Treatment and Rehabilitation on a Stroke Unit Improves 5-Year Survival
A Community-Based Study
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Background and Purpose—We have previously reported a marked reduction in mortality up to 1 year after treatment and rehabilitation on a stroke unit versus on general neurological and medical wards in unselected stroke patients. In the present study we wanted to test the hypothesis that this mortality-reducing effect is not temporary but is long lasting.

Methods—We performed a community-based comparison of outcome in 1241 stroke patients from 2 adjacent communities in Copenhagen: in one (Frederiksberg), treatment and rehabilitation were provided on general neurological and medical wards, and in the other (Bispebjerg), treatment and rehabilitation were provided on a single large stroke unit.

Results—The 2 stroke populations were comparable regarding age, sex, initial stroke severity, lesion diameter on CT, and stroke subtype (hemorrhage/infarct), but patients treated on the stroke unit had a higher frequency of comorbidity and lower incomes. One-year mortality was 39% (general wards) versus 32% (stroke unit) \( (P = 0.01) \). This difference was still present 5 years after stroke \( (71\% \text{ versus } 64\%; P = 0.02) \). In a multiple logistic regression model of 5-year mortality, treatment on a stroke unit reduced the relative risk of death by 40% \( (\text{odds ratio, } 0.60; 95\% \text{ CI, } 0.42 \text{ to } 0.85; P < 0.01) \), independent of age, sex, stroke severity, and comorbidity.

Conclusions—The mortality-reducing effect of treatment and rehabilitation on a dedicated stroke unit is long lasting rather than temporary. Stroke unit treatment reduced the relative risk of death within 5 years after stroke by 40% in an unselected, community-based stroke population. These results emphasize the need for organization of treatment and rehabilitation of unselected stroke patients on dedicated stroke units. \( \text{(Stroke. 1999;} 30:930-933.) \)

Key Words: mortality ■ rehabilitation ■ stroke management ■ stroke outcome ■ stroke units

We have previously shown that acute treatment and rehabilitation of unselected stroke patients on a dedicated stroke unit reduces in-hospital mortality, discharge rate to nursing homes, length of hospital stay, and mortality up to 1 year after stroke.\(^1\) One study has reported stroke unit treatment to reduce mortality and disability up to 5 years after stroke.\(^2\)

Stroke is a disease that generally occurs in elderly people expected to have a short remaining life span. The aim of this study was to examine whether treatment and rehabilitation on a community-based stroke unit benefit long-term outcome.

The unique design of the healthcare delivery system in Denmark has made it possible to overcome some of the problems in the design of a test of the effectiveness of dedicated stroke unit treatment of unselected stroke patients. The Danish healthcare system requires delivery of free, high-quality hospital care to all patients regardless of income, disease, and home community. All acute stroke patients are treated at their respective home community hospitals. Before this trial, stroke treatment was organized identically at 2 neighboring communities within the Copenhagen area; both communities offered routine management on medical and neurological wards to patients with acute stroke. However, restructuring of the medical wards in 1 of the communities, but not the other, required treatment for all stroke patients on a dedicated stroke unit. This local development made it possible to test, at a community-based level, whether stroke unit treatment is more effective than routine management on medical and neurological wards. The present study compares 5-year mortality between patients who had acute treatment and rehabilitation on a dedicated stroke unit versus on general neurological and medical wards.

Subjects and Methods

Study Design
The study was designed to compare outcome after stroke in 2 neighboring communities within the city of Greater Copenhagen, the...
In the community of Bispebjerg, acute treatment as well as all stages of rehabilitation took place exclusively on the stroke unit at Bispebjerg Hospital, regardless of the age of the patient, the severity of the stroke, and the condition of the patient before the stroke. The stroke unit is located in the Department of Neurology. The department has 72 beds, of which 61 beds are occupied by the stroke unit.

