Outcome after subarachnoid hemorrhage from a very small aneurysm: a case-control series

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Objective. A case-control analysis of patients with SAH was performed to compare risk factors and outcomes at 6 months posthemorrhage in patients with a very small aneurysm compared with those with a larger aneurysm.

Methods. All patients with SAH who were treated between January 1998 and December 1999 were studied. A very small aneurysm was defined as “equal to or less than 5 mm in diameter.” Clinical data and treatment summaries were maintained in an electronic database. The Glasgow Outcome Scale (GOS) score was determined by an independent registrar.

One hundred twenty-seven patients were treated. A very small aneurysm was the cause of SAH in 42 patients (33%), whereas 85 (67%) had aneurysms larger than 5 mm (mean diameter 11 mm). There were no differences in demographic variables or medical comorbidities between the two groups. Thick SAH (Fisher Grade 3 or 4) was more common in patients with a very small aneurysm than in those with a larger aneurysm (p = 0.028). One hundred eight patients underwent microsurgery (85%), 15 underwent coil embolization (12%), and four (3%) required both procedures. Vasospasm occurred in nine patients (21%) with very small aneurysms compared with 14 (16%) with larger aneurysms (p = 0.62). Shunt-dependent hydrocephalus occurred in nine patients (21%) with very small aneurysms and in 19 (22%) with larger aneurysms (p = 1). The mean GOS score for both groups was 4 (moderately disabled) at 6 months.

Conclusions. Small aneurysms produce thick SAH more often than larger aneurysms. There is no difference in outcome after SAH between patients with a very small aneurysm and those with a larger aneurysm.

Key Words • subarachnoid hemorrhage • aneurysm • risk factor • outcome • microsurgery • endovascular surgery

The risk of SAH from a small, unruptured aneurysm is a subject of continued debate. Our experience and some reports in the literature indicate, however, that SAH commonly results from aneurysms smaller than 10 mm at their greatest diameter. We reviewed consecutive cases during a 24-month period to determine the size distribution of ruptured aneurysms at our institution. A case-control analysis of patients with aneurysmal SAH was performed to compare demographic and medical risk factors and outcomes at 6 months posthemorrhage in patients who harbor a very small aneurysm and those who have a larger aneurysm.

Clinical Material and Methods

Clinical data and summaries for all patients with cerebral aneurysms who have been treated at Zale–Lipshy University Hospital at the University of Texas Southwestern Medical Center, Dallas, Texas, since January 1, 1990 are recorded on a standardized form. This information is prospectively maintained in the STAR database. Recorded data include a unique patient identifier and demographic variables. Microvascular or endovascular treatment data are summarized. A GOS score is determined through telephone contact with the patient and by a review of hospital and clinical records by an independent registrar. The registrar is employed by the hospital to gather, input, and maintain clinical databases, but is not directly involved in patient care. Although there have been improvements in grading outcome in patients with stroke, the STAR database requires independent GOS scoring at the time of discharge and at 6 months afterward. We believe that recording these data at the two time points is more accurate and informative than retrospective scoring according to chart review by using another grading system.

Since January 1998, detailed information regarding the patient’s social history and preexisting medical comorbidities has been recorded. The study period was limited to January 1998 through December 1999 because this time period represents the most accurately recorded and complete time segment in the database. A very small aneurysm was defined as an aneurysm smaller than or equal to 5 mm in its greatest dimension on preoperative angiography. An external reference marker (a dime, which has a diameter of 18 mm) was placed on the patient’s skin as near to the parent artery as possible in two planes. Measurements were made and calibrated to these markers. The greatest diameter was recorded. If more than one aneurysm was present, the greatest diameter of the largest aneurysm was recorded.

Medical comorbidities were considered present if the patient or the patient’s family provided a medical history of the patient that either specified the condition or the taking of medications specific to the condition. Vasospasm was
considered present in a patient if there was angiographic evidence of arterial narrowing and in all patients who underwent cerebral angioplasty or intraarterial papaverine infusion. Hydrocephalus was considered present if a ventriculoperitoneal shunt was placed prior to discharge from the hospital.

Categorical data were entered into contingency tables and were compared using the Fisher exact test. Patients’ GOS scores were compared using the Wilcoxon rank-sum test. The GOS scores were also dichotomized into “good” (GOS Score 5 or 4) and “poor” (GOS Score 3, 2, or 1) outcomes and compared as categorical data. Continuous data were compared using the two-tailed t-test. Statistical analysis was performed using JMP IN software (version 4.0.4; SAS Institute, Inc., Cary, NC). A probability value less than 0.05 was considered statistically significant.

**Results**

One hundred twenty-seven patients underwent treatment for a ruptured aneurysm during the study period. The female/male ratio was 80:47 and the mean age was 53 years (range 17–87 years). Twenty-nine patients (23%) had multiple aneurysms. All patients admitted to the hospital with an aneurysmal SAH during the study period were treated. One hundred eight patients (85%) underwent microsurgery, and 47 (39%) were treated with both procedures. Data were complete for 126 patients (99%) at hospital discharge. Six-month GOS scores were available for 91 patients (72%).

