# Accuracy of Prediction Instruments for Diagnosing Large Vessel Occlusion in Individuals With Suspected Stroke

## A Systematic Review for the 2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke

*Reviewed for evidence-based integrity and endorsed by the American Association of Neurological Surgeons and Congress of Neurological Surgeons*

*Endorsed by the Society for Academic Emergency Medicine*

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***Introduction***—Endovascular thrombectomy is a highly efficacious treatment for large vessel occlusion (LVO). LVO prediction instruments, based on stroke signs and symptoms, have been proposed to identify stroke patients with LVO for rapid transport to endovascular thrombectomy–capable hospitals. This evidence review committee was commissioned by the American Heart Association/American Stroke Association to systematically review evidence for the accuracy of LVO prediction instruments.

***Methods***—Medline, Embase, and Cochrane databases were searched on October 27, 2016. Study quality was assessed with the Quality Assessment of Diagnostic Accuracy-2 tool.

***Results***—Thirty-six relevant studies were identified. Most studies (21 of 36) recruited patients with ischemic stroke, with few studies in the prehospital setting (4 of 36) and in populations that included hemorrhagic stroke or stroke mimics (12 of 36). The most frequently studied prediction instrument was the National Institutes of Health Stroke Scale. Most studies had either some risk of bias or unclear risk of bias. Reported discrimination of LVO mostly ranged from 0.70 to 0.85, as measured by the C statistic. In meta-analysis, sensitivity was as high as 87% and specificity was as high as 90%, but no threshold on any instruments predicted LVO with both high sensitivity and specificity. With a positive LVO prediction test, the probability of LVO could be 50% to 60% (depending on the LVO prevalence in the population), but the probability of LVO with a negative test could still be ≥10%.

***Conclusions***—No scale predicted LVO with both high sensitivity and high specificity. Systems that use LVO prediction instruments for triage will miss some patients with LVO and milder stroke. More prospective studies are needed to assess the accuracy of LVO prediction instruments in the prehospital setting in all patients with suspected stroke, including patients with hemorrhagic stroke and stroke mimics. **(*Stroke*. 2018;49:00-00. DOI: 10.1161/STR.0000000000000160.)**

**Key Words:** AHA Scientific Statements ■ stroke ■ thrombectomy



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Endovascular thrombectomy (EVT) for large vessel occlusion (LVO) is a highly effective therapy for acute ischemic stroke,[1] but only a minority of hospitals treating stroke patients are EVT capable. Because the effect of EVT diminishes over time,[2] stroke systems of care need to rapidly identify patients with LVO and transport them to EVT-capable hospitals as quickly as possible. LVO can be reliably diagnosed by computed tomography (CT) angiography, magnetic resonance angiography, or conventional angiography, but this requires evaluation at a hospital with angiographic imaging capabilities. If a prediction instrument could reliably identify LVO in the field, patients with LVO could be transported directly to EVT-capable hospitals, bypassing primary stroke centers.

Investigators have proposed several stroke diagnostic instruments and severity scales to predict the presence or absence of LVO. Accurate prediction of LVO before angiography could help with triage and referral of acute stroke patients in at least 2 scenarios: (1) when emergency medical services (EMS) assess patients with suspected acute stroke to identify patients with LVO for triage to the nearest EVT-capable hospital, bypassing primary stroke centers that do not provide EVT, and (2) when emergency room physicians diagnose patients with acute ischemic stroke in hospitals that can perform CT but not angiography to identify patients with LVO for transfer to the nearest EVT-capable hospital.

It is not clear which LVO prediction instrument for suspected acute stroke or confirmed acute ischemic stroke is most accurate. Therefore, the writing committee for the "2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke"[3] commissioned an independent evidence review committee (ERC) to review evidence for the accuracy of LVO prediction instruments. The ERC addressed this question: What is the diagnostic accuracy of LVO prediction instruments for identifying LVO in individuals with suspected stroke or confirmed to have acute ischemic stroke in the prehospital or hospital emergency room settings?

## Methods

The ERC systematically reviewed cohort studies that described the diagnostic accuracy of LVO prediction instruments. Analyses were stratified by the population: suspected stroke (ie, patients with stroke symptoms, including patients ultimately diagnosed with hemorrhagic stroke or stroke mimics) and ischemic stroke based on diagnosis in the emergency department after initial brain imaging. Review methods adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses standards[4] and the recommendations of the "ACCF/AHA Clinical Practice Guideline Methodology Summit Report."[5]

### Search Strategy

Medline (via PubMed/OVID), Embase (via OVID), and the Cochrane Central Database of Controlled Trials (via CENTRAL) were searched on October 27, 2016, with the use of free text, medical subject headings, and synonyms for stroke screening, severity scales, and LVO. The fully specified search strategy is provided in Table I of the online Data Supplement. References of individual studies were also back-checked for relevant studies. The search strategy was developed by the ERC in consultation with Doctor Evidence (Santa Monica, CA) and carried out by Doctor Evidence medical librarians. For publications that had appeared as meeting abstracts only, we subsequently performed a targeted search on April 1, 2017 (based on first and last author) to determine whether they had later been published as peer-reviewed research articles.

### Eligibility Criteria and Review for Eligibility

Screening was performed against the predefined selection criteria (Table 1) developed by the ERC. Conference abstracts and peer-reviewed articles were considered eligible to capture recent publication activity in this rapidly expanding area of research.

Doctor Evidence imported the search results into the DOC Library (Santa Monica, CA), a fully indexed central repository, using the Doctor Evidence: Library Management System (Santa Monica, CA). The Library Management System is a web-based software platform featuring key word emphasis (coloring or bolding of keywords), search and ranking functionalities, and the ability to assign and manage reasons for rejecting references at all stages of screening.

Title and abstract eligibility was performed by a Doctor Evidence medical librarian, with subsequent reassessment by a second independent reviewer. Additional quality control was performed by an independent Doctor Evidence methodologist who validated all included abstracts and a random sample of excluded abstracts.

Full-text eligibility was performed by dual independent review by members of the ERC. Disagreements were resolved by the ERC chair.

### Quality Assessment

Two ERC members independently assessed the risk of bias and applicability of each study using the Quality Assessment of

**Table 1. Selection Criteria**

| |
|---|
| Prospective or retrospective cohort studies, cross-sectional studies, clinical trials, or systematic reviews, excluding case reports and case series |
| Either suspected stroke (which could include hemorrhagic stroke and stroke mimics in addition to ischemic stroke) or presumed ischemic stroke with brain imaging |
| Includes adults (age ≥18 y) |
| Performed in setting of prehospital care or emergency room |
| LVO presence or absence diagnosed by CTA, MRA, or conventional (invasive) angiography; studies in which LVO assessment was based on TCD only were not included. |
| An LVO prediction instrument was applied and was associated with the presence or absence of LVO using ≥1 of the following metrics: sensitivity, specificity, negative predictive value, positive predictive value, diagnostic odds ratio, likelihood ratio, area under the curve, or ROC curve. |

CTA indicates computed tomography angiography; LVO, large vessel occlusion; MRA, magnetic resonance angiography; ROC, receiver-operating characteristics; and TCD, transcranial Doppler.

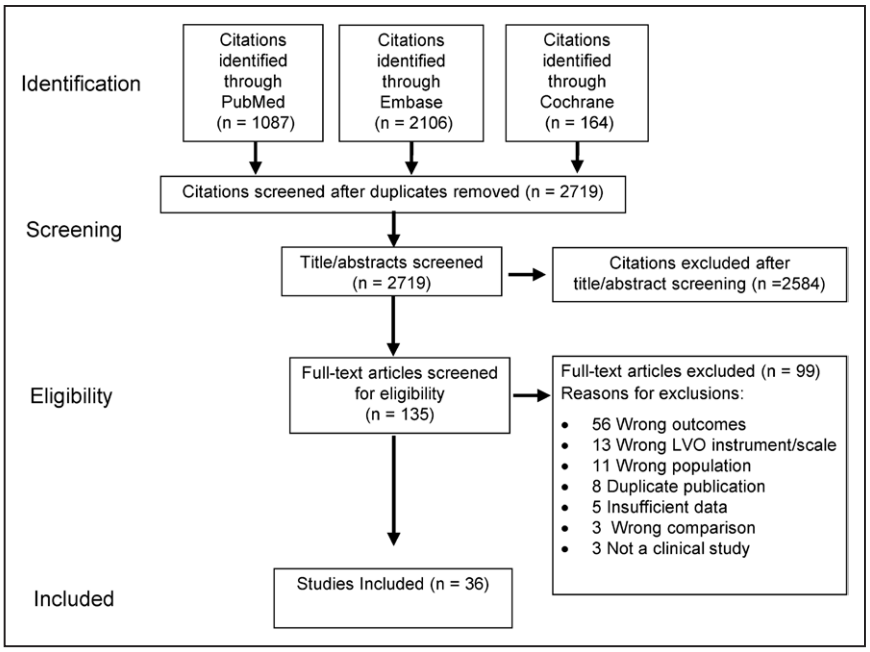


**Figure 1.** Flow diagram. LVO indicates large vessel occlusion.

Diagnostic Accuracy-2 tool[6] for studies of diagnostic accuracy, complemented by an additional assessment with the Checklist for Critical Appraisal and Data Extraction for Systematic Reviews of Prediction Modelling Studies checklist[7] if the study used prediction modeling techniques. Discrepancies were resolved by a third reviewer (the ERC chair).

## Data Abstraction

Data points and metadata were extracted by Doctor Evidence analysts from the articles and entered manually into the DOC Data 2.0 software platform (Santa Monica, CA) using an electronic extraction form and guided by a data configuration protocol with automated quality control features to prevent incorrect data-type entry. Each abstracted data point was verified manually against the source article by an independent reviewer (ie, single extraction with sequential quality control).

Ontology management was undertaken to ensure consistency in the naming of characteristics and outcomes across all studies in a data set.

Abstracted study characteristics included study design, publication type, publication year, sample size, setting, and population. The study setting was defined on the basis of the location where the LVO prediction instrument was applied, categorized as emergency room, prehospital/field (if applied before arrival at the hospital where diagnostic angiography was performed), mixed (if applied in either or both settings), and unclear/not specified. The study population was categorized as having suspected stroke if it included patients with hemorrhagic stroke and stroke mimics in addition to ischemic stroke and as having ischemic stroke if it included only patients diagnosed with ischemic stroke with noncontrast CT to rule out hemorrhagic stroke.

When sufficient data were available, the numbers of true positives, false positives, true negatives, and false negatives were abstracted or calculated from the study data.

Authors were contacted as needed to clarify study details required to determine study eligibility but were not requested to provide additional data.

## Meta-Analysis

When results from >1 study were available, forest plots were produced stratified by LVO prediction instrument and population (suspected stroke or ischemic stroke). There were too few studies in the prehospital setting for meta-analysis. Because prediction instruments are based on an ordinal score, the choice of the specific threshold used to define positive or negative results is under the control of the study authors. For studies that presented data based on a single threshold, bivariate diagnostic random-effects meta-analysis was used to produce pooled estimates of sensitivity and specificity at the single threshold.[8]

When sufficient data were available for a given LVO prediction instrument, summary receiver-operating characteristics (ROC) curves were calculated with the R package developed by Steinhauser et al.[9] We compared the restricted maximum likelihood criterion between a series of models with different specifications (ie, common random versus different random intercepts, common versus different random slopes) and picked the one with the smallest restricted maximum likelihood criterion, indicating the best model fit, using the same strategy as presented by Steinhauser et al. For the summary ROC curves, sensitivities and specificities were reported at thresholds based on clinical appropriateness and the availability of data.

The posttest probability of LVO in the presence of a positive and negative result on LVO screening was graphed across a range of LVO prevalences with the use of pooled sensitivity and specificity values from the meta-analysis. We found few published data on the population-representative prevalence of LVO[10] and substantial variation in the prevalence of LVO in the studies that we reviewed (Table II in the online Data Supplement). Furthermore, the prevalence of LVO in patients with suspected stroke is influenced by the size of the

**Table 2. Characteristics of Included Studies**

| Characteristic | Category | Suspected Stroke, n | Ischemic Stroke, n |
|---|---|---|---|
| n | | 12* | 24 |
| Design | Ambispective observational | 1 | 0 |
| | Case-control | 1 | 0 |
| | Prospective observational | 5 | 8 |
| | Retrospective observational | 5 | 16 |
| Type | Journal article | 9 | 16 |
| | Letter to the editor | 0 | 1 |
| | Meeting abstract | 3 | 7 |
| Year of publication | 2002–2007 | 2 | 3 |
| | 2008–2012 | 0 | 4 |
| | 2013–2014 | 1 | 3 |
| | 2015–2016 | 9 | 14 |
| Median size | | 459.5 | 269 |
| Setting | Emergency room | 9 | 14 |
| | Mixed | 1 | 3 |
| | Prehospital/field | 2 | 0 |
| | Unclear/not specified | 0 | 7 |
| Administrator | Neurologist | 3 | 8 |
| | Other physician | 0 | 1 |
| | EMS | 1 | 2 |
| | Mixed (EMS and neurologist) | 1 | 0 |
| | ED nurse | 0 | 1 |
| | Research staff | 1 | 1 |
| | Not specified | 6 | 11 |

Setting refers to the site where the large vessel occlusion prediction instrument was applied. ED indicates emergency department; and EMS, emergency medical services.

*One study of suspected stroke also provided diagnostic accuracy for the subset with ischemic stroke; in this table, it is included in the Suspected Stroke column.

denominator, which in turn is influenced by local dispatch and stroke activation protocols. Therefore, the positive predictive value and negative predictive value were graphed over a range of LVO prevalences that by consensus reflected realistic ranges.

## Results

The review returned 2719 articles, of which 135 received full-text review to identify 36 eligible studies (Figure 1). In total, the 36 studies presented information on 34 different LVO prediction instruments. Most prediction instruments were derived from elements of the National Institutes of Health Stroke Scale (NIHSS). The evidence table with accompanying references is provided in Table II of the online Data Supplement. A glossary of acronym definitions for the LVO prediction instruments is provided in Table III and full descriptions of commonly used scales are provided in Table IV of the online Data Supplement.

Characteristics of the included studies are shown in Table 2. There were 25 journal articles and 11 conference abstracts. Most studies (25 of 36) were performed in ischemic stroke populations; only 12 of 36 were performed in suspected stroke populations (1 study included both). The LVO prediction instrument was used in a prehospital setting in 4 of 36 studies, in a hospital emergency room in 28 of 36, and in a mixed setting including prehospital and hospital-based assessments in 4 of 36. In most studies, the administrator of the LVO prediction instrument was either a neurologist (11 of 36) or not specified (17 of 36).

Only 4 studies specified that the LVO instrument was applied by EMS.[11–14] The instruments in those studies were the NIHSS, Cincinnati Prehospital Stroke Screen, Los Angeles Motor Scale (LAMS), Los Angeles Prehospital Stroke Screen, and Rapid Arterial Occlusion Evaluation (RACE). Two of these 4 studies included suspected stroke patients,[11,13] whereas the other 2 included only patients who were diagnosed with ischemic stroke.[12,14]

Study sample sizes are summarized in Table 2. Participant numbers were skewed by 1 very large study from the Safe Implementation of Thrombolysis in Stroke–International Stroke Thrombolysis Registry with 11 632 participants.[15]

Study quality is shown in Table 3. Many studies had a high risk for bias or unclear risk for bias. Common reasons included risk for patient selection bias resulting from a lack of consecutive enrollment or potential selection bias (eg, patients were deemed ineligible for EVT for unclear reasons and not included), risk for index test bias because thresholds to predict LVO were derived in the same population in which they were tested, risk for index test bias resulting from a lack of prespecified thresholds for LVO, risk for reference standard bias because interpretation of CT angiography or magnetic resonance angiography was not blinded to stroke severity, and risk for flow and timing bias because the timing between application of the LVO prediction instrument and radiological imaging was either long or not specified (of relevance because longer times may bias toward more false-positive LVO predictions as a result of spontaneous recanalization). However, most studies were rated to be applicable to the study question. Additional explanation of the methods for determining bias is given in Table V of the online Data Supplement.

Study authors suggested preferred thresholds to identify patients with LVO for 19 different LVO prediction instruments. Thresholds were most commonly provided for the NIHSS (21 studies).* Other LVO prediction instrument thresholds for which multiple studies provided thresholds were the Cincinnati Prehospital Stroke Severity Scale (CPSSS; 8 studies),[21,23–25,35,39,42,45] RACE (6 studies),[11,13,21,25,35,45] LAMS (5 studies),[13,14,30,39,45] and 3-item stroke scale (4 studies).[21,32,35,39] Eighteen other LVO prediction instruments were described in single studies without replication.† (Some studies provided preferred thresholds for >1 scale.)

Area under the ROC curve (when reported) and sensitivity and specificity for author-recommended thresholds for scales tested in >1 study are listed in Table 4 stratified by population

*References 12, 13, 15–19, 21, 26, 27, 29–31, 33–35, 38–40, 43, 45.
†References 11, 13, 20, 21, 24, 25, 28, 34–37, 39, 41–44, 46.

**Table 3. Risk for Bias and Applicability as Determined With the QUADAS-2[6] Tool**

| Authors | Publication Year | Document Type | Risk of Bias | | | | Applicability Concerns | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Patient Selection | Index Test | Reference Standard | Flow and Timing | Patient Selection | Index Test | Reference Standard |
| Carrera et al[11] | 2016 | Journal article | ? | High | ? | ? | Low | Low | Low |
| Cooray et al[15] | 2015 | Journal article | High | High | ? | High | Low | Low | Low |
| Derex et al[16] | 2001 | Journal article | Low | Low | Low | High | ? | Low | Low |
| Fischer et al[17] | 2005 | Journal article | High | High | Low | High | High | Low | Low |
| González et al[18] | 2013 | Journal article | ? | Low | High | Low | Low | Low | Low |
| Hansen et al[19] | 2015 | Journal article | Low | High | Low | Low | Low | Low | Low |
| Hastrup et al[20] | 2016 | Journal article | High | High | High | High | High | Low | Low |
| Heldner et al[21] | 2016 | Journal article | High | High | Low | ? | Low | Low | Low |
| Heldner et al[22] | 2013 | Journal article | ? | High | Low | ? | Low | Low | Low |
| Katz et al[23] | 2015 | Journal article | High | Low | Low | High | High | Low | Low |
| Kesinger et al[12] | 2015 | Journal article | High | Low | ? | High | High | High | ? |
| Kummer et al[24] | 2016 | Journal article | ? | High | ? | ? | ? | Low | Low |
| Lima et al[25] | 2016 | Journal article | Low | High | High | ? | Low | Low | Low |
| Maas et al[26] | 2009 | Journal article | Low | Low | High | ? | Low | Low | Low |
| Matias-Guiu et al[27] | 2014 | Journal article | High | High | ? | ? | High | Low | Low |
| Moore et al[28] | 2016 | Journal article | High | Low | Low | ? | High | Low | High |
| Nakajima et al[29] | 2004 | Journal article | High | High | Low | ? | High | Low | Low |
| Nazliel et al[30] | 2008 | Journal article | High | High | Low | Low | High | Low | Low |
| Olavarria et al[31] | 2011 | Journal article | Low | High | Low | High | Low | Low | High |
| Singer et al[32] | 2005 | Journal article | Low | High | Low | ? | Low | Low | Low |
| Slivka et al[33] | 2006 | Journal article | High | High | Low | High | High | Low | Low |
| Teleb et al[34] | 2016 | Journal article | ? | Low | ? | ? | ? | Low | Low |
| Turc et al[35] | 2016 | Journal article | Low | High | Low | Low | Low | Low | Low |
| Vanacker et al[36] | 2016 | Journal article | High | High | Low | ? | High | Low | Low |
| Zuckerman et al[37] | 2016 | Journal article | High | High | ? | ? | ? | Low | High |
| Scheitz et al[38] | 2015 | Letter to the editor | High | High | ? | ? | High | Low | Low |
| Castillo et al[39] | 2016 | Abstract | ? | Low | ? | ? | ? | Low | Low |
| Christensen et al[40] | 2012 | Abstract | ? | ? | Low | ? | ? | Low | Low |
| Garcia-Cabo Fernandez et al[41] | 2015 | Abstract | ? | ? | ? | ? | ? | Low | ? |
| Gropen et al[42] | 2016 | Abstract | ? | ? | ? | ? | ? | Low | Low |
| Higashimori and Anderson[43] | 2016 | Abstract | ? | Low | ? | ? | Low | Low | ? |
| Mahdi et al[44] | 2016 | Abstract | High | ? | ? | ? | High | Low | Low |
| Noorian et al[14] | 2016 | Abstract | High | Low | ? | ? | High | Low | Low |
| Qureshi et al[45] | 2016 | Abstract | Low | Low | ? | ? | Low | Low | ? |
| Sequiera et al[13] | 2016 | Abstract | ? | Low | ? | ? | Low | Low | ? |
| Venizelos et al[46] | 2014 | Abstract | ? | ? | ? | ? | Low | Low | Low |

Low indicates low risk of bias; High, high risk of bias; and ?, unclear risk of bias. For details on definitions of high or low risk, see Reference 5 and Table V of the Online Data Supplement.

QUADAS-2 indicates Quality Assessment of Diagnostic Accuracy-2.

(ischemic stroke versus suspected stroke). The proportion of patients with suspected strokes who did not have ischemic stroke ranged from 5% to 69% (Table 4 and Table II of the online Data Supplement). One study using an NIHSS score threshold did not have sufficient information to determine sensitivity and specificity.[22]

Meta-analysis was possible for the NIHSS, CPSSS, LAMS, RACE, and 3-item stroke scale. Analyses were stratified

**Table 4. Sensitivity and Specificity of Scales Reported by ≥2 Studies**

| LVO Prediction Instrument | Stroke Type | Threshold | Authors | Year | Study Sample Size | Nonischemic Stroke, % | Setting | AUC | Sensitivity, % | Specificity, % |
|---|---|---|---|---|---|---|---|---|---|---|
| NIHSS | Ischemic stroke | ≥6 | Teleb et al[34] | 2016 | 62 | NA | ED | | 100 | 79 |
| | | ≥10 | Christensen et al[40] | 2012 | 409 | NA | Unclear | | 56 | 91 |
| | | ≥10 | Maas et al[26] | 2009 | 699 | NA | ED | | 48 | 87 |
| | | ≥10 | Matias-Guiu et al[27] | 2014 | 71 | NA | ED | 0.79 | 73 | 73 |
| | | ≥10 | Nakajima et al[29] | 2004 | 43 | NA | ED | | 89 | 88 |
| | | ≥11 | Cooray et al[15] | 2015 | 11 632 | NA | Unclear | 0.68 | 65 | 64 |
| | | ≥11 | Nazliel et al[30] | 2008 | 119 | NA | ED | 0.93 | 91 | 87 |
| | | ≥11 | Scheitz et al[38] | 2015 | 229 | NA | Unclear | 0.77 | 76 | 77 |
| | | ≥11 | Turc et al[35] | 2016 | 1004 | NA | ED | | 73 | 83 |
| | | ≥12 | Fischer et al[17] | 2005 | 226 | NA | ED | | 81 | 75 |
| | | ≥12 | Kesinger et al[12] | 2015 | 305 | NA | Prehospital | 0.77 | 52 | 87 |
| | | ≥14 | Castillo et al[39] | 2016 | 113 | NA | ED | | 27 | 95 |
| | | ≥15 | Qureshi et al[45] | 2016 | 42 | NA | Prehospital | | 32 | 96 |
| | | ≥17 | Derex et al[16] | 2002 | 50 | NA | ED | | 61 | 85 |
| | | ≥17 | Olavarría et al[31] | 2011 | 463 | NA | ED | | 37 | 92 |
| | Suspected stroke | ≥6 | Hansen et al[19] | 2015 | 637 | 25.4 | ED | | 68 | 79 |
| | | ≥6 | Sequeira et al[13] | 2015 | 1293 | Unclear | Prehospital | | 74 | 62 |
| | | ≥7 | Heldner et al[21] | 2016 | 1085 | 17.1 | ED | 0.85 | 81 | 77 |
| | | ≥7 | Higashimori and Anderson[43] | 2016 | 28 | Unclear | ED | | 83 | 77 |
| | | ≥10 | Slivka et al[33] | 2006 | 88 | 4.5 | ED | | 73 | 67 |
| | | ≥11 | González et al[18] | 2013 | 649 | Unclear | ED | | 61 | 88 |
| | | ≥15 | Qureshi et al[45] | 2016 | 92 | 54.3 | Prehospital | | 32 | 86 |
| CPSSS | Ischemic stroke | ≥2 | Castillo et al[39] | 2016 | 113 | NA | ED | | 41 | 96 |
| | | ≥2 | Gropen et al[42] | 2016 | 1663 | NA | Unclear | 0.65 | 47 | 90 |
| | | ≥2 | Katz et al[23] | 2015 | 303 | NA | Unclear | 0.67 | 83 | 40 |
| | | ≥2 | Kummer et al[24] | 2016 | 664 | NA | ED | 0.85 | 70 | 87 |
| | | ≥2 | Qureshi et al[45] | 2016 | 42 | NA | Prehospital | | 58 | 87 |
| | | ≥2 | Turc et al[35] | 2016 | 1004 | NA | ED | | 65 | 84 |
| | Suspected stroke | ≥1 | Heldner et al[21] | 2016 | 1085 | 17.1 | ED | 0.80 | 60 | 87 |
| | | ≥2 | Lima et al[25] | 2016 | 727 | 33.0 | ED | 0.75 | 56 | 85 |
| | | ≥2 | Qureshi et al[45] | 2016 | 92 | 54.3 | Prehospital | | 58 | 77 |
| LAMS | Ischemic stroke | ≥4 | Castillo et al[39] | 2016 | 113 | NA | ED | | 5 | 97 |
| | | ≥4 | Nazliel et al[30] | 2008 | 119 | NA | ED | 0.85 | 81 | 89 |
| | | ≥4 | Noorian et al[14] | 2016 | 190 | NA | Mixed | 0.70 | 74 | 58 |
| | | ≥4 | Qureshi et al[45] | 2016 | 42 | NA | Prehospital | | 47 | 96 |
| | Suspected stroke | ≥3 | Sequeira et al[13] | 2015 | 1293 | Unclear | Prehospital | | 62 | 70 |
| | | ≥4 | Qureshi et al[45] | 2016 | 92 | 54.3 | Prehospital | | 47 | 90 |
| RACE | Ischemic stroke | ≥5 | Qureshi et al[45] | 2016 | 42 | NA | Prehospital | | 63 | 96 |
| | | ≥5 | Turc et al[35] | 2016 | 1004 | NA | ED | | 67 | 85 |
| | Suspected stroke | ≥3 | Heldner et al[21] | 2016 | 1085 | 17.1 | ED | 0.83 | 74 | 80 |
| | | ≥4 | Sequeira et al[13] | 2015 | 1293 | Unclear | Prehospital | | 56 | 87 |

(*Continued*)

**Table 4. Continued**

| LVO Prediction Instrument | Stroke Type | Threshold | Authors | Year | Study Sample Size | Nonischemic Stroke, % | Setting | AUC | Sensitivity, % | Specificity, % |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ≥5 | Carrera et al[11] | 2016 | 341 | 31.7 | Mixed | 0.82 | 85 | 68 |
| | | ≥5 | Lima et al[25] | 2016 | 727 | 33.0 | ED | 0.77 | 55 | 87 |
| | | ≥5 | Qureshi et al[45] | 2016 | 92 | 54.3 | Prehospital | | 63 | 85 |
| 3-item SS | Ischemic stroke | ≥4 | Castillo et al[39] | 2016 | 113 | NA | ED | | 9 | 99 |
| | | ≥4 | Turc et al[35] | 2016 | 727 | NA | ED | | 30 | 95 |
| | Suspected stroke | ≥1 | Heldner et al[21] | 2016 | 1085 | 17.1 | ED | 0.79 | 73 | 78 |
| | | ≥4 | Singer et al[32] | 2005 | 83 | Unclear | ED | | 67 | 92 |

See Table III in the Online Data Supplement for a full description of the scales. AUC indicates area under the receiver-operating characteristics curve; CPSSS, Cincinnati Prehospital Stroke Severity Scale; ED, emergency department; LAMS, Los Angeles Motor Scale; LVO, large vessel occlusion; NA, not applicable; NIHSS, National Institutes of Health Stroke Scale; RACE, Rapid Arterial Occlusion Evaluation; and SS, stroke scale.

by patient population and performed separately for patients with suspected stroke and patients with ischemic stroke. Summary ROC curves could be modeled for NIHSS (in both confirmed and suspected stroke) and for CPSSS (in ischemic stroke only; Figure 2). Otherwise, we pooled data to calculate sensitivity and specificity for these cut points: CPSSS score ≥2, LAMS score ≥4, RACE score ≥5, and 3-item stroke scale score ≥4 (Figure 3).

