






RESEARCH

Open Access



The Rapid Arterial Occlusion Evaluation (RACE) scale accuracy for diagnosis of acute ischemic stroke in emergency department – A multicenter study

Hosein Rafiemanesh^{1,2} , Negin Barikro³, Somayeh Karimi³ , Mehran Sotoodehnia³ , Alireza Jalali³  and Alireza Baratloo^{3*} 

Abstract

Objective It seems that the available data on performance of the Rapid Arterial Occlusion Evaluation (RACE) as a prehospital stroke scale for differentiating all AIS cases, not only large vessel occlusion (LVO), from the stroke mimics is lacking. As a result, we intend to evaluate the accuracy of the RACE criteria in diagnosing of AIS in patients transferred to the emergency department (ED).

Method The present study was a diagnostic accuracy cross-sectional study during 2021 in Iran. The study population consist of all suspected acute ischemic stroke (AIS) patients who transferred to the ED by emergency medical services (EMS). A 3-part checklist consisting of the basic and demographic information of the patients, items related to the RACE scale, and the final diagnosis of the patients based on interpretation of patients' brain MRI was used for data collection. All data were entered in Stata 14 software. We used the ROC analysis to evaluate the diagnostic power of the test.

Result In this study, data from 805 patients with the mean age of 66.9 ± 13.9 years were studied of whom 57.5% were males. Of all the patients suspected of stroke who transferred to the ED, 562 (69.8%) had a definite final diagnosis of AIS. The sensitivity and specificity of the RACE scale for the recommended cut-off point (score ≥ 5) were 50.18% and 92.18%, respectively. According to the Youden J index, the best cut-off point for this tool for differentiating AIS cases was a score > 2 , at which sensitivity and specificity were 74.73% and 87.65%, respectively.

Conclusion It seems that, the RACE scale is an accurate diagnostic tool to detect and screen AIS patients in ED, Of course, not at the previously suggested cut-off point (score ≥ 5), but at the score > 2 .

Keywords Decision support techniques, Emergency service, hospital, Stroke

*Correspondence:

Alireza Baratloo

alirezabaratloo@yahoo.com; arbaratloo@sina.tums.ac.ir

¹Non-communicable Diseases Research Center, Alborz University of Medical Sciences, Karaj, Iran

²Department of Epidemiology and Biostatistics, School of Public Health, Alborz University of Medical Sciences, Karaj, Iran

³Department of Emergency Medicine, Sina Hospital, Tehran University of Medical Sciences, Tehran, Iran



© The Author(s) 2023. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>. The Creative Commons Public Domain Dedication waiver (<http://creativecommons.org/publicdomain/zero/1.0/>) applies to the data made available in this article, unless otherwise stated in a credit line to the data.

Introduction

Stroke is one of the most common leading cause of both disability and death worldwide, and more than 80% of stroke cases are ischemic types globally [1]. Despite of introduction of intravenous thrombolytic therapy and also mechanical thrombectomy for curing acute ischemic stroke (AIS) patients, due to various reasons, less than 5% of eligible AIS patients received such treatment in the therapeutic window period [2–4]. It seems that due to the delay in referring patients, considerable number of AIS patients lose the chance to receive treatment [5, 6]. Therefore, various interventions have been considered and applied by health care systems during the last decades to reduce the time between AIS onset and starting an appropriate management [7–9]. One of the most important measures was the reduction of wasting time both at the pre-hospital phase and also after admission to the emergency department (ED) [10, 11]. Several stroke screening tools have been designed in this regard that can accurately predict stroke [11], that mostly applied in prehospital setting and their performance has been rarely evaluated in ED environment. Rapid Arterial occlusion Evaluation (RACE) scale is one of such tools that designed by Pérez de la Ossa et al. not only for screening the stroke cases, but also to differentiate large vessel occlusion (LVO) cases than the others [12]. Despite of high sensitivity and negative predictive value in the primary derivation/validation study, various results were further reported by other investigators about it [13, 14]. It seems that the available data on its performance is still under debate and more focused on differentiating LVO cases and not all AIS patients, and to the best of our knowledge, no one has tested its performance in the ED till yet. We believed that it needs more study to resolve the current controversies, and more importantly, accuracy of RACE for differentiating all AIS cases from the stroke mimics should be evaluated. As a result, we intend to evaluate the accuracy of the RACE criteria in diagnosing of AIS in patients transferred to the ED.

