Can Stroke Patients Use Visual Analogue Scales?
C.I.M. Price, MRCP; R.H. Curless, FRCP; H. Rodgers, FRCP

Background and Purpose—Visual analogue scales (VAS) have been used for the subjective measurement of mood, pain, and health status after stroke. In this study we investigated how stroke-related impairments could alter the ability of subjects to answer accurately.

Methods—Consent was obtained from 96 subjects with a clinical stroke (mean age, 72.5 years; 50 men) and 48 control subjects without cerebrovascular disease (mean age, 71.5 years; 29 men). Patients with reduced conscious level or severe dysphasia were excluded. Subjects were asked to rate the tightness that they could feel on the (unaffected) upper arm after 3 low-pressure inflations with a standard sphygmomanometer cuff, which followed a predetermined sequence (20 mm Hg, 40 mm Hg, 0 mm Hg). Immediately after each change, they rated the perceived tightness on 5 scales presented in a random order: 4-point rating scale (none, mild, moderate, severe), 0 to 10 numerical rating scale, mechanical VAS, horizontal VAS, and vertical VAS. Standard tests recorded deficits in language, cognition, and visuospatial awareness.

Results—Inability to complete scales with the correct pattern was associated with any stroke (P<0.001). There was a significant association between success using scales and milder clinical stroke subtype (P<0.01). Within the stroke group, logistic regression analysis identified significant associations (P<0.05) between impairments (cognitive and visuospatial) and inability to complete individual scales correctly.

Conclusions—Many patients after a stroke are unable to successfully complete self-report measurement scales, including VAS. (Stroke. 1999;30:1357-1361.)

Key Words: neuropsychological tests ■ outcome measurement ■ rehabilitation ■ stroke ■ validity

The visual analogue scale (VAS) has been used in studies of life after stroke to obtain information from patients about aspects of their health that cannot easily be assessed by observers. It typically consists of a 10-cm line without subdivisions or numbers, anchored at either end by an extreme statement concerning the dimension that is being measured. Individuals are asked to make a mark on the line to reflect their current state between these 2 extremes, the position of which is then measured in millimeters from the lower end. Detailed examination of the psychometric properties of the VAS suggest that outside of stroke populations it is a reliable and accurate measure of continuous subjective variables such as pain and analgesia, global well-being, and functional capacity. However, there is debate about the validity of the VAS when used by older subjects and this alone may have consequences for the stroke population.

Researchers have already anticipated that stroke-related impairments such as hemianopia, inattention, and limited manual dexterity could theoretically invalidate the traditional horizontal VAS. To overcome these problems, vertical and mechanical “slide-rule” versions have been used to investigate pain, mood, and health status after stroke. In the assessment of mood, it was reported that even stroke patients without cognitive impairment were bewildered by the visual analogue mood scale. In contrast, the Euroqol vertical VAS with numbers has shown a high level of test-retest reliability. Despite this good evidence that a modified VAS can have intrasubject reliability, there has been no work to examine the actual validity and sensitivity to change of the VAS concept in stroke populations. Our study examined the influence of stroke and the resulting higher cortical impairments on the validity of the VAS, and compared it with 2 less-sensitive scales that are common alternatives.

Subjects and Methods

Study Subjects
The study was conducted in an urban district general hospital that receives approximately 350 new stroke admissions per year. Ethical approval was obtained from the Newcastle and North Tyneside Health Authority Joint Ethics Committee. Over a 4-month period, a single investigator reviewed all patients who were admitted to the acute stroke unit or referred to the day hospital after stroke. Patients were eligible if they had suffered a stroke in the last 6 months, exhibited spontaneous eye opening, and were able to understand a simple motor command to lift their nonimpaired arm and point at the ceiling. This was to exclude subjects who were too drowsy or dysphasic to understand further instructions. Control subjects with-
Subjects were asked to rate this initial tightness on the 5 scales (Figure and Table 1).

