

Review Article

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Clinical Practice Guideline for the Prehospital Stage in Acute Stroke : I.

Use of Emergency Medical Services Assessment Tools

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Abstract

Accurate and early identification of stroke and large vessel occlusion (LVO) in emergency settings is essential for improving patient outcomes and ensuring the efficient allocation of medical resources.

This clinical practice guideline systematically reviews domestic and international literature and conducts meta-analyses to evaluate the utility and diagnostic accuracy of stroke assessment tools used in prehospital emergency medical services (EMS). We developed a guideline based on evidence from systematic reviews and meta-analyses via a *de novo* process. A systematic literature review was conducted to evaluate the usefulness of diagnostic EMS assessment tools for diagnosing stroke and LVO. Overall, 70 non-randomized control studies were selected for this study. A meta-analysis was conducted with a subgroup analysis to distinguish between patients with stroke and those with LVO. EMS tools demonstrated high sensitivity but low specificity for diagnosing stroke. In the prehospital setting, using validated EMS stroke assessment tools is recommended for the early identification of stroke and LVO. Upon hospital arrival, stroke specialists should conduct further evaluation and triage to confirm the diagnosis and guide appropriate management. Delays in diagnosing LVO are frequently unacceptable. While experts advocate for the use of EMS assessment tools to facilitate early identification of LVO, these tools alone lack adequate sensitivity. Therefore, further diagnostic evaluations and consultation with stroke specialists upon hospital arrival are recommended.

Key Words : Stroke · Large vessel occlusion · Emergency medical service · Diagnostic tool · Guideline.

INTRODUCTION

Early identification of stroke in an emergency setting is crucial for improving patient outcomes. However, in real-world situations, first responders often face challenges in determining symptoms that strongly suggest stroke, especially when large vessel occlusion (LVO) is involved. Missing

critical cases can cause severe harm to patients. Moreover, even after arriving at the hospital, patients with stroke may need to be transferred to another treatment-capable center, causing significant delays in care.

Consequently, various emergency medical service (EMS) assessment tools have been developed to enhance the detection of stroke and LVO in prehospital settings. Additionally, numerous studies have evaluated the diagnostic accuracy of these tools; however, the results have been inconsistent.

Therefore, a systematic review and meta-analysis is essential to assess the validity of these tools and determine whether they should be recommended for use in identifying stroke and LVO in emergency settings.

In Korea, emergency department overcrowding has become a major social issue, particularly in tertiary hospitals. These circumstances cause patients with mild stroke to be triaged alongside severe cases, contributing to treatment delays for the more critical cases. This highlights a gap in the allocation of medical resources. Ideally, suspected severe stroke cases should be transported directly to stroke centers, while non-urgent patients should be directed to regional hospitals. In cases of acute cerebral infarction with LVO, timely thrombolysis and mechanical thrombectomy are essential for effective treatment. Recent studies have actively explored the mothership and drip-and-ship models^{10,17}). According to our meta-analysis, direct transport to a thrombectomy-capable hospital has been associated with improved functional outcomes. As the rapid identification of LVO becomes increasingly critical and important, the diagnostic accuracy of EMS assessment tools for detecting LVO has been reported. However, owing to the lack of meta-analyses and formal guidelines on the diagnostic accuracy of these tools, further research is warranted.

Through this guideline, we aimed to promote education and awareness among the public, emergency responders, and healthcare professionals, thereby facilitating appropriate resource allocation and clinical decision making. This study provides a practical and evidence-based guideline tailored to various clinical and regional settings in Korea. Particularly, we sought to establish a national protocol that would be continuously updated in accordance with the emerging evidence and changes in

healthcare delivery systems by systematically reviewing the current literature and incorporating expert consensus.

MATERIALS AND METHODS

Clinical practice guideline development process

Two key questions were established, and two recommendations were derived. For areas where recommendations could not be drawn, a systematic review was conducted to summarize the findings. Continuous revisions and further guideline development will be performed in subsequent phases. We reported this guideline in accordance with Institutional Review Board approval (UC24ZISE0069), and the requirement for informed consent was waived. Further details of the participating members and progress in developing this guideline are provided in Supplementary Material 1.

Rationale for developing the guideline process

Stroke treatment is categorized into the following three phases: prehospital care, hospital treatment, and post-treatment management. Most of the previously established Korean guidelines have focused on hospital-based treatment, and many were created by modifying or adapting existing international guidelines. In healthcare systems, overcrowded emergency rooms have a risk of delayed intervention for patients with stroke and LVO. Consequently, rapid triage—particularly the prompt recognition of suspected stroke at first medical contact—and immediate transfer to a designated stroke center are critical. We propose a set of prehospital guidelines that evaluate the initial diagnostic accuracy and feasibility of stroke assessment tools in emergency settings.

Selection of key questions

The selection of key questions for the clinical practice guideline topic began with a survey conducted among all members of the society. Following the survey and the collection of topics by the working committee, two rounds of meetings among the development committee members were held to finalize

the key questions. The key questions for each recommendation were formulated on the basis of the Population, Intervention, Comparison, Outcome (PICO) framework, and a systematic literature search was conducted accordingly. Our key questions were as follows: Early and appropriate intervention is critical in managing stroke; thus, using validated EMS assessment tools is recommended to facilitate the early identification of patients with stroke and support timely and appropriate treatment decisions.

1) Is the use of EMS diagnostic tools for stroke assessment at the prehospital stage beneficial in emergency situations? 2) Is the use of EMS diagnostic tools for LVO assessment at the prehospital stage beneficial in emergency situations? We evaluated the effectiveness of the EMS assessment tools in undiagnosed emergency patients before hospital arrival. The final diagnosis was confirmed after hospital admission. The intervention group comprised patients assessed using the EMS assessment tools, whereas the control group included those who were not assessed with the EMS assessment tools. The outcomes were as follows: diagnostic accuracy of the final stroke diagnosis, including sensitivity and specificity; and diagnostic performance for identifying LVO, which was assessed using sensitivity and specificity. A summary of each key question and its corresponding recommendation is provided in Table 1.

Literature search and selection

The literature search was conducted through discussions between methodology experts and the development committee members. An initial set of search terms was formulated, and a search strategy was established accordingly. Based on this strategy, searches were conducted across the following four major databases: MEDLINE (PubMed), Embase, Cochrane Library, and KoreaMed. The search was performed on November 11, 2024. The detailed search strategy is provided in Supplementary Material 1.

Relevant studies were selected separately for each key question, with three development committee members assigned depending on the volume of literature available for each topic. Duplicate exclusion and literature selection followed the Preferred Reporting Items for Systematic Reviews and Meta-

Analyses flowchart (Fig 1). The inclusion and exclusion criteria for each key question were formulated and applied on the basis of the PICO framework.

Publication and future updates of the clinical practice guideline

This clinical practice guideline will be published in medical journals affiliated with the Korean Neurological Society, Korean Society of Emergency Medicine, Korean Society of Cerebrovascular Surgeons, and Korean NeuroEndovascular Society (KoNES). Additionally, it will be made publicly available on the society's official website, Instagram, and other online platforms, ensuring that physicians, healthcare professionals, and the public can easily download and access the guideline. Furthermore, the guideline will be registered on the official website of KoNES for promotional purposes. A summary booklet will also be produced and actively distributed at future academic conferences and events.

The KoNES Academic Committee and the Clinical Practice Guideline Committee will continue to monitor research findings in specific areas, including early diagnosis and transfer of emergency patients with stroke and treatment selection for subarachnoid hemorrhage. Additionally, the committee will track updates from international clinical guidelines. If new research accumulates, warranting additions or modifications to the recommendations, a Clinical Guideline Revision Committee under the society will be formed to revise the guideline every 5 years.

RESULTS

We searched the literature to identify articles evaluating the usefulness of the diagnostic tools for distinguishing stroke at the prehospital stage. Ultimately, 70 articles were selected for this study. Of these, 15 publications focused on stroke as the final diagnosis, and 55 were specific to LVO. Most studies were highly heterogeneous. A meta-analysis was conducted with a subgroup analysis to distinguish between stroke- and LVO-related conditions.

Early selection and diagnosis of patients with stroke

Using EMS assessment tools for stroke diagnosis at the prehospital stage is beneficial. When suspected stroke occurs before hospital arrival, it is recommended to use a stroke diagnostic screening tool in the prehospital setting for early selection and diagnosis of patients with stroke (level of evidence [LOE]: moderate, grade of recommendation [GOR]: A).

Fifteen studies were found to use prehospital tools for stroke diagnosis. Overall, the use of these tools improved sensitivity but did not enhance the specificity of the diagnosis. The sensitivity and specificity for stroke diagnosis were 0.83 (95% confidence interval [CI]: 0.72–0.90, Fig 2) and 0.61 (95% CI: 0.48–0.73, Fig 3), respectively. Thus, the tools demonstrated high sensitivity but low specificity in diagnosing stroke. The overall area under the curve (AUC) was 0.775, with moderate heterogeneity observed across studies ($I^2 = 35.5\%$, Fig 4).

