Predictors of In-Hospital Mortality and Attributable Risks of Death After Ischemic Stroke

The German Stroke Registers Study Group

Background: There is a lack of information about factors associated with in-hospital death and the impact of neurological complications on early outcome for patients with stroke treated in community settings. We investigated predictors for in-hospital mortality and attributable risks of death after ischemic stroke in a pooled analysis of large German stroke registers.

Methods: Stroke patients admitted to hospitals cooperating within the German Stroke Registers Study Group (ADSR) between January 1, 2000, and December 31, 2000, were analyzed. The ADSR is a network of regional stroke registers, combining data from 104 academic and community hospitals throughout Germany. The impact of patients’ demographic and clinical characteristics, their co-morbid conditions, and the treating hospital expertise in stroke care on in-hospital mortality was analyzed using Cox regression analysis. Attributable risks of death for medical and neurological complications were calculated.

Results: A total of 13,440 ischemic stroke patients were included. Overall in-hospital mortality was 4.9%. In women, higher age (P<.001), severity of stroke defined by number of neurological deficits (P<.001), and atrial fibrillation (hazard ratio [HR], 1.3; 95% confidence interval [CI], 1.0-1.6) were independent predictors for in-hospital death. In men, diabetes (HR, 1.3; 95% CI, 1.0-1.8) and previous stroke (HR 1.4; 95% CI, 1.0-1.9) had a significant negative impact on early outcome in addition to the factors identified for women. The complication with the highest attributable risk proportion was increased intracranial pressure, accounting for 94% (95% CI, 93.9%-94.1%) of deaths among patients with this complication. Pneumonia was the complication with the highest attributable proportion of death in the entire stroke population, accounting for 31.2% (95% CI, 30.9%-31.5%) of all deaths. More than 50% of all in-hospital deaths were caused by serious medical or neurological complications (54.4%; 95% CI, 54.3%-54.5%).

Conclusions: Substantial differences were found in the impact of comorbid conditions on early outcome for men and women. Programs aiming at an improvement in short-term outcome after stroke should focus especially on a reduction of pneumonia and an early treatment of increased intracranial pressure.

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IN 2020, STROKE WILL BE THE SECOND LEADING CAUSE OF DEATH AND DISABILITY IN DEVELOPED REGIONS OF THE WORLD.1 To reduce the overall burden of stroke on society, the development and the establishment of an organized approach of acute stroke care is postulated.2-4 The expected benefits of the implementation of specialized stroke services in community settings are more efficient patient care, higher rates of patients receiving intravenous thrombolysis, fewer peristroke complications, and a reduced morbidity and mortality after stroke.2 The identification of predictors for mortality during hospitalization might contribute to reduce death rates after stroke by enhancing the application of specific therapeutic and management strategies to patients at high risk of dying. However, only limited information is available on predictors for in-hospital mortality and about the impact of serious medical and neurological complications on early outcome in patients with stroke. Evidence on ischemic stroke mortality in community hospitals is available only from reports using administrative records,5-8 from intercountry comparisons,9 or from single-center studies.10-13 In contrast to myocardial infarction,14 data for stroke provided by multicenter studies that collected information from routine clinical care of a large number of patients in a uniform, prospective way are lacking.

The aim of our study was to identify predictors for in-hospital mortality after acute ischemic stroke and to analyze at-
tributable risks of death for serious medical and neurological complications within a prospective cohort of 104 hospitals in Germany.

**METHODS**

All data were collected within the German Stroke Registers Study Group (Arbeitsgemeinschaft Deutscher Schlaganfall Register—ADSR). The ADSR is a network of regional hospital-based stroke registers in Germany, aiming at a continuous monitoring of the quality of stroke care. In the present study, data from the stroke registers in Hamburg, Hesse, Westphalia, and Bavaria were included. In total, 104 hospitals participated in the study, combining data from academic and community hospitals as well as from departments of neurology, internal medicine, and geriatric medicine. All ischemic stroke patients admitted to the participating hospitals between January 1, 2000, and December 31, 2000, were considered in the present analyses.

