Research

The Prehospital Ambulance Stroke Test vs. the Cincinnati Prehospital Stroke Scale: a diagnostic accuracy study

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Abstract

Introduction

Immediate diagnosis of stroke is crucial in reducing its morbidity and mortality rate. There are various pre-hospital assessment tools, such as the Prehospital Ambulance Stroke Test (PreHAST) and the Cincinnati Prehospital Stroke Scale (CPSS) used to identify stroke early in the chain of care. The aim of this study is to compare the accuracy of PreHAST with CPSS in diagnosing stroke.

Methods

In this diagnostic accuracy study patients with suspicion of stroke were included in this study. In CPSS, the criterion used to indicate stroke are facial droop, speech and arm drift. In PreHAST it is eye position, visual field, facial palsy, right and left arms paresis, right and left legs paresis, sensory and speech. After data collection, sensitivity and specificity were calculated using standard formulae. Different cut-off points for the best diagnostic accuracy were examined in both CPSS and PreHAST.

Results

In this study, 883 patients were investigated. The results demonstrated that in CPSS, the highest specificity and sensitivity was for facial droop (84.9%) and arm drift (82.7%); and in PreHAST it was eye position (99.6%) and facial palsy (49.2%). The best predictor of stroke in CPSS with highest sensitivity (78.5%) and specificity (66%) was a cut-off point of 1.5 (AUC: 0.744) ($p < 0.01$). In PreHAST, the highest sensitivity (68.4%) was a cut-off point of 2.5 and the highest specificity (90.2%) was a cut-off point of 5.5 (AUC: 0.775) ($p < 0.01$).

Conclusion

Both PreHAST and CPSS are useful screening tools in the pre-hospital diagnosis of stroke. In addition to high sensitivity, these tests provide a grading system in which higher cut-off points lead to higher specificity.

Keywords:

stroke; emergency medical services; triage; diagnosis; symptom assessment

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Introduction

Stroke is one of the most common causes of disability-adjusted life years (DALYs) and the third highest cause of death worldwide with a burden of 5.7 million people (1-3). On average, one person dies of stroke every 3 minutes in the United States and 50% of these deaths take place in the pre-hospital setting (4-6). Brain cells are highly vulnerable to ischaemia, thrombosis of a large vessel can destroy 1.9 million neurons per minute and has a high morbidity and mortality rate – hence the phrase, ‘time is brain’ (7-11). 2018 American Heart Association and American Stroke Association guidelines state the best way to manage patients with acute ischaemic stroke is immediate diagnosis with high reliability, and a timely start of thrombolytic medications or mechanical clot retrieval (12-15). Both therapeutic methods are time sensitive, therefore stroke diagnosis and determination of its severity in the pre-hospital setting is of paramount importance in order to obtain best results (16-18). Unfortunately, only half of patients with stroke call emergency medical services (EMS) for primary triage and only 15–60 of patients with stroke symptoms are referred to hospital in the first 3 hours (19-21). On the other hand, a study in 2017 estimated the rate of stroke under-diagnosis from 2% to 26% and the rate of stroke over-diagnosis from 30% to 43% in the emergency department (ED) setting (22). Given the impossibility of performing para-clinical diagnostic tests at pre-hospital stage in most countries, diagnosis and decision-making must be done based on clinical presentation. Some studies have investigated the best pre-hospital diagnostic tests based on findings of physical examination with high precision and high sensitivity in the early triage of stroke patients (23). The Cincinnati Prehospital Stroke Scale (CPSS) is one of the most commonly used pre-hospital tests used to assess symptoms based on the simplification of the National Institute of Health Stroke Scale (NIHSS), in which the presence of at least one of the three signs of facial palsy, unilateral arm weakness or speech impairment is considered as positive (24-26). The Prehospital Ambulance Stroke Test (PreHAST) was introduced in 2017 and consists of eight signs based on the NIHSS and a deficit in any sign (score 1 to 19) is defined as positive (16). In a systematic review in 2014, sensitivity and specificity of CPSS was reported at 79–95% and 24–56%, respectively; while the sensitivity and specificity of PreHAST (score of equal or more than 1 point) in stroke diagnosis was estimated at 100% and 40%, respectively (16,27). As PreHAST has not yet been compared to other scales in a similar population, we aimed to compare the accuracy of PreHAST to CPSS in terms of diagnosis of patients referred to an ED by EMS with a suspicion of stroke.

