Outcome and Time Course of Recovery in Stroke. Part II: Time Course of Recovery. The Copenhagen Stroke Study

Henrik S. Jørgensen, MD, Hirofumi Nakayama, MD, Hans O. Raaschou, MD, Jørgen Vive-Larsen, MD, Mogens Steier, MD, Tom S. Olsen, MD, PhD


Objective: To determine the time course of both neurological and functional recovery from stroke. Design: Prospective, consecutive, and community based. Setting: The stroke unit of a hospital in Copenhagen, Denmark. This setting receives all acute stroke patients admitted from a well-defined catchment area of 239,886 inhabitants within the city of Copenhagen. Acute treatment as well as all stages of rehabilitation are cared for within the stroke unit regardless of age, stroke severity, and premorbid condition. Patients: 1,197 patients with acute stroke. Main Outcome Measures: Weekly examinations of neurological deficits (using the Scandinavian Neurological Stroke Scale) and functional disabilities (Activity of Daily Living [ADL] measured by the Barthel Index) were performed from the time of acute admission to the end of rehabilitation. These evaluations were repeated 6 months poststroke. Time course of recovery was stratified according to initial stroke severity and disability. Results: Functional recovery was completed within 12.5 weeks (95% confidence interval [CI] 11.6 to 13.4) from stroke onset in 95% of the patients. However, 80% of the patients had reached their best ADL function within 6 weeks (CI 5.3 to 6.7) from onset. The time course of functional recovery was strongly related to initial stroke severity. Best ADL function was reached within 8.5 weeks (CI 8 to 9) in patients with initially mild strokes, within 13 weeks (CI 12 to 14) in patients with moderate strokes, within 17 weeks (CI 15 to 19) in patients with severe strokes, and within 20 weeks (CI 16 to 24) in patients with very severe strokes. After these time-points, no significant changes occurred. However, a valid prognosis of functional outcome can be made much earlier. Best ADL function was reached by 80% of the patients with initially mild strokes within 3 weeks (CI 2.6 to 3.4), within 7 weeks (CI 6 to 8) of the patients with moderate strokes, and within 11.5 weeks (CI 10 to 13) of the patients with severe and very severe strokes. The time course of neurological recovery followed a pattern similar to that of functional recovery, but preceded functional recovery by 2 weeks on average. Conclusions: A reliable prognosis can in all stroke patients be made within 12 weeks from stroke onset. Even in patients with severe and very severe strokes, neurological and functional recovery should not be expected after the first 5 months.

© 1995 by the American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation

Neurological and functional recovery occurs mainly within the first 6 months after stroke, and it is a general clinical impression that the majority of motor recovery occurs within the first 6 weeks. However, little is known about the time at which recovery is completed within these 6 months and how the time course of recovery is related to initial stroke severity and disability.

Detailed knowledge of the time course of recovery is indispensible both to a rational planning of rehabilitation and of discharge time and to informing patient and family about the possibility of further recovery. Furthermore, evidence of the effect of organized stroke rehabilitation is increasing these years. In the future, this treatment may be offered to a wider spectrum of stroke patients than previously, and for rational planning of health care, unbiased population-based studies of the time course of recovery from stroke are essential. This investigation was undertaken with the aim of describing the time course of both neurological and functional recovery by serial, weekly assessment from the acute admission to the completion of rehabilitation in a large community-based stroke population.

SUBJECTS AND METHODS

The patients studied were 1,197 patients with acute stroke admitted consecutively to the neurological department of a hospital in Copenhagen, Denmark, during the 25 months between September 1, 1991, and September 30, 1993 (The Copenhagen Stroke Study). Outcome was described in Part I of this study.

The study population is community based as previously described. The hospital serves a well-defined area with 239,886 inhabitants in the city of Copenhagen. All persons from the community who have an acute cerebrovascular disease that requires admission to hospital are referred to and treated at the neurological department: This is regardless of the age of the patient, the severity of the stroke, and the condition of the patient before the stroke. The patients receive acute treatment as well as all stages of rehabilitation.
within the neurological department. Referral to other departments or hospitals for further rehabilitation is therefore not required. Hospital care is free, and a very high proportion (88%) of stroke patients in the community are admitted to hospital.27 The neurological department has 74 beds and is especially assigned to take care of stroke patients: evaluation, acute treatment, and rehabilitation. Approximately 80% of the beds are occupied by stroke patients.

