Impact of Unruptured Intracranial Aneurysms on Public Health in the United States

David O. Wiebers, MD; James C. Torner, PhD; and Irene Meissner, MD

Background and Purpose: Unruptured intracranial aneurysms constitute a significant public health problem that has not been quantified. The purpose of this study is to document the magnitude of this problem in the United States.

Methods: National Hospital Discharge Survey data from 1979, 1984, and 1989 served as the basis for calculating patient numbers and frequency distributions. Cost estimates included the direct costs of hospitalization and surgery for those who had surgery, disability and lost income from morbidity, and lost income from mortality.

Results: The estimated lifetime cost (including hospitalization, surgery, morbidity, and mortality) for annual cases of patients hospitalized with unruptured intracranial aneurysms in the United States is $522,500,000 compared with $1,755,600,000 for patients with aneurysmal subarachnoid hemorrhage.

Conclusions: These data underscore the need to better understand unruptured intracranial aneurysm as a risk factor for subarachnoid hemorrhage, to define other subarachnoid hemorrhage risk factors, and to optimize the management of patients with these conditions. (Stroke 1992;23:1416-1419)

Key Words • cerebral aneurysm • epidemiology • subarachnoid hemorrhage

Several factors underscore the observation that unruptured intracranial aneurysms constitute a significant and growing public health problem. First, intracranial aneurysms are common in the general population.1-6 Several large autopsy studies have reported a wide range for overall frequency of intracranial aneurysms, defined as a saccular dilatation of an arterial wall that measures 2 mm or more. The frequency range at autopsy had been 0.2-9.9%, with a mean of approximately 5%, suggesting that among the United States population alone, approximately 11 million persons have or will have intracranial aneurysms. Second, the mean age of the population is increasing, and intracranial aneurysms appear to develop with increasing age.7 The incidence of subarachnoid hemorrhage from an intracranial aneurysm also increases progressively with age.8 Finally, in recent years, the widespread use of computed tomographic and magnetic resonance imaging head scans as well as magnetic resonance angiography9,10 has greatly increased the capacity for noninvasive and incidental diagnosis of intracranial aneurysms.

We sought in this study to document the magnitude of the problem of unruptured intracranial aneurysms in the United States.

Subjects and Methods

The National Hospital Discharge Survey (NHDS) for the United States is a survey of discharges from short-stay nonfederal hospitals in the 50 states and the District of Columbia. We reviewed the data for the years 1979, 1984, and 1989. In 1979 and 1984, the face sheet and medical summary of sampled medical records were the source documents for the data used in the survey.11,12 In 1989, a third of the hospitals in the survey submitted data in machine-readable form.13 During this period, the information was coded according to the International Classification of Diseases, Ninth Revision (ICD-9).14 Patients with primary or secondary diagnoses of unruptured intracranial aneurysm were used in this study (ICD-9 code 437.3). Cost estimates for this analysis included the direct costs of hospitalization (estimated at $1,200 per day for an average of 14 days per patient) and the cost of surgery for those who had surgery (estimated at $11,000). Length of hospital stay estimates were derived from NHDS data, with separate determinations for patients with subarachnoid hemorrhage and those with unruptured intracranial aneurysm as the primary diagnosis. The frequency of surgery was estimated at 35% of patients hospitalized based on the usual practice of 40 centers in the United States, according to a questionnaire survey conducted in 1989.

The cost of morbidity was expressed both in terms of lost income and the cost of disability, and morbidity was described for three age groups: <45 years old, 45-64 years, and ≥65 years. Patients in group 1 had an estimated survival of 25 years; patients in group 2, 15 years; and patients in group 3, 5 years. The morbidity was based on an operative morbidity figure of 6%, which is compatible with prior clinical series reporting operative morbidity and mortality for unruptured intracranial aneurysms.15-21 Severe disability from surgery was estimated at 4% and mortality at 3%.15-21 The lost income from disability and mortality was calculated as...
subarachnoid hemorrhage (SAH), unruptured intracranial aneurysm, and aneurysmal clipping in the United States (National Hospital Discharge Survey data for 1979, 1984, and 1989).

$14,000 per year, and the disability cost from severe disability was calculated as $20,000 per year.