Methods

Study design

This diagnostic accuracy study was a multicentre survey conducted in the ED of four teaching hospitals in Iran during

2018 and 2019. The implementation of the project was approved by the Ethics Committee of Tehran University of Medical Sciences (Ethic Code: IR.TUMS.MEDICINE.REC.1398,166). The patients joined the study after taking informed consent and the study did not impose any additional costs on patients or on the health system.

Participants

Patients more than 18 years of age who underwent a brain magnetic resonance imaging (MRI) with suspicion of stroke in the 12–24 hours after arriving to the ED. Information defect or inconsistencies in the recorded findings were considered as exclusion criteria. According Andsberg et al with assumption of sensitivity at 100% and specificity at 44%, accuracy at 95% and error at 5%, sample size was calculated at at least 996 people. Sampling was carried out retrospectively in sequential manner (16).

Test methods

Evaluation of stroke was based on PreHAST and CPSS. In CPSS criterion, three signs including facial droop, speech and arm drift were assessed to indicate a stroke, with the presence of one of the three signs considered as positive. PreHAST consists of eight signs: eye position, visual field, facial palsy, right and left arms paresis, right and left legs paresis, sensory and speech. The test scores stroke severity from 0 to 19 points and a score equal or more than 1 point is considered as positive.

All data were collected in a checklist of three sections based on the patient's file records. The first section was about basic information and demographic data including age, gender, past medical history (ischaemic heart disease, seizure, diabetes mellitus, hypertension, hyperlipidemia, stroke and coagulopathy), smoking habits, blood sugar level and the duration from symptom onset to arrival at the ED. Blood sugar was measured by glucometer (Accucheck, Roche, Germany). The second section included physical examination results associated with the eight items of PreHAST and three items of CPSS. The third section was devoted to the final diagnosis based on brain MRI reports confirmed by two radiologists.

Analysis

All data was added to SPSS version 24 (SPSS Inc., Chicago, IL, USA) and analysed. Continuous variables were described using mean $\pm$ standard deviation and categorical variables were described using frequency and percentage. In order to evaluate frequency among the categorical variables chi-square test and Fisher's exact test were used, one-way ANOVA test and independent t-test were applied to analyse the relationship between categorical and continuous variables. A p-value less than 0.05 was considered as statistically significant. Collected data from PreHAST and CPSS were compared with the final diagnosis after performing Bonferroni correction. Sensitivity,

specificity, accuracy, positive predictive value (PPV) and negative predictive value (NPV) for three CPSS items and eight PreHAST items were measured separately using statistical tests. In order to examine the strengths of the test and determine the best cut-off point ROC curve and the area under the curve (AUC) were used.

Results

Participants

Documents of 1000 patients were investigated, 117 were excluded. Finally, 883 patients with an average age of 67.20 ± 13.66 years with suspicion of stroke entered the study, 505 (57.2%) were men. The final diagnosis was stroke in 618 of the cases (70%). Basic and demographic information of studied patients is summarised in Table 1.

Table 1. Baseline characteristics of studied patients and their relationship with final diagnosis

Variable	Frequency (percent)	p-value*
Gender		
Female	378 (42.8%)	0.07
Male	505 (57.2%)	
Past medical history		
Smoker	134 (15.2%)	0.75
Hypertension	546 (61.6%)	0.11
Ischaemic heart disease	293 (33.2%)	0.13
Diabetes mellitus	293 (33.2%)	0.21
Coagulopathy	79 (8.9%)	<0.01
Stroke	174 (19.7%)	0.40
Hyperlipidemia	176 (19.9%)	0.27
Seizure	30 (3.4%)	0.06

* p-value refers to the relationship between each variable and final diagnosis of stroke

Previously, only a medical history of coagulopathy had a significant relationship with stroke ($p<0.01$) (Table 1). Results also showed the incidence of stroke increased significantly with increasing age ($p<0.01$) and mean level of blood sugar was significantly higher in non-stroke patients ($p=0.04$). Comparing

the duration from symptom onset to arrival at the ED with a stroke diagnosis revealed that patients with stroke diagnosis were significantly referred to the hospital in a shorter time ($p<0.01$) (Table 2).

Test results

The chi-square test showed that abnormal cases in each of the three items in CPSS and in each of the eight items in PreHAST were significantly higher in patients with a final diagnosis of stroke ($p<0.05$) (Table 3). However, after performing Bonferroni correction, arm drift and visual field had no significant difference with the final diagnosis of stroke, but the difference of other items was still statistically significant.

The study also showed that the highest specificity and sensitivity in CPSS was for facial droop (84.9%) and arm drift (82.7%); and in PreHAST, eye position (99.6%) and facial palsy (49.2%) (Table 4).