**Diagnosis of Stroke**

Stroke was diagnosed by a neurologist according to the World Health Organization (WHO) criteria: rapidly developed clinical signs of focal disturbance of cerebral function, lasting more than 24 hours or leading to death, with no apparent cause other than vascular origin.28 Subarachnoidal bleeding was not included. Computed tomography (CT) scan was performed with a Siemens Somatom, and CT description was used to divide patients into subgroups: infarction or hemorrhage (table).

**Evaluation of Neurological Deficits**

Neurological deficits were assessed on admission, the day after admission, weekly until death or end of rehabilitation, and finally 6 months poststroke using the Scandinavian Neurological Stroke Scale (SSS) score.29,30 The SSS evaluates level of consciousness, eye movement, power in arm, hand, and leg, orientation, aphasia, facial paresis, and gait on a total score from 0 to 58. The weekly examination was performed by the same neurologist (H.S.J.) in all cases. The six-month poststroke examination was also done by a study neurologist (H.S.J., V.L., M.S.). Initial stroke severity was classified into four categories according to the SSS score on admission:31 very severe (0 to 14 points); severe (15 to 29 points); moderate (30 to 44 points); mild (45 to 58 points).

**Time Course of Neurological Recovery**

The time from stroke onset to achievement of the highest score in SSS, ie, the time after which no further neurological improvement was observed, was calculated in each patient using the weekly scores. The score on admission was used as baseline score. In patients with stroke in progression, the lowest score within the first week from onset was used as baseline score. If recurrent stroke occurred during hospital stay, the time period of recovery was calculated as the time from admission to onset of the recurrent stroke. Patients who died during hospital stay were not included in the calculation of the time period of neurological recovery.

**Evaluation of Activities of Daily Living (ADL) Functions**

ADL was assessed weekly until death or end of rehabilitation by the nursing and training staff using the Barthel Index (BD),32 and again at the 6-month poststroke examination. The BI evaluates 10 different abilities on a score from 0 to 100. Initial functional disability was classified into five categories according to the initial BI score:33,34 very severe disability (0 to 20 points); severe disability (25 to 45 points); moderate disability (50 to 70 points); mild disability (75 to 95 points); no disability (100 points).

**Time Course of Functional Recovery**

The time from stroke onset to achievement of the highest score in BI, ie, the time after which no further functional improvement was observed, was calculated in each patient using the weekly scores as outlined earlier for the time course of neurological recovery.

**Rehabilitation**

Rehabilitation therapy was given based on the Bobath technique daily to all patients needing rehabilitation. It was given by nursing staff, physiotherapists, and occupational therapists within the neurological ward. The need for rehabilitation was evaluated initially in all patients by the physician, the physiotherapist, the occupational therapist, and when needed also by speech therapists and the neuropsychologists (in 27% of all patients). Rehabilitation was initiated immediately. The needs of the patient, the specific goals set for the patient, and the rehabilitation achievement were discussed weekly by the multidisciplinary team. Rehabilitation was completed within the department. Hereafter patients were discharged to either own home or to a nursing home. Patients were not discharged until further in-hospital improvement was considered unlikely by the team.

**Statistics**

Statistics were performed using the SPSS computer program. The weekly cumulated percentages of patients who have reached the point of no further score improvement have been plotted by prognostic subgroup (figs 1 through 3), and both the 80% and 95% points (fractile) recorded. It is given as the week in which the cumulative percentage just mentioned crosses the 80% and 95% level, respectively. The Kruskal-Wallis test was used to examine whether the time course of recovery was similar for all prognostic subgroups, eg, if the time course of neurological recovery was similar in patients with initially mild, moderate, severe, and very severe strokes. When this was not the case, the Mann-Whitney-Wilcoxon test was applied to test between which specific prognostic subgroups the time course of recovery differed (eg, if it was between patients with initially mild strokes and moderate strokes, ...
and/or between patients with moderate strokes v severe strokes, etc). The level of significance was set at $p < 0.05$.

**Ethics**

The study was approved by the Ethics Committee of Copenhagen.

**RESULTS**

Nine hundred forty-seven (79%) patients survived and completed rehabilitation. The basic characteristics of the 947 survivors are given in table 1. Initially, stroke was very severe in 85 (9%) patients, severe in 115 (12%) patients, moderate in 277 (29%) patients, and mild in 470 (50%) patients. One hundred and seventy-seven (19%) of the patients were discharged to nursing home, and 770 (81%) patients were discharged to their own home after completed rehabilitation.

