Recovery of Ipsilateral Dexterity After Stroke

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Background and Purpose—Previous work indicated that patients within 1 month of parietal or posterior frontal damage are often abnormally slow or clumsy when using the ipsilateral hand for dexterity tasks. This article reports a 6-month follow-up study to assess recovery and the impact on functional outcome.

Methods—Twenty-four patients (80%) were available for follow-up. They used the ipsilateral hand on a dexterity test that simulated everyday hand function. Weakness and ideomotor apraxia were also assessed. Performance was compared with that of healthy age-matched control subjects using the same hand. Rating scales for self-care and dexterity in everyday life were completed by patients and carers.

Results—Significant recovery had occurred on all measures, but patients with left hemisphere damage remained impaired on the dexterity test, with 7 patients (58%) scoring below the normal range. Five of these were apraxic. Reports of everyday functioning did not reflect this impairment, but there were inconsistencies in these reports, which raised doubts as to their accuracy.

Conclusions—Ipsilateral dexterity shows recovery during the first 6 months, but there may be persistent impairment related to apraxia after left hemisphere stroke. It appears that the impact of this on functional outcome is typically small compared with the large effect of severity of contralateral paresis. It may be a significant factor in some cases, however, and direct observation of everyday functioning would be needed to clarify more subtle effects on outcome. (Stroke. 2000;31:430-433.)

Key Words: motor activity cognition rehabilitation

A previous article1 reported a high incidence of impaired dexterity of the ipsilateral hand within 1 month of parietal or frontal damage after middle cerebral artery stroke. The impairment was not sufficient to prevent completion of everyday tasks, but there was slowing and clumsiness, which were most marked after left hemisphere damage. Cognitive deficits affecting perception and control of action appeared to be the major cause of these dexterity problems. This article reports a 6-month follow-up study to investigate the long-term impact of ipsilateral impairment on recovery and disability.

Numerous studies2-5 have documented impairments in ipsilateral hand function. These were based on single assessments of patients mostly >6 months after stroke. From these we can conclude that dexterity is impaired at the chronic stage, but these studies provided no information on earlier recovery. One small-scale study6 reported a return to normal ipsilateral grip strength over the first few weeks and a longer-term improvement in the performance of the ipsilateral arm for more cognitively demanding visual tracking and reaction time tasks. The expectation for the present study was therefore that we would observe a significant improvement in dexterity over 6 months but that there would be residual problems on complex tasks.

All studies agree that ipsilateral impairments are subtle compared with the gross sensorimotor losses on the contralateral side, so there is uncertainty over any impact on recovery and rehabilitation. The relationship between acute ipsilateral impairment and function at 6 months was therefore an additional focus of the present investigation. Given that ipsilateral impairment appeared to be due to cognitive deficits affecting skilled motor control, it was hypothesized that this might have an impact in 2 ways. First, it might slow or reduce the acquisition of ipsilateral hand skills to compensate for hemiplegia, and second, these deficits might impair relearning of control of the hemiparetic arm. Both aspects were investigated in the present study.

Subjects and Methods

Subjects
The study was approved by the Leicestershire Health Authority Ethics Committee, and all subjects gave informed consent.

Stroke Patients
Follow-up assessments are reported for 24 of the 30 patients who had taken part in the initial study.1 The reasons for dropout were unwillingness to participate (3 patients), further stroke or unrelated ill health (2 patients), and death (1 patient). All patients had suffered a middle cerebral artery stroke causing a unilateral infarct involving the parietal and/or posterior frontal lobe. Twelve patients had
suffered a left hemisphere lesion (LCVA): 8 men and 4 women with a mean age of 65 years (range, 40 to 83 years). The 12 patients with a right hemisphere lesion (RCVA) comprised 8 men and 4 women with a mean age of 58 years (range, 33 to 74 years). The difference in mean age for these 2 groups was not statistically significant (Mann-Whitney U test, \( P > 0.1 \)). The mean time since stroke at follow-up was 209 days (range, 170 to 303 days) for the LCVA group and 212 days (range, 179 to 299 days) for the RCVA group. The mean interval between initial assessment and follow-up was 191 days (range, 129 to 268 days) for the LCVA group and 184 days (range, 147 to 281 days) for the RCVA group. All patients used the hand ipsilateral to their lesion for the dexterity and apraxia tests. One RCVA patient was left-handed before the stroke; all other patients were right-handed.