Figure 4 shows the posttest probability of LVO in patients with a positive test (ie, the positive predictive value) and a

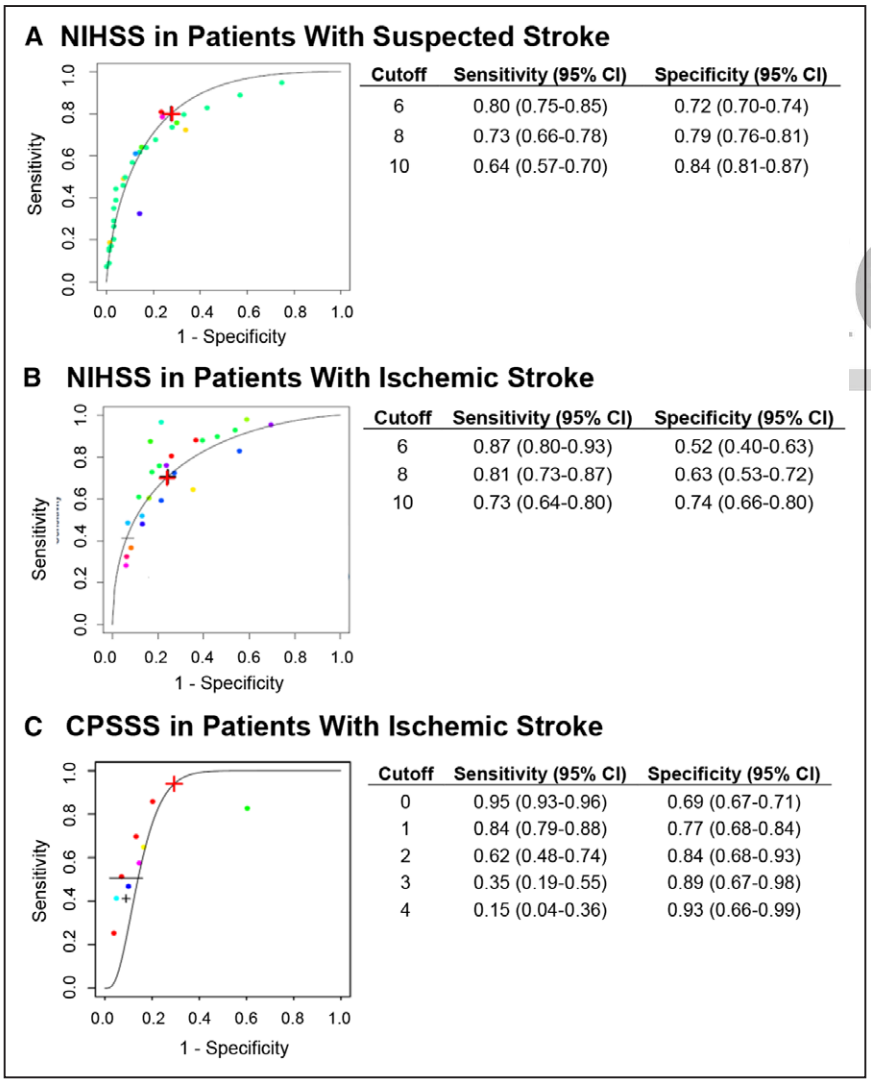


**Figure 2.** Summary pooled receiver-operating characteristics (ROC) curves. Summary pooled ROC curves and sensitivity and specificity for different scale thresholds for the National Institutes of Health Stroke Scale (NIHSS) in (**A**) suspected stroke[18,19,21,25,33,43,45] and (**B**) ischemic stroke,[12,15,16,17,26,27,29,31,34,35,38,39,45] and the (**C**) Cincinnati Prehospital Stroke Severity Scale (CPSSS) in ischemic stroke.[23,24,35,39,42,45] Data are pooled from studies in the prehospital and emergency department settings. There were too few studies in the prehospital setting for separate meta-analysis. Each data point indicates a threshold value from an individual study, with different studies indicated by different colors. The red cross indicates the optimal model-calculated threshold value if sensitivity and specificity are weighted equally. CI indicates confidence interval.

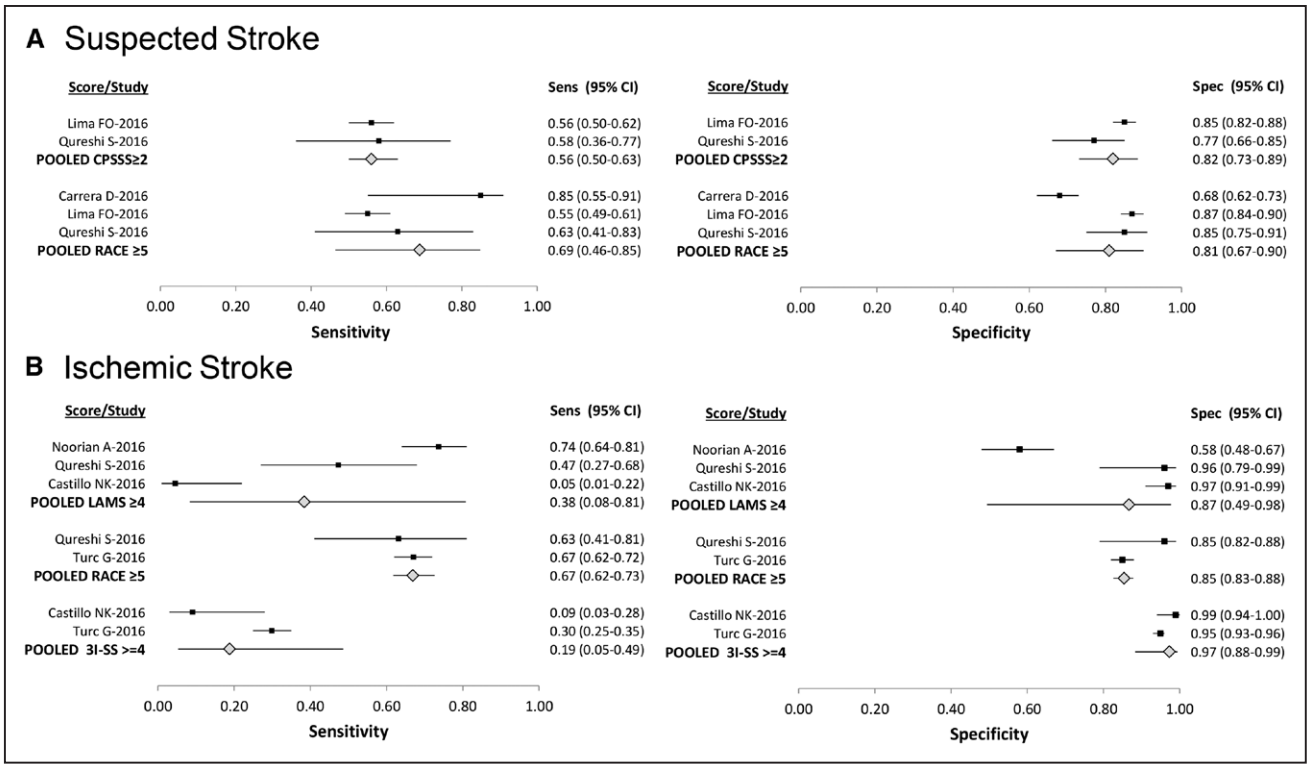


**Figure 3.** Meta-analysis of sensitivity (Sens) and specificity (Spec). Data are pooled from studies in the prehospital and emergency department settings. There were too few studies in the prehospital setting for separate meta-analysis. (National Institutes of Health Stroke Scale pooled receiver-operating characteristics curves are shown in Figure 2.) CI indicates confidence interval; CPSSS, Cincinnati Prehospital Stroke Severity Scale; LAMS, Los Angeles Motor Scale; RACE, Rapid Arterial Occlusion Evaluation; and 3I-SS, 3-item stroke scale.

negative test for different commonly reported scales and thresholds for both suspected stroke and ischemic stroke. We display results for CPSSS score ≥2, LAMS score ≥4, RACE score ≥5, 3-item stroke scale score ≥4, and NIHSS score ≥6 for suspected stroke, and for NIHSS thresholds ≥6, ≥8, and ≥10 for ischemic stroke. The posttest probability of a LVO given a positive screen ranges from ≈35% to 50% over the range of expected frequency of LVO in suspected stroke patients (Figure 4A), meaning that the false-positive rate is expected to be in the range of 50% to 65%.

## Conclusions

This systematic review found that the most frequently validated LVO prediction instruments were the NIHSS, CPSSS, LAMS, and RACE. Area under the ROC curve was mostly 0.70 to 0.85 (Table 4), indicating moderate to good discrimination of the presence versus absence of LVO in individual patients. No scale, however, determined the presence versus absence of LVO with both high sensitivity and specificity. Some studies evaluated >1 scale in the same population but without formal statistical comparison of the performance of any of the tested scales with each other. Therefore, we failed to find convincing evidence for the superiority of any 1 prediction instrument.

These findings have important implications for the design of hospital bypass and referral policies within stroke systems of care. Choice of an LVO prediction instrument and threshold should depend on the harms of failing to identify LVO (ie, false negatives) and the cost of transfer for EVT in patients in whom an LVO is absent (ie, false positives). The false-positive rates for LVO prediction are relatively high (50%–65%; Figure 4). In comparison, they exceed the goal of 30% overtriage for EMS identification of stroke (all stroke, not just LVO) recommended by American Heart Association/American Stroke Association policy for implementing stroke systems of care.[47] Choosing a more sensitive threshold will avoid missing potentially treatable patients but will lead to more transfers of patients without LVO, increasing the burden on emergency departments and stroke services at EVT-capable hospitals and depriving EVT-incapable hospitals of patients for whom are otherwise equipped to care. Depending on the interplay between the added transport time and the typical door-to-needle time at the destination hospital, bypassing primary stroke centers could either delay or, if the primary stroke centers have longer door-to-needle times than the EVT-capable hospitals, speed up the delivery of alteplase. On the contrary, choosing a more specific threshold will avoid unnecessary transfers of patients without LVO but will result in more missed opportunities for treatment with EVT.

The optimal LVO prediction instrument may also depend on the setting and administrator. We considered 2 main scenarios in which we foresaw LVO prediction instruments being applied.

First, we considered the scenario in which patients with suspected stroke would be assessed in the field by EMS to aid the decision of whether to transport the patient directly to an EVT-capable hospital. The optimal scale is unclear in this circumstance. We did not consider the NIHSS to be

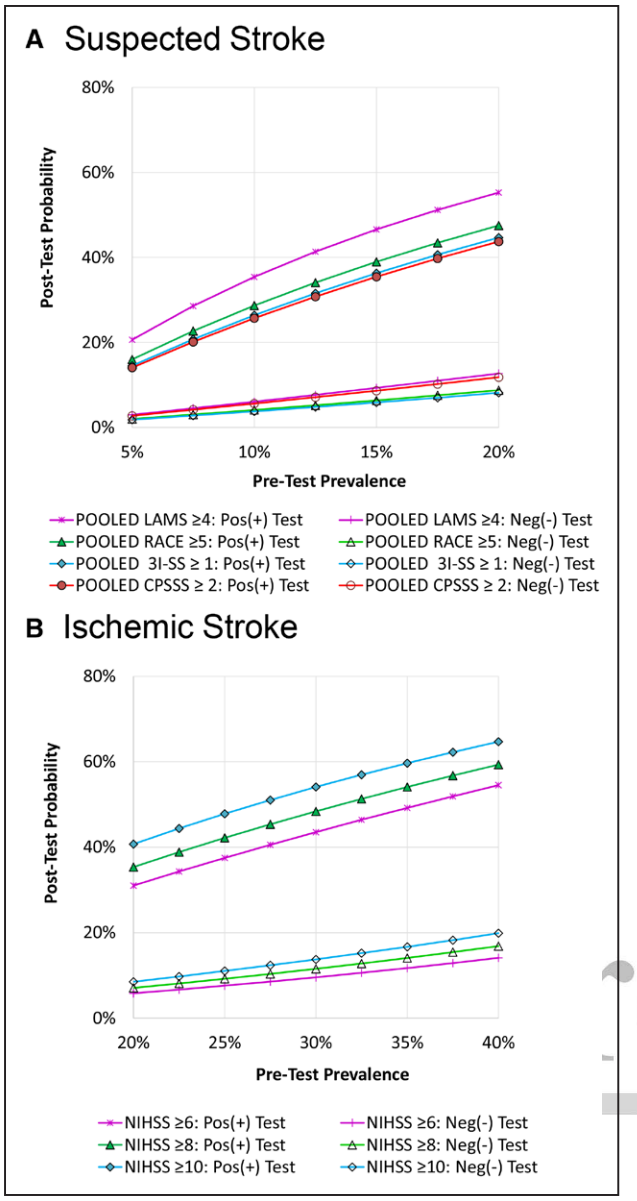


**Figure 4.** Posttest probability. Posttest probability (*y* axis) of having large vessel occlusion (LVO) when the test is positive [Pos(+) Test] or when the test is negative [Neg(-) Test] for a range of true LVO prevalences (*x* axis) for (**A**) suspected stroke and (**B**) ischemic stroke. Data are pooled from studies in the prehospital and emergency department settings. There were too few studies in the prehospital setting for separate meta-analysis. CPSSS indicates Cincinnati Prehospital Stroke Screen; LAMS, Los Angeles Motor Scale; NIHSS, National Institutes of Health Stroke Scale; RACE, Rapid Arterial Occlusion Evaluation; and 3I-SS, 3-item stroke scale.

feasible for this purpose because it requires a greater degree of training, may be too time-consuming to perform, and has not been as well validated in the prehospital setting. Currently, the CPSSS, LAMS, and RACE have been studied the most in prehospital settings (but only in 4 studies[11–14]), and no single scale has been demonstrated to have a clear advantage over the others. With the use of typical thresholds for these scales, sensitivities ranged from 47% to 73% and specificities from 78% to 90% (Figure 3). There was wide variation between studies in the proportion of suspected stroke cases that were later diagnosed as ischemic stroke (range, 5%–69%), suggesting that there may have been differences in the study definitions of suspected stroke or in ascertainment methods for ischemic stroke.

Second, we considered the scenario in which ischemic stroke patients would be assessed by a neurologist or emergency department physician in the emergency room of a hospital without CT angiography or magnetic resonance angiography capabilities. In this scenario, the NIHSS appears to be a useful LVO prediction instrument because it has the largest amount of validation data, is recommended for assessment of stroke severity by the 2013 American Heart Association/American Stroke Association guidelines,[48] is already a performance measure for quality stroke care in the United States,[49] and has acceptable reliability when administered by physicians or nurses.[50] It also provides the opportunity to select from a number of thresholds to minimize either false positives or false negatives. According to our meta-analysis, a threshold of ≥10 would equally balance sensitivity (73%) and specificity (74%; Figure 2). To maximize sensitivity (at the cost of lower specificity), a lower threshold should be used. A threshold of ≥6 (the minimum stroke severity recommended for EVT by the 2013 American Heart Association/American Stroke Association guidelines)[48] would have 87% sensitivity and 52% specificity (Figure 2). However, even this low threshold misses some cases with LVO, and the low specificity indicates that false positives will be common.

The posttest probability of LVO in the presence of a positive or negative result on the LVO prediction instrument is shown in Figure 4. This graph demonstrates how the LVO prediction instruments would work in clinical practice. A positive LVO prediction test indicates that the probability of LVO could be ≥50%, depending on the underlying true prevalence, but the probability of LVO with a negative test could still be ≥10%. Figure 4 also shows that the different prehospital LVO prediction instruments have similar performance characteristics. Given the variation in estimates and overlapping confidence limits from meta-analysis (Figure 3), there is insufficient evidence to conclude that 1 LVO prediction instrument is better than the others.

We identified limitations of the current literature. Many studies were at some risk of bias. One third were published in abstract form but not published as peer-reviewed journal articles by April 1, 2017. Some articles evaluated the accuracy of multiple scales but without formal statistical comparisons of their discrimination. There were only 4 studies conducted in the prehospital setting by EMS,[11–14] although this is the setting in which LVO prediction instruments would have the greatest impact on referral patterns. For studies of suspected stroke, the denominator population was often not defined precisely, raising questions about the applicability of the results to other stroke systems. Given the importance of the underlying prevalence of LVO on the results of using these instruments, the lack of high-quality studies on the population-representative prevalence of LVO is a major limitation.

Our findings suggest that the NIHSS is the optimal LVO prediction instrument in the hospital emergency department, whereas in the prehospital setting, a variety

of scales, including the CPSSS, LAMS, and RACE, could be used without clear evidence for superiority of 1 scale over the others. It is unlikely that a clinical stroke severity scale predicts LVO with both high sensitivity and specificity. Therefore, systems that use LVO prediction instruments must accept that some patients with LVO and fewer or milder stroke signs will be missed and false-positive results will be common. Nevertheless, on the basis of the predictive performance reported here and depending on the setting, use of a predictive instrument may be preferable to an unselected population-wide strategy (eg, bypassing the nearest hospital to transport all suspected stroke patients to the nearest EVT-capable hospital). The most important clinical question is how well LVO prediction instruments perform when administered by EMS in the prehospital setting, but this has been the least well studied. There is a need for more prospectively designed studies to compare the accuracy of different LVO prediction instruments administered by EMS in the prehospital setting in precisely defined populations with suspected stroke. In addition, decision analysis studies are needed to estimate the costs and benefits of different screening, rerouting, and transfer policies in different scenarios depending on the geographic distribution of EVT- and non–EVT-capable hospitals and their ability to handle changes in stroke case volumes. Given the limited number of studies specific to the prehospital setting, we suggest that such modeling studies examine how their conclusions are affected when a broad range of test performance characteristics and thresholds is used.

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# Accuracy of Prediction Instruments for Diagnosing Large Vessel Occlusion in Individuals With Suspected Stroke: A Systematic Review for the 2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke

Eric E. Smith, David M. Kent, Ketan R. Bulsara, Lester Y. Leung, Judith H. Lichtman, Mathew J. Reeves, Amytis Towfighi, William N. Whiteley, Darin B. Zahuranec and on behalf of the American Heart Association Stroke Council

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# Companion to: Accuracy of Prediction Instruments for Diagnosing Large Vessel Occlusion in Individuals With Suspected Stroke: A Systematic Review for the 2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke

## A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association

**Table of Contents**

**Table I. Full search strategy. All searches done on October 27, 2016**
**PUBMED**

| | |
|---|---|
| 1 | ((stroke screen*[tiab] OR stroke score[tiab] OR stroke scores[tiab] OR stroke scale[tiab] OR stroke scales[tiab] OR stroke recognition[tiab] OR stroke predict*[tiab] OR stroke severity scale[tiab] OR Los Angeles Prehospital Stroke Screen[tiab] OR LAPSS[tiab] OR "Melbourne Ambulance Stroke Scale"[tiab] OR "Melbourne Ambulance Stroke Screen"[tiab] OR Cincinnati Prehospital Stroke Severity Scale[tiab] OR CPSSS[tiab] OR Cincinnati Prehospital Stroke Scale[tiab] OR CPSS[tiab] OR "Field Assessment Stroke Triage for Emergency Destination"[tiab] OR FAST-ED[tiab] OR "Prehospital Acute Stroke Severity"[tiab] OR "Prehospital Acute Stroke Severity Scale"[tiab] OR Rapid Arterial Occlusion Evaluation[tiab] OR Ontario Prehospital Stroke Screening tool[tiab] OR OPSS[tiab] OR "Medic Prehospital Assessment for Code Stroke"[tiab] OR MedPACS[tiab] OR Face Arm Speech Test[tiab] OR "Recognition of Stroke in the Emergency Room"[tiab] OR ROSIER[tiab] OR Kurashiki Prehospital Stroke Scale[tiab] OR KPSS[tiab] OR Los Angeles Motor Scale[tiab] OR LAMS[tiab] OR "National Institutes of Health Stroke"[tiab] OR NIHSS[tiab] OR Canadian Neurological Scale[tiab] OR Scandinavian Stroke Scale[tiab] OR European Stroke Scale[tiab] OR Hemispheric Stroke Scale[tiab] OR "Matthew Stroke Scale"[tiab] OR Orgogozo Stroke Scale[tiab] OR Glasgow Coma Scale[tiab]) OR |
| 2 | ("Stroke/diagnosis"[Mesh] AND ("Emergency Medical Services/standards"[Mesh] OR "Emergency Medical Technicians/standards"[Mesh] OR "Emergency Service, Hospital/standards"[Mesh] OR "Severity of Illness Index"[Mesh]))) |
| 3 | 1 OR 2 |
| | |
| 4 | (Large-vessel[tiab] OR large-artery[tiab] OR Middle cerebral artery[tiab] OR MCA[tiab] OR M1[tiab] OR M2[tiab] OR LVO OR ELVO OR MCAO[tiab] OR tMCAO[tiab] OR Terminal internal carotid artery[tiab] OR terminal ICA[tiab] OR basilar[tiab] OR intracranial vertebral[tiab] OR "Infarction, Middle Cerebral Artery"[Mesh]) |
| 5 | (Occlusion*[tiab] OR thrombus[tiab] OR thrombosis[tiab] OR thrombotic[tiab] OR embolus[tiab] OR embolism[tiab] OR embolic[tiab]) |
| 6 | 4 OR 5 |
| | |
| 7 | 3 AND 6 |
| 8 | 7 NOT (animals[mh] NOT humans[mh]) |
| 9 | 8 AND 1975+ AND eng[la] |
| | |
| 10 | ("sensitivity and specificity"[MeSH Terms] OR predictive value of tests[MeSH] OR "Likelihood Functions"[Mesh] OR "Probability"[Mesh:NoExp] OR "Area Under Curve"[Mesh] OR "Reproducibility of Results"[Mesh] OR sensitiv*[tiab] OR accuracy[tiab] OR accurate[tiab] OR reliable[tiab] OR reliability[tiab] OR valid[tiab] OR validity[tiab] OR Likelihood ratio[tiab] OR Area under the |

| | |
|---|---|
| | curve[tiab] OR receiver operator characteristic[tiab] OR roc[tiab] OR Specificity[tiab] OR True positive*[tiab] OR true negative*[tiab] OR false positive*[tiab] OR false negative*[tiab] OR diagnostic odds ratio[tiab] OR predict*[tiab]) |
| 11 | 9 AND 10 |