Aneurysms ranged in size from 2 to 80 mm (median 7 mm and mean 9 mm). Twenty-five percent of the aneurysms were smaller than 5 mm, 33% were less than or equal to 5 mm, and 75% were less than or equal to 10 mm. The most common locations for a very small aneurysm were the anterior communicating artery (15 patients [36%] and the PCoA (11 patients [26%]). The most common locations for larger aneurysms were the anterior communicating artery (23 patients [27%]), the basilar apex (15 patients [18%]), and the middle cerebral artery bifurcation (15 patients [18%]). A comparison of demographic variables and medical comorbidities is provided in Table 1. There were no statistically significant differences in these variables between the two groups. A comparison of outcomes is given in Table 2. Thick SAH (Fisher Grade 3 or 4) was more common in patients with a very small aneurysm than in those with a larger aneurysm (p = 0.028).

In all patients, a thick SAH on the CT scan was predictive of vasospasm (p = 0.046), but was not predictive of shunt-dependent hydrocephalus (p = 0.82).

**Discussion**

In 1998 The International Study of Unruptured Intracranial Aneurysm Investigators reported the results of a retrospective study of 1449 patients with unruptured aneurysms. Approximately half of the patients had a history of prior SAH from another aneurysm and half did not. In patients without a prior SAH the 1-year cumulative rupture rate of aneurysms smaller than 10 mm in diameter was less than 0.05% per year. In those patients with a prior SAH who were left with untreated aneurysms smaller than 10 mm it was approximately 0.5% per year. In 2003 these same investigators published the results of a 5-year prospective study of 1692 patients with untreated aneurysms. In this report, patients with anterior circulation aneurysms smaller than 7 mm in diameter who had not previously experienced an SAH had a 5-year cumulative rate of SAH that was 0%. Patients without a prior SAH who harbored a PCoA or a posterior circulation aneurysm smaller than 7 mm had a 5-year rate of SAH that was 2.5%. The risk of SAH increased with the size of the aneurysm. The 5-year cumulative rupture rate for aneurysms measuring 13 to 24 mm was 14.5% for the anterior circulation and 18.4% for the posterior circulation and PCoA aneurysms.

The risk of SAH from an unruptured aneurysm can be predicted only when both the incidence of SAH and the prevalence of an unruptured aneurysm are accurately known for a defined population. Our study does not include a “denominator” and, therefore, no conclusions regarding

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**Table 1**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. of Patients (%)</th>
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<tbody>
<tr>
<td>total</td>
<td>VSA 42 (100)</td>
</tr>
<tr>
<td>mean age (yrs)</td>
<td>55</td>
</tr>
<tr>
<td>hypertension</td>
<td>27 (64)</td>
</tr>
<tr>
<td>cardiac disease (excluding hypertension)</td>
<td>10 (24)</td>
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<tr>
<td>diabetes mellitus</td>
<td>2 (5)</td>
</tr>
<tr>
<td>hypothyroidity</td>
<td>2 (5)</td>
</tr>
<tr>
<td>history of stroke</td>
<td>0 (0)</td>
</tr>
<tr>
<td>obesity</td>
<td>3 (7)</td>
</tr>
<tr>
<td>family history of SAH</td>
<td>2 (5)</td>
</tr>
<tr>
<td>alcohol use</td>
<td>7 (17)</td>
</tr>
<tr>
<td>tobacco use</td>
<td>17 (40)</td>
</tr>
<tr>
<td>intravenous drug use</td>
<td>2 (5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor</th>
<th>VSA 85 (100)</th>
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<tbody>
<tr>
<td>mean age (yrs)</td>
<td>52</td>
</tr>
<tr>
<td>hypertension</td>
<td>40 (47)</td>
</tr>
<tr>
<td>cardiac disease (excluding hypertension)</td>
<td>20 (24)</td>
</tr>
<tr>
<td>diabetes mellitus</td>
<td>2 (2)</td>
</tr>
<tr>
<td>hypothyroidism</td>
<td>4 (5)</td>
</tr>
<tr>
<td>history of stroke</td>
<td>2 (2)</td>
</tr>
<tr>
<td>obesity</td>
<td>3 (4)</td>
</tr>
<tr>
<td>family history of SAH</td>
<td>6 (7)</td>
</tr>
<tr>
<td>alcohol use</td>
<td>21 (25)</td>
</tr>
<tr>
<td>tobacco use</td>
<td>47 (55)</td>
</tr>
<tr>
<td>intravenous drug use</td>
<td>8 (9)</td>
</tr>
</tbody>
</table>

