脳血管内治療適応例を救急現場で判断するためのスケール

RACE Scale 0~9

顔面麻痺　なし（**0**）　軽度（**1**）　中等度～高度（**2**）
上肢機能　正常～軽度障害（**0**）　中等度（**1**）　高度（**2**）
下肢機能　正常～軽度障害（**0**）　中等度（**1**）　高度（**2**）
頭位・眼球偏倚　なし（**0**）　あり（**1**）
失語（右麻痺の場合）　２つ正答（**0**）　１つ正答（**1**）　正解なし（**2**）
「眼を閉じて下さい」「手を握って下さい」
失認（左麻痺の場合）　両方認識（**0**）　いずれか認識（**1**）　認識せず（**2**）
「こちらはどなたの腕（脚）ですか？」「両手を挙げて下さい」

5 点以上であれば、EVT candidate

Stroke 2014;45:87-91

CPSSS　0~4

眼球偏倚（**2**）
意識障害（**1**）　年齢、日付（月名）の問い：いずれか不正解
および
開閉眼、離握手の指示：いずれかに従えず
上肢麻痺（**1**）　いずれかの上肢を 10 秒間、45°　で保持できない

2 点以上であれば、EVT candidate

Stroke 2015;46:1508-1512

FAST-ED Scale 0~9

Facial palsy (0-1)
Arm weakness (0-2)
Speech changes (0-2)
Eye deviation (0-2)
Denial/neglect (0-2)

4 点以上であれば、EVT candidate

Nogueira RG (Massachusetts General Hospital) personal communication

Design and Validation of a Prehospital Stroke Scale to Predict Large Arterial Occlusion

The Rapid Arterial Occlusion Evaluation Scale

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Background and Purpose—We aimed to develop and validate a simple prehospital stroke scale to predict the presence of large vessel occlusion (LVO) in patients with acute stroke.

Methods—The Rapid Arterial oCclusion Evaluation (RACE) scale was designed based on the National Institutes of Health Stroke Scale (NIHSS) items with a higher predictive value of LVO on a retrospective cohort of 654 patients with acute ischemic stroke: facial palsy (scored 0–2), arm motor function (0–2), leg motor function (0–2), gaze (0–1), and aphasia or agnosia (0–2). Thereafter, the RACE scale was validated prospectively in the field by trained medical emergency technicians in 357 consecutive patients transferred by Emergency Medical Services to our Comprehensive Stroke Center. Neurologists evaluated stroke severity at admission and LVO was diagnosed by transcranial duplex, computed tomography, or MR angiography. Receiver operating curve, sensitivity, specificity, and global accuracy of the RACE scale were analyzed to evaluate its predictive value for LVO.

Results—In the prospective cohort, the RACE scale showed a strong correlation with NIHSS (r=0.76; P<0.001). LVO was detected in 76 of 357 patients (21%). Receiver operating curves showed a similar capacity to predict LVO of the RACE scale compared with the NIHSS (area under the curve 0.82 and 0.85, respectively). A RACE scale ≥5 had sensitivity 0.85, specificity 0.68, positive predictive value 0.42, and negative predictive value 0.94 for detecting LVO.

Conclusions—The RACE scale is a simple tool that can accurately assess stroke severity and identify patients with acute stroke with large artery occlusion at prehospital setting by medical emergency technicians. **(*Stroke*. 2014;45:87-91.)**

Key Words: cerebrovascular occlusion ■ prehospital emergency care ■ scales ■ stroke, acute

Pharmacological treatment of acute ischemic stroke is limited to the administration of intravenous tissue-type plasminogen activator within the first 4.5 hours from symptoms onset. Intravenous thrombolysis can be administered in Primary Stroke Centers or Community Hospitals.[1] Beyond intravenous treatment, endovascular approach is an evolving therapeutic option in patients with large vessel occlusion (LVO) because it may offer longer time window and higher rate of complete revascularization.[2] Although some recent studies have failed to demonstrate clinical benefit of endovascular treatment, data suggest that efforts to shorten the delay from symptoms onset to endovascular treatment in Comprehensive Stroke Centres (CSCs) are necessary to demonstrate the effectiveness of this therapy.[3–5] Consequently, a simple and accurate scale for paramedics may be a useful tool to identify patients with LVO and allow their rapid transfer to a CSC.

Several prehospital stroke scales have been designed and validated to identify patients experiencing an acute stroke.[6–10] Moreover, few scales have been developed to assess stroke severity at the prehospital setting.[11,12] However, these scales do not offer information about the presence of LVO. The National Institutes of Health Stroke Scale (NIHSS) may be useful to identify patients with LVO but the best cutoff point is still controversial and this scale is probably too time consuming and too complex to be used by paramedics.[13–15] Recently, 2 simple scales have been reported to identify patients with LVO but their validation by prehospital personnel has not been performed as far as we know.[16,17]

The objective of this study was to evaluate the predictive value of the Rapid Arterial oCclusion Evaluation (RACE) scale on the detection of patients with acute stroke and LVO when used by medical emergency technicians during the prehospital phase.

Received August 1, 2013; accepted October 17, 2013.

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Presented in part in abstract form at the European Stroke Conference in London 2013.

The online-only Data Supplement is available with this article at http://stroke.ahajournals.org/lookup/suppl/doi:10.1161/STROKEAHA.113.003071/-/DC1.

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Stroke **is available at http://stroke.ahajournals.org** **DOI: 10.1161/STROKEAHA.113.003071**

Methods

RACE Scale Design and Retrospective Validation

The items of the NIHSS with the highest predictive value of LVO were identified on a retrospective cohort of 654 patients with a cerebral infarction of the anterior circulation admitted at the acute stroke unit of our CSC from January 2006 to March 2010. LVO was diagnosed by transcranial duplex accordingly with thrombolysis in brain ischemia criteria[18] and considered when a thrombolysis in brain ischemia 0 to 2 pattern was observed at the middle cerebral artery at 45 to 55 mm depth. LVO was observed in 178 of 654 patients (27%). First, those items of the NIHSS with the highest association with LVO were identified in a χ^2 test. Then, the predictive value of different combinations of these items was determined by receiver operating curve analysis.