Regarding sensitivity, the Face Arm Speech Test (FAST) and the Cincinnati Prehospital Stroke Scale (CPSS) showed the highest values of 0.87 and 0.79, respectively, whereas the Los Angeles Motor Scale (LAMS) had a sensitivity of 0.68. The LAMS showed the highest specificity at 0.84, followed by CPSS at 0.59 and FAST at 0.57. A higher sensitivity indicates a lower likelihood of missing patients with stroke during the initial assessment. Higher specificity helps to correctly exclude patients without stroke and minimize false positives. Therefore, tools with high sensitivity, including FAST and CPSS, are advantageous for identifying stroke in the prehospital setting. Conversely, the LAMS is more useful to accurately rule out patients without stroke owing to its higher specificity. The FAST and CPSS assess the presence of facial palsy, arm weakness, and speech disturbance. By contrast, the LAMS assigns scores based on arm drift and grip strength. These differences in tool compositions may result in varying sensitivities and specificities for stroke diagnosis.

In clinical settings, misdiagnosing a patient with stroke during an emergency can lead to a poor prognosis, and a high number of false positives can result in emergency department overcrowding and the unnecessary consumption of medical resources. However, considering that patients with stroke are often not transferred to hospitals equipped with emergency medicine, neurology, or neurosurgery departments, and that early diagnosis and proper treatment significantly improve outcomes, we

concluded that EMS assessment tools in the prehospital stage are appropriate for stroke diagnosis. Furthermore, based on experts' opinions, EMS tools with higher sensitivity were deemed to be more suitable for use in prehospital settings. The result of the tool depends on the characteristics of each tool, resulting in varying sensitivity and specificity. Since emergency department conditions and regional settings also differ, the appropriate tool should be selected on the basis of the local context. When possible, tools with a higher sensitivity are preferred.

Early selection and diagnosis of patients with LVO

Using EMS assessment tools to diagnose LVO at the prehospital stage is beneficial. However, in clinical settings, delays in diagnosing LVO are frequently unacceptable. Owing to the diverse clinical presentations of LVO, relying solely on prehospital EMS assessment tools may be insufficient for accurate diagnosis. While experts advocate for the use of EMS assessment tools to facilitate early identification of LVO, these tools alone lack adequate sensitivity. Further diagnosis should be made using the National Institutes of Health Stroke Scale (NIHSS) and medical imaging findings after hospital arrival, and evaluations and consultation with specialists are strongly recommended (LOE: moderate, GOR: B).

Our meta-analysis showed that the usefulness of prehospital diagnostic tools for LVO diagnosis had a sensitivity and specificity of 0.68 (95% CI: 0.64–0.72, Fig 5 and 0.78 (95% CI: 0.75–0.81, Fig 6), respectively. Overall, the sensitivity of the LVO diagnosis was low, whereas its specificity was high. The overall AUC was 0.8, with low heterogeneity observed across studies ($I^2 = 13\%$). This indicates that the EMS assessment tools maintain high diagnostic accuracy within the clinically relevant range of specificity. EMS assessment tools for stroke (AUC = 0.76) and LVO (AUC = 0.80) showed good diagnostic accuracy, supporting their use in various prehospital settings. Therefore, these tools should be employed to aid early identification and appropriate triage in any suspected stroke case (Fig 4). Notably, LVO has been evaluated using various scales because it is a highly demanded topic in clinical practice. Therefore, a subgroup analysis was performed.

The CPSS showed the highest sensitivity at 0.91, indicating the greatest potential for correctly identifying patients with LVO. In contrast, Rapid Arterial occlusion Evaluation (RACE) and Field Assessment Stroke Triage for Emergency Destination (FAST-ED) had moderate sensitivities of 0.69 and 0.72, respectively, suggesting a reasonable level of reliability. LAMS had the highest specificity at 0.85, followed by Prehospital Acute Stroke Severity (PASS) (0.80), FAST-ED (0.80), and RACE (0.80), all of which showed high specificity. Conversely, the CPSS, which had the highest sensitivity, showed the lowest specificity of 0.27, indicating a high likelihood of failing to exclude patients without LVO. Therefore, it may produce a high rate of false positives. The characteristics of the disease and the clinical setting should be considered before recommending the use of diagnostic tools. LVO requires prompt and aggressive treatment because it has a poor prognosis. Consequently, patients are preferably directly transported to a stroke center capable of performing thrombolysis or thrombectomy. Prehospital diagnostic tools are more likely to be used by trained paramedics or nonmedical personnel rather than physicians. If a scale is relatively complex or includes several items, its practicality decreases; hence, simpler scales are preferred. Consequently, we recommend tools that have high sensitivity and are easy to use. However, these tools tend to have high false-positive rates. After reviewing expert opinions, we concluded that it is reasonable to prioritize the use of highly sensitive tools for LVO diagnosis. Moreover, combining these tools in clinical settings, when possible, would be beneficial owing to the limitations of each tool. For example, combining a highly sensitive tool such as CPSS with a highly specific tool, including LAMS or prioritizing the use of tools such as FAST-ED or RACE, which have balanced sensitivity and specificity, could enhance the accuracy of LVO diagnosis.

Based on the meta-analyzed studies and our emergency department data, the following cutoff values were considered for LVO diagnosis. If each EMS assessment tool exceeds the following cutoff values, the patient can be considered to have a high suspicion of LVO or a high risk of stroke at the point of emergency occurrence. A CPSS score of 1 point, Vision, Aphasia, Neglect (VAN) score ≥ 1 , Cincinnati Prehospital Stroke Severity Scale (CPSSS) and PASS scores ≥ 2 , FAST-ED and LAMS scores ≥ 4 , and RACE score ≥ 5 can be considered indicative of stroke or LVO. In certain regions of

South Korea, there are established protocols that mandate the direct transport of patients with suspected stroke who present with high prehospital stroke severity scores to thrombectomy-capable centers. Differentiating the destination hospital based on the prehospital stroke severity score is intended to expedite the identification and treatment of LVO.

According to the consensus of all experts, relying solely on prehospital diagnostic tools to identify and differentiate LVO from other conditions is clinically challenging and may pose a significant risk if misdiagnosed. Since patients with LVO can present with various clinical symptoms, it is essential to rule out other conditions, including hemorrhagic diseases or transient ischemic attack, before confirming the diagnosis of LVO. Therefore, an LVO diagnosis should be accompanied by additional diagnostic tools and imaging findings after hospital arrival.

Consequently, although the use of prehospital diagnostic tools can be recommended for initial suspicion of LVO, their standalone accuracy is likely to be limited. Therefore, a precise diagnosis should be made using the NIHSS and medical imaging after hospital arrival, and prompt and aggressive treatment should be provided within the therapeutic time window (LOE: moderate, GOR: B).

Characteristics and results of the EMS assessment tools

CPSS

The CPSS, first introduced by Kothari in 1999, is a screening tool developed to screen for severe stroke and LVO, derived from selected components of the NIHSS^{6,7}). The CPSS was originally developed to identify patients with suspected stroke who may be eligible for thrombolytic therapy, and to provide an initial assessment of stroke severity. In the initial study, a score of ≥ 1 was proposed as indicative of possible stroke. Subsequent research, including a study by Christopher et al. in 2018, suggested that the CPSS is also useful for the prehospital identification of LVO¹⁶). Subsequently, various studies have investigated the optimal cutoff value, with most recommending a threshold of 2

or 3 points for LVO suspicion^{16,20}). A key advantage of the CPSS is its simplicity and feasibility, making it particularly suitable for use by EMS personnel in prehospital settings¹⁶).

The CPSS assesses the following three clinical findings: facial palsy, arm drift, and speech disturbances. Each component has a score of 1 point, yielding a total score ranging from 0 to 3. The CPSSS comprises the following three items: gaze deviation scored as 2 points; if the patient answers at least one of the two orientation questions (age and current month) incorrectly and fails at least one of the two commands (close your eyes and make a fist), as 1 point; and inability to hold the arm up for > 10 s (NIHSS ≥ 2) is scored as 1 point. A total score of ≥ 2 is considered positive for stroke and LVO. The CPSSS was retrospectively derived from a cohort of 624 patients from the two NINDS tPA Stroke Studies and was validated using a cohort of 650 patients from the IMS-III trial^{2,11}). In patients with severe stroke defined as NIHSS ≥ 15 , the CPSSS showed sensitivity, specificity, and AUC of 92%, 51%, and 0.83, respectively. In contrast, for patients with LVO, it demonstrated sensitivity, specificity, and AUC of 83%, 40%, and 0.67, respectively⁶). Although the CPSSS shows high sensitivity, it has limitations, including a low AUC for LVO detection and the exclusion of isolated M2 occlusions in its derivation and validation cohorts.

FAST

The FAST was developed in the United Kingdom in 1998 as a stroke identification instrument and was later established as a stroke scale⁴). The FAST is one of the earliest tools proposed during the initial development of stroke scales and was designed to identify patients with stroke who may benefit from thrombolytic therapy⁴). Along with the CPSS and Los Angeles Prehospital Stroke Screen (LAPSS), FAST has been widely used in various studies comparing stroke assessment tools. Owing to the nature of its components, FAST is advantageous for identifying anterior circulation stroke. With the growing emphasis on the identification of LVO, particularly in the context of the expanded use of endovascular treatment for ischemic stroke, modified versions of the FAST have emerged. These include the G-FAST, which incorporates gaze evaluation for improved detection of posterior circulation stroke³), and FAST-ED, which includes eye deviation and neglect as assessment items³).