**Control Subjects**

Data on the 34 control subjects from the initial study\(^1\) will be referred to. These were healthy volunteers of age similar to that of the stroke patients. Inclusion criteria were no history of stroke or other neurological disease, right-handed, and no significant problems with hand movement due to arthritis, etc. They were assessed using their right hand (right-hand control subjects, RC) or the left hand (left-hand control subjects, LC). The LC group comprised 7 men and 11 women with a mean age of 63 years (range, 42 to 86). The RC group was made up of 8 men and 8 women with a mean age of 67 years (range, 47 to 83). Any effects of practice on the assessments were estimated by reassessing 8 of this group. These were 4 LC and 4 RC subjects, with a mean age of 66 years (range, 61 to 74 years). Reassessment took place at a mean interval of 230 days (range, 185 to 246 days).

**Procedure**

The following measures were repeated from the initial assessment battery.\(^1\)

**Bean Spooning**

A modification of the simulated feeding test from the Jebsen Hand Function Test was used.\(^7\) This subtest was selected from others used at the initial assessment\(^1\) because it had high sensitivity to impairment and the best interrater agreement for detection of errors. Five kidney beans were spaced at 2-cm intervals along the frontal plane \( \approx 30 \text{ cm} \) in front of the subject. The subject had to pick up a teaspoon and spoon the beans one at a time into a can placed close to body midline. This procedure was repeated for 3 trials. The total time was recorded for each trial. An error was scored whenever there was a failure to spoon each bean at the first attempt (maximum errors, 5 per trial).

**Grip Strength**

A Jamar dynamometer (model 0030J4) was used to measure grip strength over 3 trials (alternating with trials using the contralateral hand). The dynamometer was held in front of the subject so that a comfortable power grip was possible with the elbow slightly flexed. The minimum recordable grip strength was 1 kgf.

**Extended Motricity Index**

The Extended Motricity Index\(^8\) (EMI) is a global measure of range and power in the hemiparetic arm, combining ratings of shoulder abduction and elbow flexion with the measure of grip strength.

**Action Imitation**

The Action Imitation\(^9\) test for ideomotor apraxia involves the subject having to pantomime of a series of transitive actions (using a cup, key, ball, pencil, toothbrush, and hammer) and gestures (salute, threaten with a fist, wave goodbye). If the action is not correct on command, a demonstration is given for imitation. Each item was scored by the examiner on a 3-point scale: 0, unable/gross errors; 1, possible errors; 2, correct.

**Reports of Everyday Function**

A carer or relative was jointly interviewed in most cases. Independence in activities in everyday life and leisure was assessed with the Nottingham Extended Activities of Daily Living (NEADL) scale.\(^10\) A more detailed account of everyday hand function was obtained with a new 23-item questionnaire. This asked for 4-point ratings of difficulty in carrying out specified examples of everyday functional activities in washing/grooming, dressing, cooking, eating, and manipulation of objects (see Appendix). The response categories were “none/some need help/can’t/not tried/not applicable.”

**Results**

**Contralateral Recovery**

As expected, there was significant reduction in paresis of the contralateral arm since the initial assessment within 1 month of stroke. Scores on the EMI rose from a mean of 92 (SD, 34) to a mean of 116 (SD, 38). A repeated-measures ANOVA indicated that this change over time was highly significant \( [F(1,22), 14.1; \ P < 0.001] \), and there was no effect of side of stroke \( [\text{time} \times \text{side interaction}, F(1.22), 0.3; \ P = \text{NS}] \).

**Ipsilateral Recovery**

Figures 1 and 2 show that there were also gains in ipsilateral grip strength and dexterity (speed on bean-spooning). The absence of significant changes for the retested control subjects means that the change for patients cannot be ascribed to practice effects. For the stroke patients, a repeated-measures ANOVA (with sex and age removed as covariates) confirmed significant recovery for ipsilateral grip \( [F(1,20), 15.5, \ P = 0.001] \) and no significant interaction with side of stroke \( [\text{time} \times \text{side interaction}, F(1.22), 0.3; \ P = \text{NS}] \).

