



Clinical Policy: Critical Issues in the Management of Adult Patients Presenting to the Emergency Department With Acute Ischemic Stroke

From the American College of Emergency Physicians Clinical Policies Subcommittee (Writing Committee) on Acute Ischemic Stroke:

Bruce M. Lo MD, MBA (Writing Committee Chair)
 Christopher R. Carpenter, MD, MSc
 Stephen Ducey, MD
 Michael Gottlieb, MD
 Amy Kaji, MD, MPH, PhD (Methodologist)
 Deborah B. Diercks, MD, MSc (Committee Co-Chair)

Members of the American College of Emergency Physicians Clinical Policies Committee (Oversight Committee):

Deborah B. Diercks, MD, MSc (Co-Chair 2021-2022, Chair 2022-2023)	Richard D. Shih, MD
Stephen J. Wolf, MD (Chair 2017-2021, Co-Chair 2021-2022)	Scott M. Silvers, MD
John D. Anderson, MD	Andrea Slivinski, RN, DNP (ENA Representative 2021-2023)
Richard Byyny, MD, MSc (Methodologist)	Michael D. Smith, MD, MBA
Christopher R. Carpenter, MD, MSc	Molly E. W. Thiessen, MD
Benjamin Friedman, MD (Methodologists)	Christian A. Tomaszewski, MD, MS, MBA
Seth R. Gemme, MD	Stacy Trent, MD, MPH (Methodologist)
Charles J. Gerardo, MD, MHS	Jonathan H. Valente, MD
Steven A. Godwin, MD	Stephen P. Wall, MD, MSc, MAEd (Methodologist)
Sigrid A. Hahn, MD, MPH	Lauren M. Westafer, DO
Benjamin W. Hatten, MD, MPH	Yanling Yu, PhD (Washington Advocates for Patient Safety)
Jason S. Haukoos, MD, MSc (Methodologist)	Stephen V. Cantrill, MD (Liaison with Quality and Patient Safety Committee)
Amy Kaji, MD, MPH, PhD (Methodologist)	John T. Finnell, MD (Board Liaison 2020-2023)
Heemun Kwok, MD, MS (Methodologist)	Travis Schulz, MLS (AHIP Staff Liaison, Clinical Policies Committee, and Writing Committee on Acute Ischemic Stroke)
Bruce M. Lo, MD, MBA, RDMS	Kaeli Vandertulip, MSLS, MBA (AHIP Staff Liaison, Clinical Policies Committee)
Sharon E. Mace, MD	
Maggie Moran, MD (EMRA Representative 2022-2023)	
Susan B. Promes, MD, MBA	
Kaushal H. Shah, MD	

Policy statements and clinical policies are the official policies of the American College of Emergency Physicians and, as such, are not subject to the same peer review process as articles appearing in the journal. Policy statements and clinical policies of ACEP do not necessarily reflect the policies and beliefs of *Annals of Emergency Medicine* and its editors.

0196-0644/\$-see front matter

Copyright © 2023 Published by Elsevier, Inc on behalf of the American College of Emergency Physicians.

<https://doi.org/10.1016/j.annemergmed.2023.03.007>

[Ann Emerg Med. 2023;82:e17-e32.]

ABSTRACT

This clinical policy from the American College of Emergency Physicians addresses key issues in acute stroke management in adult patients presenting to the emergency department. A writing subcommittee conducted a systematic review of the literature to derive evidence-based recommendations to answer the following clinical questions: 1) In adult patients with a suspected acute ischemic stroke, can a clinical decision instrument be used to identify patients who have a large vessel occlusion on computed tomography angiography or magnetic resonance angiography? 2) In adult patients with a suspected acute ischemic stroke, does the addition of perfusion imaging to a computed tomography angiography or magnetic resonance angiography identify patients more likely to benefit from thrombectomy? 3) In adult patients with a suspected acute ischemic stroke qualifying for intravenous thrombolysis, is tenecteplase safe and effective compared with alteplase? 4) In adult patients who present with acute vertigo with possible stroke, are there history or physical examination findings (eg, Head Impulse-Nystagmus-Test of Skew examination) that can risk stratify for acute ischemic stroke? Evidence was graded, and recommendations were made based on the strength of the available data.

INTRODUCTION

Approximately 800,000 people in the United States are diagnosed with a stroke each year at an estimated cost of approximately \$46 billion. As a result, stroke remains one of the leading causes of death as well as the leading cause of disability.¹ In 1996, the Food and Drug Administration approved an intravenous tissue plasminogen activator as the first treatment for an acute ischemic stroke. Since then, endovascular thrombectomy (EVT) has also been approved for the treatment of acute strokes because of large vessel occlusions (LVO). Approximately 30% of all patients with an acute ischemic stroke have an LVO, whereas 12% of acute stroke patients are thought to be candidates for EVT.² Although the evidence supports the use of EVT for LVOs located in the middle cerebral and internal carotid arteries, research in this area is rapidly evolving, and as of the time of this publication, the benefits of EVT for LVOs in other locations remain uncertain.³⁻⁵

Because of the expertise and resources needed to perform EVT, there are only approximately 300 centers that are certified in the United States.² Because of the limited number of EVT-capable stroke centers, timely access is limited: approximately 20% of the US population live

within 15 minutes, and only 50% of the US population live within 60 minutes to an EVT-capable stroke center.^{6,7}

Diagnosing an acute stroke patient with an LVO who may be a candidate for EVT requires advanced imaging such as computed tomography angiography (CTA). However, identifying which suspected stroke patients who are likely to have an LVO can be challenging. This has implications for determining who should receive advanced imaging such as a CTA in the emergency department (ED) or potentially be diverted to an EVT-capable stroke center. Other advanced imaging, such as computed tomography perfusion (CTP), is increasingly being used to help select patients with an LVO who may also benefit from an intervention such as EVT.

The use of alteplase was reviewed in the 2015 clinical policy for acute ischemic stroke. Since then, there has been interest in the use of tenecteplase for acute ischemic stroke.⁸ Similar to its use in ST-elevation myocardial infarction patients, the protocol for giving tenecteplase makes it much easier to administer than alteplase.

Finally, patients who present with dizziness can be a diagnostic challenge trying to differentiate a peripheral from a central cause. Although the rate of misdiagnosis of stroke in patients who are discharged home from the ED with a diagnosis of peripheral vertigo is less than 0.2%,⁹ up to 37% of posterior circulation strokes are missed on initial presentation.¹⁰ Because the mortality of a missed posterior circulation stroke can be significantly higher than those with cerebellar strokes in general,¹¹ strategies are needed to prevent misdiagnosis.

This clinical policy will tackle 4 questions: 1) can a clinical decision instrument be used to identify patients who have an LVO on CTA or magnetic resonance angiography (MRA); 2) does the addition of perfusion imaging to a CTA or MRA identify patients more likely to benefit from thrombectomy; 3) is tenecteplase safe and effective compared with alteplase when given for acute ischemic strokes; and 4) are there history or physical examination findings that can risk stratify for acute ischemic stroke in patients who present with acute vertigo.

METHODOLOGY

This American College of Emergency Physicians (ACEP) clinical policy was developed by emergency physicians with input from medical librarians and a patient safety advocate and is based on a systematic review and critical descriptive analysis of the medical literature and is reported in accordance with Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines.¹²

Search and Study Selection

This clinical policy is based on a systematic review with critical analysis of the medical literature meeting the inclusion criteria. Searches of PubMed, SCOPUS, Embase, Web of Science, and the Cochrane Database of Systematic Reviews were performed by a librarian. Search terms and strategies were peer reviewed by a second librarian. All searches were limited to human studies published in English. Specific key words/phrases, years used in the searches, dates of searches, and study selection are identified under each critical question. In addition, relevant articles from the bibliographies of included studies and more recent articles identified by committee members and reviewers were included.

Using Covidence (Covidence, Melbourne, Australia), 2 subcommittee members independently reviewed the identified abstracts to assess for possible inclusion. Of those identified for potential inclusion, each full-length text was reviewed for eligibility. Those identified as eligible were subsequently abstracted and forwarded to the committee's methodology group (emergency physicians with specific research methodological expertise) for methodological grading using a Class of Evidence framework ([Appendix E1](#), available at <http://www.annemergmed.com>).

Assessment of Risk of Bias and Determination of Classes of Evidence

Each study identified as eligible by the subcommittee was independently graded by 2 methodologists. Grading was done with respect to the specific critical questions; thus, the Class of Evidence for any one study may vary according to the question for which it is being considered. For example, an article that is graded an "X" due to "inapplicability" for one critical question may be considered relevant for another question and graded I to III. As such, it was possible for a single article to receive a different Class of Evidence grade when addressing a different critical question.

Design 1 represents the strongest possible study design to answer the critical question, which relates to whether the focus was therapeutic, diagnostic, or prognostic, or a meta-analysis. Subsequent design types (ie, Design 2 and Design 3) represent respectively weaker study designs. Articles are then graded on dimensions related to the study's methodological features and execution, including but not limited to randomization processes, blinding, allocation concealment, methods of data collection, outcome measures and their assessment, selection, and misclassification biases, sample size, generalizability, data management, analyses, congruence of results and conclusions, and potential for conflicts of interest.

Using a predetermined process that combines the study's design, methodological quality, and applicability to the critical question, 2 methodologists independently assigned a preliminary Class of Evidence grade for each article. Articles with concordant grades from both methodologists received that grade as their final grade. Any discordance in the preliminary grades was adjudicated through discussion which involved at least 1 additional methodologist, resulting in a final Class of Evidence assignment (ie, Class I, Class II, Class III, or Class X) ([Appendix E2](#), available at <http://www.annemergmed.com>). Studies identified with significant methodologic limitations and/or ultimately determined to not be applicable to the critical question received a Class of Evidence grade "X" and were not used in formulating recommendations for this policy. However, content in these articles may have been used to formulate the background and to inform expert consensus in the absence of evidence. Question-specific Classes of Evidence grading may be found in the Evidentiary Table included at the end of this policy.

Translation of Classes of Evidence to Recommendation Levels

Based on the strength of evidence for each critical question, the subcommittee drafted the recommendations and supporting text, synthesizing the evidence using the following guidelines:

Level A recommendations. Generally accepted principles for patient care that reflect a high degree of scientific certainty (eg, based on evidence from one or more Class of Evidence I or multiple Class of Evidence II studies that demonstrate consistent effects or estimates).

Level B recommendations. Recommendations for patient care that may identify a particular strategy or range of strategies that reflect moderate scientific certainty (eg, based on evidence from one or more Class of Evidence II studies or multiple Class of Evidence III studies that demonstrate consistent effects or estimates).

Level C recommendations. Recommendations for patient care that are based on evidence from Class of Evidence III studies or, in the absence of adequate published literature, based on expert consensus. In instances where consensus recommendations are made, "consensus" is placed in parentheses at the end of the recommendation.

There are certain circumstances in which the recommendations stemming from a body of evidence should not be rated as highly as the individual studies on which they are based. Factors such as consistency of results, uncertainty of effect magnitude, and publication bias,

among others, might lead to a downgrading of recommendations. When possible, clinically oriented statistics (eg, likelihood ratios [LRs], number needed to treat) are presented to help the reader better understand how the results may be applied to the individual patient. This can assist the clinician in applying the recommendations to most patients but allow adjustment when applying to patients with extremes of risk ([Appendix E3](#), available at <http://www.annemergmed.com>).

Evaluation and Review of Recommendations

Once drafted, the policy was distributed for internal review (by members of the entire committee), followed by external expert review and an open comment period for all ACEP membership. Comments were received during a 60-day open comment period, with notices of the comment period sent electronically to ACEP members, published in *EM Today*, posted on the ACEP Web site, and sent to other pertinent physician organizations. The responses were used to further refine and enhance this clinical policy, although responses do not imply endorsement. Clinical policies are scheduled for revision every 3 years; however, interim reviews are conducted when technology, methodology, or the practice environment changes significantly.

Application of the Policy

This policy is not intended to be a complete manual on the evaluation and management of adult patients with acute stroke but rather a focused examination of critical questions that have particular relevance to the current practice of emergency medicine. The potential benefits and harms of implementing recommendations are briefly summarized within each critical question.

It is the goal of the Clinical Policies Committee to provide evidence-based recommendations when the scientific literature provides sufficient quality information to inform recommendations for a critical question. When the medical literature does not contain adequate empirical data to inform a critical question, the members of the Clinical Policies Committee believe that it is equally important to alert emergency physicians to this fact.

This clinical policy is not intended to represent a legal standard of care for emergency physicians. Recommendations offered in this policy are not intended to represent the only diagnostic or management options available to the emergency physician. ACEP recognizes the importance of the individual physician's judgment and patient preferences. This guideline provides clinical strategies for which medical literature exists to inform the

critical questions addressed in this policy. ACEP funded this clinical policy.

Scope of Application. This guideline is intended for physicians working in EDs.

Inclusion Criteria. This guideline is intended for adult patients 18 years and older presenting to the ED with acute ischemic stroke.

Exclusion Criteria. This guideline is not intended to be used for pediatric patients or pregnant patients.

CRITICAL QUESTIONS

1. In adult patients with a suspected acute ischemic stroke, can a clinical decision instrument be used to identify patients who have an LVO on CTA or MRA?

Patient Management Recommendations

Level A recommendations. None specified.

Level B recommendations. None specified.

Level C recommendations. In adult patients with suspected stroke, either the Los Angeles Motor Scale (LAMS) or Rapid Arterial Occlusion Evaluation Scale (RACE) may be used to identify patients with increased likelihood of an LVO.

Potential Benefit of Implementing the Recommendations:

- Increase appropriate diversion of suspected LVO patients to EVT-capable hospitals.
- Decrease time to arrival of suspected LVO to EVT-capable hospitals.
- Allow quicker mobilization of hospital resources for potential EVT patients.

Potential Harm of Implementing the Recommendations:

- Increase diversion of non-LVO patients to EVT-capable hospitals.
- Miss patients with an LVO who may benefit from EVT.

Key words/phrases for literature searches: brain ischemia, cerebral arterial disease, cerebral arterial infarction, clinical decision aid, clinical decision instrument, clinical decision rules, clinical decision support systems, clinical decision tools, computed tomography angiography, computer-assisted decisionmaking, decision support systems, decision support techniques, emergency medicine, hospital emergency service, large vessel occlusion, magnetic resonance angiography, middle cerebral artery infarction, stroke, and variations and combinations of key words/phrases. Searches included all dates up to the search dates

of November 17 and 25, 2020, December 3, 2020, January 28 and 29, 2021, and February 4 and 5, 2021.

Study Selection: Eight hundred-seven articles were identified in the searches. Ninety-six were selected from the search results as candidates for further review. After grading for methodological rigor, zero Class I studies, 2 Class II studies, and 11 Class III studies were included for this critical question ([Appendix E4](#), available at <http://www.annemergmed.com>).

Large vessel occlusion stroke includes acute and symptomatic occlusions of the internal carotid artery or proximal segments of the anterior cerebral artery, middle cerebral artery, or in a handful of studies, the posterior cerebral artery. Multiple clinical trials have demonstrated the superiority of EVT in comparison with standard medical care for LVO within the appropriate time frame when performed at experienced EVT-capable centers.^{13,14} The 2019 American Heart Association acute ischemic stroke guideline updates provide Level IIb recommendations favoring “Effective prehospital procedures to identify patients who are ineligible for intravenous thrombolysis and have a strong probability of LVO stroke should be developed to facilitate rapid transport of patients potentially eligible for thrombectomy to the closest health care facilities that are able to perform mechanical thrombectomy.”³ Each hour delay from symptom onset before EVT is associated with a 5.5% decrease in independent outcomes.¹⁵ Unfortunately, only some hospitals are capable of EVT, so out-of-hospital systems and hospitals without EVT services must sometimes transfer acute ischemic stroke patients with suspected LVOs, which increases the workload for busy receiving hospitals and can displace patients and their families far from home.