**EMBASE**

| **EMBASE SEGMENT USED Embase <1974 to 2016 October 26>** |
|---|
| ***NOTE: Record all strategies used (if separate searches used for reviews, meetings, etc)*** |
| |
| 1 "national institutes of health stroke scale"/ |
| 2 (stroke screen$ or stroke score or stroke scores or stroke scale or stroke scales or stroke recognition or stroke predict$ or stroke severity scale or Los Angeles Prehospital Stroke Screen or LAPSS or Melbourne Ambulance Stroke Scale or Melbourne Ambulance Stroke Screen or Cincinnati Prehospital Stroke Severity Scale or CPSSS or Cincinnati Prehospital Stroke Scale or CPSS or Field Assessment Stroke Triage for Emergency Destination or FAST-ED or Prehospital Acute Stroke Severity or Prehospital Acute Stroke Severity Scale or Rapid Arterial Occlusion Evaluation or Ontario Prehospital Stroke Screening tool or OPSS or Medic Prehospital Assessment for Code Stroke or MedPACS or Face Arm Speech Test or Recognition of Stroke in the Emergency Room or ROSIER or Kurashiki Prehospital Stroke Scale or KPSS or Los Angeles Motor Scale or LAMS or National Institutes of Health Stroke or NIHSS or Canadian Neurological Scale or Scandinavian Stroke Scale or European Stroke Scale or Hemispheric Stroke Scale or Matthew Stroke Scale or Orgogozo Stroke Scale or Glasgow Coma Scale).ab,kw,ti. |
| 3 exp cerebrovascular accident/di [Diagnosis] |
| 4 emergency health service/ |
| 5 rescue personnel/ |
| 6 "severity of illness index"/ |
| 7 4 or 5 or 6 |
| 8 3 and 7 |
| 9 1 or 2 or 8 |
| 10 cerebral artery disease/ |
| 11 (Large-vessel or large-artery or Middle cerebral artery or MCA or M1 or M2 or LVO or ELVO or MCAO or tMCAO or Middle cerebral artery syndrome or Terminal internal carotid artery or terminal ICA or basilar or intracranial vertebral).ab,kw,ti. |
| 12 10 or 11 |
| 13 occlusion$.ab,kw,ti. |
| 14 (thrombus or thrombosis or thrombotic or embolus or embolism or embolic).ab,kw,ti. |
| 15 12 or 13 or 14 |
| 16 9 and 16 |
| 17 16 not ((exp animal/ or nonhuman/) not exp human/) |
| 18 limit 17 to (english language and yr="1975 -Current") |
| |
| |
| 19 "sensitivity and specificity"/ |
| 20 predictive value/ |
| 21 reproducibility/ |
| 22 probability/ |
| 23 exp area under the curve/ |

| | |
|---|---|
| 24 | exp diagnostic error/ |
| 25 | (sensitiv$ or accuracy or accurate or reliable or reliability or valid or validity or Likelihood ratio or Area under the curve or receiver operator characteristic or roc or Specificity or True positive$ or true negative$ or false positive$ or false negative$ or diagnostic odds ratio or predict$).ab,kw,ti. |
| 26 | 19 or 20 or 21 or 22 or 23 or 24 or 25 |
| 32 | 22 and 30 (2106) |

**Cochrane library**

| | |
|---|---|
| | |
| | Cochrane Central Register of Controlled Trials (Clinical Trials) |
| # | Searches |
| #1 | stroke screen* or stroke score or stroke scores or stroke scale or stroke scales or stroke recognition or stroke predict* or Los Angeles Prehospital Stroke Screen or LAPSS or Melbourne Ambulance Stroke Scale or Melbourne Ambulance Stroke Screen or Cincinnati Prehospital Stroke Severity Scale or CPSSS or Cincinnati Prehospital Stroke Scale or CPSS or Field Assessment Stroke Triage for Emergency Destination or FAST-ED or Prehospital Acute Stroke Severity or Rapid Arterial Occlusion Evaluation or Ontario Prehospital Stroke Screening tool or OPSS or Medic Prehospital Assessment for Code Stroke or MedPACS or Face Arm Speech Test or Recognition of Stroke in the Emergency Room or ROSIER or Kurashiki Prehospital Stroke Scale or KPSS or Los Angeles Motor Scale or LAMS or National Institutes of Health Stroke or NIHSS or Canadian Neurological Scale or Scandinavian Stroke Scale or European Stroke Scale or Hemispheric Stroke Scale or Matthew Stroke Scale or Orgogozo Stroke Scale or Glasgow Coma Scale:ti,ab,kw (Word variations have been searched) |
| #2 | ([mh Stroke/DI] and ([mh "Emergency Medical Services"/ST] or [mh "Emergency Medical Technicians"/ST] or [mh "Emergency Service, Hospital"/ST] or [mh "Severity of Illness Index"])) |
| #3 | #1 or #2 |
| #4 | [mh "Infarction, Middle Cerebral Artery"] |
| #5 | Large-vessel or large-artery or Middle cerebral artery or MCA or M1 or M2 or LVO or ELVO or MCAO or tMCAO or Middle cerebral artery syndrome or Terminal internal carotid artery or terminal ICA or basilar or intracranial vertebral:ti,ab,kw (Word variations have been searched) |
| #6 | #4 or #5 |
| #7 | #3 and #6 Publication Year from 1975 to 2016 |
| | |
| #8 | [mh "sensitivity and specificity"] or [mh "predictive value of tests"] or [mh "Likelihood Functions"] or [mh Probability] or [mh "Area Under Curve"] or [mh "Reproducibility of Results"] |
| #9 | sensitiv* or accuracy or accurate or reliable or reliability or valid or validity or Likelihood ratio or Area under the curve or receiver operator characteristic or roc or Specificity or True positive* or true negative* or false positive* or false negative* or diagnostic odds ratio:ti,ab,kw (Word variations have been searched) |
| #10 | #8 or #9 |
| #11 | #7 and #10 |

