Stroke Units Versus General Medical Wards, I: Twelve- and Eighteen-Month Survival
A Randomized, Controlled Trial

Ole Morten Rønning, MD; Bjørn Guldvog, MD, PhD

Background and Purpose—The long-term effect on survival of treatment in stroke units is still under debate. The hypothesis that a stroke unit with short length of stay increases 1-year and 18-month survival rates was tested in this study.

Methods—A quasi-randomized, controlled study was undertaken among 802 patients ≥60 years old admitted to the Central Hospital of Akershus in Norway with a diagnosis of stroke between January 1, 1993, and February 1, 1995. All patients with onset of symptoms <24 hours before admittance were included and enrolled and were followed until death or to the end of the observation 18 months after stroke. Patients were allocated to a stroke unit (n=364) or a general medical ward (n=438).

Results—Case fatality within the first 10 days was 8.2% among patients in the stroke unit and 15.1% among patients in the general medical ward (P=.0019). One-year survival among patients treated in the stroke unit was 70.6% and in the general medical wards 64.6% (P=.026); 18-month survival rates were 65.1% and 58.0%, respectively (P=.021). Among patients with cerebral hemorrhage, 10-day case fatality was 24.5% and 51.6% (P=.004) in favor of the stroke unit.

Conclusions—Stroke units increase survival rates among stroke patients compared with general medical wards. The effect on survival occurs early after the stroke and sustains during at least 18 months of observation. (Stroke. 1998;29:58-62.)

Key Words: emergency medical services ■ outcome ■ stroke units ■ survival

In the industrialized world, stroke is still the third most common cause of death, although stroke mortality has decreased during the last decades.1-6 More than 30% of stroke patients die within 1 year after onset of stroke.7,8 After a decline in stroke incidence during the 1960s and 1970s, some reports now show a stable or increasing incidence.4,8-10 The incidence increases with age, and the consequence of demographic changes could result in stroke becoming an increasing cause of mortality and morbidity.11 Thrombolytic therapy is not recommended at the present time except for a selective group of patients. No routine treatment is effective and available for most acute stroke victims.12,13 A randomized, controlled trial showed that organized management reduced long-term institutional care, long-term dependence, use of hospital resources, and short-term mortality.14 A meta-analysis of randomized, controlled trials reported between 1962 and 1996 by Langhorne and collaborators (Stroke Unit Trialists)15 showed that management of stroke patients in stroke units was associated with a reduction in mortality 1 year after stroke. Some patients with the most severe strokes in several of these studies were likely to have died before they had a chance of entry to the stroke unit (SU) because of late entry. A question still unanswered is whether the effectiveness of SU is a result of early treatment or later rehabilitation efforts. SU are known to be effective for increased survival for selected patients; however, when the length of stay is relatively long, it has not been shown that SU are effective for increased survival for unselected stroke patients with a short length of stay.

This study was performed to test the hypothesis that stroke units with a short hospitalization time would be effective for increased survival among unselected stroke patients at least 1 year after the stroke. We also wanted to analyze whether the possible differences in survival were caused by events during hospitalization or whether treatment in SU influenced survival even in the follow-up period after discharge from hospital.

Subjects and Methods
The Central Hospital of Akershus county serves a population of 291 905, of whom 49 303 are 60 years or older.16 Since 1992, guidelines were developed that recommended all patients with acute stroke to be admitted as early as possible to the hospital. Between January 1, 1993, and February 1, 1995, 1120 patients were admitted to the hospital with a diagnosis of stroke and 802 were included in the study. The trial involved all identified patients 60 years or older assessed in the hospital within 24 hours after having a stroke. All strokes were included, both first strokes and recurrent strokes. None of the patients were included more than once. Data were collected prospectively (1994 to 1995) or retrospectively (1993) by controlling patient medical records. If the patient arrived >24 hours after the stroke occurred, they were not assessed for this study. Hence, among the 318 patients not included in this study, there are patients who arrived >24 hours after stroke and patients who after a closer examination did not have stroke or had a diagnosis mimicking stroke.

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Stroke was defined according to WHO criteria as a vascular lesion of the brain resulting in a neurological deficit persisting for ≥24 hours or resulting in death of the individual. 

Patients with primary subarachnoid hemorrhage or subdural hematomas or with focal neurological deficits with duration <24 hours were excluded from the study. None of the patients were excluded because of severity, additional diseases, cognitive deficits, prior strokes, or because they were living in nursing homes. The number of patients with coma or patients from nursing homes did not differ between the treatment groups (Table 1).