Methods

Study design and population

The present study was a diagnostic accuracy cross-sectional study that was conducted from 15 to 2021 until 28 December 2021. The research environment was the ED of research, educational and medical centers in Tehran, Isfahan, and Ahvaz cities, in Iran. The study population was all patients who transferred to the ED by EMS with suspected AIS diagnosis.

According to a study by Pérez de la Ossa et al. [12], assuming a sensitivity of 100% and a specificity of 44%, the prevalence of AIS (patients suspected of stroke transferred to an emergency department) was 45%, estimation

accuracy was 95% and error was 5%. The sample size was 841 people.

Data collection

For this purpose, a checklist consisting of three sections was prepared. The first part related to the basic and demographic information of the patients including age, gender, history of underlying diseases, etc.; the second part consisted of 5 items related to the RACE scale [facial palsy (scored 0–2), arm motor function (0–2), leg motor function (0–2), gaze (0–1), and aphasia or agnosia (0–2); each person can obtain between zero to 9 points]; and the third part included the final diagnosis. The diagnosis of AIS was made based on the findings of physical examination and also interpretation of patients' brain magnetic resonance imaging (MRI) which is considered as the gold standard method of AIS diagnosis in the current study.

Sampling was conducted prospectively. From the beginning of the study period, the checklist was included in the patients' hospital files to assess proper neurological examination of patients with any neurological complaints. A postgraduate year (PGY)-2 neurology resident used the RACE scale to evaluate the suspected patients and recorded all documents in the checklist when the patient had been arrived in the ED. A double check on the checklist was also performed by a PGY-3 emergency medicine resident.

Statistical analysis

The data collected by patient evaluation according to RACE scale was compared with the results of the physician's diagnosis, as gold standard. We used the ROC curve and the area under the ROC curve (AUC) to evaluate the differentiated power of the RACE scale. The accuracy indices of RACE scale, like sensitivity, specificity, positive and negative predictive value calculated for different cut-off point. To determine the best cutoff point, we used the Youden index and the maximum of vertical distance of ROC curve from the point (x, y) on diagonal line. Also, we used of the univariable and multivariable logistic regression model for assess of effect size of any RACE criteria scale in AIS diagnosis. All statistical analysis conducted with Stata 14 software, College Station, TX: StataCorp LP. The statistical analysis conducted menu-base if available in the software and commands are used to perform ROC analysis, like `roctab`, `dtroc`, and `cutpt` (option: `near` and `youden`) syntax. Also, we used of `tabulate` data for calculate of specifying detail of indices of RACE scale performance for each of the possible cut-points.

Results

Baseline findings

In this study, data from 805 patients with suspected AIS transferred to the ED were collected. There were 463 (57.5%) males and 342 (42.5%) females among the studied patients. The mean age \pm standard deviation (SD) of the patients was 66.9 ± 13.9 years, and the age range of the patients varied between 6 and 95 years. Table 1 presents some of frequency distribution of risk factors and underline diseases in the study patients.

The mean blood glucose level of the patients on arrival to the ED was 148.2 ± 68.1 mg/dL, and its range varied between 27.0 and 560.0 mg/dL. The mean time interval between the onset of symptoms and the arrival at the ED was 8.4 ± 9.9 h and median was 2.5 h, that varied between half an hour to 72 h.

Of all the patients suspected of stroke who transferred to the ED, 562 (69.8%) had a definite final diagnosis of AIS, and the rest of 243 (30.2%) patients were negative for this diagnosis. In other words, the prevalence of AIS in transferred patients was 69.8% (95% CI: 66.6 to 73.0%). Patients with a positive diagnosis of AIS were older than patients with a negative diagnosis. The mean age of the patients with and without AIS was 68.1 ± 13.2 years and 64.1 ± 14.9 years, respectively ($p < 0.001$). The prevalence of AIS was also higher in men than women (73.9% vs. 64.3%; $p = 0.004$). Besides that, this prevalence of AIS

diagnosis was higher in patients with a history of ischemic heart disease than patients without a similar history (74.9% vs. 67.1%; $p = 0.021$).