**Table II: Evidence Table**

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| Carrera D. 2016[1] 27720525 | **Study type:** Prospective Observational, Post-hoc; Journal Article<br><br>**Size:** N = 341 | **Inclusion criteria:** -Stroke Population, Suspected<br><br>**Exclusion criteria:** Not Reported | 68% | Mixed | Mixed: RACE by EMS, NIHSS by neurologist | LVO was defined as proximal MCA; intracranial carotid or tandem (internal carotid and MCA) occlusion; or basilar occlusion on transcranial ultrasound, CTA, MRA, or arteriography | **Prevalence of LVO**<br>71 (20.8%)<br>**AUC**<br>RACE >= 5 units: 0.821 units<br>sRACE version 1 >= 4 units: 0.805 units<br>sRACE version 2 >= 4 units: 0.791 units<br>sRACE version 3 >= 3 units: 0.783 units<br>sRACE version 4 >= 4 units: 0.798 units<br>sRACE version 5 >= 4 units: 0.791 units<br>sRACE version 6 >= 4 units: 0.77 units<br>sRACE version 7 >= 3 units: 0.757 units<br>**Sensitivity**<br>RACE >= 5 units: 84.9 %<br>sRACE version 1 >= 4 units: 84.5 %<br>sRACE version 2 >= 4 units: 84.5 %<br>sRACE version 3 >= 3 units: 88.7 %<br>sRACE version 4 >= 4 units: 87.3 %<br>sRACE version 5 >= 4 units: 83.1 %<br>sRACE version 6 >= 4 units: 83.1 %<br>sRACE version 7 >= 3 units: 87.3 %<br>**Specificity**<br>RACE >= 5 units: 67.9 %<br>sRACE version 1 >= 4 units: 56.3 %<br>sRACE version 2 >= 4 units: 62.2 %<br>sRACE version 3 >= 3 units: 48.1 %<br>sRACE version 4 >= 4 units: 55.9 %<br>sRACE version 5 >= 4 units: 57.4 %<br>sRACE version 6 >= 4 units: 63 %<br>sRACE version 7 >= 3 units: 50.7 %<br>**Overall Accuracy**<br>RACE >= 5 units: 71.4 %<br>sRACE version 1 >= 4 units: 62.2 %<br>sRACE version 2 >= 4 units: 66.9 %<br>sRACE version 3 >= 3 units: 56.6 %<br>sRACE version 4 >= 4 units: 62.5 % | • Using any of the 7 simplified versions of RACE scale increased false positive rates and resulted in a reduced ability to predict LVO in suspected acute stroke patients<br>• The study recommended use of the original RACE scale |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | sRACE version 5 >= 4 units: 62.8 %<br>sRACE version 6 >= 4 units: 67.2 %<br>sRACE version 7 >= 3 units: 58.4 % | |
| Castillo N.K. 2016[2]<br>Link to abstract | **Study type:**<br>Retrospective Observational; Meeting Abstract/Oral/Poster<br><br>**Size:**<br>N = 113 | **Inclusion criteria:**<br>-Stroke Population, Confirmed<br>-Stroke presenting within 8 hours of symptom onset<br>-From two Midwest metropolitan tertiary care centers<br>**Exclusion criteria:**<br>Not Reported | 100% | Emergency room | Unclear/ not specified; NIHSS administered prospectively and other scales calculated retrospectively | Unclear/not specified | **Prevalence of LVO**<br>22 (19.5%)<br>**Sensitivity**<br>NIHSS >= 14 units: 27 %<br>LAMS >= 4 units: 5 %<br>3I-SS >= 4 units: 9 %<br>CPSSS >= 2 units: 41 %<br>FAST >= 2 units: 86 %<br>**Specificity**<br>NIHSS >= 14 units: 95 %<br>LAMS >= 4 units: 97 %<br>3I-SS >= 4 units: 99 %<br>CPSSS >= 2 units: 96 %<br>FAST >= 2 units: 70 % | • FAST screen was the most sensitive and specific tool for predicting LVO among the 5 scales assessed in the study |
| Christensen H. 2012[3]<br>Link to abstract | **Study type:**<br>Prospective Observational; Meeting Abstract/Oral/Poster<br><br>**Size:**<br>N = 409 | **Inclusion criteria:**<br>-Stroke Population, Confirmed<br>-Stroke, Ischemic Hyper-acute<br>-Admitted for tissue plasminogen activator work up with routine computed tomography angiogram<br><br>**Exclusion criteria:**<br>Not Reported | 100% | Unclear/ not specified | Unclear/ not specified | Unclear/not specified | **Sensitivity**<br>NIHSS >= 10 units 56.1 [CI 95%: 46.9 – 65] %<br>**Specificity**<br>NIHSS >= 10 units 90.5 [CI 95%: 86.9 – 93.3] %<br>**Negative Predictive Value**<br>NIHSS >= 10 units 85.7 [CI 95%: 79.8 – 87.4] %<br>**Positive Predictive Value**<br>NIHSS >= 10 units 67 [CI 95%: 57 – 75] % | • LVO and NIHSS have a continuum relation.<br>• For a set cut off NIHSS score of 10, there is a 15% risk for missing an occlusion and a 33% risk of transportation with tPA administration |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| Cooray C. 2015[4] 25588617 | **Study type:** Prospective Observational; Journal Article<br><br>**Size:** N = 57213 | **Inclusion criteria:** -Stroke Population, Confirmed -Registered in the SITS-International Stroke Thrombolysis Register between December 2002 and March 2013 -Ischemic stroke -Treated solely with intravenous thrombolysis<br><br>**Exclusion criteria:** Note Reported | 100% | Unclear/ not specified | Unclear/ not specified | Unclear/not specified | **AUC**<br>NIHSS >= 11 units 0.678 units<br>**Disease Absent**<br>NIHSS >= 11 units 5901 (50.7%)<br>**Disease Present**<br>NIHSS >= 11 units 5731 (49.3%)<br>**Negative Predictive Value**<br>NIHSS >= 11 units 65.3 %<br>**Positive Predictive Value**<br>NIHSS >= 11 units 63.6 %<br>**Sensitivity**<br>NIHSS >= 11 units 64.5 %<br>**Specificity**<br>NIHSS >= 11 units 64.4 %<br>**Test Positive**<br>NIHSS >= 11 units 5784 (49.7%) | • Baseline NIHSS scores of 11 and 12 were identified as markers for vessel occlusion and functional independency after iv thrombolysis, respectively. |
| Derex L. 2002[5] 12011545 | **Study type:** Prospective Observational; Journal Article<br><br>**Size:** N = 54 | **Inclusion criteria:** -Stroke Population, Confirmed -Acute cerebral ischemia involving either carotid or vertebrobasilar territory -Neurological deficit lasting >1 h -Brain CT scan performed within 24 h of stroke onset -MRI performed within 24 h of stroke onset | 100% | Emergency room | Stroke team or stroke physician | Unclear/not specified | **Disease Absent**<br>NIHSS >= 17 units 27 (54%)<br>NIHSS >= 7 units 27 (54%)<br>**Disease Present**<br>NIHSS >= 17 units 23 (46%)<br>NIHSS >= 7 units 23 (46%)<br>**False Positive**<br>NIHSS >= 17 units 4 (8%)<br>NIHSS >= 7 units 16 (32%)<br>**Test Negative**<br>NIHSS >= 17 units 32 (64%)<br>NIHSS >= 7 units 11 (22%)<br>**Test Positive**<br>NIHSS >= 17 units 18 (36%)<br>NIHSS >= 7 units 39 (78%)<br>**True Positive**<br>NIHSS >= 17 units 14 (28%)<br>NIHSS >= 7 units 23 (46%) | • Good co-relation between MRA findings and NIHSS score.<br>• MRA showing the presence of cerebral arterial occlusion is directly related to baseline NIHSS score. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | **Exclusion criteria:** Not Reported | | | | | | |
| Fischer U. 2005[6] 16151026 | **Study type:** Prospective Observational: Journal Article<br><br>**Size:** N = 226 | **Inclusion criteria:** -Underwent digital subtraction arteriography (DSA) -Stroke Population, Confirmed -Acute Ischemic Stroke -Scored >=4 points on the National Institute of Health Stroke Scale or had an isolated aphasia or hemianopsia -Considered for intra-arterial thrombolysis (IAT)<br><br>**Exclusion criteria:** -Prior medical history of stroke -Cerebral hemorrhage on CT scan -Preexisting neurological illnesses that would confound the neurological evaluation | 100% | Emergency room | Stroke team or stroke physician | Arteriograms were used to divide patients into 8 groups according to the location of their arterial occlusion: (1) internal carotid artery (ICA) group, (2) main stem of the middle cerebral artery (MCA; M1) group, (3) main branch of MCA (M2) group, (4) branches of MCA (M3/4) group, (5) anterior cerebral artery (ACA) group, (6) posterior cerebral artery (PCA) group, (7) BA group, and (8) no visible occlusion (no occlusion) group. If a patient showed 2 occluded arteries, the patient was placed into the larger artery group (eg, if the ICA and the ipsilateral M1 segment were occluded, the patient was allocated to the ICA group). Analyses were performed for patients with ICA, M1, M2, or BA occlusions (central occlusion group) versus patients without visible | **Disease Absent, Central Occlusion**<br>NIHSS >= 10 units 55 (24.3%)<br>NIHSS >= 12 units 55 (24.3%)<br>**Disease Absent, No Occlusion**<br>NIHSS >= 10 units 26 (11.5%)<br>NIHSS >= 12 units 26 (11.5%)<br>**Disease Present, Central Occlusion**<br>NIHSS >= 10 units 171 (75.7%)<br>NIHSS >= 12 units 171 (75.7%)<br>**Disease Present, Occlusion**<br>NIHSS >= 10 units 200 (88.5%)<br>NIHSS >= 12 units 200 (88.5%)<br>**Positive Predictive Value, Central Occlusion**<br>NIHSS >= 12 units 91 %<br>**Sensitivity, Central Occlusion**<br>NIHSS >= 10 units 88.3 %<br>NIHSS >= 12 units 80.5 %<br>**Specificity, Central Occlusion**<br>NIHSS >= 10 units 63.6 %<br>NIHSS >= 12 units 74.5 % | • For an NIHSS ≥ 10, there is a considerable chance to find arterial occlusion and when the score rises to ≥ 12, the chances to find central occlusion are substantial. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | -Preexisting psychiatric illnesses that would confound the neurological evaluation<br>-Other preexisting illnesses that would confound the neurological evaluation | | | | occlusions or occlusions of the MCA (M3 or M4), ACA, or PCA (peripheral occlusion group). | | |
| Garcia-Cabo Fernandez C. 2015[7]<br>Link to abstract | **Study type:**<br>Retrospective Observational; Meeting Abstract/Oral/Poster<br><br>**Size:**<br>N = 235 | **Inclusion criteria:**<br>- Acute ischemic stroke<br>-Stroke Population, Confirmed<br><br>**Exclusion criteria:**<br>Not Reported | 100% | Emergency room | Neurologist or ED physician | Unclear/not specified | **AUC**<br>NIHSS-AS >= 4 units 0.73 units<br>**Sensitivity**<br>NIHSS-AS >= 4 units 77.5 %<br>**Specificity**<br>NIHSS-AS >= 4 units 64.2 % | • NIHSS-AS is an abbreviated stroke scale that can used by emergency physicians for predicting LVO in patients with Acute stroke. |
| González R.G. 2013 STOPStroke[8]<br>24003051 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 649 | **Inclusion criteria:**<br>-Suspected acute ischemic stroke<br>-Presented within 24 hours of symptom onset<br>-Multimodal computed tomography (CT) examination<br>-Stroke Population, Suspected<br><br>**Exclusion criteria:** | Unclear/ not specified | Emergency room | Other (study staff) | A major anterior circulation occlusion was defined as occlusion of the terminal ICA and proximal MCA(M1, M2) segments. | **Disease Present**<br>NIHSS >= 11 units 221 (34%)<br>NIHSS >= 16 units 221 (34%)<br>NIHSS >= 6 units 221 (34%)<br>NIHSS 0 units - 5 units 221 (34%)<br>NIHSS 11 units - 15 units 221 (34%)<br>NIHSS 6 units - 10 units 221 (34%)<br>**Positive Predictive Value**<br>NIHSS >= 11 units 72 %<br>**Test Positive**<br>NIHSS >= 11 units 188 (29%)<br>NIHSS >= 16 units 109 (16.8%)<br>NIHSS >= 6 units 297 (45.8%)<br>NIHSS 0 units - 5 units 352 (54.2%)<br>NIHSS 11 units - 15 units 79 (12.2%) | • IV tPA improved outcomes in patients with NIHSS> 10 with major anterior circulation occlusions. The better outcome rates are comparable to endovascular therapy trials. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | -Intracranial hemorrhage<br>-Contraindication to iodinated contrast agent<br>-Having a stroke while in hospital<br>-Lack of reliable National Institute of Health Stroke Scale (NIHSS) scores<br>-Lack of a reliable Modified Rankin scale (mRS) | | | | | NIHSS 6 units - 10 units 109 (16.8%)<br>**True Positive**<br>NIHSS >= 11 units 135 (20.8%) | |
| Gropen T. 2016 Comprehensive Stroke Center (CSC)[9]<br>Link to abstract | **Study type:**<br>Retrospective Observational; Meeting Abstract/Oral/Poster<br><br>**Size:**<br>N = 1663 | **Inclusion criteria:**<br>- Acute ischemic stroke (AIS)<br>-Enrolled in CSC Registry from 2008-2013<br>-Stroke Population, Confirmed<br>-Magnetic resonance angiogram (MRA)<br>-Computed tomography angiogram (CTA)<br><br>**Exclusion criteria:**<br>- < 18 years of age<br>-Non--ambulatory | 100% | Unclear/ not specified | Unclear/ not specified | LVO was defined as occlusion of the intracranial ICA, BA, or MCA. | **AUC**<br>CPSSS >= 2 units 0.646 [CI 95%: 0.598 – 0.693] units<br>LVOS >= 3 units 0.688 [CI 95%: 0.64 – 0.736] units<br>NIHSS 0.678 [CI 95%: 0.633 – 0.723] units<br>**Disease Present**<br>CPSSS >= 2 units 171 (10.3%)<br>LVOS >= 3 units 171 (10.3%)<br>NIHSS 171 (10.3%)<br>**Negative Likelihood Ratio**<br>CPSSS >= 2 units 0.238 NA<br>LVOS >= 3 units 0.162 NA<br>**Positive Likelihood Ratio**<br>CPSSS >= 2 units 2.87 NA<br>LVOS >= 3 units 1.517 NA<br>**Prevalence of LVO**<br>CPSSS >= 2 units 171 (10.3%)<br>NIHSS 171 (10.3%)<br>**Sensitivity**<br>CPSSS >= 2 units 46.8 [CI 95%: 39.7 – 54] %<br>LVOS >= 3 units 75.4 [CI 95%: 68.5 – 81.4] %<br>**Specificity** | • The LVOS compared favorably to the CPSSS in its ability to identify patients with LVO. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | CPSSS >= 2 units 90 %<br>LVOS >= 3 units 50.3 % | |
| Hansen CK 2015[10]<br>25319377 | **Study type:**<br>Prospective Observational; Journal Article<br><br>**Size:**<br>N = 637 | **Inclusion criteria:**<br>-Stroke population, suspected<br>-Acute stroke symptoms and duration of no more than 4.5 hours<br>-From a well-defined catchment area consisting of the entire Capital Region of Denmark<br>-Consecutive unselected cohort of patients admitted for thrombolysis<br><br>**Exclusion criteria:**<br>Not Reported | 75% | Emergency room | Unclear/ not specified | Anterior occlusions were defined as complete occlusions of extra cranial or intracranial ICA, MCA (M1), second division MCA (M2) and ACA and posterior as occlusions of extra cranial or intracranial VA, posterior cerebral artery (PCA) and BA. | **Disease Absent**<br>NIHSS >= 0 units 454 (71.3%)<br>NIHSS >= 1 unit 454 (71.3%)<br>NIHSS >= 10 units 454 (71.3%)<br>NIHSS >= 11 units 454 (71.3%)<br>NIHSS >= 12 units 454 (71.3%)<br>NIHSS >= 13 units 454 (71.3%)<br>NIHSS >= 14 units 454 (71.3%)<br>NIHSS >= 15 units 454 (71.3%)<br>NIHSS >= 16 units 454 (71.3%)<br>NIHSS >= 17 units 454 (71.3%)<br>NIHSS >= 18 units 454 (71.3%)<br>NIHSS >= 19 units 454 (71.3%)<br>NIHSS >= 2 units 454 (71.3%)<br>NIHSS >= 20 units 454 (71.3%)<br>NIHSS >= 21 units 454 (71.3%)<br>NIHSS >= 22 units 454 (71.3%)<br>NIHSS >= 23 units 454 (71.3%)<br>NIHSS >= 24 units 454 (71.3%)<br>NIHSS >= 25 units 454 (71.3%)<br>NIHSS >= 3 units 454 (71.3%)<br>NIHSS >= 4 units 454 (71.3%)<br>NIHSS >= 5 units 454 (71.3%)<br>NIHSS >= 6 units 454 (71.3%)<br>NIHSS >= 7 units 454 (71.3%)<br>NIHSS >= 8 units 454 (71.3%)<br>NIHSS >= 9 units 454 (71.3%)<br>**Disease Present**<br>NIHSS >= 0 units 183 (28.7%)<br>NIHSS >= 1 unit 183 (28.7%)<br>NIHSS >= 10 units 183 (28.7%)<br>NIHSS >= 11 units 183 (28.7%)<br>NIHSS >= 12 units 183 (28.7%)<br>NIHSS >= 13 units 183 (28.7%) | • Vessel occlusions can be expected in low and high NIHSS scores<br>• The best NIHSS cut off for detecting any acute vessel occlusion was determined to be 6 |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | NIHSS >= 14 units 183 (28.7%)<br>NIHSS >= 15 units 183 (28.7%)<br>NIHSS >= 16 units 183 (28.7%)<br>NIHSS >= 17 units 183 (28.7%)<br>NIHSS >= 18 units 183 (28.7%)<br>NIHSS >= 19 units 183 (28.7%)<br>NIHSS >= 2 units 183 (28.7%)<br>NIHSS >= 20 units 183 (28.7%)<br>NIHSS >= 21 units 183 (28.7%)<br>NIHSS >= 22 units 183 (28.7%)<br>NIHSS >= 23 units 183 (28.7%)<br>NIHSS >= 24 units 183 (28.7%)<br>NIHSS >= 25 units 183 (28.7%)<br>NIHSS >= 3 units 183 (28.7%)<br>NIHSS >= 4 units 183 (28.7%)<br>NIHSS >= 5 units 183 (28.7%)<br>NIHSS >= 6 units 183 (28.7%)<br>NIHSS >= 7 units 183 (28.7%)<br>NIHSS >= 8 units 183 (28.7%)<br>NIHSS >= 9 units 183 (28.7%)<br>**Negative Predictive Value**<br>NIHSS >= 10 units 82 %<br>**Positive Predictive Value**<br>NIHSS >= 10 units 71.6 %<br>**Sensitivity**<br>NIHSS >= 0 units 97 %<br>NIHSS >= 1 unit 95 %<br>NIHSS >= 10 units 49.7 %<br>NIHSS >= 11 units 46 %<br>NIHSS >= 12 units 44 %<br>NIHSS >= 13 units 39 %<br>NIHSS >= 14 units 35 %<br>NIHSS >= 15 units 29 %<br>NIHSS >= 16 units 26 %<br>NIHSS >= 17 units 20 %<br>NIHSS >= 18 units 17 %<br>NIHSS >= 19 units 16 % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | NIHSS >= 2 units 89 %<br>NIHSS >= 20 units 15 %<br>NIHSS >= 21 units 9 %<br>NIHSS >= 22 units 7 %<br>NIHSS >= 23 units 5 %<br>NIHSS >= 24 units 4 %<br>NIHSS >= 25 units 3 %<br>NIHSS >= 3 units 83 %<br>NIHSS >= 4 units 80 %<br>NIHSS >= 5 units 74 %<br>NIHSS >= 6 units 68 %<br>NIHSS >= 7 units 64 %<br>NIHSS >= 8 units 62 %<br>NIHSS >= 9 units 57 %<br>**Sensitivity, Anterior**<br>NIHSS >= 0 units 97 %<br>NIHSS >= 1 unit 97 %<br>NIHSS >= 10 units 56 %<br>NIHSS >= 11 units 53 %<br>NIHSS >= 12 units 50 %<br>NIHSS >= 13 units 46 %<br>NIHSS >= 14 units 42 %<br>NIHSS >= 15 units 34 %<br>NIHSS >= 16 units 30 %<br>NIHSS >= 17 units 25 %<br>NIHSS >= 18 units 21 %<br>NIHSS >= 19 units 20 %<br>NIHSS >= 2 units 93 %<br>NIHSS >= 20 units 18 %<br>NIHSS >= 21 units 10 %<br>NIHSS >= 22 units 7 %<br>NIHSS >= 3 units 88 %<br>NIHSS >= 4 units 85 %<br>NIHSS >= 5 units 83 %<br>NIHSS >= 6 units 79 %<br>NIHSS >= 7 units 75 %<br>NIHSS >= 8 units 73 % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | NIHSS >= 9 units 64 %<br>**Sensitivity, Posterior**<br>NIHSS >= 0 units 98 %<br>NIHSS >= 1 unit 92 %<br>NIHSS >= 10 units 23 %<br>NIHSS >= 11 units 21 %<br>NIHSS >= 12 units 19 %<br>NIHSS >= 13 units 14 %<br>NIHSS >= 14 units 12 %<br>NIHSS >= 15 units 7 %<br>NIHSS >= 16 units 7 %<br>NIHSS >= 17 units 7 %<br>NIHSS >= 18 units 7 %<br>NIHSS >= 19 units 7 %<br>NIHSS >= 2 units 79 %<br>NIHSS >= 20 units 7 %<br>NIHSS >= 21 units 7 %<br>NIHSS >= 22 units 7 %<br>NIHSS >= 3 units 63 %<br>NIHSS >= 4 units 60 %<br>NIHSS >= 5 units 43 %<br>NIHSS >= 6 units 33 %<br>NIHSS >= 7 units 30 %<br>NIHSS >= 8 units 26 %<br>NIHSS >= 9 units 25 %<br>**Specificity**<br>NIHSS >= 0 units 17 %<br>NIHSS >= 1 unit 25 %<br>NIHSS >= 10 units 92.1 %<br>NIHSS >= 11 units 93 %<br>NIHSS >= 12 units 96 %<br>NIHSS >= 13 units 96 %<br>NIHSS >= 14 units 97 %<br>NIHSS >= 15 units 97 %<br>NIHSS >= 16 units 97 %<br>NIHSS >= 17 units 97 %<br>NIHSS >= 18 units 98 % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | NIHSS >= 19 units 99 %<br>NIHSS >= 2 units 43 %<br>NIHSS >= 20 units 99 %<br>NIHSS >= 21 units 99 %<br>NIHSS >= 22 units 100 %<br>NIHSS >= 3 units 57 %<br>NIHSS >= 4 units 67 %<br>NIHSS >= 5 units 72 %<br>NIHSS >= 6 units 79 %<br>NIHSS >= 7 units 83 %<br>NIHSS >= 8 units 86 %<br>NIHSS >= 9 units 89 % | |
| Hastrup S 2016[11]<br>27272487 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 3127 | **Inclusion criteria:**<br>-Stroke Population, Confirmed<br>-Receiving intravenous tissue plasminogen activator (tPA) from January 2010 to April 2015<br>-Examined with (CTA) or (MRA) before IV tPA<br>-In Denmark from January 2010 to April 2015<br>-Acute Ischemic Stroke<br><br>**Exclusion criteria:**<br>-Inconclusive information on computed tomographic angiography (CTA) | 100% | Emergency room | Unclear / not specified; NIHSS determined prospectively and other scales retrospectively using elements of NIHSS | Large artery occlusion is defined as a visible clot in either the anterior or the posterior circulation on an intracranial CTA or a MRA. | **AUC**<br>PASS >= 2 units 0.73 units<br>**Diagnostic Odds Ratio**<br>PASS >= 2 units 7.63 [CI 95%: 5.71-10.2] NA<br>Disease Absent<br>PASS >= 2 units 2023 (64.7%)<br>**Disease Present**<br>PASS >= 2 units 1104 (35.3%)<br>**Negative Likelihood Ratio**<br>PASS >= 2 units 0.47 [CI 95%: 0.41-0.54] NA<br>**Negative Predictive Value**<br>PASS >= 2 units 80 [CI 95%: 77 – 83] %<br>**Overall Accuracy**<br>PASS >= 2 units 72 [CI 95%: 69 – 75] %<br>**Positive Likelihood Ratio**<br>PASS >= 2 units 3.59 [CI 95%: 2.98-4.33] NA<br>**Positive Predictive Value**<br>PASS >= 2 units 66 [CI 95%: 60 – 71] %<br>**Prevalence of LVO**<br>PASS >= 2 units 1104 (35.3%)<br>**Sensitivity**<br>PASS >= 2 units 61 [CI 95%: 56 – 66] %<br>**Specificity**<br>PASS >= 2 units 83 [CI 95%: 80 – 86] % | • PASS scale cut-off ≥2 is comparable to a high NIHSS score and is a simple 3 item scale to accurately identify ELVO. Further studies are needed to validate this tool in the general population |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | before intravenous tPA (tissue plasminogen activator)<br>-Missing information on computed tomographic angiography (CTA) before intravenous tPA (tissue plasminogen activator)<br>-Inconclusive information on magnetic resonance angiography (MRA) before intravenous tPA (tissue plasminogen activator)<br>-Missing information on magnetic resonance angiography (MRA) before intravenous tPA (tissue plasminogen activator)<br>-Inconclusive information on | | | | | | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | National Institutes of Health Stroke Scale (NIHSS) and grip strength before intravenous tPA (tissue plasminogen activator)<br>-Missing information on National Institutes of Health Stroke Scale (NIHSS) and grip strength before intravenous tPA (tissue plasminogen activator) | | | | | | |
| Heldner MR 2013 Bernese Stroke Registry[12] 23471266 | **Study type:** Prospective Observational; Journal Article<br><br>**Size:** N = 2152 | **Inclusion criteria:**<br>-Persisting clinical symptoms on admission due to acute ischemic stroke or transient ischemic attack in the anterior circulation<br>-Presented within 6 hours of symptom onset of acute ischemic stroke or | 83% | Emergency room | Stroke team or stroke physician | LVOs were defined as occlusions of the internal carotid artery (ICA), of the main stem and branch of the middle cerebral artery (MCA; M1/M2); peripheral occlusions as anterior cerebral (ACA) or peripheral branches of the MCA (M3/M4) vessel occlusions | **Disease Absent**<br>NIHSS >= 6 units 1109 (51.5%)<br>**Disease Present**<br>NIHSS >= 6 units 1043 (48.5%)<br>**Positive Predictive Value**<br>NIHSS >= 6 units 73 % | • Clinical scores based on NIHSS showed a significant correlation with LVO prediction. However application of score thresholds results in missed LVO and hence vessel imaging should be used for triaging or transfers as soon as possible. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | transient ischemic attack<br>-Defined time of symptom onset of acute ischemic stroke or transient ischemic attack<br>-Adequate computed tomography angiography or magnetic resonance angiography for analysis<br>-Stroke Population, Suspected<br><br>**Exclusion criteria:**<br>-Posterior circulation stroke<br>-Comatose<br>-Previous stroke | | | | | | |
| Heldner MR 2016[13]<br>27272907 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 1085 | **Inclusion criteria:**<br>-Presented within 24 hours<br>-Neurological deficit attributable to stroke or transient ischemic attack<br>-Adequate MR Angiography or CT | 83% | Emergency room | Stroke team or stroke physician; NIHSS determined prospectively and other scales | LVOs were defined as occlusions of the ICA, of the main stem and branch of the MCA (M1/M2); peripheral occlusions as ACA or peripheral branches of the MCA (M3/M4) vessel occlusions | **AUC**<br>3I-SS >= 1 unit 0.793 units<br>a-NIHSS, Item A >= 3 units 0.742 units<br>a-NIHSS, Item B >= 2 units 0.761 units<br>a-NIHSS, Item C >= 2 units 0.675 units<br>a-NIHSS, Item D >= 2 units 0.741 units<br>a-NIHSS, Item E >= 2 units 0.749 units<br>Bernese Score 1 >=5 units 0.827 units<br>Bernese Score 2 >=2 units 0.808 units<br>Bernese Score 3 >= 2 units 0.826 units<br>Bernese Score 4 >= 1 unit 0.807 units | • There is a good predictive value for NIHSS scores for vessel occlusion in the anterior circulation within 6h of symptom onset and a poor predictive value thereafter and in posterior circulation occlusions. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | Angiography for analysis<br>-Stroke Population, Confirmed<br><br>**Exclusion criteria:**<br>-Coma | | | using NIHSS elements | | Bernese Score 5 >=3 units 0.853 units<br>CPSS1 >= 2 units 0.737 units<br>CPSS2 >= 2 units 0.745 units<br>CPSSS >= 1 unit 0.802 units<br>mNIHSS >= 5 units 0.839 units<br>NIHSS >= 7 units 0.846 units<br>RACE >= 3 units 0.831 units<br>sNIHSS-1 >= 1 unit 0.749 units<br>sNIHSS-5 >= 2 units 0.815 units<br>sNIHSS-8 >= 4 units 0.834 units<br>**Disease Absent**<br>3I-SS >= 1 unit 428 (39.4%)<br>a-NIHSS, Item A >= 3 units 428 (39.4%)<br>a-NIHSS, Item B >= 2 units 428 (39.4%)<br>a-NIHSS, Item C >= 2 units 428 (39.4%)<br>a-NIHSS, Item D >= 2 units 428 (39.4%)<br>a-NIHSS, Item E >= 2 units 428 (39.4%)<br>Bernese Score 1 >=5 units 428 (39.4%)<br>Bernese Score 2 >=2 units 428 (39.4%)<br>Bernese Score 3 >= 2 units 428 (39.4%)<br>Bernese Score 4 >= 1 unit 428 (39.4%)<br>Bernese Score 5 >=3 units 428 (39.4%)<br>CPSS1 >= 2 units 428 (39.4%)<br>CPSS2 >= 2 units 428 (39.4%)<br>CPSSS >= 1 unit 428 (39.4%)<br>mNIHSS >= 5 units 428 (39.4%)<br>NIHSS >= 7 units 428 (39.4%)<br>RACE >= 3 units 428 (39.4%)<br>sNIHSS-1 >= 1 unit 428 (39.4%)<br>sNIHSS-5 >= 2 units 428 (39.4%)<br>sNIHSS-8 >= 4 units 428 (39.4%)<br>**Disease Present**<br>3I-SS >= 1 unit 657 (60.6%)<br>a-NIHSS, Item A >= 3 units 657 (60.6%)<br>a-NIHSS, Item B >= 2 units 657 (60.6%)<br>a-NIHSS, Item C >= 2 units 657 (60.6%)<br>a-NIHSS, Item D >= 2 units 657 (60.6%) | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | a-NIHSS, Item E >= 2 units 657 (60.6%)<br>Bernese Score 1 >=5 units 657 (60.6%)<br>Bernese Score 2 >=2 units 657 (60.6%)<br>Bernese Score 3 >= 2 units 657 (60.6%)<br>Bernese Score 4 >= 1 unit 657 (60.6%)<br>Bernese Score 5 >=3 units 657 (60.6%)<br>CPSS1 >= 2 units 657 (60.6%)<br>CPSS2 >= 2 units 657 (60.6%)<br>CPSSS >= 1 unit 657 (60.6%)<br>mNIHSS >= 5 units 657 (60.6%)<br>NIHSS >= 7 units 657 (60.6%)<br>RACE >= 3 units 657 (60.6%)<br>sNIHSS-1 >= 1 unit 657 (60.6%)<br>sNIHSS-5 >= 2 units 657 (60.6%)<br>sNIHSS-8 >= 4 units 657 (60.6%)<br>**Negative Predictive Value**<br>3I-SS >= 1 unit 64.7 %<br>a-NIHSS, Item A >= 3 units 55.3 %<br>a-NIHSS, Item B >= 2 units 62.8 %<br>a-NIHSS, Item C >= 2 units 49.5 %<br>a-NIHSS, Item D >= 2 units 62 %<br>a-NIHSS, Item E >= 2 units 59.1 %<br>Bernese Score 1 >=5 units 65.8 %<br>Bernese Score 2 >=2 units 63.8 %<br>Bernese Score 3 >= 2 units 62.9 %<br>Bernese Score 4 >= 1 unit 62.5 %<br>Bernese Score 5 >=3 units 70 %<br>CPSS1 >= 2 units 55.2 %<br>CPSS2 >= 2 units 62.9 %<br>CPSSS >= 1 unit 58.7 %<br>mNIHSS >= 5 units 69.4 %<br>NIHSS >= 7 units 72.4 %<br>RACE >= 3 units 67.1 %<br>sNIHSS-1 >= 1 unit 58.7 %<br>sNIHSS-5 >= 2 units 67.7 %<br>sNIHSS-8 >= 4 units 69.1 %<br>**Overall Accuracy** | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3I-SS >= 1 unit 74.5 %<br>a-NIHSS, Item A >= 3 units 65.8 %<br>a-NIHSS, Item B >= 2 units 70.8 %<br>a-NIHSS, Item C >= 2 units 60 %<br>a-NIHSS, Item D >= 2 units 70 %<br>a-NIHSS, Item E >= 2 units 68.4 %<br>Bernese Score 1 >=5 units 75.6 %<br>Bernese Score 2 >=2 units 74.2 %<br>Bernese Score 3 >= 2 units 74.5 %<br>Bernese Score 4 >= 1 unit 73.6 %<br>Bernese Score 5 >=3 units 79.3 %<br>CPSS1 >= 2 units 66.3 %<br>CPSS2 >= 2 units 72 %<br>CPSSS >= 1 unit 70.8 %<br>mNIHSS >= 5 units 77.9 %<br>NIHSS >= 7 units 79.3 %<br>RACE >= 3 units 76.6 %<br>sNIHSS-1 >= 1 unit 70 %<br>sNIHSS-5 >= 2 units 76.4 %<br>sNIHSS-8 >= 4 units 77.2 %<br>**Positive Predictive Value**<br>3I-SS >= 1 unit 83.2 %<br>a-NIHSS, Item A >= 3 units 75.9 %<br>a-NIHSS, Item B >= 2 units 76.1 %<br>a-NIHSS, Item C >= 2 units 74.6 %<br>a-NIHSS, Item D >= 2 units 75 %<br>a-NIHSS, Item E >= 2 units 75.5 %<br>Bernese Score 1 >=5 units 84.5 %<br>Bernese Score 2 >=2 units 84.3 %<br>Bernese Score 3 >= 2 units 88.2 %<br>Bernese Score 4 >= 1 unit 86 %<br>Bernese Score 5 >=3 units 87.4 %<br>CPSS1 >= 2 units 79.8 %<br>CPSS2 >= 2 units 79.3 %<br>CPSSS >= 1 unit 87.8 %<br>mNIHSS >= 5 units 84.7 %<br>NIHSS >= 7 units 84.2 % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | RACE >= 3 units 85 %<br>sNIHSS-1 >= 1 unit 83 %<br>sNIHSS-5 >= 2 units 83.5 %<br>sNIHSS-8 >= 4 units 83.5 %<br>**Sensitivity**<br>3I-SS >= 1 unit 72.5 %<br>a-NIHSS, Item A >= 3 units 63.8 %<br>a-NIHSS, Item B >= 2 units 75.3 %<br>a-NIHSS, Item C >= 2 units 51.4 %<br>a-NIHSS, Item D >= 2 units 75.5 %<br>a-NIHSS, Item E >= 2 units 70.8 %<br>Bernese Score 1 >=5 units 73.1 %<br>Bernese Score 2 >=2 units 70.5 %<br>Bernese Score 3 >= 2 units 66.8 %<br>Bernese Score 4 >= 1 unit 67.4 %<br>Bernese Score 5 >=3 units 76.9 %<br>CPSS1 >= 2 units 59.4 %<br>CPSS2 >= 2 units 72.8 %<br>CPSSS >= 1 unit 60.1 %<br>mNIHSS >= 5 units 77.5 %<br>NIHSS >= 7 units 81 %<br>RACE >= 3 units 74.4 %<br>sNIHSS-1 >= 1 unit 66.3 %<br>sNIHSS-5 >= 2 units 76.1 %<br>sNIHSS-8 >= 4 units 77.8 %<br>**Specificity**<br>3I-SS >= 1 unit 77.6 %<br>a-NIHSS, Item A >= 3 units 68.9 %<br>a-NIHSS, Item B >= 2 units 63.8 %<br>a-NIHSS, Item C >= 2 units 73.1 %<br>a-NIHSS, Item D >= 2 units 61.4 %<br>a-NIHSS, Item E >= 2 units 64.7 %<br>Bernese Score 1 >=5 units 79.4 %<br>Bernese Score 2 >=2 units 79.9 %<br>Bernese Score 3 >= 2 units 86.2 %<br>Bernese Score 4 >= 1 unit 83.2 %<br>Bernese Score 5 >=3 units 82.9 % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | CPSS1 >= 2 units 76.9 %<br>CPSS2 >= 2 units 70.8 %<br>CPSSS >= 1 unit 87.1 %<br>mNIHSS >= 5 units 78.5 %<br>NIHSS >= 7 units 76.6 %<br>RACE >= 3 units 79.9 %<br>sNIHSS-1 >= 1 unit 80.1 %<br>sNIHSS-5 >= 2 units 76.9 %<br>sNIHSS-8 >= 4 units 76.4 % | |
| Higashimori T. 2016[14]<br>Link to abstract | **Study type:**<br>Retrospective Observational; Meeting Abstract/Oral/Poster<br><br>**Size:**<br>N = 28 | **Inclusion criteria:**<br>-Stroke<br>-Stroke Population, Suspected<br>-Arriving in less than 6 hours with prehospital stroke alert activated by emergency medical services (EMS)<br><br>**Exclusion criteria:**<br>-Stroke, Hemorrhagic | Unclear/ not specified | Emergency room | Unclear/ not specified; NIHSS prospectively assessed then MPSS derived from NIHSS elements | Emergent LVO (ELVO) defined by locations ICA, M1 and M2 | **Disease Absent**<br>MPSS >= 6 units 22 (78.6%)<br>NIHSS >= 7 units 22 (78.6%)<br>**Disease Present**<br>MPSS >= 6 units 6 (21.4%)<br>NIHSS >= 7 units 6 (21.4%)<br>Negative Predictive Value<br>MPSS >= 6 units 96 %<br>NIHSS >= 7 units 94 %<br>**Overall Accuracy**<br>MPSS >= 6 units 96 %<br>NIHSS >= 7 units 79 %<br>**Positive Predictive Value**<br>MPSS >= 6 units 100 %<br>NIHSS >= 7 units 50 %<br>**Sensitivity**<br>MPSS >= 6 units 83 %<br>NIHSS >= 7 units 83 %<br>**Specificity**<br>MPSS >= 6 units 100 %<br>NIHSS >= 7 units 77 % | • MPSS is a simple tool that uses 5 parameters with scores ranging from 0-10<br>• MPSS may be useful for predicting ELVO, however more robust studies are needed to conclusively validate the usefulness of this scoring tool |
| Katz BS 2015[15]<br>25899242 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 650 | **Inclusion criteria:**<br>-Stroke Population, Confirmed<br>-Interventional Management of | 100% | Unclear/ not specified | Physician not further specified; NIHSS assessed prospectively then | Proximal LVO was defined as extracranial internal carotid artery, intracranial internal carotid artery, M1, tandem cervical internal carotid artery plus M2, | **AUC**<br>CPSSS >= 2 units 0.67 units<br>Disease Present<br>CPSSS >= 2 units 222 (73.3%)<br>Negative Likelihood Ratio<br>CPSSS >= 2 units 0.42 NA<br>**Positive Likelihood Ratio** | • CPSSS has high sensitivity in detecting LVO among AIS patients and can identify stroke patients with NIHSS≥15 and LVO. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | Stroke III (IMS-III) patients<br>-Complete pretreatment National Institutes of Health Stroke Scale (NIHSS) component scores<br>-Moderate to severe stroke<br>-National Institutes of Health Stroke Scale (NIHSS), 8-40<br>-Treated with tissue plasminogen activator (tPA)<br><br>**Exclusion criteria:**<br>Not Reported | | | CPSSS derived from NIHSS elements | or basilar artery occlusions (excluding M3, M4, posterior cerebral artery occlusion sites, and isolated M2) | CPSSS >= 2 units 1.38 NA<br>**Sensitivity**<br>CPSSS >= 2 units 83 %<br>**Specificity**<br>CPSSS >= 2 units 40 % | |
| Kesinger MR 2015 Comprehensive Stroke Center (CSC)[16] 25538202 | **Study type:**<br>Prospective Observational; Journal Article<br><br>**Size:**<br>N = 305 | **Inclusion criteria:**<br>-Stroke Population, Confirmed<br>-Transported by a single helicopter emergency medical service (HEMS) to a Comprehensive Stroke Center (CSC)<br>-National Institutes of | 100% | Mixed | Mixed, EMS and stroke neurologist each assessed NIHSS | Unclear/not specified | **AUC**<br>NIHSS >= 12 units, HEMS 0.768 units<br>NIHSS >= 12 units, Stroke Team 0.77 units<br>**Disease Present**<br>NIHSS >= 12 units, HEMS 210 (68.9%)<br>NIHSS >= 12 units, Stroke Team 210 (68.9%)<br>Positive Predictive Value<br>NIHSS >= 12 units, HEMS 80.5 %<br>NIHSS >= 12 units, Stroke Team 88.5 %<br>**Prevalence of LVO**<br>NIHSS >= 12 units, HEMS 210 (68.9%)<br>NIHSS >= 12 units, Stroke Team 210 (68.9%)<br>**Sensitivity**<br>NIHSS >= 12 units, HEMS 51.9 % | • LVO can be identified with high sensitivity using the prehospital NIHSS<br>• Prehospital NIHSS tool could be used to triage patients who are ineligible for tPA |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | Health Stroke Scale (NIHSS) scores were assigned by helicopter emergency medical service (HEMS)<br>-National Institutes of Health Stroke Scale (NIHSS) scores were assigned by a stroke neurologist at emergency department (ED) arrival<br>-Ischemic stroke, Acute<br><br>**Exclusion criteria:**<br>-Intubated<br>-Sedated | | | | | NIHSS >= 12 units, Stroke Team 48.6 %<br>**Specificity**<br>NIHSS >= 12 units, HEMS 87.4 %<br>NIHSS >= 12 units, Stroke Team 93.7 %<br>**Test Positive**<br>NIHSS >= 12 units, HEMS 121 (39.7%)<br>NIHSS >= 12 units, Stroke Team 108 (35.4%) | |
| Kummer BR 2016[17]<br>26971037 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 664 | **Inclusion criteria:**<br>-Stroke Population, Confirmed<br>-Acute ischemic stroke<br><br>**Exclusion criteria:**<br>Not Reported | 100% | Emergency room | Stroke team or stroke physician; NIHSS assessed prospectively and then other scales derived | Occlusions were defined as extracranial or intracranial internal carotid artery, M1 segment of the middle cerebral artery, tandem occlusion involving both the extracranial internal carotid artery and the M2 segment of the middle cerebral artery, or basilar artery. LVO | **AUC**<br>CPSSS >= 0 units 0.85 [CI 95%: 0.81 – 0.9] units<br>CPSSS >=1 unit 0.85 [CI 95%: 0.81 – 0.9] units<br>CPSSS >=2 units 0.85 [CI 95%: 0.81 – 0.9] units<br>CPSSS >=3 units 0.85 [CI 95%: 0.81 – 0.9] units<br>CPSSS >=4 units 0.85 [CI 95%: 0.81 – 0.9] units<br>sCPSSS >= 0 units 0.84 [CI 95%: 0.8 – 0.89] units<br>sCPSSS >= 1 unit 0.84 [CI 95%: 0.8 – 0.89] units<br>sCPSSS >= 2 units 0.84 [CI 95%: 0.8 – 0.89] units<br>sCPSSS 3 units 0.84 [CI 95%: 0.8 – 0.89] units<br>**Disease Absent**<br>CPSSS >= 0 units 584 (88%) | • CPSSS has reasonable sensitivity and selectivity for predicting LVO and severe stroke (NIHSS ≥ 15) |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | | | | from NIHSS elements | was considered present if any of these occlusions were demonstrated on at least 1 vessel imaging study (magnetic resonance angiography, computed tomographic angiography, or digital subtraction angiography). | CPSSS >=1 unit 584 (88%)<br>CPSSS >=2 units 584 (88%)<br>CPSSS >=3 units 584 (88%)<br>CPSSS >=4 units 584 (88%)<br>sCPSSS >= 0 units 584 (88%)<br>sCPSSS >= 1 unit 584 (88%)<br>sCPSSS >= 2 units 584 (88%)<br>sCPSSS 3 units 584 (88%)<br>**Disease Present**<br>CPSSS >= 0 units 80 (12%)<br>CPSSS >=1 unit 80 (12%)<br>CPSSS >=2 units 80 (12%)<br>CPSSS >=3 units 80 (12%)<br>CPSSS >=4 units 80 (12%)<br>sCPSSS >= 0 units 80 (12%)<br>sCPSSS >= 1 unit 80 (12%)<br>sCPSSS >= 2 units 80 (12%)<br>sCPSSS 3 units 80 (12%)<br>**Negative Likelihood Ratio**<br>CPSSS >=1 unit 0.2 NA<br>CPSSS >=2 units 0.3 NA<br>CPSSS >=3 units 0.5 NA<br>CPSSS >=4 units 0.8 NA<br>sCPSSS >= 1 unit 0.2 NA<br>sCPSSS >= 2 units 0.5 NA<br>sCPSSS 3 units 0.5 NA<br>**Positive Likelihood Ratio**<br>CPSSS >= 0 units 1 NA<br>CPSSS >=1 unit 4.3 NA<br>CPSSS >=2 units 5.3 NA<br>CPSSS >=3 units 7.3 NA<br>CPSSS >=4 units 6.6 NA<br>sCPSSS >= 0 units 1 NA<br>sCPSSS >= 1 unit 4.7 NA<br>sCPSSS >= 2 units 6 NA<br>sCPSSS 3 units 7.9 NA | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | | | | | | **Sensitivity**<br>CPSSS >= 0 units 100 %<br>CPSSS >=1 unit 86.3 %<br>CPSSS >=2 units 70 %<br>CPSSS >=3 units 51.2 %<br>CPSSS >=4 units 25 %<br>sCPSSS >= 0 units 100 %<br>sCPSSS >= 1 unit 82.5 %<br>sCPSSS >= 2 units 58.8 %<br>sCPSSS 3 units 50 %<br>Specificity<br>CPSSS >= 0 units 0 %<br>CPSSS >=1 unit 79.8 %<br>CPSSS >=2 units 86.8 %<br>CPSSS >=3 units 93 %<br>CPSSS >=4 units 96.2 %<br>sCPSSS >= 0 units 0 %<br>sCPSSS >= 1 unit 82.5 %<br>sCPSSS >= 2 units 90.2 %<br>sCPSSS 3 units 93.7 %<br>**Test Negative**<br>CPSSS >= 0 units 0 (0%)<br>CPSSS >=1 unit 477 (71.8%)<br>CPSSS >=2 units 531 (80%)<br>CPSSS >=3 units 582 (87.7%)<br>CPSSS >=4 units 622 (93.7%)<br>**Test Positive**<br>CPSSS >= 0 units 664 (100%)<br>CPSSS >=1 unit 187 (28.2%)<br>CPSSS >=2 units 133 (20%)<br>CPSSS >=3 units 82 (12.3%)<br>CPSSS >=4 units 42 (6.3%) | |
| Lima FO 2016 STOPStroke[18] 27364531 | **Study type:** Prospective Observational; Journal Article | **Inclusion criteria:** -Stroke Population, Suspected | Unclear/ not specified | Emergency room | Other (research personnel); NIHSS assessed | Unilateral acute complete symptomatic occlusion of the intracranial internal carotid artery | **AUC**<br>CPSSS >= 2 units 0.752 (SE ± 0.021) units<br>FAST-ED >= 1 unit 0.813 (SE ± 0.018) units<br>FAST-ED >= 2 units 0.813 (SE ± 0.018) units<br>FAST-ED >= 3 units 0.813 (SE ± 0.018) units | • FAST-ED scale has high sensitivity and specificity for detecting LVO.<br>• The scale has comparable accuracy to NIHSS and |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | **Size:**<br>N = 727 | -Noncontrast computed tomography scans<br>-Computed tomographic angiography (CTA)<br><br>**Exclusion criteria:**<br>-Iodinated contrast agent administration was contraindicated<br>-History of contrast agent allergy<br>-Pregnancy<br>-Congestive heart failure<br>-Increased creatinine level<br>-Evidence of intracranial hemorrhage | | | prospectively and then other scales derived from NIHSS elements | (intracranial ICA), M1 and M2 segments of the middle cerebral artery (MCA) and basilar artery | FAST-ED >= 4 units 0.813 (SE ± 0.018) units<br>FAST-ED >= 5 units 0.813 (SE ± 0.018) units<br>FAST-ED >= 6 units 0.813 (SE ± 0.018) units<br>FAST-ED >= 7 units 0.813 (SE ± 0.018) units<br>FAST-ED >= 8 units 0.813 (SE ± 0.018) units<br>FAST-ED >= 9 units 0.813 (SE ± 0.018) units<br>NIHSS >= 10 units 0.799 (SE ± 0.018) units<br>NIHSS >= 6 units 0.799 (SE ± 0.018) units<br>RACE >= 5 units 0.771 (SE ± 0.02) units<br>**Disease Present**<br>CPSSS >= 2 units 240 (33%)<br>FAST-ED >= 1 unit 240 (33%)<br>FAST-ED >= 2 units 240 (33%)<br>FAST-ED >= 3 units 240 (33%)<br>FAST-ED >= 4 units 240 (33%)<br>FAST-ED >= 5 units 240 (33%)<br>FAST-ED >= 6 units 240 (33%)<br>FAST-ED >= 7 units 240 (33%)<br>FAST-ED >= 8 units 240 (33%)<br>FAST-ED >= 9 units 240 (33%)<br>NIHSS >= 10 units 240 (33%)<br>NIHSS >= 6 units 240 (33%)<br>RACE >= 5 units 240 (33%)<br>**Negative Predictive Value**<br>CPSSS >= 2 units 78 %<br>FAST-ED >= 1 unit 91 %<br>FAST-ED >= 2 units 89 %<br>FAST-ED >= 3 units 84 %<br>FAST-ED >= 4 units 82 %<br>FAST-ED >= 5 units 78 %<br>FAST-ED >= 6 units 74 %<br>FAST-ED >= 7 units 70 %<br>FAST-ED >= 8 units 68 %<br>FAST-ED >= 9 units 67 %<br>NIHSS >= 10 units 83 %<br>NIHSS >= 6 units 85 %<br>RACE >= 5 units 79 % | higher accuracy than RACE and CPSS for prediction of LVO. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | | | | | | **Overall Accuracy**<br>CPSSS >= 2 units 75 %<br>FAST-ED >= 1 unit 55 %<br>FAST-ED >= 2 units 70 %<br>FAST-ED >= 3 units 76 %<br>FAST-ED >= 4 units 79 %<br>FAST-ED >= 5 units 78 %<br>FAST-ED >= 6 units 75 %<br>FAST-ED >= 7 units 70 %<br>FAST-ED >= 8 units 68 %<br>FAST-ED >= 9 units 67 %<br>NIHSS >= 10 units 78 %<br>NIHSS >= 6 units 72 %<br>RACE >= 5 units 77 %<br>**Positive Predictive Value**<br>CPSSS >= 2 units 65 %<br>FAST-ED >= 1 unit 42 %<br>FAST-ED >= 2 units 53 %<br>FAST-ED >= 3 units 62 %<br>FAST-ED >= 4 units 72 %<br>FAST-ED >= 5 units 76 %<br>FAST-ED >= 6 units 82 %<br>FAST-ED >= 7 units 79 %<br>FAST-ED >= 8 units 82 %<br>FAST-ED >= 9 units 80 %<br>NIHSS >= 10 units 68 %<br>NIHSS >= 6 units 55 %<br>RACE >= 5 units 68 %<br>**Prevalence of LVO**<br>CPSSS >= 2 units 240 (33%)<br>FAST-ED >= 1 unit 240 (33%)<br>FAST-ED >= 2 units 240 (33%)<br>FAST-ED >= 3 units 240 (33%)<br>FAST-ED >= 4 units 240 (33%)<br>FAST-ED >= 5 units 240 (33%)<br>FAST-ED >= 6 units 240 (33%)<br>FAST-ED >= 7 units 240 (33%) | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | | | | | | FAST-ED >= 8 units 240 (33%)<br>FAST-ED >= 9 units 240 (33%)<br>NIHSS >= 10 units 240 (33%)<br>NIHSS >= 6 units 240 (33%)<br>RACE >= 5 units 240 (33%)<br>**Sensitivity**<br>CPSSS >= 2 units 56 %<br>FAST-ED >= 1 unit 92 %<br>FAST-ED >= 2 units 83 %<br>FAST-ED >= 3 units 71 %<br>FAST-ED >= 4 units 61 %<br>FAST-ED >= 5 units 48 %<br>FAST-ED >= 6 units 30 %<br>FAST-ED >= 7 units 14 %<br>FAST-ED >= 8 units 4 %<br>FAST-ED >= 9 units 1.7 %<br>NIHSS >= 10 units 64 %<br>NIHSS >= 6 units 76 %<br>RACE >= 5 units 55 %<br>**Specificity**<br>CPSSS >= 2 units 85 %<br>FAST-ED >= 1 unit 37 %<br>FAST-ED >= 2 units 64 %<br>FAST-ED >= 3 units 78 %<br>FAST-ED >= 4 units 89 %<br>FAST-ED >= 5 units 93 %<br>FAST-ED >= 6 units 97 %<br>FAST-ED >= 7 units 98 %<br>FAST-ED >= 8 units 99.59 %<br>FAST-ED >= 9 units 99.79 %<br>NIHSS >= 10 units 85 %<br>NIHSS >= 6 units 70 %<br>RACE >= 5 units 87 % | |
| Maas MB 2009 STOPStroke[19] 19608992 | **Study type:** Prospective Observational; Journal Article | **Inclusion criteria:** -Symptoms consistent with | 100% | Emergency room | Other (research personnel) | Proximal occlusion was defined as occlusion of the basilar artery, internal carotid artery, | **Disease Absent**<br>NIHSS >= 10 units 322 (46.1%)<br>**Disease Present**<br>NIHSS >= 10 units 377 (53.9%) | • Only high NIHSS score correlates well with proximal occlusions and could lead to failure in |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | **Size:**<br>N = 699 | acute cerebral ischemia<br>-Stroke population, Confirmed<br>-Nonenhanced head CT in patients presenting with signs of acute cerebral ischemia<br>-Nonenhanced CT angiographic imaging in patients presenting with signs of acute cerebral ischemia<br><br>**Exclusion criteria:**<br>-Contraindication to iodinated contrast agent administration<br>-History of contrast agent allergy<br>-Pregnancy<br>-Congestive heart failure<br>-Renal insufficiency<br>-Evidence of intracranial hemorrhage | | | | MCA M1 and/or M2 segment, anterior cerebral artery A1 and/or A2 segment, posterior cerebral artery, or vertebral artery | Positive Predictive Value<br>NIHSS >= 10 units 81 %<br>**Sensitivity**<br>NIHSS >= 10 units 48 % | diagnosing patients presenting with low NIHSS scores.<br>• NIHSS is an unreliable screening tool due its poor negative predictive value. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| Mahdi Z. 2016[20] Link to abstract | **Study type:** Retrospective Observational; Meeting Abstract/Oral/Poster<br><br>**Size:** N = 167 | **Inclusion criteria:** -National Institutes of Health Stroke Scale (NIHSS) documentation -Plain CT/MRI brain analysis -Stroke Population, Confirmed -Stroke, Acute<br><br>**Exclusion criteria:** Not Reported | 100% | Unclear/ not specified | Unclear/ not specified | Unclear/not specified | **Disease Present**<br>Gaze Deviation 78 (47%)<br>**Positive Likelihood Ratio**<br>Gaze Deviation 10 NA<br>**Positive Predictive Value**<br>Gaze Deviation 90 %<br>**Sensitivity**<br>Gaze Deviation 60 %<br>**Specificity**<br>Gaze Deviation 94 %<br>**Test Positive**<br>Gaze Deviation 52 (31%) | • Use of gaze deviation is a good predictor of LVO, and incorporating its use in prehospital stroke scales can improve the time to intervention in acute care. |
