The Canadian Neurological Scale: A Preliminary Study in Acute Stroke

ROBERT CÔTÉ, M.D., F.R.C.P.(C).* VLADIMIR C. HACHINSKI, M.D., F.R.C.P.(C),† BETTE L. SHURVELL, M.SC.,§ JOHN W. NORRIS, M.D., F.R.C.P.(C),‡ and CHRISTINA WOLFSON, PH.D.§

SUMMARY Acute central nervous system dysfunction resulting in coma can be measured simply and reliably by the Glasgow scale. However, when the injury does not impair consciousness and the patient has aphasia, no comparable scale exists. A complementary scale to assess conscious and aphasic patients is proposed. Preliminary validation has been carried out in acute stroke patients, who commonly suffer neurological deficits without loss of consciousness. A simple standardized scale aids in the monitoring of neurological status, and may help in the assessment of prognoses and therapy.

Stroke Vol 17, No 4, 1986

IN SPITE OF MAJOR advances in technology over the past two decades, the sensitivity of skilled observers in detecting neurological change in stroke patients has not been surpassed. Stroke ranks as the third cause of mortality in North America and is even a greater cause of physical disability. Furthermore, up to fifty percent of acute stroke patients admitted to hospital can go on to deteriorate clinically after their admission. Detection of neurological deterioration and earlier therapeutic intervention in those patients could possibly result in limiting the extension of the neurological damage and provide a better prognosis. A standardized system for clinical monitoring of acute stroke patients which could be used by physicians and nurses alike would permit a consistent, accurate and more constant appraisal of patients. It could also function as an alerting mechanism prompting neurological reevaluation if needed. Presently, no universally accepted or reliable standardized method exists for the clinical monitoring of acute stroke. This paper presents such a grading system and some preliminary results on its clinical reliability.

Patients and Methods

Scoring System

Based on a review of the literature and our own clinical experience we have designed a standardized neurological assessment to evaluate stroke patients who are alert or drowsy (Appendix). Figure 1 shows the scoring sheet used for clinical monitoring. Such a standardized neurological assessment system ideally should a) have simple and non-ambiguous definitions for each modality tested, b) have a minimum number of grades per modality, to minimize as much as possible interobserver variability. A consequence of this might be a loss of sensitivity but our goal is not to duplicate the neurological examination but rather to detect clinically noteworthy differences in neurological status. c) be relevant for modalities which are most commonly affected in acute stroke, d) be easy to use and interpret by observers with different medical training, e) be brief, f) be practical and simple. Patients who are stuporous or comatose should be evaluated with the Glasgow Coma Scale which has previously been shown to be reliable and is also widely used by the neurological and neurosurgical community. Although presently used in certain centers to follow stroke patients, the Glasgow Coma Scale is felt to be too insensitive in most of those cases especially if the patient’s level of consciousness is not impaired.

Patients and Procedure

Selected patients who were alert or drowsy with a diagnosis of ischemic or hemorrhagic stroke (excluding subarachnoid hemorrhage) were chosen for this study from the neurology wards at University Hospital and St. Joseph’s Hospital in London, Ontario. Patients with differing degrees of neurological deficit were evaluated in order to test the full spectrum of grading possibilities provided by the scoring scale. Almost all of the patients were examined in the acute phase (i.e. first two to three days) of their illness. Four raters, consisting of one neurologist, one resident in neurology and two nurses proceeded in patient evaluation using this standardized assessment. All raters were given identical definitions and guidelines and instructed in the practical aspects of patient evaluation. Individual assessments were done independently and all raters were blinded to each other’s assessment. Each patient was scored by the raters within a short time interval (i.e. 2 to 4 hours). A few patients with fluctuating neurological deficits were examined twice.

