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Citation

Stroke

CLINICAL AND POPULATION SCIENCES

Comparison of Prehospital Assessment by Paramedics and In-Hospital Assessment by Physicians in Suspected Stroke Patients: Results From 2 Prospective Cohort Studies

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BACKGROUND: It is unknown if ambulance paramedics adequately assess neurological deficits used for prehospital stroke scales to detect anterior large-vessel occlusions. We aimed to compare prehospital assessment of these stroke-related deficits by paramedics with in-hospital assessment by physicians.

METHODS: We used data from 2 prospective cohort studies: the LPSS (Leiden Prehospital Stroke Study) and PRESTO study (Prehospital Triage of Patients With Suspected Stroke). In both studies, paramedics scored 9 neurological deficits in stroke code patients in the field. Trained physicians scored the National Institutes of Health Stroke Scale (NIHSS) at hospital presentation. Patients with transient ischemic attack were excluded because of the transient nature of symptoms. Spearman rank correlation coefficient (r_s) was used to assess correlation between the total prehospital assessment score, defined as the sum of all prehospital items, and the total NIHSS score. Correlation, sensitivity and specificity were calculated for each prehospital item with the corresponding NIHSS item as reference.

RESULTS: We included 2850 stroke code patients. Of these, 1528 had ischemic stroke, 243 intracranial hemorrhage, and 1079 stroke mimics. Correlation between the total prehospital assessment score and NIHSS score was strong (r_s=0.70 [95% CI, 0.68–0.72]). Concerning individual items, prehospital assessment of arm (r_s=0.68) and leg (r_s=0.64) motor function correlated strongest with corresponding NIHSS items, and had highest sensitivity (arm 95%, leg 93%) and moderate specificity (arm 71%, leg 70%). Neglect (r_s=0.31), abnormal speech (r_s=0.50), and gaze deviation (r_s=0.51) had weakest correlations. Neglect and gaze deviation had lowest sensitivity (52% and 66%) but high specificity (84% and 89%), while abnormal speech had high sensitivity (85%) but lowest specificity (65%).

CONCLUSIONS: The overall prehospital assessment of stroke code patients correlates strongly with in-hospital assessment. Prehospital assessment of neglect, abnormal speech, and gaze deviation differed most from in-hospital assessment. Focused training on these deficits may improve prehospital triage.

GRAPHIC ABSTRACT: A graphic abstract is available for this article.

Key Words: hemorrhagic stroke ■ cerebrovascular disorders ■ ischemic stroke ■ paramedics ■ thrombectomy ■ transient ischemic attack ■ triage

> ### Nonstandard Abbreviations and Acronyms
>
> **aLVO**   anterior large-vessel occlusion
> **LPSS**   Leiden Prehospital Stroke Study
> **NIHSS**   National Institutes of Health Stroke Scale
> **PRESTO** Prehospital Triage of Patients With Suspected Stroke Study

To prevent delays in treatment of patients with ischemic stroke due to anterior circulation large vessel occlusion (aLVO), the American Heart Association/American Stroke Association stroke triage algorithm recommends the use of prehospital aLVO stroke scales to help ambulance paramedics identify patients with aLVO for direct transportation to a thrombectomy-capable stroke center.[1] However, sensitivity of these scales is relatively low, ranging between 38% and 67%.[2,3] A possible explanation for this is that neurological deficits are not adequately recognized by ambulance paramedics in the field. Ambulance paramedics only encounter stroke code patients sporadically during their shifts and adequate assessment of neurological deficits could require more extensive training. Meanwhile, neurological deficits are routinely assessed with the standardized National Institutes of Health Stroke Scale (NIHSS) by experienced physicians upon arrival at the hospital.[4] Some studies have compared the overall prehospital assessment of aLVO stroke scales by paramedics with assessment of physicians, but focused on total scores of a single scale and did not evaluate separate items.[5–8] Only 4 small studies have evaluated to what extent examination of individual neurological deficits by paramedics matches the in-hospital assessment by physicians.[9–12] Furthermore, only 2 of these studies included all stroke code patients, including patients with a stroke mimic, and in only one the paramedical assessment was performed on-site in the prehospital setting.[9,10] Further knowledge of the level of agreement could guide training programs for paramedics and improve prehospital aLVO triage by focusing training on the more challenging neurological deficits. Therefore, we aimed to compare prehospital assessment of stroke code patients by paramedics with in-hospital assessment by physicians.