In the community of Frederiksberg, acute treatment as well as rehabilitation took place exclusively on a general neurological ward (patients aged \( \leq 70 \) years) and on 2 medical wards (patients \( > 70 \) years) at Frederiksberg Hospital. No stroke patient from the community of Frederiksberg received treatment on a stroke unit during the study period.

Bispebjerg and Frederiksberg hospitals are public hospitals serving urban communities of 124,000 and 85,600 inhabitants, respectively. The 2 communities share a border, and the distance between the 2 study hospitals is 2 miles. Expenditures per bed day are comparable between the hospitals. They both possess all major medical and surgical specialties as well as radiological and laboratory facilities needed for modern evaluation of stroke patients. There are no differences in the quality of the staff employed in the care of patients at the 2 hospitals, and salaries for doctors, nurses, and training staff are identical. Both hospitals have a good reputation, and one is not considered superior to the other. Frederiksberg is a more wealthy community than Bispebjerg, and the average income is higher.

For patients treated on the stroke unit, a plan for evaluation, medical treatment, and rehabilitation was made on admission. A standardized diagnostic evaluation program, including routine blood tests, ECG on admission, chest radiography, and CT scan, was performed in each patient. Other diagnostic procedures, such as Doppler examination of the carotid arteries, single-photon emission CT, and echocardiography, were performed when required. Aspirin 150 mg/d was given to all patients with ischemic strokes. Anticoagulation treatment with warfarin was given to ischemic stroke patients with atrial fibrillation if not contraindicated by the overall clinical condition. Anticoagulation treatment with heparin and warfarin was given to patients with stroke in progression if not contraindicated. As prophylaxis against pulmonary embolism, patients with severe lower extremity paresis were given hose for thromboembolic disease. Low-dose heparin was not used. Rehabilitation was given to all patients by a trained stroke team of medical and nursing staff, physiotherapists, occupational therapists, speech therapists, and neuropsychologists. The rehabilitation program was individualized according to the needs of the patient and started on arrival to the stroke unit.

Patients on general neurological and medical wards at Frederiksberg Hospital were given the traditional treatment offered to patients at Danish hospitals without a stroke unit; there was no standardized program for diagnostic evaluation except for CT scan. Aspirin 150 mg/d was given to all patients with ischemic strokes. Physical therapy, occupational therapy, and speech therapy were given when prescribed by physicians.

Inclusion Criteria and Data Collection

The principal investigator (H.S.J.) was responsible for the prospective collection of data in the 2 communities. Patients from the Frederiksberg community were studied in the period from April 1, 1989, to March 31, 1990, during H.S.J.'s engagement at Frederiksberg Hospital. Patients from the Bispebjerg community were studied from the establishment of the stroke unit on September 1, 1991, to September 30, 1993, during H.S.J.'s engagement at Bispebjerg Hospital. An analogous approach to data collection was thus ensured by the fact that the same neurologist was responsible for the data collection in the 2 populations. Funding made it possible to extend the length of the second inclusion period.

The following information was obtained on patients in both communities: (1) sociodemographic data: age, sex, marital status, and residence (home/nursing home); (2) risk factors and comorbidity: previous myocardial infarction (a clinical event diagnosed as a myocardial infarct confirmed by hospital records and either ECG and/or enzymes), ischemic heart disease (a history of ischemic heart disease), hypertension (in treatment with antihypertensive drugs at the time of admission), diabetes (known diabetes before stroke), smoking (daily smoking of any kind of tobacco), former stroke, atrial fibrillation (if present on ECG obtained on admission), and blood pressure on admission; and (3) initial stroke severity: consciousness (lowered/not lowered), paresis of extremity (present or not), and aphasia (present or not). This information was entered into a computerized database together with CT data (see below) and date of death within the first 5 years after the stroke.

Exclusion Criteria

Patients admitted \( > 2 \) weeks after a stroke were excluded from the study. Ninety-five percent in both communities were admitted within the first week after onset.