Statistical Methods

The internal consistency of the neurological assessment scale was evaluated using the statistic Cronbach’s alpha. This is a measure of reliability based on the internal correlation of the items on the scale. Observer agreement was analyzed using Kappa for the two (2) category items on the scale and weighted Kappa for items involving more than two (2) ordinal categories. The advantage of using Kappa statistics is...
**STROKE ASSESSMENT SYSTEM (S.A.S.)**

**Observation Record**

**Section A: Patient Alert Or Drowsy**

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
</table>

**MENTATION**

<table>
<thead>
<tr>
<th>LEVEL CONSCIOUSNESS:</th>
<th>Alert(3)</th>
<th>Drowsy(1.5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORIENTATION:</td>
<td>Oriented(1)</td>
<td>Disoriented or Non Applicable(0)</td>
</tr>
<tr>
<td>SPEECH</td>
<td>Normal(1)</td>
<td>Expressive Deficit(0.5)</td>
</tr>
</tbody>
</table>

**MOTOR FUNCTIONS:**

**WEAKNESS:**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FACE:</strong></td>
<td>None(0.5)</td>
<td>Present(0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ARM:PROXIMAL</strong></td>
<td>None(1.5)</td>
<td>Mild(1)</td>
<td>Significant(1.5)</td>
<td>Total(0)</td>
<td></td>
</tr>
<tr>
<td><strong>ARM:DISTAL</strong></td>
<td>None(1.5)</td>
<td>Mild(1)</td>
<td>Significant(1.5)</td>
<td>Total(0)</td>
<td></td>
</tr>
<tr>
<td><strong>LEG:</strong></td>
<td>None(1.5)</td>
<td>Mild(1)</td>
<td>Significant(1.5)</td>
<td>Total(0)</td>
<td></td>
</tr>
</tbody>
</table>

**MOTOR RESPONSE:**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FACE:</strong></td>
<td>Symmetrical(0.5)</td>
<td>Asymmetrical(0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>ARMS:</strong></td>
<td>Equal(1.5)</td>
<td>Unequal(0)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>LEGS:</strong></td>
<td>Equal(1.5)</td>
<td>Unequal(0)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GRAPH FOR TOTAL SCORE**

![Graph for Total Score](image)

**Figure 1. Scoring Sheet.**
that one can quantify the agreement among observers over and above that expected by chance alone.\textsuperscript{20} The weights used for the weighted Kappa statistics are the dichotomous-ordinal weights proposed by Cicchetti.\textsuperscript{31} Using these weights, complete agreements receive a weight of 1, complete disagreement a weight of 0 and there is a gradation of weights inbetween depending upon the type of disagreement. For example, consider the item Proximal Arm Weakness. The categories are Normal (N), Mild (M), Significant (S) and Total (T). Clearly the disagreement between N and M is not the same as between M and S even though they are each one category apart. In the former case there is disagreement about the absence or presence of weakness, while in the latter the two observers agree on the presence of weakness but disagree about the extent. Table 1 displays the disagreement weights used.

\textbf{Results}

Altogether, thirty-four (34) patients were evaluated either by three or four observers for a total of 129 assessments; four patients were assessed twice. There were 13 females and 21 males and the age varied from 20 to 87 years old with a mean of 61.2 years. The clinical categories were as follows: 2 patients were classified as having transient ischemic attacks with neurological deficits that resolved within 24 hours; 28 had a cerebral infarction and 4 suffered an intracerebral hematoma. Risk factors included hypertension in 47% of the patients, heart disease (myocardial infarction, angina, congestive heart failure) 30%, diabetes mellitus 17% and peripheral vascular disease 6%. A consensus was reached between physicians on the patient’s deficits, as follows: All patients were alert or drowsy and more than 50% were well oriented. Half the patients had normal speech as defined by the speech scale in the Appendix. Twenty-three percent of the patients were classified as having an expressive deficit and twenty-seven percent had a receptive disorder. In all, more than 84% of the patients had at least one motor deficit present. Statistical analysis of the different modalities based on the 129 assessments is shown in table 2. The level of internal consistency of the items on the scale was excellent with Cronbach’s alpha of 0.896 and greater. Interobserver agreement was good to excellent with Kappa values on the different items ranging from 0.535 to 1.000. There were no apparent differences in the level of agreement between nurses, between physicians or between nurses and physicians. In the 10 patients with comprehension deficits, complete agreement (K of 1.00) was observed for each observer pair and on each item in Section A2 of the scale.