Historically, out-of-hospital decision aids have been developed to facilitate prompt recognition of stroke. Contemporaneously, some of these same instruments as well as instruments derived from the National Institute of Health Stroke Scale (NIHSS) have been evaluated to screen suspected stroke patients for LVO in out-of-hospital and ED settings.¹⁶ These include the 3-item Stroke Scale (3I-SS),¹⁷ Cincinnati Prehospital Stroke Scale (CPSS),¹⁸ Field Assessment Stroke Triage for Emergency Destination (FAST-ED),¹⁹ Los Angeles Motor Scale (LAMS),²⁰ Prehospital Acute Stroke Severity Scale (PASS),²¹ and Rapid Arterial Occlusion Evaluation Scale (RACE),²² as well as modifications to the NIHSS.²³⁻²⁷ Novel instruments such as the Vision-Aphasia-Neglect (VAN)²⁸ and 7-Item Japan Urgent Stroke Triage (JUST-7)²⁹ score were also created to evaluate potential stroke patients with LVO. The components and scoring of 3 of these LVO

decision aids are provided in [Table 1](#), and the diagnostic accuracy of these same instruments is summarized in [Table 2](#). Diagnostic accuracy research for LVO decision aids seeks to simultaneously optimize sensitivity and specificity. Sensitivity represents the proportion of patients with LVO who are correctly identified as having an LVO, whereas specificity represents the proportion of patients without LVO who are correctly identified as not having an LVO. For example, 1 single-center registry study noted that an NIHSS of more than 6 provided the highest sensitivity (68%) and specificity (80%) for LVO with higher thresholds reducing sensitivity but increasing specificity, and lower cut points increasing sensitivity but reducing specificity.³⁰ The problem with either sensitivity or specificity in isolation is that they do not alter the pretest probability of the presence or absence of LVO, so likelihood ratios are more clinically useful.^{31,32}

The theoretical value of these decision aids is to identify individuals with LVO in the out-of-hospital setting or immediately on ED arrival to expedite requisite imaging and neuro-interventional consultations, including transportation of higher risk suspected LVO patients to EVT-capable hospitals. Ideally, the hierarchy of clinical evidence for these decision aids would progress from accuracy alone to diagnostic randomized controlled trials (RCT) comparing different approaches to risk-stratifying suspected LVO patients during the initial minutes of their medical care.^{33,34} Unfortunately, diagnostic RCT are rare, so clinical guideline recommendations are often extrapolated from diagnostic accuracy research.³⁵ A multiorganizational systematic review of the American Heart Association’s “2018 Guidelines for the Early Management of Patients with Acute Ischemic Stroke” concluded that “no scale predicted LVO with both high sensitivity and specificity” in out-of-hospital settings.²⁶ Nonetheless, out-of-hospital systems currently use some of these LVO decision aids in protocols to transport suspected LVO patients to EVT-capable hospitals, with some evidence that the use of these scales reduces time-to-intervention without overwhelming these EVT-capable hospitals.^{36,37}

Two Class II studies were identified.^{38,39} The first Class II study by Nguyen et al was a prospective out-of-hospital cohort study in the Netherlands more than a 15-month period that included 2,812 acute stroke codes across 2 emergency medical services (EMS) agencies, 3 comprehensive stroke centers, and 4 primary stroke centers. Researchers retrospectively evaluated LAMS, RACE, PASS, gaze-face-arm-speech-time (G-FAST), FAST-ED, and the Cincinnati Stroke Triage Assessment Tool (C-STAT) stroke prediction instruments using applications completed

Table 1. Components of LVO prediction instruments.

LVO Prediction Instrument	Instrument Components	Instrument Scoring
LAMS ²⁰	Facial droop—Ask the person to smile. Arm drift—Hold arm extended forward for 10 seconds. Is there any drift or drop of the arm? Grip strength—Ask the person to grip your hand. Does one hand have less power than the other?	0 = facial droop absent; 1 = facial droop present 0 = absent; 1 = drifts down; 2 = falls rapidly 0 = normal; 1 = weak grip; 2 = no grip;
RACE ²²	Facial palsy Arm motor Leg motor Head/gaze deviation Aphasia (if right hemiparesis) – ask the patient to “close your eyes and make a fist” Agnosia (if left hemiparesis) – evaluate the patient’s recognition of deficit by 1) showing the paretic arm and asking, “Whose arm is this?” and 2) asking patient “Can you lift both arms and clap?”	0 = absent; 1 = mild; 2 = moderate/severe 0 = normal/mild; 1 = moderate; 2 = severe 0 = normal/mild; 1 = moderate; 2 = severe; 0 = absent; 1 = present 0 = performs both tasks; 1 = performs one task; 2 = performs neither task 0 = patient recognizes arm and impairment; 1 = unable to recognize arm or impairment; 2 = unable to recognize arm and impairment
VAN ²⁸	Visual disturbance Aphasia Neglect	Positive VAN if patient reports double-vision, field cut, or loss of vision. Any new difficulty forming words? If yes, positive VAN. Can the patient repeat a short sentence, recognize 2 objects and follow simple commands? If unable to perform any of these tasks—positive VAN. Does the patient present with an acute forced gaze or conjugate gaze palsy? Is the patient unable to track an object to one side? With patient’s eyes are they unable to feel sensation to an arm or leg when one or both are stimulated? Positive VAN if “yes” to any of these.

VAN, Vision-Aphasia-Neglect.

on site or during transportation by EMS personnel. The researchers reported the accuracy for a symptomatic anterior LVO for each instrument, as well as the feasibility rates based on the proportion for whom each instrument could be computed with the available data. A LAMS of 4 or more (sensitivity 38%, specificity 93%, positive LR 5.4, negative LR 0.67) and RACE of 5 or more (sensitivity 56%, specificity 90%, positive LR 5.6, negative LR 0.49) were significantly more specific than the other LVO instruments.³⁸ The PASS scale was the most feasible to extrapolate from EMS documentation, whereas the RACE scale was the least feasible with full stroke code reconstruction achieved in only 57% of the included records.³⁸ No patient-centered outcomes or process measures were reported, but hypothetically applying LAMS to this population would require 155 stroke patients to be screened to identify 1 LVO patient to transfer to an EVT-capable hospital who otherwise would have been transferred to a hospital without EVT services, whereas 53 patients with

high LAMS scores but without LVO would have also been transferred to an EVT-capable hospital.

The second Class II study by Zhao et al³⁹ was a prospective out-of-hospital cohort transporting suspected stroke patients to 15 urban and 17 rural Australian hospitals over a 20-month period. The likelihood of LVO was evaluated by paramedics using the ambulance clinical triage for acute stroke treatment (ACT-FAST) severity-based triage algorithm, which demonstrated 76% sensitivity (95% confidence interval [CI] 69% to 82%), 82% specificity (95% CI 79% to 84%), positive LR 4.2 (95% CI 3.3 to 5.1), and negative LR 0.30 (95% CI 0.2 to 0.39) for LVO and similar accuracy for predicting EVT. Theoretically, if ACT-FAST were incorporated into out-of-hospital decisionmaking, it would have reduced transport times to an EVT-capable hospital by 98 minutes for LVO patients, whereas increasing the number of suspected LVO patient arrivals at the EVT-capable hospital by between 3.5 and 9.5 patients per week.³⁹

Table 2. Diagnostic accuracy for LVO decision aids with Level II or Level III evidence.

Decision Aid	Included Studies	Number Patients	Sensitivity (95% CI), %	Specificity (95% CI), %	Positive LR (95% CI)	Negative LR (95% CI)
LAMS ≥ 4	Class II Nguyen et al ³⁸ (2020)	2007	38 (29–46)	93 (89–92)	5.4 (NR)	0.67 (NR)
	Class III Duvekot et al ⁴¹ (2021)	1039	63 (55–72)	84 (82–87)	4.1 (3.3 to 4.9)	0.44 (0.34–0.54)
	Helwig et al ⁴² (2019)	116	78 (43–96)	71 (63–74)	2.6 (1.2 to 3.7)	0.32 (0.06–0.90)
RACE ≥ 5	Class II Nguyen et al ³⁸ (2020)	2007	56 (46–65)	90 (89–92)	5.6 (NR)	0.49 (NR)
	Class III Duvekot et al ⁴¹ (2021)	1039	67 (58–75)	87 (85–89)	5.2 (4.1–6.1)	0.38 (0.30–0.49)
	Pérez de le Ossa et al ²² (2014)	654	85 (NR)	68 (NR)	2.7 (NR)	0.22 (NR)
	Lima et al ¹⁹ (2016)	727	55 (NR)	87 (NR)	4.2 (NR)	0.52 (NR)
VAN	Class III Vidale et al ⁴⁰ (2018)*	62	100 (77–100)	90 (83–90)	10 (5–10)	0 (0–0.27)

NR = not reported and unable to recalculate.

*Systematic review with VAN assessed in one single-center study of 62 consecutive code stroke activations.

Eleven Class III studies were identified, which evaluated a variety of LVO decision aids, including LAMS, RACE, VAN, CPSS, C-STAT, G-FAST, PASS, Conveniently-Grasped Field Assessment Stroke Triage (CG-FAST), Face-Arm-Speech-Time plus severe arm or leg motor deficit (FAST-PLUS), field cut, aphasia, neglect, gaze preference, and dense hemiparesis (FANG-D), the JUST-7 score, and the NIHSS.^{19,22,29,40–47} For brevity, this clinical policy will only highlight the diagnostic accuracy results for decision aids evaluated in more than 1 study and with the highest positive LR or lowest negative LR across studies. A systematic review of 19 instruments from 13 studies of 9,824 patients by Vidale et al reported sensitivities ranging from 60% to 100% and specificities from 31% to 90%.⁴⁰ The VAN (positive LR 10, negative LR 0) and LAMS scores of 4 and more demonstrated superior accuracy to rule-in (positive LR 7.4) or rule-out (negative LR 0.21) LVO.⁴⁰ The LAMS of 4 or more was evaluated by 2 Class III studies^{41,42} and RACE of 5 or more by 3 Class III studies^{19,22,41} with the accuracy results summarized in Table 2. Because only 1 study evaluated VAN, which evaluated 62 patients and received a grade of Class X by the methodologists, and was the only study on VAN included in the Class III systematic review by Vidale et al, VAN was not included in the recommendations.^{28,40} Other than Lima et al, in which hospital personnel obtained each component of these decision aids, the elements for each decision aid were obtained by EMS personnel in out-of-hospital settings. Based on these Class III studies, LAMS and RACE are similarly accurate to identify individuals at higher risk for LVO (RACE positive LR range 2.7 to 5.6 compared with LAMS positive LR range 2.6 to 5.4) or

lower risk for LVO (RACE negative LR 0.22 to 0.52 compared with LAMS negative LR range 0.32 to 0.67).^{19,22,40–42}

The definition of LVO varied among studies. For example, Duvekot et al⁴¹ defined occlusions of the internal carotid artery, M1 or M2 segments of the middle cerebral artery, and A1 or A2 segments of the anterior cerebral artery as LVO. Helwig et al⁴² defined LVO as occlusion of the internal carotid artery, M1 segment of the middle cerebral artery, or the basilar artery. These subtle differences among studies in defining LVO are likely impactful for posterior circulation strokes because decision aids were often derived retrospectively from elements of the NIHSS, which was not designed to diagnose stroke or LVO and is a relatively inaccurate indicator of posterior circulation strokes in particular. None of the included studies evaluated between-rater reproducibility or EMS/physician acceptability of their use, which may affect integration and implementation into local health care protocols. Nonetheless, if the risk of LVO in an out-of-hospital patient is 10%, then a LAMS of 4 and more or RACE of 5 and more would increase the probability of LVO in that individual from 22% to 38% for LAMS or from 23% to 38% for RACE. On the other hand, LAMS of less than 4 or RACE of less than 5 would decrease the probability of LVO to 3% (from 7%) for LAMS or to 2% (from 5%) for RACE. Individual health care systems currently using or considering incorporating LVO decision aids into stroke protocols should contemplate their objectives in selecting an instrument. In rural areas with prolonged travel times to EVT-capable hospitals, a higher positive LR is of more importance to avoid unnecessary

transports. On the other hand, in urban areas with crowded EVT-capable hospitals, decision aids with lower negative LR are more important to limit the unintended consequences of exacerbating ED crowding.⁴⁸

Summary

Multiple out-of-hospital decision aids exist with the intent to distinguish high-risk or low-risk suspected stroke patients for LVO. LAMS and RACE have the largest quantity and highest quality of research to support their incorporation into out-of-hospital or non-EVT capable hospital stroke protocols, although the actual result of their use on resource use, time-to-intervention, or EVT outcomes remains unevaluated.

Future Research

Based on this clinical policy question and the research identified and included, multiple high-priority areas exist for future investigators. The ACT-FAST and VAN appear promising as LVO prediction instruments but await external validation and affect analysis. The LAMS, RACE, VAN, and ACT-FAST also await interrater reproducibility assessment in real-world settings because neurologic examination findings often fluctuate over short time intervals, and some elements of these instruments are subjective. In addition to measures of accuracy and reliability, future researchers should explicitly quantify the number of suspected stroke patients to be screened with each instrument to identify 1 patient likely to benefit from EVT. Because the definition of LVO varies across studies, comparative accuracy assessments for each instrument for the same subtypes of LVO are lacking. Between instrument impact analyses that quantify differences in out-of-hospital scene times and time-to-EVT along with patient-centric outcomes of functional recovery are also lacking. Finally, the factors that promote or impede the uptake of each instrument, including local culture, feasibility, adaptability, costs, fidelity, unintended consequences, and sustainability, will be essential implementation components to evaluate in future research.

2. In adult patients with a suspected acute ischemic stroke, does the addition of perfusion imaging to a CTA or MRA identify patients more likely to benefit from thrombectomy?

Patient Management Recommendations

Level A recommendations. None specified.

Level B recommendations. None specified.

Level C recommendations. Obtain CTP or MR-based diffusion/perfusion imaging in patients with acute ischemic stroke because of LVO, especially if the time the patient was last known normal was between 6 and 24 hours before arrival to the ED.

Potential Benefit of Implementing the Recommendations:

- Otherwise ineligible patients who present later in their stroke course may become eligible for EVT, leading to improved patient outcomes.
- Patients most likely to benefit from EVT can be distinguished from those without salvageable brain tissue in whom risks outweigh benefits.

Potential Harm of Implementing the Recommendations:

- More patients may receive advanced imaging, potentially leading to increased costs, more radiation exposure, and preventable patient care delays.
- More patients may be transferred to an EVT-capable center for advanced imaging alone, potentially leading to increased costs, preventable patient care delays, and increased hospital crowding at the receiving EVT-capable hospital.
- Inaccurate CTP findings may lead to both underuse and overuse of EVT in some patients.

Key words/phrases for literature searches: brain ischemia, cerebral arterial disease, cerebral arterial infarction, computed tomography angiography, CT angiography, CTA, emergency medicine, hospital emergency service, magnetic resonance angiography, mechanical thrombolysis, middle cerebral artery infarction, MRA, MRI angiography, perfusion imaging, perfusion magnetic resonance imaging, perfusion scintigraphy, stroke, thrombectomy, and variations and combinations of key words/phrases. Searches included all dates up to the search dates of November 19, 24, and 25, 2020, and December 3, 2020.

Study Selection: Two hundred fifty-two articles were identified in the searches. Thirty-four articles were identified from the search results as candidates for further review. After grading for methodological rigor, zero Class I studies, zero Class II studies, and 3 Class III studies were included for this critical question ([Appendix E4](#)).

Historically, when evaluating patients with a potential stroke, emergency physicians used imaging to exclude diagnoses such as intracranial hemorrhage that would make therapies such as thrombolytics unsafe.⁴⁹ In the past decade, the imaging paradigm has evolved toward the addition of advanced imaging such as CTA and CTP to identify patients who may benefit from EVT.⁵⁰ With

perfusion imaging, the amount of brain tissue that appears to be infarcted, also known as the ischemic core, and the amount of brain tissue that is hypoperfused and at risk for infarction, or the penumbra, can be quantified. It is hypothesized that CTP may be able to select patients who are more likely to benefit from EVT.

A Class III study by Marks et al assessed the relationship of angiographic collateral score to the target mismatch profile and clinical outcomes.⁵¹ The study included patients within 12 hours of stroke onset because of an LVO. Patients underwent magnetic resonance diffusion-weighted imaging and perfusion-weighted imaging. Magnetic resonance data were used to calculate an ischemic core as well as hypoperfused tissue to calculate a target mismatch profile. The target mismatch profile was defined as the ratio between hypoperfused tissue and ischemic core of 1.8 or more, with an absolute difference of 15 mL. Additional criteria were an ischemic core of 70 mL or less and volume of tissue with severe hypoperfusion 100 mL or more. Sixty patients with a target mismatch were included. Collateral score correlated with the amount of hypoperfused tissue. A good neurologic outcome at 90 days was related to reperfusion scores, regardless of the collateral score. In patients with good reperfusion, the odds ratio (OR) of a good neurologic outcome at 90 days was 12.0 (95% CI 1.6 to 98) in patients with a poor collateral score and 4.7 (95% CI 0.8 to 26) in patients with a good collateral score. The study suggests that endovascular therapy can benefit patients with a target mismatch profile on MR-based diffusion/perfusion imaging, regardless of the collateral score.