The FAST evaluates the following three symptoms: facial palsy, arm weakness, and speech impairment. Any of these findings are considered FAST positive.

VAN

The VAN scale was introduced by Teleb in 2016 as a screening tool specifically developed for emergent LVO detection¹⁸). The VAN scale assesses the functional neurovascular anatomy and comprises the following four components: arm weakness, visual disturbance, aphasia, and neglect. Arm weakness is classified as absent, mild, moderate, or severe. However, only the presence or absence of weakness is considered in the final assessment. Visual disturbances are evaluated based on the presence of field cuts, double vision, or sudden blindness. Aphasia can be categorized as expressive, receptive, or mixed. Neglect is assessed using indicators such as forced gaze, the inability to feel both sides, or ignoring one side. A VAN-positive result was defined as the presence of arm weakness along with at least one abnormal finding in either vision, aphasia, or neglect. The VAN test is simple to administer, yields dichotomous (positive/negative) results, and can be performed rapidly. Consequently, initial studies have demonstrated the inter-rater reliability of this tool¹²). VAN is classified as a cortical symptom-based stroke scale, similar to FAST-ED and RACE^{1,12}). The VAN may have higher sensitivity but potentially lower specificity than screening tools that do not assess cortical signs. Some studies have suggested that its dichotomous structure contributes to its reduced specificity¹²).

LAMS

The LAMS was developed by Llanes in 2004 as a simplified modification of the LAPSS, aiming to identify patients with stroke and simultaneously assess stroke-related motor deficits⁹). Initially, no specific cutoff value was proposed; however, it was noted to correlate well with the NIHSS. Later, in 2008, Nazliel suggested that a LAMS score of 4 or more could indicate suspected LVO, and subsequent studies have reported similar findings^{13,14}). LAMS evaluates the following three components: facial droop, arm drift, and grip strength. Facial droop was scored as either 0 or 1, based

on its presence. Arm drift and grip strength were scored from 0 to 2, depending on their presence and severity. The total score ranged from 0 to 5.

RACE

The RACE scale was developed to screen for LVO¹⁵) and comprises the following five components: facial palsy is scored as follows: 0 points, absent; 1 point, if mild (NIHSS 1); and 2 points, if moderate-to-severe (NIHSS 2–3); arm motor function is scored as follows: 0, if absent or mild (NIHSS score 0–1), 1 point if moderate (NIHSS score 2), and 2 points if severe (NIHSS score 3–4); leg motor function is evaluated using the same criteria and scoring system as those for the arm; gaze deviation is scored as 1 point if present (NIHSS score 1–2); and, language and neglect are assessed depending on the side of hemiparesis. Aphasia is evaluated using two commands (close your eyes and make a fist) for right-sided weakness: 0 points if both are correctly performed, 1 point if only one is completed, and 2 points if neither is performed. Agnosia is assessed using two tasks (“Whose arm is this?” while showing the paralyzed arm, and “Clap your hands” while raising both arms) for left-sided weakness: 0 points if both are answered correctly, 1 point if only one is answered correctly, and 2 points if neither is answered correctly. A total score of ≥ 5 is considered positive for LVO. The RACE scale was retrospectively derived from the data of 654 patients admitted to a stroke unit at a single institution between January 2006 and March 2010, and prospectively validated in a cohort of 885 patients admitted between February 2011 and March 2013. The RACE scale demonstrated sensitivity, specificity, and AUC of 85%, 68%, and 0.82, respectively, for diagnosing LVO. Despite high sensitivity, nearly half of the LVO diagnoses were based on transcranial duplex ultrasound, which may have reduced diagnostic accuracy.

FAST-ED

The FAST-ED scale was developed as a screening tool for LVO⁸) and comprises the following five components: facial palsy scored as 0 points if absent or mild (NIHSS 0–1) and 1 point if partial or complete (NIHSS 2–3); arm weakness scored as 0 points if absent (NIHSS 0), 1 point if the arm

cannot be held up but can resist gravity (NIHSS 1–2), and 3 points if the arm cannot overcome gravity (NIHSS 3–4); speech impairment scored as 0 points if absent (NIHSS 0), 1 point if mild-to-moderate (NIHSS 1), or 2 points if severe (NIHSS 2–3); gaze deviation scored as 0 if absent (NIHSS 0), 1 point if partial (NIHSS 1), or 2 points if complete (NIHSS 2); and neglect scored as 0 if absent (NIHSS 0), 1 point if extinction is present on double simultaneous stimulation (NIHSS 1), or 2 points if the patient is unaware of one side or direction (NIHSS 2). A total score of ≥ 4 is considered positive for LVO. The FAST-ED scale was derived from the data of 741 patients enrolled in the Screening Technology and Outcomes Project in Stroke (STOPStroke) cohort and demonstrated sensitivity, specificity, and AUC of 61%, 89%, and 0.813, respectively. Although the FAST-ED scale is characterized by a high specificity, its low sensitivity is a limitation. One advantage of this scale is that it stratifies the LVO risk into three distinct groups based on the score as follows: a score of 0–1 corresponds to an LVO probability of $< 15\%$, 2–3 to approximately 30%, and ≥ 4 to approximately 60%.

PASS

The PASS scale was developed as a screening tool for LVO⁵) and comprises the following three items: the patient is given 1 point if they fail to answer either their age or the current month; gaze palsy or deviation is scored 1 point; and arm weakness is scored as 1 point if present (NIHSS ≥ 1). A total score of ≥ 2 is considered positive. The PASS scale was retrospectively derived from two-thirds of a dataset of 5,864 patients registered in the Danish Stroke Registry, validated using the remaining one-third of patients¹⁹). The PASS scale demonstrated sensitivity, specificity, and AUC of 61%, 83%, 0.73, respectively, and an odds ratio of 7.63 (95% CI: 5.71–10.20)⁵) for LVO prediction. Although the PASS scale has high specificity, its low sensitivity limits its use as a screening tool.

Prehospital use of EMS assessment tools in the diagnosis and triage of stroke

It is impossible to accurately diagnose stroke or LVO before hospital arrival. Owing to the nature of these conditions, delayed diagnosis, misdiagnosis, or delayed transfer to a specialized stroke center

may have serious consequences for both patients. Therefore, these guidelines aim to provide practical recommendations to members of the public, emergency medical personnel, hospital staff, and government health authorities for using stroke diagnostic tools during emergency transportation. In conclusion, among the currently available tools, some demonstrate high sensitivity, whereas others show reasonably balanced sensitivity and specificity. Consequently, we strongly recommend the use of EMS assessment tools to aid in the early identification of stroke at the prehospital stage (GOR: A). Additionally, tools for the prehospital identification of LVO may be utilized; however, owing to the inherent difficulty in diagnosing LVO and the wide variability in patient presentation, such tools should not be solely relied upon. Rather, their use should be followed by further evaluation using other validated clinical and imaging modalities upon arrival at the hospital (GOR: B). If a stroke or LVO is strongly suspected in an emergency patient, the patient should be transported to a designated stroke center. We aim to provide emergency medical personnel with proper information on hospitals capable of receiving and treating patients with stroke.

Based on our research, currently available stroke diagnostic tools have some limitations. No single tool demonstrated consistently high accuracy for stroke and LVO detection. This is reflected in the variation of sensitivity and specificity observed across the tools. With the rapid global advancement of telemedicine, new diagnostic approaches will likely emerge for use in the prehospital setting. Future studies are needed to explore, validate, and potentially integrate these technologies to improve early identification of stroke and LVO.

The KoNES has established certification systems for endovascular neurosurgeons and stroke intervention-certified hospitals capable of performing acute management of stroke (<https://www.konesonline.or.kr/certification/certiList.php>; Supplementary Table 4). As of November 29, 2024, South Korea had 311 certified stroke interventionists and 106 certified institutions. In Japan, acute stroke treatment can be administered at centers certified by academic societies. Thus, when an emergency occurs, paramedics can use the EMS assessment tool; if the score meets a certain threshold, stroke or LVO is suspected. In such cases, the patient can be transported to a stroke intervention-certified hospital within 1 h of travel time. As South Korea has many stroke centers,

patients with suspected stroke can be transported to nearby facilities and receive appropriate treatment within an established infrastructure. If proper transport guidelines are in place and consistently followed, the quality of care for patients with stroke is likely to improve, and the redistribution of medical resources can be achieved more efficiently. In the future, KoNES plans to investigate and monitor emergency room visits of patients with stroke using these guidelines. These guidelines should be actively introduced to paramedics, emergency room medical staff, stroke specialists, and the public. Through nationwide education, this effort is expected to enable the faster identification of patients with stroke and contribute to the appropriate redistribution of medical resources.

AUTHOR'S DECLARATION

Conflicts of interest

No potential conflict of interest relevant to this article was reported.

Informed consent

This type of study does not require informed consent.

