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The Accuracy of CPSS, LAPSS and MASS in Terms of Early Acute Ischemic Stroke Diagnosis

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Abstract

Aim: This study aimed to investigate the diagnostic accuracy of the Cincinnati Prehospital Stroke Scale (CPSS), Los Angeles Prehospital Stroke Screen (LAPSS), and Melbourne Ambulance Stroke Scale (MASS) in detecting acute ischemic stroke (AIS) in suspected cases and to compare these scales with each other.

Materials and Methods: This diagnostic accuracy study included patients with suspected AIS brought to the emergency department. Patients' data were collected from their medical records. All test data were compared with the final diagnosis of AIS based on the brain magnetic resonance imaging (MRI) report. Sensitivity, specificity, accuracy, positive predictive value, and negative predictive value were measured separately using statistical tests with confidence interval of 95%.

Results: Finally, 766 patients were included, among which 57.6% were male. The mean age of the patients was 66.8±13.7 years. All patients underwent brain MRI, which showed that 537 (70.1%) patients had an actual diagnosis of AIS. The accuracy rates of CPSS, MASS, and LAPSS were 82.9%, 79.2%, and 78.1%, respectively. In this study, the differences between the sensitivity and specificity of these scales were significant ($p<0.001$).

Conclusion: This study showed that the number of true-positive cases diagnosed by CPSS was higher than that by MASS, and the number of MASS true-positive cases was higher than that of LAPSS. The number of LAPSS true-negative cases was higher than that of MASS, and the number of MASS true-negative cases was higher than that of CPSS.

Keywords: Accuracy, decision support techniques, emergency medical service, stroke

Introduction

Acute ischemic stroke (AIS) is considered one of the leading causes of death as well as permanent disability worldwide (1,2). Early recognition of AIS events is associated with proper management, better clinical outcomes and faster neurologic recovery (3). Moreover, the duration between onset of AIS clinical symptoms and its recognition by healthcare providers is considered as a very crucial factor in deciding the treatment modality (4). Therefore, several prehospital stroke scales have been designed to come up with diagnostic tools that can allow paramedics and emergency medicine physicians to recognize patients with a high probability of having AIS based on clinical criteria and/or past medical history (5). However, there is no consensus regarding which Prehospital/Hospital Stroke Scale can provide the most accurate assessment of those patients.

The Cincinnati Prehospital Stroke Scale (CPSS) was first introduced in the medical literature during the 1990s (6). Although the study investigators suggested excellent CPSS reproducibility by physicians and paramedics, and also good validity of CPSS as a

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stroke screening tool, they have still stated that the study sample might have not been representative of the general patient population (6). Moreover, further studies revealed low sensitivity and specificity of CPSS as screening tool for AIS (7,8). Los Angeles Prehospital Stroke Screen (LAPSS) was also first introduced to the medical field in the late 1990s (8), and further validated by another study later on (9), yet a major issue still exists for LAPSS, which is the inability to reproduce the same reliable sensitivity when tested in a recent validation study (10). In 2005, Melbourne Ambulance Stroke Scale (MASS) was first investigated as a potential screening tool for stroke, and it was suggested to be a simple tool for use by paramedics with high sensitivity and specificity (11). However, MASS was not validated by many investigators in further studies after that.

In this study, we aimed to investigate the diagnostic accuracy of these three scales in detecting stroke events in suspected patients, and to compare these scales with each other in terms of sensitivity and specificity.

Materials and Methods

Study Design and Setting

This is a diagnostic accuracy study that included patients with suspected AIS brought to the emergency department (ED) of three educational medical centers in Tehran, Iran in January 2018 to December 2019. The implementation protocol was approved by the Ethics Committee of Tehran University of Medical Sciences (ethics code: IR.TUMS.MEDICINE.REC.1398.326, date: 06.07.2019). This study did not impose additional cost on the patients and the treatment system.

Study Population

Patients with suspected AIS diagnosis by the prehospital emergency services or via primary triage at the hospital were eligible. Patients with incomplete medical records and patients who left the ED against medical advice, before undergoing brain magnetic resonance imaging (MRI) were excluded. According to previous studies that reported a stroke prevalence in suspected patients referred to the emergency department, confidence interval of 95% and error of 5%, the sample size was calculated at a minimum of 610 cases.