Campbell et al was another Class III study which randomized patients to intravenous alteplase plus EVT versus intravenous alteplase alone based on CTP findings.⁵⁰ It was a prospective, randomized, open-label study of patients with acute ischemic stroke within 4.5 hours who were treated with intravenous alteplase. Patients were selected if the stroke was caused by anterior circulation LVO and if CTP imaging showed an ischemic core of less than 70 mL, a ratio of hypoperfused tissue to ischemic core of more than 1.2, and an absolute difference of 10 mL. Perfusion imaging was analyzed through proprietary automated software (RAPID, iSchemaView). The trial enrolled 70 patients but was stopped early by the data and safety monitoring board because of superior efficacy. Patients who received EVT had improved functional outcomes based on an OR of 4.2 (95% CI 1.4 to 12) for a modified Rankin score (mRS) of 0 to 2 at 90 days. Two patients who received EVT developed parenchymal hematomas, and 1 developed a groin hematoma that required a blood transfusion. Of note, the number of

needed CTAs to be performed to avoid EVT in patients who were recanalized with thrombolytic therapy was 9, since 35 CT evaluations were performed, and 4 patients had complete lysis of thrombus and did not undergo EVT (35/9 = 4).⁵⁰

Nogueira et al⁵² performed a prospective, randomized, open-label Class III study sponsored by Stryker Neurovascular that enrolled patients with acute ischemic stroke because of anterior LVO, symptom onset within 6 to 24 hours, and a mismatch between the severity of their clinical deficit and infarct volume.⁵² The definition had 3 groups. The first group consisted of patients 80 years or older, an NIHSS of 10 and more, and an infarct volume of less than 21 mL. The second group consisted of patients less than 80 years old, an NIHSS of 10 and more, and an infarct volume of less than 31 mL. The third group consisted of patients less than 80 years old, an NIHSS of 20 and more, and an infarct volume of 31 to less than 51 mL. Infarct volume was assessed through magnetic resonance imaging or CTP imaging. Perfusion imaging was also analyzed through automated software (RAPID, iSchemaView). Patients were randomized to standard medical care versus standard medical care plus thrombectomy. A total of 206 patients were enrolled, but the trial was stopped early because of efficacy. Infarct volume was slightly smaller in patients randomized to thrombectomy, 7.6 mL versus 8.9 mL. Time since symptom onset was slightly shorter in patients randomized to thrombectomy, 12.2 hours versus 13.3 hours. The NIHSS was similar between both groups. A score of 0 to 2 on the mRS scale at 90 days was achieved in 49% of patients in the EVT group versus 13% in the control group, an adjusted difference of 33% (95% CI 21 to 44). Death at 90 days was similar 19% versus 18%. Symptomatic intracranial hemorrhage (ICH) at 24 hours was seen in 6% versus 3%.

Summary

The CTP imaging can be used to assess the volume of infarcted and hypoperfused brain tissue in patients with an acute ischemic stroke. Although there have been no randomized trials of EVT with perfusion imaging versus EVT without perfusion imaging, advanced imaging is associated with better EVT outcomes. This is based on randomized trials of thrombolysis plus EVT with perfusion imaging versus thrombolysis alone. If patients have a favorable perfusion imaging profile, they may benefit from EVT up to 24 hours after they were last known to be normal. Of note, whereas other guidelines suggest using tools such as the Alberta Stroke Program Early Computerized Tomography Score (ASPECTS) to assess for

EVT eligibility within a certain time frame, our review did not assess this issue.³

Future Research

Future studies should seek to find the optimal ratio of the ischemic core to penumbra at which patients can be chosen for EVT. Studies should also evaluate whether patients with favorable perfusion imaging could benefit from EVT regardless of the time of last known normal. Studies should seek to evaluate the cost-effectiveness of perfusion imaging, including quantifying the number needed to scan with perfusion imaging to identify 1 patient likely to benefit from EVT. Additionally, studies could evaluate whether perfusion imaging could be used to guide the decision on whether to administer thrombolytic therapy, including in patients without LVO. Future studies should look at pathways improving the timing of perfusion imaging to prevent delays in identifying patients who are candidates for intervention. This includes which patients should obtain perfusion imaging upfront before confirmation of an LVO. Future studies should evaluate other methods (eg, ASPECTS) compared with perfusion imaging to select patients for EVT.

3. In adult patients with a suspected acute ischemic stroke qualifying for intravenous thrombolysis, is tenecteplase safe and effective compared with alteplase?

Patient Management Recommendations

Level A recommendations. None specified.

Level B recommendations. Use either tenecteplase or alteplase in patients with acute ischemic stroke who qualify for thrombolysis.*

Level C recommendations. None specified.

Potential Benefit of Implementing the Recommendations:

- Reduce errors in administration compared with alteplase.
- Improved short-term neurologic outcomes.
- Improve the ease of patients needing to be transferred to a stroke facility.
- Improved 3-month outcomes in patients with confirmed LVO.

Potential Harm of Implementing the Recommendations:

- Incorrect dosing may increase the risk of complications.

*For tenecteplase, use 0.25 mg/kg maximum dose 25 mg bolus; for alteplase, use 0.9 mg/kg maximum dose 90 mg with 10% given as a bolus and the remaining as an infusion over 60 minutes.

Key words/phrases for literature searches: alteplase, brain ischemia, cerebral arterial disease, cerebral arterial infarction, emergency medicine, fibrinolytic agents, fibrinolytic therapy, hospital emergency service, intravenous thrombolysis, intravenous thrombolytics, IV thrombolysis, IV thrombolytics, large vessel occlusion, metalyze, rtPA, rt-PA, stroke, Tenecteplase, thrombolytic therapy, tissue plasminogen activator, TNKase, tPA, t-PA, and variations and combinations of key words/phrases. Searches included all dates up to the search dates of November 19, 24, and 25, 2020, and December 4 and 5, 2020.

Study Selection: Five hundred ninety-seven articles were identified in the searches. Twenty-four articles were identified from the search results as candidates for further review. After grading for methodological rigor, zero Class I studies, 5 Class II studies, and 13 Class III studies were included for this critical question ([Appendix E4](#)).

Tenecteplase is a genetically engineered form of tissue plasminogen activator that is more fibrin-specific and has a longer half-life than alteplase. Because of its longer half-life, tenecteplase can be administered as a single bolus more than 5 seconds.⁵³ In contrast, alteplase requires a bolus followed by a continuous infusion for 60 minutes, making tenecteplase easier to administer. One study reported a 64% dosing/administration error rate in stroke patients who received alteplase.⁵⁴ Because of the ease of administration, there is interest in using tenecteplase instead of alteplase for acute stroke thrombolysis. This question will explore the evidence of tenecteplase as an alternative to alteplase for both clinical and safety outcomes.

Randomized Controlled Trials

Eight studies were identified with 7 RCT and 3 subgroup analysis from a single RCT. In a Class II study, the EXTEND-IA TNK trial⁵⁵ randomized 202 acute stroke patients who had an occlusion of either the internal carotid artery, middle cerebral artery, or basilar artery within 4.5 hours of onset to either tenecteplase (0.25 mg/kg, maximum dose 25 mg) or alteplase (0.9 mg/kg, maximum dose 90 mg). The primary outcome of reperfusion of 50% or more of the involved ischemic territory or absence of retrievable thrombus at the time of angiography occurred in 22% with tenecteplase versus 10% with alteplase (adjusted incidence ratio 2.2, 95% CI 1.1 to 4.4). Median 90-day mRS was better in the tenecteplase group than in the alteplase group (2 versus 3, common OR 1.7, 95% CI 1.0 to 2). Symptomatic ICH occurred in 1% of patients in both groups.

In another Class II study, the Norwegian Tenecteplase Stroke Trial (NOR-TEST)⁵⁶ enrolled 1,107 patients that presented within 4.5 hours of an acute ischemic stroke or from waking up with an acute ischemic stroke to receive either alteplase 0.9 mg/kg (maximum dose 90 mg) or tenecteplase 0.4 mg/kg (maximum dose 40 mg). The primary outcome was a 3-month mRS score of 0 to 1 and was achieved in 64% in the tenecteplase group and 63% in the alteplase group (OR 1.08; 95% CI 0.84 to 1.38). Secondary outcomes such as major clinical improvement (ie, NIHSS score of 0 or an improvement of at least 4 points at 24 hours), ICH, symptomatic ICH, and death were similar between 2 groups.

In a Class III study, the ACT trial randomized 1,577 patients to receive either alteplase (0.9 mg/kg) or tenecteplase (0.25 mg/kg).⁵⁷ Noninferiority was achieved as the primary outcome with an mRS of 0 to 1 at 90 to 120 days (36.9% in the tenecteplase group compared with 34.8% in the alteplase group). Safety outcomes such as 24-hour symptomatic ICH and 90-day mortality were similar between both groups.⁵⁷

In a Class III study, Parsons et al conducted a phase 2b trial (Australian-TNK) randomizing 75 patients who presented with a hemispheric stroke within 6 hours of onset who had an intracranial occlusion of the anterior, middle, or posterior cerebral artery on CTA and a perfusion lesion at least 20% more than infarct-core lesion on CTP imaging.⁵⁸ Patients were randomized to receive alteplase 0.9 mg/kg (maximum dose of 90 mg), tenecteplase 0.1 mg/kg (maximum dose 10 mg), or tenecteplase 0.25 mg/kg (maximum dose 25 mg). Primary endpoints were the percentage of perfusion lesions that were perfused and the change in NIHSS after treatment at 24 hours. For the coprimary endpoints, the percentage of reperfusion at 24 hours was higher in the combined tenecteplase group than alteplase (79.3% versus 55.4%, difference 23.9%; 95% CI 8.1 to 39.7) as well as improvement in NIHSS score between baseline and at 24 hours (mean change 8.0 versus 3.0, difference 5.0; 95% CI 2.2 to 7.8). Tenecteplase administration of 0.25 mg/kg was superior for both coprimary endpoints compared with tenecteplase at 0.1 mg/kg (complete perfusion at 24 hours: 88.8% versus 69.3%, difference 19.5%, 95% CI 3.9 to 35.1; mean NIHSS improvement 9.6 versus 6.3, difference 3.3, 95% CI 0.3 to 6.3). Symptomatic ICH was similar among all 3 groups.

In a Class III study, the Alteplase-Tenecteplase Trial Evaluation for Stroke Thrombolysis (ATTEST) trial⁵⁹ enrolled 104 patients who were randomized to receive either alteplase (0.9 mg/kg, maximum dose 90 mg) or tenecteplase (0.25 mg/kg, maximum dose 25 mg) within

4.5 hours of onset. The primary outcome of the percentage of penumbra salvaged did not differ between the 2 groups (68% versus 68%). Safety outcomes, including any ICH or symptomatic ICH, did not differ between the 2 groups.

The TASTE-A trial, a Class III study, was a phase 2, open-label, out-of-hospital trial using a mobile stroke unit that enrolled 104 patients.⁶⁰ Patients received either tenecteplase at 0.25 mg/kg or alteplase at 0.9 mg/kg. The primary outcome of perfusion lesion on arrival to the hospital was smaller in the tenecteplase group compared with the alteplase group (adjusted incidence ratio of 0.55; 95% CI 0.37 to 0.81). Secondary outcomes such as 90-day mRS, symptomatic ICH, any ICH, and death were similar between both groups. The NOR-TEST 2, part A trial, another Class III study, enrolled 204 patients in an open-label, phase 3 trial.⁶¹ In this trial, patients were randomized to receive either tenecteplase at 0.4 mg/kg or alteplase at 0.9 mg/kg. This study was terminated early because of safety reasons. Primary outcomes of favorable functional outcome (ie, mRS of 0 to 1 at 3 months) were lower with tenecteplase compared with alteplase (32% versus 51%; unadjusted OR 0.45; 95% CI 0.25 to 0.80). Complications such as any ICH, symptomatic ICH, and 30-day mortality were higher with tenecteplase. Of note, part B of NOR-TEST 2 is evaluating tenecteplase at 0.25 mg/kg and is still ongoing as of this writing.

Three Class III studies involving subgroup analysis from the NOR-TEST trial were also included. Patients who had moderate stroke (NIHSS 6 to 14) or severe stroke (NIHSS ≥ 15) had similar outcomes between alteplase or tenecteplase.⁶² Similar outcomes were also seen in patients treated between 3 to 4.5 hours as well as patients aged 80 years or older.^{63,64}

Meta-analyses

Three Class II and 5 Class III meta-analyses were included.⁶⁵⁻⁷² These meta-analyses used similar studies, differing in patient cohorts evaluated.^{55,56,58,59,73,74} The outcomes evaluated were similar and included excellent functional outcomes (ie, mRS of 0 to 1 at 3 months), good functional outcomes (ie, mRS of 0 to 2 at 3 months), and early neurologic improvement (ie, of 8 point difference or more in NIHSS at 24 hours). Safety measures were also similarly defined for dependency (ie, mRS of 3 to 5) and mortality (ie, death at 3 months). Recanalization and symptomatic ICH were defined based on individual study definitions that were included. Other outcome measures for each study were described separately.

In a Class II study, Burgos et al⁶⁵ reviewed 5 trials that included 1,585 patients. Their primary endpoint was noninferiority of tenecteplase compared with alteplase with an mRS score of 0 to 1 at 3 months. The risk difference between tenecteplase compared with alteplase was 4% favoring tenecteplase (95% CI, -1% to 8%), meeting the predefined assessed noninferiority margin. In another Class II study, Xu et al⁶⁶ included 4 trials that had a total of 1,390 patients. In their analysis, all doses of tenecteplase were superior to alteplase in early neurologic improvement (relative risk [RR] 1.52; 95% CI 1.03 to 2.25) with tenecteplase of 0.25 mg/kg superior to other tenecteplase doses (RR 2.1; 95% CI 1.43 to 3.09). Finally, in another Class II study, Thelengana et al⁶⁷ evaluated 4 trials that included 1,334 patients. In their analysis, tenecteplase was found to be superior to alteplase in early major neurologic improvement (RR 1.56; 95% CI 1.00 to 2.43). All other outcomes, such as excellent and good functional outcomes, recanalization at 24 or 48 hours, any ICH, symptomatic ICH, and mortality, were similar between tenecteplase and alteplase.

Three Class III meta-analyses evaluated similar trials.⁶⁸⁻⁷⁰ In a Class III study consisting of 3 trials of 291 patients,⁶⁸ only tenecteplase of 0.25 mg/kg showed superiority to alteplase in early neurologic improvement (OR 1.9; 95% CI 0.8 to 4.4). All other clinical outcomes and safety measures did not show a statistical difference. Similarly, in a study of 5 trials including 1,585 patients,⁶⁹ tenecteplase was found to be superior to alteplase only in rates of recanalization (OR 2.01; 95% CI 1.04 to 3.87) and early neurologic improvement (OR 1.43; 95% CI 1.01 to 2.03). No difference in safety or other clinical outcomes was noted between the 2 drugs. Finally, in a study consisting of 6 trials with 5 comparing tenecteplase with alteplase,⁷⁰ tenecteplase had significantly improved early major neurologic improvement compared with alteplase (RR 1.59; 95% CI 1.08 to 2.34) and reduced parenchymal hematoma (RR 0.26; 95% CI 0.10 to 0.71). No other differences in the clinical or safety outcomes were observed.

In a Class III study, Rivard et al⁷¹ combined the results of ATTEST and Australian-TNK trials. Overall, there was no difference with early clinical improvement, excellent functional outcome, or poor functional outcome (ie, mRS of 5 to 6) in patients receiving either tenecteplase or alteplase. However, in a subgroup of patients that had documented target mismatch by advanced imaging (33 tenecteplase, 35 alteplase), tenecteplase had greater early clinical improvement (median NIHSS score change of 6 versus 1), higher excellent functional outcomes (OR 2.33; 95% CI 1.13 to 5.94), and less poor functional outcomes (mRS of 5 to 6: OR 0.3; 95% CI 0.09 to 0.97).

Finally, in a Class III meta-analysis looking at tenecteplase versus alteplase in patients with confirmed LVO,⁷² 4 studies were identified that included 433 patients. Patients receiving tenecteplase had higher odds of good functional outcome (OR 2.06; 95% CI 1.15 to 3.69), successful recanalization (OR 3.05; 95% CI 1.73 to 5.40), and better functional improvement defined as a 1-point decrease across all mRS grades (common OR 1.84; 95% CI 1.18 to 2.87) at 3 months than alteplase. No difference in excellent functional outcome, early neurologic improvement, ICH, symptomatic ICH, or mortality at 3 months was found.

Summary

Multiple RCTs show either an improvement in early neurologic outcomes or no difference between tenecteplase versus alteplase except for 1 Class III trial, which used a tenecteplase dose of 0.4 mg/kg, which showed worse outcomes.⁶¹ Similarly, multiple meta-analyses show an improvement in early neurologic improvement with tenecteplase, especially at 0.25 mg/kg compared with alteplase, with all other outcome and safety measures showing no difference between the 2 drugs.⁶⁵⁻⁷² When tenecteplase is used for the treatment of stroke, a dose of 0.25 mg/kg (maximum dose of 25 mg) should be used based on current data. However, because the use of thrombolytics in acute stroke requires coordination of care with multiple stakeholders, the use of tenecteplase should be adopted ideally as part of an institutional protocol.