From January 1, 1993, patients older than 60 years were to be treated in either the general medical ward or in the neurological department. The selection of patients to either department was based on the first two digits in the birth number. In the period January 1 to December 31, 1993, stroke patients born between the 1st and the 10th of each month were treated in the SU, and patients born between the 11th and 31st were treated in the general medical ward. From 1994, December 31, 1993, stroke patients born between the 1st and the 10th of each month were treated in the SU, and patients born between the 11th and 31st were treated in the general medical ward. From 1994, the SU expanded and patients born between the 1st and 15th were treated in the SU expanded and patients born between the 16th and 31st were treated in the general medical ward.

Duration of stay, d (SD) 9.1 (6.7) 8.5 (7.8) .52

Prior medical history

Transient ischemic attack 59 (13) 61 (17) .21
Prior stroke 85 (19) 70 (19) .54
Myocardial infarction 75 (17) 55 (15) .18
Atrial fibrillation 81 (18) 62 (17) .52
Hypertension 162 (37) 145 (40) .19
Diabetes 71 (16) 42 (12) .25
Malignancy 38 (9) 30 (8) .54

Continuous data are expressed as mean±SD. Categorical data are expressed as number of patients with/without a given characteristic and also in (%).

Stroke Unit
The 10-bed acute SU could expand or contract with demand. The medical treatment in the SU followed current practice guidelines for the management of patients with acute stroke. 

A standard examination was performed including neurological assessment, blood tests, electrocardiography, and a computed tomography (CT) of the brain within 2 hours after admittance. If an ischemic stroke was suspected after clinical and CT evaluation, acetylic acid 160 mg was administered intravenously. The physiotherapists followed the Bobath technique and instructed the staff to follow this approach during 24 hours. A multidisciplinary team met with the relatives weekly to plan treatment and support after discharge.

General Medical Ward
The hospital has one department of medicine with five wards. Stroke patients were admitted to all these wards, dependent on capacity. Patients treated within the general medical wards (GMW) were given traditional, good medical treatment without special efforts or standardized effort toward this patient group. As in the SU, a CT scan was requested but not routinely as an emergency examination. Patients were immobilized until hemorrhage was excluded by CT scan. Patients with ischemic strokes were then mobilized, whereas patients with hemorrhages were often immobilized for 1 week. Aspirin was given if the CT scan did not reveal a bleeding. Prophylactic administration of low-molecular-weight heparin was given to prevent venous thrombosis for immobilized patients. There was no routine of giving antipyretics or parenteral isosmolar fluids, as in the SU. Anticoagulation was started when a possible cardiogenic embolic source was detected. Patients were offered physiotherapy, occupational therapy, and evaluation of a neurologist when it was requested by the staff.

Both Departments
After acute medical treatment, stabilization and early rehabilitation patients were discharged either home, to nursing homes, to community-based long-term rehabilitation, or to hospital-based long-term rehabilitation. This treatment was given independent of their early treatment. Among the patients in this study, 67 from the SU and 66 from the GMW were transferred to the hospital rehabilitation unit (SU, 18.4%, and GMW, 15.1%). The difference was 3.3% (95% confidence interval, 1.9% to 5.8%). The diagnosis was confirmed by autopsy for patients who died in the hospital. CT scan of the brain was performed on 793 patients (98.9%) and were interpreted by the same radiologists.

Patients were followed up from entry to the study until August 1, 1996. Details of age, gender, stroke type (hemorrhage or infarct), and duration of hospitalization were recorded. The outcome measure in this study was death. Information on death was collected through the National Register, an official register containing name, date of birth, address, and date of death. This register is continually updated. The observation period for patients who had a stroke between January 1, 1993, and February 1, 1995, ranged from 547 to 1310 days for those who were not dead by the end of the observation.

Twelve patients were excluded. They had either passed through the county or visited family in the county when admitted to this hospital with acute stroke and they were later transferred to their home in another part of the country, or they had moved out of the district during follow-up. Some of the patients in this study were involved in a study evaluating the effect of supplemental oxygen (24.2% from SU and 19.2% from GMW, NS) and a study evaluating the effect of late rehabilitation (18.4% from SU and 15.1% from GMW, NS).