- **FPRS**: Four words typed in order: none, mild, moderate, severe.
- **NRS**: Numbers 0 to 10 arranged vertically, with “0” labeled “no tightness at all” and “10” labeled “as tight as it could be.”
- **Horizontal VAS**: 10 cm line labeled at the extremes with “no tightness” and “as tight as it could be.”
- **Vertical VAS**: 10 cm line labeled at the bottom with “no tightness” and at the top with “as tight as it could be.”
- **Mechanical VAS**: Thirty-centimeter slide rule with a 0 to 100 number scale marked on the reverse. The side of the ruler seen by the subject was marked only with “no tightness” at the bottom and “as tight as it could be” at the top. Each division on the reverse was the equivalent of 3 mm, so for further analysis the readings could be directly compared with the Horizontal and Vertical VASs.

These were presented in a predetermined, computer-generated random order. Instructions for each scale were typed clearly on a laminated A4-size card and read aloud to the subjects before they rated the tightness. Subjects who could not hold a pen were all able to point to the scales to indicate the position of their answer. The rating on each scale was recorded by the observer. The Mechanical, Horizontal, and Vertical VAS results were measured in millimeters from the lowest end.

The cuff was further inflated to twice the initial pressure (40 to 60 mm Hg), and subjects were asked to indicate the level of tightness on the scales presented to them in a random sequence. Finally, the cuff was deflated to 0 mm Hg before subjects were asked to rate perceived cuff tightness for a third time. To report on the scales at each level of tightness took less than 1 minute, and there were no complaints of discomfort.

To confirm that subjects were correctly sensing the cuff tightness, they were also asked after the second and final changes to indicate whether the pressure that they felt on their arm was the “same, more, or less” (SML) than before. This SML scale was used to check that the change was correctly perceived in simple terms and that the increase in cuff tightness would not necessarily trigger a movement up to a more intense category, e.g., from mild to moderate.

Subjects were defined as using the scale correctly if the decrease to the initial rating. Because the scales were treated as ordinal rather than ratio measures, subjects were required to demonstrate the appropriate pattern of cuff tightness only.

Each type of scale possesses a different degree of sensitivity, according to the number of options available to record the degree of tightness. The following criteria for correct scale completion were defined in advance: (1) The SML scale was scored correctly if subjects indicated an increase and decrease as the first and second changes from the initial tightness level. (2) The 4 categories of the 4-point rating scale (FPRS) were judged to be broad enough so that the increase in cuff tightness would not necessarily trigger a movement up to a more intense category, e.g., from mild to moderate.

Subjects were defined as using the scale correctly if the decrease to
0 mm Hg resulted in a decrease on the scale to below the initial level. (3) The numerical rating scale was considered sensitive enough with its 11 points (0 to 10) that the increase and decrease in tightness could be reflected by a change of at least 1 point. (4) The VAS in its mechanical, vertical, and horizontal forms was the most sensitive scale used. We defined that correct use of the scale required subjects to mark at least a 5-mm change from the chosen starting mark for both the cuff increase and decrease.

**Assessment of Stroke Impairment**

After the examination of scales, all stroke subjects underwent a structured examination of stroke-related impairments in the following sequence: language (the comprehension and expression sections of the Frenchay Aphasia Screening Test [FAST]23), cognition (Abbreviated Mental Test Score [AMTS]24), visuospatial impairment (the Star Cancellation Test [SCT]25), visual field defect by confrontation, tactile inattention by perception of bilateral light touch,26 presence of clinically obvious hemineglect if inattention was not assessable, and limb power (Motricity Score27). When it was not possible to determine the absence of an impairment in subjects with aphasia (eg, cognitive deficit), it was assumed to be present. The clinical stroke subtype28 at time of maximal impairment was examined, and it had the greatest number of mistakes. The only scale used correctly by the majority of the stroke group was the SML scale, but this instrument clearly provides limited information about the status of an individual. The higher cortical impairments upon success in scale completion varied significantly with stroke subtype (Table 4).