Some items were excluded to avoid difficulties and inconsistencies in the assessment by paramedic personnel although they had a high correlation with LVO (visual field and sensory, for instance). A high global accuracy was obtained with the combination of 5 items that finally built the RACE scale: facial palsy, arm motor function, leg motor function, gaze, and aphasia or agnosia, graded as detailed in Table 1. Each item was scored using a simpler grading system than the NIHSS, as detailed in Table 1 and Table I in the online-only Data Supplement.

Validation of RACE on a Prospective Prehospital Cohort

To the prospective validation, the RACE scale was included on the usual Stroke Code (SC) protocol. SC system has been working in our area for the past 8 years and it is activated by Emergency Medical Services (EMS) or community hospitals in front of any patient with clinical suspicion of an acute stroke within 6 hours from symptoms onset. More than 60% of patients with acute stroke arrive at our hospital transferred by basic or advance vital care ambulances.[19,20]

Between February 2011 and March 2013, patients with acute stroke or stroke mimics in whom SC was activated from a community hospital or directly by EMS who were transferred by basic vital care ambulances to our CSC were considered for the prospective validation. The RACE was completed in the field by emergency medical technicians, written on a sheet form before hospital arrival and given to the neurologist at the hospital. Medical emergency technicians operating into our geographical area received a training program at the beginning of the study. The program consisted of 1-hour training session on the use of the RACE scale plus 4 shorter sessions during the first year to solve doubts and to ensure good compliance of the protocol. Moreover, when possible, the scale was discussed with the neurologist at the CSC for each individual case after its completion by medical emergency technicians.

Baseline characteristics, stroke subtype, and revascularization treatment were recorded prospectively. The presence of LVO was documented on admission using transcranial duplex (thrombolysis in brain ischemia grades, 0–2) as a screening tool in most of the patients and using computed tomography angiography or MR angiography in patients with suspicion of LVO. Angiography was performed when endovascular treatment was finally indicated. LVO was defined as occlusion of the terminal intracranial carotid artery, proximal middle cerebral artery (M1 segment), tandem (extracranial carotid artery plus middle cerebral artery) and basilar artery. The study protocol was approved by the institutional Ethics Committee of the Hospital Universitari Germans Trias i Pujol.

Statistical Analysis

For statistical analysis, SPSS version 15.0 software was used. Receiver operating curves and areas under receiver operating curve (c-statistics) were calculated as a measure of predictive ability for LVO of the RACE and NIHSS scales. Ideal prediction produces a c-statistic of 1.00; precision no better than chance is associated with c-statistic of ≤0.50. Correlation between both scales was analyzed with the nonparametric Spearman coefficient. Cross tables for different cutoff values of the RACE scale were used to evaluate sensitivity, specificity, positive predictive value, negative predictive values, and overall accuracy for the presence of VO.

Table 1. RACE Scale

Item	RACE Score	NIHSS Score Equivalence
Facial palsy		
Absent	0	0
Mild	1	1
Moderate to severe	2	2–3
Arm motor function		
Normal to mild	0	0–1
Moderate	1	2
Severe	2	3–4
Leg motor function		
Normal to mild	0	0–1
Moderate	1	2
Severe	2	3–4
Head and gaze deviation		
Absent	0	0
Present	1	1–2
Aphasia* (if right hemiparesis)		
Performs both tasks correctly	0	0
Performs 1 task correctly	1	1
Performs neither tasks	2	2
Agnosia† (if left hemiparesis)		
Patient recognizes his/her arm and the impairment	0	0
Does not recognized his/her arm or the impairment	1	1
Does not recognize his/her arm nor the impairment	2	2
Score total	0–9	

NIHSS, National Institutes of Health Stroke Scale; and RACE, Rapid Arterial oCclusion Evaluation.

*Aphasia: Ask the patient to (1) "close your eyes"; (2) "make a fist" and evaluate if the patient obeys.

†Agnosia: Ask the patient: (1) while showing him/her the paretic arm: "Whose arm is this" and evaluate if the patient recognizes his own arm. (2) "Can you lift both arms and clap" and evaluate if the patient recognizes his functional impairment.

Results

In the retrospective cohort of 654 patients the RACE scale was calculated based on NIHSS at admission (Table 1) and showed a similar predictive value compared with the NIHSS for detecting LVO (area under the curve, 0.81 versus 0.80). Correlation between RACE and NIHSS scores was 0.93 (P<0.001).

In the second phase the RACE scale was assessed prospectively by medical emergency technicians in the field in patients transferred to our CSC via SC activation in a 24-month period. Of the 1184 patients admitted to our center via SC in this period, we excluded 231 patients who arrived by private transport directly at the emergency department and 68 patients who had an in-hospital stroke. These cases were not attended and transferred by ambulance so the RACE scale was not evaluated. Thus, 885 patients with extrahospital SC activation were studied. The RACE scale was completed in 357 of 885 patients (40%): 291 of 536 (54%) transferred directly from home or public location by EMS, 34 of 278 (12%) transferred from community hospitals, and 32 of 71 (45%) transferred from primary care centers. Patients with RACE scale assessment were similar to those in whom the scale was not evaluated (n=528/885) although clinical severity was higher (Table II in the online-only Data Supplement).

Finally, a total of 357 patients with a prehospital RACE scale evaluation were included for the analysis (54% men; mean±SD age, 73±13 years; median [quartiles] NIHSS score, 8 [3–16]). Time from symptoms onset was unknown or during sleep in 104 of 357 (29%) patients. In the rest of the cases, mean time from symptoms onset to EMS attention was 40 (24–104) minutes and to neurological attention at the CSC was 95 (63–180) minutes. The stroke subtype was ischemic stroke in 240 of 357 (67.2%), hemorrhagic stroke in 52 of 357 (14.6%), transient ischemic attack in 20 of 357 (5.6%), and stroke mimic in 45 of 357 (12.6%).

