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Short Communication

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A nomogram-based clinical tool for acute ischemic stroke screening in prehospital setting

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Alireza Baratloo[1,2], Mahtab Ramezani[3,4], Hosein Rafiemanesh[5,6], Meisam Sharifi[2], Somayeh Karimi[2]

[1] Research Center for Trauma in Police Operations, Directorate of Health, Rescue & Treatment, Police Headquarter, Tehran, Iran
[2] Prehospital and Hospital Emergency Research Center, Tehran University of Medical Sciences, Tehran, Iran
[3] Department of Neurology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[4] Skull Base Research Center, Loghman Hakim Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[5] Non-Communicable Diseases Research Center, Alborz University of Medical Sciences, Karaj, Iran
[6] Department of Epidemiology and Biostatistics, School of Public Health, Alborz University of Medical Sciences, Karaj, Iran

Keywords
Decision Support Techniques; Emergency Medical Services; Magnetic Resonance Imaging; Nomograms; Stroke

Abstract

Background: We believe that designing a new tool which is comparable in terms of both sensitivity and specificity may play an important role in rapid and more accurate diagnosis of acute ischemic stroke (AIS) in prehospital stage. Therefore, we intended to develop a new clinical tool for the diagnosis of AIS in the prehospital stage.

Methods: This was a cross-sectional diagnostic accuracy study. All patients transferred to the emergency department (ED) who underwent brain magnetic resonance imaging (MRI) with impression of AIS were evaluated by 9 clinical tools for stroke diagnosis in the pre-hospital phase including Rapid Arterial Occlusion Evaluation (RACE), Cincinnati Prehospital Stroke Scale (CPSS), Los Angeles Prehospital Stroke Screen (LAPSS), Melbourne Ambulance Stroke Screen (MASS), Medic Prehospital Assessment for Code Stroke (Med PACS), Ontario Prehospital Stroke Screening Tool (OPSS), PreHospital Ambulance Stroke Test (PreHAST), Recognition of Stroke in the Emergency Room (ROSIER), and Face Arm Speech Test (FAST), and totally 19 items were reviewed and recorded. The new clinical tool was developed based on backward method of multivariable logistic regression analysis. The discrimination power of the new clinical tool for diagnosis of AIS was assessed with the area under the receiver operating characteristic curve (AUC-ROC).

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Corresponding Author: Somayeh Karimi
Email: karimisomi@gmail.com

In the multivariable model, 8 items remained. **Results:** Data from 806 patients were analyzed; of them, 57.4% were men. The mean age of the study patients was 66.9 years [standard deviation (SD) = 13.9]. The AUC-ROC of the new clinical tool was 0.893 [95% confidence interval (CI): 0.869-0.917], and its best cut-off point was score ≥ 3 for positive AIS. At this cut-off point, sensitivity and specificity were 84.42% and 79.72%, respectively.
Conclusion: We introduced a new nomogram-based clinical tool for the diagnosis of AIS in the prehospital stage, which has acceptable specificity and sensitivity; moreover, it is comparable with previous tools.

Introduction

Acute ischemic stroke (AIS) is a medical emergency and immediate treatment is necessary. Thrombolysis as an effective treatment is now available for AIS in developing countries, but golden hour has been defined for it. Unfortunately, due to the delay in patients' referring, only 1%-8% of the patients with AIS benefit from this treatment.[1,2] Therefore, it is necessary to take executive measures to identify the patient with an AIS in the pre-hospital stage. In recent decades, several prehospital clinical tools have been introduced for this purpose. These tests often emphasize on avoidance of misdiagnosis of AIS cases, so their sensitivity is highlighted more, while the low specificity can lead to over-triage, overload of stroke centers, and wasting the resources.[3-6] We believe that designing a new tool that is comparable in terms of both sensitivity and specificity may play an important role in rapid and more accurate diagnosis of AIS in prehospital stage. Therefore, we intended to develop a new clinical tool for the diagnosis of AIS in the prehospital stage.

Materials and Methods

The present study was a multi-center cross-sectional diagnostic accuracy study conducted during first 3 months of 2020, in Tehran, Iran. This study was approved by the ethical committee of Tehran University of Medical Sciences (IR.TUMS.SINAHOSPITAL.REC.1400.047). All patients transferred to the emergency department (ED) who underwent brain magnetic resonance imaging (MRI) at the discretion of the responsible physician with impression of AIS were included. Patients who left the hospital against medical advice before performing brain MRI were excluded. To meet the objectives of this study, the minimum required sample size of 750 people was determined. Sampling was continued until the specified minimum sample size was reached.