Future Research

Although the current literature suggests that the use of tenecteplase is noninferior to alteplase, more studies should be performed to confirm the optimal dosing of tenecteplase. Also, research on other cohorts comparing alteplase with tenecteplase, including patients with different types of strokes (eg, different types of LVO, before and after thrombectomy, extended thrombolytic window), should be evaluated.

4. In adult patients who present with acute vertigo with possible stroke, is there a history or physical examination findings (eg, HINTS examination) that can risk stratify for acute ischemic stroke?

Patient Management Recommendations

Level A recommendations. None specified.

Level B recommendations. None specified.

Level C recommendations. In addition to a standard comprehensive history and physical examination,

physicians may use specific findings such as ABCD2 score, ocular motor examination, presence of additional neurologic deficits, and HINTS to risk stratify patients with a possible stroke.

Before employing a maneuver such as HINTS, physicians should have sufficient education to perform the technique (Consensus recommendation).

Potential Benefit of Implementing the Recommendations:

- May improve risk stratification to identify patients with a possible stroke.

Potential Harm of Implementing the Recommendations:

- Without adequate risk stratification tools, patients are more likely to be admitted.
- Without adequate risk stratification tools, patients are more likely to undergo expensive testing (eg, magnetic resonance imaging) and prolonged length of stay.
- Not using tools such as HINTS may lead to excessive testing and admission.
- Incorrect implementation may lead to an increased risk of misdiagnosis.

Key words/phrases for literature searches: acute ischemic stroke, acute vertigo, bedside testing, brain ischemia, cerebral arterial disease, cerebral arterial infarction, Dix-Hallpike, dizziness, emergency medicine, Head-Impulse—Nystagmus—Test of Skew, HINTS, HINTS examination, HINTS test, hospital emergency service, large vessel occlusion, physical examination, physiologic nystagmus, point of care, point-of-care testing, stroke, vertigo, and variations and combinations of key words/phrases. Searches included all dates up to the search dates of November 20 and 25, 2020, and December 3 and 4, 2020.

Study Selection: Five hundred twenty-six articles were identified in the searches. Thirty-seven articles were identified from the search results as candidates for further review. After grading for methodological rigor, zero Class I studies, zero Class II studies, and 2 Class III studies were included for this critical question ([Appendix E4](#)).

Dizziness or vertigo is a common presentation to the ED, comprising more than 3.9 million presentations per year and an annual cost of \$3.9 billion.⁷⁵ Patients presenting with dizziness have an increased likelihood of imaging, longer ED lengths of stay, and higher admission rates compared with other ED patients.⁷⁶ However, only approximately 3.3% of cases ultimately have a cerebrovascular cause.⁷⁵ Whereas we have used the term vertigo in our clinical question, it is important to note that the term dizziness is the more inclusive term which includes vertigo.^{77,78} The terms dizziness and vertigo are

used interchangeably in this document to include the full spectrum of symptoms.

There have been numerous attempts to identify historical features, physical examination findings, and clinical decision tools to guide the assessment of patients to reduce unnecessary imaging and admissions. Two commonly described and studied clinical decision tools include the ABCD2 (age, blood pressure, clinical features, duration, and diabetes) score and the HINTS (head impulse test, change in nystagmus, and test of skew) examination. The ABCD2 is considered low-risk when the score is less than 4, whereas the HINTS examination is considered low-risk if all 3 findings are not consistent with stroke (ie, suggestive of a peripheral cause) in a patient with active dizziness symptoms and nystagmus. However, most studies have been limited by performance outside the ED setting by nonemergency physicians. Whereas we identified several studies in our review that involved formal training programs for maneuvers such as HINTS,⁷⁹⁻⁸¹ these studies were among a limited number of emergency physicians and received a grade of Class X because of methodological issues. As such, none of the studies included reviewed training requirements.

In a Class III study, Kerber et al⁸² prospectively evaluated patients presenting to the ED with acute dizziness without an obvious cause using magnetic resonance imaging as the gold standard for stroke. They assessed history, the ABCD2 score, the HINTS examination, and performed a general neurologic examination. All examinations were performed by a neurologist fellowship trained in neuro-otology, a neurologist who was vascular trained, or an emergency physician who was fellowship trained in vascular neurology. They enrolled 272 patients (10.7% stroke). Most parameters had limited use for diagnosing stroke, with the most useful components being the ABCD2 score (OR 1.74; 95% CI 1.20 to 2.51), a central pattern of nystagmus (OR 3.56; 95% CI 1.55 to 8.16), and concomitant neurologic symptoms (eg, visual field deficit, dysmetria, sensory symptoms/deficits; OR 2.54; 95% CI 1.06 to 6.08). Additionally, the authors found that none of these findings in isolation were able to adequately stratify patients as low-risk, with the stroke frequency in the low-risk groups being more than 5% for all the components. The HINTS examination also did not demonstrate a statistically significant difference (OR 2.82; 95% CI 0.96 to 8.30), although the wide CIs do not exclude that a meaningful difference may exist. This study was limited in that all examinations were performed by either a neurologist who was fellowship trained in neuro-otology or an emergency physician who was fellowship

trained in vascular neurology, which may not reflect the average emergency physician.

In another Class III study, Ohle et al⁸³ performed a systematic review and meta-analysis of the diagnostic accuracy of the HINTS examination to rule out a central cause of vertigo. The meta-analysis included 5 studies (N=617 participants; 34.8% stroke) and demonstrated that the HINTS examination was 96.7% sensitive (95% CI 93.1% to 98.5%) and 94.8% specific (95% CI 91% to 97.1%) when performed by neurologists. However, when the HINTS examination was performed by a cohort of emergency physicians and neurologists, the sensitivity decreased to 83% (95% CI 63% to 95%) and specificity decreased to 44% (95% CI 36% to 51%).

Summary

There is limited data evaluating the role of historical or physical examination features, alone or in combination, to accurately risk stratify patients with acute vertigo from possible stroke included in this clinical policy. The included studies suggest that the history and physical examination findings, alone or as combined tools, should not be used in isolation as they are unable to adequately risk stratify patients with acute ischemic stroke even when performed by trained emergency physicians.

Future Research

Future research would benefit from additional trials assessing the diagnostic accuracy of emergency physicians for identifying acute ischemic stroke using existing features and risk assessment tools. Studies should also be performed to identify the ideal training to enhance emergency physician accuracy with tools such as the HINTS examination. Research should also evaluate the effect of technology (eg, Frenzel goggles, ocular tracking software) to enhance the potential accuracy of the HINTS examination. Additional research could also involve the derivation of new diagnostic tools to assess for the presence of acute ischemic stroke among patients presenting with acute vertigo, and the derivation of new decision tools using a combination of existing tests to enhance risk stratification.

Relevant industry relationships: *There were no relevant industry relationships disclosed by the subcommittee members for this topic.*

Relevant industry relationships are those relationships with companies associated with products or services that significantly affect the specific aspect of disease addressed in the critical question.

REFERENCES

- Virani SS, Alonso A, Aparicio HJ, et al. Heart disease and stroke statistics-2021 update: a report from the American Heart Association. *Circulation*. 2021;143:e254-e743.
- Bulwa Z, Chen M. Stroke center designations, neurointerventionalist demand, and the finances of stroke thrombectomy in the United States. *Neurology*. 2021;97:S17-S24.
- Powers WJ, Rabinstein AA, Ackerson T, et al. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. [published correction appears in *Stroke*. 2019 Dec;50:e440-e441]. *Stroke*. 2019;50:e344-e418.
- Liu X, Dai Q, Ye R, et al. Endovascular treatment versus standard medical treatment for vertebrobasilar artery occlusion (BEST): an open-label, randomised controlled trial. *Lancet Neurol*. 2020;19:115-122.
- Langezaal LCM, van der Hoeven EJ, Mont'Alverne FJA, et al. Endovascular therapy for stroke due to basilar-artery occlusion. *N Engl J Med*. 2021;384:1910-1920.
- Sarraj A, Savitz S, Pujara D, et al. Endovascular thrombectomy for acute ischemic strokes: current US access paradigms and optimization methodology. *Stroke*. 2020;51:1207-1217.
- Aldstadt J, Waqas M, Yasumiishi M, et al. Mapping access to endovascular stroke care in the USA and implications for transport models. *J Neurointerv Surg*. 2022;14; neurintsurg-2020-016942.
- Noh L, Pham F, Haddad L, et al. A practice game changer: impact of tenecteplase for acute ischemic stroke in a multicenter quality improvement project. *Am J Health Syst Pharm*. 2022;79: e149-e153.
- Atzema CL, Grewal K, Lu H, et al. Outcomes among patients discharged from the emergency department with a diagnosis of peripheral vertigo. *Ann Neurol*. 2016;79:32-41.
- Arch AE, Weisman DC, Coca S, et al. Missed ischemic stroke diagnosis in the emergency department by emergency medicine and neurology services [published correction appears in *Stroke*. 2016 Mar;47:e59]. *Stroke*. 2016;47:668-673.
- Tarnutzer AA, Berkowitz AL, Robinson KA, et al. Does my dizzy patient have a stroke? A systematic review of bedside diagnosis in acute vestibular syndrome. *CMAJ*. 2011;183:E571-E592.
- Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372:n71.
- Hui W, Wu C, Zhao W, et al. Efficacy and safety of recanalization therapy for acute ischemic stroke with large vessel occlusion: a systematic review. *Stroke*. 2020;51:2026-2035.
- Pride GL, Fraser JF, Gupta R, et al. Prehospital care delivery and triage of stroke with emergent large vessel occlusion (ELVO): report of the Standards and Guidelines Committee of the Society of Neurointerventional Surgery. *J Neurointerv Surg*. 2017;9:802-812.
- Mueller-Kronast NH, Zaidat OO, Froehler MT, et al. Systematic evaluation of patients treated with neurothrombectomy devices for acute ischemic stroke: primary results of the STRATIS registry. *Stroke*. 2017;48:2760-2768.
- Brott T, Adams HP Jr, Olinger CP, et al. Measurements of acute cerebral infarction: a clinical examination scale. *Stroke*. 1989;20:864-870.
- Singer OC, Dvorak F, du Mesnil de Rochemont R, et al. A simple 3-item stroke scale: comparison with the National Institutes of Health Stroke Scale and prediction of middle cerebral artery occlusion. *Stroke*. 2005;36:773-776.
- Kothari RU, Pancioli A, Liu T, et al. Cincinnati prehospital stroke scale: reproducibility and validity. *Ann Emerg Med*. 1999;33:373-378.
- Lima FO, Silva GS, Furie KL, et al. Field assessment stroke triage for emergency destination: a simple and accurate prehospital scale to detect large vessel occlusion strokes. *Stroke*. 2016;47:1997-2002.

20. Nazliel B, Starkman S, Liebeskind DS, et al. A brief prehospital stroke severity scale identifies ischemic stroke patients harboring persisting large arterial occlusions. *Stroke*. 2008;39:2264-2267.
21. Hastrup S, Damgaard D, Johnsen SP, et al. Prehospital acute stroke severity scale to predict large artery occlusion: design and comparison with other scales. *Stroke*. 2016;47:1772-1776.
22. Pérez de la Ossa N, Carrera D, Gorchs M, et al. Design and validation of a prehospital stroke scale to predict large arterial occlusion: the rapid arterial occlusion evaluation scale. *Stroke*. 2014;45:87-91.
23. Antipova D, Eadie L, Macaden A, et al. Diagnostic accuracy of clinical tools for assessment of acute stroke: a systematic review. *BMC Emerg Med*. 2019;19:49.
24. Birnbaum L, Wampler D, Shadman A, et al. Paramedic utilization of Vision, Aphasia, Neglect (VAN) stroke severity scale in the prehospital setting predicts emergent large vessel occlusion stroke. *J Neurointerv Surg*. 2021;13:505-508.
25. Crowe RP, Myers JB, Fernandez AR, et al. The Cincinnati prehospital stroke scale compared to stroke severity tools for large vessel occlusion stroke prediction. *Prehosp Emerg Care*. 2021;25:67-75.
26. Smith EE, Kent DM, Bulsara KR, et al. 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 [published correction appears in *Stroke*. 2018 Mar;49:e139]. *Stroke*. 2018;49:e111-e122.
27. Krebs W, Sharkey-Toppen TP, Cheek F, et al. prehospital stroke assessment for large vessel occlusions: a systematic review. *Prehosp Emerg Care*. 2018;22:180-188.
28. Teleb MS, Ver Hage A, Carter J, et al. Stroke vision, aphasia, neglect (VAN) assessment-a novel emergent large vessel occlusion screening tool: pilot study and comparison with current clinical severity indices. *J Neurointerv Surg*. 2017;9:122-126.
29. Uchida K, Yoshimura S, Sakakibara F, et al. Simplified prehospital prediction rule to estimate the likelihood of 4 types of stroke: the 7-item Japan Urgent Stroke Triage (JUST-7) score. *Prehosp Emerg Care*. 2021;25:465-474.
30. Hansen CK, Christensen A, Ovesen C, et al. Stroke severity and incidence of acute large vessel occlusions in patients with hyper-acute cerebral ischemia: results from a prospective cohort study based on CT-angiography (CTA). *Int J Stroke*. 2015;10:336-342.
31. Gallagher EJ. Evidence-based emergency medicine/editorial. The problem with sensitivity and specificity. *Ann Emerg Med*. 2003;42:298-303.
32. Hayden SR, Brown MD. Likelihood ratio: a powerful tool for incorporating the results of a diagnostic test into clinical decisionmaking. *Ann Emerg Med*. 1999;33:575-580.
33. Stiell IG, Wells GA. Methodologic standards for the development of clinical decision rules in emergency medicine. *Ann Emerg Med*. 1999;33:437-447.
34. Kanzaria HK, McCabe AM, Meisel ZM, et al. Advancing patient-centered outcomes in emergency diagnostic imaging: a research agenda. *Acad Emerg Med*. 2015;22:1435-1446.
35. El Dib R, Tikkinen KAO, Akl EA, et al. Systematic survey of randomized trials evaluating the impact of alternative diagnostic strategies on patient-important outcomes. *J Clin Epidemiol*. 2017;84:61-69.
36. Zhao H, Coote S, Pesavento L, et al. Large vessel occlusion scales increase delivery to endovascular centers without excessive harm from misclassifications. *Stroke*. 2017;48:568-573.
37. Jumaa MA, Castonguay AC, Salahuddin H, et al. Long-term implementation of a prehospital severity scale for EMS triage of acute stroke: a real-world experience. *J Neurointerv Surg*. 2020;12:19-24.
38. Nguyen TTM, van den Wijngaard IR, Bosch J, et al. Comparison of prehospital scales for predicting large anterior vessel occlusion in the ambulance setting. *JAMA Neurol*. 2021;78:157-164.
39. Zhao H, Smith K, Bernard S, et al. Utility of severity-based prehospital triage for endovascular thrombectomy: ACT-FAST validation study. *Stroke*. 2021;52:70-79.
40. Vidale S, Agostoni E. Prehospital stroke scales and large vessel occlusion: a systematic review. *Acta Neurol Scand*. 2018;138:24-31.
41. Duvekot MHC, Venema E, Rozeman AD, et al. Comparison of eight prehospital stroke scales to detect intracranial large-vessel occlusion in suspected stroke (PRESTO): a prospective observational study. *Lancet Neurol*. 2021;20:213-221.
42. Helwig SA, Ragoschke-Schumm A, Schwindling L, et al. Prehospital stroke management optimized by use of clinical scoring vs mobile stroke unit for triage of patients with stroke: a randomized clinical trial. *JAMA Neurol*. 2019;76:1484-1492.
43. Demeestere J, Garcia-Esperon C, Lin L, et al. Validation of the national institutes of health stroke scale-8 to detect large vessel occlusion in ischemic stroke. *J Stroke Cerebrovasc Dis*. 2017;26:1419-1426.
44. Gropen TI, Gazi M, Minor M, et al. Centrally guided identification of patients with large vessel occlusion: lessons from trauma systems. *J Stroke Cerebrovasc Dis*. 2019;28:2388-2397.
45. Høglund J, Strong D, Rhoten J, et al. Test characteristics of a 5-element cortical screen for identifying anterior circulation large vessel occlusion ischemic strokes. *J Am Coll Emerg Physicians Open*. 2020;1:908-917.
46. Mayasi Y, Goddeau RP Jr, Moonis M, et al. Leukoaraiosis attenuates diagnostic accuracy of large-vessel occlusion scales. *AJNR Am J Neuroradiol*. 2018;39:317-322.
47. Richards CT, Huebinger R, Tataris KL, et al. Cincinnati prehospital stroke scale can identify large vessel occlusion stroke. *Prehosp Emerg Care*. 2018;22:312-318.
48. Heldner MR, Mattle HP, Fischer U. Letter by Heldner et al regarding article, "Prehospital acute stroke severity scale to predict large artery occlusion: design and comparison with other scales.". *Stroke*. 2016;47:e231.
49. Schriger DL, Kalafut M, Starkman S, et al. Cranial computed tomography interpretation in acute stroke: physician accuracy in determining eligibility for thrombolytic therapy. *JAMA*. 1998;16:1293-1297.
50. Campbell BC, Mitchell PJ, Kleinig TJ, et al. Endovascular therapy for ischemic stroke with perfusion-imaging selection. *New Engl J Med*. 2015;372:1009-1018.
51. Marks MP, Lansberg MG, Mlynash M, et al. Effect of collateral blood flow on patients undergoing endovascular therapy for acute ischemic stroke. *Stroke*. 2014;45: 1035-1009.
52. Nogueira RG, Jadhav AP, Haussen DC, et al. Thrombectomy 6 to 24 hours after stroke with a mismatch between deficit and infarct. *New Engl J Med*. 2018;378:11-21.
53. FDA Insert Tenecteplase. Accessed October 13, 2021. https://www.accessdata.fda.gov/drugsatfda_docs/label/2018/103909s5187lbl.pdf
54. Chung LS, Tkach A, Lingenfelter EM, et al. Tissue plasminogen activator prescription and administration errors within a regional stroke system. *J Stroke Cerebrovasc Dis*. 2016;25:565-571.
55. Campbell BCV, Mitchell PJ, Churilov L, et al. tenecteplase versus alteplase before thrombectomy for ischemic stroke. *N Eng J Med*. 2018;378:1573-1582.
56. Logallo N, Novotny V, Assmus J, et al. Tenecteplase versus alteplase for management of acute ischaemic stroke (NOR-TEST): a phase 3, randomised, open-label, registry-linked, blinded endpoint trial. *Lancet Neurol*. 2017;16:781-788.
57. Menon BK, Buck BH, Singh N, et al. Intravenous tenecteplase compared with alteplase for acute ischaemic stroke in Canada (AcT): a pragmatic, multicentre, open-label, registry-linked, randomised, controlled, non-inferiority trial. *Lancet*. 2022;400:161-169.
58. Parsons M, Spratt N, Bivard A, et al. A randomized trial of tenecteplase versus alteplase for acute ischemic stroke. *N Engl J Med*. 2012;366:1099-1107.