A strong correlation was observed between the RACE scale assessed by medical emergency technicians before hospital arrival and the NIHSS assessed by neurologist at admission (r=0.76; P<0.001).

LVO was detected in 76 of 357 (21.3%) patients. Diagnostic methodology and site of occlusion are detailed in Table 2.

Receiver operating curves demonstrated that the RACE scale was highly effective in identifying patients with LVO (c-statistic, 0.82; 95% CI, 0.77–0.87). Cutoff values of the RACE scale for predicting LVO were evaluated (Figure 1; Table 3). The best predictive value of RACE was established as ≥5; this cutoff value showed sensitivity 0.85, specificity 0.68, positive predictive value 0.42, and negative predictive value 0.94 for detecting LVO. In the subgroup of patients with a final diagnosis of ischemic stroke of the anterior circulation (n=214), the global accuracy of the RACE scale for LVO was slightly higher (c-statistic, 0.84; 95% CI, 0.79–0.89).

The higher the RACE score, the higher the proportion of patients with ischemic stroke because of LVO and the lower the proportion of patients with ischemic stroke without LVO or stroke mimics. Proportion of hemorrhagic stroke in patients with high scores on the scale was also high (Figure 2).

Table 2. Diagnostic Method for LVO and Site of Occlusion

	Transcranial Color Doppler (n=197)	Angio-TC or Angio-RM (n=53)	Arteriography (n=28)	Site of Occlusion, Total (n=278)
No occlusion	159	36	7	202
MCA M1	29	9	11	49
TICA	5	3	6	14
Tandem	4	4	4	12
Basilar	0	1	0	1

A total of 77 of 357 patients were not evaluated for LVO because they experienced a hemorrhagic stroke (n=50) or a stroke mimic with no diagnostic doubt (n=27). These patients were considered as having no occlusion for the analysis. LVO indicates large vessel occlusion; MCA, middle cerebral artery; RACE, Rapid Arterial oCclusion Evaluation; and TICA, terminal intracranial carotid artery.

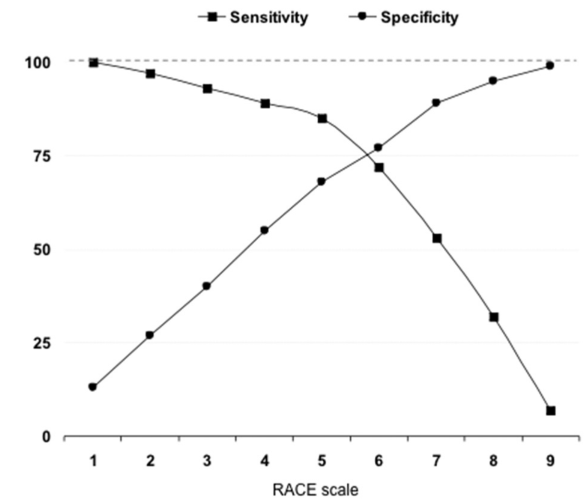

Figure 1. Sensitivity (squares) and specificity (circles) of different cutoff values of the Rapid Arterial oCclusion Evaluation (RACE) scale for the detection of large vessel occlusion.

Importantly, 29 of 154 (19%) patients with a RACE ≥5 received endovascular treatment compared with 4 of 203 (2%) of those with RACE scale <5 (P<0.001).

RACE scale was comparable with NIHSS to predict LVO (c-statistic, 0.85; 95% CI, 0.81–0.89). Best overall accuracy for the NIHSS scale was achieved for a score of ≥11, with a sensitivity 0.88, specificity 0.72, and overall accuracy 0.76.

Discussion

This study demonstrates that the RACE scale is a simple tool highly predictive of the presence of a large arterial occlusion in patients with a suspicion of an acute stroke. Moreover, we have shown that its use at the prehospital setting is feasible as the accuracy of the RACE scale evaluated by medical emergency technicians is comparable with the NIHSS assessed by neurologist at hospital admission. The RACE scale shows a high sensitivity (85%) and specificity (65%) to identify LVO when considering a cutoff point of 5, or even higher sensitivity (89%) with lower specificity (55%) with a lower cutoff point of 4.

This scale is the first validated tool to detect patients with acute stroke and LVO at prehospital setting. Only 2 scales have

Table 3. Sensitivity, Specificity, PPV, NPV, and Overall Accuracy of Different Cutoff Values of the RACE Scale for the Detection of Large Artery Occlusion

RACE Score	No.	Sensitivity	Specificity	PPV	NPV	Accuracy
≥1	320	1.00	0.13	0.24	1.00	0.31
≥2	278	0.97	0.27	0.27	0.97	0.42
≥3	239	0.93	0.40	0.30	0.96	0.51
≥4	194	0.89	0.55	0.35	0.95	0.62
≥5	154	0.85	0.68	0.42	0.94	0.72
≥6	120	0.72	0.77	0.46	0.91	0.76
≥7	71	0.53	0.89	0.56	0.87	0.81
≥8	37	0.32	0.95	0.65	0.84	0.82
9	9	0.07	0.99	0.56	0.79	0.79

NPV indicates negative predictive value; PPV, positive predictive value; and RACE, Rapid Arterial oCclusion Evaluation.

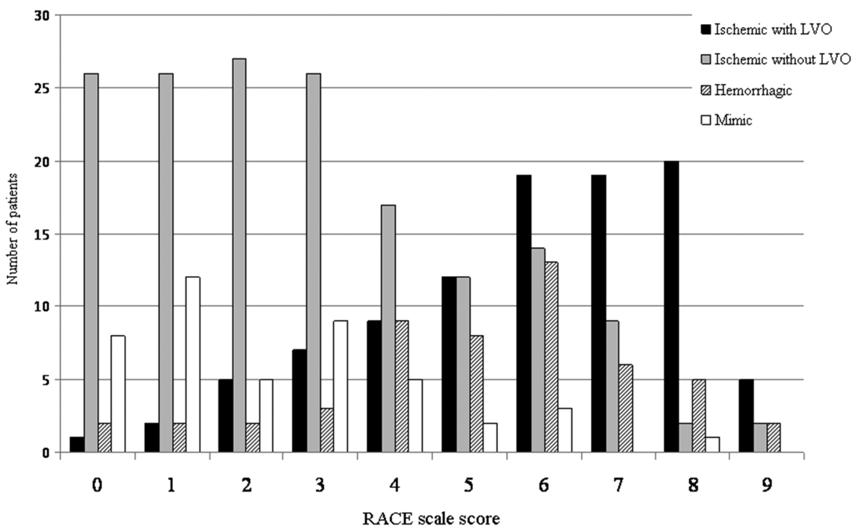

Figure 2. Proportion of patients with ischemic stroke with large vessel occlusion (LVO; black), ischemic stroke without LVO (gray), hemorrhagic stroke (dashed), or stroke mimic (white) for every Rapid Arterial oCclusion Evaluation (RACE) scale score.