Table 4. Sensitivity and specificity of CPSS and PreHAST items

Test		Sensitivity	Specificity
CPSS	Facial droop	49%	84.9%
	Arm drift	82.7%	23.4%
	Speech	77.5%	60.8%
PreHAST	Commands	16.7%	97%
	Eye position	16.2%	99.6%
	Visual field	5.3%	98.1%
	Facial palsy	49.2%	76.6%
	Right arm paresis	Score 1	17.6%
		Score 2	17.6%
	Left arm paresis	Score 1	14.1%
		Score 2	24.3%
	Right leg paresis	Score 1	17.3%
		Score 2	17.8%
	Left leg paresis	Score 1	16%
		Score 2	21.8%
	Sensory	Score 1	34.6%
		Score 2	24.8%
	Speech	Score 1	43.5%
		Score 2	23.9%

Table 2. The relationship between continuous variables and stroke

Variable	Stroke				p-value*
	Positive (n=618)		Negative (n=265)		
	Mean	SD	Mean	SD	
Age (years)	68.22	13.29	64.85	14.24	<0.01
Blood sugar level (mg/dL)	152.41	67.95	165.28	96.41	0.04
Duration from symptom onset to arrival at ED (hour)	4.21	6.71	11.92	10.09	<0.01

* p-value refers to the relationship between each continuous variable and final diagnosis of stroke

Table 3. Relationship between CPSS and PreHAST items and final diagnosis of patient

Item		Stroke		p-value*
		Positive (n=618)	Negative (n=265)	
Facial droop	Normal	315	225	<0.01
	Abnormal	303	40	
Speech	Normal	139	161	<0.01
	Abnormal	479	104	
Arm drift	Normal	107	62	0.04
	Abnormal	511	203	
Commands	Both correct (0)	515	257	<0.01
	One or none correct (2)	103	8	
Eye position	Normal (0)	518	264	<0.01
	The patient 'gaze' at one side without purpose (2)	100	1	
Visual field	Normal (0)	585	260	0.01
	Perceives only waving on one side (2)	33	5	
Facial palsy	Normal (0)	314	203	<0.01
	One corner of the mouth hanging (1)	304	62	
Right arm paresis	Holds for 10 seconds (0)	400	238	<0.01
	Drifts but does not reach bed in 10 seconds (1)	109	25	
	Drifts and reaches bed in 10 seconds or falls immediately (2)	109	2	
Left arm paresis	Holds for 10 seconds (0)	381	220	<0.01
	Drifts but does not reach bed in 10 seconds (1)	87	27	
	Drifts and reaches bed in 10 seconds or falls immediately (2)	150	18	
Right leg paresis	Holds for 5 seconds (0)	401	236	<0.01
	Drifts but does not reach bed in 5 seconds (1)	107	25	
	Drifts and reaches bed in 5 seconds or falls immediately (2)	110	4	
Left leg paresis	Holds for 5 seconds (0)	384	221	<0.01
	Drifts but does not reach bed in 5 seconds (1)	99	26	
	Drifts and reaches bed in 5 seconds or falls immediately (2)	135	18	
Sensory	Normal (0)	251	216	<0.01
	Perceives less or different on one side (1)	214	45	
	Perceives only on one side (2)	153	4	
Speech	Normal (0)	201	178	<0.01
	Slight or moderate dysarthria or aphasia. Communication possible (1)	269	79	
	Severe dysarthria or aphasia. Communication not intelligible (2)	148	8	

*p-value refers to the relationship between each item and the final diagnosis of stroke

The best predictor of stroke in CPSS with a maximum sensitivity of 78.5% and specificity of 66% was a cut-off point of 1.5. In a cut-off point of 1.5, the highest sensitivity was 78.5% and in a cut-off point of 2.5, the highest sensitivity was 91.3%. (AUC: 0.744, $p < 0.01$) (Table 5, Figure 1).

The best predictor score for stroke in PreHAST was a cut-off point of 2.5–5.5, and it has the highest sensitivity (68.4%) in cut-off point of 2.5 and highest specificity (90.2%) in a cut-off point of 5.5 (AUC: 0.775) ($p < 0.01$) (Table 5, Figure 2).

Discussion

In our study, CPSS and PreHAST had high sensitivity and specificity in diagnosing stroke. CPSS had the highest sensitivity at a cut-off point of 1.5 and the highest specificity at a cut-off point of 2.5. PreHAST had the best predictor status at cut-off points of 2.5, 3.5, 4.5 and 5.5. On both tests, with an increase in cut-off points, the sensitivity was decreased and the specificity was increased.