Detailed results of RACE criteria

Based on the total RACE score, 221 patients (27.5%) had a score of zero. The prevalence of AIS in patients with a zero score was 29.4%, while this value was 100% for patients with a score of 8 and 9 (Table 2).

Assessment of the relationship between each item of the RACE criterion showed that all items of this criterion have a statistically significant relationship with the final diagnosis of stroke. So that the frequency of disorders in each item was higher in patients who had a definitive diagnosis of AIS than the others (Table 3).

The accuracy of AIS diagnosis, and best diagnostic cut-off points

The area under the ROC curve of the RACE scale in the diagnosis of AIS was 0.86 (95% confidence interval (CI): 0.83 to 0.88; $p < 0.001$). (Fig. 1).

The recommended cut-off point for the RACE tool for stroke screening in suspected patients was a score greater than 4. Based on this cut-off point, 62.8% of the patients had an appropriate classification. In other words, at this cut-off, 19 patients (2.4%) were negatively screened for AIS by mistake (false negative), and 280 patients (34.8%)

Table 1 Frequency distribution of risk factors and underline diseases in the study patients

Variable	Number (%)	Total	Missing
Smoking			number
Yes	143 (17.8)	803	2
No	660 (82.2)		
Hypertension			
Yes	506 (62.9)	804	1
No	298 (37.0)		
Ischemic heart disease			
Yes	287 (35.7)	804	1
No	517 (64.3)		
Diabetes			
Yes	245 (30.5)	803	2
No	558 (69.5)		
Coagulopathy			
Yes	23 (2.9)	802	3
No	779 (97.1)		
Cerebrovascular accident			
Yes	127 (15.8)	805	0
No	678 (84.2)		
Hyperlipidemia			
Yes	161 (20.0)	803	2
No	642 (80.0)		
Epilepsy			
Yes	19 (2.4)	804	1
No	785 (97.6)		

Table 2 Frequency distribution (prevalence) of AIS in the patients with suspected stroke transferred to emergency department by RACE score

RACE score	Total patient for each score	Definite diagnosis of acute ischemic stroke	
		Positive	Negative
		Number (%)	
0	221	65 (29.4)	156 (70.6)
1	31	14 (45.2)	17 (54.8)
2	103	63 (61.2)	40 (38.8)
3	52	45 (86.5)	7 (13.5)
4	97	93 (95.5)	4 (4.1)
5	45	37 (82.2)	8 (17.8)
6	83	77 (92.8)	6 (7.2)
7	78	73 (93.6)	5 (6.4)
8	63	63 (100)	0 (0.0)
9	32	32 (100)	0 (0.0)

Table 3 Frequency distribution and relationship of each RACE criteria with a definitive diagnosis of AIS in the patients with suspected stroke transferred to emergency department (n = 805)

Variable	Total number (%)	Final diagnosis		P-value
		Stroke (n = 562)	Non-stroke (n = 243)	
Facial Palsy				<0.001
Absent (0)	455 (56.5)	248 (44.1)	207 (85.2)	
Mild (1)	82 (10.2)	75 (13.3)	7 (2.9)	
Moderate to severe (2)	268 (33.3)	239 (42.5)	29 (11.9)	
Arm Motor Function				<0.001
Normal to mild (0)	350 (43.4)	144 (25.6)	206 (84.8)	
Moderate (1)	173 (21.5)	151 (26.9)	22 (9.1)	
Severe (2)	282 (35.0)	267 (47.5)	15 (6.2)	
Leg Motor Function				<0.001
Normal to mild (0)	371 (46.1)	167 (29.7)	204 (84.0)	
Moderate (1)	170 (21.1)	149 (26.5)	21 (8.6)	
Severe (2)	264 (32.8)	246 (43.8)	18 (7.4)	
Head & Gaze Deviation				<0.001
Absent (0)	697 (86.6)	456 (81.1)	241 (99.2)	
Present (1)	108 (13.4)	106 (18.9)	2 (0.8)	
Aphasia or Agnosia				<0.001
Normal (0)	354 (44.0)	159 (28.3)	195 (80.2)	
Moderate (1)	222 (27.6)	195 (34.7)	27 (11.1)	
Severe (2)	229 (28.4)	208 (37.0)	21 (8.6)	

were positively screened for AIS incorrectly (false positive). However, the highest percentage of correct classification (81.5%) and consequently the lowest error in screening according to RACE tool related to the cut-off point greater than one (Table 4).