For comparison, the cost of aneurysmal subarachnoid hemorrhage was calculated in a similar manner by using primary or secondary diagnoses of subarachnoid hemorrhage (ICD-9 code 430) from NHDS data. The overall number of cases of subarachnoid hemorrhage was multiplied by 0.75 because as many as 25% of patients with subarachnoid hemorrhage may have another source, such as an arteriovenous malformation or an unknown source. Direct hospital costs were estimated as $1,500 a day for a mean of 18 days, and an estimated 25% of patients underwent surgical clipping.\(^7\) For the costs of morbidity and mortality, the same age groups of patients were used with estimates of overall morbidity, including operative morbidity of 6%, 12%, and 23.4% for age groups 1, 2, and 3, respectively, and serious disability of 4% in all age groups.\(^2\) Overall mortality by group was estimated at 15%, 28%, and 44%, respectively, based on prior results from the Cooperative Aneurysm study\(^2\) and population-based experience.\(^8\) The number of patients by age group with unruptured and ruptured aneurysms was based on prior clinical series.\(^7\) \(^2\)\(^4\)\(^25\)

### Results

Figure 1 illustrates the numbers of patients with subarachnoid hemorrhage, unruptured intracranial aneurysms, and aneurysmal clipping according to NHDS data for the years 1979, 1984, and 1989. Tables 1 and 2 reflect the economic impact of unruptured intracranial aneurysms and aneurysmal subarachnoid hemorrhage, respectively.

We used a conservative estimate of 10,300 patients hospitalized annually with unruptured intracranial aneurysm, which reflects the mean of the 1979, 1984, and 1989 survey years. The estimated lifetime cost for annual cases of patients with unruptured intracranial aneurysms hospitalized in the United States is $522,500,000, including hospitalization, surgery, morbidity, and mortality. The analogous figure for patients with aneurysmal subarachnoid hemorrhage in the United States is $1,755,600,000 for annual cases (Figure 2).

### Discussion

The NHDS data subsequent to 1989 were not available at the time of this study. Although ongoing technological developments such as high-resolution magnetic resonance and magnetic resonance angiography are providing much more powerful tools for making the diagnosis of unruptured intracranial aneurysms as small as 3 mm in diameter,\(^9\) the impact of these technologies may not be fully reflected in NHDS data. Because only hospitalized patients are included in the NHDS, these data undoubtedly underestimate the impact of patients with unruptured intracranial aneurysms. This underestimation may be more pronounced in the future if more patients are studied and followed with outpatient technologies.

An additional consideration regarding the impact of unruptured intracranial aneurysms involves patients with future rupture from unclipped aneurysms. Such patients would be included in subsequent NHDS data under the classification of subarachnoid hemorrhage. The overall cost for these subsequent ruptures is estimated at $181,100,000 based on rupture rates of 2% per year and current cost estimates, as presented in “Subjects and Methods.” This number suggests that approximately 1/10 of the impact of subarachnoid hemorrhage derives from previously identified unruptured intracranial aneurysms.

Because this study is predicated on several assumptions, a sensitivity analysis was conducted by varying several parameters, including incidence rates, morbidity and mortality from surgery and subarachnoid hemorrhage, surgical rates, length of hospital stay, and life expectancy, to illustrate the effect such variation would have on the total cost estimates (Table 3).

Despite convincing evidence for an overall decrease in stroke rates from 1945 to 1984,\(^2\) there has been no apparent change in incidence or age at onset of subarachnoid hemorrhage from 1945 to 1984. Although mortality from subarachnoid hemorrhage showed a decreasing trend for this period,\(^2\) the change was only marginally significant. The lack of significant declines in incidence of subarachnoid hemorrhage relates at least in part to an inability to identify and properly manage risk factors. Unruptured intracranial aneurysm constitutes the most definitive risk factor for subarachnoid hemorrhage.
## TABLE 1. Estimated Lifetime Cost Calculations by Age Group for Annual Cases of Unruptured Intracranial Aneurysm Patients Hospitalized in the United States in 1979, 1984, and 1989