**DATA COLLECTION**

Design and methodology of the ADSR network were previously described in detail. Briefly, data from consecutively admitted stroke patients were collected prospectively by the treating physician. Sociodemographic characteristics, comorbid conditions, neurological deficits, incident complications, diagnostic workup, and treatments were documented during the whole stay in hospital. The registers used a standardized data set for all stroke patients. Stroke was defined according to the World Health Organization criteria. The diagnosis of cerebral infarction was confirmed in each case by computed tomography or magnetic resonance imaging.

In the present analyses, the influence of the following variables on early stroke outcome was assessed: age (categorized as <65, 65-74, 75-84, and ≥85 years old); hypertension (reported blood pressure ≥160 mm Hg [systolic] or ≥95 mm Hg [diastolic] or patient's self-report of treated hypertension); diabetes mellitus (reported pathological elevated fasting blood glucose level, patient's self-report of diabetes, or use of antidiabetic drugs); previous stroke (neurological deficit >24 hours prior to current event); atrial fibrillation (documented by electrocardiogram); number of neurological deficits of current stroke as index of stroke severity (the cumulative number of the following neurological deficits was calculated: limb or arm weakness/paresis, aphasia, dysarthria, and disturbances of consciousness); discharge destination from acute care hospital (dead, home, residential/nursing home, rehabilitation unit, or other hospital). Information on the following serious medical and neurological complications during hospitalization was collected: recurrent stroke (new neurological deficit >24 hours after current event); pulmonary embolism (clinical findings and/or diagnostic findings); epileptic seizure (clinical diagnosis of focal and/or general seizure in nonepileptic patients); pneumonia (clinical findings and/or diagnostic findings); increased intracranial pressure (evidence of symptomatic increased intracranial pressure by edema, mass effect, or brain shift syndrome on computed tomography or magnetic resonance imaging, with clinical findings). To investigate the impact of the number of medical and/or neurological complications on early outcome, patients were classified as having none or 1 or more of these complications. We defined the total number of stroke patients treated in an individual hospital per year as the hospital expertise with acute stroke treatment. This definition is based on the number of acute stroke patients treated per hospital in 2000 was dichotomized into 2 categories: low volume (<250 patients per year) and high volume (≥250 patients per year). In a priori analyses, we explored the influence of a number of different cutoff points on early outcome. The cutoff point of 250 patients was selected because it best represented an association between hospital volume and in-hospital mortality.

**STATISTICAL ANALYSIS**

The t test was used to test differences in continuous variables and the χ² test for those in proportions. To estimate hazard ratios (HRs) and the resulting 95% confidence intervals (CIs) of predictors of in-hospital mortality, Cox regression analysis was performed. Length of stay in an acute care hospital was defined as survival time. In-hospital death was defined as outcome event. Patients were censored if they were alive at discharge. In multivariate analyses, the influence of age, sex, comorbid conditions, severity of stroke (defined by number of neurological deficits), and the expertise of the individual hospital in acute stroke treatment on in-hospital mortality were investigated. Possible interactions between sex, comorbid conditions, neurological complications, and hospital expertise were controlled by adding terms of interaction to the regression model. The statistical significance of the resulting coefficient was tested by the likelihood ratio test. Significant terms of interaction between sex and diabetes mellitus (χ² = 4.64) and between sex and previous stroke (χ² = 5.36) were found. Therefore, multivariate analyses were stratified for sex by running different regression models for men and women. Variables in multivariate analyses were eliminated using the backward elimination procedure. Attributable proportions of death for incident complications were calculated using the HR from a Cox regression model adjusted for variables significant in multivariate analyses. The following attributable proportions were obtained: The attributable risk proportion of death in the exposed (ARP), which gives the proportion by which the rate of death among the exposed would be reduced if the complication was absent (ARP = HR - 1)/HR and the attributable proportion of death in the population (PARP), which indicates the proportion by which the rate of death would be reduced in the entire population of ischemic stroke patients if the complication would be absent (PARP = P × ARP, where P is the exposed patients who died in the hospital divided by all patients who died in the hospital). Confidence intervals were calculated using the Δ method for estimating the variance of the attributable risk proportions. In the Cox regression model patients without any complication were chosen as a control group for patients with a particular complication to avoid a potential influence of the other serious complications. Because tissue-type plasminogen activator treatment was shown to increase the risk of in-hospital death in our study population, 461 patients receiving thrombolytic therapy after ischemic stroke (77 with intra-arterial and 384 with intravenous thrombolysis) were excluded from statistical analyses. Also, 1257 patients after ischemic stroke were removed from further analyses owing to missing values, and 922 patients with length of stay in an acute care hospital longer than 25 days were not included in the analyses because the proportional hazard assumption for the Cox regression model was not fulfilled for a number of investigated variables after day 25 of the hospital stay. All tests were 2-tailed, and statistical significance was determined at an α level of .05. Statistical analyses were performed with the SPSS 11.0 software package (SPSS Inc, Chicago, Ill).