The sensitivity and specificity of RACE scale for the recommended cut-off point (score > 4) were 50.18% and 92.18%, respectively. According to the Youden J index and maximum of vertical distance, the best cut-off point for this tool was a score greater than 2, at which sensitivity and specificity were 74.73% and 87.65%, respectively. In the best cut-off point the positive and negative predictive values of the RACE tool were 93.3% and 60.0%, respectively (Table 5).

Logistic regression results of RACE scale

Logistic regression analysis showed that among the RACE criteria in univariable analysis, all criteria unaccompanied had a significant relationship with AIS diagnosis, to put it another way, the risk of AIS in patients for whom each of the criteria was positive was significantly higher and this relation for the “Head & Gaze Deviation” criterion was the highest, and the risk of AIS in the patients who were positive for this criterion was more than 28 times than that of the patients who were not.

Multivariable regression showed that the variables “Arm Motor Function” and “Head & Gaze Deviation” had the highest and most significant relationship with AIS diagnosis. So, the risk of AIS for the patients with

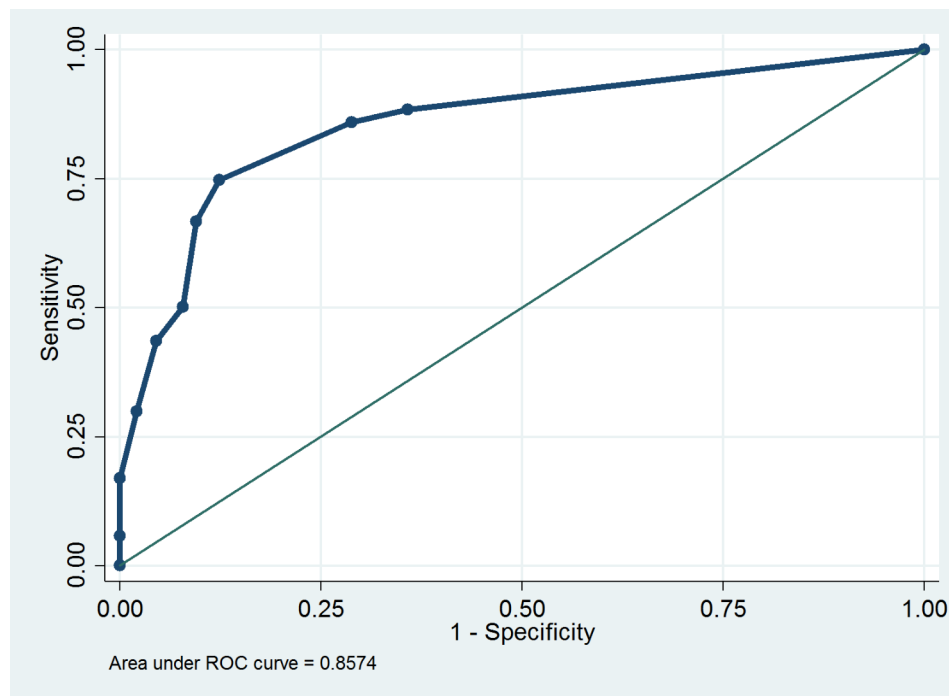


Fig. 1 ROC curve for RACE scale in the diagnosis of AIS in patients suspected of stroke transferred to emergency department

Table 4 Frequency distribution of true and false positives and negatives in the diagnosis of AIS based on various cut-off points of the RACE scale and the percentage of correct classification