\textbf{Discussion}

The Glasgow Coma Scale\textsuperscript{12} was developed as a standardized method for the periodic evaluation of head injury patients. The emphasis in this scale is on neurological deficits not frequently found in acute stroke patients (i.e. failure of eye opening, decerebration, decortication). Important modalities such as dysphasia and gradation of motor deficits are not included. Clearly this type of scale does not apply specifically to acute stroke. Clinical scales and scoring systems have also been devised to evaluate the stroke patient in the rehabilitation phase.\textsuperscript{13–14} Jimenez et al\textsuperscript{14} presented such a scoring system which took into account assessment of social independence and self-care in the non-acute phase in order to plan better rehabilitation programs. In the chronic phase of stroke, the emergence of spasticity, the effect of rehabilitation and motivation of patients are all important elements which may be less relevant in the acute phase. Most of the present scoring systems in acute stroke were developed for drug trial evaluation. In 1980, Britton et al\textsuperscript{15} used a fairly extensive scoring system with a scale of 0 to 100 points. This system included activities of daily living and briskness of reflexes in the modalities to be tested. As mentioned previously, activities of daily living are only partly relevant when evaluating the acute phase of stroke and the briskness of reflexes has little impact on the functional status of the patients. Another limitation of this system lies in its complexity which makes it time consuming and restricted to physicians only. The same remarks apply to the system used by Mathew.\textsuperscript{16} Patten et al\textsuperscript{17} developed a scoring system which was heavily weighted towards higher cortical function including recent recall, digit span, remote memory and apraxia. These modalities are rarely perturbed specifically in acute stroke. Testing them greatly increases the length of the neurological assessment, making it less practical as a monitoring device. Oxbury et al\textsuperscript{18} identified a few simple factors which predicted the short term outcome in acute stroke. They failed to include evaluation of speech as a modality to be tested while the majority of points were allocated to evaluate the level of consciousness. Woolfard et al\textsuperscript{19} used a

\begin{table}[h]
\centering
\caption{Dichotomous-Ordinal Weights, Proximal Arm Weakness, Observer 2}
\begin{tabular}{|c|c|c|c|c|}
\hline
 & N & M & S & T \\
\hline
Observer 1 & 1.0 & 0.6 & 0.2 & 0.0 \\
\hline
Observer 2 & 0.6 & 1.0 & 0.8 & 0.4 \\
\hline
Observer 3 & 0.2 & 0.8 & 1.0 & 0.8 \\
\hline
Observer 4 & 0.0 & 0.4 & 0.8 & 1.0 \\
\hline
\end{tabular}
\end{table}