**ETHICS**

The design of the study was approved by the ethics committee of the Westphalian Board of Physicians and the University of Muenster, Muenster, Germany. The identity of the individual care. The number of acute stroke patients treated per hospital in 2000 was dichotomized into 2 categories: low volume (<250 patients per year) and high volume (≥250 patients per year).
patients was completely anonymous. Therefore, no specific informed consent was signed by patients. The data pooling center at the University of Muenster was blinded to hospital identities; these were only known to the regional stroke registers.

RESULTS

A total of 13,440 patients with ischemic stroke were admitted to the 104 hospitals within the ADSR network from January 1, 2000, to December 31, 2000. The characteristics of the participating hospitals are presented in Table 1. Mean length of stay in the hospital for patients with ischemic stroke included in the present analyses was 10.6 days (median, 10 days). Duration of stay was lower in low-volume compared with high-volume hospitals (mean [median] days, 12.5 [12] vs 9.7 [9], respectively).

Mean patient age was 70 years (median, 72 years); 46.8% were women (Table 2). Comorbid conditions and severity of stroke, defined by number of neurological deficits, are given in Table 2. Significant differences in patient characteristics between male and female patients were found for age, diabetes, hypertension, atrial fibrillation, and severity of stroke.

IN-HOSPITAL MORTALITY

The overall proportion of in-hospital death was 4.9%. The percentage of patients who died during hospitalization varied across the participating hospitals between 0% and 25% with 1 outlier of 46.7% (7 of 15 patients), with a range from 0% to 25% in low-volume and 0.4% to 9.3% in high-volume hospitals. Of in-hospital deaths in our study population, 34.3% occurred within the first 3 days in the hospital and 66% within the first 7 days in the hospital (data not shown).

Findings from univariate analyses of factors related to death during hospitalization are given in Table 3. Patients were more likely to die during their stay in the hospital if they were older, had a previous stroke, or had atrial fibrillation. Increasing stroke severity (defined as

Table 1. Hospital Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department, No. (%)</td>
<td></td>
</tr>
<tr>
<td>Neurology</td>
<td>64 (62)</td>
</tr>
<tr>
<td>Internal medicine</td>
<td>36 (35)</td>
</tr>
<tr>
<td>Geriatric medicine</td>
<td>4 (3)</td>
</tr>
<tr>
<td>Stroke unit service provided, No. (%)</td>
<td>44 (42)</td>
</tr>
<tr>
<td>Stroke patients per hospital in 2000, No. (%)*</td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>26 (25)</td>
</tr>
<tr>
<td>50-149</td>
<td>33 (32)</td>
</tr>
<tr>
<td>150-249</td>
<td>17 (16)</td>
</tr>
<tr>
<td>250-349</td>
<td>8 (8)</td>
</tr>
<tr>
<td>≥350</td>
<td>20 (19)</td>
</tr>
<tr>
<td>No. of stroke patients per hospital, median (range)*</td>
<td>130 (1-1135)</td>
</tr>
<tr>
<td>Patients treated per hospital, %*</td>
<td></td>
</tr>
<tr>
<td>Low volume (&lt;250)</td>
<td>32.2</td>
</tr>
<tr>
<td>High volume (≥250)</td>
<td>67.8</td>
</tr>
</tbody>
</table>

*Includes all stroke patients admitted to an individual hospital during a 1-year period (including those with transient ischemic attack and hemorrhagic stroke).