A researcher-made checklist was used to collect information. The checklist consisted of three sections: the first part related to basic and demographic information of patients including age, gender, history of underlying diseases, etc.; the second part included items related to the 9 clinical tools [including Rapid Arterial Occlusion Evaluation (RACE), Cincinnati Prehospital Stroke Scale (CPSS), Los Angeles Prehospital Stroke Screen (LAPSS), Melbourne Ambulance Stroke Screen (MASS), Medic Prehospital Assessment for Code Stroke (Med PACS), Ontario Prehospital Stroke Screening Tool (OPSS), PreHospital Ambulance Stroke Test (PreHAST), Recognition of Stroke in the Emergency Room (ROSIER), and Face Arm Speech Test (FAST)] that in total, consisted of 19 items that were reviewed and recorded by the researcher on admission to the ED; and the third part included the final diagnosis of patients. The gold standard in this study for the diagnosis of AIS was the final opinion of a specialist physician based on brain MRI interpretation.

The data were described with the frequency with percentage and mean with standard deviation (SD), as appropriate. The final diagnosis of AIS based on brain MRI was considered as gold standard, and the frequency distribution of variable of each criterion between patients with and without stroke was compared with chi-square test. Besides, the univariate logistic regression analysis was conducted for all common variables presented in all 9 stroke screening criteria.

The new screening tool was developed based on backward method of multivariable logistic regression analysis. The discrimination power of new screening tool for diagnosis of AIS was assessed with the area under the receiver operating characteristic curve (AUC-ROC). We calculated the sensitivity, specificity, positive likelihood ratio (PLR), negative likelihood ratio (NLR), positive predictive value (PPV), and negative predictive value (NPV) with confidence interval (CI) of 95% in different cut-off points. The best cut-off point of new screening tool was reported using the Youden's J statistics. Moreover, we developed nomogram of new screening tool based on final multivariable logistic regression model. All analyses were performed using STATA software (version 14, Stata Corporation, College Station, TX, USA).

Results

In this study, data from 806 patients were analyzed; of them, 57.4% were men. The mean age of the study patients was 66.9 years (SD = 13.9). The univariate analysis of the "sensory (pain) perception only on one side vs. normal" [odds ratio (OR) = 38.57], "head and gaze deviation" (OR = 28.01), "unilateral arm/leg weakness or drift" (OR = 13.12), "arm drift or weakness/hand grip" (OR = 11.60), and "leg weakness/drift" (OR = 11.11) were stronger criteria for predicting diagnosis of AIS. In the multivariable model, 8 criteria were remained, of which "head and gaze deviation" (OR = 10.40), "sensory (pain) perception only on one side vs. normal" (OR = 8.81), and "blood glucose between 50 and 400 mg/dl" (OR = 9.73) were stronger criteria for predicting diagnosis of AIS (Table 1). The Nagelkerke R squared of this model was 0.573. The new clinical tool developed based on multivariable analysis. We developed a nomogram of the new clinical tool of the AIS diagnosis. Based on this nomogram, probability of AIS was higher than 90%, for patients with total score higher than 23 (Figure 1). The AUC-ROC of the clinical tool was 0.893 (95% CI: 0.869-0.917). The best cut-off point of new screening criteria was ≥ 3 for positive AIS. At this cut-off point, sensitivity and specificity were 84.42% and 79.72%, respectively.

Discussion

We recently evaluated the accuracy of previous known clinical tools with the same gold standard for the final diagnosis of AIS, as we used here in this study.[7] To reduce the interpretation bias, we made our discussion based on the findings of our previous survey, and compared the characteristics of the new tool with previous ones. At the best cut-off point, the new clinical tool had 89.3% accuracy. This finding revealed higher accuracy of the new tool than that of all other clinical tools in our previous study.[7]

It seems that developing LAPSS, like the new tool, was intended to increase the specificity, as its specificity in our previous study was calculated as 82.9% that was higher than all the other clinical tools, but 71.9% sensitivity raised some concerns regarding its safe use.[7] The same low sensitivity, even as low as 49%, has also been reported in other studies for LAPSS,[8] while the new tool, despite comparable specificity (79.72% vs. 82.90%), had higher sensitivity (84.42% vs. 71.90%).

