Changing Pattern of Brain Hemorrhage During 12 Years of Computed Axial Tomography

Hansjoerg Schuetz, MD; Thomas Dommer; Rolf-H. Boedeker, DSc; Maxwell Damian, MD; Paul Krack, MD; and Wolfgang Dorndorf, MD

Background and Purpose: We examined whether the pattern of cerebral hemorrhage changed after the introduction of computed tomography.


Results: The case-fatality ratio decreased from 49% in the period 1978–1981 to 31% in 1986–1989 (p=0.006); early mortality (day 1–4) decreased from 28% to 12% (p=0.0017). The incidence of hypertension decreased from 78% in the period 1978–1981 to 64% in 1986–1989 (p=0.01). Systolic and diastolic blood pressure at admission sank (p=0.09). The decrease of the case-fatality ratio correlated best with a less severe initial disturbance of consciousness (p<0.01) and with a higher Mathew score (p=0.038). The activities of daily living score remained unchanged.

Conclusions: The case-fatality ratio and early mortality decreased after the introduction of computed tomography. This was basically due to a decreased incidence of comatose and stuporous patients with severe neurological deficit paralleled by a decrease of mean systolic and diastolic blood pressure values at admission. (Stroke 1992, 23:653–656)

KEY WORDS • cerebral hemorrhage • hematoma • tomography, x-ray computed

The mortality of cerebrovascular disease has been decreasing for decades.¹⁻⁴ Reasons proposed have been lower incidence¹⁻⁵⁻⁶ or a lower case-fatality ratio⁷ due to improved diagnostic and therapeutic methods during the acute stage.⁸ The decrease in mortality has been particularly impressive for brain hemorrhage.⁹⁻¹³ More than a decade after the introduction of computed tomography (CT) for routine diagnosis of stroke, we analyzed changes in the case-fatality ratio, incidence of risk factors, and severity of symptoms in 488 consecutive patients admitted to our department during 12 years.

Subjects and Methods

We included all patients admitted to the Neurological Department of the University Hospital of Giessen with a supratentorial brain hemorrhage between January 1, 1978, and December 31, 1989. The city (population 80,000) and area (population 335,000) of Giessen have one medical center, which from 1978 to 1987 possessed the only CT scanner in the area. During this period all cerebral hematomas were diagnosed in this department. A municipal hospital acquired a CT scanner in 1988; we reviewed all CT scans performed there and found four spontaneous, nonlethal brain hemorrhages. These patients were included in our collective.

During the first years, diagnosis was confirmed by lumbar puncture alone in some moribund patients with typical history and symptoms (in 1978, 10 or 47%; in 1979, three or 9%; in 1981, one or 3%; in 1982, two or 4%; and in 1984, one or 2%). In all other cases, CT or autopsy was performed. The percentage of patients with CT in 1978 was 47%, in 1979 91%, in 1980 88%, in 1981 93%, in 1983 93%, and in all the other years 100%. Infratentorial hematomas were not analyzed because some brain stem and cerebellar symptoms cannot be classified according to the Mathew score.

We evaluated the case-fatality ratio prior to discharge (comparable with 30-day mortality), deaths during the first 4 days, and the incidences of hypertension and hemorrhage during anticoagulant therapy. Hypertension was defined as a blood pressure of more than 160 mm Hg systolic and 95 mm Hg diastolic. We excluded patients with transient hypertension at admission and during the following hours that normalized later and those who did not show cardiac hypertrophy on chest roentgenogram or electrocardiogram and had no history of elevated blood pressure. Thus, we excluded otherwise normotensive patients with space-occupying hematomas causing reflex and autonomic dysregulation from the group diagnosed as having hypertensive intracerebral hemorrhage.¹⁵ For the years 1978, 1979, 1980, 1982, 1983, 1988, and 1989, clinical status on admission was evaluated retro
spectively from case notes according to the Mathew score. Patients of 1978 were included in the study despite CT having been done in only 47% because severity of symptoms by the Mathew score did not change significantly during the next 2 years. For the periods 1978–1979 and 1988–1989, we compared the initial systolic and diastolic blood pressure values registered in the clinical notes. Status at discharge was also recorded in the clinical notes. Status at discharge was also recorded in the clinical notes. Status at discharge was also recorded in the clinical notes. Status at discharge was also recorded in the clinical notes.

Statistical tests used were the $x^2$ and Fisher’s exact tests. The influence of year of admission on the Mathew score was examined using the Kruskal-Wallis H test. We compared data from clinical notes using a standardized checklist for all stroke patients connected to a data bank initiated in 1978, which also enabled calculation of the relation of cerebral infarction to brain hemorrhage.