Outcome Measure

To avoid observer bias, mortality was chosen to measure outcome. Mortality data for both communities were obtained from the Central Patient Registry.

Definition of Acute Stroke

Stroke was defined according to the World Health Organization criteria: rapidly developed clinical signs of focal disturbance of cerebral function, lasting \( >24 \) hours or leading to death, with no apparent cause other than vascular origin. Traditionally, patients with subarachnoid hemorrhage are treated in departments of neurosurgery in Denmark and were therefore not included.

CT Measurements

CT was performed with a Siemens Somatom DR scanner at Bispebjerg Hospital and with a Phillips Somoscan 310 at Frederiksberg Hospital. The frequency of CT scan was comparable between groups: 73% on the general wards and 80% of the patients on the stroke unit had a CT scan. The time from the onset of stroke to CT examination was also comparable between groups and depended on the accessibility of the scanner. In most cases the scan was done within 2 weeks after the stroke. All scans were interpreted by 2 radiologists participating in the study (H.O.R., Bispebjerg, and K.L., Frederiksberg), both blinded to the clinical data. Description included type and size of lesion. Size was determined as the largest visible diameter of the lesion on CT.

Statistical Analysis

Statistical analysis was performed with the use of the SPSS package. In the univariate analyses, the Student's \( t \) test was used for the comparison of continuous data between 2 groups. The \( \chi^2 \) test was used for noncontinuous data. Multiple logistic regression was used to assess the independent effect on mortality of stroke unit treatment. All variables of interest were tested with the backward procedure. The level of significance was chosen to be \( P < 0.05 \).

Results

Comparison of Demography, Comorbidity, and Stroke Severity

Patient demographics were essentially similar between the hospitals. Specifically, there were no differences in age, sex, marital status, and nursing home residence (Table 1).

The risk factor distribution in the 2 groups is shown in Table 2. Hypertension and diabetes were significantly more
Long-Term Benefit of Stroke Unit Treatment

TABLE 1. Basic Characteristics of the Patients

<table>
<thead>
<tr>
<th></th>
<th>Patients Treated on General Wards</th>
<th>Patients Treated on Stroke Unit</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>305</td>
<td>936</td>
<td></td>
</tr>
<tr>
<td>Age, y</td>
<td>74.9±10.1</td>
<td>74.4±11.2</td>
<td>0.44</td>
</tr>
<tr>
<td>Male sex</td>
<td>139 (46%)</td>
<td>428 (46%)</td>
<td>0.96</td>
</tr>
<tr>
<td>Married or cohabitation</td>
<td>123 (40%)</td>
<td>391 (42%)</td>
<td>0.63</td>
</tr>
<tr>
<td>Nursing home residence</td>
<td>13 (4%)</td>
<td>29 (3%)</td>
<td>0.36</td>
</tr>
</tbody>
</table>

Continuous data are expressed as mean±SD. Categorical data are expressed as number of patients (%).

frequent in patients treated at the stroke unit. The groups were comparable regarding frequency of previous myocardial infarction, ischemic heart disease, smoking, previous stroke, atrial fibrillation, and blood pressure on admission.

A comparison of initial stroke severity, type of stroke, and size of lesion is shown in Table 3, and, similar to patient demographics, there were no differences between groups. Level of consciousness, frequency of extremity paresis and aphasia, frequency of stroke subtypes, and lesion diameter were similar.

Outcome

A univariate comparison of mortality between the 2 groups at various times is given in Table 4. Mortality was at all times significantly decreased in patients treated on the stroke unit. Table 5 shows the relative risk of death at the different times if treated on the stroke unit, independent of age, sex, presence of atrial fibrillation, former myocardial infarction, former stroke, ischemic heart disease, diabetes, hypertension, blood pressure on admission, level of consciousness, aphasia, and extremity paresis. Treatment on the stroke unit increased the relative chance of survival 5 years after stroke by a factor of 1.8.