When it comes to OPSS, we realized that it excluded hypoglycemic patients, terminally ill patients, those under palliative care, transient ischemic attack cases, and patients with Glasgow Coma Scale (GCS) less than 10, that none of them where considered neither in other clinical tools, nor in the new tool. It seems that OPSS tries to increase its specificity by such considerable exclusion criteria, but this strategy does not seem to have been very effective; as in our previous study, it had a very low specificity (almost 54.3%).[7]

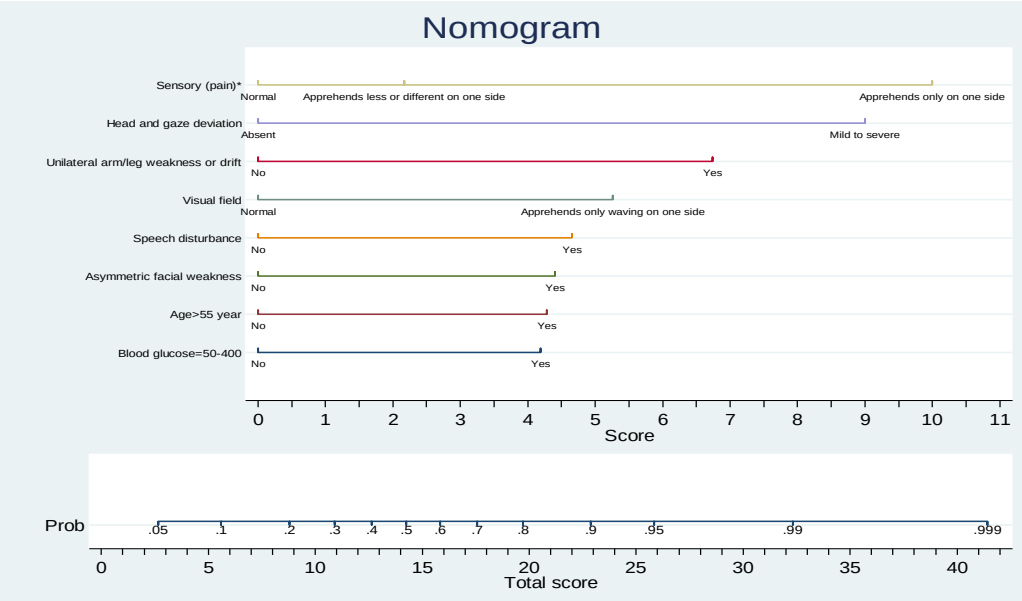

Figure 1. The nomogram of new screening tool of the acute ischemic stroke (AIS) (*Pinch the bend of the arms and legs, respectively. Pinch simultaneously at left and right side. Ask if she can feel the pinch in the same way on both sides)

Table 1. The distribution, univariate and multivariable logistic regression model of the acute ischemic stroke (AIS)