METHODS

Patients

We used data from stroke code patients included in the LPSS (Leiden Prehospital Stroke Study) and the PRESTO study (Prehospital Triage of Patients With Suspected Stroke).[2,3] LPSS and PRESTO were both prospective multiregional observational cohort studies that included stroke code patients from 4 ambulance regions in the Netherlands. Together these regions serve roughly 3.7 million inhabitants with 10 primary stroke centers and 5 thrombectomy-capable stroke centers, including 13 ambulance posts with ≈600 paramedics. Both studies included all patients aged ≥18 years in whom an acute stroke code was activated by ambulance paramedics between July 2018 and October 2019. A stroke code was activated in case of a positive face-arm-speech-time test (PRESTO) or other acute neurological deficits at the insight of the individual paramedic (LPSS). The final diagnosis was made by local clinicians either at discharge (PRESTO) or after 3 months (LPSS). In PRESTO, an imaging core laboratory committee re-assessed CT angiographies for presence of aLVO. The complete study designs, procedures, and results of the PRESTO and LPSS studies can be found elsewhere.[2,3,13] For this study, we excluded patients with a final diagnosis of transient ischemic attack since the transient nature of symptoms would hamper a fair comparison. We used the STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology) for reporting this observational study.[14] In compliance with Dutch law, patient data cannot be made available, since participants were not informed during the opt-out procedure about the public sharing of their individual participant data in de-identified form. The syntax and output files of the statistical analyses can be made available from the corresponding author upon reasonable request. The LPSS and PRESTO were approved by the relevant medical ethical review committees and the institutional review boards of all participating centers. For both studies, the need for informed consent was waived.[2,3]

Prehospital and In-Hospital Assessment

Paramedics scored 9 to 11 neurological deficits from the NIHSS on-site upon arrival at the patient and stored these in a web-based application (Table S1). In PRESTO, the following 9 items were assessed: answering questions, following commands, abnormal speech, gaze deviation, facial palsy, arm motor function, leg motor function, grip strength, and agnosia (recognition of own arm and impairment). In the LPSS, the same items were assessed with the addition of sensory deficits and tactile extinction. Completing all items was required in PRESTO. In the LPSS, paramedics could score the items abnormal speech, grip strength, arm and leg motor function, and tactile extinction as untestable, for example, if the patient had a decreased level of consciousness or was fixed for transport. For this study, all untestable items were scored as missing. In the Netherlands, ambulance paramedics are registered nurses, who generally completed an additional 2-year training in either intensive, cardiac, anesthetic or emergency medical care, plus a 1-year training in ambulance care. Before the initiation of each study, they received a brief introductory session (30–45 minutes) focusing on the use of the application and assessment of the clinical items required for the studied prehospital aLVO scales. At the emergency department, the NIHSS was assessed as part of routine work-up by a trained neurologist, neurology resident, or emergency physician from the stroke team. In case NIHSS items were not documented, these were reconstructed using a standardized scoring chart (PRESTO) or validated algorithm (LPSS) based on neurological examination reports.[15] The time between ambulance arrival at the patient location and hospital arrival (ambulance-arrival-to-door time) was used to estimate the time-interval between the prehospital and in-hospital assessment.