Author contributions

Conceptualization : JSO; Data curation : JSO, DWS; Formal analysis : JSO; Funding acquisition : JSO; Methodology : JSO; Project administration : JSO, YNJ, JML, HSA, JJK, KMJ, GYY, JHK, DWS, HJL, JWJ, KCC, YSC, SJK, JKP, WSC, HK, YWK, SHS, SWL, JWL, TGK, SKH, SQP, SCK; Visualization : JSO; Writing-original draft : JSO, DWS; Writing-review & editing : JSO, YNJ

Data sharing

This guideline is based on a meta-analysis of previously published studies. No new data were generated or analyzed in this study, and therefore, data sharing is not applicable.

Preprint

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• Supplementary materials

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Table 1. Summary of the key questions and recommendations

Key question	Recommendation	Recommendation level	Level of evidence
Early and appropriate intervention is critical in managing stroke and LVO. The use of validated EMS assessment tools is recommended to facilitate the early identification of patients with stroke and support timely and appropriate treatment decisions.			
Is the use of EMS diagnostic tools for stroke assessment at the prehospital stage beneficial in emergency situations?	The use of EMS assessment tools for stroke diagnosis at the prehospital stage is beneficial. When a suspected stroke occurs before hospital arrival, it is recommended to use a stroke diagnostic screening tool in the prehospital setting for early selection and diagnosis of patients with stroke.	A	Moderate
Is the use of EMS diagnostic tools for LVO assessment at the prehospital stage beneficial in emergency situations?	Using EMS assessment tools to diagnose LVO at the prehospital stage is beneficial. However, in clinical settings, delays in diagnosing LVO are often unacceptable. Owing to the diverse clinical presentations of LVO, relying solely on prehospital EMS	B	Moderate

	assessment tools may be insufficient for accurate diagnosis. While experts advocate for the use of EMS assessment tools to facilitate early identification of LVO, these tools alone lack adequate sensitivity. Further diagnosis should be made using the NIHSS and medical imaging after hospital arrival, and evaluations and consultation with specialists are strongly recommended.		
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EMS, emergency medical service; LVO, large-vessel occlusion; NIHSS, National Institutes Stroke

Scale

Figure Legends

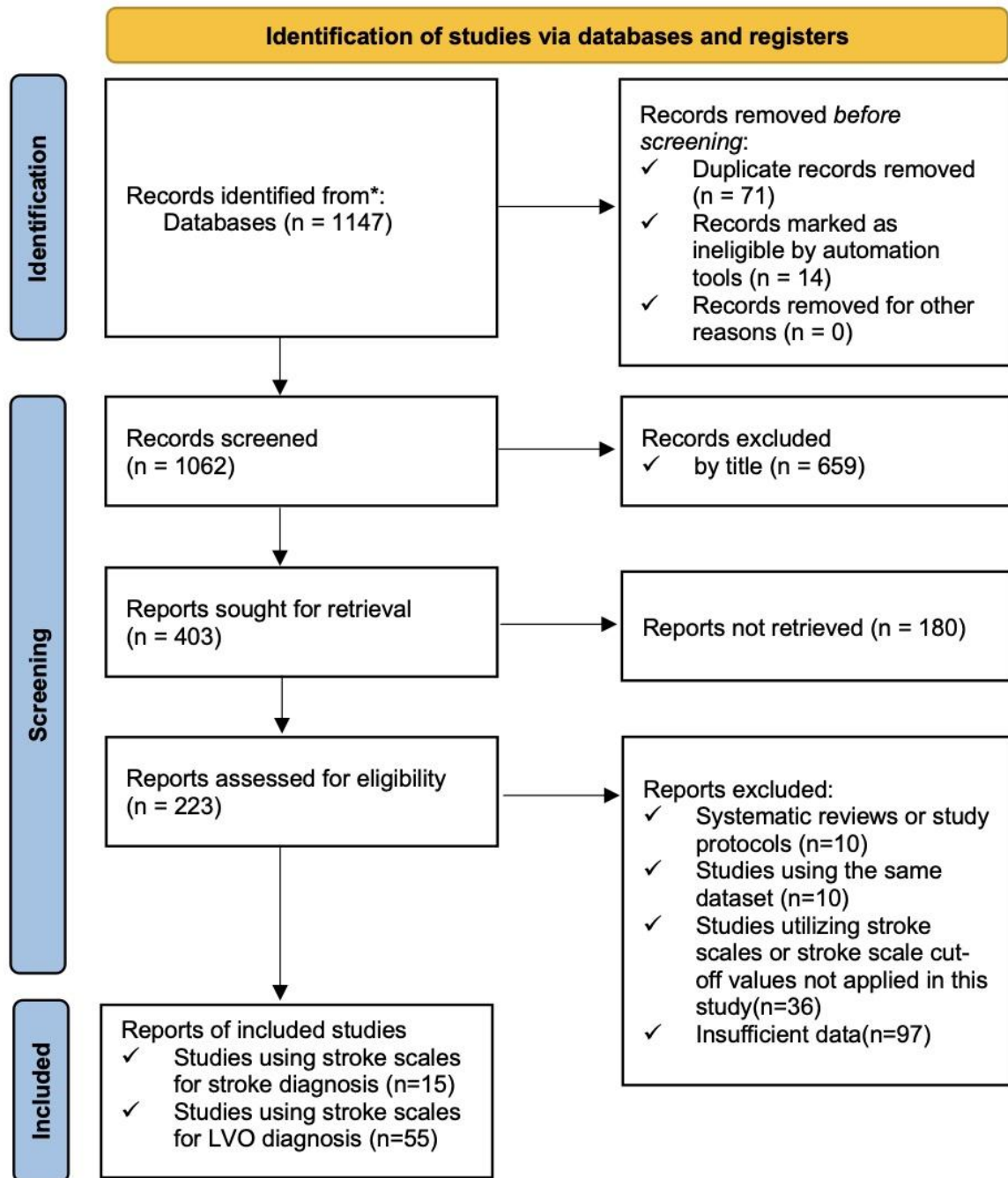


Fig. 1. PRISMA flow of the systematic review and meta-analysis. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses

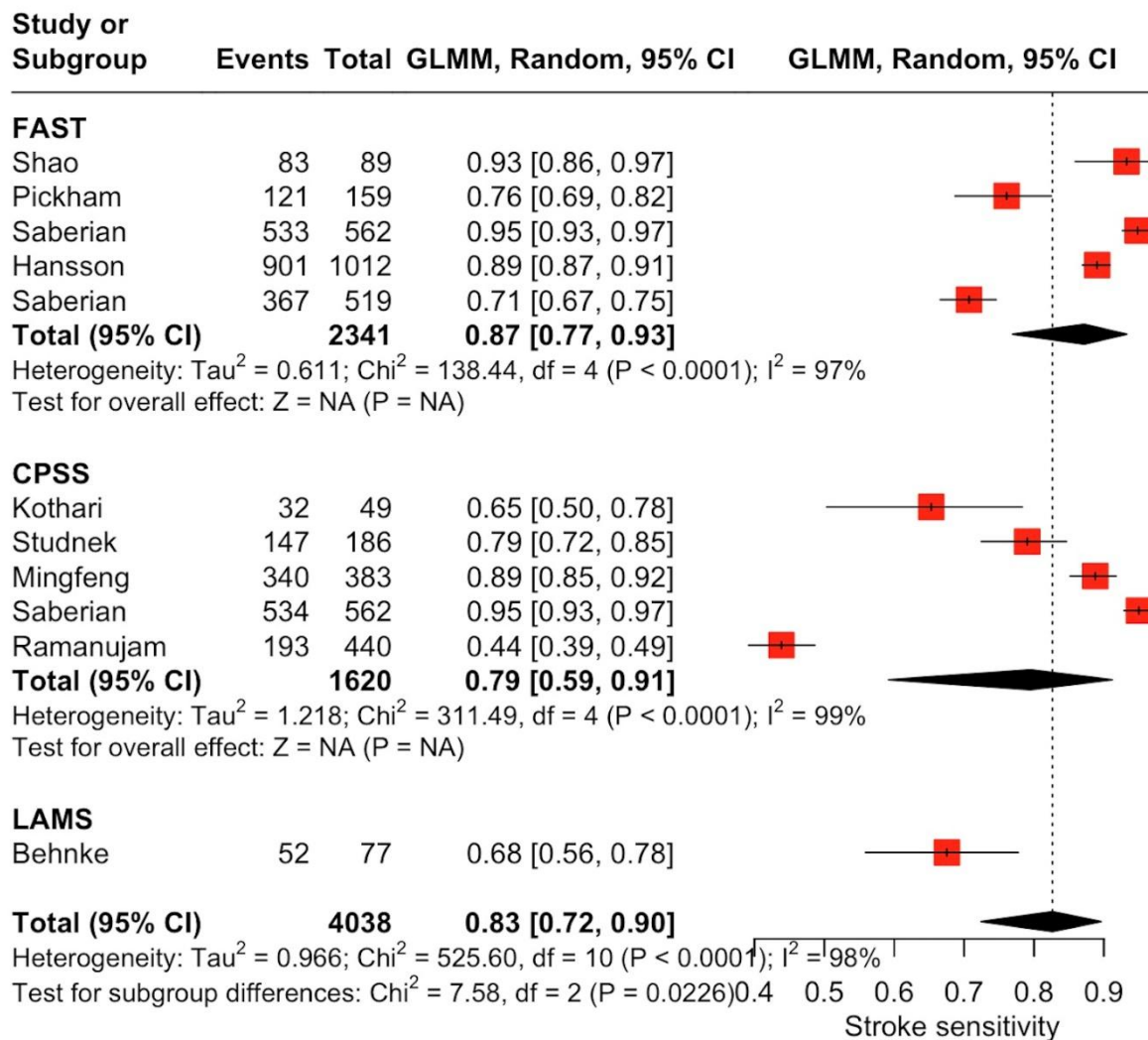


Fig. 2. Meta-analysis of sensitivity for diagnosing stroke.