Data Gathering

Data gathering was conducted prospectively. For this purpose, an appropriate checklist was prepared and inserted to the patients' files in educational centers in which both emergency medicine and neurology residents are working together. On admission to the ED, after proper neurological examination of the patients with any neurological complaint beside all documentation, filling of this checklist was also performed by the residents regularly; so, all required data for calculating the scales are easily available. Actually, all the findings of neurological examination are routinely recorded when the patient arrives to the ED. The checklist was provided in five parts. In the first part of this checklist, the baseline characteristics and demographic data including age, gender, smoking status (categorized as positive in those who have smoked more than 100 cigarettes in lifetime and needs to smoke every day or someday), past medical history [hypertension (HTN), ischemic heart diseases (IHD), diabetes mellitus (DM), coagulopathy, hyperlipidemia (HLD), seizure/epilepsy and previous history of stroke] were collected. The second, third and fourth parts were assigned to the criteria of MASS, CPSS and LAPSS, respectively. The fifth part of the checklist was assigned to the final diagnosis based on the brain MRI report (considered as the gold standard method of AIS diagnosis), which was extracted from the picture archiving and communication system (PACS). All imaging was performed by 1.5 T MRI scanners made by Siemens company. All reports were conducted with a team including one neurologist, one radiologist and one emergency medicine attending physicians, who participated in this study.

Stroke Evaluation

All eligible patients were evaluated by a trained emergency medicine/neurology resident. Totally, five PGY-3 emergency medicine residents and four PGY-2 neurology residents were involved. The required information for MASS, CPSS and LAPSS are simply completed via usual history taking and physical exam of a patient who referred to ED. In the CPSS criteria, three items (facial droop, speech, arm drift) are supplemented to decide a diagnosis of stroke. The abnormality of a single item of these criteria indicates a primary diagnosis of stroke according to the CPSS. LAPSS criteria for stroke diagnosis consist of four items related to the patient's medical history (age >45 years, absence of history of seizure or epilepsy, not being wheelchair bound or bedridden before the symptoms onset and arriving at the ED within less than 24 hours from the onset of symptoms), one item for blood glucose level (considered positive in the range from 60 to 400 mg/dL) and three items from the physical examination (facial droop, arm drift, and hand grip). Patients who met all the history criteria and had a blood glucose level in the aforementioned range with at least one positive physical examination criterion, were considered LAPSS positive (Table 1). MASS criteria are similar to those of LAPSS. However, in MASS criteria, there is no limitation in the time between the onset of symptoms and the arrival at the ED. Furthermore, the range of the blood glucose level in MASS is 50-400 mg/dL, and in the physical assessment part, speech is also included. Patients who met all the history criteria and had

Table 1. Detailed criteria of study tools			
Assessment criteria	LAPSS	CPSS	MASS
History			
Age >45 years	*		*
No history of seizures or epilepsy	*		*
At baseline, not wheelchair bound or bedridden	*		*
Blood glucose level between 2.8 and 22.2 mmol/L	*		*
Physical exam			
Facial droop	*	*	*
Arm drift	*	*	*
Hand grip	*		*
Speech		*	*
Stroke identification criteria			
Presence of any physical exam finding	*	*	*
All history items answered yes	*		*
LAPSS: Los Angeles Prehospital Stroke Screen, CPSS: Cincinnati Prehospital Stroke Scale, MASS: Melbourne Ambulance Stroke Scale			

a blood glucose level in the aforementioned range with at least one positive physical assessment criterion were considered MASS positive.

Statistical Analysis

All data were analyzed by SPSS version 25. Quantitative variables were described using means ± standard deviation (SD) and qualitative variables were described using frequency and percentage. Sensitivity, specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV) were measured separately using statistical tests with confidence interval (CI) of 95%. In order to examine the strengths of the test, the receiver operating curve (ROC) curve and the area under the curve (AUC) were used, and to compare the difference between aforementioned items, McNemar test was used. We used McNemar's chi-square test for comparing the sensitivities and specificities of each screening test based on the final diagnosis, which presents the difference between predicted stroke cases and final diagnosis for each screening tool. P value <0.05 was considered statistically significant.

Results

Data of 1,200 patients with suspected AIS were reviewed. After assessing their medical records, 434 patients were excluded due to deficient data and incomplete medical records. Finally, 766 patients were included, of whom 57.6% were males. The mean age for the study population was 66.8±13.7 years (minimum and maximum of 11 and 95, respectively). Baseline and demographic characteristics are listed in Table 2. Most of the participants were non-smokers with a history of HTN. All patients underwent brain MRI and the results showed that 537 patients (70.1%) had an actual diagnosis of AIS. Most of the rest had no remarkable/new finding, except for three cases who were diagnosed with brain tumor, one case with hemorrhagic stroke, and six with old ischemic stroke.