Statistical Analysis

We analyzed the correlation between the total prehospital assessment score (range, 0–15) and the total in-hospital NIHSS score (range, 0–42) using Spearman rank correlation coefficient (r_s) and constructed 95% CIs using Fisher Z transformation. The total prehospital assessment score was defined as the summation of all scores of the 9 stroke items that were assessed in both the LPSS and PRESTO. Patients with incomplete prehospital or NIHSS assessments were excluded from this analysis. To evaluate possible differences in assessment between diagnoses, this analysis was repeated after stratifying by final diagnosis. Similarly, since spontaneous clinical improvement or deterioration might occur especially in the first few hours after onset, we also assessed Spearman correlation after dividing the cohort in quartiles based upon the time between onset and ambulance arrival.[16–18] A Spearman coefficient of 0 to 0.19 was regarded as very weak, 0.2 to 0.39 as weak, 0.40 to 0.59 as moderate, 0.6 to 0.79 as strong, and 0.8 to 1 as very strong correlation.[19]

Second, to identify more challenging items, we calculated the correlation, sensitivity and specificity of each prehospital item compared with its corresponding in-hospital item from the NIHSS. To calculate sensitivity and specificity, we dichotomized all prehospital and in-hospital findings as either normal or abnormal, using the in-hospital NIHSS as reference. We constructed 95% CIs for sensitivity and specificity using the normal approximation method based on estimated standard errors. If LPSS and PRESTO used different scoring methods for the same item, scores were combined and adjusted to match the NIHSS (Table S1). For correlation, the combined score of LPSS and PRESTO was compared with the NIHSS. Because prehospital assessment of arm motor function did not include an isolated drift without paresis in PRESTO, a drift on the LPSS and NIHSS item arm motor function was scored as normal. Similarly, since both PRESTO and LPSS did not score a drift without paresis for leg motor function, a drift on this NIHSS item was also scored as normal. The prehospital item abnormal speech was compared with any symptoms on the language or dysarthria items on the NIHSS. Prehospital assessment of agnosia was compared with the NIHSS item neglect. In PRESTO, agnosia was only scored in patients with left sided hemiparesis, according to the Rapid Arterial Occlusion Evaluation scale.[20] Additionally, because tactile extinction was also assessed in the LPSS and since the NIHSS item neglect encompasses more modalities than only agnosia, we also compared neglect with the combined prehospital assessment of agnosia and tactile extinction in the LPSS cohort. Patients with missing prehospital or NIHSS assessments were excluded on a per item basis for these comparisons. Lastly, grip strength was excluded from the analysis of individual items, since there is no corresponding item on the NIHSS.

Statistical analyses were performed using R (version 4.1.2) and R Studio (version 2022.2.0.443).

RESULTS

Of the 3321 stroke code patients included in LPSS and PRESTO, 470 patients with a transient ischemic attack and 1 patient younger than 18 years were excluded (Figure). Of the remaining 2850 patients, 1528 (53.6%) had
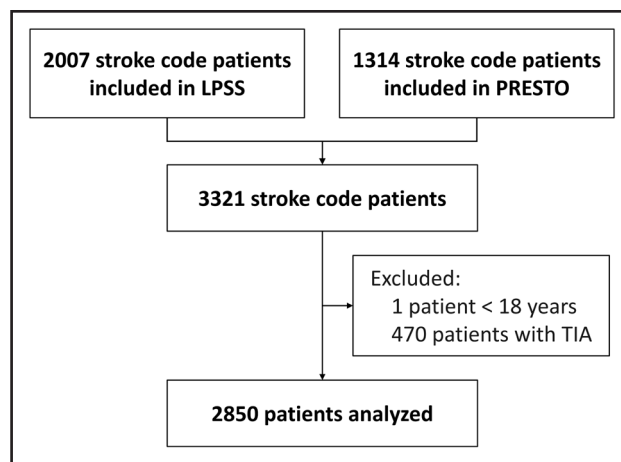
Figure. Flowchart of analyzed patients.
LPSS indicates Leiden Prehospital Stroke Study; PRESTO, Prehospital Triage of Patients With Suspected Stroke Study; and TIA, transient ischemic attack.

an ischemic stroke (295 with aLVO), 243 (8.5%) had an intracranial hemorrhage, and 1079 (37.9%) a stroke mimic. Median age was 73 years and 49% were female (Table 1). Median ambulance-arrival-to-door time was 29 minutes (interquartile range, 23–36 minutes). Median total prehospital assessment score was 2, and in-hospital NIHSS score was 3. These were higher for patients with aLVO ischemic stroke (median prehospital assessment score: 8, NIHSS score: 12) and patients with an intracranial hemorrhage (prehospital assessment score: 6, NIHSS score: 10; Table S2).