been designed to identify patients with LVO but they have not been validated in the field. The 3-Item Stroke Scale assesses level of consciousness, gaze, and motor function.[16] However, these items were not selected based on a comprehensive analysis of the predictive value of the NIHSS items. The Los Angeles Motor Scale is based on the motor items of a previous stroke identification instrument, which includes the facial droop, arm drift, and grip strength.[17] However, cortical signs that are usually impaired in stroke with LVO are not evaluated. Finally, the NIHSS is the only scale that has demonstrated to be predictive of LVO, but prehospital assessment by medical emergency technicians may be difficult, time-consuming, and has not been validated as far as we know.[13–15] Although shorter and simplified NIHSS have been designed and validated,[21,22] no studies have analyzed its capacity to identify patients with acute stroke and LVO.

The RACE scale may be a valuable tool for prehospital care systems to detect and transfer acute stroke patients with a high likelihood of experiencing a large arterial occlusion to a CSC. SC systems have been developed worldwide to ensure specialized medical attention and early intravenous thrombolytic therapy for patients with acute stroke. However, a new era for stroke treatment is evolving because endovascular revascularization therapies are spreading worldwide.[2] Indeed, in patients with contraindications or who do not respond to intravenous treatment, an endovascular approach can be offered to achieve more effective arterial recanalization. However, clinical benefit of endovascular therapies is still being investigated. Delay to CSC arrival and low rate of early arterial recanalization of patients treated with endovascular therapy may be one of the principal causes of the failure of latest clinical studies.[3–5] Indeed, some studies have demonstrated that the earlier the arterial recanalization, the higher the clinical benefit of revascularization therapies.[23,24] Therefore, early triage of patients for endovascular treatment may have an important clinical impact. Our results demonstrate that the use of the RACE scale at a prehospital scenario is feasible by trained medical emergency technicians and might be a useful and simple tool to identify patients with LVO. Considering a cutoff value of RACE ≥5, medical emergency technician would identify 85% of patients with LVO. In our series, 35% of these patients received systemic thrombolysis and 19% were finally treated with endovascular therapy. Direct transfer to a CSC may imply a significant number of patients bypassing Primary Stroke Centers potentially delaying intravenous tissue-type plasminogen activator and not being eligible for endovascular therapy. Thus, we suggest to investigate this new scale initially as a triage tool in areas where Primary Stroke Centers are not far from a CSC. We need stronger evidence about the efficacy of endovascular treatment to extend the use of the scale into a broader region. On the other hand, our results show a moderate specificity and positive predictive value of the RACE scale, mostly because of the inclusion of patients with hemorrhagic stroke with severe symptoms and high scores on the RACE and also the NIHSS scale. In our opinion this fact does not hamper the usefulness of the scale because these patients benefit from admission into a CSC where they may receive neurosurgical evacuation, external ventricular derivation, or hemicraniectomy. Future investigation of serum biomarkers aimed to differentiate ischemic and hemorrhagic stroke may complement this clinical tool at the prehospital setting.

This study has some limitations. First, the RACE scale was not evaluated in 60% of patients transferred by EMS. Patients not included had less severe strokes and less frequency of LVO than patients included in the analysis (Table II in the online-only Data Supplement). Most of them were transferred from community hospitals (as a secondary transfer made by EMS in where the scale was not evaluated). Thus, we cannot rule out a selection bias, and a larger validation study may be necessary to generalize our results. Second, LVO was diagnosed using transcranial duplex in half of the patients, which may be less accurate than computed tomography angiography or MR angiography. However, previous studies have demonstrated a high sensitivity (0.82) and specificity (0.94) of transcranial Doppler in diagnosing LVO.[25] Third, the RACE scale was designed based on data from patients with anterior circulation acute ischemic stroke, but the prospective validation study also included few patients with posterior circulation ischemic stroke (7%) and brain hemorrhage (14.6%). Although accuracy for detecting LVO was higher for the subset of patients with anterior circulation ischemic stroke, results were also good when analyzing the whole sample. Finally, during the study period, ambulance dispatchers were trained regularly on the RACE evaluation so we cannot conclude on maintained accuracy of the scale over time in nontrained dispatchers.

As a strength of this study, one of the known limitations of the NIHSS is improved by the RACE scale: left hemispheric strokes tend to score more than those on the right because 7 of the items of the NIHSS are directly related to language, whereas only 2 are directly related to agnosia.[26] In the RACE scale both items score a maximum of 2 points. However, right hemisphere symptoms may be more difficult to assess by medical emergency technicians because predictive value was lower than for left hemisphere strokes.

In conclusion, the RACE scale is a novel and simple tool for a prehospital use by medical emergency technicians that can accurately assess stroke severity and detect patients with acute stroke with large intracranial vessel occlusion. This tool may be useful to early detection of patients with acute stroke who should be transferred to a CSC for endovascular treatment.

Disclosures

None.