59. Huang X, Cheripelli BK, Lloyd SM, et al. Alteplase versus tenecteplase for thrombolysis after ischaemic stroke (ATTEST): a phase 2, randomised, open-label, blinded endpoint study. *Lancet Neurol.* 2015;14:368-376.
60. Bivard A, Zhao H, Churilov L, et al. Comparison of tenecteplase with alteplase for the early treatment of ischaemic stroke in the Melbourne Mobile Stroke Unit (TASTE-A): a phase 2, randomised, open-label trial. *Lancet Neurol.* 2022;21:520-527.
61. Kvistad CE, Næss H, Helleberg BH, et al. Tenecteplase versus alteplase for the management of acute ischaemic stroke in Norway (NOR-TEST 2, part A): a phase 3, randomised, open-label, blinded endpoint, non-inferiority trial. *Lancet Neurol.* 2022;21:511-519.
62. Kvistad CE, Novotny V, Kurz MW, et al. Safety and outcomes of tenecteplase in moderate and severe ischemic stroke. *Stroke.* 2019;50:1279-1281.
63. Rønning OM, Logallo N, Thommessen B, et al. Tenecteplase versus alteplase between 3 and 4.5 hours in low national institutes of health stroke scale. *Stroke.* 2019;50:498-500.
64. Thommessen B, Næss H, Logallo N, et al. Tenecteplase versus alteplase after acute ischemic stroke at high age. *Int J Stroke.* 2021;16:295-299.
65. Burgos AM, Saver JL. Evidence that tenecteplase is noninferior to alteplase for acute ischemic stroke: meta-analysis of 5 randomized trials. *Stroke.* 2019;50:2156-2162.
66. Xu N, Chen Z, Zhao C, et al. Different doses of tenecteplase vs alteplase in thrombolysis therapy of acute ischemic stroke: evidence from randomized controlled trials. *Drug Des Devel Ther.* 2018;12:2071-2084.
67. Thelengana A, Radhakrishnan DM, Prasad M, et al. Tenecteplase versus alteplase in acute ischemic stroke: systematic review and meta-analysis. *Acta Neurol Belg.* 2019;119:359-367.
68. Huang X, Maclsaac R, Thompson JL, et al. Tenecteplase versus alteplase in stroke thrombolysis: an individual patient data meta-analysis of randomized controlled trials. *Int J Stroke.* 2016;11:534-543.
69. Kheiri B, Osman M, Abdalla A, et al. Tenecteplase versus alteplase for management of acute ischemic stroke: a pairwise and network meta-analysis of randomized clinical trials. *J Thromb Thrombolysis.* 2018;46:440-450.
70. Zang Y, Hou J, Wang LY. Therapeutic effect of tenecteplase on treatment of cerebral arterial thrombosis: a meta-analysis. *Eur Rev Med Pharmacol Sci.* 2016;20:4369-4379.
71. Bivard A, Huang X, McElduff P, et al. Impact of computed tomography perfusion imaging on the response to tenecteplase in ischemic stroke: analysis of 2 randomized controlled trials. *Circulation.* 2017;135:440-448.
72. Katsanos AH, Safouris A, Sarraj A, et al. Intravenous thrombolysis with tenecteplase in patients with large vessel occlusions: systematic review and meta-analysis. *Stroke.* 2021;52:308-312.
73. Parsons MW, Miteff F, Bateman GA, et al. Acute ischemic stroke: imaging-guided tenecteplase treatment in an extended time window. *Neurology.* 2009;72:915-921.
74. Haley EC Jr, Thompson JL, Grotta JC, et al. Phase IIB/III trial of tenecteplase in acute ischemic stroke: results of a prematurely terminated randomized clinical trial. *Stroke.* 2010;41:707-711.
75. Saber Tehrani AS, Coughlan D, Hsieh YH, et al. Rising annual costs of dizziness presentations to U.S. emergency departments. *Acad Emerg Med.* 2013;20:689-696.
76. Newman-Toker DE, Hsieh YH, Camargo CA Jr, et al. Spectrum of dizziness visits to US emergency departments: cross-sectional analysis from a nationally representative sample. *Mayo Clin Proc.* 2008;83:765-775.
77. Stanton VA, Hsieh YH, Camargo CA Jr, et al. Overreliance on symptom quality in diagnosing dizziness: results of a multicenter survey of emergency physicians [published correction appears in *Mayo Clin Proc.* 2013 Jul;88:777. Lovett, Paris [corrected to Lovett, Paris B]]. *Mayo Clin Proc.* 2007;82:1319-1328.
78. Kerber KA, Newman-Toker DE. Misdiagnosing dizzy patients: common pitfalls in clinical practice. *Neurol Clin.* 2015;33:565-viii.
79. Gerlier C, Hoarau M, Fels A, et al. Differentiating central from peripheral causes of acute vertigo in an emergency setting with the HINTS, STANDING, and ABCD2 tests: a diagnostic cohort study. *Acad Emerg Med.* 2021;28:1368-1378.
80. Vanni S, Pecci R, Casati C, et al. STANDING, a four-step bedside algorithm for differential diagnosis of acute vertigo in the emergency department. *Acta Otorhinolaryngol Ital.* 2014;34:419-426.
81. Vanni S, Pecci R, Edlow JA, et al. Differential diagnosis of vertigo in the emergency department: a prospective validation study of the STANDING algorithm. *Front Neurol.* 2017;8:590.
82. Kerber KA, Meurer WJ, Brown DL, et al. Stroke risk stratification in acute dizziness presentations: a prospective imaging-based study. *Neurology.* 2015;85:1869-1878.
83. Ohle R, Montpellier RA, Marchadier V, et al. can emergency physicians accurately rule out a central cause of vertigo using the HINTS examination? A systematic review and meta-analysis. *Acad Emerg Med.* 2020;27:887-896.

Appendix E1. Literature classification schema*.

Design/Class	Therapy [†]	Diagnosis [‡]	Prognosis [§]
1	Randomized, controlled trial or meta-analysis of randomized trials	Prospective cohort using a criterion standard or meta-analysis of prospective studies	Population prospective cohort or meta-analysis of prospective studies
2	Nonrandomized trial	Retrospective observational	Retrospective cohort Case control
3	Case series	Case series	Case series

*Some designs (eg, surveys) will not fit this schema and should be assessed individually.

[†]Objective is to measure therapeutic efficacy comparing interventions.

[‡]Objective is to determine the sensitivity and specificity of diagnostic tests.

[§]Objective is to predict outcome, including mortality and morbidity.

Appendix E2. Approach to downgrading strength of evidence.

Downgrading	Design/Class		
	1	2	3
None	I	II	III
1 level	II	III	X
2 levels	III	X	X
Fatally flawed	X	X	X

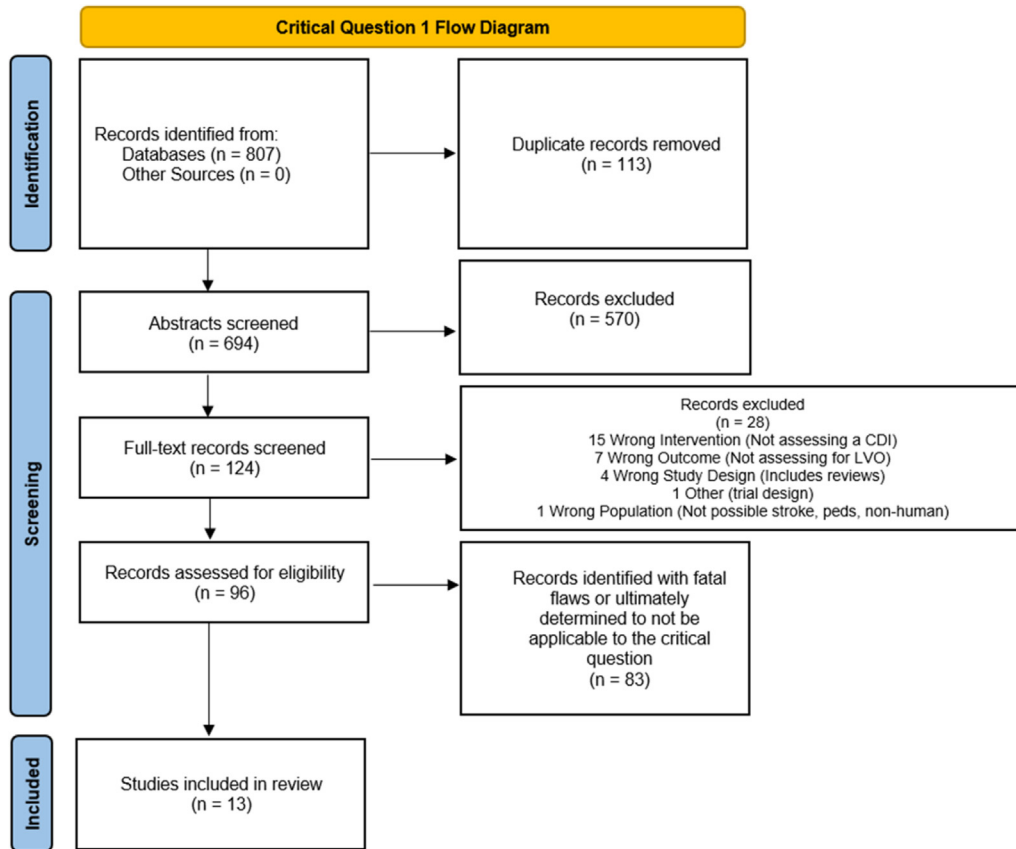
Appendix E3. Likelihood ratios and number needed to treat.*

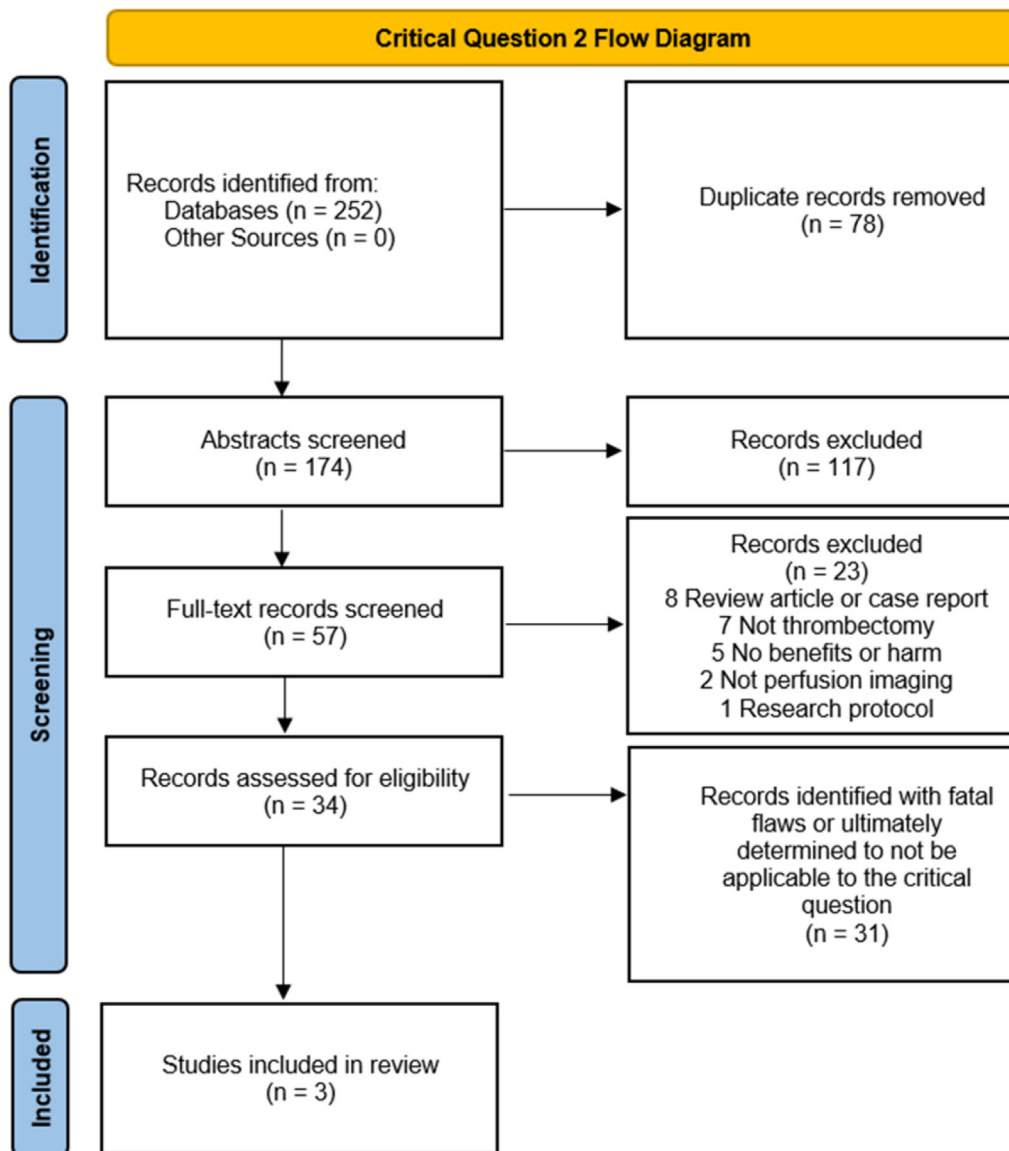
LR (+)	LR (-)	
1.0	1.0	Does not change pretest probability
1-5	0.5-1	Minimally changes pretest probability
10	0.1	May be diagnostic if the result is concordant with pretest probability
20	0.05	Usually diagnostic
100	0.01	Almost always diagnostic, even in the setting of low or high pretest probability