	Total number (n = 806)	Final diagnosis		Univariate analysis		Multivariable analysis	
		Stroke (n = 562)	Non-stroke (n = 244)	OR (95% CI)	P	OR (95% CI)	P
Facial droop or palsy[9]	342 (42.5)	311 (55.3)	31 (12.8)	8.43 (5.58-12.73)	< 0.001	2.36 (1.39-3.99)	0.001
Arm drift or weakness/hand grip[2]	511 (63.5)	449 (79.9)	62 (25.5)	11.60 (8.14-16.54)	< 0.001		
Speech disturbance or aphasia[9]	512 (63.6)	440 (78.3)	72 (29.6)	8.57 (6.09-12.04)	< 0.001	4.23 (2.68-6.67)	< 0.001
Absent history of seizure or epilepsy[5]	786 (97.5)	553 (98.4)	233 (95.5)	2.90 (1.19-7.09)	0.020		
Symptoms of the stroke have resolved[4]	40 (5.0)	23 (4.1)	17 (7.0)	0.57 (0.30-1.08)	0.085		
Blood glucose between 50 (or 60) and 400 mg/dl[6]	756 (98.1)	546 (99.3)	210 (95.0)	7.15 (2.25-22.70)	0.001	9.73 (1.62-58.39)	0.013
Leg weakness/drift[5]	501 (62.2)	441 (78.5)	60 (24.7)	11.11 (7.80-15.84)	< 0.001		
Blood sugar < 4 mmol/l[4]	8 (1.0)	4 (0.7)	4 (1.8)	0.40 (0.10-1.60)	0.193		
Loss of consciousness or syncope[9]	177 (22.0)	149 (26.5)	28 (11.5)	0.34 (0.22-0.53)	< 0.001		
Glasgow Coma Scale < 10[4]	35 (4.3)	31 (5.5)	4 (1.6)	3.45 (1.22-9.99)	0.020		
At baseline, patient is not wheelchair-bound or bedridden[1]	790 (98.0)	552 (98.2)	238 (97.5)	1.39 (0.50-3.87)	0.527		
Head & gaze deviation[7]	108 (13.4)	106 (18.9)	2 (0.8)	28.01 (6.86-114.46)	< 0.001	10.40 (1.29-83.98)	0.028
Age > 45 years[1]	751 (93.2)	532 (94.7)	219 (89.8)	2.02 (1.16-3.52)	0.016	2.69 (1.21-5.96)	0.015
Age > 55 years	720 (89.4)	513 (91.4)	207 (84.8)	1.91 (1.21-3.02)	0.006		
Symptom duration less than 24-25 hours[5]	700 (87.0)	522 (92.9)	178 (73.3)	4.76 (3.10-7.32)	< 0.001		
Unilateral arm/leg weakness or drift[4]	537 (66.8)	469 (83.6)	68 (28.0)	13.12 (9.17-18.77)	< 0.001	5.24 (3.29-8.34)	< 0.001
Terminally ill or palliative care patient[4]	18 (2.2)	14 (2.5)	4 (1.6)	1.53 (0.50-4.69)	0.460		
Visual field defect[8]	34 (4.3)	31 (5.6)	3 (1.3)	4.62 (1.40-15.25)	0.012	3.41 (0.78-14.88)	0.103
Commands (one or non-correct)[8]	136 (17.3)	112 (20.4)	24 (10.1)	1.51 (1.19-1.91)	0.001		
Sensory (pain)[8]							
0: Normal	401 (50.1)	199 (35.7)	202 (83.1)	1.0		1.0	
1: Perceived less or differently on one side	243 (30.4)	206 (37.0)	37 (15.2)	5.65 (3.79-8.44)	< 0.001	1.66 (0.97-2.83)	0.066
2: Perceived only on one side	156 (19.5)	152 (27.3)	4 (1.6)	38.57 (14.02-106.11)	< 0.001	8.81 (2.89-26.83)	< 0.001

Based on: 1. LAPSS: Los Angeles Prehospital Stroke Screen; 2. CPSS: Cincinnati Prehospital Stroke Scale; 3. FAST: Face Arm Speech Test; 4. OPSS: Ontario Prehospital Stroke Screening Tool; 5. Med PACS: Medic Prehospital Assessment for Code Stroke; 6. MASS: Melbourne Ambulance Stroke Screen; 7. RACE: Rapid Arterial Occlusion Evaluation; 8. PreHAST: PreHospital Ambulance Stroke Test; 9. ROSIER: Recognition of Stroke in the Emergency Room

Data are presented as number and percentage

OR: Odds ratio; CI: Confidence interval

Hypoglycemia is one of the most stroke-mimic situations that can easily be checked on patients' bedside. This item has been taken into consideration by the new tool as well as LAPSS, MASS, and Med PACS, while this is not considered in CPSS, FAST, ROSIER, and PreHAST. In our opinion, ignoring this important item is a significant weakness of other clinical tools that there can be no logical justification.

Limitations: The applicability of a tool in any emergency medical services depends on so many different factors and we did not assess the performance of this tool in the field. It is highly expected that level of knowledge and experience of the emergency medical technicians (EMTs) is one of the most important effective factors and preparing calculators on their cellphones or notebooks would be helpful.

Conclusion

We introduced a new nomogram-based clinical tool for the diagnosis of AIS in the prehospital stage, which has acceptable specificity and sensitivity, and is comparable with previous tools.

Conflict of Interests

The authors declare no conflict of interest in this study.

Acknowledgments

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