Spearman correlation coefficient between the total prehospital assessment score and in-hospital NIHSS score was strong (0.70 [95% CI, 0.68–0.72]) (Table 2 and Figure S1). After stratification by final diagnosis, correlation was moderate for patients with a stroke mimic (0.55 [95% CI, 0.49–0.59]), strong for patients with non-aLVO ischemic stroke (0.61 [95% CI, 0.56–0.64]), stronger for aLVO ischemic stroke (0.76 [95% CI, 0.69–0.81]), and very strong for intracranial hemorrhage (0.83 [95% CI, 0.77–0.87]; Table 2). As can be seen in Table S3, the correlation was highest in the first quartile, but fluctuated throughout the entire onset-to-ambulance-arrival time range.

Concerning comparison of the prehospital and in-hospital items, Spearman coefficient was highest for arm motor function (0.68 [95% CI, 0.66–0.70]) and leg motor function (0.64 [95% CI, 0.61–0.66]). In contrast, correlation was poorest for neglect (0.31 [95% CI, 0.27–0.35]), followed by abnormal speech (0.50 [95% CI, 0.47–0.53]) and gaze deviation (0.51 [95% CI, 0.48–0.54]; Table 3). Sensitivity was highest for arm motor function (95% [95% CI, 93–97]) and leg motor function (93% [95% CI, 91–96]), and lowest for neglect (52% [95% CI, 45–59]) and gaze deviation (66% [95% CI, 61–70]). While specificity was highest for gaze deviation (89% [95% CI, 88–90]), answering questions (87% [95% CI, 85–88]),

Table 1. Baseline Characteristics of Analyzed Patients

Characteristic	n=2850
Age, median (IQR)	73 (61–82)
Female sex, n/N (%)	1401/2850 (49)
Premorbid mRS score 0–2, n/N (%)	2208/2641 (84)
History	
Atrial fibrillation, n/N (%)	421/2829 (15)
Hypertension, n/N (%)	1720/2835 (61)
Hypercholesterolemia, n/N (%)	1470/2828 (52)
Diabetes, n/N (%)	579/2830 (21)
Ischemic stroke or TIA, n/N (%)*	811/2832 (29)
Myocardial infarction, n/N (%)	316/2825 (11)
Intracranial hemorrhage, n/N (%)	86/2841 (3)
Use of antiplatelet medication, n/N (%)	1002/2822 (36)
Use of oral anticoagulation, n/N (%)	457/2809 (16)
Primarily presented at a PSC, n/N (%)	1196/2850 (42)
Primarily presented at a TSC, n/N (%)	1654/2850 (58)
Onset-to-ambulance-arrival time, min, median (IQR)	91 (30–277)
Ambulance-arrival-to-door time, min, median (IQR)	29 (23–36)
Total prehospital assessment score (range, 0–15), median (IQR)	2 (1–5)
Total in-hospital NIHSS score (range, 0–42), median (IQR)	3 (1–7)

IQR indicates interquartile range; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; PRESTO, Prehospital Triage of Patients With Suspected Stroke; PSC, primary stroke center; TIA, transient ischemic attack; and TSC, thrombectomy-capable stroke center.

*In PRESTO only information on a history of ischemic stroke was collected.

and following commands (85% [95% CI, 84–87]), and lowest for abnormal speech (65% [95% CI, 62–67]). Furthermore, in patients with neglect on the NIHSS, the prehospital assessment of neglect was frequently missing (72/269; 27%; Table S4). Also, the number of false-positive patients (n=252) was higher than true-positive patients (n=102), resulting in a very low positive predictive value (102/354=29%) of neglect. A complete overview of prehospital and in-hospital observations per item can be found in Table S4.

The additional analysis of the extended definition of neglect (agnosia with the addition of tactile extinction) in the LPSS cohort showed an increase in sensitivity of neglect from 52% to 64%, with a specificity of 79% (95% CI, 77–82). However, due to the low prevalence of abnormal findings (7%) and low number of complete cases (89/168), the 95% CI of sensitivity of the extended definition of neglect was wide (54–74%; Table 3 and Table S4). Furthermore, 47% of patients with neglect on the NIHSS had a missing or untestable prehospital assessment of either agnosia or tactile extinction (79/168).