<table>
<thead>
<tr>
<th>Patients</th>
<th>Direct cost</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age (yr)</td>
<td>Number</td>
<td>Hospital</td>
<td>Surgery</td>
<td>Morbidity</td>
<td>Mortality</td>
</tr>
<tr>
<td></td>
<td>&lt;45</td>
<td>2,472</td>
<td>41.5</td>
<td>9.5</td>
<td>101.4</td>
<td>26.0</td>
</tr>
<tr>
<td></td>
<td>45–64</td>
<td>4,944</td>
<td>83.1</td>
<td>19.1</td>
<td>121.6</td>
<td>31.1</td>
</tr>
<tr>
<td></td>
<td>≥65</td>
<td>2,884</td>
<td>48.5</td>
<td>11.1</td>
<td>23.6</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>10,300</td>
<td>173.0</td>
<td>39.7</td>
<td>246.6</td>
<td>63.2</td>
</tr>
</tbody>
</table>

Cost given in millions of dollars. Data are from National Hospital Discharge Surveys for 1979, 1984, and 1989.

## TABLE 2. Estimated Lifetime Cost Calculations by Age Group for Annual Cases of Aneurysmal Subarachnoid Hemorrhage Patients Hospitalized in the United States in 1979, 1984, and 1989

<table>
<thead>
<tr>
<th>Patients</th>
<th>Direct cost</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age (yr)</td>
<td>Number</td>
<td>Hospital</td>
<td>Surgery</td>
<td>Morbidity</td>
<td>Mortality</td>
</tr>
<tr>
<td></td>
<td>&lt;45</td>
<td>5,175</td>
<td>139.7</td>
<td>14.2</td>
<td>134.6</td>
<td>271.7</td>
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<tr>
<td></td>
<td>45–64</td>
<td>6,555</td>
<td>177.0</td>
<td>18.0</td>
<td>184.9</td>
<td>385.4</td>
</tr>
<tr>
<td></td>
<td>≥65</td>
<td>5,520</td>
<td>149.0</td>
<td>15.2</td>
<td>95.9</td>
<td>170.0</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>17,250</td>
<td>465.7</td>
<td>47.4</td>
<td>415.4</td>
<td>827.1</td>
</tr>
</tbody>
</table>

Cost given in millions of dollars. Data are from National Hospital Discharge Surveys for 1979, 1984, and 1989.


<table>
<thead>
<tr>
<th>Parameter</th>
<th>Range of variation</th>
<th>Total cost variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unruptured aneurysm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incidence</td>
<td>7,500–12,500/yr</td>
<td>380.4–634.1</td>
</tr>
<tr>
<td>Operative morbidity</td>
<td>±50%</td>
<td>399.2–645.8</td>
</tr>
<tr>
<td>Operative mortality</td>
<td>±50%</td>
<td>490.9–554.1</td>
</tr>
<tr>
<td>Surgery rate</td>
<td>25–45%</td>
<td>511.1–533.8</td>
</tr>
<tr>
<td>Length of hospital stay</td>
<td>7–21 days</td>
<td>436.0–609.0</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>65–75 years</td>
<td>502.9–715.1</td>
</tr>
<tr>
<td>Aneurysmal subarachnoid hemorrhage (SAH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incidence</td>
<td>20,000–26,000/yr</td>
<td>1,526.7–1,984.7</td>
</tr>
<tr>
<td>SAH Morbidity</td>
<td>±50%</td>
<td>1,548.0–1,961.0</td>
</tr>
<tr>
<td>SAH Mortality</td>
<td>±50%</td>
<td>1,342.1–2,169.2</td>
</tr>
<tr>
<td>Surgery rate</td>
<td>15–35%</td>
<td>1,736.7–1,774.6</td>
</tr>
<tr>
<td>Length of hospital stay</td>
<td>9–27 days</td>
<td>1,522.8–1,988.5</td>
</tr>
<tr>
<td>Life expectancy</td>
<td>65–75 years</td>
<td>1,451.2–2,525.8</td>
</tr>
</tbody>
</table>

Total cost variation given in millions of dollars. Data are from National Hospital Discharge Surveys for 1979, 1984, and 1989.
hemorrhage. These data underscore the need to further
delineate the relation of this risk factor and other
cerebrovascular risk factors to subsequent aneurysmal
rupture and to optimize the management of patients
with these conditions.

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