Cut-off point	Diagnosis of stroke				Correct classification (%)
	True negative Number (%)	False negative	True positive	False positive	
>0	156 (19.4)	87 (10.8)	497 (61.7)	65 (8.1)	81.1
>1	173 (21.5)	70 (8.7)	483 (60.0)	79 (9.8)	81.5
>2	213 (26.5)	30 (3.7)	420 (52.2)	142 (17.6)	78.7
>3	220 (27.3)	23 (2.9)	375 (46.6)	187 (23.2)	73.9
>4	224 (27.8)	19 (2.4)	282 (35.0)	280 (34.8)	62.8
>5	232 (28.8)	11 (1.4)	245 (30.4)	317 (39.4)	59.2
>6	238 (29.6)	5 (0.6)	168 (20.9)	394 (48.9)	50.5
>7	243 (30.2)	0 (0.0)	95 (11.8)	467 (58.0)	42.0
>8	243 (30.2)	0 (0.0)	32 (4.0)	530 (65.8)	43.2

Table 5 Accuracy and predictive value indicators for RACE tool at different cut-off points for screening of AIS

Optimal cutoff point	Sensitivity Value (95% CI)	Specificity	PLR	NLR	PPV	NPV
>0	88.43 (85.5–91.0)	64.20 (57.8–70.2)	2.47 (2.1–2.9)	0.18 (0.1–0.2)	85.1 (82.0–87.9)	70.6 (64.1–76.5)
>1	85.94 (82.8–88.7)	71.19 (65.1–76.8)	2.98 (2.4–3.6)	0.20 (0.2–0.2)	87.3 (84.3–90.0)	68.7 (62.5–74.3)
>2*	74.73 (70.9–78.3)	87.65 (82.8–91.5)	6.05 (4.3–8.5)	0.29 (0.2–0.3)	93.3 (90.6–95.5)	60.0 (54.7–65.1)
>3	66.73 (62.7–70.6)	90.53 (86.1–93.9)	7.05 (4.8–10.4)	0.37 (0.3–0.4)	94.2 (91.5–96.3)	54.1 (49.1–59.0)
>4	50.18 (46.0–54.4)	92.18 (88.1–95.2)	6.42 (4.1–10.0)	0.54 (0.5–0.6)	93.7 (90.3–96.2)	44.4 (40.1–48.9)
>5	43.59 (39.4–47.8)	95.47 (92.0–97.7)	9.63 (5.4–17.3)	0.59 (0.5–0.6)	95.7 (92.4–97.8)	42.3 (38.1–46.5)
>6	29.89 (26.1–33.9)	97.94 (95.3–99.3)	14.53 (6.0–34.9)	0.72 (0.7–0.8)	97.1 (93.4–99.1)	37.7 (33.9–41.6)

*The best cut-off point for stroke screening based on RACE criteria. PLR: positive likelihood ratio; NLR: Negative likelihood ratio; PPV: Positive predictive value; NPV: Negative predictive value; CI: Confidence interval

severe “Arm Motor Function” compared to normal ones, regardless of the status of other variables, was 20.6 times higher. The results of multivariable analysis showed that among the RACE criteria, the “Leg Motor Function”, after removing the confounding effect of other variables, had no significant relationship with AIS. Therefore, this criterion has the lowest screening value among other RACE criteria (Table 6).

Discussion

In this study, we assessed the accuracy and other statistic characteristics of the RACE scale in terms of AIS diagnosis for patients with symptoms of stroke referring by EMS to the ED, which showed that the RACE scale is a helpful and accurate diagnostic tool to detect and screen AIS patients. As it was mentioned, the primary derivation/validation study on the RACE scale was performed for differentiated LVO cases, and not all AIS patients [12]. But here, we assessed its accuracy to differentiating, not only LVO cases but also all AIS cases; so the findings should be discussed cautiously, keeping this important issue in mind. Furthermore, in this study, the RACE scale which designed for using in the prehospital settings, was evaluated at the time of the patient arrival in ED. Therefore, we did not examine the validity of the RACE scale as a prehospital scale. Rather, we investigated the performance of this tool for diagnosis of AIS in ED.

The best cut-off point proposed in original article of RACE was score ≥ 5 for differentiating LVO cases [12], but we found that at this cut-off, the criteria had a sensitivity as low as 43.59, and a specificity of 95.47 for differentiating all AIS cases. While we suggest score > 2 as the best cut off for differentiating all AIS cases and improving the sensitivity of the RACE tool that showed a sensitivity of 74.73 and a specificity 87.65 at this cut-off point.