DISCUSSION

We found that the overall prehospital assessment of stroke code patients by paramedics correlates strongly with in-hospital examination by physicians, indicating that paramedics adequately assess stroke-related neurological deficits in the prehospital setting. Correlation was strongest in patients with a final diagnosis of aLVO ischemic stroke or intracranial hemorrhage. Concerning individual items, prehospital assessment of arm and leg motor function correlated best with in-hospital findings and had the highest sensitivity. In contrast, neglect, abnormal speech, and gaze deviation had weakest correlation. Neglect and gaze deviation had lowest sensitivity, while abnormal speech had lowest specificity.

The most recent American Heart Association/American Stroke Association stroke triage algorithm for ambulance paramedics recommends the use of a prehospital aLVO stroke scale.[1] However, the quality of assessment of individual stroke-related deficits by paramedics was only studied in 4 small (n<190) studies and often in cohorts including only patients with stroke rather than unselected stroke code patients.[9–12] A few other studies evaluated prehospital assessment of complete aLVO stroke scales by paramedics with assessment by physicians.[5–8] One small study found very good agreement in assessment of the Rapid Arterial Occlusion Evaluation scale by ambulance paramedics on-site and stroke neurologists using video telemedicine in 31 stroke code patients.[5] Three other studies found that paramedics scored the Field Assessment Stroke Triage for Emergency Destination and Los Angeles Motor Scale similarly to emergency physicians and vascular neurologists.[6–8] However, these studies had smaller sample sizes than

Table 2. Correlation Between the Total Prehospital Assessment Score (Range, 0–15) and In-Hospital NIHSS Score (Range, 0–42), and Stratified by Final Diagnosis

	N*	Spearman r_s (95% CI)	Median total prehospital assessment score (IQR)	Median total in-hospital NIHSS score (IQR)
Total cohort	2058	0.70 (0.68–0.72)	2 (1–5)	3 (1–7)
aLVO ischemic stroke	211	0.76 (0.69–0.81)	8 (4–10)	12 (6–17)
Non-aLVO ischemic stroke	959	0.61 (0.56–0.64)	2 (1–5)	3 (2–5)
Intracranial hemorrhage	153	0.83 (0.77–0.87)	6 (3–10)	10 (4–18)
Stroke mimic	735	0.55 (0.49–0.59)	1 (0–3)	1 (0–3)

aLVO indicates anterior large vessel occlusion; IQR, interquartile range; and NIHSS, National Institutes of Health Stroke Scale.

*Analyses were performed in patients of whom both complete prehospital assessment and in-hospital NIHSS scores were available.

Table 3. Comparison of Prehospital and In-Hospital Assessments of Individual Items

	N	Spearman r_s* (95% CI)	Sensitivity* (95% CI)	Specificity* (95% CI)
Questions	2735	0.61 (0.59–0.64)	78 (75–81)	87 (85–88)
Commands	2736	0.55 (0.52–0.57)	74 (70–78)	85 (84–87)
Abnormal speech	2729	0.50 (0.47–0.53)	85 (83–87)	65 (62–67)
Gaze deviation	2713	0.51 (0.48–0.54)	66 (61–70)	89 (88–90)
Facial palsy	2759	0.58 (0.55–0.60)	76 (73–79)	79 (77–81)
Arm motor function	2443	0.68 (0.66–0.70)	95 (93–97)	71 (69–73)
Leg motor function	2225	0.64 (0.61–0.66)	93 (91–96)	70 (68–72)
Neglect (compared with agnosia)†	1725	0.31 (0.27–0.35)	52 (45–59)	84 (82–85)
Neglect (compared with agnosia and tactile extinction)‡	1249	0.26 (0.21–0.31)	64 (54–74)	79 (77–82)

LPSS indicates Leiden Prehospital Stroke Study; NIHSS, National Institutes of Health Stroke Scale; and PRESTO, Prehospital Triage of Patients With Suspected Stroke.

