Cerebral atrophy has been shown to be a protective factor in large supratentorial ischemic strokes. To date, there are no data on the role of cerebral atrophy in spontaneous intracerebral hemorrhage (ICH). This might be of interest because ICH, including the perihematomal edema, exerts similar space-occupying effects. In the present study, we aimed to investigate the influence of relative cerebral volume (RCV) on outcome after supratentorial ICH.

**Methods**
We used initial computed tomography (CT) scans of 320 patients included in a prospective, multicenter trial were used for a segmentation analysis to determine the supratentorial cerebral volume. A logistic regression analysis was used to explore its effect on outcome after 90 days in addition to other clinical and imaging parameters.

**Results**
Cerebral volume loss significantly reduced the odds for favorable outcome after 90 days (odds ratio=0.91; confidence interval, 0.85–0.99; \( P=0.02 \)).

**Conclusions**
Cerebral atrophy is an independent predictor of unfavorable outcome after intracerebral hemorrhage, indicating reduced functional recovery potential in these individuals. *(Stroke. 2013;44:00-00.)*

**Key Words:** cerebral atrophy ■ computed tomography ■ intracerebral hemorrhage ■ intracranial hemorrhage ■ outcomes
Statistical Analysis

Original RCV scaled between 0 and 1 was multiplied by 100 to get percentage counts. For comparison of groups, Student t test, Mann-Whitney U, or the χ² test was used. The odds for unfavorable outcome or death within 90 days for different predictors were estimated using a multivariate logistic regression analysis. All analyses were performed using a standard software package (Statistical Package for Social Sciences; SPSS, Version 17.0). Level of significance was set to 0.05.

Results

A total of 320 patients had initial CT scans of sufficient quality for the segmentation analysis. There were no signs of older ischemic or hemorrhagic stroke or any other focal brain damage. ICH was located in the basal ganglia in 90% of patients with favorable outcome and in 85% of patients with an unfavorable outcome (P=0.23).

The inter-rater agreement for the calculated RCV values was very good, with a κ of 0.84 (r=0.85; P<0.0001). Patients with an unfavorable outcome were significantly older (67.6 vs 61.3 years; P<0.001), had a lower GCS score on admission (14 vs 15; P<0.001), lower RCV (0.85 vs 0.88; P<0.001), and larger hematoma (18.9 vs 6.5 mL; P<0.001) as well as more severe LA (2 vs 1; P=0.023). RCV showed a negative correlation with patients’ age and LA severity (r=−0.674; P<0.001 and r=−0.297; P=0.01, respectively), but not with hematoma size (Table).

The adjusted odds ratio (OR) for unfavorable outcome at 90 days was significantly higher with increasing ICH volume (OR=1.09; confidence interval [CI], 1.05–1.1; P<0.001) and LA severity (OR=1.25; CI, 1.01–1.54; P=0.04) and was lower with reduced initial GCS score (OR=0.79; CI, 0.63–0.99; P=0.04) and RCV (OR, 0.91; CI, 0.85–0.99; P=0.02; Figure 2). The OR for unfavorable outcome was higher with increasing age (OR, 1.03; CI, 0.99–1.06; P=0.07), which was not significant.

Patients with unfavorable outcome had nonsignificant reductions of RCV in all age subgroups. Only in the youngest (<50 years of age) and oldest (<80 years of age) subgroup, RCV had a significant negative correlation with outcome (r=−0.291; P=0.05 and r=−0.253; P=0.04, respectively).

There was no significant influence of RCV on the OR for survival versus death (P=0.979). The different study arms

Table. Clinical and Imaging Characteristics in General (n=320) and for Outcome Subgroups