Table 2. Patient Characteristics Stratified by Sex*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Total (N = 10,800)</th>
<th>Female (n = 5,049)</th>
<th>Male (n = 5,751)</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), y</td>
<td>70.0 (12.8)</td>
<td>73.2 (13)</td>
<td>67.3 (12)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Age group, y, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65</td>
<td>30.1</td>
<td>20.7</td>
<td>38.3</td>
<td></td>
</tr>
<tr>
<td>65-74</td>
<td>28.1</td>
<td>24.6</td>
<td>33.1</td>
<td></td>
</tr>
<tr>
<td>75-84</td>
<td>28.6</td>
<td>35.9</td>
<td>22.1</td>
<td></td>
</tr>
<tr>
<td>≥85</td>
<td>12.2</td>
<td>18.8</td>
<td>6.5</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Comorbidities, %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>28.9</td>
<td>30.4</td>
<td>27.7</td>
<td>.002</td>
</tr>
<tr>
<td>Hypertension</td>
<td>71.9</td>
<td>73.2</td>
<td>70.8</td>
<td>.005</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>19.0</td>
<td>19.0</td>
<td>18.9</td>
<td>.94</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>21.4</td>
<td>25.8</td>
<td>17.5</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Index of stroke severity, %‡</td>
<td></td>
<td></td>
<td></td>
<td>&lt;.001</td>
</tr>
<tr>
<td>0-1</td>
<td>59.4</td>
<td>56.3</td>
<td>62.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>30.2</td>
<td>30.8</td>
<td>29.6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8.7</td>
<td>10.3</td>
<td>7.3</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1.8</td>
<td>2.6</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>

*Includes all stroke patients admitted to an individual hospital during a 1-year period (including those with transient ischemic attack and hemorrhagic stroke).

†Female vs male patients.
‡Defined by number of neurological deficits. Paresis and/or weakness, aphasia, dysarthria, and a disturbed level of consciousness were included for calculating the number of neurological deficits.

NEUROLOGICAL COMPLICATIONS AND THEIR ATTRIBUTABLE RISK OF DEATH

Table 3. Medical and Neurological Complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aphasia</td>
<td>7.3</td>
<td>5.7</td>
<td>9.0</td>
<td>.002</td>
</tr>
<tr>
<td>Dysarthria</td>
<td>8.7</td>
<td>6.5</td>
<td>10.9</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Dysphasia</td>
<td>2.6</td>
<td>2.0</td>
<td>3.3</td>
<td>.005</td>
</tr>
<tr>
<td>Anosognosia</td>
<td>4.9</td>
<td>3.7</td>
<td>6.3</td>
<td>.001</td>
</tr>
<tr>
<td>Confusion</td>
<td>6.3</td>
<td>5.0</td>
<td>7.7</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Delirium</td>
<td>10.8</td>
<td>10.6</td>
<td>11.0</td>
<td>.94</td>
</tr>
<tr>
<td>Amnestic disorder</td>
<td>1.8</td>
<td>1.5</td>
<td>2.2</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Abulia</td>
<td>2.2</td>
<td>2.1</td>
<td>2.4</td>
<td>.94</td>
</tr>
<tr>
<td>Behavioral disorder</td>
<td>5.7</td>
<td>4.9</td>
<td>6.5</td>
<td>.005</td>
</tr>
</tbody>
</table>

†Female vs male patients.