Carrera et al. (that seems to be participated in the primary derivation/validation study on the RACE scale [12]) conducted another two studies on this scale [13, 15]. First they tried to assess predictive value of modified versions of the RACE scale and defined 7 simpler versions of this scale, in this regard; but finally concluded that the original RACE has priority upon all modified versions [13]. Thereafter, they performed another study to revalidation of the RACE scale, in which they confirmed the scale's accuracy to identify AIS patients with LVO [15]. In both studies by Carrera et al., and also all other conducted studies, the investigators considered the score ≥ 5 as the cut off of their analysis [13–17], and we cannot find any paper, in which somebody tried to assess to find another cut-off with aim of using this test for screening all AIS cases and not just LVO ones.

Thavarajah et al. [18] recently published an article in which they determined that the RACE scale has an acceptable discriminative power for identifying LVO patients in USA, however the reported statistical characteristics was lower than that of reported by the main study conducted in Spain [12] (sensitivity of 0.71 vs. 0.85, specificity of 0.65 vs. 0.68). However, we found even a lower sensitivity, meanwhile, a higher specificity than that of reported by United States-based study [18] and also Spanish-based ones [12, 13, 15].

In a multicenter, prospective, observational cohort study, Duvekot et al. [19] compared 8 prehospital stroke scales to detect LVO cases and reported that of all assessed scales, the AUC for RACE was highest and it was equal to 0.83 (95%CI: 0.79–0.86). While, we found that the AUC of the RACE scale in the diagnosis of AIS was 0.86 (95%CI: 0.83–0.88).

The results of logistic regression analysis in this study showed that among the variables of the RACE scale,

Table 6 Univariable and multivariable logistic regression of RACE criteria in the diagnosis of ischemic stroke in patients suspected of stroke transferred to a hospital emergency department

Variable	Univariable analysis		Multivariable analysis	
	OR (95% CI)	P-value	OR (95% CI)	P-value
Facial Palsy				
Mild (1) vs. Absent (0)	8.94 (4.03, 19.8)	<0.001	1.99 (0.74, 5.30)	0.171
Moderate to severe (2) vs. Absent (0)	6.88 (4.49, 10.55)	<0.001	4.84 (2.96, 7.90)	<0.001
Arm Motor Function				
Moderate (1) vs. Normal to mild (0)	9.82 (5.98, 16.11)	<0.001	5.52 (2.41, 12.67)	<0.001
Severe (2) vs. Normal to mild (0)	25.46 (14.52, 44.67)	<0.001	20.58 (5.56, 76.21)	<0.001
Leg Motor Function				
Moderate (1) vs. Normal to mild (0)	8.67 (5.25, 14.30)	<0.001	1.33 (0.56, 3.13)	0.518
Severe (2) vs. Normal to mild (0)	16.70 (9.92, 28.09)	<0.001	0.30 (0.08, 1.06)	0.062
Head & Gaze Deviation				
Present (1) vs. Absent (0)	28.01 (6.86, 114.456)	<0.001	5.10 (1.15, 22.74)	0.033
Aphasia or Agnosia				
Moderate (1) vs. Normal (0)	8.86 (5.63, 13.94)	<0.001	1.95 (1.08, 3.51)	0.027
Severe (2) vs. Normal (0)	12.15 (7.40, 19.93)	<0.001	3.43 (1.85, 6.39)	<0.001

“Arm Motor Function” and “Head & Gaze Deviation” have a larger effect size than other variables for predicting AIS. In the clinic, the importance of these two variables, or in fact, the findings from the physical examination of patients referred to ED in terms of stroke diagnosis, is very high. These findings are in line with other studies, in which, it has also been claimed that patients who are positive for these variables have a higher chance of having a definite diagnosis of AIS than those patients who are negative for these variables [13, 20].