Discussion

This is the first study to report a long-term benefit of stroke unit treatment on a community-based level, and it confirms the long-term results of the Norwegian stroke unit trial.2

TABLE 2. Comparison of Risk Factor Distribution Between Patients Treated on the Stroke Unit vs on General Neurological and Medical Wards

<table>
<thead>
<tr>
<th></th>
<th>Patients Treated on General Wards</th>
<th>Patients Treated on Stroke Unit</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Former myocardial infarction</td>
<td>32/243 (12%)</td>
<td>94/781 (11%)</td>
<td>0.68</td>
</tr>
<tr>
<td>Ischemic heart disease</td>
<td>55/224 (20%)</td>
<td>207/664 (24%)</td>
<td>0.16</td>
</tr>
<tr>
<td>Hypertension</td>
<td>67/216 (24%)</td>
<td>289/586 (33%)</td>
<td>0.003</td>
</tr>
<tr>
<td>Diabetes</td>
<td>33/252 (12%)</td>
<td>145/745 (16%)</td>
<td>0.05</td>
</tr>
<tr>
<td>Smoking</td>
<td>116/91 (56%)</td>
<td>434/350 (55%)</td>
<td>0.86</td>
</tr>
<tr>
<td>Former stroke</td>
<td>60/236 (20%)</td>
<td>212/677 (24%)</td>
<td>0.20</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>42/251 (14%)</td>
<td>153/732 (17%)</td>
<td>0.24</td>
</tr>
<tr>
<td>Systolic blood pressure*</td>
<td>161.3±27.8</td>
<td>162.9±32.7</td>
<td>0.45</td>
</tr>
<tr>
<td>Diastolic blood pressure*</td>
<td>90.0±14.4</td>
<td>89.6±16.9</td>
<td>0.66</td>
</tr>
</tbody>
</table>

Continuous data are expressed as mean±SD. Categorical data are expressed as number of patients (%).

*On admission.

TABLE 3. Comparison of Initial Stroke Severity, Stroke Type, and Lesion Size Between Patients Treated on the Stroke Unit vs on General Neurological and Medical Wards

<table>
<thead>
<tr>
<th></th>
<th>Patients Treated on General Wards</th>
<th>Patients Treated on Stroke Unit</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowered consciousness</td>
<td>69 (23%)</td>
<td>233 (25%)</td>
<td>0.44</td>
</tr>
<tr>
<td>Extremity paresis</td>
<td>224 (73%)</td>
<td>686 (73%)</td>
<td>0.91</td>
</tr>
<tr>
<td>Aphasias</td>
<td>106 (39%)</td>
<td>293 (35%)</td>
<td>0.20</td>
</tr>
<tr>
<td>Infarction on CT</td>
<td>147 (66%)</td>
<td>472 (63%)</td>
<td>0.56</td>
</tr>
<tr>
<td>Hemorrhage on CT</td>
<td>17 (8%)</td>
<td>63 (8%)</td>
<td>0.056</td>
</tr>
<tr>
<td>No focal abnormality on CT</td>
<td>58 (26%)</td>
<td>223 (29%)</td>
<td>0.68</td>
</tr>
<tr>
<td>Lesion diameter on CT</td>
<td>38.5±30.5</td>
<td>39.2±27.4</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Continuous data are expressed as mean±SD. Categorical data are expressed as number of patients (%).

Treatment and rehabilitation on a stroke unit of unselected stroke patients reduced the relative risk of death within 5 years by 40%, independent of other prognostic factors such as age, sex, stroke severity, and comorbidity.

