Improvement in Motor Performance in Paretic and Paralyzed Extremities Following Nonembolic Cerebral Infarction

BY FLETCHER MCDOWELL, M.D., AND SYDNEY LOUIS, M.D.

Abstract:
The problems involved in measuring improvement as well as the conceptual difficulties in considering this phenomenon were considered in general terms. Data on 300 patients with nonembolic cerebral infarction followed from five to nine years are presented, indicating that improvement in function of a paralyzed extremity may occur in the early phase after stroke but was extremely unlikely to continue during long-term follow-up from three months to five years. It was concluded that improvement in function might be determined more by retraining of the nonaffected muscles and particularly of the unaffected side rather than by recovery of the area paralyzed.

ADDITIONAL KEY WORDS stroke improvement in motor function late recovery

Comment exists in the literature suggesting that substantial improvement in function may occur over many months or years following a stroke. Conversely, it is known that central neural tissue, once destroyed, does not regenerate or recover. Though at first these ideas may appear contradictory, the concepts may not be irreconcilable.

Difficulties exist in studies of improvement following stroke for a number of reasons which merit full recognition and discussion prior to the presentation of data. In the early phases following a stroke there are certain inherent difficulties which complicate the interpretation of improvement. Clinically, cerebral ischemia cannot satisfactorily be distinguished by any test from cerebral infarction. An inference is made that when improvement in neurological function is rapid and marked that the patient probably suffered ischemia. The degree of infarction, the amount of ischemia peripheral to an infarct, the amount of collateral circulation, and the quantity of edema surrounding an infarct will all determine the reversibility or irreversibility of the initial symptoms and signs and hence the improvement potential.

If, as in the present study, the initial period of hospitalization is regarded separately, there remain other difficulties in studying long-term improvement. For instance, there is no evidence of the ability of uninvolved neural tissue to compensate for a loss of function. The significance of bilateral innervation or innervation of lower motor neurons from two separate areas of brain may or may not play a part in determining the potential for recovery. Once again, no studies are available to determine the importance of these points in the study of improvement. Another point in such studies is that care must be taken to separate improvement in the function of the paretic extremities from improvement in overall function of the
TABLE 1
Criteria for Evaluating Improvement of Motor Performance After Discharge from Hospital

<table>
<thead>
<tr>
<th>No motor deficit</th>
<th>Mild to moderate motor deficit</th>
<th>Severe motor deficit</th>
</tr>
</thead>
<tbody>
<tr>
<td>No weakness detected on examination.</td>
<td>Paresis on formal neurological testing.</td>
<td>Complete paralysis of leg. Severe weakness resulting in necessity of braces, crutches or assistance on walking.</td>
</tr>
<tr>
<td>Little or no defect of gait.</td>
<td>Defective gait but able to walk alone without support, braces, etc.</td>
<td></td>
</tr>
</tbody>
</table>

Improvement was noted when a patient changed category, particularly insofar as lower extremity function and gait were concerned.

patient which may occur by virtue of improvement in function of the normal side. Improvement may also be determined by natural selection. Thus, the early death of those with the most severe strokes and the fact that bedridden patients rarely reach convalescent and rehabilitation hospitals may well bias studies in favor of those patients with the least severe damage and perhaps most potential for recovery. The presence and severity of concomitant diseases and the variable factor of motivation will also determine the patients' potential for retraining.

For these reasons, we have examined early improvement and long-term improvement separately and have concentrated more specifically on the latter.

Methods

Three hundred patients admitted to Bellevue Hospital during the years 1956 to 1961 with diagnosis of nonembolic cerebral infarction were examined and followed regularly until death or for a period of five to nine years. The diagnosis of nonembolic cerebral infarction was made clinically according to the criteria set forth by the Ad Hoc Committee for the classification and diagnosis of cerebrovascular disease. Twenty percent of the patients had four-vessel arteriograms and 20% of those who died had autopsies confirming the diagnoses. An adequate physical therapy program was available at Bellevue Hospital at the time these patients were originally seen. During the acute phase of the stroke, daily passive exercises were given to the involved parts in all patients who had moderate to severe pareses. As soon as the patients were able to go to the Department of Physical Therapy, a program of active exercises and gait training with necessary bracing was carried out. A few patients were transferred to the Physical Therapy Service where they spent two to three months receiving an active program of treatment. The Physical Therapy Programs, whether carried out on the Physical Therapy Service or by daily visits to the Physical Therapy Service from the Neurology Service, continued for about the same amount of time, averaging two to three months. Individuals with mild to moderate disability were discharged after a shorter hospital stay than those more severely involved and returned for physical therapy as outpatients on a weekly basis. The patients were seen regularly at the Stroke Follow-up Clinic or were visited in their homes, nursing homes, or state hospitals at regular intervals. Detailed records of return of strength and functional ability were kept. Only 11 patients (3%) were lost to follow-up during the period of the study.

Improvement in the early phase was defined as improvement in motor performance of the affected extremities in the inpatient phase, a period of one and one-half months to three months. It was defined in clinical terms as marked, moderate or slight return of use of weakened or paralyzed extremities. As discussed in the introductory remarks, we were fully aware that the influence of many factors including alteration in the patients' general health might modify our clinical impression in this phase. For these reasons, no efforts were made to produce an impression of precision. Early improvement was, therefore, judged clinically as being markedly, moderately, slightly or not at all improved by comparing motor performance at discharge with that on admission.