Statistical Analysis
We used a Cox regression model to calculate risk ratios (95% confidence intervals) and cumulative survival in both groups. The risk ratio of patients treated in the SU versus patients treated in the GMW is the ratio of the estimated risk for a case treated in the SU to that for a case treated in the GMW. χ² statistics and two-sample t test were used when appropriate to determine significance of differences among background variables compared. Patients are studied on intention-to-treat basis. Even though data were collected retrospectively, the sampling was on the basis of an input variable (treatment) and hence produces a cohort (prospective) study.
**Results**

Demographic characteristics and prior medical history did not differ between 364 patients randomized to the stroke unit and 438 patients to the medical wards (Table 1). The distributions of the type of stroke were similar in the groups: 14.6% in the SU and 14.4% in the GMW had intracerebral bleeding confirmed by CT scan. Characteristics and medical history of the patients with intracerebral bleeding are shown in Table 2. Survival plots of the two groups are shown in Fig 1. After an initially higher case-fatality rate among patients in the GMW during the first weeks, the slope of the two curves is marginally different. A difference in case fatality of about 5% to 6% occurred during the initial period and was sustained until the end of the observation. Table 3 shows the percent mortality and the risk ratios between treatment at different follow-up intervals. Survival rates were significantly higher among patients treated in the stroke unit at all time intervals. Tables 4 and 5 show mortality and risk ratios for patients with cerebral infarction and intracerebral hemorrhage, separately. The initial mortality was especially high among the 115 patients who had an intracerebral hemorrhage. Figs 2 and 3 show cumulative survival plots among patients with cerebral infarction and intracerebral hemorrhages for the two treatment groups. During the first weeks the case fatality is significantly higher among patients with intracerebral hemorrhage treated in the GMW, but the slope of the two curves seems similar after the initial period. The ≈20% to 25% absolute difference in the proportion of patients who died in the two groups appeared during the first 50 days and then stabilized.

**Discussion**

This study confirmed the effectiveness of SU to enhance survival among stroke patients even among unselected stroke patients with a short length of stay. It is the first randomized, controlled trial focusing on survival showing significant differences in survival as long as 18 months after the stroke, and it is the largest randomized study of its kind. In this particular study, patients with hemorrhages benefited the most. Patients entering this study presented with an acute stroke, and the diagnosis was confirmed during the hospitalization. Some previous controlled trials found SU beneficial in reducing short-term case fatality.21,22 One study showed increased survival among patients treated in SU, but the difference had disappeared at follow-up 12 months after the stroke.14 In other randomized stroke trials, survival was not affected by treatment in GMW or SU.23,24 A meta-analysis of SU trials reported a significant improvement in survival after 1 year.15 However, this analysis was as the authors described, based on a heterogeneous group of trials. Because of reports of discrepancies between the results of meta-analysis and findings of large randomized trials, some researchers have focused on the limitations of such analyses.25,26

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**TABLE 2. Characteristics of Stroke Patients With Intracerebral Bleeding**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Stroke Unit (n=53)</th>
<th>Medical Wards (n=62)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age, y (SD)</td>
<td>76.2 (7.5)</td>
<td>75.7 (7.6)</td>
<td>.74</td>
</tr>
<tr>
<td>Female sex</td>
<td>24 (45)</td>
<td>20 (32)</td>
<td>.15</td>
</tr>
<tr>
<td>Patients with coma</td>
<td>13 (25)</td>
<td>18 (29)</td>
<td>.55</td>
</tr>
<tr>
<td>Duration of stay, d (SD)</td>
<td>9.6 (7.8)</td>
<td>7.1 (7.4)</td>
<td>.09</td>
</tr>
<tr>
<td>Prior medical history</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transient ischemic attack</td>
<td>5 (9)</td>
<td>6 (10)</td>
<td>.96</td>
</tr>
<tr>
<td>Prior stroke</td>
<td>8 (15)</td>
<td>6 (10)</td>
<td>.38</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>4 (8)</td>
<td>11 (17)</td>
<td>.09</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>6 (11)</td>
<td>7 (11)</td>
<td>.99</td>
</tr>
<tr>
<td>Hypertension</td>
<td>13 (25)</td>
<td>145 (40)</td>
<td>.19</td>
</tr>
<tr>
<td>Diabetes</td>
<td>71 (16)</td>
<td>42 (12)</td>
<td>.25</td>
</tr>
<tr>
<td>Malignancy</td>
<td>38 (9)</td>
<td>30 (8)</td>
<td>.54</td>
</tr>
</tbody>
</table>

Continuous data are expressed as mean±SD. Categorical data are expressed as number of patients with/without a given characteristic and also in (%).