The frequency of medical and neurological complications during the hospital stay and the proportion of patients who died with a specific complication are given in Table 4. Each of these medical and neurological complications was associated with an increased risk of in-
We evaluated predictors of in-hospital mortality in a large population of patients with ischemic stroke treated in community hospitals in Germany. Our study found that older age, stroke severity, and atrial fibrillation were independent predictors for a poor early outcome. We observed different effects of diabetes and previous stroke on in-hospital death in men and women. The highest death rate attributed to a specific complication was found for an increased intracranial pressure in all patients exposed to a specific complication, while pneumonia had the largest impact on in-hospital mortality in the entire stroke population. More than 50% of all in-hospital deaths after ischemic stroke were caused by serious medical or neurological complications.

**IN-HOSPITAL MORTALITY IN ROUTINE CLINICAL PRACTICE**

A number of previous studies reported proportions of patients who died during hospitalization after ischemic stroke. The observed mortalities ranged from 3% to 9%. Thus, the proportion of 4.9% in our analyses is comparable with previous findings. Only a few studies have evaluated variables influencing in-hospital mortality after ischemic stroke in community settings. Reed and colleagues and Wong demonstrated a higher risk of in-hospital death among older patients, which is similar in the magnitude to our results. In accordance with our findings, 2 single-center studies identified neurological deficits, including an impaired consciousness and limb weakness, as influencing factors for early outcome. In
addition, atrial fibrillation was found to be associated with increased rates of in-hospital mortality,\(^5\) which is also comparable with our results. The impact of diabetes on early outcome in male patients in our study was similar to the combined analysis of male and female stroke patients in the study by Wong\(^6\) (HR, 1.3 [95% CI, 1.0-1.8] vs odds ratio, 1.5 [95% CI, 1.0-2.2]). The overall negative effect of diabetes on outcome in that study, which reported combined results for men and women, might be because a higher proportion of men were included in the analysis compared with our study (58.3\%)\(^9\) vs 53.2\%).

Our study provides evidence that the impact of specific comorbid conditions on early stroke outcome differs between men and women. After adjusting for potential confounders, older age had a consistently lower impact on early death in women compared with men. This difference is in accordance with previous findings from epidemiological studies that demonstrate that men have higher age-adjusted mortality rates compared with women.\(^22\) However, owing to the observational design of our study, it remains unclear if the detected sex differences were caused by biological variations in the influence of the investigated variables, by unobserved differences in the patient characteristics, or by different treatment and management strategies for men and women. The latter might be caused by different proportions of etiological stroke subtypes in male and female patients.

In recent years, increasing evidence suggests that ischemic stroke is a heterogeneous mixture of different etiological stroke subtypes representing large variations in underlying risk factors, recurrence rates, and outcomes.\(^23\) Hypertension and diabetes were found to be more frequent in lacunar compared with nonlacunar strokes.\(^24\)

In our study, the larger proportion of hypertension and diabetes in women might be an indicator for a higher number of lacunar strokes among women compared with men. Petty and colleagues\(^25\) demonstrated that lacunar strokes predict a better early outcome independent of stroke severity. Therefore, the lower rate of in-hospital deaths among hypertensive women might be attributable to a higher proportion of lacunar strokes in the specific female subgroup. An alternative explanation might be given by differences in treatment and management strategies for male and female patients. In multivariate analysis, men showed lower mortality rates if they were admitted to centers treating large numbers of stroke patients. The number of stroke patients treated per hospital per year was defined to be an indicator for hospital expertise in our study. These results were in accordance with the study of Gillum and colleagues,\(^3\) who demonstrated that the presence of a vascular neurologist and existing guidelines for tissue-type plasminogen activator use are associated with a lower rate of in-hospital mortality. However, in our study, no independent influence of hospital expertise on early outcome in women was demonstrated. This divergent result might support the notion that actual treatment and management strategies differ between sexes. In the management of coronary artery disease, it was shown that women were less likely to receive specific diagnostic or therapeutic procedures.\(^14\)

A recently published report identified elderly women to be less likely receiving preventive treatment after stroke compared with men.\(^26\) Therefore, the different influences of hospital expertise on in-hospital death in male and female patients could be caused by a lower probability of female patients to be treated aggressively.