To examine the relative influence of stroke-related impairments on failure to use each scale correctly, the following factors were used simultaneously in a logistic regression analysis: sex, age, clinical stroke subtype, first or recurrent stroke, left or right handedness, limb side affected, days since stroke, overall limb power (Motricity Score), FAST status, AMTS status, SCT status, presence of tactile inattention or clear hemineglect, and presence of visual field defect. Those factors significantly associated with incorrect completion of the rating scales and their odds ratios are described in Table 5.

**Discussion**

This study demonstrated that subjects with stroke are less likely than an age-matched control group to correctly complete 5 subjective rating scales. Specific stroke-related impairments were associated with inability to use each scale in the stroke group. Furthermore, increasing scale sensitivity was associated with poorer completion by both control and stroke subjects. The VAS was the most sensitive scale examined, and it had the greatest number of mistakes. The only scale used correctly by the majority of the stroke group was the SML scale, but this instrument clearly provides limited information about the status of an individual. The ability of most stroke subjects to use the SML scale suggests that although they correctly registered changes in cuff tightness, they were not able to express this information using more complicated instruments with greater sensitivity.

Clinical stroke subtype influenced scale completion. After posterior circulation stroke, subjects were likely to be successful in all scales. The lacunar circulation stroke group

<table>
<thead>
<tr>
<th><strong>TABLE 2. Frequency of Impairments Among Stroke Subjects</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test</strong></td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>FAST</td>
</tr>
<tr>
<td>AMTS</td>
</tr>
<tr>
<td>SCT</td>
</tr>
<tr>
<td>Tactile inattention examination</td>
</tr>
<tr>
<td>Visual field defect examination</td>
</tr>
</tbody>
</table>

**Results**

Between September and December 1997, 111 patients with stroke were reviewed. Fifteen were excluded because of drowsiness or severe aphasia. Of the remaining 96 patients (50 male; mean age, 72.5 years) 21 were within 1 week of their stroke, 20 between 1 week and 1 month, and 55 between 1 and 6 months. Eighty-three had undergone a CT scan, which confirmed an infarct in 75 and primary intracerebral hemorrhage in 8. This was the first-ever stroke for 74 patients. The frequencies of stroke-related impairments are described in Table 2. Forty-eight control subjects (29 male; mean age, 71.5 years) agreed to take part.

The number of stroke and control subjects who successfully completed each scale are given in Table 3. It can be seen that apart from the SML scale, stroke was associated with a significantly lower proportion of subjects using each of the rating scales correctly. Within the stroke group, successful scale completion varied significantly with stroke subtype (Table 4).

To examine the relative influence of stroke-related impairments on failure to use each scale correctly, the following factors were used simultaneously in a logistic regression analysis: sex, age, clinical stroke subtype, first or recurrent stroke, left or right handedness, limb side affected, days since stroke, overall limb power (Motricity Score), FAST status, AMTS status, SCT status, presence of tactile inattention or clear hemineglect, and presence of visual field defect. Those factors significantly associated with incorrect completion of the rating scales and their odds ratios are described in Table 5.

**TABLE 3. Numbers of Subjects Who Used Each Scale Correctly**

<table>
<thead>
<tr>
<th>Scale</th>
<th>Control Subjects n=48</th>
<th>Stroke Subjects n=96</th>
</tr>
</thead>
<tbody>
<tr>
<td>SML</td>
<td>48 (100)</td>
<td>91 (95)</td>
</tr>
<tr>
<td>FPRS†</td>
<td>46 (96)</td>
<td>62 (65)</td>
</tr>
<tr>
<td>NRS*</td>
<td>41 (85)</td>
<td>51 (53)</td>
</tr>
<tr>
<td>Mechanical VAS*</td>
<td>41 (85)</td>
<td>50 (52)</td>
</tr>
<tr>
<td>Vertical VAS†</td>
<td>42 (88)</td>
<td>45 (47)</td>
</tr>
<tr>
<td>Horizontal VAS*</td>
<td>39 (81)</td>
<td>45 (47)</td>
</tr>
</tbody>
</table>

Values in parentheses are percent.