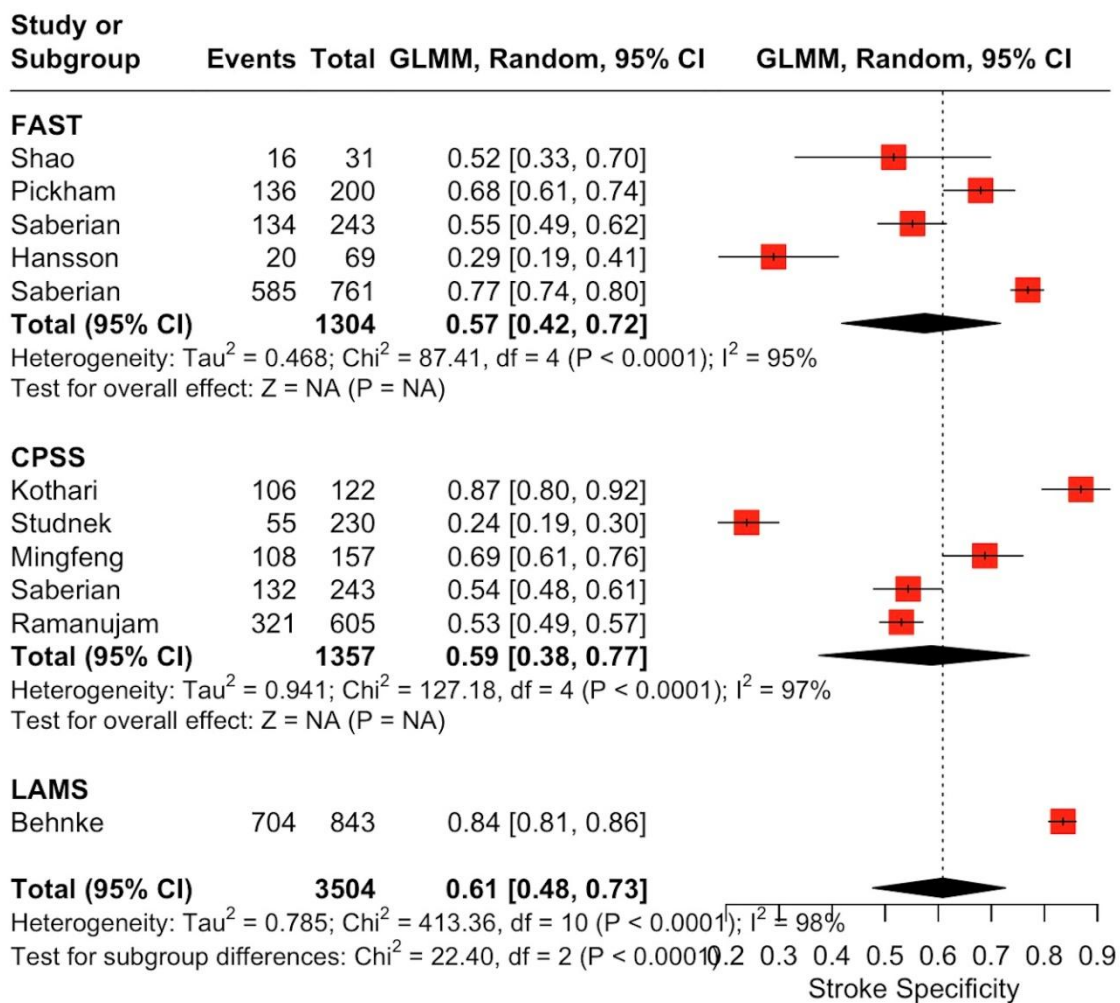


Fig. 3. Meta-analysis of specificity for diagnosing stroke.

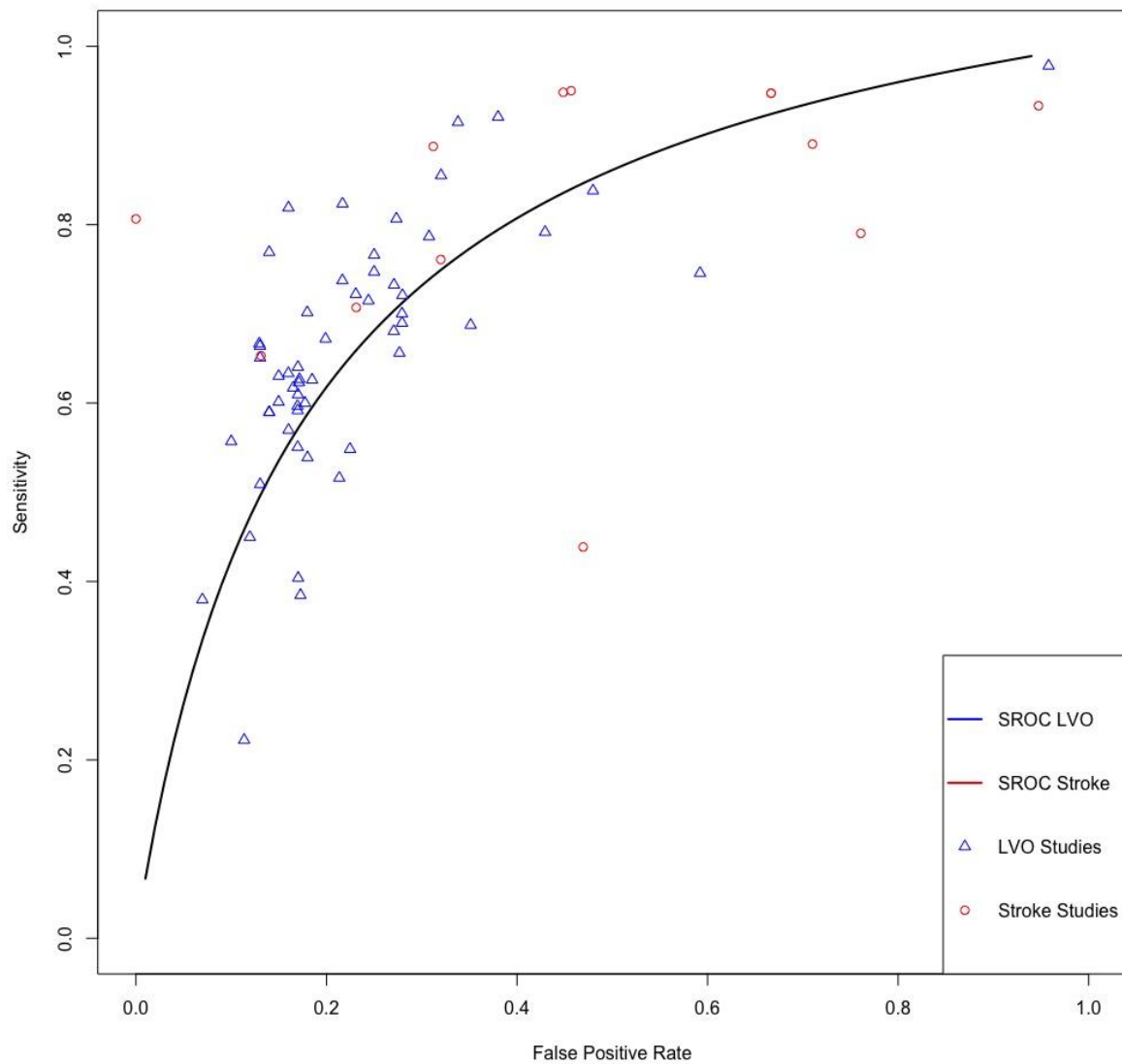


Fig. 4. Summary receiver operating characteristic (SROC) of emergency medical service assessment tools for diagnosing stroke and large vessel occlusion. LVO, large vessel occlusion.