| Matias-Guiu JA 2014[21] 24075584 | **Study type:** Retrospective Observational; Journal Article<br><br>**Size:** N = 167 | **Inclusion criteria:** -Stroke Population, Confirmed -Acute ischaemic stroke -Admitted to the stroke unit, neurology department, or intensive care unit of the hospital<br><br>**Exclusion criteria:** -Transient ischaemic attack whose symptoms resolved before arriving at the hospital | 100% | Emergency room | Unclear/ not specified | Large artery occlusion is defined as a contrast-filling defect in any of these arteries: internal carotid artery, middle cerebral artery (M1 and M2 segments), anterior cerebral artery, vertebral artery, basilar artery, and posterior cerebral artery. | **AUC**<br>NIHSS >= 10 units 0.789 units<br>NIHSS >= 12 units 0.789 units<br>NIHSS >= 6 units 0.789 units<br>**Disease Absent**<br>NIHSS >= 10 units 34 (47.9%)<br>NIHSS >= 12 units 34 (47.9%)<br>NIHSS >= 6 units 34 (47.9%)<br>**Disease Present**<br>NIHSS >= 10 units 37 (52.1%)<br>NIHSS >= 12 units 37 (52.1%)<br>NIHSS >= 6 units 37 (52.1%)<br>**Sensitivity**<br>NIHSS >= 10 units 72.5 %<br>NIHSS >= 12 units 59.4 %<br>NIHSS >= 6 units 84.3 %<br>**Specificity**<br>NIHSS >= 10 units 72.5 %<br>NIHSS >= 12 units 79.5 %<br>NIHSS >= 6 units 44.3 % | • NIHSS is a useful in predicting LVO and cut-off point of 6 provides good sensitivity.<br>• More than 20% of acute stroke cases had LVO. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | -Transferred from other hospitals for endovascular treatment<br>-Transferred from other hospitals at more than 8 hours after onset | | | | | | |
| Moore RD 2016[22]<br>26769727 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 522 | **Inclusion criteria:**<br>-Stroke Population, Suspected<br>-Patients who presented to the Erlanger Hospital Emergency Department<br>-At least 18 years old<br>-Stroke-like signs or symptoms<br>-Evaluation by board-certified neurologist within 12 hours of presentation<br>-Evaluation by board-certified neurologist prior to imaging<br>-Computed tomography angiography (CTA) of the head<br>-Computed tomography | 37% | Emergency room | Stroke team or stroke physician | Acute occlusion or ≥70% stenosis in a proximal vessel (ICA, MCA 1st or 2nd segment, vertebral artery, BA) | **Negative Predictive Value**<br>NIHSS 3 Criteria 96 %<br>NIHSS 4 Criteria 98 %<br>NIHSS 5 Criteria 99 %<br>NIHSS Hypothesis 93 %<br>**Positive Predictive Value**<br>NIHSS 3 Criteria 28 %<br>NIHSS 4 Criteria 27 %<br>NIHSS 5 Criteria 25 %<br>NIHSS Hypothesis 26 %<br>**Sensitivity**<br>NIHSS 3 Criteria 92 %<br>NIHSS 4 Criteria 96 %<br>NIHSS 5 Criteria 99 %<br>NIHSS Hypothesis 85 %<br>**Specificity**<br>NIHSS 3 Criteria 44 %<br>NIHSS 4 Criteria 39 %<br>NIHSS 5 Criteria 28 %<br>NIHSS Hypothesis 45 % | • It might be more valuable to utilize the presence of specific signs or symptoms based on NIHSS criteria rather than the actual score, in determining which patients should be imaged for LVO. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | angiography (CTA) of the neck<br><br>**Exclusion criteria:**<br>-Received computed tomography angiography (CTA) for isolated headache<br>-Received computed tomography angiography (CTA) for craniofacial trauma | | | | | | |
| Nakajima M 2004[23] 14970023 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 43 | **Inclusion criteria:**<br>-Admitted within 6 hr of ischemic stroke onset\|Received intra-arterial digital subtraction angiograms (IA-DSA)<br>-Carotid acute ischemic stroke<br>-Assessed by using the National Institutes of Health Stroke Scale (NIHSS) immediately before intra-arterial digital subtraction | 100% | Emergency room | Unclear/ not specified | Unclear/not specified | **Negative Predictive Value**<br>NIHSS >= 10 units 63.6 %<br>**Positive Predictive Value**<br>NIHSS >= 10 units 96.9 %<br>**Prevalence of LVO**<br>NIHSS >= 10 units 35 (81.4%)<br>**Sensitivity**<br>NIHSS >= 10 units 88.6 %<br>**Specificity**<br>NIHSS >= 10 units 87.5 %<br>**Test Positive**<br>NIHSS >= 10 units 32 (74.4%)<br>**True Positive**<br>NIHSS >= 10 units 31 (72.1%) | • The optimal value for predicting occlusions within 6h of stroke onset is an NIHSS≥10. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | angiograms IA-DSA<br>-Stroke Population, Confirmed<br><br>**Exclusion criteria:**<br>-Posterior circulation strokes<br>-Modified Rankin Scale score >=2 before stroke onset | | | | | | |
| Nazliel B 2008[24]<br>18556587 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 119 | **Inclusion criteria:**<br>-Last known well time within 12 hours of initial Emergency Department (ED) examination<br>-Final diagnosis of acute ischemic stroke in the anterior circulation<br>-Stroke Population, Suspected<br><br>**Exclusion criteria:**<br>Not Reported | 100% | Emergency room | Unclear/ not specified; NIHSS assessed prospectively and then LAMS derived from NIHSS elements | Persistent large vessel occlusions (PLVOs) were defined as follows. Findings on the first vessel imaging study performed were used to classify patients in 1 to 6 groups according to the location of their arterial occlusion. 1. ICA, 2. MCA main stem (M1), 3. MCA (M2), 4. MCA branches (M3-M4), 5. ACA, 6. No visible occlusion (No occlusion). Patients with 2 or more tandem occluded arteries were classified in the group of the largest occluded artery. | **AUC**<br>LAMS >= 4 units 0.854 units<br>NIHSS >= 11 units 0.933 units<br>**Negative Likelihood Ratio**<br>LAMS >= 4 units 0.21 NA<br>**Overall Accuracy**<br>LAMS >= 4 units 85 %<br>NIHSS >= 11 units 89 %<br>**Positive Likelihood Ratio**<br>LAMS >= 4 units 7.36 NA<br>**Sensitivity**<br>LAMS >= 0 units 100 %<br>LAMS >= 1 unit 96.9 %<br>LAMS >= 2 units 94.1 %<br>LAMS >= 3 units 86.3 %<br>LAMS >= 4 units 81 %<br>LAMS >= 5 units 71.4 %<br>NIHSS >= 11 units 91 %<br>**Specificity**<br>LAMS >= 0 units 0 %<br>LAMS >= 1 unit 6 %<br>LAMS >= 2 units 7 %<br>LAMS >= 3 units 46.2 % | • The performance of the LAMS stroke severity scores is comparable to NIHSS in predicting LVO.<br>• The high sensitivity and selectivity of the LAMS scale makes it a promising tool to triage select stroke patients for direct transport to CSC. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | | | | | | LAMS >= 4 units 89 %<br>LAMS >= 5 units 88.6 %<br>NIHSS >= 11 units 87 % | |
| Noorian A. 2016[25]<br>Link to abstract | **Study type:**<br>Prospective Observational; Meeting Abstract/Oral/Poster<br><br>**Size:**<br>N = 190 | **Inclusion criteria:**<br>-Stroke Population, Confirmed<br>-First vessel imaging done within 6 hours of last known well<br>-First vessel imaging done prior to intravenous tissue plasminogen activator (tPA)<br>-Acute cerebral ischemia<br><br>**Exclusion criteria:**<br>Not Reported | 100% | Mixed | Mixed; LAMS done by both EMS and research staff | occlusion in the Intracranial Portion of ICA, Cervical Portion of ICA, MCA 1, MCA 2, Basilar | **AUC**<br>HA LAMS >= 4 units 0.73 units<br>HA NIHSS >= 10 units 0.77 units<br>PM LAMS >= 4 units 0.7 units<br>**Disease Present**<br>HA LAMS >= 4 units 95 (50%)<br>HA NIHSS >= 10 units 95 (50%)<br>PM LAMS >= 4 units 95 (50%)<br>**Negative Likelihood Ratio**<br>PM LAMS >= 4 units 0.46 NA<br>Positive Likelihood Ratio<br>PM LAMS >= 4 units 1.76 NA<br>**Sensitivity**<br>PM LAMS >= 4 units 74 %<br>**Specificity**<br>PM LAMS >= 4 units 58 % | • LAMS ≥4 identified LVO comparable to the standard NIHSS. |
| Olavarría VV 2011[26]<br>21205696 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 463 | **Inclusion criteria:**<br>-Stroke Population, Suspected<br>-Admission National Institutes of Health Stroke Scale (NIHSS) score<br>-Acute ischemic stroke<br>-Brain computed tomography (CT) | 100% | Emergency room | Stroke team or stroke physician | We defined acute vessel occlusion as an obstruction of a large (carotid, M1), medium (M2, A1), or small (lacunar) intracranial artery of the anterior or posterior circulation (vertebral, basilar, P1) in the same territory of the suspected infarction, diagnosed by CTA or MRA | **Disease Absent**<br>NIHSS >= 17 units 359 (77.5%)<br>NIHSS >= 17 units and Time to Neurological Assessment < 6 hours 154 (71%)<br>NIHSS >= 17 units and Time to Neurological Assessment >= 6 hours 137 (84%)<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 137 (84%)<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 154 (71%)<br>NIHSS 0 units - 4 units 359 (77.5%)<br>NIHSS 0 units - 4 units and Time to Neurological Assessment < 6 hours 154 (71%)<br>NIHSS 0 units - 4 units and Time to Neurological | • The effect of time to clinical evaluation tested by NIHSS showed that the validity of the scale is time-dependent. The NIHSS validity in predicting occlusion was higher when less than 6 hours of time to clinical evaluation. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | or diffusion-weighted MRI<br>-Admission computed tomography angiography (CTA), magnetic resonance angiography (MRA), or digital subtraction angiography (DSA) of cerebral vessels<br>-Registry of computed tomography angiography (CTA) results<br>-Registry of digital subtraction angiography (DSA) results<br>-Registry of magnetic resonance angiography (MRA) results<br><br>**Exclusion criteria:**<br>-Transient ischemic attack<br>-Nonischemic stroke | | | | | Assessment >= 6 hours 137 (84%)<br>NIHSS 13 units - 16 units 359 (77.5%)<br>NIHSS 13 units - 16 units and Time to Neurological Assessment < 6 hours 154 (71%)<br>NIHSS 13 units - 16 units and Time to Neurological Assessment >= 6 hours 137 (84%)<br>NIHSS 5 units - 8 units 359 (77.5%)<br>NIHSS 5 units - 8 units and Time to Neurological Assessment < 6 hours 154 (71%)<br>NIHSS 5 units - 8 units and Time to Neurological Assessment >= 6 hours 137 (84%)<br>NIHSS 9 units - 12 units 359 (77.5%)<br>NIHSS 9 units - 12 units and Time to Neurological Assessment < 6 hours 154 (71%)<br>NIHSS 9 units - 12 units and Time to Neurological Assessment >= 6 hours 137 (84%)<br>**Disease Present**<br>NIHSS >= 17 units 104 (22.5%)<br>NIHSS >= 17 units and Time to Neurological Assessment < 6 hours 63 (29%)<br>NIHSS >= 17 units and Time to Neurological Assessment >= 6 hours 26 (16%)<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 26 (16%)<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 63 (29%)<br>NIHSS 0 units - 4 units 104 (22.5%)<br>NIHSS 0 units - 4 units and Time to Neurological Assessment < 6 hours 63 (29%)<br>NIHSS 0 units - 4 units and Time to Neurological Assessment >= 6 hours 26 (16%)<br>NIHSS 13 units - 16 units 104 (22.5%)<br>NIHSS 13 units - 16 units and Time to Neurological Assessment < 6 hours 63 (29%)<br>NIHSS 13 units - 16 units and Time to Neurological Assessment >= 6 hours 26 (16%)<br>NIHSS 5 units - 8 units 104 (22.5%) | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | | | | | | NIHSS 5 units - 8 units and Time to Neurological Assessment < 6 hours 63 (29%)<br>NIHSS 5 units - 8 units and Time to Neurological Assessment >= 6 hours 26 (16%)<br>NIHSS 9 units - 12 units 104 (22.5%)<br>NIHSS 9 units - 12 units and Time to Neurological Assessment < 6 hours 63 (29%)<br>NIHSS 9 units - 12 units and Time to Neurological Assessment >= 6 hours 26 (16%)<br>**False Negative**<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 9 (5.5%)<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 15 (6.9%)<br>**False Positive**<br>NIHSS >= 17 units 29 (6.3%)<br>NIHSS >= 17 units and Time to Neurological Assessment < 6 hours 13 (6%)<br>NIHSS >= 17 units and Time to Neurological Assessment >= 6 hours 10 (6.1%)<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 52 (31.9%)<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 46 (21.2%)<br>NIHSS 0 units - 4 units 226 (48.8%)<br>NIHSS 0 units - 4 units and Time to Neurological Assessment < 6 hours 88 (40.6%)<br>NIHSS 0 units - 4 units and Time to Neurological Assessment >= 6 hours 98 (60.1%)<br>NIHSS 13 units - 16 units 11 (2.4%)<br>NIHSS 13 units - 16 units and Time to Neurological Assessment < 6 hours 6 (2.8%)<br>NIHSS 13 units - 16 units and Time to Neurological Assessment >= 6 hours 4 (2.5%)<br>NIHSS 5 units - 8 units 67 (14.5%)<br>NIHSS 5 units - 8 units and Time to Neurological Assessment < 6 hours 31 (14.3%) | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | | | | | | NIHSS 5 units - 8 units and Time to Neurological Assessment >= 6 hours 19 (11.7%)<br>NIHSS 9 units - 12 units 26 (5.6%)<br>NIHSS 9 units - 12 units and Time to Neurological Assessment < 6 hours 16 (7.4%)<br>NIHSS 9 units - 12 units and Time to Neurological Assessment >= 6 hours 6 (3.7%)<br>**Negative Likelihood Ratio**<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 0.6 [CI 95%: 0.3-0.9] NA<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 0.34 [CI 95%: 0.22-0.5] NA<br>**Negative Predictive Value**<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 90.4 [CI 95%: 84 – 97] %<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 87.8 [CI 95%: 81.6 – 94] %<br>**Positive Likelihood Ratio**<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 1.7 [CI 95%: 1.2-2.6] NA<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 2.55 [CI 95%: 1.9-3.4] NA<br>**Positive Predictive Value**<br>NIHSS >= 17 units and Time to Neurological Assessment < 6 hours 69.3 %<br>NIHSS >= 17 units and Time to Neurological Assessment >= 6 hours 28.6 %<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 24.6 [CI 95%: 13.8 – 35.5] %<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 51.1 [CI 95%: 40.4 – 61.7] %<br>NIHSS 0 units - 4 units and Time to Neurological Assessment < 6 hours 9.3 %<br>NIHSS 0 units - 4 units and Time to Neurological Assessment >= 6 hours 9.3 %<br>NIHSS 13 units - 16 units and Time to Neurological Assessment < 6 hours 60 % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | NIHSS 13 units - 16 units and Time to Neurological Assessment >= 6 hours 33.3 %<br>NIHSS 5 units - 8 units and Time to Neurological Assessment < 6 hours 24.4 %<br>NIHSS 5 units - 8 units and Time to Neurological Assessment >= 6 hours 32.1 %<br>NIHSS 9 units - 12 units and Time to Neurological Assessment < 6 hours 27.3 %<br>NIHSS 9 units - 12 units and Time to Neurological Assessment >= 6 hours 14.2 %<br>**Sensitivity**<br>NIHSS >= 17 units 36.5 %<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 65.4 [CI 95%: 45.2 – 85.6] %<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 76.2 [CI 95%: 64.9 – 87.5] %<br>NIHSS 0 units - 4 units 23.1 %<br>NIHSS 13 units - 16 units 11.5 %<br>NIHSS 5 units - 8 units 19.2 %<br>NIHSS 9 units - 12 units 9.7 %<br>**Specificity**<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 62 [CI 95%: 53.6 – 70.5] %<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 70.1 [CI 95%: 62.6 – 77.7] %<br>**Test Negative**<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 94 (57.7%)<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 123 (56.7%)<br>**Test Positive**<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 69 (42.3%)<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 94 (43.3%)<br>**True Negative**<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | | | | | | hours 85 (52.1%)<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 108 (49.8%)<br>**True Positive**<br>NIHSS >= 17 units 38 (8.2%)<br>NIHSS >= 17 units and Time to Neurological Assessment < 6 hours 29 (13.4%)<br>NIHSS >= 17 units and Time to Neurological Assessment >= 6 hours 4 (2.5%)<br>NIHSS >= 4 units and Time to Neurological Assessment >= 6 hours 17 (10.4%)<br>NIHSS >= 7 units and Time to Neurological Assessment < 6 hours 48 (22.1%)<br>NIHSS 0 units - 4 units 24 (5.2%)<br>NIHSS 0 units - 4 units and Time to Neurological Assessment < 6 hours 9 (4.1%)<br>NIHSS 0 units - 4 units and Time to Neurological Assessment >= 6 hours 10 (6.1%)<br>NIHSS 13 units - 16 units 12 (2.6%)<br>NIHSS 13 units - 16 units and Time to Neurological Assessment < 6 hours 9 (4.1%)<br>NIHSS 13 units - 16 units and Time to Neurological Assessment >= 6 hours 2 (1.2%)<br>NIHSS 5 units - 8 units 20 (4.3%)<br>NIHSS 5 units - 8 units and Time to Neurological Assessment < 6 hours 10 (4.6%)<br>NIHSS 5 units - 8 units and Time to Neurological Assessment >= 6 hours 9 (5.5%)<br>NIHSS 9 units - 12 units 10 (2.2%)<br>NIHSS 9 units - 12 units and Time to Neurological Assessment < 6 hours 6 (2.8%)<br>NIHSS 9 units - 12 units and Time to Neurological Assessment >= 6 hours 1 (0.6%) | |
| Qureshi S. 2016[27]<br>Link to abstract | **Study type:**<br>Prospective Observational; Meeting | **Inclusion criteria:**<br>-Stroke population, suspected | 46% | Pre-hospital/ field | Unclear/ not specified | Unclear/not specified | **Disease Absent**<br>CPSSS >= 2 units Suspected Ischemic Stroke 73 (79.3%)<br>CPSSS >= 2 units Confirmed Ischemic Stroke 23 (54.8%)<br>LAMS >= 4 units Suspected Ischemic Stroke 73 (79.3%) | • NIHSS, LAMS, RACE and CPSSS have high specificity for detecting LVO |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | Abstract/Oral/Poster<br><br>**Size:**<br>N = 92 | -Presenting to a stroke center with stroke symptoms or a positive FAST screen by EMS within 6 hours from stroke onset or wakeup<br><br>**Exclusion criteria:**<br>Not Reported | | | | | LAMS >= 4 units Confirmed Ischemic Stroke 23 (54.8%)<br>NIHSS >= 15 units Suspected Ischemic Stroke 73 (79.3%)<br>NIHSS >= 15 units Confirmed Ischemic Stroke 23 (54.8%)<br>RACE >= 5 units Suspected Ischemic Stroke 73 (79.3%)<br>RACE >= 5 units Confirmed Ischemic Stroke 23 (54.8%)<br>**Disease Present**<br>CPSSS >= 2 units Suspected Ischemic Stroke 19 (20.7%)<br>CPSSS >= 2 units Confirmed Ischemic Stroke 19 (45.2%)<br>LAMS >= 4 units Suspected Ischemic Stroke 19 (20.7%)<br>LAMS >= 4 units Confirmed Ischemic Stroke 19 (45.2%)<br>NIHSS >= 15 units Suspected Ischemic Stroke 19 (20.7%)<br>NIHSS >= 15 units Confirmed Ischemic Stroke 19 (45.2%)<br>RACE >= 5 units Suspected Ischemic Stroke 19 (20.7%)<br>RACE >= 5 units and Confirmed Ischemic Stroke 19 (45.2%)<br>**Prevalence of LVO**<br>CPSSS >= 2 units Suspected Ischemic Stroke 19 (20.7%)<br>CPSSS >= 2 units Confirmed Ischemic Stroke 19 (45.2%)<br>LAMS >= 4 units Suspected Ischemic Stroke 19 (20.7%)<br>LAMS >= 4 units Confirmed Ischemic Stroke 19 (45.2%)<br>NIHSS >= 15 units Suspected Ischemic Stroke 19 (20.7%)<br>NIHSS >= 15 units Confirmed Ischemic Stroke 19 (45.2%)<br>RACE >= 5 units Suspected Ischemic Stroke 19 (20.7%)<br>RACE >= 5 units and Confirmed Ischemic Stroke 19 (45.2%)<br>**Sensitivity**<br>CPSSS >= 2 units Suspected Ischemic Stroke 58%<br>CPSSS >= 2 units Confirmed Ischemic Stroke 58%<br>LAMS >= 4 units Suspected Ischemic Stroke 47%<br>LAMS >= 4 units Confirmed Ischemic Stroke 47%<br>NIHSS >= 15 units Suspected Ischemic Stroke 32%<br>NIHSS >= 15 units Confirmed Ischemic Stroke 32%<br>RACE >= 5 units Suspected Ischemic Stroke 63%<br>RACE >= 5 units Confirmed Ischemic Stroke 63%<br>**Specificity**<br>CPSSS >= 2 units Suspected Ischemic Stroke 77%<br>CPSSS >= 2 units Confirmed Ischemic Stroke 87%<br>LAMS >= 4 units Suspected Ischemic Stroke 90%<br>LAMS >= 4 units Confirmed Ischemic Stroke 96% | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | | | | | | NIHSS >= 15 units Suspected Ischemic Stroke 86%<br>NIHSS >= 15 units Confirmed Ischemic Stroke 96%<br>RACE >= 5 units Suspected Ischemic Stroke 85%<br>RACE >= 5 units Confirmed Ischemic Stroke **96**% | |
| Scheitz JF 2015[28] 26202713 | **Study type:**<br>Retrospective Observational; Letter/Commentary<br><br>**Size:**<br>N = 229 | **Inclusion criteria:**<br>- Stroke Population, Confirmed<br>-Anterior circulation stroke<br>-Stroke presenting within 4.5 hour time window<br><br>**Exclusion criteria:**<br>Not Reported | 100% | Unclear/ not specified | Unclear/ not specified | Proximal vessel occlusion was defined as terminal ICA, carotid-T, MCA-M1) | **AUC**<br>NIHSS >= 11units 0.77 units<br>NIHSS >= 5 units 0.77 units<br>**Disease Absent**<br>NIHSS >= 11units 132 (57.6%)<br>NIHSS >= 5 units 132 (57.6%)<br>**Disease Present**<br>NIHSS >= 11units 97 (42.4%)<br>NIHSS >= 5 units 97 (42.4%)<br>**Negative Predictive Value**<br>NIHSS >= 11units 81.5 %<br>NIHSS >= 5 units 90.9 %<br>**Positive Predictive Value**<br>NIHSS >= 11units 70.5 %<br>NIHSS >= 5 units 50.3 %<br>**Sensitivity**<br>NIHSS >= 11units 76.3 %<br>NIHSS >= 5 units 95.8 %<br>Specificity<br>NIHSS >= 11units 76.5 %<br>NIHSS >= 5 units 30.3 % | • NIHSS > 10 is the optimal cutoff for predicting LVO. |
| Sequeira D. 2015[29] Link to abstract | **Study type:**<br>Retrospective Observational; Meeting Abstract/Oral/Poster<br><br>**Size:**<br>N = 1293 | **Inclusion criteria:**<br>-Stroke Population, Suspected<br>-Prehospital National Institute of Health Stroke Scale (NIHSS) measurement | 100% | Pre-hospital/ field | Emergency medical services personnel in field; NIHSS assessed prospectively and then other scales | Unclear/not specified | **Sensitivity**<br>CPSS >= 2 units 78 %<br>LAMS >= 3 units 62 %<br>LAPSS 43 %<br>NIHSS >= 6 units 74 %<br>RACE >= 4 units 56 %<br>**Specificity**<br>CPSS >= 2 units 54 %<br>LAMS >= 3 units 70 %<br>LAPSS 88 %<br>NIHSS >= 6 units 62 % | • The study recommends development of a new tool to improve accuracy to identify LVO as most scores currently used has low sensitivity for LVO and stroke detection. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | -Discharge Diagnosis of Stroke<br><br>**Exclusion criteria:** Not Reported | | | derived from NIHSS elements | | RACE >= 4 units 87 % | |
| Singer OC 2005[30] 15731478 | **Study type:** Prospective Observational; Journal Article<br><br>**Size:** N = 171 | **Inclusion criteria:** -Clinical suspicion of an acute cerebrovascular event -Symptom onset <= 6 hours -Stroke population, Suspected -Clinical Suspicion of Hemorrhagic or ischemic stroke<br><br>**Exclusion criteria:** Not Reported | unclear/ unspecified | Emergency room | Stroke team or stroke physician | Proximal vessel occlusion was defined as T or M1 occlusion of MCA | **Negative Predictive Value**<br>3I-SS >= 1 unit 96 %<br>3I-SS >= 2 units 96 %<br>3I-SS >= 3 units 91 %<br>3I-SS >= 4 units 89 %<br>3I-SS >= 5 units 83 %<br>3I-SS >= 6 units 78 %<br>NIHSS >= 14 units 95 %<br>**Overall Accuracy, MCA** Occlusion, Proximal<br>3I-SS >= 1 unit 57 %<br>3I-SS >= 2 units 75 %<br>3I-SS >= 3 units 83 %<br>3I-SS >= 4 units 86 %<br>3I-SS >= 5 units 84 %<br>3I-SS >= 6 units 78 %<br>**Positive Predictive Value**<br>3I-SS >= 1 unit 36 %<br>3I-SS >= 2 units 50 %<br>3I-SS >= 3 units 64 %<br>3I-SS >= 4 units 74 %<br>3I-SS >= 5 units 100 %<br>3I-SS >= 6 units 100 %<br>NIHSS >= 14 units 86 %<br>**Sensitivity**<br>3I-SS >= 1 unit 95 %<br>3I-SS >= 2 units 90 %<br>3I-SS >= 3 units 76 %<br>3I-SS >= 4 units 67 %<br>3I-SS >= 5 units 38 %<br>3I-SS >= 6 units 14 % | • The 3 -item stroke scale is well associated with NIHS and has an overall good accuracy for detection of MCA occlusion. . |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | | | | | | NIHSS >= 14 units 86 %<br>**Specificity**<br>3I-SS >= 1 unit 44 %<br>3I-SS >= 2 units 69 %<br>3I-SS >= 3 units 85 %<br>3I-SS >= 4 units 92 %<br>3I-SS >= 5 units 100 %<br>3I-SS >= 6 units 100 %<br>NIHSS >= 14 units 95 % | |
| Slivka AP 2006[31] 17904044 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 88 | **Inclusion criteria:**<br>- Stroke Population, Suspected<br>-Seen within 6 hours of symptoms of a stroke<br>-Underwent screening cerebral angiography<br>-Carotid or vertebral distribution clinical signs<br>-Carotid or vertebral distribution symptoms<br>-Considered thrombolytic candidates<br>-Had a screening National Institutes of Health Stroke Scale (NIHSS)<br><br>**Exclusion criteria:** | 95% | Emergency room | Unclear/ not specified | Occlusion was defined according to the Oxford Community Stroke Project (OCSP) classification system. The following sites were considered: CCA, Proximal ICA, Distal ICA, Proximal MCA, Distal MCA, Proximal ACA, Distal Vertebral | **Disease Absent**<br>NIHSS <= 9 units 33 (37.5%)<br>NIHSS >= 15 units 33 (37.5%)<br>NIHSS >= 20 units 33 (37.5%)<br>**Disease Present**<br>NIHSS <= 9 units 55 (62.5%)<br>NIHSS >= 15 units 55 (62.5%)<br>NIHSS >= 20 units 55 (62.5%)<br>**False Negative**<br>NIHSS <= 9 units 15 (17%)<br>**False Positive**<br>NIHSS >= 15 units 2 (2.3%)<br>NIHSS >= 20 units 0 (0%)<br>**Test Positive**<br>NIHSS <= 9 units 37 (42%)<br>NIHSS >= 15 units 29 (33%)<br>NIHSS >= 20 units 10 (11.4%)<br>**True Negative**<br>NIHSS <= 9 units 22 (25%)<br>**True Positive**<br>NIHSS >= 15 units 27 (30.7%)<br>NIHSS >= 20 units 10 (11.4%) | • Scoring NIHSS > 14 is more likely to be associated with having an occlusion<br>• Stroke scales, time from stroke onset to angiography and stroke classification do not predict the specific occlusion site but predicts the presence or absence of cerebral occlusion. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
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| | | -Treated with intravenous tissue plasminogen activator (t-PA)<br>-International normalized ratio greater than 1.5 for patients treated with Coumadin | | | | | | |
| Teleb MS 2016[32]<br>26891627 | **Study type:**<br>Prospective Observational; Journal Article<br><br>**Size:**<br>N = 62 | **Inclusion criteria:**<br>-Stroke Population, Confirmed<br><br>**Exclusion criteria:**<br>Not Reported | 100% | Emergency room | ED nurse | ELVO was defined as thromboembolic occlusion of an M1 segment of the MCA, ICA, BA, or M2 segment | **Disease Absent**<br>NIHSS >= 6 units 48 (77.4%)<br>VAN Positive 48 (77.4%)<br>**Disease Present**<br>NIHSS >= 6 units 14 (22.6%)<br>VAN Positive 14 (22.6%)<br>**False Negative**<br>NIHSS >= 6 units 0 (0%)<br>VAN Positive 0 (0%)<br>**False Positive**<br>NIHSS >= 6 units 10 (16.1%)<br>VAN Positive 5 (8.1%)<br>**Negative Predictive Value**<br>NIHSS >= 6 units 100 %<br>VAN Positive 100 %<br>**Overall Accuracy**<br>NIHSS >= 6 units 84 %<br>VAN Positive 92 %<br>**Positive Predictive Value**<br>NIHSS >= 6 units 58 %<br>VAN Positive 74 %<br>**Prevalence of LVO**<br>NIHSS >= 6 units 14 (22.6%)<br>VAN Positive 14 (22.6%)<br>**Sensitivity**<br>NIHSS >= 6 units 100 % | • VAN tool was developed to assess the functional neurovascular anatomy<br>• This screening tool outperformed a NIHSS≥ 6 severity threshold and accurately predicted LVO |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | VAN Positive 100 %<br>**Specificity**<br>NIHSS >= 6 units 79 %<br>VAN Positive 90 %<br>**Test Negative**<br>NIHSS >= 6 units 38 (61.3%)<br>VAN Positive 43 (69.4%)<br>**Test Positive**<br>NIHSS >= 6 units 24 (38.7%)<br>VAN Positive 19 (30.6%)<br>**True Negative**<br>NIHSS >= 6 units 38 (61.3%)<br>VAN Positive 43 (69.4%)<br>**True Positive**<br>NIHSS >= 6 units 14 (22.6%)<br>VAN Positive 14 (22.6%) | |
| Turc G 2016[33] 27125526 | **Study type:**<br>Retrospective Observational; Journal Article<br><br>**Size:**<br>N = 1004 | **Inclusion criteria:**<br>- Magnetic resonance angiography (MRA) or computed tomographic angiography (CTA) performed on admission<br>-Ischemic stroke<br>-Stroke Population, Confirmed<br>-Admitted to comprehensive stroke center within 6 hours after ischemic stroke onset | 100% | Emergency room | Stroke team or stroke physician; NIHSS was assessed prospectively and then other scales derived from NIHSS elements | LAO (large artery occlusion) was defined as occlusion of the ICA, proximal (M1) segment of the MCA, or BA | **Disease Present**<br>3I-SS >= 0 units 328 (32.7%)<br>3I-SS >= 4 units 328 (32.7%)<br>Abbreviated NIHSS >= 1 unit 328 (32.7%)<br>CPSSS >= 0 units 328 (32.7%)<br>CPSSS >=2 units 328 (32.7%)<br>mNIHSS >= 3 units 328 (32.7%)<br>mNIHSS >= 7 units 328 (32.7%)<br>MPSS >= 2 units 328 (32.7%)<br>MPSS >= 3 units 328 (32.7%)<br>NIHSS >= 10 units 328 (32.7%)<br>NIHSS >= 11 units 328 (32.7%)<br>NIHSS >= 14 units 328 (32.7%)<br>NIHSS >= 4 units 328 (32.7%)<br>NIHSS >= 5 units 328 (32.7%)<br>NIHSS >= 6 units 328 (32.7%)<br>NIHSS 0-3 hours >= 9 units or NIHSS 3-6 hours >= 7 units 328 (32.7%)<br>OoH-NIHSS >= 1 unit and CPSS >= 1 unit 328 (32.7%)<br>RACE >= 1 unit 328 (32.7%)<br>RACE >= 5 units 328 (32.7%) | • Clinical scores only provide a rough estimate for LVO prediction and result in inaccurate triaging.<br>• Within 6 hours of symptom onset, MRA or CTA should be performed in all patients. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | **Exclusion criteria:**<br>-Unknown time of symptom onset<br>-Missing admission National Institute of Health Stroke Scale score items<br>-Previous stroke with significant disability<br>-Modified Rankin Scale score, >1<br>-Insufficient quality of magnetic resonance angiography to assess large artery occlusion status<br>-Insufficient quality of computed tomographic angiography to assess large artery occlusion status<br>-Patients transferred from a primary stroke center to receive endovascular therapy | | | | | rNIHSS Item A, B, C, D, or E 328 (32.7%)<br>ROSIER >= 2 units 328 (32.7%)<br>ROSIER >= 4 units 328 (32.7%)<br>sNIHSS-1 >= 0 units 328 (32.7%)<br>sNIHSS-1 >= 2 units 328 (32.7%)<br>sNIHSS-5 >= 1 unit 328 (32.7%)<br>sNIHSS-5 >= 4 units 328 (32.7%)<br>sNIHSS-8 >= 2 units 328 (32.7%)<br>sNIHSS-8 >= 6 units 328 (32.7%)<br>**Negative Likelihood Ratio**<br>3I-SS >= 4 units 0.7 [CI 95%: 0.7-0.8] NA<br>Abbreviated NIHSS >= 1 unit 0.2 [CI 95%: 0.1-0.3] NA<br>CPSSS >=2 units 0.4 [CI 95%: 0.4-0.5] NA<br>mNIHSS >= 7 units 0.3 [CI 95%: 0.2-0.4] NA<br>MPSS >= 3 units 0.2 [CI 95%: 0.2-0.3] NA<br>NIHSS >= 10 units 0.3 [CI 95%: 0.2-0.4] NA<br>NIHSS >= 11 units 0.3 [CI 95%: 0.3-0.4] NA<br>NIHSS >= 14 units 0.4 [CI 95%: 0.4-0.5] NA<br>NIHSS >= 4 units 0.1 [CI 95%: 0.1-0.2] NA<br>NIHSS >= 5 units 0.2 [CI 95%: 0.1-0.3] NA<br>NIHSS >= 6 units 0.2 [CI 95%: 0.2-0.3] NA<br>NIHSS 0-3 hours >= 9 units or NIHSS 3-6 hours >= 7 units 0.3 [CI 95%: 0.2-0.3] NA<br>OoH-NIHSS >= 1 unit and CPSS >= 1 unit 0.2 [CI 95%: 0.1-0.3] NA<br>RACE >= 5 units 0.4 [CI 95%: 0.3-0.4] NA<br>rNIHSS Item A, B, C, D, or E 0.3 [CI 95%: 0.2-0.4] NA<br>ROSIER >= 4 units 0.3 [CI 95%: 0.2-0.3] NA<br>sNIHSS-1 >= 2 units 0.4 [CI 95%: 0.4-0.5] NA<br>sNIHSS-5 >= 4 units 0.4 [CI 95%: 0.3-0.4] NA<br>sNIHSS-8 >= 6 units 0.3 [CI 95%: 0.2-0.4] NA<br>**Negative Predictive Value**<br>3I-SS >= 4 units 74 [CI 95%: 71 – 77] %<br>Abbreviated NIHSS >= 1 unit 92 [CI 95%: 89 – 96] %<br>CPSSS >=2 units 83 [CI 95%: 80 – 86] %<br>mNIHSS >= 7 units 87 [CI 95%: 85 – 90] %<br>MPSS >= 3 units 89 [CI 95%: 87 – 92] % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | NIHSS >= 10 units 87 [CI 95%: 85 – 90] %<br>NIHSS >= 11 units 86 [CI 95%: 84 – 89] %<br>NIHSS >= 14 units 82 [CI 95%: 80 – 85] %<br>NIHSS >= 4 units 93 [CI 95%: 91 – 96] %<br>NIHSS >= 5 units 92 [CI 95%: 89 – 94] %<br>NIHSS >= 6 units 91 [CI 95%: 88 – 94] %<br>NIHSS 0-3 hours >= 9 units or NIHSS 3-6 hours >= 7 units 89 [CI 95%: 86 – 91] %<br>OoH-NIHSS >= 1 unit and CPSS >= 1 unit 93 [CI 95%: 89 – 97] %<br>RACE >= 5 units 84 [CI 95%: 82 – 87] %<br>rNIHSS Item A, B, C, D, or E 88 [CI 95%: 85 – 91] %<br>ROSIER >= 4 units 88 [CI 95%: 85 – 91] %<br>sNIHSS-1 >= 2 units 83 [CI 95%: 80 – 86] %<br>sNIHSS-5 >= 4 units 85 [CI 95%: 83 – 88] %<br>sNIHSS-8 >= 6 units 88 [CI 95%: 85 – 90] %<br>**Overall Accuracy**<br>3I-SS >= 0 units 33 [CI 95%: 30 – 36] %<br>3I-SS >= 4 units 74 [CI 95%: 71 – 76] %<br>Abbreviated NIHSS >= 1 unit 52 [CI 95%: 49 – 55] %<br>CPSSS >= 0 units 33 [CI 95%: 30 – 36] %<br>CPSSS >=2 units 78 [CI 95%: 75 – 80] %<br>mNIHSS >= 3 units 64 [CI 95%: 61 – 67] %<br>mNIHSS >= 7 units 77 [CI 95%: 74 – 80] %<br>MPSS >= 2 units 60 [CI 95%: 57 – 63] %<br>MPSS >= 3 units 71 [CI 95%: 69 – 74] %<br>NIHSS >= 10 units 78 [CI 95%: 76 – 81] %<br>NIHSS >= 11 units 79 [CI 95%: 77 – 82] %<br>NIHSS >= 14 units 79 [CI 95%: 77 – 82] %<br>NIHSS >= 4 units 62 [CI 95%: 59 – 65] %<br>NIHSS >= 5 units 66 [CI 95%: 63 – 69] %<br>NIHSS >= 6 units 69 [CI 95%: 66 – 72] %<br>NIHSS 0-3 hours >= 9 units or NIHSS 3-6 hours >= 7 units 75 [CI 95%: 73 – 78] %<br>OoH-NIHSS >= 1 unit and CPSS >= 1 unit 47 [CI 95%: 44 – 50] %<br>RACE >= 1 unit 55 [CI 95%: 52 – 58] % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | RACE >= 5 units 79 [CI 95%: 77 – 82] %<br>rNIHSS Item A, B, C, D, or E 68 [CI 95%: 66 – 71] %<br>ROSIER >= 2 units 58 [CI 95%: 55 – 61] %<br>ROSIER >= 4 units 77 [CI 95%: 74 – 79] %<br>sNIHSS-1 >= 0 units 33 [CI 95%: 30 – 36] %<br>sNIHSS-1 >= 2 units 76 [CI 95%: 73 – 79] %<br>sNIHSS-5 >= 1 unit 56 [CI 95%: 53 – 59] %<br>sNIHSS-5 >= 4 units 77 [CI 95%: 75 – 80] %<br>sNIHSS-8 >= 2 units 55 [CI 95%: 52 – 58] %<br>sNIHSS-8 >= 6 units 78 [CI 95%: 75 – 80] %<br>**Positive Likelihood Ratio**<br>3I-SS >= 4 units 5.8 [CI 95%: 4-8.3] NA<br>Abbreviated NIHSS >= 1 unit 1.4 [CI 95%: 1.3-1.4] NA<br>CPSSS >=2 units 4 [CI 95%: 3.3-4.8] NA<br>mNIHSS >= 7 units 3.4 [CI 95%: 2.9-3.9] NA<br>MPSS >= 3 units 2.4 [CI 95%: 2.2-2.7] NA<br>NIHSS >= 10 units 3.7 [CI 95%: 3.2-4.4] NA<br>NIHSS >= 11 units 4.2 [CI 95%: 3.5-5] NA<br>NIHSS >= 14 units 5.3 [CI 95%: 4.2-6.6] NA<br>NIHSS >= 4 units 1.7 [CI 95%: 1.6-1.9] NA<br>NIHSS >= 5 units 2 [CI 95%: 1.8-2.1] NA<br>NIHSS >= 6 units 2.2 [CI 95%: 2-2.4] NA<br>NIHSS 0-3 hours >= 9 units or NIHSS 3-6 hours >= 7 units 2.9 [CI 95%: 2.6-3.4] NA<br>OoH-NIHSS >= 1 unit and CPSS >= 1 unit 1.3 [CI 95%: 1.2-1.3] NA<br>RACE >= 5 units 4.6 [CI 95%: 3.8-5.6] NA<br>rNIHSS Item A, B, C, D, or E 2.1 [CI 95%: 1.9-2.4] NA<br>ROSIER >= 4 units 3.3 [CI 95%: 2.8-3.8] NA<br>sNIHSS-1 >= 2 units 3.4 [CI 95%: 2.9-4.1] NA<br>sNIHSS-5 >= 4 units 3.6 [CI 95%: 3-4.2] NA<br>sNIHSS-8 >= 6 units 3.5 [CI 95%: 3-4] NA<br>Positive Predictive Value<br>3I-SS >= 4 units 74 [CI 95%: 66 – 81] %<br>Abbreviated NIHSS >= 1 unit 40 [CI 95%: 36 – 43] %<br>CPSSS >=2 units 66 [CI 95%: 61 – 71] %<br>mNIHSS >= 7 units 62 [CI 95%: 57 – 67] % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | MPSS >= 3 units 54 [CI 95%: 50 – 58] %<br>NIHSS >= 10 units 64 [CI 95%: 60 – 69] %<br>NIHSS >= 11 units 67 [CI 95%: 62 – 72] %<br>NIHSS >= 14 units 72 [CI 95%: 67 – 77] %<br>NIHSS >= 4 units 46 [CI 95%: 42 – 50] %<br>NIHSS >= 5 units 49 [CI 95%: 45 – 53] %<br>NIHSS >= 6 units 52 [CI 95%: 47 – 56] %<br>NIHSS 0-3 hours >= 9 units or NIHSS 3-6 hours >= 7 units 59 [CI 95%: 54 – 63] %<br>OoH-NIHSS >= 1 unit and CPSS >= 1 unit 38 [CI 95%: 35 – 41] %<br>RACE >= 5 units 69 [CI 95%: 64 – 74] %<br>rNIHSS Item A, B, C, D, or E 51 [CI 95%: 47 – 55] %<br>ROSIER >= 4 units 61 [CI 95%: 57 – 66] %<br>sNIHSS-1 >= 2 units 63 [CI 95%: 57 – 68] %<br>sNIHSS-5 >= 4 units 63 [CI 95%: 59 – 68] %<br>sNIHSS-8 >= 6 units 63 [CI 95%: 58 – 67] %<br>**Sensitivity**<br>3I-SS >= 0 units 100 [CI 95%: 100 – 100] %<br>3I-SS >= 4 units 30 [CI 95%: 25 – 35] %<br>Abbreviated NIHSS >= 1 unit 95 [CI 95%: 92 – 97] %<br>CPSSS >= 0 units 100 [CI 95%: 100 – 100] %<br>CPSSS >=2 units 65 [CI 95%: 60 – 70] %<br>mNIHSS >= 3 units 91 [CI 95%: 88 – 94] %<br>mNIHSS >= 7 units 77 [CI 95%: 72 – 81] %<br>MPSS >= 2 units 93 [CI 95%: 90 – 96] %<br>MPSS >= 3 units 84 [CI 95%: 80 – 88] %<br>NIHSS >= 10 units 76 [CI 95%: 72 – 81] %<br>NIHSS >= 11 units 73 [CI 95%: 68 – 78] %<br>NIHSS >= 14 units 61 [CI 95%: 56 – 66] %<br>NIHSS >= 4 units 93 [CI 95%: 91 – 96] %<br>NIHSS >= 5 units 90 [CI 95%: 87 – 93] %<br>NIHSS >= 6 units 88 [CI 95%: 84 – 91] %<br>NIHSS 0-3 hours >= 9 units or NIHSS 3-6 hours >= 7 units 81 [CI 95%: 77 – 85] %<br>OoH-NIHSS >= 1 unit and CPSS >= 1 unit 96 [CI 95%: 94 – 98] % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | RACE >= 1 unit 96 [CI 95%: 94 – 98] %<br>RACE >= 5 units 67 [CI 95%: 62 – 72] %<br>rNIHSS Item A, B, C, D, or E 83 [CI 95%: 79 – 87] %<br>ROSIER >= 2 units 91 [CI 95%: 88 – 94] %<br>ROSIER >= 4 units 79 [CI 95%: 74 – 83] %<br>sNIHSS-1 >= 0 units 100 [CI 95%: 100 – 100] %<br>sNIHSS-1 >= 2 units 66 [CI 95%: 61 – 71] %<br>sNIHSS-5 >= 1 unit 92 [CI 95%: 89 – 95] %<br>sNIHSS-5 >= 4 units 72 [CI 95%: 67 – 77] %<br>sNIHSS-8 >= 2 units 93 [CI 95%: 91 – 96] %<br>sNIHSS-8 >= 6 units 77 [CI 95%: 73 – 82] %<br>**Specificity**<br>3I-SS >= 0 units 0 [CI 95%: 0 – 0] %<br>3I-SS >= 4 units 95 [CI 95%: 93 – 96] %<br>Abbreviated NIHSS >= 1 unit 31 [CI 95%: 27 – 34] %<br>CPSSS >= 0 units 0 [CI 95%: 0 – 0] %<br>CPSSS >=2 units 84 [CI 95%: 81 – 87] %<br>mNIHSS >= 3 units 51 [CI 95%: 47 – 55] %<br>mNIHSS >= 7 units 77 [CI 95%: 74 – 80] %<br>MPSS >= 2 units 44 [CI 95%: 40 – 48] %<br>MPSS >= 3 units 65 [CI 95%: 62 – 69] %<br>NIHSS >= 10 units 80 [CI 95%: 77 – 83] %<br>NIHSS >= 11 units 83 [CI 95%: 80 – 86] %<br>NIHSS >= 14 units 88 [CI 95%: 86 – 91] %<br>NIHSS >= 4 units 46 [CI 95%: 43 – 50] %<br>NIHSS >= 5 units 54 [CI 95%: 50 – 58] %<br>NIHSS >= 6 units 60 [CI 95%: 57 – 64] %<br>NIHSS 0-3 hours >= 9 units or NIHSS 3-6 hours >= 7 units 72 [CI 95%: 69 – 76] %<br>OoH-NIHSS >= 1 unit and CPSS >= 1 unit 24 [CI 95%: 20 – 27] %<br>RACE >= 1 unit 35 [CI 95%: 31 – 39] %<br>RACE >= 5 units 85 [CI 95%: 83 – 88] %<br>rNIHSS Item A, B, C, D, or E 61 [CI 95%: 58 – 65] %<br>ROSIER >= 2 units 42 [CI 95%: 38 – 45] %<br>ROSIER >= 4 units 76 [CI 95%: 73 – 79] %<br>sNIHSS-1 >= 0 units 0 [CI 95%: 0 – 0] % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | sNIHSS-1 >= 2 units 81 [CI 95%: 78 – 84] %<br>sNIHSS-5 >= 1 unit 38 [CI 95%: 35 – 42] %<br>sNIHSS-5 >= 4 units 80 [CI 95%: 77 – 83] %<br>sNIHSS-8 >= 2 units 37 [CI 95%: 33 – 70] %<br>sNIHSS-8 >= 6 units 78 [CI 95%: 75 – 81] %<br>**Test Negative**<br>3I-SS >= 0 units 0 (0%)<br>3I-SS >= 4 units 871 (86.8%)<br>Abbreviated NIHSS >= 1 unit 225 (22.4%)<br>CPSSS >= 0 units 0 (0%)<br>CPSSS >=2 units 680 (67.7%)<br>mNIHSS >= 3 units 373 (37.2%)<br>mNIHSS >= 7 units 597 (59.5%)<br>MPSS >= 2 units 322 (32.1%)<br>MPSS >= 3 units 493 (49.1%)<br>NIHSS >= 10 units 616 (61.4%)<br>NIHSS >= 11 units 648 (64.5%)<br>NIHSS >= 14 units 726 (72.3%)<br>NIHSS >= 4 units 335 (33.4%)<br>NIHSS >= 5 units 398 (39.6%)<br>NIHSS >= 6 units 448 (44.6%)<br>NIHSS 0-3 hours >= 9 units or NIHSS 3-6 hours >= 7 units 552 (55%)<br>OoH-NIHSS >= 1 unit and CPSS >= 1 unit 172 (17.1%)<br>RACE >= 1 unit 250 (24.9%)<br>RACE >= 5 units 684 (68.1%)<br>rNIHSS Item A, B, C, D, or E 469 (46.7%)<br>ROSIER >= 2 units 310 (30.9%)<br>ROSIER >= 4 units 583 (58.1%)<br>sNIHSS-1 >= 0 units 0 (0%)<br>sNIHSS-1 >= 2 units 657 (65.4%)<br>sNIHSS-5 >= 1 unit 286 (28.5%)<br>sNIHSS-5 >= 4 units 632 (62.9%)<br>sNIHSS-8 >= 2 units 269 (26.8%)<br>sNIHSS-8 >= 6 units 599 (59.7%)<br>**Test Positive**<br>3I-SS >= 0 units 1004 (100%) | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 3I-SS >= 4 units 133 (13.2%)<br>Abbreviated NIHSS >= 1 unit 779 (77.6%)<br>CPSSS >= 0 units 1004 (100%)<br>CPSSS >=2 units 324 (32.3%)<br>mNIHSS >= 3 units 631 (62.8%)<br>mNIHSS >= 7 units 407 (40.5%)<br>MPSS >= 2 units 682 (67.9%)<br>MPSS >= 3 units 511 (50.9%)<br>NIHSS >= 10 units 388 (38.6%)<br>NIHSS >= 11 units 356 (35.5%)<br>NIHSS >= 14 units 278 (27.7%)<br>NIHSS >= 4 units 669 (66.6%)<br>NIHSS >= 5 units 606 (60.4%)<br>NIHSS >= 6 units 556 (55.4%)<br>NIHSS 0-3 hours >= 9 units or NIHSS 3-6 hours >= 7 units 452 (45%)<br>OoH-NIHSS >= 1 unit and CPSS >= 1 unit 832 (82.9%)<br>RACE >= 1 unit 754 (75.1%)<br>RACE >= 5 units 320 (31.9%)<br>rNIHSS Item A, B, C, D, or E 535 (53.3%)<br>ROSIER >= 2 units 694 (69.1%)<br>ROSIER >= 4 units 421 (41.9%)<br>sNIHSS-1 >= 0 units 1004 (100%)<br>sNIHSS-1 >= 2 units 347 (34.6%)<br>sNIHSS-5 >= 1 unit 718 (71.5%)<br>sNIHSS-5 >= 4 units 372 (37.1%)<br>sNIHSS-8 >= 2 units 735 (73.2%)<br>sNIHSS-8 >= 6 units 405 (40.3%) | |
| Vanacker P 2016 Bernese Stroke Registry[34] 26958750 | **Study type:** Retrospective Observational; Journal Article<br><br>**Size:** N = 2023 | **Inclusion criteria:** -Consecutive acute ischemic stroke -Vascular Imaging within 6 and 12 hours of symptom onset | 100% | Emergency room | Stroke team or stroke physician, NIHSS assessed prospectively and then ASTRAL | Occlusion was defined as absent filling of examined arterial segment during the initial acquisition of contrast medium images, and the presence and the site of LVOs and intra- and | **AUC**<br>ASTRAL >= 16 units 0.84 units<br>NIHSS >= 10 units 0.84 units<br>**Negative Predictive Value**<br>ASTRAL >= 16 units 92 %<br>NIHSS >= 10 units 92 %<br>**Positive Predictive Value**<br>ASTRAL >= 16 units 54 %<br>NIHSS >= 10 units 55 % | • The developed score adds more complexity in assessment compared to the NIHSS scale with only marginal additional predictive value. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | -Stroke Population, Confirmed<br><br>**Exclusion criteria:** Not Reported | | | derived from NIHSS elements | extracranial stenoses greater than or equal to 50% were recorded as described previously. Intracranial occlusions in the ischemic territory were categorized according to their site in "large" versus "intermediate" occlusions. Large intracranial, endovascular treatable occlusions were defined as an occlusion of the basilar artery (with or without intracranial vertebral artery occlusion), the intracranial carotid siphon including the carotid T, and the M1 segment of the MCA before its bifurcation, with and without ipsilateral carotid occlusion. Intermediate intracranial occlusions were defined as occlusions in anterior cerebral artery (A1 or A2 segments), peripheral MCA (M2), PCA (P1 or P2 segments), intracranial part of the vertebral artery (V4), and siphon of the internal carotid | **Prevalence of LVO**<br>ASTRAL >= 16 units 273 (32.2%)<br>NIHSS >= 10 units 273 (32.2%)<br>NIHSS 273 (32.2%)<br>**Sensitivity**<br>ASTRAL >= 16 units 84 %<br>NIHSS >= 10 units 85 %<br>**Specificity**<br>ASTRAL >= 16 units 71 %<br>NIHSS >= 10 units 73 % | |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | artery without distal T occlusion; the latter two were considered "intermediate" because thrombus load and clinical symptoms are usually minor in the absence of extension into the BA and the carotid T, respectively. M2 occlusions were considered "intermediate" because of the different outcome and treatment strategy in comparison with M1 MCA occlusions. FROM THE ABSTRACT: large vessel occlusion was defined as intracranial carotid, basilar, and M1 segment of middle cerebral artery occlusions. | | |
| Venizelos A. 2014[35] Link to abstract | **Study type:** Retrospective Observational; Meeting Abstract/Oral/Poster<br><br>**Size:** N = 155 | **Inclusion criteria:** -Stroke Population, Confirmed -Consecutive ischemic stroke<br><br>**Exclusion criteria:** Not Reported | 100% | Emergency room | Unclear/ not specified | Unclear/not specified | **Disease Absent**<br>LEGS >= 4 110 (71%)<br>**Disease Present**<br>LEGS >= 4 45 (29%)<br>**Negative Predictive Value**<br>LEGS >= 4 86 %<br>**Positive Predictive Value**<br>LEGS >= 4 60 %<br>**Sensitivity**<br>LEGS >= 4 69 %<br>**Specificity**<br>LEGS >= 4 81 %<br>**Test Negative** | • LEGS score ≥4 is specific for predicting LVOs and has a good correlation with NIHSS≥ 10. |