| VSA = very small aneurysm; — = not applicable. |

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**Table 2**

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of Patients (%)</th>
</tr>
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<tbody>
<tr>
<td>thick SAH</td>
<td>34 (81)</td>
</tr>
<tr>
<td>vasospasm</td>
<td>9 (21)</td>
</tr>
<tr>
<td>hydrocephalus</td>
<td>9 (21)</td>
</tr>
<tr>
<td>mean duration of hospital stay (days)†</td>
<td>18 ± 1.9</td>
</tr>
<tr>
<td>deaths</td>
<td>6 (14)</td>
</tr>
<tr>
<td>mean GOS score at discharge</td>
<td>3 (4)</td>
</tr>
<tr>
<td>good outcome at discharge</td>
<td>15 (36)</td>
</tr>
<tr>
<td>mean GOS score at 6 mos post-SAH</td>
<td>4 (4)</td>
</tr>
<tr>
<td>good outcome at 6 mos post-SAH</td>
<td>19 (58)</td>
</tr>
</tbody>
</table>

| VSA = very small aneurysm; — = not applicable. |

†Values are expressed as means ± standard deviations.
the rate of rupture for a small aneurysm can be made. It is
intriguing, however, that fully one third of the ruptured an-
eurysms treated at our institution over a 2-year period were
5 mm or smaller at their greatest diameter. One might hy-
pothesize that a referral bias for large and giant aneurysms
would cause our series to underestimate the incidence of
SAH from very small aneurysms.

Almost all patients admitted to Zale–Lipsky University
Hospital are transferred from other hospitals and, therefore,
a selection bias exists against patients with poorer grades.
This and a policy of treating all patients unless prevented by
family wishes or overwhelming medical comorbidities ex-
plain why no patients were excluded from treatment during
this relatively short study period.

The GOS is a crude measure of outcome after SAH; how-
ever, the results of this small series indicate that inci-
dences of morbidity and mortality from SAH are not pre-
dicted by the size of the ruptured aneurysm. This finding
contradicts those of Roos, et al.,5 who compared patients
with SAH who had aneurysms smaller than 10 mm with those
who had aneurysms 10 mm or larger. In that study, patients
with larger aneurysms were more likely to have a poor outcome (GOS Score 3, 2, or 1) at 3 months post-
SAH than patients with smaller aneurysms. Nevertheless,
patients with larger aneurysms also underwent surgery less
frequently, had more episodes of rebleeding, and were more
likely to die as a result of the initial bleeding episode or sec-
ondary ischemia compared with patients with smaller aneu-
rysms in their series. The differences in findings between
these two studies may be due to the fact that we treated all
patients with microsurgery or endovascular surgery and that
our follow-up period was longer.

In the Danish Aneurysm Study reported by Rosenorn and
Eskesen the 2-year mortality rate was lower in patients har-
boring aneurysms between 5 and 10 mm in diameter (39%) than in patients with aneurysms smaller than 5 mm (47%)
or those with lesions between 11 and 24 mm (51%). Of the
survivors, however, patients with aneurysms measuring 10
mm or smaller were more likely to have attained a “normal
daily functional capacity,” more likely to have resumed
their previous occupation, and more likely to have a “nor-
mal mental outcome” compared with patients with aneu-
rysms measuring between 11 and 24 mm.

Our finding of a higher incidence of thick SAH in pa-
patients with a very small aneurysm agrees with the finding of
Roos, et al.,7 that patients who had a large aneurysm “tend-
ted to have smaller amounts of extravasated blood on ad-
mission CT” scans. More recently, Russell, et al.,7 reported a
semiquantitative study of the volume of SAH on CT scans
compared with aneurysm size. They found a correlation be-
between smaller aneurysm size and more extensive SAH. The
implication of this finding with respect to outcome remains
to be determined.

The mechanism by which smaller aneurysms produce a
greater quantity of subarachnoid blood is currently the sub-
ject of speculation. Roos, et al.,7 did not suggest a hypothe-
sis for this finding in their report. Russel, et al.,7 discussed
several possibilities for this finding including the effect of
the lesion’s radius on wall tension, the relationship between
aneurysm walls and their surrounding environment, and the
compressive force of the subarachnoid blood itself. Al-
though application of the Laplace law (for a sphere, wall
tension = [transmural pressure × radius]/2) is attractive,
unlike ideal spheres, aneurysms have heterogeneous histo-
pathological conditions within their walls. Defects in the
medial and internal elastic lamina as well as atheromatous
changes have been described.8 These variations likely result
in unequal resistance to pressure at different points on the
aneurysm dome. It may be hypothesized that smaller aneu-
rysms require a greater transmural pressure to rupture due
to multiple factors that include both a smaller radius and a
dome that is relatively more intact according to histological
criteria.

Conclusions

Seventy-five percent of patients who were treated at our
institution for SAH were found to harbor ruptured aneur-ysms smaller than 10 mm at their greatest diameter on pre-
operative angiography studies. We confirm the finding of
two previous studies that smaller aneurysms are associated
with more extensive subarachnoid bleeding. Although the
sensitivity of this study is somewhat limited by our meth-
od of assessing outcome, we found no difference in out-
come after SAH between patients who harbored an aneu-
rysm smaller than or equal to 5 mm when compared with those
who had a larger aneurysm.

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