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 $\geq 5$ 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.
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 criteria14 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 χ2 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.9,20 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.

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

<table>
<thead>
<tr>
<th>Transcranial Color Doppler</th>
<th>Angio-TC or Angio-RM</th>
<th>Arteriography</th>
<th>Site of Occlusion, Total (n=278)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No occlusion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCA M1</td>
<td>159</td>
<td>36</td>
<td>7</td>
</tr>
<tr>
<td>TICA</td>
<td>29</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>Tandem</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Basilar</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

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.

Importantly, 29 of 154 (19%) patients with a RACE ≥5 received endovascular treatment compared with 4 of 203 (2%) of those with RACE <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 been validated to detect patients with ischemic stroke at the prehospital setting: TIA, which is highly predictive of ischemic stroke (c-statistic, 0.90; 95% CI, 0.83–0.95) but has a lower specificity (55%) with a lower cutoff point of 4; and TICA, which is less predictive of ischemic stroke (c-statistic, 0.76; 95% CI, 0.67–0.84) but has a higher specificity (88%) with a lower cutoff point of 4. The RACE scale is the first validated tool to detect patients with acute stroke and LVO at prehospital setting.
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. 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. 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. Although shorter and simplified NIHSS have been designed and validated, 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. 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.

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

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

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