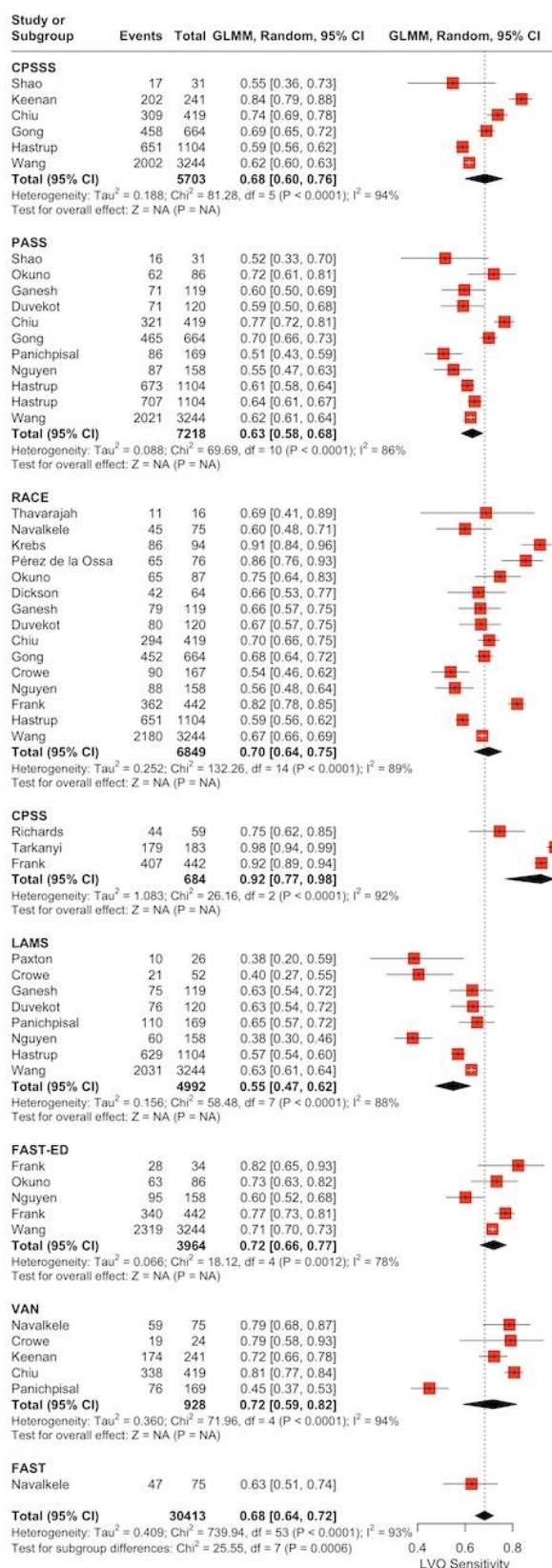


Fig. 5. Meta-analysis of sensitivity for diagnosing large vessel occlusion. CI, confidence interval; GLMM, generalized linear mixed model.

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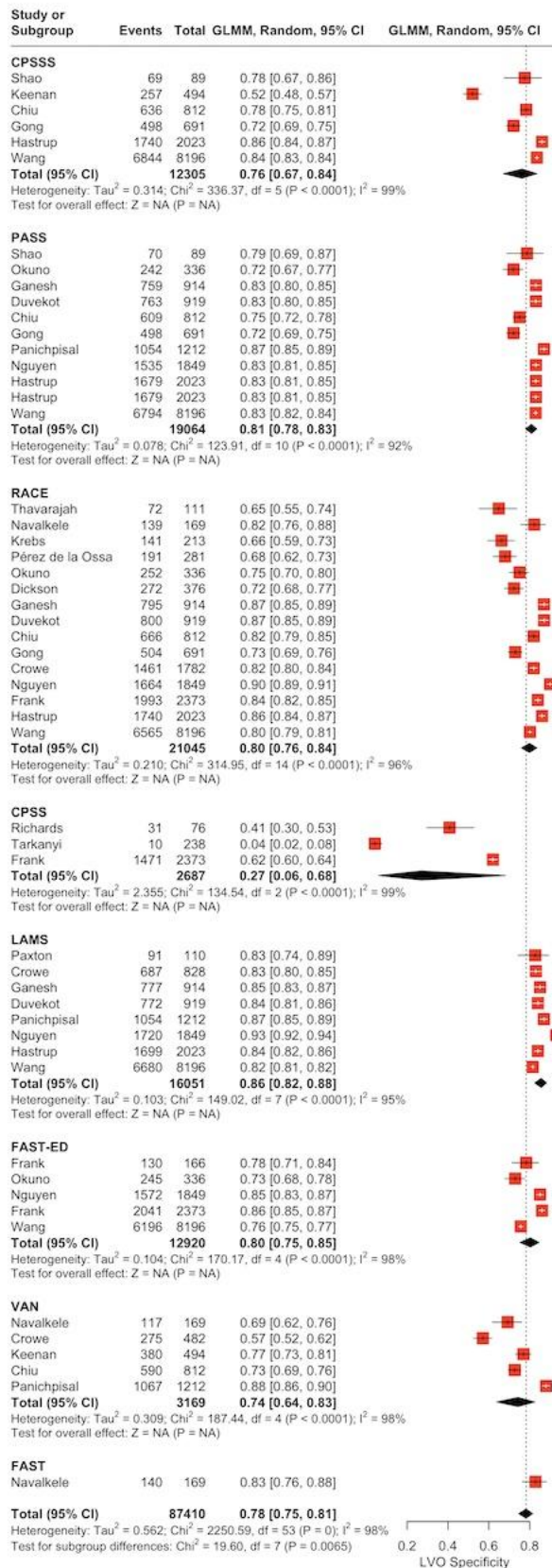


Fig. 6. Meta-analysis of specificity for diagnosing large vessel occlusion. CI, confidence interval; GLMM, generalized linear mixed model.

Accepted article

Supplementary Material 1. TITLE

Composition of the clinical practice guideline committee and multidisciplinary participation

The Clinical Practice Guideline Committee comprises an Executive Committee, a Working Committee, and both Internal and External Review Committees. The Executive Committee, led by the president and executives of the society, establishes the strategy and direction for guideline development, reviews and approves the budget, coordinates stakeholders, and ensures the independence of the development process.

The Working Committee is primarily composed of the president of the Korean NeuroEndovascular Society (KoNES), the Chair of the Clinical Practice Guideline Committee, and key executive board members. Additionally, representatives from the Korean Society of Emergency Medicine and the Korean Society of Cerebrovascular Surgeons were appointed to the committee. Neurologists and methodology experts also participated, forming a multidisciplinary panel. The committee was structured as follows: Executive Committee: 10 members, Guideline Development Working Committee: 14 members, Advisory Committee: 8 members, Conflict of Interest Committee: 7 members, Administrative Support Team: 2 members, Internal Review Committee: 2 members, and External Review Committee: 2 members.

In January 2024, during the KoNES's New Year Executive Meeting (Clinical Practice Guideline Director: Jae Sang Oh, President: Soon-Chan Kwon), the establishment of the guideline was officially announced. Throughout 2024, a total of 13 meetings were held, followed by five additional meetings in 2025, including committee executive meetings, public hearings, and internal/external surveys.

Clinical medical guideline development process

The development of stroke medical guidelines is not the first trial in Korea. Therefore, existing medical guidelines, both domestic and international, were reviewed to define the scope and target population of the new guidelines. Based on this review, it was determined that stroke is an extremely

broad topic. Attempting to cover all aspects of stroke in the first edition of the guidelines might lead to an excessively extensive scope and potential overlap with existing international guidelines.

Stroke treatment is categorized into the following three phases: prehospital care, hospital treatment, and post-treatment management. Most of the previously established Korean guidelines have focused on hospital-based treatment, and many were created by modifying or adapting existing international guidelines.

Selection of key questions

The selection of key questions for the clinical practice guideline topic began with a survey conducted among all members of the society. The survey was collected before and after ASCENT from May to June 2024. Following the survey and the collection of topics by the working committee, two rounds of meetings among the development committee members were held to finalize the key questions.

Although two key questions were initially proposed with the participation of nearly all development committee members, due to the current medical conflicts in Korea and the shortage of medical personnel, it was determined that the guideline should first focus on the three most critical topics. This decision was finalized through a development committee meeting and additional committee discussions.

Supplementary Table 1. Key clinical question

Disease	Category	Clinical question
Stroke	Diagnosis	Is the use of EMS diagnostic tools for stroke assessment at the prehospital stage beneficial in emergency situations?
		Is the use of EMS diagnostic tools for large vessel occlusion assessment at the prehospital stage beneficial in emergency situations?

EMS, emergency medical services

Supplementary Material 2. TITLE

Literature search and selection

The literature search was conducted through discussions between methodology experts and the development committee members. An initial set of search terms was formulated, and a search strategy was established accordingly. Based on this strategy, searches were conducted across the following four major databases: MEDLINE (PubMed), Embase, Cochrane Library, and KoreaMed. The search was performed on November 11, 2024.