**Results**

Four hundred eighty-eight patients with a supratentorial hemorrhage were treated in the department between 1978 and 1989. The case–fatality ratio decreased from 49% in the period 1978–1981 to 31% in 1986–1989 ($p=0.006$) (Table 1). The case–fatality ratio of supratentorial hemorrhages corresponded to the death rate of all brain hemorrhages in our hospital during this period (in 1978 64%, in 1979 47%, in 1980 48%, in 1981 35%, in 1982 53%, in 1983 48%, in 1984 32%, in 1985 29%, in 1986 31%, in 1987 29%, and in 1988 34%). The ratio of brain hemorrhage to cerebral infarction between early 1978 and late 1989, which was between 0.13 and 0.19 during the study period, did not change ($p=0.63$). The mean age at presentation increased from 65 years in the period 1978–1980 to 68 years in 1987–1989 (trend with $p=0.065$). The average duration of inpatient treatment did not change significantly, being 11 days in the period 1978–1980 and 19 days in 1987–1989 ($p=0.3$). Men and women were affected equally in the periods 1978–1980 and 1987–1989 ($p=0.25$).

Early mortality (i.e., during the first 4 days) decreased from 28% in the period 1978–1981 to 12% in 1986–1989 ($p=0.0017$) (Table 2). A comparison of early and late mortality showed that 57% of the deaths occurred within 4 days in the period 1978–1981 but only 40% in 1986–1989 ($p=0.058$) (Table 3).

The incidence of hypertension as a risk factor fell significantly, being 11 days in the period 1978–1980 and 19 days in 1987–1989 ($p=0.063$). The mean age at presentation increased from 65 years in the period 1978–1980 to 68 years in 1987–1989 (trend with $p=0.065$). The average duration of inpatient treatment did not change significantly, being 11 days in the period 1978–1980 and 19 days in 1987–1989 ($p=0.3$). Men and women were affected equally in the periods 1978–1980 and 1987–1989 ($p=0.25$).

**Discussion**

The case–fatality ratio of our patients with supratentorial hemorrhages was almost identical to that of all patients with brain hemorrhages treated in our hospital during these 12 years. Our results are therefore comparable with those of other studies examining hematomas of all localizations, showing that the case–fatality ratio

### Table 1. Case–Fatality Ratio of All Patients

<table>
<thead>
<tr>
<th>Years</th>
<th>All patients</th>
<th>Case–fatality ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978–1981</td>
<td>148</td>
<td>72 (49%)</td>
<td>0.407–0.566</td>
</tr>
<tr>
<td>1982–1985</td>
<td>167</td>
<td>70 (42%)</td>
<td>0.347–0.495</td>
</tr>
<tr>
<td>1986–1989</td>
<td>173</td>
<td>53 (31%)</td>
<td>0.248–0.387</td>
</tr>
</tbody>
</table>

CI, confidence interval.

### Table 2. Case–Fatality Ratio of All Patients for Days 1–4

<table>
<thead>
<tr>
<th>Years</th>
<th>All patients</th>
<th>Deaths, days 1–4</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978–1981</td>
<td>148</td>
<td>41 (28%)</td>
<td>0.211–0.354</td>
</tr>
<tr>
<td>1982–1985</td>
<td>167</td>
<td>42 (25%)</td>
<td>0.192–0.322</td>
</tr>
<tr>
<td>1986–1989</td>
<td>173</td>
<td>21 (12%)</td>
<td>0.083–0.183</td>
</tr>
</tbody>
</table>

$p=0.0017$

CI, confidence interval.

### Table 3. Early Mortality as Percentage of All Deaths

<table>
<thead>
<tr>
<th>Years</th>
<th>All deaths</th>
<th>Deaths, days 1–4</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978–1981</td>
<td>72</td>
<td>41 (57%)</td>
<td>0.454–0.677</td>
</tr>
<tr>
<td>1982–1985</td>
<td>70</td>
<td>42 (60%)</td>
<td>0.483–0.707</td>
</tr>
<tr>
<td>1986–1989</td>
<td>53</td>
<td>21 (40%)</td>
<td>0.276–0.531</td>
</tr>
</tbody>
</table>

$p=0.058$

CI, confidence interval.
continued to decrease after CT became routinely available. Silver et al. reported a 58% case-fatality ratio for supratentorial hemorrhages between 1975 and 1980. Garraway et al. computed a 30% case-fatality ratio of 58% for patients of the Mayo Clinic between 1975 and 1979. In 1982, Douglas and Haerer reported a case-fatality ratio of only 40% for hematomas of all localizations. Hungerbühler et al. reported a ratio of 36% and Helweg-Larsen et al. reported a 27% death rate in 1988, and we found a case-fatality ratio of 27% in 100 consecutive cases gathered over 32 months, starting in July 1985.

Several theories have been employed to explain the decreasing mortality: the incidence of the illness is largely due to hypertensive cerebrovascular disease, with decreases paralleling acceptance and improvement of antihypertensive treatment; more frequent diagnosis of small hematomas that earlier would have been misdiagnosed as infarcts leads to a relative increase in the number of benign courses and therefore to an apparent decrease in the death rate, especially in hospital-based studies; improved imaging today enables subclassification of disease and improved therapeutic regimens in severe cases; the number of severe cases may itself have decreased; and, finally, reduced mortality may be due to both a lower overall incidence and the improved detection of small hematomas.

