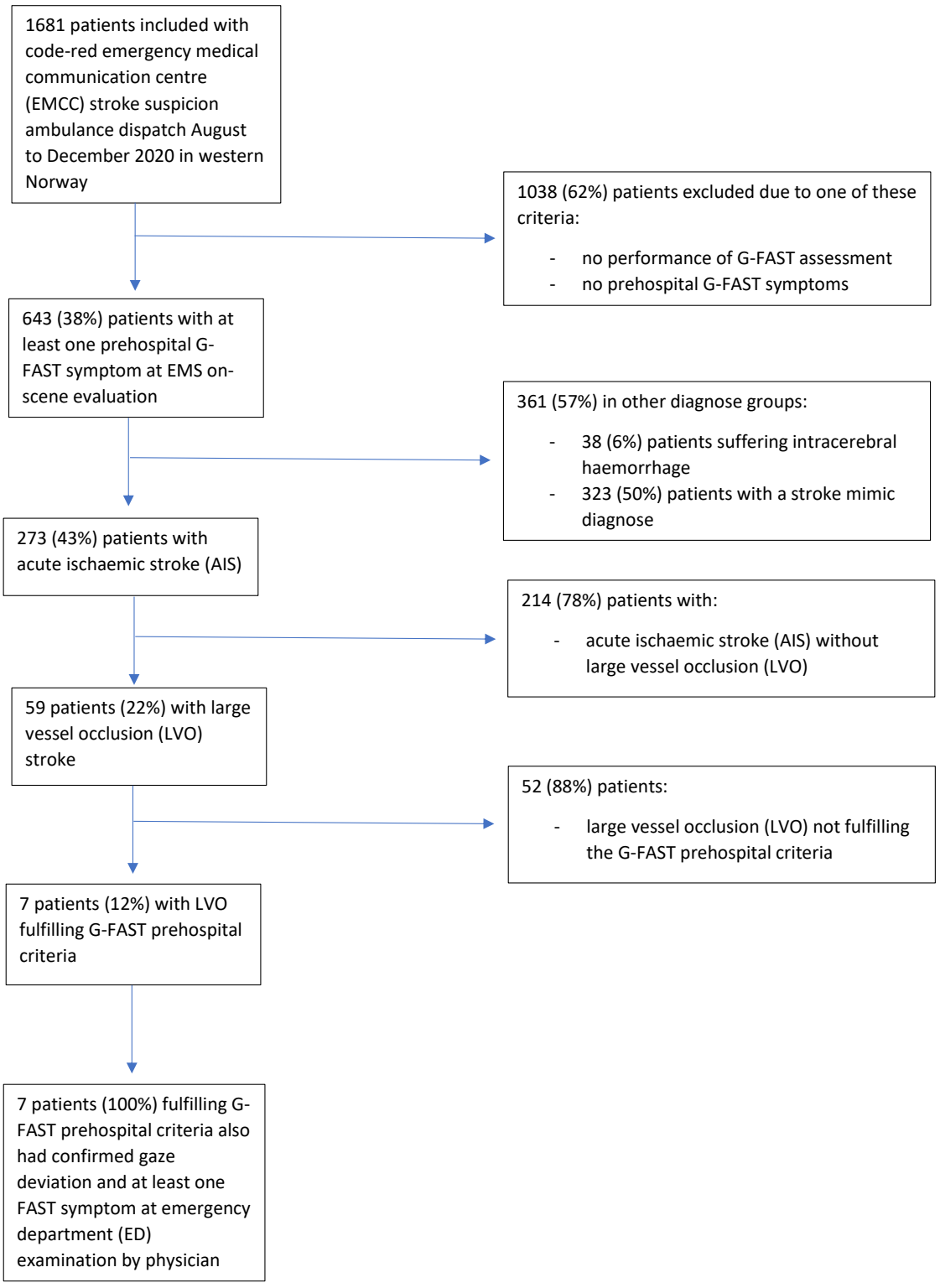

Figure 1 Flow chart presenting study population by diagnosis after ED assessment including imaging. For the AIS group, proportion of patients with LVO is presented, including the proportion of patients fulfilling G-FAST prehospital criteria for LVO stroke suspicion. Fulfilled G-FAST criteria demanded presence of gaze deviation, and at least one of the following symptoms present: facial palsy, arm weakness, visual loss and speech difficulties. EMS, emergency medical service; G-FAST, Gaze deviation, Facial palsy, Arm weakness, Visual loss, Speech disturbance.