*For correlation, the combined score of LPSS and PRESTO was compared with the NIHSS. For sensitivity and specificity, items were dichotomized as either normal or abnormal and the in-hospital NIHSS was used as reference. Values are shown in percentages (%).

†In PRESTO, agnosia was only scored in patients with left sided hemiparesis.

‡Only shown for the LPSS cohort, because tactile extinction was not examined in PRESTO.

our study and did not investigate separate clinical items. Additionally, the times between both assessments were generally longer than in our study, and one study compared Los Angeles Motor Scale assessment only in selected patients with a final diagnosis of stroke.[6]

Stratified by final diagnosis, we found that overall correlation was strongest for patients with an intracranial hemorrhage or aLVO ischemic stroke, who also had highest NIHSS scores. This indicates that the prehospital assessment by paramedics is especially adequate in case of severe neurological deficits, which is often the case in patients who require direct transportation to a thrombectomy-capable stroke center. Correlation was poorest in patients with a stroke mimic, possibly due to more prevalent fluctuations of symptoms in certain mimics, such as seizures or functional neurological disorders.

Our findings suggest that neglect is the most challenging item for paramedics to assess. In almost half of patients in whom neglect was observed in the hospital, this was missed at prehospital assessment. Furthermore, the positive predictive value of the prehospital assessment of neglect was very low. These findings are in line with a previous study in a small subgroup of patients with suspected stroke, in which neglect had the lowest interrater agreement between paramedics and the hospital stroke team.[10] Following neglect, sensitivity was lowest for gaze deviation. Of note, these are both cortical symptoms and sensitive for aLVO

ischemic stroke when assessed by an experienced neurologist, further emphasizing the importance of correct prehospital assessment of these symptoms for aLVO detection.[21] Our findings suggest that in a setting with relatively well-trained paramedics the assessment of neurological deficits can still be enhanced, which might improve the value of the use of aLVO scales in prehospital stroke triage. Future research should address this, ideally also taking into account efficacy of other aLVO triage modalities, such as mobile stroke units, telemedicine, dry-electrode electroencephalography, or transcranial doppler systems.[22]

Strengths of this study include the large sample size of unselected stroke code patients from multiple ambulance regions with several primary stroke centers and thrombectomy-capable stroke centers. In addition, prehospital assessments were performed by paramedics in the field and implemented in regular workflow, representing the real-world setting, and making results well generalizable for routine practice. Furthermore, due to the prospective designs, the amount of missing data was limited. This allowed for extensive evaluation of the separate clinical items, which enabled identification of the items that are most challenging for paramedics.

Limitations of this study include that subtle motor deficits could not be compared, since an arm and leg drift was scored as normal. This may in part explain the high sensitivity of motor function items, although correlation was still strongest for these items. Furthermore, we used the prehospital assessment of agnosia for comparison with neglect, while this does not encompass all modalities of the NIHSS definition of neglect. However, even in the additional analysis in the LPSS cohort with the addition of tactile extinction to agnosia, the sensitivity of neglect remained lowest. These results should be interpreted with caution since a high proportion of patients who had neglect on the NIHSS missed prehospital assessment of agnosia and tactile extinction. This again suggests that assessment of neglect is challenging, which is in line with previous literature.[10] Possibly, since completing all items was not required in the LPSS, paramedics could have refrained from documenting prehospital assessment in certain cases, for example, if patients could not be instructed because of a decreased consciousness or if patients were fixed for transport. We cannot exclude that this may have influenced the estimations of correlation, sensitivity, and specificity. Furthermore, symptoms might have altered between the assessments due to spontaneous improvement or worsening, which may explain some of the disparities.[16–18] However, we found no clear or clinically relevant trend in correlation after stratification for onset-to-ambulance-arrival time, the time interval between both assessments was relatively short (median 29 minutes), and patients with a final diagnosis of transient ischemic attack were excluded. We, therefore, expect this effect to be limited.