**Time Course of Recovery in All Patients**

Figure 1 shows the time course of neurological recovery in all the patients who survived. Best neurological recovery was reached in 80% of the patients within 4.5 weeks (95% Confidence Interval [CI] 4.0 to 5.0), and in 95% within 11 weeks (CI 10.1 to 11.9) from stroke onset. Figure 2 shows the time course of functional recovery. Best ADL function was reached in 80% of the patients within 6 weeks (CI 5.3 to 6.7), and in 95% within 12.5 weeks (CI 11.6 to 13.4) from onset.

**Time Course of Recovery in Patients With Initially Very Severe Strokes**

Eighty-five (38%) of the 223 patients with initially very severe strokes survived. Best neurological recovery was reached in 80% of the patients within 10 weeks (CI 8.7 to 11.3), and in 95% within 13 weeks (CI 11.6 to 14.4) from stroke onset (fig 1). Best ADL function was reached in 80% of the patients within 11.5 weeks (CI 9.2 to 13.8), and in 95% within 20 weeks (CI 16.0 to 24.0) from onset (fig 2).

**Time Course of Recovery in Patients With Initially Severe Strokes**

One hundred fifteen (67%) of the 171 patients with initially severe strokes survived. Best neurological recovery was reached in 80% of the patients within 9 weeks (CI 7 to 11), and in 95% within 15 weeks (CI 13 to 17) from stroke onset (fig 1). Best ADL function was reached in 80% of the patients with initially severe stroke within 11.5 weeks (CI 10 to 13), and in 95% within 17 weeks (CI 15 to 19) from onset (fig 2).
The time course of recovery in survivors shown as the cumulated rate of patients having reached their best ADL function. Rates are given: † for all patients, □ for patients with initial moderate stroke severity, ▲ for patients with initial severe stroke severity, * for patients with initial very severe stroke severity, ◊. The ANOVA test showed an overall difference in the time course of recovery between the groups, \( p < 0.0001 \). Further analyses showed that the time course of recovery differed significantly between patients with initially mild strokes versus moderate strokes, \( p < 0.0001 \), and between patients with moderate strokes versus severe strokes, \( p < 0.01 \). No difference was found between patients with severe versus very severe strokes, \( p = 0.37 \).

**Time Course of Recovery in Patients With Initially Moderate Strokes**

Two hundred seventy-six (89%) of the 316 patients with initially moderate strokes survived. Best neurological recovery was reached in 80% of the patients within 5.5 weeks (CI 4.4 to 6.6), and in 95% within 10.5 weeks (CI 9.5 to 11.5) from stroke onset (fig 1). Best ADL function was reached in 80% of the patients with initially moderate strokes within 7 weeks (CI 6 to 8), and in 95% within 13 weeks (CI 12 to 14) from onset (fig 2).

**Time Course of Recovery in Patients With Initially Mild Strokes**

Four hundred seventy-two (97%) of the 487 patients with initially mild strokes survived. Best neurological recovery was reached in 80% of the patients within 2.5 weeks (CI 2.2 to 2.8), and in 95% within 6.5 weeks (CI 5.4 to 7.6) from stroke onset (fig 1). Best ADL function was reached in 80% of the patients with initially mild strokes within 3 weeks (CI 2.6 to 3.4), and in 95% within 8.5 weeks (CI 8.0 to 9.0) from onset (fig 2).

**Time Course of Functional Recovery in Patients With Initially Very Severe Disability**

Fifty percent of the patients with initially very severe disability in ADL functions survived. Figure 3 shows the time course of functional recovery in these patients. Best ADL function was reached in 80% of the patients within 11 weeks (CI 10 to 12), and in 95% within 17 weeks (CI 15 to 19) from onset.

**Time Course of Functional Recovery in Patients With Initially Severe Disability**

Ninety-two percent of the patients with initially severe disability in ADL functions survived. Best ADL function was reached in 80% of the patients within 11.5 weeks (CI 10.5 to 12.5), and in 95% within 16 weeks (CI 13.5 to 18.5) from onset (fig 3).

**Time Course of Functional Recovery in Patients With Initially Moderate Disability**

Ninety-seven percent of the patients with initially moderate disability in ADL functions survived. Best ADL function was reached in 80% of the patients within 6 weeks (CI 5 to 7), and in 95% within 9 weeks (CI 7.5 to 10.5) from onset (fig 3).

**Time Course of Functional Recovery in Patients With Initially Mild Disability**

Ninety-eight percent of the patients with initially mild disability in ADL functions survived. Best ADL function
was reached in 80% of the patients within 2.5 weeks (CI 2 to 3), and in 95% within 5 weeks (CI 4 to 6) from onset.