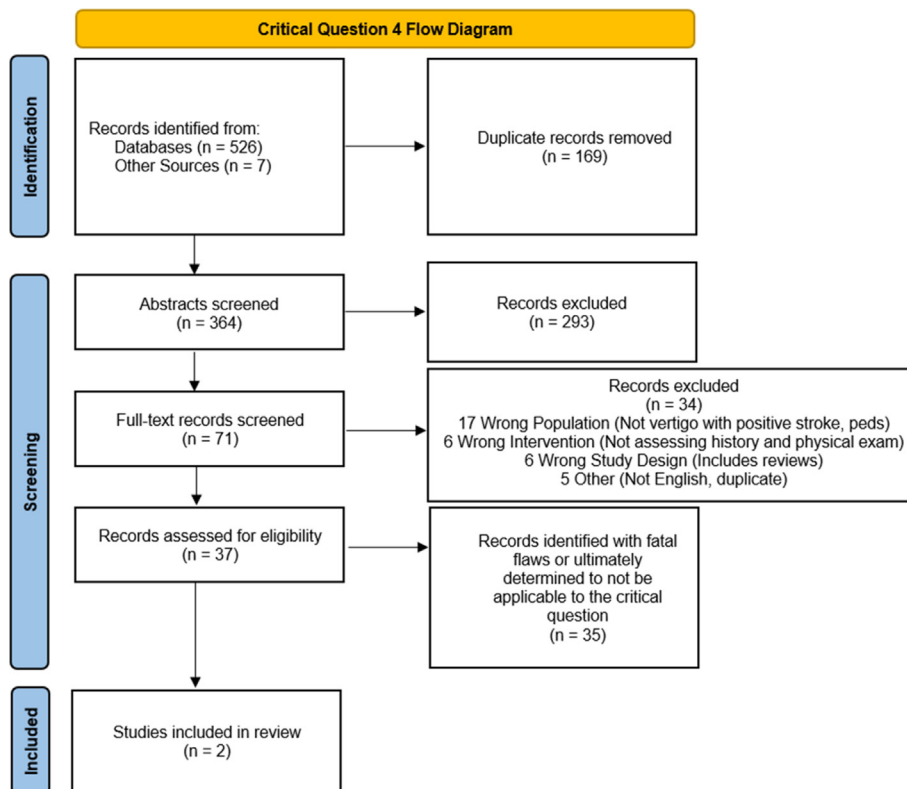
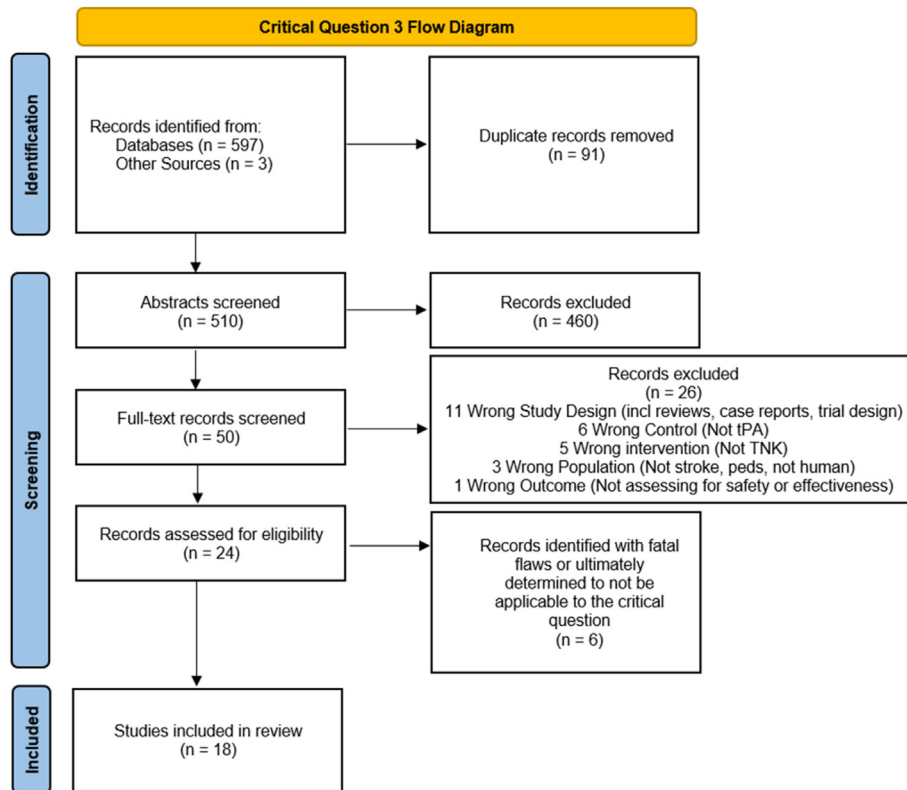
LR, likelihood ratio.

*Number needed to treat (NNT): number of patients who need to be treated to achieve 1 additional good outcome; $NNT=1/\text{absolute risk reduction} \times 100$, where absolute risk reduction is the risk difference between 2 event rates (ie, experimental and control groups).

APPENDIX E4. PRISMA¹² FLOW DIAGRAMS.







Evidentiary Table.

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Uchida et al ²⁹ (2020)	III for Q1	Multicenter, academic; prospective cohort study	EMS patients with suspected stroke who had neuroimaging (CT or MRI) EMS professionals completed the 21-item Japan Urgent Stroke Triage (JUST) score; JUST-7 included 7 of 21 elements; LVO determined by CTA, MRA, or cerebral angiography with corresponding ischemic changes on neuroimaging or treating neurologist assessment; multivariable logistic regression model derived from the derivation cohort	Historical derivation cohort: N=2,236 with 11% LVO prevalence; AUC for LVO was 0.89; prospective validation cohort: N=964 with 11% LVO prevalence; AUC for LVO was 0.81 ($P=.004$ for comparison with derivation cohort)	The proportion of patients excluded for lack of neuroimaging not reported and could result in verification bias; the clinical prediction model did not perform as well in the validation cohort and has not been validated externally

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Nguyen et al ³⁸ (2021)	II for Q1	Prospective cohort study: patients recruited from the Leiden and The Hague regions, Netherlands, encompassing 2 EMS systems, 3 comprehensive stroke centers, and 4 primary stroke centers, serving a total population of approximately 2 million	Externally validated field performance, of 7 prediction scales; an acute stroke code was initiated by EMS if there was an out-of-hospital suspicion of acute stroke with a positive FAST or other focal neurologic symptoms; when symptom onset or last seen well was 6 hours or less, it was routine policy to transport these patients to the nearest hospital, and when symptom onset was 6 to 24 hours, it was policy to transport patients to a comprehensive stroke center; primary outcome was symptomatic large anterior vessel occlusion (sLAVO) clinically assessed by the treating stroke team taking the following radiologic criteria into account: occlusion of the intracranial carotid	<p>N=2,007, 41% with stroke diagnosis, 7.9% with sLAVO;</p> <p>C-STAT ≥ 2: Sensitivity: 0.62 (95% CI 0.54 to 0.69) Specificity: 0.80 (95% CI 0.78 to 0.82) PPV: 0.21 (95% CI 0.18 to 0.24) NPV: 0.96 (95% CI 0.95 to 0.96)</p> <p>PASS ≥ 2: Sensitivity: 0.55 (95% CI 0.47 to 0.64) Specificity: 0.83 (95% CI 0.81 to 0.85) PPV: 0.21 (95% CI 0.18 to 0.25) NPV: 0.95 (95% CI 0.95 to 0.96)</p> <p>G-FAST ≥ 3 Sensitivity: 0.61 (95% CI 0.53 to 0.69) Specificity: 0.84 (95% CI 0.82 to 0.86) PPV: 0.24 (95% CI 0.21 to 0.27) NPV: 0.96 (95% CI 0.95 to 0.97)</p>	Study strength: study included mimics and subarachnoid hemorrhage cases providing more accurate performance characteristics; likely more severe scores got more imaging; no adjudication mentioned of unclear findings; seems that RACE was used for transport, and NIHSS for clinical decisions, whereas the other scores were just calculated for later analysis; filling out these scores also might have swayed EMS transport and care decisions; excluded 805 acute stroke codes (28.6%), because no application was used (752 [26.7%]) or because no clinical data were available in the electronic patient record (53 [1.9%])

			artery, tandem intracranial carotid artery, MCA (M1 or M2 segment), or ACA (A1 or A2 segment)	<p>FAST-ED ≥ 4 Sensitivity: 0.60 (95% CI 0.53 to 0.69) Specificity: 0.85 (95% CI 0.83 to 0.87) PPV: 0.25 (95% CI 0.22 to 0.29) NPV: 0.96 (95% CI 0.95 to 0.97)</p> <p>RACE ≥ 5 Sensitivity: 0.56 (95% CI 0.46 to 0.65) Specificity: 0.90 (95% CI 0.89 to 0.92) PPV: 0.32 (95% CI 0.27 to 0.38) NPV: 0.96 (95% CI 0.95 to 0.97)</p> <p>LAMS ≥ 4 Sensitivity: 0.38 (95% CI 0.29 to 0.46) Specificity: 0.93 (95% CI 0.91 to 0.94) PPV: 0.28 (95% CI 0.22 to 0.34) NPV: 0.95 (95% CI 0.94 to 0.96)</p>	
--	--	--	---	--	--

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Zhao et al ³⁹ (2021)	II for Q1	Prospective cohort study: patients recruited by Ambulance Victoria, the sole public provider of emergency services to a population of 5.33 million in the greater metropolitan Melbourne area; 15 metropolitan and 17 rural hospitals, incorporating a mixture of comprehensive, primary, telemedicine-enabled, and nonstroke designated centers	Evaluated the ambulance clinical triage for acute stroke treatment (ACT-FAST) severity-based triage algorithm to diagnose LVO; LVO defined as intracranial ICA, M1, and basilar artery occlusions, representing those generally regarded as eligible for EVT; and extended definitions not eligible for EVT	N=517; 54.4% were transported to a noncomprehensive stroke center, including 14.9% (77/517) patients transported to a rural or regional hospital; ACT-FAST positive in 32.5% (168/517) cases; hospital brain imaging data identified ICA/ M1/BA occlusion in 17.8% (92/517); sensitivity 82.6; specificity 77.9; PPV 44.7; NPV 95.4; AUC 0.802 (0.75 to 0.85); estimates also provided for extended definitions including comprehensive center needed (including LVO/ICH/tumor), etc	Scores determined triage, so there is work-up bias for patients sent to higher levels of care centers; investigators paid by pharma; attrition from those seen to those having assessments was not reported

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Vidale et al ⁴⁰ (2018)	III for Q1	Systematic review and meta-analysis of prospective/retrospective studies of out-of-hospital LVO scores published between January 1990 and September 2017	Fixed-effect and random-effects models quantify pooled estimates of accuracy for different scores; individual study quality was evaluated using Quality Assessment Diagnostic Accuracy Studies-2 (QUADAS-2)	19 LVO scoring systems from 13 studies: Cincinnati Prehospital Stroke Severity Scale (CPSSS), Recognition Of Stroke In the Emergency Room score (ROSIER), RACE, Acute Stroke Registry and Analysis of Lausanne (ASTRAL), modified NIHSS (mNIHSS), abbreviated NIHSS (aNIHSS), shortened NIHSS 5 items (sNIHSS 5), NIHSS-R, LAMS, PASS, 3I-SS, VAN, Lower extremity strength, Eyes/visual fields, Gaze deviation, Speech difficulty score (LEGS), Large Vessel Occlusion Scale (LVOS), Maria Prehospital Stroke Scale (MPSS), FAST-ED, G-FAST, and sNIHSS-EMS; VAN-positive had overall best accuracy with 100% sensitivity, 90% specificity, AUC 0.92; other instruments: sensitivity 60% to 95%; specificity 39% to 89%	Starts as design 2, but only 3 databases searched, they say that assessed quality of studies but QUADAS2 not described, no meta-analysis was performed because of $I^2 > 50\%$ (significant statistical heterogeneity), and the authors report risk of publication bias assessed by Funnel plot, although this was not detailed in methods, and despite heterogeneity, lump together different instruments using different outcomes in summary receiver operating characteristic curve with reporting of pooled positive LR and negative LR

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Duvekot et al ⁴¹ (2021)	III for Q1	Multicenter prospective observational cohort including 8 hospitals and 2 ambulance services in the southwest Netherlands	<p>The primary objective was to validate and quantitatively compare the accuracy of 8 out-of-hospital stroke scales for the diagnosis of LVO in persons with suspected stroke; inclusion criteria included at least one abnormality on the FAST test, age >18, normal glucose, and symptom onset <6 h prior; paramedics in the Netherlands are registered nurses with specialized education in emergency medicine, intensive care, or anesthesiology and prior to the study FAST was used routinely in suspected stroke. Prior to the study, paramedics received training on the study protocol and use of a mobile app to enter all components of each LVO decision instrument; 4 neuroradiologists and 3 interventional neuroradiologists determined the presence or absence of LVO from CTA; LVO defined by occlusion of ICA, M1 or M2 segment of MCA, A1 or A2 segment of ACA</p>	<p>Among 1,039 included patients, median age 72 y, 12% were diagnosed with LVO, and 25% with a stroke mimic; AUCs ranged from 0.72 for face-Arm-Speech-Time plus severe arm or leg motor deficit (FAST-PLUS) to 0.83 for RACE, but the clinician NIHSS was superior to all the out-of-hospital stroke scales AUC 0.86 (95% CI 0.83 to 0.89); among all the out-of-hospital stroke scales using the cutoff points originally described for each, RACE ≥ 5 demonstrated the highest combined sensitivity 67% (95% CI 58 to 75) and specificity 87% (95% CI 85 to 89); sensitivity analysis demonstrated no significant change in AUC when BA occlusions were included as LVO</p>	<p>EVT was performed only in 74% of patients with LVO, mostly because the LVO was undetected by the local radiologist</p>

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Helwig et al ⁴² (2019)	III for Q1	The prospective multicenter trial was randomized by week to either treatment by EMS using the LAMS [OPM group] or an MSU in Germany	The primary outcome was the proportion of patients with an LVO or ICH that were accurately triaged to a comprehensive stroke center capable of endovascular therapy	The trial was terminated at interim analysis after 116 patients of the planned 232 patients had been enrolled, including 53 patients in the OPM group and 63 patients in the MSU group; the triage decision was accurate for 37 of 53 patients (69.8%) in the OPM group and for 63 of 63 patients (100%) in the MSU group (difference, 30.2%; 95% CI 17.8% to 42.5%; $P < .001$)	Patients were not randomized individually; the trial was terminated early based on the primary outcome, which may have led to missed differences in secondary outcomes; CTA from the MSU was used to diagnose LVO; therefore, confirmation bias of LVO in the MSU group leading to the 100% sensitivity
Lima et al ¹⁹ (2016)	III for Q1	Prospective cohort study at 2 university-based hospitals in Brazil	Evaluated FAST-ED scale to predict LVOS used to triage out-of-hospital patients to endovascular capable centers; noncontrast computed tomography scans and CTA were obtained in all patients suspected of having an ischemic stroke (stroke, transient ischemic attack, or stroke mimics) in the first 24 h of symptom onset; patients with unilateral acute complete symptomatic occlusion of the intracranial ICA, M1, and M2 segments of the MCA, and BA were selected and compared with patients without a proximal intracranial occlusion	$N=727$; LVO rate 33%; FAST-ED had comparable accuracy in predicting LVO to the NIHSS and higher accuracy than RACE and CPSS (AUROC: FAST-ED=0.81 as a reference; NIHSS=0.80, $P=.28$; RACE=0.77, $P=.02$; and CPSS=0.75, $P=.002$); A FAST-ED ≥ 4 had a sensitivity of 0.60, specificity of 0.89, PPV of 0.72, and NPV of 0.82 versus RACE ≥ 5 of 0.55, 0.87, 0.68, and 0.79, and CPSS ≥ 2 of 0.56, 0.85, 0.65, and 0.78, respectively	Patients with symptomatic bilateral and anterior plus posterior circulation occlusions were excluded from the analysis; subjects with equivocal occlusion scores were excluded from the analysis; authorship disclosures with imaging and pharmaceutical companies related to the research; strength is all patients underwent imaging, including mimics; readers were blinded to results and adjudicated scores when required

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Pérez de la Ossa et al ²² (2014)	III for Q1	Combination of retrospective derivation and prospective validation of the RACE score performed in Spain	Retrospective derivation of the RACE scale assessed various components of the NIHSS for their highest level of association in predicting LVO as diagnosed by transcranial Doppler, MRI, or CTA; prospective validation was performed in patients in whom a “code stroke” was activated either by EMS or at a community hospital	In the retrospective cohort of 654 patients, the RACE scale was calculated based on NIHSS at admission and showed a similar predictive value compared with the NIHSS for detecting LVO (AUC 0.81 versus 0.80); the correlation between RACE and NIHSS scores was 0.93 ($P<.001$); the best predictive value of RACE was established as ≥ 5 ; this cutoff value showed sensitivity 0.85, specificity 0.68, PPV 0.42, and NPV 0.94 for detecting LVO	It is not surprising that the RACE scale had a good correlation with NIHSS given that it was derived from the NIHSS; in the validation study, 40% of the patients who were “code strokes” were not enrolled; furthermore, among patients who were enrolled stroke severity was higher increasing concerns about the effects of spectrum bias on the diagnostic accuracy; neither sensitivity nor specificity was particularly high
Demeestere et al ⁴³ (2017)	III for Q1	Retrospective cohort study; single academic institution in Australia and a comprehensive stroke center	Consecutive patients for whom the stroke team was activated by EMS and assessed by the stroke team on arrival from 2012 to 2016; retrospective assessment of the NIHSS and neuro-imaging; outcome=LVO	N=551: N=381 confirmed ischemic stroke, N=136 with LVO; National Institutes of Health Stroke Scale-8 (NIHSS-8) had an area under AUROC of 0.82 for LVO; NIHSS-8 with a cutoff of 8 or more had sensitivity=81% and specificity=75%	Limited by retrospective assessment, although NIHSS-8 was applied prospectively; single center in an established system that may limit generalizability; need for external validation