Also, even despite this possible disturbance, the overall correlation between both assessments was still strong. Furthermore, we would expect that a possible difference over time would apply to all prehospital items equally and therefore, not explain differences between the individual items. Lastly, in the Netherlands, ambulance paramedics are well-trained registered nurses who received additional education in ambulance care. This may have improved their neurological examination and prehospital stroke assessment may be more challenging in regions where paramedics are less-extensively trained.

CONCLUSIONS

The overall prehospital assessment of stroke code patients by paramedics correlates strongly with in-hospital assessment by physicians, indicating that paramedics can adequately assess stroke-related neurological deficits in a prehospital setting. Prehospital assessment of neglect, abnormal speech, and gaze deviation differed most from in-hospital assessment. Focused training on these 3 items may help to improve prehospital stroke triage.

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Supplemental Material

STROBE Checklist
Tables S1–S4
Figure S1

APPENDIX

REFERENCES

1. Jauch EC, Schwamm LH, Panagos PD, Barbazzeni J, Dickson R, Dunne R, Foley J, Fraser JF, Lassers G, Martin-Gill C, et al. recommendations for regional stroke destination plans in rural, suburban, and urban communities from the prehospital stroke system of care consensus conference: a consensus statement from the american academy of neurology, american heart association/american stroke association, american society of neuroradiology, national association of ems physicians, national association of state EMS officials, society of neurointerventional surgery, and society of vascular and interventional neurology: endorsed by the neurocritical care society. *Stroke.* 2021;52:e133–e152. doi: 10.1161/strokeaha.120.033228

2. Nguyen TTM, van den Wijngaard IR, Bosch J, van Belle E, van Zwet EW, Dofferhoff-Vermeulen T, Duijndam D, Koster GT, de Schryver E, Kloos LMH, et al. Comparison of prehospital scales for predicting large anterior vessel occlusion in the ambulance setting. *JAMA Neurol.* 2020;78:157–164. doi: 10.1001/jamaneurol.2020.4418

3. Duvekot MHC, Venema E, Rozeman AD, Moudrous W, Vermeij FH, Biekart M, Lingsma HF, Maasland L, Wijnhoud AD, Mulder L, et al. Comparison of eight prehospital stroke scales to detect intracranial large-vessel occlusion in suspected stroke (PRESTO): a prospective observational study. *The Lancet Neurol.* 2021;20:213–221. doi: 10.1016/S1474-4422(20)30439-7

4. Brott T, Adams HP Jr, Olinger CP, Marler JR, Barsan WG, Biller J, Spilker J, Holleran R, Eberle R, Hertzberg V. Measurements of acute cerebral infarction: a clinical examination scale. *Stroke.* 1989;20:864–870. doi: 10.1161/01.str.20.7.864

5. Hackett CT, Rahangdale R, Protetch J, Saleemi MA, Rana SS, Wright DG, Fishman R, Noah P, Tayal AH. Rapid arterial occlusion evaluation scale agreement between emergency medical services technicians and neurologists. *J Stroke Cerebrovasc Dis.* 2020;29:104745. doi: 10.1016/j.jstrokecerebrovasdis.2020.104745

6. Kim JT, Chung PW, Starkman S, Sanossian N, Stratton SJ, Eckstein M, Pratt FD, Conwit R, Liebeskind DS, Sharma L, et al. Field validation of the los angeles motor scale as a tool for paramedic assessment of stroke severity. *Stroke.* 2017;48:298–306. doi: 10.1161/STROKEAHA.116.015247

7. Guillory BC, Gupta AA, Cubeddu LX, Boge LA. Can prehospital personnel accurately triage patients for large vessel occlusion strokes? *J Emerg Med.* 2020;58:917–921. doi: 10.1016/j.jemermed.2020.01.015

8. Bhatt NR, Frankel MR, Nogueira RG, Fleming C, Bianchi NA, Morgan O, Chester K, English SW, Janocko N, Navalkele D, et al. Reliability of field assessment stroke triage for emergency destination scale use by paramedics: mobile stroke unit first-year experience. *Stroke.* 2021;52:2530–2536. doi: 10.1161/strokeaha.120.033775