Table 3 shows a comparison between the results of MASS, CPSS, LAPSS criteria and final diagnosis of AIS or non-AIS based on the brain MRI. MASS criteria could not diagnose AIS among 77 patients (14%), of whom 26 patients did not meet any of MASS criteria. LAPSS or CPSS criteria could not either diagnose AIS among all those 26 patients. Fifty-one patients could not be diagnosed due to other reasons such as the absence of history of seizure or epilepsy, age of less than 45 years, being wheelchair bound or being bedridden before the onset of the stroke symptoms, and having a blood glucose level of less or higher value than that of the considered range. Also, among those 51 patients, none of them was diagnosed as a AIS patient based on LAPSS criteria, but all of them were diagnosed to have AIS based on CPSS criteria. LAPSS was not able to diagnose 130 patients with AIS (24%) and had 53 more false negative cases (10%) as compared to MASS. Twenty-one patients (4%) had just the abnormality on speech item which is not included in LAPSS criteria, and 32 patients (6%) were assumed to be false negative because of arriving at ED within more than 24 h from symptoms onset. CPSS criteria were unable to diagnose only 27 patients (5%) who had a positive AIS diagnosis by the brain MRI. None of these patients was diagnosed using CPSS criteria either and only one patient was diagnosed using MASS and LAPSS criteria due to having an abnormality in hand grip item which is excluded from CPSS criteria. The ROC Curve of MASS, LAPSS, CPSS are shown in Figure 1 and the statistics of each scale are reported in Table 4. In the present study, the differences between the sensitivity and specificity of MASS, CPSS, and LAPSS criteria were statistically significant (p=0.000).

Discussion

The present study assessed the sensitivity, specificity and accuracy of MASS, LAPSS and CPSS criteria in diagnosing AIS using brain MRI as the gold standard method of AIS diagnosis. This study was conducted in educational medical centers, in which both neurology residents and emergency medicine residents are working. All brain MRIs were performed within first 24 hours of patients' admission; And based on presence of compatible lesions on ADC map and DW views, the final diagnoses were made. Apparently, those with old infarct were not considered as AIS, as detection of old stroke is not the purpose of these tests.

Table 2. Baseline characteristics of studied population (n=766)	
Variables	**Number (%)**
Gender	
Male	441 (57.6)
Female	325 (42.4)
Past medical history	
Smoker	141 (18.4)
Hypertension	479 (62.5)
Ischemic heart disease	275 (35.9)
Diabetes mellitus	235 (30.7)
Coagulopathy	22 (2.9)
Previous stroke	118 (15.4)
Hyperlipidaemia	150 (19.6)
Seizure or epilepsy	18 (2.3)
n: Number	

The majority of patients had actual diagnosis of AIS based on brain MRI. CPSS had higher sensitivity than MASS, and MASS had higher sensitivity than LAPSS. LAPSS had higher specificity than MASS, and MASS had higher specificity than CPSS. In this regard, a simple combination of LAPSS and CPSS, MASS criteria, could provide appropriate and reasonable statistical sensitivity and specificity value for the identification of AIS in suspected patients. Among the patients who did not meet MASS criteria, all and one third, were not also diagnosed by LAPSS and CPSS criteria, respectively.

Stroke is heterogenous and multifaced disorder causes more than one million deaths worldwide, annually. Despite the fact that stroke mortality has decreased in recent decades, but the reported rates still revealed high mortality rates (12). Early and accurate identification of stroke is one of the most important and crucial factors implicated in timely stroke management and better recovery after that. Therefore, emergency medical services always attempt to use better and less time-consuming screening tools for identifying stroke. A variety of prehospital screening stroke scales were designed to improve diagnostic accuracy and reduce the delay of therapy initiation. In this regard, CPSS and LAPSS are considered to be standard prehospital tools which were designed to be sensitive and accurate (12,13). CPSS criteria are based on clinical assessment of related stroke symptoms and LAPSS criteria also contain history and blood glucose measurements. In the same vein, MASS criteria were designed to inherit the strengths of both CPSS and LAPSS criteria (14,15).

Various studies assessed the CPSS statistical value for identification of stroke. Similar to the result of our study, Kothari et al. (16) indicated that CPSS had 100% sensitivity in identification of stroke. However, two years later in another study, they showed a significant reduction of sensitivity to 59% that had disagreement with our results. The reasons for those significant reduction in the sensitivity of CPSS were explained by the change of the study from community to ED and high rates of selection bias (17).