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**TABLE 3. Percent Mortality by Treatment Groups at Different Times After Initial Stroke**

<table>
<thead>
<tr>
<th>Time After Initial Stroke</th>
<th>Stroke Unit</th>
<th>GMW</th>
<th>RR</th>
<th>CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 d</td>
<td>9.1</td>
<td>16.7</td>
<td>.72</td>
<td>0.59-0.89</td>
<td>.0018</td>
</tr>
<tr>
<td>1 mo</td>
<td>13.7</td>
<td>22.4</td>
<td>.76</td>
<td>0.64-0.90</td>
<td>.0016</td>
</tr>
<tr>
<td>3 mo</td>
<td>19.0</td>
<td>27.5</td>
<td>.80</td>
<td>0.69-0.93</td>
<td>.0036</td>
</tr>
<tr>
<td>6 mo</td>
<td>24.2</td>
<td>30.7</td>
<td>.86</td>
<td>0.75-0.98</td>
<td>.0229</td>
</tr>
<tr>
<td>12 mo</td>
<td>30.8</td>
<td>37.3</td>
<td>.87</td>
<td>0.78-0.99</td>
<td>.0289</td>
</tr>
<tr>
<td>18 mo</td>
<td>34.9</td>
<td>41.9</td>
<td>.88</td>
<td>0.78-0.98</td>
<td>.0237</td>
</tr>
</tbody>
</table>

GMW indicates general medical ward; RR, relative risk; and CI, confidence interval.

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**TABLE 4. Percent Mortality After Cerebral Infarction by Treatment Groups at Different Times**

<table>
<thead>
<tr>
<th>Time After Initial Stroke</th>
<th>Stroke Unit</th>
<th>GMW</th>
<th>RR</th>
<th>CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 d</td>
<td>6.4</td>
<td>10.3</td>
<td>.78</td>
<td>0.60-1.03</td>
<td>.077</td>
</tr>
<tr>
<td>1 mo</td>
<td>9.6</td>
<td>16.0</td>
<td>.77</td>
<td>0.61-0.95</td>
<td>.017</td>
</tr>
<tr>
<td>3 mo</td>
<td>15.4</td>
<td>21.4</td>
<td>.83</td>
<td>0.69-0.99</td>
<td>.043</td>
</tr>
<tr>
<td>6 mo</td>
<td>20.6</td>
<td>24.9</td>
<td>.89</td>
<td>0.76-1.04</td>
<td>.140</td>
</tr>
<tr>
<td>12 mo</td>
<td>27.0</td>
<td>31.7</td>
<td>.90</td>
<td>0.78-1.03</td>
<td>.144</td>
</tr>
<tr>
<td>18 mo</td>
<td>31.2</td>
<td>36.6</td>
<td>.90</td>
<td>0.79-1.03</td>
<td>.112</td>
</tr>
</tbody>
</table>

GMW indicates general medical ward; RR, relative risk; and CI, confidence interval.

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Figure 1. Cumulative survival rates by treatment group (n=802). — indicates stroke unit; - - - - - , medical wards.
In our study, the difference in long-term survival could be explained mostly by a lower case fatality among the patients treated in the SU during the first 10 days, indicating the importance of the treatment offered during this period. Analyzing the subgroup with hemorrhage showed even more pronounced contrasts. From our study, we may hypothesize that a considerable proportion of the effect of stroke units on mortality is due to the treatment of patients with hemorrhage. A noticeable feature in treatment that differed between the SU and GMW was onset of mobilization of patients with intracerebral bleeding. Patients treated in the SU were mobilized early, independent of type of stroke, whereas in the GMW, stroke patients with an intracerebral hemorrhage were mobilized later and with more caution. Other investigators have suggested that early mobilization of stroke patients is important for a good result.14,15,27 Previous studies have reported significantly longer length of stay in our study was just above 1 week in both treatment groups. The relatively short length of stay suggests that early and acute treatment and intensive mobilization is adequate to reduce mortality, but we do not consider a length of stay of 1 week to be sufficient to achieve a good functional recovery.

Randomization and Ethics

The formal randomization procedure should ensure that groups be comparable. The age and sex distribution and the proportion of stroke subgroups indicate that the randomization was effective. In this particular study the intention-to-treat and on-treatment groups were practically identical.

This is the first study of an SU with a short length of stay that has shown a reduction of mortality. One-year survival in our treatment groups is lower than in the groups reported in the meta-analysis by Langhorne and collaborators (Stroke Unit Trialists).15 The most probable explanation is that our study included all patients with acute stroke, even those with the worst prognosis and who were suspected to die within the first few days. We did not include patients under the age of 60 years because they were all treated in the SU. Because of that, we had a higher age distribution in our selection of stroke patients and of course a population with an overall higher risk of death. One strength of our study is the higher number of patients included compared with previous SU trials, thereby increasing the power of the study. We did not show an absolute difference in survival rates that was much higher than in many SU trials. We believe the reason for some studies failing to document significant differences in long-term survival has been due to lack of power of the study.