Table 2 Characteristics of patients with acute ischaemic stroke with and without LVO

	LVO stroke n=59	Non-LVO stroke n=214	P value
Median NIHSS score at CSC arrival (IQR)	12 (5–20)	3 (1–5)	p<0.01
Age, years (IQR)	78 (67–84)	76 (66–83)	p=0.77
Female sex, n (%)	25 (42)	107 (50)	p=0.32
Intravenous thrombolysis treatment, n (%)	29 (49)	83 (39)	p=0.15
EVT, n (%)	38 (64)		n.a.
Patients directly transported to CSC, n (%)	42 (71)	122 (57)	p=0.049

Fulfilled G-FAST prehospital criteria: combined presence of gaze deviation (G) and one FAST symptom at EMS arrival
CSC, comprehensive stroke centre; EMS, emergency medical service; EVT, endovascular treatment; G-FAST, Gaze deviation, Facial palsy, Arm weakness, Visual loss, Speech disturbance; LVO, large vessel occlusion; NIHSS, National Institutes of Health Stroke Scale.

after symptom onset.[13] Implementing NIHSS in prehospital care thus may improve LVO identification and streamline the communication between prehospital and in-hospital staff. Prehospital stroke scales are all simplified versions of the NIHSS, and the NIHSS score is related to LVO, particularly in anterior circulation strokes, making it a valuable tool for LVO assessment.[14] Applying NIHSS cut-offs for increasing LVO identification is worth considering, and a trial is currently underway to investigate this use of NIHSS by trained paramedics in the EMS.[15]

We found lower median NIHSS scores for patients with LVO initially admitted to a PSC compared with scores for patients admitted directly to a CSC. A low NIHSS score during stroke assessment is a known diagnostic challenge, as some LVOs may involve limited clinical features because of well-developed collateral circulation, subtotal occlusion or intermittent partial reperfusion.[13] This pattern emphasises the difficulty in defining LVO presence based only on clinical symptoms and the necessity of implementing neuroimaging in EMS.[16]

Median time from arrival at the PSC to start of EVT at the CSC was 163 min, indicating that delay in transfer results in treatment delay for patients with LVO. Their median door-to-groin time at CSC was 41 min shorter due to prenotification of the CSC stroke team, completed acute diagnostics at the PSC and the direct transfer to the endovascular intervention suite at the CSC in most cases. However, if these patients were identified prehospitally as LVO and transported directly to a CSC, the onset-to-groin puncture time might still have been lower.

In registry-based studies, interhospital transfer of patients with LVO has been associated with EVT delay and worse outcomes.[17–19] However, a recent randomised controlled trial conducted in Spain found no benefit for patients with LVO who underwent PSC bypass and proceeded directly to a CSC.[20] Longer extensions of transport were allowed in that study, compared with maximum 30 min transfer delay to a CSC in our study. Both the current study and registry-based studies with the opposite findings need to be interpreted with caution. Generalisability to other settings is limited because of the large distances in the involved health region. Distances between PSCs and the nearest CSC are long, and bypassing the PSC may prolong onset-to-needle time in patients eligible for intravenous thrombolysis treatment, especially if the patient for any reason cannot be transported immediately, for example, by air ambulance. In Bergen, local data show improved EVT time metrics for patients admitted directly to a CSC (data not shown), and for patients with LVO, direct transport will most likely be beneficial when an air ambulance is available.