### MEDICAL AND NEUROLOGICAL COMPICATIONS AFTER ISCHEMIC STROKE

A number of previous studies reported on the complication rates during acute care hospital stays in ischemic stroke patients.\(^24,27-30\) Serious complications within 7 days after ischemic stroke were reported from a combined analyses of 23 neurological departments in Germany\(^24\) and from a subsample of 14 of these departments.\(^30\) Proportions of epileptic seizures, pulmonary embolisms, and pneumonias were similar to our analysis. However, complication rates of recurrent stroke and increased intracranial pressure were substantially higher in the studies of Grau and colleagues\(^24\) and Weimar and colleagues\(^30\) than in our study (4.3\% vs 2.5\%; 6.3\% vs 7.6\% vs 2.8\%). These variations might be caused by a different selection of patients in these reports compared with our data. To provide valid estimates on routine clinical care, we observed academic and community hospitals as well as departments of neurology, internal medi-

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**Table 4. Predictors for In-Hospital Mortality: Multivariate Analyses Stratified by Sex**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Female HR (95% CI)</th>
<th>P Value</th>
<th>Male HR (95% CI)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age group, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;65</td>
<td>1.0 (Reference)</td>
<td></td>
<td>1.0 (Reference)</td>
<td></td>
</tr>
<tr>
<td>65-74</td>
<td>1.2 (0.8-1.9)</td>
<td>&lt;.001</td>
<td>1.9 (1.3-2.9)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>75-84</td>
<td>1.8 (1.2-2.7)</td>
<td>&lt;.001</td>
<td>3.0 (2.0-4.5)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>≥85</td>
<td>2.3 (1.3-3.4)</td>
<td>.04</td>
<td>3.1 (1.9-5.1)</td>
<td>.04</td>
</tr>
<tr>
<td>Comorbidities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>0.9 (0.7-1.1)</td>
<td>.37§</td>
<td>1.3 (1.0-1.8)</td>
<td>.04</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.8 (0.6-1.0)</td>
<td>.05§</td>
<td>1.0 (0.7-1.4)</td>
<td>.99§</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>0.9 (0.6-1.1)</td>
<td>.03</td>
<td>1.4 (1.0-1.9)</td>
<td>.03</td>
</tr>
<tr>
<td>Atrial fibrillation</td>
<td>1.3 (1.0-1.6)</td>
<td>.04</td>
<td>1.7 (1.3-2.3)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Index of stroke severity†</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-1</td>
<td>1.0 (Reference)</td>
<td></td>
<td>1.0 (Reference)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2.5 (1.8-3.3)</td>
<td>&lt;.001</td>
<td>1.9 (1.4-2.7)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>3</td>
<td>6.7 (4.9-9.3)</td>
<td>&lt;.001</td>
<td>6.1 (4.2-8.6)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>4</td>
<td>11.1 (7.6-16.2)</td>
<td>&lt;.001</td>
<td>11.8 (7.2-19.2)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Total No. of stroke patients treated per hospital per year‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High volume (≥250)</td>
<td>1.0 (0.8-1.2)</td>
<td>.84§</td>
<td>0.7 (0.6-1.0)</td>
<td>.053</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; HR, hazard ratio.