\( 431 \)
Patient Scores at Follow-Up Compared With Initial Control Results

<table>
<thead>
<tr>
<th>Grip strength, kgf</th>
<th>LCVA (n=12)</th>
<th>LC (n=18)</th>
<th>RCVA (n=12)</th>
<th>RC (n=16)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean, contralateral</td>
<td>8.1*</td>
<td>26.7</td>
<td>6.5*</td>
<td>28.4</td>
</tr>
<tr>
<td>Range</td>
<td>0–27</td>
<td>7–56</td>
<td>0–33</td>
<td>9–52</td>
</tr>
<tr>
<td>Mean, ipsilateral</td>
<td>23.3</td>
<td>30.9</td>
<td>37.3</td>
<td>26.0</td>
</tr>
<tr>
<td>Range</td>
<td>6–45</td>
<td>11–53</td>
<td>8–59</td>
<td>7–56</td>
</tr>
<tr>
<td>Ipsilateral bean spooning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean time, s</td>
<td>14.3*</td>
<td>9.7</td>
<td>8.8</td>
<td>9.1</td>
</tr>
<tr>
<td>Range</td>
<td>8–20</td>
<td>5–13</td>
<td>6–12</td>
<td>6–12</td>
</tr>
<tr>
<td>Mean total errors</td>
<td>3.8</td>
<td>1.8</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Range</td>
<td>0–12</td>
<td>0–6</td>
<td>0–2</td>
<td>0–5</td>
</tr>
<tr>
<td>Action imitation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean accuracy</td>
<td>13.6*</td>
<td>17.8</td>
<td>17.5</td>
<td>17.8</td>
</tr>
<tr>
<td>Range</td>
<td>2–18</td>
<td>16–18</td>
<td>16–18</td>
<td>16–18</td>
</tr>
</tbody>
</table>

Note. Mann-Whitney U tests comparing patient groups with controls,
*P<0.001. All others, P=NS.

recovery for bean spooning time [F(1,20), 7.8; P<0.01], and the change was greater for the LCVA group [interaction with side, F(1,20), 4.4; P<0.05]. At initial assessment, LCVA patients often needed frequent attempts to get beans onto the spoon (median errors, 6; range, 1 to 15). This had improved significantly by follow-up (median, 2; range, 0 to 12; Wilcoxon matched pairs test, P<0.05). The error rate was low for RCVA patients at initial assessment (median, 1; range, 0 to 3), and performance was nearly perfect at follow-up (see the Table).

At the initial assessment, only LCVA patients showed severe impairment on the action imitation test, and the median score was 10/18. This rose to 14/18 on reassessment (Wilcoxon matched pairs test, P<0.05). One RCVA patient had an abnormal score on initial assessment (15/18), but all were in the normal range when reassessed (see the Table).

Prognostic Value of Acute Ipsilateral Impairment

Ipsilateral performance at the initial assessment correlated strongly with the same measures at follow-up [test-retest correlations: grip strength, r(22)=0.82, P=0.001; beans time, r(22)=0.55, P<0.01; beans errors, r(22)=0.62, P=0.001], but there were no significant correlations with functional outcome as measured by the NEADL index (all r<0.25, P=NS). A similar picture emerged for motor recovery of the contralateral arm as measured by the EMI. Here, there was again a strong test-retest correlation for EMI scores [r(22)=0.84, P<0.001], but the presence of acute ipsilateral impairment was not a prognostic indicator for contralateral EMI at 6 months (all r<0.3, P=NS).

Chronic Ipsilateral Impairment

The Table shows that there was no significant impairment of ipsilateral grip strength for the LCVA or RCVA groups but that the LCVA group was much slower than control subjects on the bean spooning task. The trend toward greater error rate in the LCVA group did not reach statistical significance (Mann Whitney U test, P=0.06, 1-tailed). In terms of individual patients, no RCVA patient fell beyond the normal range on speed or errors on the bean spooning task, whereas 7 LCVA patients were abnormal on speed (4 patients) or speed and errors (3 patients). Five of these cases were definitely apraxic on action imitation (scores of ≤15).

Reports of Everyday Function

The LCVA and RCVA groups produced similar mean scores on the NEADL scale (RCVA, 11.5, range, 3 to 21; LCVA, 11.2, range, 4 to 19). When the 2 groups were combined, there was no significant correlation between NEADL scores and bean-spooning time or errors (all P>0.1).

Across the 23 everyday tasks listed in the dexterity questionnaire, a rating of “some problem” or worse was reported for a mean of 4 items (range, 0 to 16) for the LCVA group and a mean of 5 items (range, 0 to 9) for the RCVA group. The 7 LCVA who were impaired on bean-spooning reported a mean of 7 problem items (range, 1 to 16), which was not significantly greater than for the 17 unimpaired patients (mean, 4; range, 0 to 13; Mann-Whitney U test, P>0.1). However, questions about the validity of reports were raised by the failure of the questionnaire to distinguish between the 12 patients with no voluntary grip in the paretic hand (mean problems reported, 5) and those with some contralateral function (mean problems reported, 5). Furthermore, 5 patients with no contralateral grip reported that they had “no problem” on some activities that are normally bimanual, such as tying shoelaces or opening a jar.