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Gropen et al ⁴⁴ (2019)	III for Q1	Single-center prospective cohort: 1 academic hospital and 3 EMS organizations in Birmingham, Alabama	The objective was to develop and quantify the diagnostic accuracy and reliability of the EMSA; staff (24) training is a 7.5-minute EMSA video, 18-minute stroke review video, and 20-question examination; staff then guided on-scene EMS using a scripted EMSA card; vascular neurologist reviewed communication center-EMS interactions and provided feedback; LVO determined by CTA/MRA if occlusion of ICA/M1/BA occlusion, determined by a vascular neurologist blinded to out-of-hospital data; excluded patients w/missing recorded EMSA or vascular imaging	891 EMS professionals received EMSA training; from September 2016 to February 2018, 463 eligible stroke patients were analyzed; mean age of 63 y and 56% non-White; LVO in 9.6% (45) of whom 46.7% (21) had MT; Number Needed to Screen of 22 to identify one suspected stroke patient who will undergo MT (21/463). EMSA ≥ 4 , sensitivity 76%, specificity 62%, positive LR 2.0, negative LR 0.40 for LVO in initial 9 mo; NIHSS ≥ 6 sensitivity 89%, specificity 42%, positive LR 1.5 and negative LR 0.3 for LVO; NIHSS ≥ 10 , sensitivity 69%, specificity 65%, positive LR 2.0, and negative LR 0.50 for LVO	Starts as design 1, but 24 EMS professionals performed the EMSA, and no reliability assessment between the EMS professionals, no adjustment for correlation of outcome by the EMS professional, and variable diagnostic studies were used to make a criterion standard diagnosis, including transient ischemic attacks which could have LVO, single center.

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Hoglund et al ⁴⁵ (2020)	III for Q1	Single center, urban, academic prospective cohort study	Adult patients with possible arterial ischemic stroke and LKWT <4.5 hours; treating emergency physician assessed FANG-D score, and some patients had multiple assessments to assess interrater reliability; outcome=anterior circulation LVO (ICA, M1, or M2) per CTA interpreted by treating radiologist	Of 640 eligible patients, 23% were excluded because of missing FANG-D score or imaging; N=491 patients included in the analysis with 608 assessments; 51/491 patients had anterior circulation large vessel occlusion (ACLVO) (64/608 assessments). FANG-D had a sensitivity 91% (95% CI 81% to 96%) and specificity 35% (95% CI 31% to 39%) for anterior LVO; FANG-D Fleiss' kappa was 0.77 (95% CI 0.64 to 0.88) with hemiparesis demonstrating the highest agreement (Fleiss' kappa 0.78) and neglected the lowest agreement (Fleiss' kappa 0.63)	The analysis did not appropriately account for multiple assessments per patient, resulting in overly precise estimates of sensitivity and specificity; an industry-funded study

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Mayasi et al ⁴⁶ (2018)	III for Q1	Retrospective cohort, single academic center stroke registry in Worcester, Massachusetts	Objective was to quantify whether leukoaraiosis severity affects the diagnostic accuracy of out-of-hospital stroke scales; LVO determined by CTA/MRA by a neuroradiologist w/ICA/M1/M2/BA occlusion; leukoaraiosis was defined as MRI supratentorial white matter FLAIR hyperintensity lesions; degree of leukoaraiosis dichotomized according to the median Fazekas scale score 0 to 2 (absent to mild) or 3 to 6 (moderate to severe); multivariable logistic regression to determine whether individual scales identified LVO independent of leukoaraiosis	Between January 2013 and January 2014; 274 consecutive patients, mean age 69; NIHSS 5, 48% absent-to-mild Fazekas (65% in LVO versus 43% in no LVO); absent-mild Fazekas increased sensitivity of 3I-SS/VAN/RACE but decreased CPSS and FAST-ED unchanged; specificity VAN/CPSS/RACE/FAST-ED increase; specificity 3I-SS decreased; moderate-to-severe Fazekas increased sensitivity of 3I-SS and CPSS, but decreased sensitivity of other tools; specificity decreased for every tool except 3I-SS; FAST-ED and RACE predict LVO independent of leukoaraiosis	Starts as design 2 because the scales are retrospectively calculated, no description of abstraction methods as to who did it or whether they were blinded to the radiology reads, single center, unique MRI predictor of LVO, and only 46 had LVO

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Richards et al ⁴⁷ (2018)	III for Q1	Secondary analysis of an AIS registry: single academic institution	Consecutive patients with a diagnosis of AIS from August 2012 to April 2014; retrospective assessment of the CPSS: outcome=LVO	N=138; N=59 with LVO; CPSS cutoff of 3 resulted in sensitivity=41% and specificity=88%	Limited by retrospective assessment, although CPSS was applied prospectively; single center in an established system that may limit generalizability; need for external validation

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Marks et al ⁵¹ (2014)	III for Q2	Secondary analysis of a prospective study, Diffusion and Perfusion Imaging Evaluation for Understanding Stroke Evolution 2 study (DEFUSE 2)	Prospective patient identification and inclusion from 2008 to 2011; outcome=reperfusion, infarct growth, and mRS at 90 d	N=60; collateral score correlated with NIHSS ($P=.002$)	Small sample; limited by secondary analysis of the existing data set, although collateral score was applied in a blinded fashion; limited methodological detail
Campbell et al ⁵⁰ (2015)	III for Q2	This was a randomized trial comparing endovascular therapy plus alteplase to alteplase alone among stroke patients with LVO and perfusion mismatch on CT perfusion scanning; the study was performed in New Zealand and Australia	Patients were enrolled if they had anterior circulation strokes within 4.5 h of symptom onset with LVO of the carotid or first or second segments of the middle cerebral artery; they also needed to have evidence of perfusion mismatch on CT perfusion imaging	From August 2012 through October 2014, a total of 70 patients underwent randomization (35 to the endovascular-therapy group and 35 to the alteplase-only group) at 10 study centers; 25% of clinically eligible patients with vessel occlusion were excluded on the basis of perfusion imaging criteria; endovascular therapy led to greater early neurologic recovery at 3 d ($P=.002$) and improved functional outcome in an ordinal analysis of the score on the mRS at 90 d (generalized OR 2.0, 95% CI 1.2 to 3.8; $P=.006$)	This study did not compare the addition of perfusion imaging without the addition of perfusion imaging for risk stratification; the primary purpose of the study was comparing EVT to alteplase alone; all patients had to have evidence of perfusion mismatching; 25% of patients were excluded because of the absence of perfusion mismatch

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Nogueira et al ⁵² (2018)	III for Q2	Multicenter randomized open-label trial with blinded outcomes: September 2014 to February 2017	AIS Patients because of anterior LVO symptom onset 6 to 24; NIHSS >10 and ischemic volume <21 ml if >80 y; <31 ml if <80 y; OR NIHSS >20, <80 y, and ischemic volume 31 to 51 ml; do patients with a mismatch between clinical deficit and infarct by perfusion benefit from endovascular therapy versus standard therapy	206 patients. mRS 0 to 2 at 90 Å— 49% versus 13%; mortality 19% versus 18%; sICH 6% versus 3%	Starts as design 1, but there is no group that had the ICA or M1 occlusion on CTA but no mismatch that underwent MT (What happens if you just use the CTA findings? How many patients no longer qualify by calculating the infarct volume, and how many of those patients had they received MT would have been harmed or improved?) 43 outcomes were done through phone, not in-person, and industry sponsored, indirectly applicable. Trial stopped early because of interim analysis showing efficacy

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Campbell et al ⁵⁵ (2018)	II for Q3	Multicenter RCT	Adult patients with acute stroke, LKWT <4.5 hours, LVO, and candidates for thrombectomy arms: tenecteplase (0.25 mg/kg) versus alteplase (0.9 mg/kg) primary outcome: reperfusion of >50% of ischemic territory or absence of retrievable thrombus; secondary outcomes: sICH, mRS at 90 d, death at 90 d	N=202 (tenecteplase 101); primary outcome: 22% for tenecteplase versus 10% for alteplase (adjusted OR 2.6, 95% CI 1.1 to 5.9); secondary outcomes: median mRS 2 for tenecteplase versus 3 for alteplase, common OR 1.7 (95% CI 1.0 to 2.8); sICH 1% in both groups	Open label, received industry funding
Logallo et al ⁵⁶ (2017)	II for Q3	RCT, phase 3; multicenter, 13 institutions	Prospective enrollment of adult patients eligible for systemic thrombolysis after clinical diagnosis of AIS within 4.5 h of symptom onset or who were eligible for bridging therapy prior to thrombectomy; allocated to either 0.4 mg/kg tenecteplase or 0.9 mg/kg alteplase; outcome=mRS of 0 to 1 at 3 mo	N=1,100; primary outcome achieved in 64% of those allocated to tenecteplase and 63% of those allocated to alteplase ($P=.52$); 3-month mortality the same in both groups (5% for both groups); SAEs occurred in similar proportions (26% for both groups) ($P=.74$)	Multiple centers extended generalizability; open label, which may have introduced treatment bias

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Menon et al ⁵⁷ (2022)	III for Q3	Multicenter RCT, phase 3 trial: 22 primary and comprehensive stroke centers in Canada	Adult patients ≥ 18 y with an acute ischemic stroke within 4.5 hours of symptoms onset that qualified for thrombolytics; patients were randomized to receive 0.9 mg/kg alteplase or 0.25 mg/kg tenecteplase; primary outcome: mRS 0 to 1 at 90 to 120 d; secondary outcomes: sICH at 24 hours, mRS at 90 d	N=1,577 (tenecteplase 806); primary outcome: mRS 0 to 1 in 36.9% for tenecteplase and 34.8% for alteplase (unadjusted risk difference 2.1% [95% CI – 2.6 to 6.9]); no difference in sICH at 24 h (3.4% tenecteplase versus 3.2% alteplase) or death at 90 h (15.3% tenecteplase versus 15.4% alteplase)	Open label: noninferiority trial
Parsons et al ⁵⁸ (2012)	III for Q3	Randomized trial, radiological, and clinical outcome assessments were blinded to intervention	The objective was to compare the standard dose of alteplase with 0.1 or 0.25 mg/kg tenecteplase, <6 h LKWT and use CT perfusion to select patients most likely to benefit from LVO and large perfusion lesion in the absence of large infarct core (perfusion lesion >20% of infarct core, infarct-core lesion had to be <1/3 of MCA territory or <1/2 of ACA or posterior cerebral artery); compared 0.1 or 0.25 mg/kg; primary outcome: proportion reperfused at 24 hours (on MRI) and extent of clinical improvement in 24 hours	The 3 treatment groups had 25 patients a mean NIHSS of 14.4 \pm 2.6 and time to treatment was 2.9 \pm 0.8 and 2 tenecteplase groups, higher tenecteplase (0.25 mg/kg) was superior to lower dose and to alteplase for absence of serious disability at 90 d (72% versus 40%); dose-response identified with higher tenecteplase dose being superior to lower tenecteplase and alteplase for all imaging and clinical efficacy outcomes; reperfusion at 24 h (79% tenecteplase versus 55% alteplase, $P=.004$), improvement in NIHSS in 24 h (8 versus 3, tenecteplase versus alteplase, $P<.001$); no change in ICH or death	Starts as design 1, but a highly selected study population with perfusion mismatch, small sample sizes in groups of 25 each, 3 Australian centers, treating physician not blinded, endpoints modified during trial, and slight imbalance in diabetes and smoking status; phase 2b trial

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Huang et al ⁵⁹ (2015)	III for Q3	RCT, phase 2: single academic center	Prospective enrollment of adult patients eligible for systemic thrombolysis after clinical diagnosis of AIS within 4.5 h of symptom onset; allocated to either 0.25 mg/kg tenecteplase or 0.9 mg/kg alteplase; outcome=% penumbra salvaged at 24 to 48 hours	N=104; 71 contributed to the primary endpoint, 35 from the tenecteplase group, and 36 from the alteplase group; no difference in endpoint between groups, 68% for both ($P=.8$)	Single-center limits generalizability; open label, which may have introduced treatment bias; per protocol analysis, not intention-to-treat; only 68% of the enrolled cohort contributed to the primary endpoint, which may have introduced selection bias
Bivard et al ⁶⁰ (2022)	III for Q3	Prehospital RCT, phase 2 trial	Adult patients ≥ 18 y with an acute ischemic stroke within 4.5 hours of symptom onset that qualified for thrombolytics; patients were randomized to receive 0.9 mg/kg (maximum 90 mg) alteplase or 0.25 mg/kg (maximum 25 mg) tenecteplase; primary outcome: the volume of perfusion lesion at receiving hospital. Secondary outcome: sICH at 36 h and death at 90 d	N=104 (tenecteplase 55); primary outcome: perfusion lesion volume smaller with tenecteplase versus alteplase (12 ml vs 35 ml, adjusted incidence ratio 0.55, 95% CI 0.37 to 0.81); death at 90 d: 9% for tenecteplase and 10% for alteplase; no difference in sICH	Open label; noninferiority trial; utilized a prehospital MSU to evaluate and give thrombolytics

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Kvistad et al ⁶¹ (2022)	III for Q3	Multicenter RCT, phase 3 trial	Adult patients ≥ 18 y with an acute ischemic stroke within 4.5 hours of symptoms onset that qualified for thrombolytics; patients were randomized to receive 0.9 mg/kg (maximum 90 mg) alteplase or 0.4 mg/kg (maximum 40 mg) tenecteplase; primary outcome: mRS 0 to 1 at 90 d; secondary outcomes: any ICH and 3-month mortality	N=204 (tenecteplase 100); primary outcome: 32% tenecteplase versus 51% alteplase OR 0.45 (95% CI 0.25 to 0.80); secondary outcomes: any ICH was higher in tenecteplase versus alteplase (21% versus 7%, OR 3.68, 95% CI 1.49 to 9.11), 3-month mortality higher with tenecteplase (16% versus 5%, 3.56, 95% CI 1.24 to 10.21)	Open label; noninferiority trial, stopped early because of prespecified safety criteria
Kvistad et al ⁶² (2019)	III for Q3	The study design is a post-hoc analysis of NOR-TEST of moderate (NIHSS 6–14) and severe (NIHSS ≥ 15)	The objective was to assess the safety and efficacy of tenecteplase 0.4mg/kg versus 0.9 mg/kg alteplase with moderate and severe ischemic stroke; outcomes: favorable outcome (mRS 0 to 1 at 90 days, clinical improvement 7 d), sICH, death (7 and 90 d)	In 261 moderate stroke patients (123 tenecteplase versus 138 alteplase) no difference in outcome, sICH, or death, and in 87 severe stroke (40 tenecteplase versus 47 alteplase), no differences in outcome sICH or 7-d mortality but 90-d all-cause mortality increased in tenecteplase 26.3% (10) versus 9.1% (4)	Starts as design 2, while the patients are taken from an RCT, this is a subgroup analysis of patients identified retrospectively specifically with moderate and severe stroke, also open label; unclear if powered to detect a difference in only 87 severe patients or even in 261 severe patients

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Rønning et al ⁶³ (2019)	III for Q3	Prespecified secondary analysis of the NOR-TEST; multicenter randomized trial comparing tenecteplase to alteplase in patients with acute ischemic stroke arriving within 4.5 h of symptom onset	This substudy only included a subset of patients arriving between 3 to 4.5 h of onset time from the larger trial of all patients arriving within 4.5 h of symptom onset; outcomes were the proportion of patients with a mRS of 0 to 1 at 3 mo	194 patients were treated between 3 and 4.5 hours of which 105 were randomized to tenecteplase and 89 to alteplase; the median NIHSS was 3 in both treatment groups at admission, and in total 66 % had an NIHSS score of 0 to 4; 60 (57%) of 105 patients that received tenecteplase and 47 (53%) of 89 patients that received alteplase reached good clinical outcome (mRS score of 0 to 1) at 3 mo (OR 1.19, 95% CI 0.68 to 2.10); the rates of any ICH within 48 hours were 5.7% in the tenecteplase group and 6.7% in the alteplase group (OR 0.84, 95% CI 0.26 to 2.70); there were 7 with sICH, 5 (4.8%) in the tenecteplase group and 2 (2.2%) in the alteplase group	Secondary analysis of another study: power and randomization were not performed based on the population included in this study because it is a secondary analysis; no differences in outcomes were found, but the study was not designed at the outset as a noninferiority trial