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SUPPLEMENTAL MATERIAL

Table I. RACE scale: items and NIHSS score equivalence

Item	Instruction		RACE score	NIHSS score equivalence
Facial palsy	Ask the patient to show teeth	Absent (symmetrical movement)	0	0
		Mild (slightly asymmetrical)	1	1
		Moderate to severe (completely asymmetrical)	2	2-3
Arm motor function	Extending the arm of the patient 90 degrees (if sitting) or 45 degrees (if supine)	Normal to mild (limb upheld more than 10 seconds)	0	0-1
		Moderate (limb upheld less than 10 seconds)	1	2
		Severe (patient do not rise the arm against gravity)	2	3-4
Leg motor function	Extending the leg of the patient 30 degrees (in supine)	Normal to mild (limb upheld more than 5 seconds)	0	0-1
		Moderate (limb upheld less than 5 seconds)	1	2
		Severe (patient do not rise the leg against gravity)	2	3-4
Head and gaze deviation	Observe eyes and cephalic deviation to one side	Absent (eye movements to both sides were possible and no cephalic deviation was observed)	0	0
		Present (eyes and cephalic deviation to one side was observed)	1	1-2
Aphasia (if right hemiparesis)	Ask the patient two verbal orders - "close your eyes" - "make a fist"	Normal (performs both tasks correctly)	0	0
		Moderate (performs one task correctly)	1	1
		Severe (performs neither tasks)	2	2
Agnosia (if left hemiparesis)	Asking: - "Who is this arm" while showing him/her the paretic arm (asomatognosia) - "Can you move well this arm?" (anosognosia)	Normal (no asomatognosia nor anosognosia)	0	0
		Moderate (asomatognosia or anosognosia)	1	1
		Severe (both of them)	2	2
RACE Score total			0-9	

Supplemental Table II.

Comparison of patients transferred by EMS in whom the RACE scale was complimented (included n the study, n=357) or not complimented (not included, n=528).

	Included n=357	Not included n=528	p value
Age, years	73 ± 13	69 ± 13	0.34
Gender (man)	54.1%	54.0%	0.98
NIHSS at admission	8 [3-16]	5 [2-15]	0.006
LVO (%)	21%	14%	0.004

Stroke
JOURNAL OF THE AMERICAN HEART ASSOCIATION

Design and Validation of a Prehospital Stroke Scale to Predict Large Arterial Occlusion: The Rapid Arterial Occlusion Evaluation Scale

Natalia Pérez de la Ossa, David Carrera, Montse Gorchs, Marisol Querol, Mònica Millán, Meritxell Gomis, Laura Dorado, Elena López-Cancio, María Hernández-Pérez, Vicente Chicharro, Xavier Escalada, Xavier Jiménez and Antoni Dávalos

Stroke. 2014;45:87-91; originally published online November 26, 2013;
doi: 10.1161/STROKEAHA.113.003071
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0039-2499. Online ISSN: 1524-4628

Design and Validation of a Prehospital Scale to Predict Stroke Severity

Cincinnati Prehospital Stroke Severity Scale

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Opeolu Adeoye, MD, MS; Joseph P. Broderick, MD

Background and Purpose**—**We derived and validated the Cincinnati Prehospital Stroke Severity Scale (CPSSS) to identify patients with severe strokes and large vessel occlusion (LVO).

Methods**—**CPSSS was developed with regression tree analysis, objectivity, anticipated ease in administration by emergency medical services personnel and the presence of cortical signs. We derived and validated the tool using the 2 National Institute of Neurological Disorders and Stroke (NINDS) tissue-type plasminogen activator Stroke Study trials and Interventional Management of Stroke III (IMS III) Trial cohorts, respectively, to predict severe stroke (National Institutes of Health Stroke Scale [NIHSS] ≥15) and LVO. Standard test characteristics were determined and receiver operator curves were generated and summarized by the area under the curve.

Results**—**CPSSS score ranges from 0 to 4; composed and scored by individual NIHSS items: 2 points for presence of conjugate gaze (NIHSS ≥1); 1 point for presence of arm weakness (NIHSS ≥2); and 1 point for presence abnormal level of consciousness commands and questions (NIHSS level of consciousness ≥1 each). In the derivation set, CPSSS had an area under the curve of 0.89; score ≥2 was 89% sensitive and 73% specific in identifying NIHSS ≥15. Validation results were similar with an area under the curve of 0.83; score ≥2 was 92% sensitive, 51% specific, a positive likelihood ratio of 3.3, and a negative likelihood ratio of 0.15 in predicting severe stroke. For 222 of 303 IMS III subjects with LVO, CPSSS had an area under the curve of 0.67; a score ≥2 was 83% sensitive, 40% specific, positive likelihood ratio of 1.4, and negative likelihood ratio of 0.4 in predicting LVO.

Conclusions**—**CPSSS can identify stroke patients with NIHSS ≥15 and LVO. Prospective prehospital validation is warranted. **(*Stroke*. 2015;46:1508-1512. DOI: 10.1161/STROKEAHA.115.008804.)**

Key Words: acute stroke ■ NIHSS ■ prehospital emergency care ■ severe stroke ■ vessel occlusion

Currently, Primary Stroke Centers and Comprehensive Stroke Centers (CSC) form a 2-tier regionalized system of care for the efficient emergent management of patients with acute stroke.[1] Although both Primary Stroke Centers and CSCs provide acute stroke care,[1] CSCs are better equipped to provide state-of-the-art care for patients with severe ischemic and hemorrhagic stroke, including endovascular therapies, advanced diagnostic imaging, continuous in-hospital neurosurgical availability, and neurocritical care. These capabilities have led to improved cost-effectiveness and outcomes for ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage at CSCs compared with non-CSCs.[2–12] Large volume stroke centers provide faster treatment and improve the use of thrombolysis for patients with acute ischemic stroke (AIS).[13] With the recent findings that timely endovascular therapy may improve outcomes in AIS patients with confirmed large vessel occlusions (LVO),[14–16] and the greater likelihood of LVO in AIS patients with more severe AIS,[17,18] there is now greater clinical need to care for patients with severe stroke at CSCs early in their clinical course.