9. Nor AM, McAllister C, Louw SJ, Dyker AG, Davis M, Jenkinson D, Ford GA. Agreement between ambulance paramedic- and physician-recorded neurological signs with Face Arm Speech Test (FAST) in acute stroke patients. *Stroke*. 2004;35:1355–1359. doi: 10.1161/01.str.0000128529.63156.c5

10. Demeestere J, Garcia-Esperon C, Lin L, Bivard A, Ang T, Smoll NR, Garnett A, Loudfoot A, Miteff F, Spratt N, et al. Validation of the national institutes of health stroke scale-8 to detect large vessel occlusion in ischemic stroke. *Journal of stroke and cerebrovascular diseases: the official journal of National Stroke Association*. 2017;26:1419–1426. doi: 10.1016/j.jstrokecerebrovasdis.2017.03.020

11. Whelley-Wilson CM, Newman GC. A stroke scale for emergency triage. *Journal of stroke and cerebrovascular diseases: the official journal of National Stroke Association*. 2004;13:247–253. doi: 10.1016/j.jstrokecerebrovasdis.2004.04.005

12. Kothari RU, Pancioli A, Liu T, Brott T, Broderick J. Cincinnati prehospital stroke scale: reproducibility and validity. *Ann Emerg Med*. 1999;33:373–378. doi: 10.1016/s0196-0644(99)70299-4

13. Venema E, Duvekot MHC, Lingsma HF, Rozeman AD, Moudrous W, Vermeij FH, Biekart M, van der Lugt A, Kerkhoff H, Dippel DWJ, et al. Prehospital triage of patients with suspected stroke symptoms (PRESTO): protocol of a prospective observational study. *BMJ Open*. 2019;9:e028810. doi: 10.1136/bmjopen-2018-028810

14. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP; STROBE Initiative. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet (London, England)*. 2007;370:1453–1457. doi: 10.1016/S0140-6736(07)61602-X

15. Williams LS, Yilmaz EY, Lopez-Yunez AM. Retrospective assessment of initial stroke severity with the NIH Stroke Scale. *Stroke*. 2000;31:858–862. doi: 10.1161/01.str.31.4.858

16. Shkirkova K, Schuberg S, Balouzian E, Starkman S, Eckstein M, Stratton S, Pratt FD, Hamilton S, Sharma L, Liebeskind DS, et al. Paramedic global impression of change during prehospital evaluation and transport for acute stroke. *Stroke*. 2020;51:784–791. doi: 10.1161/strokeaha.119.026392

17. Saver JL, Altman H. Relationship between neurologic deficit severity and final functional outcome shifts and strengthens during first hours after onset. *Stroke*. 2012;43:1537–1541. doi: 10.1161/STROKEAHA.111.636928

18. Balucani C, Levine SR, Sanossian N, Starkman S, Liebeskind D, Gornbein JA, Shkirkova K, Stratton S, Eckstein M, Hamilton S, et al. Neurologic improvement in acute cerebral ischemia: frequency, magnitude, predictors, and clinical outcomes. *Neurology*. 2023;100:e1038–e1047. doi: 10.1212/WNL.0000000000201656

19. Swinscow TDV. *Statistics at Square One*. BMJ Publishing Group; 2009.

20. Perez de la Ossa N, Carrera D, Gorchs M, Querol M, Millan M, Gomis M, Dorado L, Lopez-Cancio E, Hernandez-Perez M, Chicharro V, et al. Design and validation of a prehospital stroke scale to predict large arterial occlusion: the rapid arterial occlusion evaluation scale. *Stroke*. 2014;45:87–91. doi: 10.1161/strokeaha.113.003071

21. Beume LA, Hieber M, Kaller CP, Nitschke K, Bardutzky J, Urbach H, Weiller C, Rijntjes M. Large vessel occlusion in acute stroke. *Stroke*. 2018;49:2323–2329. doi: 10.1161/strokeaha.118.022253

22. Patrick L, Smith W, Keenan KJ. Large vessel occlusion stroke detection in the prehospital environment. *Curr Emerg Hosp Med Rep*. 2021;9:64–72. doi: 10.1007/s40138-021-00234-9