Late improvement in function was determined primarily by the patient's ability to use his affected extremities during formal neurological testing and rested especially heavily on improvement of lower extremity function in walking. A simple grading system was utilized with the patients being classed as having no disability or mild, moderate, or severe disability (table 1). It is appreciated that changes may well occur within one of these categories which would not be evident in the final analysis. The patients' ability
to walk normally, with slight, moderate, or severe difficulty or not at all, was used extensively in determining in which category a patient should be placed. Most of the examinations, particularly the latter ones, were carried out by Drs. Ellen McDevitt, Sydney Louis, and Fletcher McDowell.

**Results**

**THE PHASE IN HOSPITAL**

As may be seen from table 2, some improvement occurred in the use of the involved extremities in just over half of the patients during hospitalization. Marked improvement occurred in 16.7% and moderate improvement in 20%.

**THE POSTHOSPITALIZATION PHASE**

Figures 1 and 2 show what late improvement occurred in those patients classed as mild to moderate or as severely disabled at the time of discharge. As may be seen, a very small, but constant, proportion of patients were found to show improvement during the five years of follow-up. The patients classed as mildly to moderately disabled showed a slightly higher proportion of improvement during the first year than the severely disabled patients. Figures 1 and 2 also show the number of surviving patients, and the fate of those who died, is shown for the five years after discharge.

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**IMPROVEMENT IN FUNCTION IN PARETIC LOWER EXTREMITY (53 cases)**

<table>
<thead>
<tr>
<th>DISCHARGE</th>
<th>6 MONTHS</th>
<th>1 YEAR</th>
<th>5 YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(53) Mild or moderate</td>
<td>(36) Mild or moderate</td>
<td>(30) Mild or moderate</td>
<td>(17) Mild or moderate</td>
</tr>
<tr>
<td>(1) Normal</td>
<td>(1) No information</td>
<td>(1) Normal</td>
<td>(1) No information</td>
</tr>
<tr>
<td>(2) Dead</td>
<td>(4) Dead</td>
<td>(4) Dead</td>
<td>(5) Dead</td>
</tr>
<tr>
<td>(1) Severe</td>
<td>(1) Dead</td>
<td>(6) No information</td>
<td>(1) Dead</td>
</tr>
<tr>
<td>(7) No information</td>
<td>(7) No information</td>
<td>(7) No information</td>
<td></td>
</tr>
<tr>
<td>(5) Dead</td>
<td>(5) Dead</td>
<td>(5) Dead</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 1**

The fate of 53 patients, having mild or moderate motor deficit at the time of stroke, is shown. The follow-up period is from the time of discharge to five years or death.
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IMPROVEMENT IN FUNCTION IN PARETIC LOWER EXTREMITY (75 cases)

FIGURE 2

The fate of 75 patients, having severe motor deficit at the time of stroke, is shown. The follow-up period is from the time of discharge to five years or death.

Patients showing no improvement in motor function or disability rating over the five-year period of follow-up. It is apparent that 95% to 96% of the patients classed as severe, who survived each period, showed little or no change in their functional status. In those classed as mild to moderate the figure was slightly, but not significantly, lower at almost 90%.

Figure 3 shows the percentage mortality in each of these two categories during each time period following stroke. It is evident that the mortality rates in the mild to moderate group and in the severe group were essentially the same at six months, at one year, and at five years.

MORTALITY RATE IN EACH TIME-PERIOD OF FOLLOW-UP

<table>
<thead>
<tr>
<th>Severity of paresis</th>
<th>6 months</th>
<th>1 year</th>
<th>5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild or moderate at discharge</td>
<td>9%</td>
<td>21%</td>
<td>58%</td>
</tr>
<tr>
<td>Severe at discharge</td>
<td>8%</td>
<td>20%</td>
<td>64%</td>
</tr>
</tbody>
</table>

FIGURE 3

The percentage mortality in the mild to moderate group of patients with nonembolic cerebral infarction is compared with the severely paralyzed group over the five-year follow-up.

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Discussion
Mortality rates for those surviving the initial hospitalization were approximately equal in the severe and in the mild to moderate strokes. This tends to suggest, as has previous work by us, that mortality is related more to associated diseases than to the stroke and its sequelae. Moreover, it is evident from the similarity of mortality rates, that mortality in these two groups could not have affected the proportions showing or not showing improvement.

It is evident from our data that improvements in motor function are to be expected in just about half of the patients during the very early phases following a stroke. The reasons for this improvement and problems with interpreting this information have been dealt with and are determined by the reversibility or irreversibility of damage in and around an area of infarction. It is also apparent that beyond the period of hospitalization, despite adequate physical therapy, encouragement and frequent close, friendly supervision, improvement in paralysis occurred in an insignificantly small number of patients. This does not imply that patients failed to return to work or to become increasingly independent. Such improvement occurred mainly because of increasing use of the remaining musculature, particularly on the intact side, and usually could not be attributed to a return of function in the paralyzed extremities.

References
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