Studnek et al. (18) evaluated the diagnostic value of CPSS for 461 suspected strokes and showed that CPSS had 79% sensitivity and 23.9% specificity in diagnosing stroke. Which was lower than the estimated values in our study which may be due to their lower sample size than ours.

In our previous study, the prevalence of stroke, among 899 suspected cases, was 69.5% based on brain MRI. CPSS cut-off 2.5 had 91.3% and 36.4% sensitivity and specificity, respectively (19). CPSS in the previous study had similar sensitivity and lower specificity than present study, although both studies were conducted in the same places and had almost the same sample size. The difference may be due to the more qualified implementation of the tests in the present study after enhancing the education and knowledge on this field in our prehospital setting.

Statistical value comparison of different stroke scales in different studies, increases the value of choosing the best diagnostic

Table 3. Comparing the results of MASS, CPSS, LAPSS criteria and final diagnosis of AIS based on brain MRI			
Scale	**Diagnosis by the scale**	**Final diagnosis of acute ischemic stroke by brain MRI (n)**	
		Positive (n=537)	**Negative (n=229)**
MASS	Positive	460 (85.7)	82 (35.8)
	Negative	77 (14.3)	147 (64.2)
CPSS	Positive	510 (95)	104 (45.4)
	Negative	27 (5)	125 (54.6)
LAPSS	Positive	407 (75.8)	38 (16.6)
	Negative	130 (24.2)	191 (83.4)
AIS: Acute ischemic stroke, MASS: Melbourne Ambulance Stroke Scale, CPSS: Cincinnati Prehospital Stroke Scale, LAPSS: Los Angeles Prehospital Stroke Screen, MRI: Magnetic resonance imaging, n: Number			

Table 4. Statistic indexes of MASS, LAPSS, and CPSS according to the final diagnosis of AIS based on brain MRI considering 95% confidence interval

Scale	Sensitivity	Specificity	PPV	NPV	PLR	NLR	Accuracy	AUC
MASS	85.7% (82.3-88.5)	64.2% (57.6-70.3)	84.9% (81.5-87.7)	65.6% (59/0-71.7)	2.39 (2.00-2.85)	0.22 (0.18-0.28)	79.2%	0.749 (0.708-0.790)
CPSS	95.0% (92.7-96.7)	54.6% (47.9-61.1)	83.1% (79.8-88.9)	82.2% (75.0-87.8)	2.09 (1.81-2.41)	0.09 (0.06-0.13)	82.9%	0.748 (0.705-0.791)
LAPSS	75.8% (71.9-79.3)	83.4% (77.8-87.9)	91.5% (88.4-93.8)	59.5% (53.9-64.9)	4.57 (3.40-6.13)	0.29 (0.25-0.34)	78.1%	0.796 (0.761-0.831)

MASS: Melbourne Ambulance Stroke Scale, CPSS: Cincinnati Prehospital Stroke Scale, LAPSS: Los Angeles Prehospital Stroke Screen, PPV: Positive predictive value, NPV: Negative predictive value, PLR: Platelet-to-lymphocyte ratio, NLR: Neutrophil-to-lymphocyte ratio, AUC: Area under the curve

method. Similar to the result of the present study, Bergs et al. (13) investigated the statistical value of stroke scales in a Belgian prehospital setting. For 31 suspected strokes enrolled in the study, the CPSS had sensitivity of 95% and specificity of 33%. LAPSS had sensitivity of 74% and specificity of 83%. MASS had sensitivity of 74% and specificity 67%. Purrucker et al. (20) indicated that CPSS had sensitivity of 76%-88% and specificity of 64%-73%. LAPSS and MASS had sensitivity of 44%-71% and specificity of 92%-98%.

A systematic review of eight studies conducted by Brandler et al. (21) compared the statistical value of CPSS, MASS, LAPSS and four other scales in diagnosis of stroke. They showed that each stroke scale had a wide range sensitivity and specificity. CPSS had sensitivity of 79%-95% and specificity of 24%-79%. LAPSS had sensitivity of 78%-91% and specificity of 85%-99%. MASS had sensitivity of 83%-90% and specificity of 74%-86%. A systematic review conducted by Rudd et al. (22) showed that CPSS had sensitivity of 44%-95% and specificity of 24%-79%, LAPSS had sensitivity of 59%-91% and specificity of 48%-97%, and MASS had sensitivity of 83%-90% and specificity of 74%-85%.