The reduced mortality was initially explained by a reduced incidence. In our study, the annual frequency of admission of cases of supratentorial hemorrhage remained constant. It is important that the ratio of cerebral infarction versus brain hemorrhage did not change during the 12 years. Our study began with the implementation of routine CT. Because the average Mathew score did not change from 1978 (when not every stroke patient was examined by CT) to 1979–1980 (when CT was routine), it appears unlikely that an inflated incidence of small hematomas might be responsible for the reduction of in-hospital mortality in our study. Our hospital-based study does not allow conclusions regarding possible changes in the incidence of brain hemorrhage in the general population, but it points to a decrease of the case-fatality ratio as a main reason for the lower mortality.

Russell and other authors predicted a major impact of antihypertensive treatment on brain hemorrhages and lacunar infarcts, which was confirmed by our study. The frequency of admission due to spontaneous intracerebral hemorrhage was unchanged, but hypertension became a less important risk factor. It appears that more patients were admitted with cerebral amyloid angiopathy or so-called intracerebral hematoma of unknown etiology, both of which are comparatively benign. The 25% decrease in the incidence of hypertension as a risk factor, however, explains only part of the 50% decrease of the case-fatality ratio. Likewise, the marked decrease of mortality in patients with hematomas receiving anticoagulant medication explains improved prognosis only incompletely because the case-fatality ratio decreased even after excluding patients receiving anticoagulants.

Fatalities during the first 4 days after supratentorial cerebral hemorrhage are mostly due to transtentorial herniation. This is caused by a large hematoma or localization near the diencephalon. Silver et al. in their study of patients between 1975 and 1980 reported a 40% early mortality in supratentorial hemorrhages, representing 67% of all deaths. This is comparable to our data of the period 1978–1981 (28% and 57%, respectively). Early mortality decreased to 12% during the period 1986–1989 and represented only 40% of total mortality, indicating a preferential decrease of early mortality. This may suggest more efficient treatment during the acute phase, without excluding a possible decrease in the incidence of large, rapidly lethal hemorrhages.

The Mathew scores of the periods 1978–1979, 1982–1983, and 1988–1989 are impaired by retrospective coding and by the fact that, especially in 1978, some of the very rapidly lethal cases (27%) could not be confirmed by CT or autopsy. Because the Mathew score of patients treated in 1979 and 1980, when approximately 90% of hematomas were examined by CT, corresponded to the average Mathew score of patients treated in 1978 (CT examination in 47%), the number of CT examinations probably had little influence. It cannot be excluded that in 1978 some small hematomas without extension into the subarachnoid space may have been misinterpreted as infarcts, but the number cannot have been large because patients fit for transport were examined by CT more frequently than moribund patients.

In a hospital-based study over 12 years the age at admission, sex distribution, duration of inpatient treatment, and mode of admission may change. The trend toward a higher age at admission and the unchanged length of hospital stay and sex distribution argue against major changes in our collective. The mode of admission is less easy to define. Generally, during the first years in which CT was available many patients were transported from distant hospitals to centers equipped with CT scanners, resulting in a concentration of seriously ill hematoma patients pushing up the case-fatality ratio. Later, with CT scanners in many peripheral hospitals, moribund patients were examined there, which resulted in a decrease of the case-fatality ratio in centers through a decreased concentration of severe cases. This did not happen in our area because our department was the only neurological center and intensive care unit in a comparatively large area without other CT scanners. The second scanner in a hospital without a neurological department was operative only from 1988 onward and did not change admission patterns.

Bearing these limitations in mind, the Mathew score still rose drastically from 1978 to 1989. The most impressive statistic was the decrease in percent of stuporous or comatose patients during the 12 years. Even excluding impairment of consciousness, the severity of localized symptoms decreased. This result is comparable with the Allegheny County study, which attributed the decrease of lethality after stroke from 1971 to 1980 to the decreased incidence of comatose patients. The study of Howard et al. also showed a decrease in the proportion of comatose stroke patients, from 42% to 28%, from 1973 to 1980.

Our results provide further evidence that the decrease of the case-fatality ratio is primarily due to the fact that patients with brain hemorrhage and severe impairment of consciousness and/or major neurological focal signs had become less common during the 12 years studied. Granted that patients with large hematomas more often have severe neurological deficits and impair-
ment of consciousness and that the size of the hemorrhage depends on the caliber of the ruptured vessel and the systolic blood pressure at the moment of rupture, the hypothesis that today fewer patients have an extremely high blood pressure at the moment of rupture than 10 years ago seems plausible. This hypothesis is supported by the trend to lower average systolic and diastolic blood pressure values in our patients on admission in the period 1988–1989 than in 1978–1979.

Our study is a further indication that besides the lower mortality of hematomas under anticoagulation therapy and improved diagnosis and treatment during the acute phase, better control of hypertension has played a major role in improving the prognosis of brain hemorrhage.

References
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