All in all, we found that, if the RACE would be considered by a health system, as a established AIS diagnostic clinical tool, the cut-off >2 would be more suitable. If the referral stroke centers for AIS cases could be differ based on equipment and availability of thrombectomy facilities, then proposed cut-off ≥ 5 should be considered. But such a facilities are not frequently available in most low and middle-income countries, so it is better to choose a proper clinical tool for stablishing in EMS system, based on each country situation, that can accurately differentiate AIS from none-AIS cases at the first step.

Limitations

We did not define and categorize the diagnosis of not AIS cases who studied in this survey, and we could not report the stroke mimics that would be valuable. Also, we did not divide the LVO cases from all AIS cases, so we can not exactly validate the defined RACE scale in its original article.

Future directions

To the best of our knowledge, almost all of previous studies were conducted to evaluate the validity or accuracy of the RACE scale, comparing its statistical indexes with other similar scales, or its performance in real practice for detecting LVO cases. We cannot find any paper, in which somebody tried to assess to find another cut-off with aim of using this test for screening all AIS cases and not just LVO ones. Therefore, we suggest other investigators to consider this point in their future researches.

Conclusion

It seems that, the RACE scale is an accurate diagnostic tool to detect and screen AIS patients in ED, Of course, not at the previously suggested cut-off point (score ≥ 5), but at the score >2 .

Abbreviations

AIS	acute ischemic stroke
AUC	area under the ROC curve
CI	confidence interval
ED	emergency department
EMS	emergency medical services
LVO	large vessel occlusion (LVO)
MRI	magnetic resonance imaging
PGY	postgraduate year

RACE Rapid Arterial occlusion Evaluation
SD standard deviation

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12873-023-00825-7>.

Supplementary Material 1

Acknowledgements

We would like to express our commitment and appreciation to the Prehospital and Hospital Emergency Research Center affiliated with the Tehran University of Medical Sciences.

Authors' contributions

The conception and design of the work by All the authors; Data acquisition by SK and AB; Analysis and interpretation of data by HR and AB; Drafting the work by NB, SK and AJ; Revising it critically for important intellectual content by HR, MS and AB; All the authors approved the final version to be published; AND agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work.

Funding

This study has been funded and supported by the Tehran University of Medical Sciences (Grant No: 98-01-30-41417). The funding body played no role in the design of the study and collection, analysis, interpretation of data, and in writing the manuscript.

Data Availability

The study used data is available via contacting the corresponding author.

Declarations

Ethics approval and consent to participate

The study proposal was approved by the ethical committee of Tehran University of Medical Sciences (IR.TUMS.MEDICINE.REC.1398.164). All methods were performed in accordance with the ethical principles for medical research involving human subjects (Declaration of Helsinki). Informed consent was obtained from all the participants or their legal guardian. All methods were performed in accordance with the relevant guidelines. No additional costs were imposed to the patients or the health system.

Consent for publication

Not Applicable for this study.

Competing interests

The authors declare no competing interests.

Received: 20 July 2022 / Accepted: 17 May 2023

Published online: 24 May 2023

References

1. Krishnamurthi RV, Ikeda T, Feigin VL. Global, regional and country-specific burden of ischaemic stroke, intracerebral haemorrhage and subarachnoid haemorrhage: a systematic analysis of the global burden of disease study 2017. *Neuroepidemiology*. 2020;54(2):171–9.
2. Saini V, Guada L, Yavagal DR. Global epidemiology of Stroke and Access to acute ischemic stroke interventions. *Neurology*. 2021;97(20 Suppl 2):6–16.
3. Fassbender K, Balucani C, Walter S, Levine SR, Haass A, Grotta J. Streamlining of prehospital stroke management: the golden hour. *Lancet Neurol*. 2013;12(6):585–96.
4. Zhao W, Wu C, Dornbos D III, Li S, Song H, Wang Y, et al. Multiphase adjuvant neuroprotection: a novel paradigm for improving acute ischemic stroke outcomes. *Brain Circ*. 2020;6(1):11–8.