\begin{table}[h]
\centering
\caption{Results}
\begin{tabular}{|l|c|c|}
\hline
 & Cronbach's Alpha & Range of Kappa* \\
\hline
Orientation & 0.979 & 0.744–1.000 \\
Speech & 1.000 & 0.934–1.000 \\
Facial weakness & 0.934 & 0.535–1.000 \\
Proximal arm weakness & 0.980 & 0.788–1.000 \\
Distal arm weakness & 0.969 & 0.758–0.974 \\
Leg weakness & 0.896 & 0.722–0.842 \\
\hline
*Range including all 6 possible pairs of raters, all significant $p < 0.05$. Difference between alert and drowsy not formally evaluated during first part of study.
\end{tabular}
\end{table}
similar system in a drug trial in 1978. Mulley et al. in a trial evaluating the effect of dexamethasone in acute stroke, used a system which included the level of consciousness, speech deficits, urinary incontinence and arm power. Here again, this scale was highly weighted towards activities of daily living and leg power was omitted as a separate modality to be tested. The grading system developed by Tuthill was fairly comprehensive but here again the state of deep tendon and plantar reflexes were given a prominent place. Motor assessment included such non-relevant modalities as involuntary movements, dystonia and quadriplegia but omitted to grade the severity of the motor deficits. Cranial nerve examination included respiratory arrhythmias and akinetik mutism, modalities which complicated the scoring system further without adding any useful information. Finally, this last type of scoring system is clearly restricted to neurologists. In another steroid trial, Norris introduced the idea of weighing modalities in a system of nearly 300 points. Fawer in 1978 used a similar system to evaluate the effects of glycerol in cerebral infarction. Here again, the use of such systems for monitoring is limited by their complexity and the length of time needed to evaluate patients. The same remarks apply equally to a more recent index proposed by Hamrin et al. In summary, problems vary from one scoring system to the other, but basically their inadequacy stems from several factors, a) they are in general too complex and impractical, b) they suffer from observer variability, c) modalities tested are not relevant to the acute stroke patient, d) their use is almost exclusively restricted to physicians. Few attempts have been made to simplify the neurological assessment to a few meaningful criteria which could accurately reflect the patient’s condition while permitting the nursing personnel to communicate adequately a changing neurological status to the attending physician. The present system tests 10 simple clinical modalities. Under the section on mentation, one evaluates in all patients, first the level of consciousness, then orientation and speech. The next 7 items can be regrouped in two sections based on the presence or absence of a comprehension defect. If a patient has no comprehension defect, he is scored using section A which tests motor function in the face, arm proximal and distal and in the legs. However, if a comprehension defect is present, section A is used to evaluate motor response in the face, arms and legs. In general, each rater took between 5 and 10 minutes to assess completely each patient using the scale described. The choice of modalities to be tested was based on our own clinical experience and on the pertinent literature. However, gaze paresis found to be useful in some previous studies was omitted from our standardized assessment for two reasons. Firstly, if one looks at the data from Oxbury et al., gaze paresis was almost always associated with either hemiplegia or altered level of consciousness. Thus, incorporating this modality in a scoring system which already includes evaluation of the level of consciousness and motor function would appear redundant and lengthen the assessment without improving the sensitivity. Secondly, nurses in our own center found it quite difficult to evaluate gaze and visual field defects. Thus, testing of this modality in our own experience proved unreliable. Deep tendon reflexes, sensory deficits and plantar reflexes were not included in our assessment because these modalities rarely have a significant impact on the functional status of the patient. They are often liable to subjectivity and are difficult to quantify. Furthermore, their incorporation in a scoring assessment would only complicate the system and restrict its usage to physicians. The numerical weighting of neurological deficits in this scale was based on our own clinical experience and also on the importance given in the literature to different modalities in regards to the patient’s outcome after stroke. Furthermore, it is certainly tempting to sum up all of the different values into a total score which would instantly give the observer an overall assessment of the patient’s condition at all times. One could also envisage correlating the patient’s functional outcome with scores above or below a certain threshold during the acute period. Clearly however, the usefulness of such a total score will greatly depend on its components. It is important to make sure that the values given to each item or modality represents their respective importance in reflecting the neurological status and their capacity to predict the functional outcome. With this in mind, the present numerical values have to be seen as tentative. We are presently engaged in a multicenter effort where more patients and observers will be involved in testing this scale. This will also include comparing the patient’s initial score using this scoring system, with a standard neurological examination performed by physicians and also with the patient’s functional status at different times in the six months period following the neurological event. Based on these correlations, we assume that it would be possible to re-adjust the present weighting of each modality as to reflect their relative importance. As a consequence of this readjustment, the summing of these values into a total score might prove to be of value in providing meaningful and useful information earlier on in the acute phase. Our goal in designing this standardized assessment was not to replace the formal neurological examination but rather to provide the medical staff with a simple and accurate means of quickly monitoring the neurological evolution of the patient. The subgroup of patients with transient ischemic attacks, but with no detectable neurological deficits, should also be followed closely using this assessment. In addition, regular enquiries should be made regarding their symptomatology. This aspect is also covered in the appendix. The apparent high kappa values obtained in this pilot study differ greatly from those obtained in previous work by Shinar et al. This latter group observed a maximum kappa of 0.77 on items of neurological examination as compared to several kappa values of 1.0 in our study. There are, however, a number of differences between the two studies all of which would account for
the higher kappa values in the present study. Perhaps the most striking and significant difference is that many of the items in our scale are dichotomous (present/absent) compared to multiple category items in the Shinar work. Clearly it is much more likely to have higher agreement if it is only necessary to classify a patient into one of two categories rather than one of six or seven. Secondly, partial agreements on the more than two category items on the present scale were assigned partial agreement weights increasing the level of agreement over what would have been found if only unweighted kappas had been used as in Shinar et al.