* P<0.001; † P<0.0001.
TABLE 4. Number of Stroke Subjects Who Used Each Scale Correctly According to Subtype

<table>
<thead>
<tr>
<th>Scale</th>
<th>POCs</th>
<th>LACS</th>
<th>PACS</th>
<th>TACS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SML</td>
<td>12 (100)</td>
<td>22 (100)</td>
<td>35 (95)</td>
<td>22 (88)</td>
</tr>
<tr>
<td>FPRS*</td>
<td>12 (100)</td>
<td>19 (86)</td>
<td>24 (65)</td>
<td>7 (28)</td>
</tr>
<tr>
<td>NRS*</td>
<td>9 (75)</td>
<td>14 (64)</td>
<td>22 (60)</td>
<td>6 (24)</td>
</tr>
<tr>
<td>Mechanical VAS*</td>
<td>11 (92)</td>
<td>14 (64)</td>
<td>18 (49)</td>
<td>7 (28)</td>
</tr>
<tr>
<td>Vertical VAS*</td>
<td>10 (83)</td>
<td>13 (59)</td>
<td>15 (41)</td>
<td>7 (28)</td>
</tr>
<tr>
<td>Horizontal VAS*</td>
<td>8 (67)</td>
<td>14 (64)</td>
<td>19 (51)</td>
<td>4 (16)</td>
</tr>
</tbody>
</table>

Values in parentheses are percent. POCs indicates posterior circulation stroke; LACS, lacunar circulation stroke; PACS, partial anterior circulation stroke; and TACS, total anterior circulation stroke.

* P<0.01.

demonstrated a high level of competency for the FPRS. The partial and total anterior circulation stroke groups showed low levels of correct scale use beyond the SML measure. This would suggest that the ability to use these scales is impaired by loss of higher cortical function.

Plausible associations between stroke impairments and the correct use of individual scales were identified when possible dependent factors were entered into the regression analysis. The dominant factor for the FPRS, NRS, and Mechanical VAS was cognitive, whereas the Horizontal and Vertical VAS showed a greater reliance on visuospatial factors. It is possible that the former require greater cognitive competence in view of their linguistic, mathematical, and mechanical basis, while the latter need an intact appreciation of a 10-cm line arranged horizontally or vertically.

Aphasia was not significantly associated with mistakes using these scales, although impairment of language is also likely to be an important factor determining their comprehension. Aphasia has been associated with a reduction in the amount of pain medication received by patients, and a recent review examining the definition of pain emphasized the need to develop scales that allow for limitations in expression. However, in this study it should be noted that patients with aphasia which prevented them from understanding a simple command were excluded. In addition, subjects who were unable to answer the questions of the AMTS or complete the SCT for any reason were scored accordingly (Table 2). This simple pragmatic approach may explain the lack of additional value of the FAST score in the regression analysis.

This study did not include a comparison of higher cortical impairments found in the stroke and nonstroke populations, because the control group was not formally assessed with the AMTS, FAST, and SCT. This should not undermine the validity of these results, as our intention was to examine the overall influence of stroke on scale performance and then further investigate the impact of higher cortical deficits within the stroke population alone. A careful survey of medical records excluded control subjects with any undeclared cognitive and sensory deficits. It would require a more complicated design to include subjects with similar higher cortical impairments not due to cerebrovascular disease, and so it is currently unknown whether the difficulties in using these scales extend beyond the stroke population.