*Analyses were restricted to patients not receiving thrombolytic therapy, without missing values, and with length of stay in acute care hospital ≤25 days.
†Defined by number of neurological deficits. Paresis and/or weakness, aphasia, dysarthria, and a disturbed level of consciousness were included for calculating the number of neurological deficits.
‡Includes all stroke patients admitted to an individual hospital during a 1-year period (including those with transient ischemic attack and hemorrhagic stroke).
§Variable not statistically significant in multivariate analyses; nonsignificant variables were removed from the equation at an \(α\) level >.05; HR, 95% CI, and \(P\) value were given just before removal.
Table 5. Complications During Stay in Acute Care Hospital

<table>
<thead>
<tr>
<th>Specific complication</th>
<th>% From Population</th>
<th>% Dead at Discharge†</th>
<th>HR‡ (95% CI)</th>
<th>P Value</th>
<th>ARP (95% CI), %</th>
<th>PARP (95% CI), %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recurrent stroke</td>
<td>2.5</td>
<td>16.1</td>
<td>5.2 (3.7-7.2)</td>
<td>&lt;.001</td>
<td>80.7 (79.4-82.0)</td>
<td>6.7 (5.3-8.0)</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>0.4</td>
<td>46.8</td>
<td>14.3 (9.0-22.7)</td>
<td>&lt;.001</td>
<td>93.0 (92.3-93.7)</td>
<td>3.8 (3.1-4.5)</td>
</tr>
<tr>
<td>Epileptic seizure</td>
<td>1.5</td>
<td>19.3</td>
<td>5.0 (3.4-7.4)</td>
<td>&lt;.001</td>
<td>80.0 (77.3-82.7)</td>
<td>4.7 (2.0-7.3)</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>6.0</td>
<td>30.1</td>
<td>6.6 (5.3-8.2)</td>
<td>&lt;.001</td>
<td>84.8 (84.5-85.2)</td>
<td>31.2 (30.9-31.5)</td>
</tr>
<tr>
<td>Increased intracranial pressure</td>
<td>2.8</td>
<td>53.1</td>
<td>16.8 (13.1-21.5)</td>
<td>&lt;.001</td>
<td>94.0 (93.9-94.1)</td>
<td>28.6 (28.5-28.7)</td>
</tr>
</tbody>
</table>

Abbreviations: ARP, attributable risk proportion of death in patients with the respective medical or neurological complications; CI, confidence interval; HR, hazard ratio; PARP, attributable proportion of death in the entire stroke population.

Analyses were restricted to patients not receiving thrombolytic therapy, without missing values, and with length of stay in acute care hospital ≥25 days.

†Proportion refers to patients with the respective complication.

‡Hazard ratio was adjusted for age, sex, comorbidities, stroke severity (defined by number of neurological deficits), and hospital expertise.

cine, and geriatric medicine. In the 2 other studies, only neurological departments with an acute stroke unit were included, which were the main providers for acute stroke care in the particular region.24,30 Patients with severe strokes were identified to be at increased risk for serious complications.28 In Germany, patients with severe strokes are recommended to be admitted to hospitals with high expertise in acute stroke treatment, especially to centers providing acute stroke unit services.31 Therefore, the higher complication rates in the studies of Grau and colleagues24 and Weimar and colleagues30 might be caused by a higher proportion of more severe stroke patients compared with our data. The percentage of medical and neurological complications reported from other studies27-29 are persistently higher than in our analyses, except a lower proportion of patients with epileptic seizure in the analyses by Pinto et al29 and a fewer number of recurrent strokes in the report by Davenport et al.27 It is noteworthy that 2 of the studies that found higher complication rates demonstrated substantially longer stays in hospital compared with the findings in our analyses (mean length of stay, 37 days27 and up to 13.8 days28 vs 10.6 days, respectively).

Previous studies did not estimate the proportion of in-hospital deaths attributable to a specific medical or neurological complication. We found that more than 50% of deaths were attributable to 1 or more complications. Our analysis suggest that in routine clinical care, especially reductions in the rates of pneumonia and increased intracranial pressure will result in substantially decreased rates of hospital death in stroke patients.