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Thommessen et al ⁶⁴ (2020)	III for Q3	Multicenter RCT	Adult patients ≥80 y with acute stroke and LKWT <4.5 hours; arms: tenecteplase (0.4 mg/kg) versus alteplase (0.9 mg/kg); primary outcome: mRS 0 to 1 at 90 d; secondary outcomes: sICH, mRS at 90 d, MNI at 24 h, death at 90 d	N=273 (tenecteplase 130); primary outcome: favorable neurologic outcome 43% for tenecteplase versus 40% for alteplase (OR 1.14, 95% CI 0.70 to 1.9); no significant differences in secondary outcomes	Post-hoc subgroup analysis and not powered to test superiority; open label
Burgos et al ⁶⁵ (2019)	II for Q3	Meta-Analysis	The objective of the study was to perform a formal noninferiority meta-analysis of tenecteplase as an alternative to alteplase with AIS and no major intracranial occlusion; compared tenecteplase (0.1, 0.25, 0.4 mg/kg) versus alteplase (0.9 mg/kg); primary outcome: mRS 0 to 1 at 3 mo (noninferiority); secondary outcomes: ICH and death (noninferiority)	1,585 patients (5 studies); tenecteplase was noninferior to alteplase in mRS 0 to 1; noninferior to safety; baseline NIHSS mean=7; alteplase received 0.9 mg/kg; tenecteplase varied from 0.1 mg/kg (6.8%), 0.25 mg/kg (24.6%), 0.4 mg/kg (68.6%); crude effect for 3 mo mRS 0 to 1 was 57.9% versus 55.4%; risk difference random effects was 4% (-1 to 8%), which was within the prespecified noninferiority margin (set at -6.5%) and for mRS 0 to 2 it was tenecteplase 71.9% versus alteplase 70.5%, for risk difference 2% (-3-6%) and the mRS shift analysis common OR 1.21 (95% CI 0.93 to 1.57); random-effects model used; safety end points were also consistent with noninferiority	Inclusion criteria are limited between January 2005 and August 2018 (nothing about language and only PubMed), and the treatment had to be administered up to 6 h of LKWT; does not state that 2 investigators conducted the search, heterogeneity is described only for modification of the treatment effect by TNKtenecteplase dose; the NOR-TEST study has 1,100/1,585 patients or 69% of the subjects

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Xu et al ⁶⁶ (2018)	II for Q3	Meta-analysis and systematic review assessing thrombolysis with tenecteplase to alteplase in acute ischemic stroke	MEDLINE, Embase, and Cochrane Library were searched for RCT comparing tenecteplase to alteplase in acute ischemic stroke between January 2001 to April 2018	Out of 513 titles and abstracts initially identified 4 RCTs, with 1,390 patients, were included in the final analysis; tenecteplase showed a neutral effect on excellent functional outcome (58.7 versus 55.6% for tenecteplase vs alteplase; RR 1.04; 95% CI 0.96 to 1.14; <i>P</i> =.31) and good functional outcome (70.8 versus 68.6% for tenecteplase vs alteplase; RR 1.16; 95% CI 0.89 to 1.53; <i>P</i> =.275); tenecteplase showed a significantly early neurologic improvement at 24 h (40.6 versus 33.9% for tenecteplase vs alteplase; RR 1.52; 95% CI 1.03 to 2.25; <i>P</i> =.035) compared with alteplase; in addition, tenecteplase showed a neutral effect on recanalization within 24 h or 24 to 48 h (61.8% versus 54.9% for tenecteplase vs alteplase; RR 1.26; 95% CI 0.53 to 3.01; <i>P</i> =.3); no significant differences in other safety outcomes were demonstrated	The main issues with the results from the meta-analysis are that at least 1 of the included trials included a high risk of bias associated with allocation concealment; 2 included high risk of bias associated with blinding of outcomes assessment

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Thelengana et al ⁶⁷ (2018)	II for Q3	Meta-Analysis of 1,344 patients from 4 RCT: Australian tenecteplase, NOR-TEST, TNK-S2B, ATTEST	The objective of the study was to investigate whether tenecteplase is superior to alteplase for efficacy and safety outcomes for AIS; outcomes: early 24-h improvement with NIHSS ≥ 8 , mRS 0 to 1 at 90 d, mRS 0 to 2 at 90 d, any ICH, sICH, and death; Cochrane risk of bias tool used. If $I^2 > 50\%$, the random-effects model used but otherwise fixed effects model: heterogeneity between inclusion and exclusion criteria	RR for early neuro improvement 1.56 (95% CI 1.0 to 2.43), no difference in mRS 0 to 1, RR 1.06 (95% CI 0.97 to 1.16) or mRS 0 to 2, RR 1.18 (85% CI 0.86 to 1.61); no difference in any ICH RR 0.84 (95% CI 0.61 to 1.15) or sICH RR 1.07 (95% CI 0.6 to 1.93) or death RR 1.03 (95% CI 0.69 to 1.52) at 90 d; sensitivity analysis removed Logallo and favored early neuro improvement RR 1.93 (95% CI 1.32 to 2.81)	Starts as design 1, sensitivity analysis consisted of removing the Logallo study, and they say they accounted for heterogeneity by using random-effects modeling, and again disproportionate number coming from the 1,100 Logallo patients

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Huang et al ⁶⁸ (2016)	III for Q3	Meta-analysis using both summary and individual patient data from randomized studies to examine current evidence for the efficacy and safety of tenecteplase compared with alteplase	Primary outcome mRS 0 to 1 at 3 mo (excellent outcome); secondary outcomes included good outcome (mRS 0 to 2 at 3 mo); all analyses were performed on an intention-to-treat basis, including all randomized patients; group-level meta-analysis using the DerSimonian–Laird test and the Breslow–Day test to evaluate heterogeneity between studies with I^2 for inconsistency; random-effects models were undertaken to account for study heterogeneity; outcomes were expressed as ORs and their 95% CIs	N=3 studies for inclusion having a total of 291 patients; 108 patients were allocated to 0.25 mg/kg tenecteplase, 56 patients to 0.1 mg/kg tenecteplase, and 19 patients to 0.4 mg/kg tenecteplase, and 108 patients to alteplase; the 0.25 mg/kg tenecteplase group showed significantly greater odds of early neurologic improvement at 24 h (OR 3.4, 95% CI 1.6 to 7.4, $P=.002$) compared with alteplase; no significant differences in other efficacy or safety outcomes were demonstrated; no significant heterogeneity was detected among studies; no significant differences were found in any outcome between 0.1 mg/kg tenecteplase and alteplase-treated patients; only 19 patients received tenecteplase 0.4 mg/kg, and outcomes did not differ from alteplase	Limited search terms were used to identify papers; selection criteria were not well developed nor explained; no specification of number of investigators selecting/screening articles; quality of studies was not assessed; no sensitivity analyses were done

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Kheiri et al ⁶⁹ (2018)	III for Q3	Meta-analysis of RCTs	Efficacy outcomes included early neurologic improvement, defined as ≥ 4 points reduction in the NIHSS; calculated summary ORs and 95% CIs using the Mantel–Haenszel method for dichotomous data; used a random-effects model to account for the between-study heterogeneity and measured the heterogeneity using the Cochrane’s Q statistic and I^2 statistic test; sensitivity analyses were performed by removing trials sequentially and based on study design (single/multiple centers, phase 2/3 trials, double-blinded/open-label trials, timing of symptom onset to thrombolysis); meta-regression analyses were conducted based on the study-level covariates (age and baseline NIHSS scores)	N=5 RCTs with 1,585 patients, of whom 828 received tenecteplase and 757 received alteplase; there was a significant increase in complete recanalization of the occluded vascular territory in the tenecteplase-treated patients (30% versus 15%; OR 2.01, 95% CI 1.04 to 3.87; $P=.04$; $I^2=0\%$); although statistically nonsignificant, there was an increased rate of complete/partial recanalization with tenecteplase (54% versus 41%; OR 1.51, 95% CI 0.70 to 3.26; $P=.30$; $I^2=50\%$); significant increase in early neurological improvement with tenecteplase-treated patients compared with the alteplase group (45% versus 41%; OR 1.43, 95% CI 1.01 to 2.03; $P=.05$; $I^2=34\%$); sensitivity analysis showed no heterogeneity after removing one RCT that allowed up to 6 h from stroke onset to the start of treatment ($I^2=0\%$), but with the loss of a statistically significant result ($P=.10$); network meta-analysis showed trend towards worse outcomes with advanced age ($R^2=76\%$; $b=-0.38$; $SE=0.25$; $P=.13$)	Search terms seem cursory, no librarian assisted with the strategy; some trials were industry sponsored; treatment times varied from 3 to 4.5 hours; most trials (N=4) were open-label; 1 prematurely terminated trial was double-blinded

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Zhang et al ⁷⁰ (2016)	III for Q3	Systematic review and meta-analysis	Inclusion of participants included prospectively in controlled clinical trials; standardized extraction with random effects modeling to account for study heterogeneity; outcome = MNI defined by an improvement in NIHSS of 8 or more points	N=6 studies; N=497 patients; N=276 received tenecteplase 0.25mg/kg tenecteplase had better MNI than 0.1mg/kg tenecteplase ($P=.005$); tenecteplase has better MNI than alteplase ($P=.02$) with decreased parenchymal hematoma ($P=.009$)	Comprehensive search; quality of evidence assessment; significant heterogeneity across studies but random effects modeling to account for study heterogeneity; sensitivity analysis to account for study quality and to evaluate influence of each individual study
Bivard et al ⁷¹ (2017)	III for Q3	Secondary analysis of 2 RCT (Australia-TNK and ATTEST); Australia-TNK included 3 sites; ATTEST included 1 site	Prospective enrollment of adult patients eligible for thrombolysis after clinical diagnosis of AIS within 4.5 h for ATTEST and 6 h for Australia-TNK from onset of symptoms; pooled analysis of patients receiving 0.25mg/kg tenecteplase versus 0.9 mg/kg alteplase; outcome=change in NIHSS	N=146 (96 from ATTEST and 50 from Australia-tenecteplase); 71 received alteplase 74 received tenecteplase; those who received tenecteplase had improved earlier outcomes vs alteplase ($P=.02$) with less ICH ($P=.02$); both groups had similar long-term mRS ($P=.1$)	Trials were open label; secondary analysis, pooling, and post hoc assessments; generalizability extended given pooling of 2 trials with different population characteristics

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Katsanos et al ⁷² (2021)	III for Q3	Meta-analysis and systematic review assessing thrombolysis with tenecteplase to alteplase in acute ischemic stroke in patients with large vessel occlusion	Searched MEDLINE and Scopus for RCT in patients with acute ischemic stroke with confirmed LVO; primary outcome was mRS of 0 to 2 at 3 mo	4 RCT including a total of 433 patients; patients with confirmed LVO receiving tenecteplase had higher odds of mRS of 0 to 2 (OR 2.06 [95% CI 1.15 to 3.69]), successful recanalization (OR 3.05 [95% CI 1.73 to 5.40]), and functional improvement defined as 1-point decrease across all mRS (common OR 1.84 [95% CI 1.18 to 2.87]) at 3 mo compared with patients with confirmed LVO receiving alteplase; no difference in the outcomes of early neurological improvement, sICH, any intracranial hemorrhage, and the rates of mRS 0 to 1 or all-cause mortality at 3 mo was detected between patients with LVO receiving intravenous thrombolysis with either tenecteplase or alteplase	Only reviewed 2 possible sources for available literature; no description of the quality of the included studies; many studies include patients who received thrombectomy

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Kerber et al ⁸² (2015)	III for Q4	Prospective cohort study at 1 center in Michigan; the target population was patients presenting for acute dizziness without an obvious cause who also had examination findings (ie, nystagmus [spontaneous or gaze-evoked] or imbalance when walking) that could be attributable to neurologic dysfunction	Evaluated the ability of the combination of bedside predictors of stroke—including both the ABCD2 score and the specialized OM examination—to stratify stroke risk using an MRI-based industry standard; study examinations were performed before the MRI whenever possible or blinded to the results of the MRI; OM examination was performed including a nystagmus assessment, assessment of skew deviation, and the head impulse test; primary outcome was an imaging-based definition of stroke, specifically any acute infarction or ICH on MRI as determined by a neuroradiologist	N=320 patients; stroke rate 11%; in multivariable logistic regression models, ABCD2 OR 1.74 (95% CI 1.20 to 2.5); HINTS positive OR 2.82 (95% CI 0.96 to 8.30); false-negative frequency (ie, frequency of stroke in the lowest-risk categories) was as follows: ABCD2 <4, 5.1% (8/157); OM assessment, 5.9% (9/152) (4.9% [4/82], for HINTS peripheral findings); other CNS features, 7.8% (17/219); and prior stroke, 10.8% (28/260); the OM assessment was positive for a central lesion in 20 of the 29 stroke patients (69%); of the 9 stroke patients who did not have the central OM findings, 7 patients were in the no-nystagmus category (5) and/or had an acute infarction that was possibly incidental (3)	15% did not receive MRI within 14 d; physical examination was performed in a structured fashion by a study investigator, either a neurologist fellowship trained in neuro-otology or vascular neurology, or an emergency medicine physician fellowship trained in vascular neurology—not generalizable to the general EM professional population

Evidentiary Table. (continued)

Author & Year Published	Class of Evidence	Setting & Study Design	Methods & Outcome Measures	Results	Limitations & Comments
Ohle et al ⁸³ (2020)	III for Q4	Systematic review and meta-analysis	Inclusion of participants included prospectively; standardized extraction by independent reviewers	N=5 studies; N=617 patients; HINTS examination with sensitivity=97% and specificity=95% when performed by neurologists; HINTS examination with sensitivity=83% and specificity=44% when performed by emergency physicians and/or neurologists	Comprehensive search; quality of evidence assessment; random effects modeling to account for study heterogeneity; no sensitivity analyses

3I-SS, 3-Item Stroke Scale; *A1*, first segment anterior cerebral artery; *A2*, second segment anterior cerebral artery; *ABCD2*, age, blood pressure, clinical features, duration, diabetes; *ACA*, anterior cerebral artery; *ACT-FAST*, Ambulance Clinical Triage for Acute Stroke Treatment; *AIS*, acute ischemic stroke; *ATTEST*, Alteplase-Tenecteplase Trial Evaluation for Stroke Thrombolysis; *AUC*, area under the curve; *AUROC*, area under the receiver operating characteristics; *BA*, basilar artery; *CPSS*, Cincinnati Prehospital Stroke Severity; *CSC*, comprehensive stroke center; *CT*, computed tomography; *CTA*, computed tomography angiography; *d*, day; *ED*, emergency department; *EMS*, emergency medical service; *EMSA*, Emergency Medical Stroke Assessment; *EVT*, endovascular thrombectomy; *FANG-D*, field cut, aphasia, neglect, gaze preference, and dense hemiparesis; *FAST*, face-arm-speech test; *FAST-PLUS*, Face-Arm-Speech-Time plus severe arm or leg motor deficit; *FAST-ED*, Field Assessment Stroke Triage for Emergency Destination; *G-FAST*, gaze-face-arm-speech-time; *h*, hour; *HINTS*, Head Impulse-Nystagmus-Test of Skew; *ICA*, internal carotid artery; *ICH*, intracranial hemorrhage; *LAMS*, Los Angeles Motor Scale; *LKWT*, last known well time; *LVO*, large vessel occlusion; *M1*, first segment middle cerebral artery; *M2*, second segment middle cerebral artery; *MCA*, middle cerebral artery; *MNI*, major neurologic improvement; *mo*, month; *MRA*, magnetic resonance imaging; *mRS*, modified Rankin scale score; *MSU*, mobile stroke unit; *MT*, mechanical thrombectomy; *NOR-TEST*, Norwegian Tenecteplase Stroke Trial; *NPV*, negative predictive value; *OM*, ocular motor; *OPM*, optimize prehospital management; *PASS*, Prehospital Acute Stroke Severity Scale; *PPV*, positive predictive value; *RACE*, Rapid Arterial Occlusion Evaluation; *RCT*, randomized controlled trial; *RR*, relative risk; *sICH*, symptomatic intracerebral hemorrhage; *VAN*, Vision-Aphasia-Neglect; *y*, year.