A systematic review conducted by Zhelev et al. (5) investigated the CPSS, LAPSS, MASS criteria and three other stroke scales and included 23 studies. It showed that CPSS had similar sensitivity to MASS and higher sensitivity than LAPSS. In the same systematic review, MASS had similar specificity to LAPSS and higher specificity than CPSS. The investigators favored MASS criteria, which had comparable sensitivity and higher accuracy than CPSS, to achieve better overall accuracy of stroke diagnosis.

In general, the statistical value of CPSS, MASS and LAPSS criteria in our study, mostly confirmed the results of previous studies which calls for testing reproducibility of these scales in different settings. LAPSS and CPSS were better in one of the two metrics

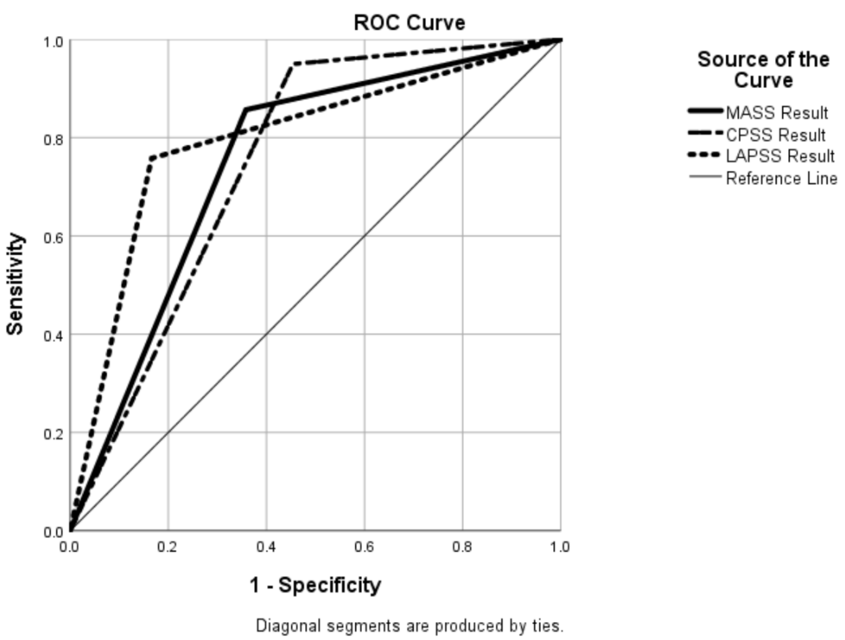

Figure 1. The ROC Curve of MASS, LAPSS, CPSS

ROC: Receiver operating characteristic, MASS: Melbourne Ambulance Stroke Scale, LAPSS: Los Angeles Prehospital Stroke Screen, CPSS: Cincinnati Prehospital Stroke Scale as assessed and MASS could be an appropriate alternative which provide reasonable sensitivity and specificity in stroke diagnosis.

Study Limitations

This study assessed the AIS diagnostic power of three stroke screening scales in a large population of patients with suspected stroke. Here we just considered those with signs of acute infarcts on brain MRI, and transient ischemic attack was not included.

Conclusion

Choosing the most efficient scale, with the best statistical value, for stroke screening is of paramount importance to ensure early and adequate management of stroke in the ED. Our study showed that the number of true positive cases diagnosed by CPSS was higher than those of MASS, and MASS true positives were higher than those diagnosed by LAPSS criteria. The number of true negative cases of LAPSS was higher than MASS criteria, and MASS true negatives were higher than CPSS criteria. The high prevalence of stroke in males, elders, those without history of seizure and those with a blood sugar level of 50 to 400 mg/dL calls for greater attention to this issue and greater emphasizes on the importance of enhanced physicians and patients' knowledge in these areas.

Ethics

Ethics Committee Approval: The implementation protocol was approved by the Ethics Committee of Tehran University of Medical Sciences (ethics code: IR.TUMS.MEDICINE.REC.1398.326, date: 06.07.2019).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Concept: A.P., S.K., A.B., Design: M.E., S.B., E.A., A.B., Data Collection or Processing: A.P., S.K., Analysis or Interpretation: M.E., S.B., E.A., A.B., Literature Search: M.E., A.B., Writing: A.P., S.K., M.E., S.B., E.A., A.B.