| Study Acronym; Author; Year Published | Study Type/Design; Study Size | Patient Population | Ischemic Stroke (%) | Ascertain-ment Location | Instrument Adminis-trator | LVO Definition | Primary Endpoint and Results (P values; OR or RR; & 95% CI) | Summary/Conclusion Comment(s) |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | LEGS >= 4 103 (66.5%)<br>**Test Positive**<br>LEGS >= 4 52 (33.5%)<br>**True Negative**<br>LEGS >= 4 89 (57.4%)<br>**True Positive**<br>LEGS >= 4 31 (20%) | |
| Zuckerman SL 2016[36]<br>26842606 | **Study type:**<br>Case Control; Journal Article<br><br>**Size:**<br>N = 397 | **Inclusion criteria:**<br>- Stroke Population, Confirmed<br>-Acute large-vessel ischemic stroke in case patients<br>-Stroke mimics or strokes without LVO in control patients<br><br>**Exclusion criteria:**<br>-Had no record of NIHSS | 31% | Emergency room | Unclear/ not specified; NIHSS was assessed prospectively and then sNIHSS-3 derived from NIHSS elements | Evidence of major vessel occlusion on CTA or MRA. The six vessels were: ICA, ACA, MCA, PCA, BA or VA. M2 or M3 occlusions were categorized as MCA, and this same categorization scheme was followed for all vessels. | **Disease Absent**<br>sNIHSS-3 >= 5 units 272 (68.5%)<br>**Disease Present**<br>sNIHSS-3 >= 5 units 125 (31.5%)<br>**Prevalence of LVO**<br>sNIHSS-3 >= 5 units 125 (31.5%)<br>Stroke Mimic or Stroke Without LVO 125 (46%)<br>**Sensitivity**<br>sNIHSS-3 >= 5 units 16 %<br>Specificity<br>sNIHSS-3 >= 5 units 90.2 % | • This NIHSS subset tool has a > 90% specificity but with low sensitivity and could be used for improving diagnostic accuracy for interhospital transfer and regionalization of care |