Which are the possible sources of bias of this study? The information about the patients and the type of stroke in the records should hold high standards. One of the researchers examined every record carefully before coding. To test accuracy of coding, several sets of records were assessed twice, revealing identical results. The validity of the hospital records describing the neurological conditions is assumed to be high because most patients were observed for several days and examined by different doctors, ensuring an accurate diagnosis. A study of this kind cannot be blinded, and therefore there is a risk of exchange of information between the departments regarding treatment. During the last decade an increasing interest in stroke by the public and the professionals has taken place. This interest in stroke may have increased the effort in the GMW and could have reduced the benefit of the SU. The hospital, which is among the five largest in Norway, should be of a high standard. It has participated in international multicenter stroke trials (ECASS I)26 and now takes part in ECASS II.29 The number of patients included in these trials from this hospital as other hospitals is relatively small and should not affect the results of this study. The external validity of our trial should be high for the group of patients with acute stroke who are 60 years and older, because all patients with this diagnosis in the catchment area were offered treatment in the hospital. General

**TABLE 5.** Percent Mortality After Intracerebral Hemorrhage by Treatment Groups at Different Times

<table>
<thead>
<tr>
<th>Time After Initial Stroke</th>
<th>Stroke Unit</th>
<th>GMW</th>
<th>RR</th>
<th>CI</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 d</td>
<td>24.5</td>
<td>51.6</td>
<td>.62</td>
<td>0.45-0.86</td>
<td>.0041</td>
</tr>
<tr>
<td>1 mo</td>
<td>37.7</td>
<td>58.10</td>
<td>.71</td>
<td>0.54-0.93</td>
<td>.0143</td>
</tr>
<tr>
<td>3 mo</td>
<td>39.6</td>
<td>61.3</td>
<td>.71</td>
<td>0.54-0.92</td>
<td>.0104</td>
</tr>
<tr>
<td>6 mo</td>
<td>45.3</td>
<td>62.9</td>
<td>.74</td>
<td>0.57-0.95</td>
<td>.0205</td>
</tr>
<tr>
<td>12 mo</td>
<td>52.8</td>
<td>69.4</td>
<td>.76</td>
<td>0.60-0.96</td>
<td>.0217</td>
</tr>
<tr>
<td>18 mo</td>
<td>56.6</td>
<td>71.0</td>
<td>.77</td>
<td>0.61-0.97</td>
<td>.0291</td>
</tr>
</tbody>
</table>

GMW indicates general medical ward; RR, relative risk; and CI, confidence interval.
practitioners in the area were reminded several times to refer all persons with acute stroke to the hospital without delay. Which are the possible explanations of the increased survival among patients treated in the SU? Because we did not isolate specific parts of the treatment package, we are still uncertain about which components are most important. We believe, as other investigators do, that the effects are probably caused by many components but mainly the combination of early acute treatment and rehabilitation, the multidisciplinary approach, and early detection and aggressive treatment of complications. In contrast to other stroke unit or rehabilitation studies, patients in this study were admitted exclusively very early after onset. As a consequence, the early acute treatment may have contributed more than in other trials. SU patients were examined with a CT within 2 hours after admission and given an acetylic acid tablet (entercoated acetylic acid 160 mg) immediately after CT examination when infarction was suspected. Early administration of acetylic acid could have prevented some early secondary strokes, reduced worsening of the initial stroke, or prevented thromboembolic complications. The most common diagnosis of those who die immediately after stroke is primary intracerebral hemorrhage. When patients with cerebral infarctions die within the first days after stroke, it is often due to complications of immobilization such as pneumonia, new strokes, or pulmonary embolism. Patients in the SU were brought out of bed soon after admittance, and some events of aspirations may have been prevented because of this. Early mobilization may have reduced the occurrence of both deep-vein thrombosis and pulmonary embolism. The SU proved especially successful for patients with hemorrhages. These patients are easier to diagnose correctly because hemorrhages show up on CT scans within the first hours after onset. The diagnosis was confirmed by autopsy for patients who died in the hospital. In conclusion, we found that treatment in the SU increased survival at 12 and 18 months after stroke onset. Patients with hemorrhages benefited the most.

We expect our study to provide further information about whether an SU with short length of stay has effect on morbidity, impairment, depression, patient satisfaction, and quality of life.

References
15. Sern I, Hlatky MA. Growing pains of meta-analysis: advances in methodology will not remove the need for well designed trials. BMJ. 1996;313:702-703.
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