The special organization of the Danish healthcare system made this study possible. This allowed us to study the effect of stroke unit treatment at an unselected, community-based level. Patients were allocated to treatment on the stroke unit/general ward not by chance but by home community. Although the randomized controlled trial remains the most reliable method for assessing the effectiveness of interventions, the design of this study possesses several advantages over the traditionally randomized stroke unit studies. A randomized study would require informed consent from every patient. The patients with the most severe strokes would thus not qualify for inclusion (because of such factors as decreased consciousness, disorientation, and severe aphasia). Furthermore, in comparing stroke unit treatment and treatment on general wards at the same hospital, it would be difficult to prevent dissemination of the program and methods used on the stroke unit to the general wards (treatment contamination). Finally, because of the ethical problems of denying some patients therapy believed to be effective, it has become impossible to conduct a traditional randomized study of the long-term effect of stroke unit treatment. These serious problems have been overcome by the present design because we compared stroke unit treatment with general ward treatment in 2 different communities.

The allocation-by-community method could have resulted in incomparable groups of stroke patients if the 2 community

TABLE 4. Mortality at Various Times in Patients Treated on the Stroke Unit vs in Patients Treated on General Neurological and Medical Wards

<table>
<thead>
<tr>
<th></th>
<th>Patients Treated on General Wards</th>
<th>Patients Treated on Stroke Unit</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case-fatality rate (30 days)</td>
<td>69 (23%)</td>
<td>161 (17%)</td>
<td>0.03</td>
</tr>
<tr>
<td>Died during hospital stay</td>
<td>89 (29%)</td>
<td>214 (23%)</td>
<td>0.01</td>
</tr>
<tr>
<td>6-month mortality</td>
<td>106 (35%)</td>
<td>258 (28%)</td>
<td>0.01</td>
</tr>
<tr>
<td>1-year mortality</td>
<td>120 (39%)</td>
<td>300 (32%)</td>
<td>0.01</td>
</tr>
<tr>
<td>5-year mortality</td>
<td>216 (71%)</td>
<td>597 (64%)</td>
<td>0.02</td>
</tr>
</tbody>
</table>
populations had differed in demographic or medical factors, but the 2 groups were comparable in all relevant aspects: age, sex, marital status, living place before stroke, and stroke severity. That patients were not blinded to the investigators at the time of evaluation and data entry could present a theoretical bias to baseline characteristics. However, patients were comparable not only regarding soft data such as clinical evaluation of stroke severity but also with regard to age, sex, marital status, living place, and lesion type and size on CT. Patients treated at the stroke unit had a higher rate of comorbidity, which could have biased the results toward lower significance. When all possible differences between groups were accounted for in the multivariate analysis, the conclusion of the study remained unchanged.

A difference in general quality of treatment at the 2 hospitals could also have biased the results because of the allocation-by-community method used. However, the quality of treatment was directly comparable except for the presence of the stroke unit. Hospital expenditures, staff wages, the quality of physicians, nurses, and training staff, and the reputation of the 2 hospitals were comparable.

Secular changes in mortality could theoretically interfere with results because of the small difference in study periods between the 2 communities. However, a profound spontaneous change in mortality in the study period is not probable, and no new treatment was introduced in the study period. The incidence rates of stroke patients admitted to the hospital were identical in the 2 communities, at 3.6 per 1000 inhabitants. The admission policy seems therefore unchanged during the 2 periods of inclusion. Thus, stroke unit treatment is a likely explanation of the better long-term outcome found in patients from the Bispebjerg community.

Because the differences in mortality between the 2 groups were achieved during acute treatment and rehabilitation and then merely sustained during the follow-up period, it is unlikely that factors affecting the patients after the end of rehabilitation (such as secondary prevention and medication) would explain the difference in long-term mortality.

Stroke units are not standardized entities. They may differ in several aspects from country to country or even within the same country. Results may therefore not be readily generalizable. It is important to realize that the marked improvement in outcome shown in this and in other studies1,2,6–12 is the result of the stroke unit’s emphasis on a team approach to nursing and rehabilitation and on patient and family participation13 and not on acute intensive monitoring. In the stroke unit, a beneficial effect of caring for patients in an intensive or semi-intensive way in the first few days after stroke has not been proven.14 This further highlights rehabilitation as the most important aspect of stroke unit treatment.

**Acknowledgments**

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**References**


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