**Table III. Glossary of scale acronyms used in this report**

| ACRONYM | FULL NAME |
|---|---|
| **3 ITEM NIHSS** | Three-Item National Institutes of Health Stroke Scale |
| **3 ITEM-SS** | 3-item Stroke Scale (3I-SS) |
| **aNIHSS** | Abbreviated National Institute of Health Stroke Scale |
| **A-NIHSS, ITEM A** | Admission National Institutes of Health Stroke Scale, Item Profile A |
| **A-NIHSS, ITEM B** | Admission National Institutes of Health Stroke Scale, Item Profile B |
| **A-NIHSS, ITEM C** | Admission National Institutes of Health Stroke Scale, Item Profile C |
| **A-NIHSS, ITEM D** | Admission National Institutes of Health Stroke Scale, Item Profile D |
| **A-NIHSS, ITEM E** | Admission National Institutes of Health Stroke Scale, Item Profile E |
| **ASTRAL** | Acute STroke Registry and Analysis of Lausanne (ASTRAL)-Occlusion score 6 |
| **BERNESE SCORE 1** | Bernese Score 1 |
| **BERNESE SCORE 2** | Bernese Score 2 |
| **BERNESE SCORE 3** | Bernese Score 3 |
| **BERNESE SCORE 4** | Bernese Score 4 |
| **BERNESE SCORE 5** | Bernese Score 5 |
| **CPSS** | Cincinnati Prehospital Stroke Screen |
| **CPSS1** | Cincinnati Prehospital Stroke Scale 1 |
| **CPSS2** | Cincinnati Prehospital Stroke Scale 2 |
| **CPSSS** | Cincinnati Prehospital Stroke Severity Scale (CPSSS) |
| **FAST-ED** | Field Assessment Stroke Triage for Emergency Destination |
| **LAMS** | Los Angeles Motor Scale |
| **LAPSS** | Los Angeles Prehospital Stroke Screen |
| **LEGS** | Lower Extremity Strength, Eyes/Visual Fields, Gaze Deviation, Speech Difficulty Score |
| **LVOS** | Large Vessel Occlusion Scale |
| **MNIHSS** | Modified National Institute of Health Stroke Scale |
| **MPSS** | Maria Prehospital Stroke Scale |
| **MPSS** | Minnesota Prehospital Stroke Scale |
| **NIHSS** | National Institute of Health Stroke Scale |
| **NIHSS 3 CRITERIA** | National Institute of Health Stroke Scale, 3 Criteria |
| **NIHSS 4 CRITERIA** | National Institute of Health Stroke Scale, 4 Criteria |
| **NIHSS 5 CRITERIA** | National Institute of Health Stroke Scale, 5 Criteria |
| **NIHSS HYPOTHESIS** | National Institute of Health Stroke Scale, Hypothesis |
| **NIHSS-AS** | National Institutes of Health Stroke Scale-Asturias |
| **OOH-NIHSS** | Out of Hospital National Institute of Health Stroke Scale |
| **PASS** | Prehospital Acute Stroke Severity scale |
| **RACE** | Rapid Arterial Occlusion Evaluation Scale |
| **rNIHSS ITEM A, B, C, D, OR E** | Retrospective NIHSS Scale: Profile A, B, C, D or E (vs Profile F) |
| **ROSIER** | Recognition of Stroke in the Emergency Room (ROSIER) Score |
| **SCPSSS** | Simplified Cincinnati Prehospital Stroke Severity Scale (sCPSSS) |
| **sNIHSS-1** | Shortened Versions of The National Institute of Health Stroke Scale-1 Score |

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| **sNIHSS-5** | Shortened Versions of The National Institute of Health Stroke Scale-5 Score |
| **sNIHSS-8** | Shortened Versions of The National Institute of Health Stroke Scale-8 Score |
| **SRACE VERSION 1** | Simplified Rapid Arterial oCclusion Evaluation Scale version 1 |
| **SRACE VERSION 2** | Simplified Rapid Arterial oCclusion Evaluation Scale version 2 |
| **SRACE VERSION 3** | Simplified Rapid Arterial oCclusion Evaluation Scale version 3 |
| **SRACE VERSION 4** | Simplified Rapid Arterial oCclusion Evaluation Scale version 4 |
| **SRACE VERSION 5** | Simplified Rapid Arterial oCclusion Evaluation Scale version 5 |
| **SRACE VERSION 6** | Simplified Rapid Arterial oCclusion Evaluation Scale version 6 |
| **SRACE VERSION 7** | Simplified Rapid Arterial oCclusion Evaluation Scale version 7 |
| **VAN** | Vision, Aphasia, Neglect (VAN) Positive |