Subjective states such as pain and quality of life cannot be measured objectively in a reliable fashion. In the absence of a clear gold standard, there are difficulties in evaluating scale validity. It is a minimum requirement that measurement scales be ordinal if they are to have any practical value. Studies using thermal electrodes to produce a controlled temperature stimulus suggest that the VAS is valid as a ratio scale, but other researchers have not confirmed this. We defined correct usage of the VAS when subjects indicated the correct directional change in tightness. Thus, we were examining the validity of these scales as ordinal measures only. The majority of the control group were able to use the VAS correctly according to these criteria (Mechanical, 85%; Vertical, 88%; and Horizontal, 81%). This concurs with results from previous studies which have suggested that older subjects can use VAS formats as competently as their younger counterparts. The horizontal VAS was the least successful scale used by the control group, supporting a previous report that it is the least suitable design for general use in the elderly.

The cuff tightness test used in this study is a low-pressure alternative to the Submaximal Effort Tourniquet Test, in which the sphygmomanometer cuff is used to occlude the arterial supply to the hand for a set time, while repeated flexion/extension movements cause lactic acidosis to occur in the forearm muscles. The time for which occlusion is maintained has been found to reliably agree with the amount of discomfort that subjects report on the VAS. Our painless alternative requires subjects to rate the perceived sensation of tightness on the upper arm to validate the self-report scales as ordinal measures. The property of tightness does not necessarily reflect the difficulties faced by subjects rating pain intensity but has allowed an exploration of how stroke affects scale comprehension.

**TABLE 5. Results of Logistic Regression Analysis for Factors Associated With Incorrect Use of Each Scale**

<table>
<thead>
<tr>
<th>Factors Linked With Incorrect Use, by Scale</th>
<th>P</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPRS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fail AMTS</td>
<td>0.001</td>
<td>7.3</td>
<td>2.3–23.2</td>
</tr>
<tr>
<td>Tactile inattention or hemineglect</td>
<td>0.02</td>
<td>4.1</td>
<td>1.3–13.6</td>
</tr>
<tr>
<td>Fail SCT</td>
<td>0.04</td>
<td>3.4</td>
<td>1.0–11.5</td>
</tr>
<tr>
<td>Mechanical VAS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fail AMTS</td>
<td>&lt;0.0001</td>
<td>10.3</td>
<td>3.6–29.0</td>
</tr>
<tr>
<td>Tactile inattention or hemineglect</td>
<td>0.01</td>
<td>4.1</td>
<td>1.3–12.6</td>
</tr>
<tr>
<td>Horizontal VAS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fail SCT</td>
<td>0.02</td>
<td>3.9</td>
<td>1.3–11.9</td>
</tr>
<tr>
<td>Fail AMTS</td>
<td>0.02</td>
<td>3.4</td>
<td>1.3–9.0</td>
</tr>
<tr>
<td>Vertical VAS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tactile inattention or hemineglect</td>
<td>0.01</td>
<td>4.5</td>
<td>1.4–14.4</td>
</tr>
<tr>
<td>Fail SCT</td>
<td>0.04</td>
<td>2.7</td>
<td>1.0–7.1</td>
</tr>
</tbody>
</table>
Because of the obvious nature of many stroke impairments, it is important to acknowledge that it was not possible for the observer to be completely blinded to which subjects had suffered a stroke. However, to minimize sources of observer error, the data collection was carried out by a single researcher who was not involved in the care of the subjects, the scale performance was always recorded before the stroke impairments were formally measured, and the predetermined definitions for correct scale use were strictly adhered to. Whenever possible, attempts were made to standardize other factors during the assessments, such as setting and timing. To minimize a carry-over effect between scales, these were presented in a predetermined random order each time.

This study suggests that caution is needed when using traditional scales to obtain subjective health status data from stroke patients with higher cortical deficits. Scales that have been designed and validated in the nonstroke population will not necessarily be either valid or useful for stroke patients. We do not recommend that the VAS in any format is generally employed as a self-report measurement tool after stroke. Accurate assessments of subjective health states after stroke, such as pain, are still needed in both clinical and research settings.

Acknowledgments

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References

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