Emergency medical services (EMS) providers are the first medical contact for half of all stroke patients[19] and are responsible for triaging patients to appropriate hospitals. EMS bypass of nonstroke centers in favor of Primary Stroke Centers has been advocated,[1,20,21] but the concept of bypassing a Primary Stroke Center for a CSC has been recommended for consideration but not yet been widely adopted.[22] Bypass could be justified because interfacility transfer of patients introduces significant unnecessary delays in care and patient charges compared with direct EMS transport to a specialty care center.[23–27] Other prehospital stroke scales[28–30] have been proposed to identify patients experiencing an acute stroke or LVO,[30–32]

Received January 19, 2015; final revision received February 18, 2015; accepted February 25, 2015.

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Presented in part at the European Stroke Organization Conference, Glasgow, Scotland, April 17–19, 2015, and the Society for Academic Emergency Medicine Annual Meeting, San Diego, CA, May 12–15, 2015.

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Stroke **is available at http://stroke.ahajournals.org** **DOI: 10.1161/STROKEAHA.115.008804**

but have not been widely adopted in clinical practice because of the absence of positive LVO endovascular therapy trials.

We describe the retrospective derivation and validation of a new brief neurological scale, the Cincinnati Prehospital Stroke Severity Scale (CPSSS), in prediction of severe AIS and LVO.

Methods

Data Sets

To derive the CPSSS, we used the 2 National Institute of Neurological Disorders and Stroke (NINDS) tissue-type plasminogen activator (tPA) Stroke Study trials data set,[33] which is composed of a diverse cohort of patients having mild to severe strokes (National Institutes of Health Stroke Scale [NIHSS] 1–37) randomized to treatment with tPA or placebo within 3 hours of onset. The IMS-III data set served as the validation cohort.[34] IMS-III was a prospective randomized trial comparing outcomes of moderate to severe stroke patients (NIHSS, 8–40) treated with tPA with or without endovascular intervention. In both trials, pretreatment NIHSS scores (component and composite) were collected by NIHSS-certified study physicians at the time of enrollment. Subjects in each data set with complete pretreatment NIHSS component scores were included in the derivation or validation cohorts. Because the IMS-III cohort had higher NIHSS scores per the eligibility criteria, we chose to derive the CPSSS from the 2 NINDS tPA Stroke Study cohort to study sensitivity and specificity among a broader severity of stroke patients.

Outcome Measures

The primary outcome was the CPSSS ability to identify a severe stroke defined as NIHSS ≥15 because >95% of AIS patients with NIHSS ≥15 have a LVO by baseline imaging[17,18] and is the lower limit of stroke severity for the consideration of hemicraniectomy.[9,10] Secondary outcomes included CPSSS ability to identify moderate stroke severity (NIHSS ≥10) and proximal LVO [extracranial internal carotid artery, intracranial internal carotid artery, M1, tandem cervical internal carotid artery plus M2, or basilar artery occlusions (excluding M3, M4, posterior cerebral artery occlusion sites, and isolated M2)] by computed tomographic angiography before intravenous tPA therapy.

Derivation and Validation Methods

CPSSS was designed with a similar approach to that used in the development of the original Cincinnati Prehospital Stroke Scale.[35] A classification and regression tree (CART) analysis was used to identify subsets of NIHSS items, as well as item score cut points, working together to predict severe stroke defined as NIHSS total score ≥15. Next, important candidate items identified by the classification tree were reviewed by the study clinicians (including board-certified EMS, emergency medicine, and vascular neurology physicians), and those items that are objective (eg, correctly answering questions or following commands) were chosen by expert consensus over those that are subjective (ie, degree of aphasia) to ensure ease of use by EMS personnel. Selected items were given a point score of 1 or 2 based on importance in predicting severe stroke as determined by the CART analysis. Receiver operating characteristic curves were generated to determine the accuracy of the CPSSS and to identify an optimal cut point to define an abnormal/positive screening assessment.

After derivation, the tool performance was assessed using the IMS III Trial data (validation data set), where, in addition to predicting AIS severity, the CPSSS was assessed for its accuracy in detecting LVO. Sensitivity, specificity, and positive and negative likelihood ratios were calculated for the optimal cut point.

Results

The 2 NINDS tPA Stroke Study trials data set contained 624 patients, of which there were 447 patients (71.6%) with pretreatment NIHSS ≥10 and 311 patients (49.8%) with pretreatment NIHSS ≥15. The presence of pretreatment proximal LVO was not obtained. CART analysis was used to identify potential NIHSS items for consideration by scale designers. CART analysis identified 5 NIHSS items that were important factors in predicting severe stroke (NIHSS ≥15). The most important factor, first defining split, was abnormal gaze (best gaze >0). For those with normal gaze (best gaze=0), motor function (right arm, right leg, and left leg) and language were found to be important factors. Of these, abnormal gaze and arm motor function were chosen to be included in the CPSSS, and the presence of abnormal gaze was weighted heavier on the CPSSS based on its predictive value on the CART and because of its suggestion of focal cortical dysfunction. Motor function of arm falling to bed was selected for ease of EMS providers to ascertain. Language was specifically not chosen to be included, despite being an important predictive factor, because of subjectivity of interpretation. Language was replaced with level of consciousness questions and commands because of the objective interpretation for EMS providers, yielding the CPSSS (Figure 1). A score is given for the presence of each clinical feature. The total CPSSS score is calculated as the sum of the individual scores and ranges from 0 to 4, with higher score reflecting higher stroke severity.

In the derivation set, the CPSSS score had an area under the receiver operating characteristic of 0.89 for detecting severe stroke (Figure 2). A CPSSS score ≥2 was 89% sensitive, 73% specific, positive likelihood ratio of 3.30, and negative likelihood ratio of 0.15 in identifying severe stroke (NIHSS of ≥15). For identification of stroke patients with a moderate stroke, a CPSSS score of ≥2 had a sensitivity of 75%, a specificity of 85%, positive likelihood ratio of 5.00, and negative likelihood ratio of 0.29 (Table 1).

The performance of CPSSS was validated using the IMS III data set, which was composed of 650 patients, of which 390 patients (60%) presented with an NIHSS ≥15 and 641 patients (99%) presented with an NIHSS ≥10. In the IMS III data set, the CPSSS had similar area under the receiver operating characteristic and test characteristics to the derivation set (Table 1; Figure 3).