Our study has several limitations. The retrospective data collection from a real-life setting in a large geographical area did not provide complete data on prehospital patient evaluation. Further, it was not possible to obtain complete data for direct dispatch selection to a CSC, or to guarantee the stringent use of the involved prehospital G-FAST criteria algorithm by all EMS staff during the study period. The EMS records only included the patient's home address, not the pick-up address. As a result, we cannot accurately determine the nearest hospital to the pick-up location, or whether the patient was bypassed directly to a CSC hospital. However, we believe that the differences in pick-up location did not have a significant impact on the hospital choice, because there are only a few PSCs with large distances in between, and only two CSCs available in our region.

Our study also included a low number of patients with LVO. Finally, documentation regarding flight weather conditions and air ambulance availability were not available, factors that may have influenced primary admission to a PSC in some cases, even if patients possibly met the prehospital G-FAST criteria.

The use of the current local G-FAST prehospital criteria by EMS personnel for identification of AIS patients with LVO is not suitable for LVO patient selection for direct transfer to a CSC. Implementing a systematic scoring scale in prehospital stroke assessment may further improve LVO detection and patient selection for direct transfers. Further research is needed to improve the accuracy of prehospital detection of LVO and

Table 4 G-FAST prehospital criteria test characteristics

Sensitivity (95% CI)	12% (5%–23%)
Specificity (95% CI)	99.66% (98.77%–99.96%)
Positive predictive value (95% CI)	78% (40%–97%)
Negative predictive value (95% CI)	92% (89%–94%)

Presentation of G-FAST prehospital criteria test characteristics. G-FAST prehospital assessment included presence of gaze deviation, facial palsy, arm weakness, visual loss and speech difficulties. Patients with both gaze deviation and at least one other G-FAST symptom fulfilled the prehospital criteria for LVO suspicion.
G-FAST, Gaze deviation, Facial palsy, Arm weakness, Visual loss, Speech disturbance; LVO, large vessel occlusion.

Table 3 2×2 cross-table G-FAST prehospital criteria

	LVO stroke	Non-LVO stroke or other condition
Patients fulfilling G-FAST prehospital criteria (combined presence of Gaze deviation and at least one other G-FAST symptom)	7	2
Patients not fulfilling G-FAST prehospital criteria (no combined presence of gaze deviation and at least one other G-FAST symptom)	52	582

2×2 table presenting the study population by presence of acute ischaemic stroke with LVO and if patients fulfilled G-FAST prehospital criteria. G-FAST prehospital assessment included presence of gaze deviation, facial palsy, arm weakness, visual loss and speech difficulties. Patients with both gaze deviation and at least one other G-FAST symptom fulfilled the prehospital criteria for LVO suspicion.
G-FAST, Gaze deviation, Facial palsy, Arm weakness, Visual loss, Speech disturbance; LVO, large vessel occlusion.

Table 5 Comparison between patients with large vessel occlusion first admitted to a PSC or first admitted directly to a CSC

	Initial PSC admission n=18	Initial CSC admission n=41	P value
Median NIHSS score (IQR)	5 (2–15)	13 (7–20)	p=0.004
Female patients, n (%)	7 (39)	18 (44)	p=0.72
Male patients, n (%)	11 (61)	23 (56)	p=0.88
Median door-to-groin puncture time, min (IQR)	33 (25–33)	74 (64–112)	p=0.003
Median time from PSC arrival to start of endovascular treatment (groin puncture) at CSC, min (IQR)	163 (85–200)	NA	NA

CSC, comprehensive stroke centre; NIHSS, National Institutes of Health Stroke Scale; PSC, primary stroke centre.

any implemented stroke scale needs validation in a prospective study design.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting, or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the Regional Ethics Committee in Western Norway (ID 202432) and the local Data Protection Officer (DPO). The Western Norway Regional Ethics Committee gave the permission to not require patient consent for this study. All the patients received a patient information letter regarding this retrospective study with the option to decline study participation by contacting the first authors of this paper.

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