The patient reporting the most frequent dexterity problems was a 77-year-old man who had suffered a left parietofrontal infarct. At follow-up, there was no arm paresis (grip strength, right hand, 23 kgf; left hand, 22 kgf), but he was severely apraxic (action imitation, 12/18) and impaired on bean spooning (median time, 18 seconds; 8/15 errors). He was independent for self-care and leisure activities (NEADL, 15/22) but reported difficulties for most items on the dexterity questionnaire (no problem, 4 items; some problem, 13 items; need help/cannot, 3 items; N/A, 3). He reported that he tended to grasp objects with the wrong orientation (eg, holding a table knife with blade upward) and had “a bit of a battle” trying to put it right.

Discussion

These results are consistent with a number of previous studies showing that late after stroke, there may be abnormal clumsiness when the patient uses the nonparetic hand.\(^2\)\(^-\)\(^5\) Significant recovery had occurred since the subacute stage, and we confirmed the observation by Jones et al\(^6\) of return of simple sensorimotor function, such as ipsilateral grip strength. However, there was persistent impairment on a more complex, functional task: among this group of patients with parietal or posterior frontal damage after a first stroke, nearly 30% were beyond the normal range on the bean-spooning dexterity test. This was a small sample of patients, and larger studies are needed to confirm the generality of these findings, but the consistency with previous research and strength of the findings for this carefully selected group gives confidence in the validity of these results.
Significant impairment was limited to patients with left hemisphere damage. At the subacute stage, ipsilateral impairment was found to be most severe after left hemisphere damage, and high error rates were correlated with the presence of ideomotor apraxia on an action imitation test. There has been little previous research on recovery from ideomotor apraxia. Basso et al. used a 24-item gesture imitation test for apraxia. They found that ~50% of the patients who were classified as apraxic at the subacute stage showed an impairment that persisted for ≥6 months. A similar picture emerged from the present study, suggesting that significant recovery occurs but that ideomotor apraxia does outlast the subacute stage for a significant proportion of patients and is a major contributor to chronic impairment of ipsilateral dexterity. However, apraxia alone appeared to be insufficient to explain all cases of impairment at the subacute stage, when slowing (as opposed to errors) seemed to be due to a separate problem in high-level control of movement. This could not be investigated further in this briefer follow-up study because the single dexterity task used was such that errors and speed were tightly coupled, but the presence of some cases of dexterity impairment in which there was no definite apraxia on action imitation was confirmed.

As at the subacute stage, no patient failed to complete the dexterity task if given sufficient time. This is probably why we observed no impact on reports of activities of daily living. However, given the high face validity of the bean spooning task as a simulation of an everyday functional skill, it seems likely that there is some impact of ipsilateral impairment on functional outcome, which we were unable to estimate with this small patient sample. The dexterity questionnaire proved unhelpful because it failed to detect even the large effects of hemiparesis on everyday dexterity. It seems that asking whether aspects of dexterity are problematic is the wrong approach, probably because patients and their families understandably tend to perceive something as no longer problematic when the patient is able to succeed on an everyday task despite impaired dexterity. Furthermore, the large impact of hemiparesis will tend to overshadow the more subtle effects of ipsilateral impairment. This may be why the strongest report of impairment related to apraxia came from a patient with no paresis. It seems that valid assessment of the everyday impact of ipsilateral impairment may require direct observation of performance in a large patient sample, which would allow estimates of the added impact of ipsilateral losses at different levels of paresis.

Acknowledgments
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Appendix
Items in the Dexterity Questionnaire
Washing/Grooming. Do you have any problems:  
- cleaning your teeth with a toothbrush?
- turning on a tap?
- shaving/applying makeup?
- combing/brushing your hair?
Dressing. Do you have any problems:  
- fastening buttons, zips, belts?
- putting on socks or stockings?
- tying up shoe laces?
Meals and Kitchen. Do you have any problems:  
- drinking from a cup or glass?
- turning on a cooker/microwave?
- getting food onto a fork?
- getting food onto a spoon?
- dropping food from a fork/spoon?
- cutting food with a knife?
- opening a jar or packet?
Everyday Tasks. Do you have any problems:  
- turning a key in a lock?
- turning the handle of a door?
- turning pages of a book/newspaper?
- sorting out money, coins, and notes?
- writing shopping lists or messages?
- dialing a telephone?
Television and Radio. Do you have any problems:  
- changing the TV channel by reaching and pressing button?
- by remote control pad?
- turning on a radio and selecting a channel?
Response categories: none/some/need help/can’t/not tried/not applicable.

References
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