**Table IV. Description of commonly used scales**

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| **3I-SS** | **Disturbance of consciousness** (0= no, 1= mild, 2= severe), **gaze and head deviation** (0= absent, 1= incomplete gaze/head deviation, 2= forced gaze/head deviation), **hemiparesis** (0= absent, 1= moderate, 2= severe) |
| **CPSS** | **Facial droop** (0= normal, 1= Abnormal), **arm drift** (both arms straight out for 10 s) (0= normal, 1= abnormal), **speech** (patient repeats « the sky is blue in Cincinnati) (0= normal, 1= abnormal) |
| **CPSSS** | **Conjugate gaze deviation** : 2 points if present, **incorrectly answers at least one of two level of consciousness questions on NIHSS** (age or current month) AND **does not follow at least one of two commands** (close eyes, open and close hand) : 1 point, **cannot hold arm (right or left or both) up for 10 s before arm(s) falls to bed** : 1 point |
| **LAMS** | **Facial droop** (0= absent, 1= present), **arm drift** (0= normal, 1= drifts down, 2= falls rapidy), **grip strength** (0= normal, 1= weak grip, 2= no grip) |
| **NIHSS** | **Level of consciousness (LOC)** (0= alert, 1= no alert but arousable by minor stimulation to obey, answer, or respond, 2= not alert, requires repeated stimulation to attend, or is obtunded and requires strong or painful stimulation to make movements (not stereotyped), 3= responds only with reflex motor or autonomic effects or totally unresponsive, flaccid, and areflexic), **LOC questions** (0= answers both questions correctly, 1= answers one question correctly, 2= answers neither question correctly), **LOC commands** (0= performs both tasks correctly, 1= performs one task correctly, 2= performs neither task correctly), **best gaze** (0= normal, 1= partial gaze palsy, 2= forced deviation), **visual** (0= no visual loss, 1= partial hemianopia, 2= complete hemianopia, 3= bilateral hemianopia), **facial palsy** (0= normal, 1= minor paralysis, 2= partial paralysis, 3= complete paralysis), **motor arm (a and b for both sides)** (0= no drift : limbs holds 90° for full 10 s, 1= drift down but does not hit bed, 2= some effort against gravity : drift down to bed but has some effort against gravity, 3= no effort against gravity, 4= no movement), **motor leg (a and b for both sides)** (0= no drift, 1= drift, 2= some effort against gravity, 3= no effort against gravity, 4= no movement), **limb ataxia** (0= absent, 1= present in one limb, 2= present in two limbs), **sensory** (0= normal, 1= mild to moderate sensory loss, 2= severe to total sensory loss), **best language** (0= no aphasia, 1= mild to moderate aphasia, 2= severe aphasia, 3= mute or global aphasia), **dysarthria** (0= normal, 1= mild to moderate dysarthria, 2= severe dysarthria), **extinction and inattention** (0= no abnormality, 1= visual, tactile, auditory, spatial, or personal inattention, 2= profound hemi-inattention or extinction to more than one modality) |

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| **RACE** | **Facial palsy** (0= absent, 1= mild, 2= moderate to severe), **arm motor function** (0= normal to mild, 1= moderate, 2= severe), **leg motor function** (0= normal to mild, 1= moderate, 2= severe), **head and gaze deviation** (0= absent, 1= present), **aphasia** (if right hemiparesis) (0= performs both "LOC commands" tasks of the NIHSS correctly, 1= performs one task correctly, 2= performs neither tasks), **agnosia** (if left hemiparesis) (0= patient recognizes his/her arm and the impairment, 1= does not recognized his/her arm or the impairment, 2= does not recognize his/her arm **nor** the impairment |

**Table V. Criteria for Assigning Risk of Bias and Applicability Using QUADAS-2**

| **RISK OF BIAS** | If the answers to all signaling questions for a domain were "yes," then risk of bias was judged to be low. If any signaling question were answered "no," potential for bias exists. Review authors then used clinical/scientific judgment to judge risk of bias. The "unclear" category was used only when insufficient data were reported to permit a judgment. | |
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| **Domain** | **Instructions** | **Signaling questions** |
| **Patient selection** | A study ideally should enroll a consecutive or random sample of eligible patients with suspected disease to prevent the potential for bias. Studies that make inappropriate exclusions (for example, not including "difficult-to-diagnose" patients) may result in overestimation of diagnostic accuracy. If the study population was intended to be patients with confirmed ischemic stroke only, without including suspected stroke, please enter "Yes" if consecutive ischemic stroke patients were enrolled. | **1. Was a consecutive or random sample of patients enrolled?**<br>**2. Was a case-control study design avoided?**<br>**3. Did the study avoid inappropriate exclusions?** |
| **Index test** | N/A | 1. **Were the index test results interpreted without knowledge of the results of the reference standard?** Knowledge of the reference standard may influence interpretation of index test results. The potential for bias is related to the subjectivity of interpreting index test and the order of testing. If the index test is always conducted and interpreted before the reference standard, this item can be rated "yes." Therefore it is expected that most of our studies will be rated "Yes". |

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| | | 2. **If a threshold was used, was it pre-specified?** Selecting the test threshold to optimize sensitivity and/or specificity may lead to overestimation of test performance. Test performance is likely to be poorer in an independent sample of patients in whom the same threshold is used. For studies in which a threshold was derived using a data driven approach, the answer "No" should be selected unless the derived threshold was also tested and validated in a completely independent dataset. Internal validation methods such as splitting the sample or bootstrapping are NOT considered sufficient protection against model overfitting; therefore, "No" should be selected if these methods were used. |
| **Reference standard** | A study ideally should enroll a consecutive or random sample of eligible patients with suspected disease to prevent the potential for bias. Studies that make inappropriate exclusions (for example, not including "difficult-to-diagnose" patients) may result in overestimation of diagnostic accuracy. | 1. **Is the reference standard likely to correctly classify the target condition?** Estimates of test accuracy are based on the assumptions that the reference standard is 100% sensitive and that specific disagreements between the reference standard and index test result from incorrect classification by the index test. If the study includes patients assessed by transcranial Doppler ultrasound (TCD) but the |

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| | | number with TCD was not specified, please indicate "Unclear risk of bias".<br>2. **Were the reference standard results interpreted without knowledge of the results of the index test?** Potential for bias is related to the potential influence of previous knowledge on the interpretation of the reference standard. In the case of angiography, knowledge of the presence of severe stroke symptoms could lead the radiologist to spend more time searching for an occlusion than if the patient only if had mild symptoms. Review the paper to determine if the radiology review was blinded to the index test. If clinical information that overlaps with the index test (e.g. stroke severity) was known to the radiologist then indicate "No". If it was not clear whether the radiology review was done blinded to the index test or not, then select "Unclear". Therefore, studies that use clinical radiology reports will usually be recorded as "No" or "Unclear". |
| **Flow and timing** | N/A | 1. **Was there an appropriate interval between index test(s) and reference standard?** Results of the index test and reference standard are ideally collected on the same patients at the same time. If |

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| | | a delay occurs or if treatment begins between the index test and the reference standard, recovery or deterioration of the condition may cause misclassification. The interval leading to a high risk of bias varies among conditions. We suggest that a time interval of up to 60 minutes between pre-hospital assessment and reference standard, or 25 minutes between ED arrival and reference standard, would reflect typical time intervals in clinical practice. (These benchmarks are based on clinical experience and unpublished Get With The Guidelines Stroke registry data). Studies where mean index test to imaging times exceed those benchmarks may not reflect typical practice, giving results biased toward a higher than expected false positive rate (due to recanalization after the index test but prior to the reference standard). If the time interval from index test to reference standard is not reported, then select "Unclear".<br>2. **Did all patients receive a reference standard?** Verification bias occurs when only a proportion of the study group receives confirmation of the diagnosis by the reference standard. If the results of the index test influence the |

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| | | decision on whether to perform the reference standard or which reference standard is used, estimated diagnostic accuracy may be biased. If the decision to perform angiography was based on stroke severity, eligibility for reperfusion therapy, or the results of the index test then select "no". If only a subset of patients received the reference standard without explanation, select "Unclear".<br>3. **Did patients receive the same reference standard?** Verification bias occurs when some patients receive a different reference standard. If the results of the index test influence the decision on whether to perform the reference standard or which reference standard is used, estimated diagnostic accuracy may be biased. If the index test results influenced the choice of angiographic method used, please select "No". If different angiographic methods were used but the choice of method was independent of the index test, please select "Yes". If it was unclear why different angiographic methods were used and whether the choice of method was influenced by the index test then select "Unclear".<br>**4. Were all patients included in the analysis?** All |

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| | | participants recruited into the study should be included in the analysis. A potential for bias exists if the number of patients enrolled differs from the number of patients included in the 2 x 2 table of results, because patients lost to follow-up differ systematically from those who remain. |
| **APPLICABILITY** | Categorized as Low Concern, High Concern, or Unclear Concern | |
| **Patient selection** | Concerns about applicability may exist if patients included in the study differ from those targeted by the review question in terms of severity of the target condition, demographic features, presence of differential diagnosis or comorbid conditions, setting of the study, and previous testing protocols.<br><br>Based on the review question, patients should be selected to be representative of either all patients with suspected stroke in the pre-hospital setting, or ED patients with confirmed ischemic stroke. For example, if the study targeted patients with confirmed ischemic stroke only, you may select "Low concern" even though the study did not include all patients with suspected stroke. | |
| **Index test** | Variations in test technology, execution, or interpretation may affect estimates of the diagnostic accuracy of a test. If index test methods vary from those specified in the review question, concerns about applicability may exist.<br><br>In the context of this study, please consider whether the index text is feasible in the setting in which it was tested: pre-hospital assessment by EMS personnel, or ED assessment at an Acute Stroke Ready hospital or Primary Stroke Center. Review any information from the paper on test reliability or feasibility of implementation. Consider the NIHSS as a potential benchmark. By consensus most would agree that the NIHSS can be administered reliably by physicians and nurses in an ED, but is not practical for use in the pre-hospital setting. Index tests that are as complex as the NIHSS are therefore probably not applicable to the pre-hospital setting, while tests that are more complex than the NIHSS are probably also not applicable even to the ED setting. | |
| **Reference standard** | The reference standard may be free of bias, but the target condition that it defines may differ from the target condition specified in the review question. | |

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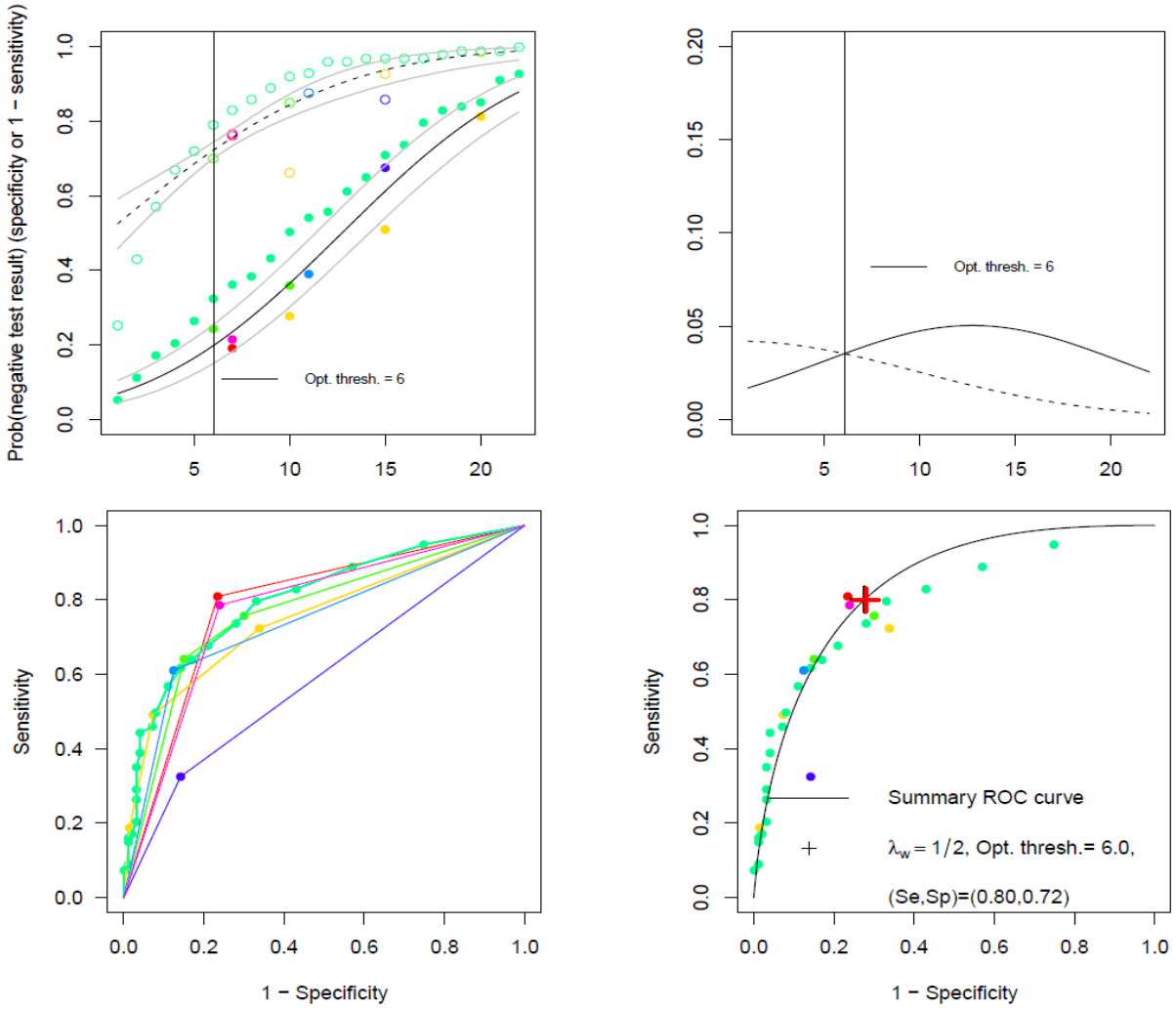
| | For this review question, please consider that most centers perform non-invasive CT angiography or MR angiography to diagnose vascular occlusions eligible for EVT. If a significant number of patients may have had transcranial Doppler ultrasound as the reference standard select "High concern".<br><br>AHA guidelines recommend EVT for patients with "occlusion of the ICA or proximal MCA (M1)", and patients with basilar artery occlusion are considered EVT eligible based on routine standard of care. If the study reference standard includes occlusions of other arteries, the findings may not be entirely applicable to AHA guideline-based care or routine care. If >10% of occlusions were not in the ICA, M1 or basilar artery then select "High concern". If some occlusions were not in the ICA, M1 or basilar artery but the proportion is not clear, then select "Unclear concern". |

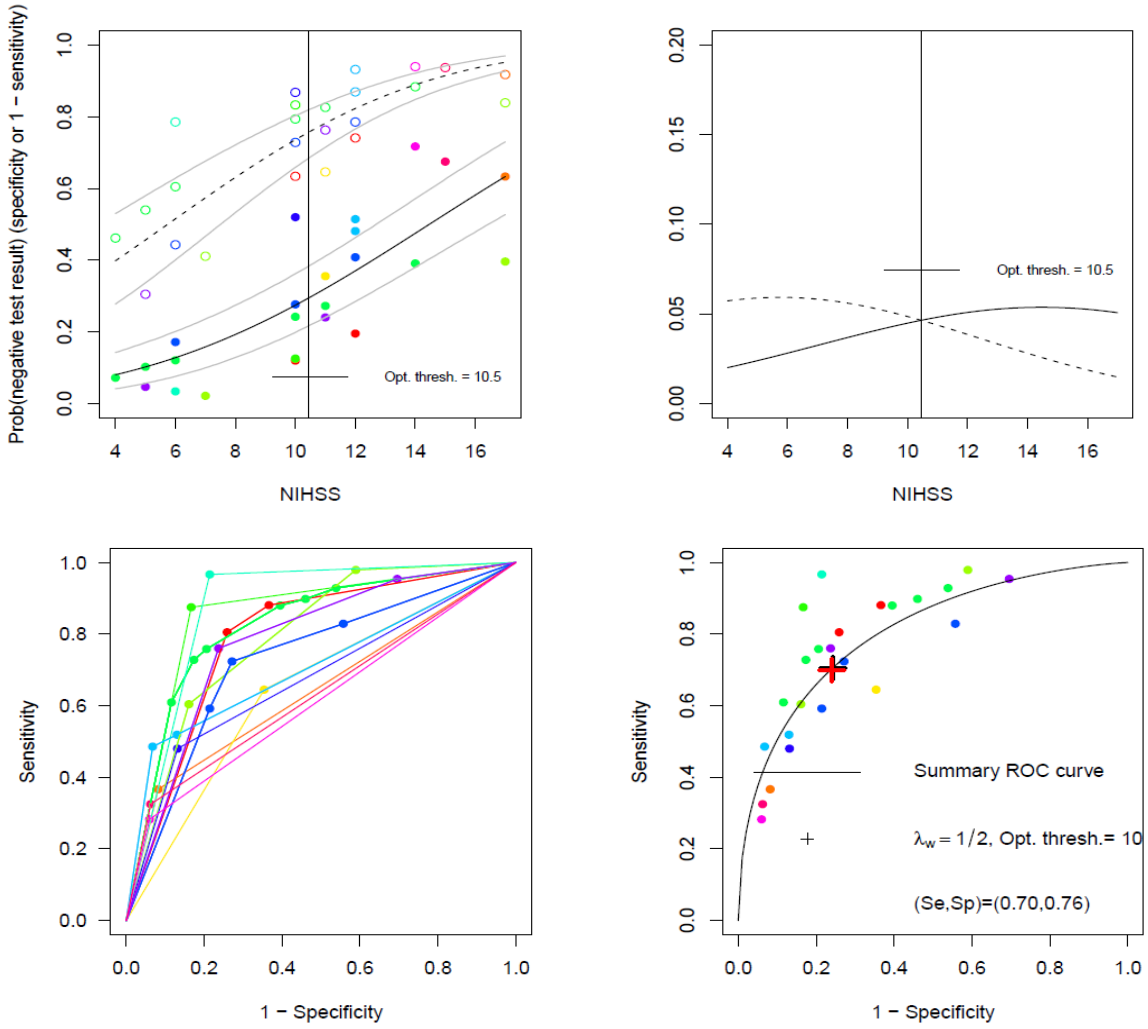
These criteria were based on the QUADAS-2 tool, with added instructions for the specific review question and setting: Whiting PF, Rutjes AW, Westwood ME, Mallett S, Deeks JJ, Reitsma JB, Leeflang MM, Sterne JA, Bossuyt PM and Group Q-. QUADAS-2: a revised tool for the quality assessment of diagnostic accuracy studies. *Ann Intern Med*. 2011;155:529-36.

**Figure I. Summary ROC curves for NIH Stroke Scale (NIHSS) as Predictor of LVO in Patients with Suspected Stroke**



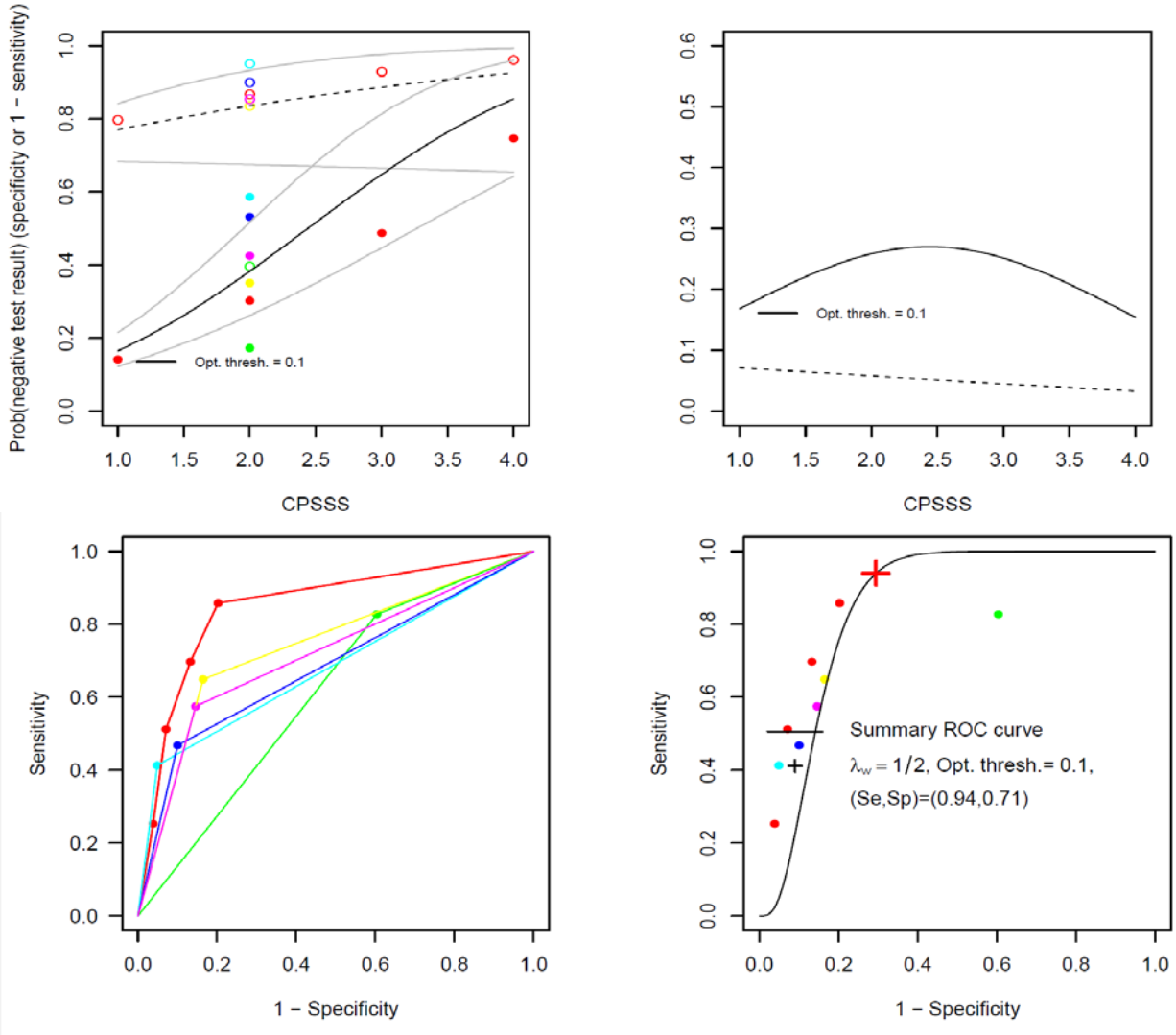

Individual data points represent published NIHSS thresholds. Different colors represent different studies. Data pooled from Heldner 2016, Slivka 2006, Lima 2016, Hansen 2015, Gonzalez 2013, Qureshi 2016, Higashimoria 2016. **Top left**: Y-axis: Probability of a negative test result within non-LVO patients (i.e. specificity; dashed line), and probability of a negative test result within LVO patients (i.e. 1-sensitivity; solid line), along with 95% confidence limits. **Top right:** Probability distribution of NIHSS score within non-LVO patients (dashed line) and within LVO patients (solid line). **Bottom left:** Individual ROC curves (one per study). **Bottom right:** Summary ROC curve, determined using a linear mixed effect model with different random intercepts and different random slopes. The red cross indicates the optimal threshold, giving equal weight to sensitivity and specificity.

**Figure II. Summary ROC curves for NIH Stroke Scale (NIHSS) as Predictor of LVO in Patients with Confirmed Ischemic Stroke**




Individual data points represent published NIHSS thresholds. Different colors represent different studies. Data pooled from Castillo 2016, Cooray 2015, Derex 2002, Fisher 2005, Kesinger 2015, Maas 2009, Matias-Guiu 2014, Nakajima 2004, Olavarria 2011, Scheitz 2015, Qureshi 2016, Teleb 2016, Turc 2016. **Top left**: Y-axis: Probability of a negative test result within non-LVO patients (i.e. specificity; dashed line), and probability of a negative test result within LVO patients (i.e. 1-sensitivity; solid line), along with 95% confidence limits. **Top right:** Probability distribution of NIHSS score within non-LVO patients (dashed line) and within LVO patients (solid line). **Bottom left:** Individual ROC curves (one per study). **Bottom right:** Summary ROC curve, determined using a linear mixed effect model with different random intercepts and a common random slope. The red cross indicates the optimal threshold, giving equal weight to sensitivity and specificity.

**Figure III. Summary ROC curves for Cincinnati Prehospital Stroke Severity Scale (CPSSS) as Predictor of LVO in Patients with Suspected Stroke**




Individual data points represent published CPSSS thresholds. Different colors represent different studies. Data pooled from Kummer et al 2016, Turc et al 2016, Katz et al 2015, Castillo et al 2016, Gropen et al 2016, Qureshi et al 2016. **Top left**: Y-axis: Probability of a negative test result within non-LVO patients (i.e. specificity; dashed line), and probability of a negative test result within LVO patients (i.e. 1-sensitivity; solid line), along with 95% confidence limits. **Top right:** Probability distribution of NIHSS score within non-LVO patients (dashed line) and within LVO patients (solid line). **Bottom left:** Individual ROC curves (one per study). **Bottom right:** Summary ROC curve, determined using a linear mixed effect model with with a common intercept and different random slopes. The red cross indicates the optimal threshold, giving equal weight to sensitivity and specificity.

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