For identifying LVO, 303 IMS III subjects had data available and were included in the analysis, of which, 222 had LVO. For LVO, CPSSS had an AUC of 0.67 and a score ≥2 was 83% sensitive, 40% specific, a positive likelihood ratio of 1.4, and negative likelihood ratio of 0.4 (Table 1).

Cincinnati Prehospital Stroke Severity Scale

2 points: Conjugate gaze deviation (≥ 1 on NIHSS item for Gaze)

1 point: Incorrectly answers at least one of two level of consciousness questions on NIHSS (age or current month) **and** does not follow at least one of two commands (close eyes, open and close hand) (≥ 1 on the NIHSS item for Level of Consciousness 1b and 1c)

1 point: Cannot hold arm (either right, left or both) up for 10 seconds before arm(s) falls to bed (≥ 2 on the NIHSS item for Motor Arm)

Figure 1. The Cincinnati Prehospital Stroke Severity Scale's individual items and scoring. NIHSS indicates National Institutes of Health Stroke Scale.

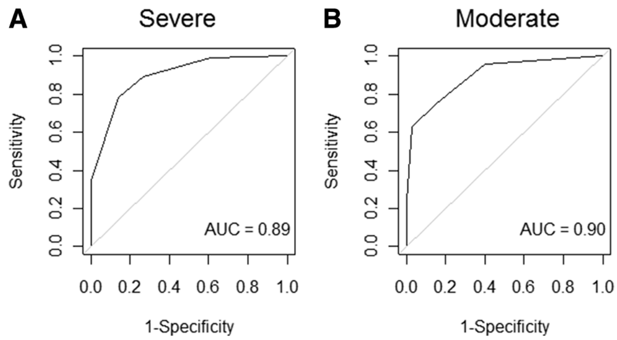

Figure 2. The receiver operating characteristic curve for Cincinnati Prehospital Stroke Severity Scale in detecting stroke severity in the derivation data set. AUC indicates area under the curve.

A comparison of the CPSSS to other prehospital stroke scales is shown in Table 2.

Discussion

We found that the CPSSS has high sensitivity and acceptable specificity in detecting the presence of severe stroke, moderate stroke, and LVO among populations of patients with AIS. Specifically, the CPSSS can identify stroke patients who could be most likely to benefit from rapid triage to a CSC, including those who harbor proximal LVO that are appropriate targets for intravenous tPA and endovascular therapy. These patients may also be eventual candidates for hemicraniectomy and benefit from a dedicated Neurological Intensive Care Unit (ICU). Given the time-sensitivity of the above therapies, accurate initial triage of patients to hospitals, where these therapies are available, is a key to prevent delays in care and increased costs associated with transfers.

Three screening tools to identify severe ischemic strokes have been previously proposed, but none has been widely adopted into EMS practice (Table 2). The Los Angeles Motor Scale (LAMS)[31] is limited by the fact that a sizable proportion of the population studied to derive LAMS occurred retrospectively and included patients enrolled in clinical trials >11 years at a single institution. The Rapid Arterial Occlusion Evaluation (RACE) scale was developed to predict LVO.[30] However, RACE scale was not evaluated in 60% of patients transferred by EMS, and patients not included had less severe strokes and less frequency of LVO than patients included in the analysis. The complexity of RACE (6 domains requiring subjective interpretation in several of the domains) further poses a significant challenge for accurate EMS implementation. It should be noted that we constructed the CPSSS before awareness of the recent RACE publication, but there are similarities between the 2 scales. The major differences are that the CPSSS is shorter, uses dichotomous answers, and rates conjugate gaze deviation more heavily. Finally, the 3-Item Stroke Scale (3ISS)[32] is most similar to our prehospital scale given modalities that were tested. The 3ISS was limited by sample size and requires subjective grades, such as none, moderate, or severe disturbance of consciousness.

Table 1. Accuracy of Cincinnati Prehospital Stroke Severity Scale (CPSSS) ≥2 in Detecting Moderate/Severe Stroke and LVO

Outcome	Data Set	Sensitivity	Specificity	PLR	NLR
Stroke severity					
Severe (NIHSS≥15)	Derivation	89%	73%	3.30	0.15
	Validation	92%	51%	1.89	0.16
Moderate (NIHSS≥10)	Derivation	75%	85%	5.00	0.29
	Validation	79%	89%	7.18	0.24
LVO	Validation	83%	40%	1.38	0.42

LVO defined as occlusion sites of internal carotid artery, M1, tandem cervical internal carotid artery plus M2, or basilar arteries. LVO indicates large vessel occlusion; NIHSS, National Institutes of Health Stroke Scale; NLR, negative likelihood ratio; and PLR, positive likelihood ratio.

Using a prehospital scale, such as the CPSSS, as a triage tool in the field would affect the initial transport of patients in many communities in the United States and potentially other countries depending on the prehospital system. However, because almost 80% of patients with ischemic stroke have a baseline NIHSS <10[36] and nearly 90% have a baseline NIHSS <15, the actual number of patients with ischemic stroke triaged to CSCs would have relatively limited impact on individual community hospitals that are not comprehensive centers. The NIHSS distribution of hemorrhagic stroke within a population is unknown; as such we are unable to reliably estimate the proportion of patients with hemorrhagic stroke that may be