For all key questions, no restrictions were applied regarding publication year, language, or publication status. The retrieved records were compiled using EndNote, and duplicates were removed on the basis of the title, author name, publication year, and journal name. The final search strategy was as follows:

Medline

1. "Emergency Medical Services"[Mesh] 177512
2. "Emergicenters"[TIAB] OR "Emergicenter"[TIAB] OR "Prehospital Emergency Care"[TIAB] OR "Emergency Health Services"[TIAB] OR "Emergency Health Service"[TIAB] OR "Medical Emergency Service"[TIAB] OR "Medical Emergency Services"[TIAB] OR "Emergency Care"[TIAB] OR "Emergency Medical Service"[TIAB] OR "Emergency Medical Services"[TIAB] 27790
3. 1 OR 2 188263
4. Prehospital[TIAB] AND Stroke[TIAB] AND (Assessment[TIAB] OR Screening[TIAB] OR Screen[TIAB] OR Scale[TIAB]) 797
5. 3 AND 4 515

Embase

1. "emergency health service"/exp 359548
2. "emergicenters":ab,ti OR "emergicenter":ab,ti OR "prehospital emergency care":ab,ti OR "emergency health services":ab,ti OR "emergency health service":ab,ti OR "medical emergency service":ab,ti OR

"medical emergency services":ab,ti OR "emergency care":ab,ti OR "emergency medical service":ab,ti
OR "emergency medical services":ab,ti 32996

3. 1 OR 2 370893

4. Prehospital:ab,ti AND Stroke:ab,ti AND (Assessment:ab,ti OR Screening:ab,ti OR Screen:ab,ti OR
Scale:ab,ti) 1629

5. 3 AND 4 877

Cochrane

1. MeSH descriptor: [Emergency Medical Services] explode all trees 6244

2. "Emergicenters" OR "Emergicenter" OR "Prehospital Emergency Care" OR "Emergency Health
Services" OR "Emergency Health Service" OR "Medical Emergency Service" OR "Medical
Emergency Services" OR "Emergency Care" OR "Emergency Medical Service" OR "Emergency
Medical Services":ti,ab,kw 27790

3. 1 OR 2 9966

4. Prehospital AND Stroke AND (Assessment OR Screening OR Screen OR Scale):ti,ab,kw 797

5. 3 AND 4 109

6. 5/trials 92

Quality assessment of the literature and meta-analysis

The quality assessment of primary studies was conducted on the basis of their respective study designs. Six reviewers independently performed the evaluation, and any discrepancies in the assessment results were resolved through consensus between at least two reviewers. To minimize inconsistencies in evaluations among committee members, individual meetings and workshop training sessions on literature assessment were conducted. The results of individual evidence level assessments were provided within each key question section of the clinical recommendations. For quality assessment, the following tools were used: Diagnostic studies: QUADAS-2. A meta-analysis was conducted if no substantial unexplained heterogeneity was observed among the included studies and if

at least two studies reported comparable outcomes. However, if the included studies had different study designs, their results were not combined but presented separately.

In cases where duplicate data were suspected, the most recently published study or the study with the largest sample size was selected for inclusion in the final meta-analysis. A random-effects model was applied for meta-analysis, and statistical heterogeneity was evaluated using I^2 statistics. The meta-analysis considered the benefits and harms associated with the intervention under investigation.

Systematic review

For each subtopic selected by the Clinical Practice Guideline Executive Committee, at least two responsible reviewers were designated. Subsequently, a systematic review was conducted on the basis of the key questions, literature selection processes, supporting evidence, and meeting records. While each emergency medical service assessment tool has been individually evaluated through meta-analyses based on specific study outcomes, a systematic review was conducted to comprehensively describe the characteristics and scale properties of these tools.

To ensure objective validation of the drafted content, two reviewers independently evaluated each subtopic. The manuscript drafted by the Clinical Practice Guideline Development Committee was then reviewed by two independent stroke emergency experts who had not been directly involved in the guideline development process.

Derivation of recommendations, determination of recommendation strength, and evidence level

The evaluation of recommendation strength and evidence level followed the criteria established by the Grading of Recommendations Assessment, Development, and Evaluation (GRADE). The final clinical recommendations were determined through a review process involving the internal and external committees. The recommendation levels were classified into four grades based on the balance between benefits and harms associated with each intervention.

- A. Strong Recommendation: Applied when the desirable effects of an intervention clearly and substantially outweigh the undesirable effects. In such cases, most well-informed patients choose this intervention.
- B. Recommendation: Applied when the desirable effects of an intervention outweigh the undesirable effects; however, some well-informed patients still consider alternative interventions.
- C. Conditional Use: Suggested when the decision to use an intervention depends on clinical circumstances or patient social values, recommending selective or conditional use.
- D. Not Recommended: Applied when the harms of an intervention outweigh its benefits, advising against its use.
- E. Not Recommended: Harm is considered to outweigh the benefit.

Quality of evidence

We applied the GRADE approach to rate the quality of evidence of each outcome and judge the strength of each recommendation. The GRADE evidence level was determined through discussions among key question reviewers to ensure objectivity and consistency across all clinical recommendations. Subsequently, the entire process was disclosed during a public hearing for transparency. The evidence level was assigned separately for each outcome measure, and the final recommendation was based on the highest priority primary outcome within each clinical guideline. The evidence levels were classified into four categories and summarized using GradePro: high, moderate, low, and very low. Evidence-level downgrading and upgrading were considered based on the following criteria:

For observational studies, evidence was upgraded if (1) a large effect size was observed, (2) a dose-response relationship was identified, and (3) confounding factors increased confidence in the estimated effect. Each key question reviewer summarized the evidence and its level, considering various factors, including the strength and limitations of the available evidence, the balance of benefits and harms, patient values and preferences, potential barriers for physicians, financial

implications, and feasibility in clinical settings. Based on these considerations, the initial draft of the clinical recommendations and recommendation grading was developed.

Accepted article

Supplementary Table 2. TITLE

Grade	Meaning	Level of Evidence Definition
A	High	1. Highly reliable evidence: At least one randomized controlled trial (RCT) with consistency. 2. High-quality meta-analysis.
B	Moderate	1. Reliable evidence: Well-designed controlled trials exist, but no RCTs. 2. Moderate-quality meta-analysis.
C	Low	1. Evidence is unclear. 2. Physiological or mechanistic studies in human participants.
D	Very low	1. Insufficient evidence. 2. Consensus of expert opinion based on clinical experience.

Supplementary Table 3. TITLE

Grade	Meaning	Grade of Recommendation Definition
A	Strongly Recommended	Clinical benefit significantly outweighs harm.
B	Recommended	Clinical benefit is considered to outweigh harm.
C	Consider as an Option	The balance between benefit and harm is unclear.
D	No Recommendation	Insufficient evidence to determine the balance of benefit and harm.
E	Not Recommended	Harm is considered to outweigh the benefit.

Sensitivity	0.83 (95% CI: 0.72–0.90)	Prevalences	30%		
Specificity	0.61 (95% CI: 0.48–0.73)				

Outcome	No of studies (No of patients)	Study design	Factors that may decrease the certainty of evidence					Effect per 1000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias	pre-test probability of 30%	
True positives (patients with Stroke)	11 studies 7542 patients	cohort & case-control type studies	not serious	serious ^a	not serious ^a	not serious	none	249 (216–270)	⊕⊕⊕○ Moderate ^a
False negatives (patients incorrectly classified as not having Stroke)								51 (30–84)	

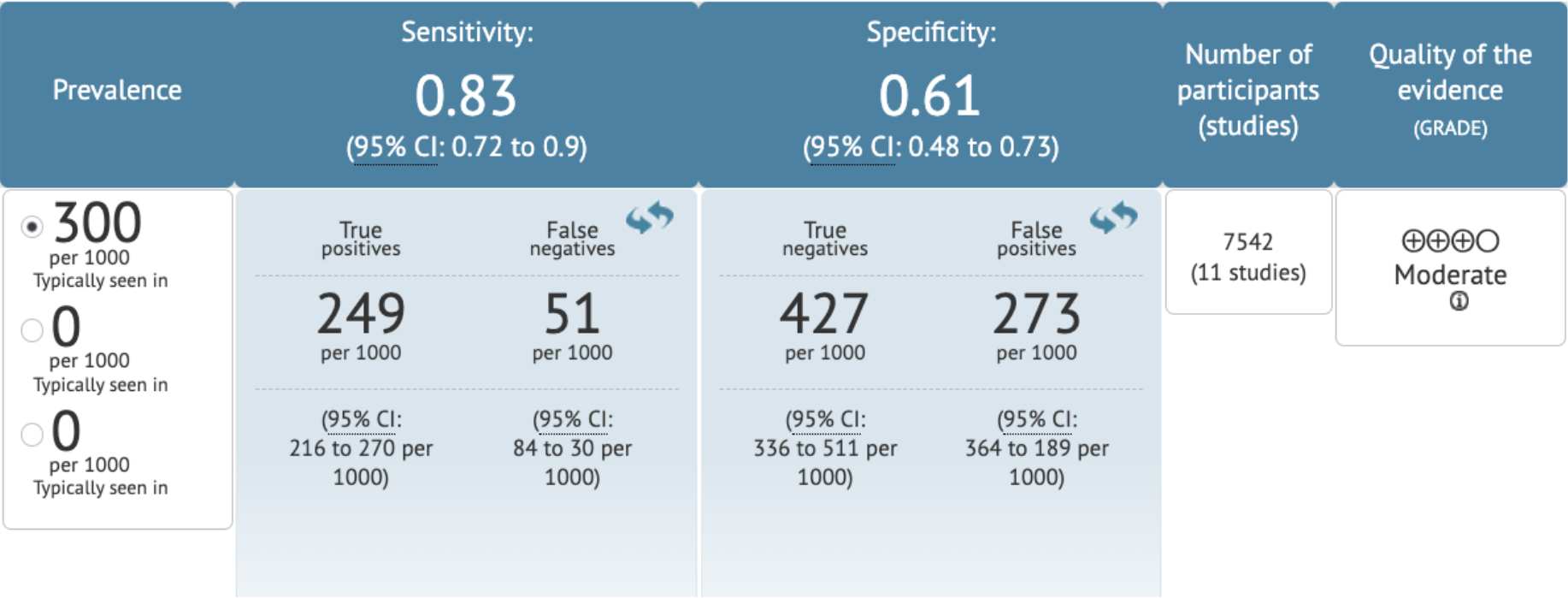
True negatives (patients without Stroke)	11 studies 7542 patients	cohort & case-control type studies	not serious	serious ^a	not serious ^a	not serious	none	427 (336–511)	⊕⊕⊕○ Moderate ^a
False positives (patients incorrectly classified as having Stroke)								273 (189–364)	

Explanations

a. heterogeneity >75

CI, confidence interval

article



Supplementary Fig. 1. Certainly of recommendation of an emergency medical service tool for stroke diagnosis of emergent patients.