DISCUSSION

This is the first study to our knowledge to provide detailed prospective information on the neurological and functional time course of recovery from stroke. All 947 stroke survivors from a community-based stroke population were prospectively studied with weekly examinations throughout the whole rehabilitation period. Discharge scores were compared with scores at the 6-month follow-up. Status at the end of rehabilitation plausibly accounted for the final outcome of stroke, as discussed in Part I of this study.25

This study shows that recovery in ADL function occurs in most patients within 13 weeks from stroke onset. After this time, rehabilitation did not change ADL function to any significant degree. The majority of patients had even reached their best ADL function much earlier; eg. 80% of the patients had reached their best function within the first 6 weeks from onset. These results are in agreement with the common finding that recovery from stroke occurs within the first 6 months.1–30 However, apart from three studies describing recovery of arm function4,19 and walking function,18,30 frequent serial assessment of recovery in stroke patients during the whole period of recovery has not been attempted before.

The time course of both neurological and functional recovery was strongly related to initial stroke severity. Neurological recovery was achieved faster than functional recovery, as also found by others4,20; it was on average reached 2 weeks earlier. Best ADL function was reached within 9 weeks in patients with initially mild strokes, within 13 weeks in patients with moderate strokes, within 17 weeks in patients with severe strokes, and within 20 weeks in patients with very severe strokes. However, a valid prognosis of ADL function can be made much earlier. Best ADL function was reached by 80% of the patients with initially mild strokes within 3 weeks, within 7 weeks of the patients with moderate strokes, and within 12 weeks of the patients with severe and very severe strokes. Thus, a reliable prognosis can in all stroke patients treated with organized stroke rehabilitation be made within 12 weeks from stroke onset.

Only two other studies have stratified the time course of recovery to the initial extent of neurological deficits. Nakayama and colleagues16 studied recovery of upper-extremity function in a community-based study of 421 acute stroke patients. Best upper-extremity function was reached within 6 weeks in patients with initially mild upper-extremity paresis, and within 11 weeks in patients with initially severe upper-extremity paresis. Jørgensen and associates17 studied recovery of walking function in a community-based study of 804 acute stroke patients. Best
walking function was reached within 4 weeks in patients with initially mild paresis of the affected lower extremity, within 6 weeks in patients with moderate paresis, and within 11 weeks in patients with initially severe paresis or paralysis of the affected lower extremity. Olsen17 studied the time course of recovery in arm and leg function in 75 patients referred to a rehabilitation center and found that patients with severe paresis 4 weeks after admission reached best arm function within 13 weeks, and best leg function within 14 weeks from stroke onset. The corresponding figures for patients with moderate/mild paresis 4 weeks poststroke were 10 and 13 weeks, respectively.

The time course of functional recovery was also strongly related to initial functional disability. Best ADL function was reached within 5 weeks in patients with initially mild disability, within 9 weeks in patients with initially moderate disability, within 16 weeks in patients with initially severe disability, and within 17 weeks in patients with initially very severe disability. However, 80% of the patients reached best ADL function much earlier, within 2.5 weeks in patients with initially mild disability, within 6 weeks in patients with moderate disability, and within 11 weeks in patients with initially severe or very severe disability.

Only one other study has stratified the time course of functional recovery to the degree of initial functional disability level. Skilbeck and associates’ compared initial ADL function with ADL function at 3, 6, 12 months poststroke in 92 patients and found no significant change in ADL function beyond the 3-month examination neither in patients with initially severe disability, in patients with moderate disability, nor in patients with mild disability. That patients with initially severe disability had no statistically significant improvement beyond the first 3 months is probably owing to the small sample studied.

Only 5% of survivors (1 out of 25 of all stroke patients) improved in ADL function after the first 3 months, and even fewer experienced neurological improvement after this point. Recovery from stroke is thus mainly, although not exclusively, achieved within this period. However, even patients with the longest period of recovery (very severe strokes) should not expect further functional in-hospital recovery after the first 5 months: Such late recovery was seen in only 9 of the 1,197 patients.

In conclusion, this community-based study gives unbiased and detailed information of the time course of recovery of both neurological deficits and ADL-function in stroke patients stratified according to initial level of stroke severity and disability. This information is essential not only to rational health care planning, but also to reliable prognostication of the time course of recovery and duration of rehabilitation in single patients characterized by initial stroke severity and/or disability.

Acknowledgment: The authors wish to thank Jörgen Hilden for his statistical advice.

References
28. Report of the WHO task force on stroke and other cerebrovascular

Supplier
a. Siemens Somatom; Siemens A/S, Boruprang 3, DK-2750 Ballerup, Denmark.