5. Barber P, Zhang J, Demchuk A, Hill M, Buchan A. Why are stroke patients excluded from TPA therapy?: an analysis of patient eligibility. *Neurology*. 2001;56(8):1015–20.
6. Seo AR, Song H, Lee WJ, Park KN, Moon J, Kim D. Factors associated with delay of emergency medical services activation in patients with acute stroke. *J Stroke Cerebrovasc Dis*. 2021;30(1):105426.
7. Sangari A, Akhoundzadeh K, Vahedian M, Sharifipour E. Effect of pre-hospital notification on delays and neurological outcomes in acute ischemic stroke. *Australas Emerg Care*. 2022;25(2):172–5.
8. Park P, Frost T, Tan S, Wong J, Pope A, Dewey H, et al. The quest to reduce stroke treatment delays at a Melbourne metropolitan primary stroke centre over the last two decades. *Intern Med J*. 2021;52(11):1978–85.
9. Katz J, Wang J, Boltyenkov A, Martinez G, O'Hara J, Feizullayeva C, et al. Rescan time delays in ischemic stroke imaging: a retrospective observation and analysis of causes and clinical impact. *AJNR Am J Neuroradiol*. 2021;42(10):1798–806.
10. Baratloo A, Mohamadi M, Mohammadi M, Toloui A, Neishaboori AM, Alavi SNR, et al. The value of predictive instruments in the screening of acute stroke: an umbrella review on previous systematic reviews. *Front Emerg Med*. 2022;6(3):e38.
11. Saberian P, Rafiemanesh H, Heydari F, Mirbaha S, Baratloo A. A multicenter diagnostic accuracy study on prehospital stroke screening scales. *Arch Iran Med*. 2021;24(6):453–60.
12. de la Pérez N, Carrera D, Gorchs M, Querol M, Millán M, Gomis M, et al. Design and validation of a prehospital stroke scale to predict large arterial occlusion: the rapid arterial occlusion evaluation scale. *Stroke*. 2014;45(1):87–91.
13. Carrera D, Campbell BC, Cortés J, Gorchs M, Querol M, Jiménez X, et al. Predictive value of modifications of the Prehospital Rapid arterial occlusion evaluation scale for large vessel occlusion in patients with Acute Stroke. *J Stroke Cerebrovasc Dis*. 2017;26(1):74–7.
14. Dickson RL, Crowe RP, Patrick C, Crocker K, Aiken M, Adams A, et al. Performance of the RACE score for the Prehospital Identification of large vessel occlusion stroke in a Suburban/Rural EMS Service. *Prehosp Emerg Care*. 2019;23(5):612–8.
15. Carrera D, Gorchs M, Querol M, Abilleira S, Ribó M, Millán M, et al. Revalidation of the RACE scale after its regional implementation in Catalonia: a triage tool for large vessel occlusion. *J Neurointerv Surg*. 2019;11(8):751–6.
16. Mehta BP, Jadhav A, Sessa J, Katz R, Duong H, Lima A, et al. Assessment of the Rapid arterial occlusion evaluation (RACE) scale in real-world practice for prediction of large vessel occlusion and reducing time to thrombectomy. *Stroke*. 2018;49(Suppl1):A96.
17. Hackett CT, Rahangdale R, Protetch J, Saleemi MA, Rana SS, Wright DG, et al. Rapid arterial occlusion evaluation scale agreement between Emergency Medical Services Technicians and Neurologists. *J Stroke Cerebrovasc Dis*. 2020;29(6):104745.
18. Thavarajah S, Langston Z, Sarayusa A, Fowler LA, Sivakumar S, Shah N. Evaluation of the Rapid arterial occlusion evaluation (RACE) scale in Upstate South Carolina, USA. *J Stroke Cerebrovasc Dis*. 2022;31(11):106746.
19. Duvetkot MH, Venema E, Rozeman AD, Moudrous W, Vermeij FH, Biekart M, et al. Comparison of eight prehospital stroke scales to detect intracranial large-vessel occlusion in suspected stroke (PRESTO): a prospective observational study. *Lancet Neurol*. 2021;20(3):213–21.
20. Panichpisal K, Erpenbeck S, Vilar P, Babygirija RP, Singh M, Colella MR, et al. Stroke Network of Wisconsin (SNOW) Scale predicts large vessel occlusion stroke in the Prehospital setting. *J Patient Cent Res Rev*. 2022;9(2):108–16.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.