Finally, on a more clinical note, in the present study each patient was scored by the observers within a two to four hour period reducing disagreements due to the patients changing status. Shinar et al report only that the observers saw the patients sometime in the same day.

Our preliminary data suggests that for medical and nursing personnel this standardized neurological assessment is reliable. It has also proven simple and practical and is now routinely used in a few Canadian institutions. Further studies are needed to test its clinical validity, utility and reproducibility in other centers as well as its ability to predict patient outcome. Should this system also prove to be valid and useful in different institutions, one could use it a) as a monitoring tool to improve the quality of care provided to patients suffering from acute stroke, b) as an objective evaluation of stroke patients for the comparison of clinical trial data collected from different centers.

Acknowledgments

We thank David Craig, M.D., Marybeth Hopkins, R.N. and Zann Spiller, R.N. for their help in assessing the patients.

Editor's Note: In accordance with Stroke Policy, this article was guest-edited by Dr. JP Mohr.

Appendix

Level of Consciousness

— Alert: Normal consciousness

— Drowsy: Patient when stimulated verbally remains awake and alert for a short period of time but tends to doze even when examined.

— Stuporous: Patient responds to loud verbal stimuli and/or strong touch; may vocalize but does not become alert or completely wake up.

— Comatose: Patient responds to deep pain (i.e. sternum pressure).

(1) Only by purposeful movement of limb towards noxious stimuli and/or grimacing and/or moaning (no verbal response).

(2) By nonpurposeful movements, flexion of upper limbs (i.e. decortication) or extension of upper limbs (i.e. decerebration).

(3) No response to noxious stimuli.

* If patient alert or drowsy monitor progress with Section A.

* If patient stuporous or comatose monitor progress with Section B.

Section A

1. Mentation

1) Orientation

— Oriented: Patient is oriented to both place (i.e. city or hospital) and to time (i.e. patient must give at least correct month and year). If early in month (i.e. first 3 days) previous month is acceptable. Speech can be dysarthric (mispronounced or slurred) but intelligible.

— Disoriented or non applicable: If for any reason patient cannot answer the preceding questions on orientation (i.e. does not know answer, gives wrong answer, answers only partially, cannot express himself either by lack of words or unintelligible speech or finally ignores questions).

2) Speech (Language and Pronunciation):

a) Receptive Language:

— Patient is asked:

(i) Close your eyes.

(ii) "Does a stone sink in water?"

(iii) Point to the ceiling. Repeat twice if necessary.

— If patient obeys 3 commands continue to b) expressive language.

— If patient obeys only 2 or less commands, score receptive defect in Speech Scale, and then proceed directly to motor function testing.

b) Expressive Language:

— Objects needed: pencil, key, watch.

— In this section pay special attention not only to answer but also to word pronunciation (i.e. dysarthria or slurred speech).

1) Ask patient to name each object. Make sure patient sees objects.

— If patient names only two or less of the objects, patient is scored expressive defect in Speech Scale.

— If patient names correctly 3 objects, proceed to #2 below.

2) Ask the patient the following questions

— What do you do with a pencil?

— What do you do with a key?

— What do you do with a watch?

— If patient answers correctly 3 questions, he/she is scored normal speech.

— If patient answers only two or less questions he/she is scored expressive defect in Speech Scale.

N.B. The above scoring system relates to language only, problems with pronunciation of words (i.e. dysarthria or slurred speech) is graded directly on Speech Scale below.

* Patient should always be scored according to worst speech deficit (i.e. language score or mispronunciation).

* Do not mimic commands in Section a) on Receptive Language.

Speech Scale

— Normal Speech: Answers all commands and questions in speech section, patient can have slurred speech (dysarthria) but still intelligible.

— Expressive Defect: Patient obeys command in re-
ceptive language section but makes one or more errors in section on expressive language and/or mispronunciation of words (slurred speech), with speech totally or partially non intelligible (severe dysarthria).
— Receptive Defect: Patient obeys only two or less commands in section on receptive language.

II. Motor Function
* When evaluating strength and range of motion in limbs always submit both limbs to same testing (i.e. apply same resistance at same position bilaterally).