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References

1. Donkor ES. Stroke in the 21st Century: A Snapshot of the Burden, Epidemiology, and Quality of Life. Stroke Res Treat. 2018;2018:3238165.
2. Guzik A, Bushnell C. Stroke Epidemiology and Risk Factor Management. Continuum (Minneap Minn). 2017;23:15-39.
3. Karimi S, Heydari F, Mirbaha S, Elfil M, Baratloo A. Accuracy of prehospital ambulance stroke test in terms of diagnosis of patients with acute ischemic stroke: A multi-center study. Curr J Neurol. 2020;19:196-9.
4. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. 2018 Guidelines for the Early Management of Patients With Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. Stroke. 2018;49:e46-110.
5. Zhelev Z, Walker G, Henschke N, Fridhandler J, Yip S. Prehospital stroke scales as screening tools for early identification of stroke and transient ischemic attack. Cochrane Database Syst Rev. 2019;4:CD011427.
6. Kothari RU, Pancioli A, Liu T, Brott T, Broderick J. Cincinnati Prehospital Stroke Scale: reproducibility and validity. Ann Emerg Med. 1999;33:373-8.
7. Ramanujam P, Guluma KZ, Castillo EM, Chacon M, Jensen MB, Patel E, et al. Accuracy of stroke recognition by emergency medical dispatchers and paramedics--San Diego experience. Prehosp Emerg Care. 2008;12:307-13.
8. Kidwell CS, Saver JL, Schubert GB, Eckstein M, Starkman S. Design and retrospective analysis of the Los Angeles Prehospital Stroke Screen (LAPSS). Prehosp Emerg Care. 1998;2:267-73.
9. Kidwell CS, Starkman S, Eckstein M, Weems K, Saver JL. Identifying stroke in the field. Prospective validation of the Los Angeles prehospital stroke screen (LAPSS). Stroke. 2000;31:71-6.
10. Chen S, Sun H, Lei Y, Gao D, Wang Y, Wang Y, et al. Validation of the Los Angeles pre-hospital stroke screen (LAPSS) in a Chinese urban emergency medical service population. PLoS One. 2013;8:e70742.
11. Bray JE, Martin J, Cooper G, Barger B, Bernard S, Bladin C. Paramedic identification of stroke: community validation of the melbourne ambulance stroke screen. Cerebrovasc Dis. 2005;20:28-33.
12. Peisker T, Koznar B, Stetkarova I, Widimsky P. Acute stroke therapy: A review. Trends Cardiovasc Med. 2017;27:59-66.
13. Bergs J, Sabbe M, Moons P. Prehospital stroke scales in a Belgian prehospital setting: a pilot study. Eur J Emerg Med. 2010;17:2-6.
14. Bray JE, Coughlan K, Barger B, Bladin C. Paramedic diagnosis of stroke: examining long-term use of the Melbourne Ambulance Stroke Screen (MASS) in the field. Stroke. 2010;41:1363-6.
15. Rudd MP, Price CI, Ford GA. Prehospital stroke scales in urban environments: a systematic review. Neurology. 2015;84:962.
16. Kothari RU, Pancioli A, Liu T, Brott T, Broderick J. Cincinnati Prehospital Stroke Scale: reproducibility and validity. Ann Emerg Med. 1999;33:373-8.
17. Kothari R, Hall K, Brott T, Broderick J. Early stroke recognition: developing an out-of-hospital NIH Stroke Scale. Acad Emerg Med. 1997;4:986-90.
18. Studnek JR, Asimos A, Dodds J, Swanson D. Assessing the validity of the Cincinnati prehospital stroke scale and the medic prehospital assessment for code stroke in an urban emergency medical services agency. Prehosp Emerg Care. 2013;17:348-53.
19. Karimi S, Motamed H, Aliniagerdroudbari E, Babaniamansour S, Jami A, Baratloo A. The Prehospital Ambulance Stroke Test vs. the Cincinnati Prehospital Stroke Scale: a diagnostic accuracy study. Australasian Journal of Paramedicine. 2020;17. doi:10.33151/ajp.17.784
20. Purrucker JC, Hametner C, Engelbrecht A, Bruckner T, Popp E, Poli S. Comparison of stroke recognition and stroke severity scores for stroke detection in a single cohort. J Neurol Neurosurg Psychiatry. 2015;86:1021-8.
21. Brandler ES, Sharma M, Sinert RH, Levine SR. Prehospital stroke scales in urban environments: a systematic review. Neurology. 2014;82:2241-9.
22. Rudd M, Buck D, Ford GA, Price CI. A systematic review of stroke recognition instruments in hospital and prehospital settings. Emerg Med J. 2016;33:818-22.