Accepted article

Sensitivity	0.68 (95% CI: 0.64–0.72)	Prevalences	20%		
Specificity	0.78 (95% CI: 0.75–0.81)				

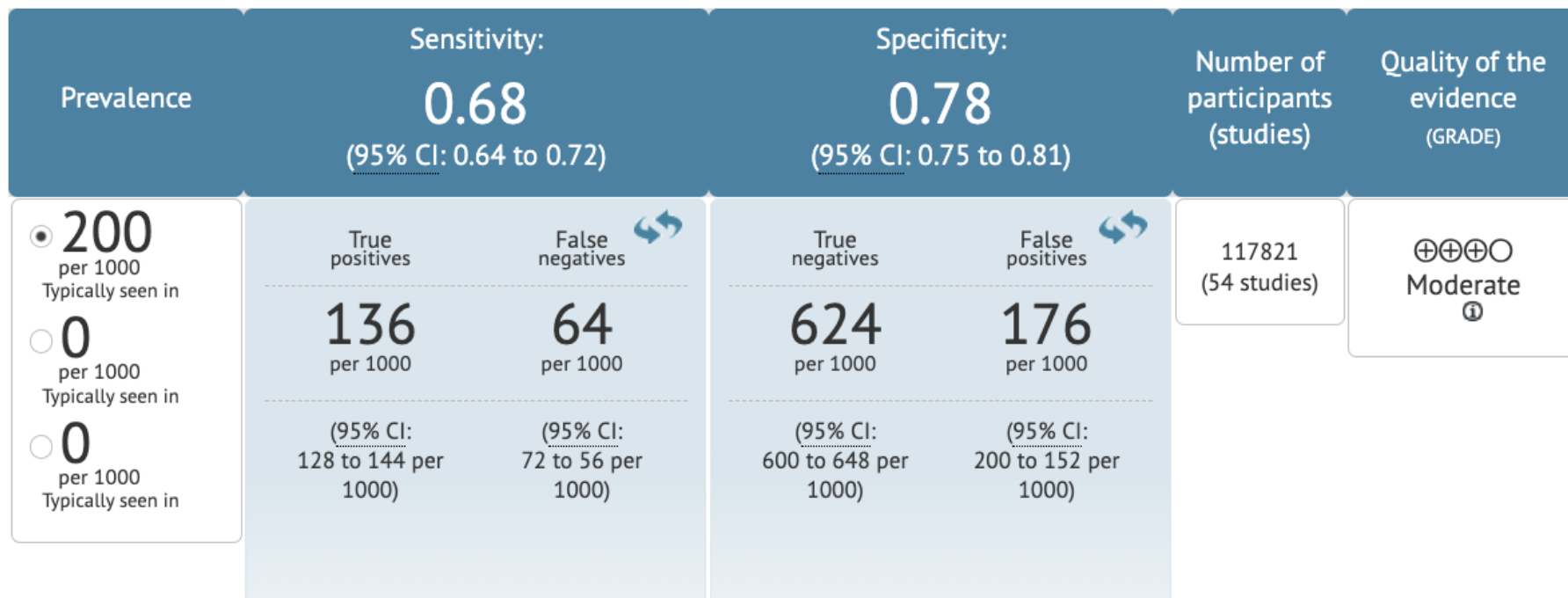
Outcome	No of studies (No of patients)	Study design	Factors that may decrease the certainty of evidence					Effect per 1000 patients tested	Test accuracy CoE
			Risk of bias	Indirectness	Inconsistency	Imprecision	Publication bias	pre-test probability of 20%	
True positives (patients with large vessel occlusion)	54 studies 117821 patients	cohort & case-control type studies	not serious ^a	serious ^a	not serious ^a	not serious	none	136 (128–144)	⊕⊕⊕○ Moderate ^a

False negatives (patients incorrectly classified as not having large vessel occlusion)								64 (56–72)	
True negatives (patients without large vessel occlusion)	54 studies 117821 patients	cohort & case-control type studies	not serious ^a	serious ^a	not serious ^a	not serious	none	624 (600–648)	⊕⊕⊕○ Moderate ^a
False positives (patients incorrectly classified as having large vessel occlusion)								176 (152–200)	

Explanations

a. high heterogeneity

CI, confidence interval



Supplementary Fig. 2. Certainty of recommendation of an emergency medical service tool for large vessel occlusion diagnosis of emergent patients.

Supplementary Material 3. TITLE

Consensus and adoption of recommendations

The guideline recommendations were derived under two major topics, resulting in a total of two recommendations. The principle for determining recommendation grades within the internal committee required that at least 80% of committee members participate, and a minimum of 70% approval was needed for a decision to be considered a consensus. If the approval rate did not reach 70%, the committee engaged in further discussions to draft a revised proposal, followed by a second round of voting. Recommendations that failed to gain final approval in the first round were revised and subjected to a second vote. During the second voting round, the two revised recommendations reached consensus, and one final recommendation was adopted. A summary of each key question and its corresponding recommendation is provided in Table 1.

Internal and external review

For each recommendation, the designated reviewers selected by the Clinical Practice Guideline Executive Committee drafted manuscripts on the basis of the key questions, the recommendation development process, supporting literature, and meeting records.

To ensure objective validation, two independent stroke emergency experts who were not directly involved in the development process reviewed the manuscripts prepared by the Clinical Practice Guideline Development Committee. Feedback from internal and external reviews was discussed and incorporated through an internal revision process.

For external expert review, on March 5, 2025, a draft of the clinical practice guideline recommendations was presented to a broad audience, including specialists in emergency medicine, neurosurgery, neurology, and radiology, as well as representatives from related academic societies and non-member physicians, along with members of the patient and public people. The

recommendations were fully disclosed, and an open public discussion was conducted to collect feedback.

All meetings were conducted online. Based on the feedback received, revised recommendations were formulated and underwent a second round of expert review before finalization.

Financial support and independence in clinical practice guideline development

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Research Ethics Committee of The Catholic University of Korea, Uijeongbu St. Mary's Hospital (IRB number. UC23ZISE0023). The requirement for informed consent was waived due to the retrospective nature of the study.

This guideline was developed with funding from KoNES and the Korea Health Industry Development Institute; however, no conflicts of interest were associated with this funding. The Clinical Practice Guideline Development Committee operated independently from KoNES, and throughout the entire guideline development process, the funding sources had no direct, indirect, or potential influence on the content of the guideline or the development process.

To ensure transparency, all participating committee members underwent a conflict of interest disclosure process to confirm that no actual or potential conflicts of interest were present. The evaluation included the following: 1) any advisory roles or honoraria received in the past 2 years related to topics covered in the guideline development, 2) financial interests, such as stock holdings or shares, in institutions related to the guideline content, 3) any official or unofficial positions held at organizations relevant to the guideline, and 4) intellectual property right, including patents related to medications covered in the guideline. Through this process, it was confirmed that no committee member had any actual or potential conflicts of interest that could influence the development of this guideline.

Supplementary Table 4. Stroke procedure certification organization according to the Korea NeuroEndovascular Society: institutions capable of managing stroke

지역	기관명
부산	부산부민병원
경기	시화병원
세종	세종충남대학교병원
전남	목포한국병원
경기	화홍병원
인천	인천사랑병원
경기	월스기념병원
부산	동남권원자력의학원
울산	울산중앙병원
경기	오산한국병원
인천	가톨릭관동대학교 국제성모병원
서울	서울의료원
서울	연세대학교 세브란스병원
충북	청주하나병원
경기	한림대학교 동탄성심병원
경기	의정부 을지대학교병원
대구	대구굿모닝병원
강원	울산대학교 강릉아산병원
경기	명지병원
서울	홍익병원
경남	창원한마음병원
충남	단국대학교병원
경기	한양대학교 구리병원
경기	참조은병원
경기	연세대학교 용인세브란스병원
경기	남양주현대병원
인천	나사렛국제병원
서울	한일병원
충북	청주성모병원
충북	청주한국병원
충북	건국대학교 충주병원

경남	양산부산대학교병원
부산	인제대학교 해운대백병원
광주	광주기독병원
울산	울산병원
경남	연세에스병원
경북	차의과학대학교 구미차병원
경기	인제대학교 일산백병원
서울	가톨릭대학교 은평성모병원
경남	창원경상국립대학교병원
경기	PMC 박병원
경북	포항성모병원
경기	김포우리병원
인천	인천세종병원
경북	포항세명기독병원
서울	한림대학교 강남성심병원
경북	순천향대학교 구미병원
전북	원광대학교병원
부산	인제대학교 부산백병원
대전	유성선병원
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