Section A1 This section to be used if patient does not have comprehension problems (i.e. normal speech or expressive defect only).

1) Face:
— Test: Ask patient to show teeth or gums.
— Grading of deficit
— No weakness: Symmetrical grin, no asymmetry in smile.
— Weakness: Facial asymmetry. One corner of mouth lower than other, either at rest or while showing teeth.

2) Upper Limb (Proximal):
* Patient should be tested in sitting position if possible.
— Test: Abduction arms (to 90°).
* If patient lying in bed.
— Test: Elevate arms to approximately 45° to 90°.
— Strength in both arms tested simultaneously.
Resistance applied at midpoint between shoulder and elbow at all times.

3) Upper Limb (Distal):
* Patient tested in sitting or lying position arms elevated.
— Test: Patient asked to make fists and to extend wrists.
* Compare range of movement in both wrists simultaneously.
— If full range of extension in both wrists proceed to test strength by applying resistance separately to both fists while stabilizing patient’s arm firmly.

4) Lower Limb:
* Patient lying in bed for testing should always be scored according to worst deficit either a) or b).
— Test: (a) Hip flexion. Ask patient to flex thighs toward trunk with knees flexed at 90°. Movement in both thighs tested separately.
(b) Dorsiflexion foot. Ask patient to point toes and foot upwards. Compare both feet simultaneously (i.e. complete or partial movement).
— In both a) and b) apply resistance alternately to each thigh and foot after the full movement has been completed to test strength.
— Gradation of Motor Deficit
— No weakness: No detectable weakness.
— Mild weakness: Normal range of motion against gravity, but succumbs to resistance by observer either partially or totally.
— Significant weakness: Cannot completely overcome gravity in range of motion (i.e. partial movement).
— Total weakness: Absence of motion in movement tested or only contraction of muscles without actual movement of limb.

Section A2 — This section to be used for patients with comprehension problems (i.e. receptive defect in Speech Scale).
* Motor function in this section can be monitored in one of two ways:
  a) The ability of the patient to maintain a fixed posture in upper or lower limbs for a few seconds (3-5 seconds). The observer will alternate the limbs in the desired position.
  (1) Upper limbs: Place arms outstretched at 90° in front of patient.
  (2) Lower limbs: Flexion of thighs with knees flexed at 90°.
  (3) Facial Power: Have patient mimic your own grin. If patient does not cooperate then one proceeds to:
  b) Comparison of motor response to a noxious stimuli (i.e. pressure on nailbed of fingers or toes alternately with a pencil). Facial response (grimacing) to pain is tested by applying pressure on sternum.
— Symmetrical
— Asymmetrical (note side)

2) Upper Limbs:
— Equal motor response: Patient can maintain the fixed posture equally in both upper limbs for a few seconds or withdraws equally on both sides to pain.
— Unequal motor response: Patient cannot maintain equally on both sides the fixed posture, weakness is noted on one side or there is an unequal withdrawal to pain. Note side where withdrawal not as brisk.

3) Lower Limbs:
— Equal motor response: Patient can maintain the fixed posture equally in both lower limbs for a few seconds or withdraws equally on both sides to pain.
— Unequal motor response: Patient cannot maintain equally on both sides the fixed posture, weakness is noted on one side or there is an unequal withdrawal to pain. Note side where withdrawal not as brisk.

III. Symptomatology
(1) Presenting symptoms (recurrence)
— Type
— Localization
— Duration
— Frequency
(2) New Symptoms
— Type
— Localization
— Duration
— Frequency
* The above symptoms and any remarks should be noted in the progress notes.
* Side of weakness should be identified by "R" or "L" on scoring sheet.
* On scoring sheet, modalities graded with different numerical values.

If patient stuporous or comatose, monitor progress with Section B.

Section B
Use Glasgow Coma Scale.

References
The Canadian Neurological Scale: a preliminary study in acute stroke.
R Côté, V C Hachinski, B L Shurvell, J W Norris and C Wolfson

Stroke. 1986;17:731-737
doi: 10.1161/01.STR.17.4.731

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://stroke.ahajournals.org/content/17/4/731