Andsberg et al investigated the ability of PreHAST in diagnosing stroke and transient ischaemic attack. They showed that the test required 2–3 minutes to execute and a positive PreHAST increased the diagnostic sensitivity and specificity up to 100% and 40%, respectively. It also revealed that PPV was

50% among patients with a positive test, and NPV was 100%. The ROC analysis showed an AUC of 0.77. The best predictor was for PreHAST with 5 points that had 90% specificity and 20% sensitivity. The study attributed high limitation of CPSS to its fewer items as it could not evaluate isolated hemianopia, neglect or leg paresis (16). The results were similar to the results in our study.

Zhao et al investigated pre-hospital measures such as CPSS in the diagnosis of stroke among 565 patients with suspicion of stroke. They showed that the sensitivity and specificity of CPSS in diagnosing stroke with minimum score of 2 was 56% and 86%, respectively, with an AUC of 0.71 (28). Our study also showed the same results.

In another study conducted by Katz et al, the ability of CPSS in diagnosing stroke was assessed and showed that CPSS is a test with high sensitivity and favorable specificity. This test can evaluate the patient faster due to its dichotomous answers. They found that CPSS with a score of equal or more than 2 (AUC of 0.89) diagnosed moderate stroke (NIHSS ≥ 10) with lower sensitivity (75%) and higher specificity (85%) in comparison with severe stroke (NIHSS 15) with a sensitivity of 89% and specificity of 73% (19). In contrast, in our study the specificity was higher in higher scores and sensitivity was higher in lower scores.

Table 5. Results from the ROC-curve analysis for various cut-off points of CPSS and PreHAST

Area under the curve								
Test result variable(s)	Area	Cut-off	Sensitivity	Specificity	Std. error	Asymptotic sig.	Asymptotic 95% confidence interval	
							Lower bound	Upper bound
CPSS	.744	1.50	78.5%	66%	.018	.000	.709	.779
		2.50	36.4%	91.3%				
Pre HAST	.775	2.50	68.4%	76.2%	.016	.000	.745	.806
		3.50	63.8%	81.9%				
		4.50	56.5%	86.4%				
		5.50	47.6%	90.2%

Figure 1. ROC curve of CPSS

Figure 2. ROC curve of PreHAST

Studnek et al investigated the validity of CPSS and Medic Prehospital Assessment for Code Stroke (Med PACS) in pre-hospital diagnosis of stroke among 461 suspected patients. They indicated that the sensitivity of CPSS was 79%, higher than Med PACS with a sensitivity of 74%. But the specificity of both tests was low: 23.9% and 32.6%, respectively. In our study we found a more valuable role for CPSS in diagnosing stroke by differentiation of two effective cut-off points with higher sensitivity and specificity. The difference between the results of the two studies may be due to the lower study population in the study of Studnek (29).

In a study by Maddali et al the validity of CPSS was assessed in comparison to the findings on computed tomography (CT) among 66 patients with suspected stroke. They revealed that 62 patients (93%) had stroke and the sensitivity of CPSS was 81% when combined with a CT scan. Only seven patients (11%) with an abnormal CT scan had zero points in the CPSS test. The study showed that CPSS items including facial droop, arm drift and speech were impaired in 71% and 80% and 74% of patients, respectively. Sensitivity and specificity for facial droop was 75.8% and 100%; arm drift 79.03% and 75%, and for speech it was 74.1% and 100%, respectively (30). Our study also showed that the highest sensitivity for arm drift and the highest specificity for facial droop.

Kummer et al investigated CPSS sensitivity and specificity among 751 patients with acute ischaemic stroke in the United States. They showed that using the cut-off point of 2, CPSS had 87.2% sensitivity and 94.3% specificity in diagnosing severe stroke (31). Accordingly, our study showed that the highest specificity was a cut-off point of 2.5. Removal of some patients before final diagnosis and high missing rate of some variables were problems encountered in this study. It is hoped that in future studies, sensitivity and specificity of various tests be differentiated for different types of stroke and true and false negative causes also be investigated.

Conclusion

Both PreHAST and CPSS are useful screening tools in the pre-hospital diagnosis of stroke. In addition to high sensitivity, these tests provide a grading system in which higher cut-off points lead to higher specificity.

Competing interests

The authors declare no competing interests. Each author of this paper has completed the ICMJE conflict of interest statement.

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