<table>
<thead>
<tr>
<th>Outcome Subgroups</th>
<th>Favorable (mRs&lt;2; n=110)</th>
<th>Unfavorable (mRs&gt;2; n=210)</th>
<th>Level of Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>mRs 90</td>
<td>3 (0–6)</td>
<td>61.3±13.3</td>
<td>67.6±12.7</td>
</tr>
<tr>
<td>Age</td>
<td>65.5±13.2</td>
<td>68.8±10.04</td>
<td>67.5±10.3</td>
</tr>
<tr>
<td>RCV</td>
<td>0.86±0.05</td>
<td>0.85±0.05</td>
<td>0.85±0.05</td>
</tr>
<tr>
<td>GCS</td>
<td>15 (7–15)</td>
<td>15 (9–15)</td>
<td>14 (7–15)</td>
</tr>
<tr>
<td>ICH volume</td>
<td>12.8 (0.3–153.4)</td>
<td>6.6 (0.7–77)</td>
<td>18.9 (0.3–153.7)</td>
</tr>
<tr>
<td>IVH</td>
<td>119/320</td>
<td>30/110</td>
<td>89/210</td>
</tr>
<tr>
<td>IVH volume</td>
<td>0 (0–67)</td>
<td>0 (0–25.2)</td>
<td>0 (0–67)</td>
</tr>
<tr>
<td>LA</td>
<td>2 (0–4)</td>
<td>1 (0–4)</td>
<td>2 (0–4)</td>
</tr>
<tr>
<td>Basal ganglia location</td>
<td>279/320</td>
<td>99/110</td>
<td>179/210</td>
</tr>
</tbody>
</table>

GCS indicates Glasgow coma scale; ICH, intracerebral hemorrhage; IVH, intraventricular hemorrhage; LA, leukoaraiosis; mRs, modified Rankin scale; and RCV, relative cerebral volume.

*Student t test.
†Mann-Whitney U test.
‡χ² test.
were distributed evenly among the present collective and had no influence on the outcome in the regression analysis, as reported previously.5

Discussion

The present study investigated the relationship between cerebral volume and clinical outcome after supratentorial ICH. Previous studies identified several factors increasing the risk for poor outcome after ICH, such as age,8 initial GCS score,9 initial size of the hematoma,10 as well as existence and amount of intraventricular hemorrhage.10 According to that, all these parameters were significantly different between patients with favorable and unfavorable outcomes in the present study. Recently, ischemic LA could be identified as a novel risk factor for unfavorable outcome in ICH11 after being already recognized as a predictor of poor outcome in ischemic stroke.12 Using the same score to assess LA,7 we found it to be significantly more severe in patients with unfavorable outcome. Another risk factor for unfavorable outcome after ischemic stroke is reduced cerebral volume.1 In the present study, cerebral volume was significantly reduced in patients with unfavorable outcome. As expected, RCV was also negatively correlated with age as well as with the extent of LA. However, a multivariate regression analysis identified cerebral atrophy as an independent predictor of unfavorable outcome. As expected, RCV was also negatively correlated with age as well as with the extent of LA. However, a multivariate regression analysis identified cerebral atrophy as an independent predictor of unfavorable outcome.4 We further stresses an independent effect of cerebral atrophy. This indicates a reduced recovery potential in these individuals, which may be attributable to preexisting cerebral damage. This may be attributable to degenerative processes, such as dementia or subcortical vascular encephalopathy. As a limitation, it has to be kept in mind that the data in the present analysis are derived from a clinical trial with defined inclusion and exclusion criteria. Therefore, the results of the present analysis are only partially representative.

Conclusions

We found cerebral atrophy to be an independent risk factor for unfavorable outcome after spontaneous supratentorial ICH. This indicates a reduced recovery potential in these individuals, which may be attributable to preexisting neurodegenerative process.

Disclosures

None.

References

8. Fogelholm R, Nuutila M, Vuorela AL. Primary intracerebral haemorrhage in the Jyväskylä region, central Finland, 1985-89: incidence, case performed a semiautomatic threshold-based segmentation to assess cerebral volume more accurately. Furthermore, we calculated the ratio between the cerebral and the intracranial volume. This technique has been already established13 and has resulted in a very high inter-rater agreement in the present analysis.

In the study by Lee et al,1 cerebral atrophy not only reduced the odds for malignant outcome but also for acceptable functional outcome (mRS<4). Preexisting neurodegenerative processes seem to be a likely explanation for this association. In 2 studies, Tang et al, using the same volumetric approach as we did, have shown that cerebral atrophy in ischemic stroke patients is associated with prestroke14 as well as with post-stroke dementia.15 Accordingly, cerebral volume was correlated with the extent of LA in the present study. We, therefore, hypothesize that in ICH, unfavorable outcome in the presence of cerebral atrophy is at least in part attributable to preexisting cerebral damage. This may be attributable to degenerative processes, such as dementia or subcortical vascular encephalopathy.

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Cerebral Atrophy is an Independent Risk Factor for Unfavorable Outcome After Spontaneous Supratentorial Intracerebral Hemorrhage

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