There are several strengths and limitations of our study. Previous studies focusing on stroke mortality in community settings were derived from reports using administrative records,3-8 from intercountry comparisons,9 or from single-center studies.10-13 The study design used in these previous reports might influence some of their findings. Studies using administrative records are known to lack information on important clinical data,32 results from intercountry comparisons might be biased by large differences in health care settings,33 and the statistical power of reports from single-center studies is often limited by a small number of patients. In our study, all data were collected in a prospective, uniform way, which was specially designed for the purpose to provide a continuous monitoring of the quality of stroke care in community hospitals. This approach was recently judged to provide the most useful information in quantifying health care quality.32 We cannot rule out that some of our findings were caused by unobserved variations in patient characteristics or in comorbid conditions. However, statistical analyses were adjusted for valid markers of demographic characteristics, stroke severity, comorbidity of the individual stroke patient, and for the hospital expertise. We had no information about the individual experience of treating physicians on early outcome. However, in the case of stroke, a multidisciplinary team is regularly involved in acute care. Therefore, it is difficult to estimate the specific impact of the physician expertise on stroke outcome. We had no information on etiological subtype and location of stroke in our study population; therefore, a potential independent impact of these variables on in-hospital mortality remains unclear. The present study focused on identifying predictors for in-hospital mortality, regarding death as a valid end point for assessing stroke outcome in community settings. Thus, no information was provided about factors influencing disability at discharge. The definition of increased intracranial pressure as a complication used in our study required clinical signs and symptoms in addition to imaging results. Therefore, no information was available about the effect of midline shift alone without signs of clinical deterioration on in-hospital mortality. Finally, patients in our study were observed only during the period of hospitalization. Therefore, no information was available about variables predicting outcome after discharge from hospital. Factors influencing stroke mortality in hospitals might be different from variables predicting long-term outcome.

In our study, age, stroke severity, and atrial fibrillation were found to be independent predictors for in-hospital mortality after ischemic stroke in routine clinical care. Diabetes and previous stroke demonstrated a significant impact on in-hospital mortality only in men. Therefore, future studies on early stroke outcome have to consider carefully potential variations in the impact of the investigated variables between men and women. More
Hospitals That Participated in the Present Data Analysis of the ADSR

Stroke Register Bavaria

Stroke Register Hamburg

Stroke Register Hesse
Bad Zwesten: Neurologische Akutklinik; Darmstadt: Neurologische Klinik des Klinikums; Eschwege: Medizinische Abteilung des Kreiskrankenhauses; Friedberg: Innere Abteilung des Kreiskrankenhauses Friedberg; Fulda: Neurologische Klinik des Klinikums; Frankfurt/Main: Neurologische Klinik der Universitaet Frankfurt/ Main, Neurologische Klinik des Krankenhauses Nordwest, Neurologische Klinik des St Katharinen-Krankenhauses, Neurologische Klinik der Staatlichen Kliniken Hoechst; Gelnhausen: Medizinische Klinik des Kreiskrankenhauses; Kassel: Neurologische Klinik des Klinikums, Geriatri sche Abteilung des Kurhessischen Diakonissenkrauses; Limburg: St Vincenz Krankenhaus; Lindenfels: Innere Abteilung des Luisenkrankenhauses; Marburg: Neurologische Klinik der Universitaet Marburg; Nidda-Bad Salzhausen: Asklepios Neurologische Klinik; Offenbach: Neurologische Klinik des Klinikums, Medizinische Klinik I des Klinikums; Schwalmtstadt: Fach klinik fuer Neurologie der Hepatoklinik; Sechtem-Jugenheim: Medizinische Abteilung des Kreiskrankenhauses; Weil auster: Neurologische Klinik des Klinikums Weil umeister; Wiesbaden: Medizinische Klinik I des St Josef-Hospitals, Neurologische Klinik der Dr Horst-Schmidt-Kliniken; Coordinating Center: Geschäftsstelle der Arbeitsgemeinschaft Externe Qualitaetssicherung Hessen, Eschborn

Stroke Register Westphalia


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than 50% of all deaths in this stroke patient population were caused by serious medical or neurological complications. Thus, programs aiming at a decrease in rates of in-hospital death should focus on the reduction of serious complications after stroke, especially pneumonia and increased intracranial pressure.

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