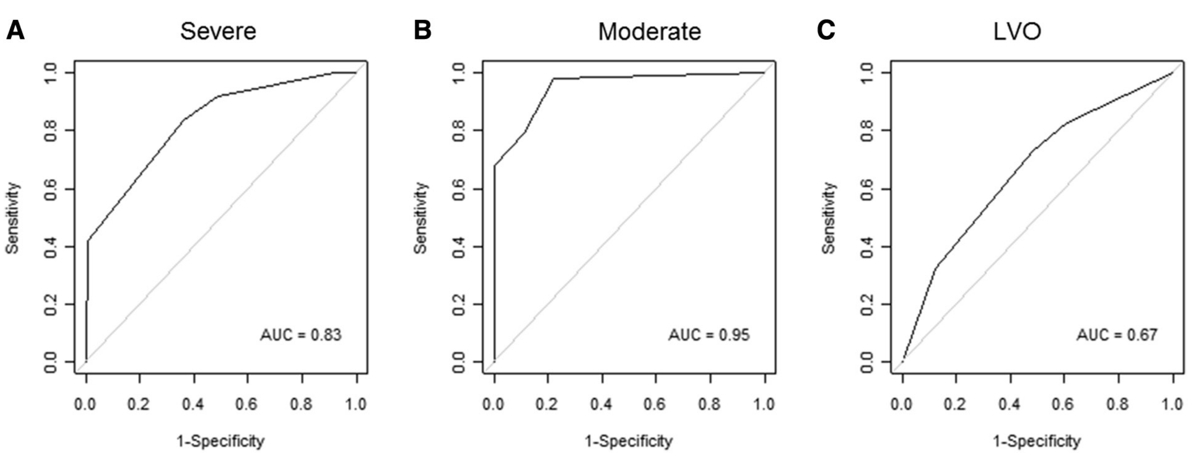

Figure 3. The receiver operating characteristic curve for Cincinnati Prehospital Stroke Severity Scale in detecting stroke severity and large vessel occlusion in the validation data set. AUC indicates area under the curve.

Table 2. Comparison of CPSSS to Other Published Prehospital Stroke Severity Scales

	CPSSS	LAMS	RACE	I3SS
Derivation data set (n)	624	119	654	171
Validated in independent data set (Y/N)	Y	N	Y	N
No. of items scored	3	3	6	3
Sensitivity/specificity for severe stroke	89%/72%	NA	NA	86%/95%*
Sensitivity/specificity for LVO	83%/40%	81%/89%†	85%/67%‡	67%/92%§
Evaluated in prehospital setting (Y/N)	N	N	Y	N

CPSSS indicates Cincinnati Prehospital Stroke Severity Scale; CTA, computed tomography angiography; I3SS, 3-Item Stroke Scale; LAMS, Los Angeles Motor Scale; LVO, large vessel occlusion; MRA, magnetic resonance angiography; N, no; NA, not applicable; RACE, Rapid Arterial Occlusion Evaluation; and Y, yes.

*Severe stroke defined as National Institutes of Health Stroke Scale (NIHSS) ≥14.

†LVO defined as terminal intracranial carotid artery occlusion, M1 segment middle cerebral artery occlusion, M2 segment middle cerebral artery occlusion, and M3/M4 segment middle cerebral artery occlusion using catheter angiography, MRA, CTA, and carotid ultrasound.

‡LVO was defined as occlusion of the terminal intracranial carotid artery, proximal middle cerebral artery (M1 segment), tandem (extracranial carotid artery plus middle cerebral artery) and basilar artery with transcranial duplex (50% of cases), CTA, and MRA.

§LVO defined as T/M1 occlusion all using MRA.

triaged to CSCs by EMS personnel using the CPSSS. In the greater Cincinnati/Northern Kentucky region, severe strokes have a mean estimated time difference between direct EMS transport to the CSC and direct EMS transport to the nearby community hospital of 6.7+/−(6.0) minutes.[37] In patients with severe strokes, further investigation is needed to determine the acceptable delay in tPA administration for direct EMS transport to a CSC for faster endovascular treatment[23] and neurological ICU monitoring. The impact of preferential triage of patients from the closest or requested community hospitals to a CSC on stroke-onset-to-hospital-arrival times depends on size of the region and location of hospitals.

An effective prehospital triage system for severe strokes would substantially decrease emergent hospital-to-hospital transfers and decrease the time from symptom onset to endovascular therapy, if applicable. Costs of transfers may be ≤$1000 by ambulance and $4000 to $25 000 by helicopter[25,26] and are borne by patients and their families because they are not reimbursed by hospital diagnosis-related groups.[27]

This study has some limitations. First, this was a retrospective analysis of 2 existing ischemic stroke trial cohorts; therefore, prospective evaluation by EMS providers is required. Second, there is variability of the NIHSS during the first few hours of AIS onset,[17,18] and it is possible that the stroke severity at the time of EMS examination will change by the time a treatment decision for ischemic stroke is made by medical providers. Next, isolated M2 lesions were not included in the CPSSS's LVO prediction analysis; however, only a minority of isolated M2 occlusions (2%–8% of patients) was included in recent positive endovascular trials.[14–16] The CPSSS has not been tested in populations of patients with hemorrhagic stroke or in a general population of patients with potential stroke who are evaluated by EMS personnel in the field. The CPSSS is likely to be less sensitive to subarachnoid hemorrhage in which patients' presentations are often nonfocal, unless the patient presents in coma. However, patients with sudden onset of coma are probably more likely to be preferentially triaged to tertiary centers.

In summary, the CPSSS was designed to be user-friendly and applicable for EMS providers in the field. CPSSS ≥2 has promising characteristics in predicting severe strokes and LVO and should be prospectively evaluated to demonstrate clinical use. This study serves as the foundation for an ongoing study assessing the feasibility of CPSSS by EMS providers in the prehospital setting among patients with potential stroke. The eventual goal is a prehospital scale that can be used as a reliable and practical method of prehospital triage of stroke patients in which the large majority of patients are transported to the location, where the best therapy can be delivered as rapidly as possible.

Sources of Funding

This study was supported by grants from the National Institute of Neurological Disorders and Stroke T-32 Cerebrovascular Fellowship Training Program for Cerebrovascular Disease.

Disclosures

Dr Broderick has received research monies to Department of Neurology from Genentech for PRISMS Trial; travel to Australian stroke conference paid for by Boerhinger Ingelheim. Study medication from Genentech for IMS III Trial and study catheters supplied during Protocol Versions 1 to 3 by Concentric Inc, EKOS Corp, and Cordis Neurovascular. The other authors report no conflicts.

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Stroke. 2015;46:1508-1512; originally published online April 21, 2015;
doi: 10.1161/STROKEAHA.115.008804
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231

Print ISSN: 0039-2499. Online ISSN: 1524-4628