Angiographic frequency of anterior circulation intracranial aneurysms

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A retrospective angiographic analysis was designed to extrapolate the frequency of angiographically defined asymptomatic intracranial aneurysms in the anterior circulation from a relatively unbiased clinical series. A total of 9295 angiograms were reviewed from January, 1980, to January, 1987, and, based on these, 278 patients with minimal bias for the presence of an aneurysm were selected. Three patients were found to have incidental aneurysms; thus, the angiographic frequency of patients with asymptomatic aneurysms in this series was 1%. This patient population is skewed toward the older age groups and probably over-represents the incidence of these aneurysms in the population at large. Comparing current subarachnoid hemorrhage statistics and the low frequency of asymptomatic aneurysms suggests that a larger percentage of these aneurysms than was previously thought subsequently rupture. This study contrasts sharply with previous reports quoting a high incidence of aneurysms, and significantly alters the concept and treatment of this disease.

KEY WORDS: angiography • cerebral aneurysm • unruptured aneurysm • subarachnoid hemorrhage

The current controversy surrounding prophylactic surgery for incidental asymptomatic aneurysms makes it necessary to determine the incidence of these lesions in the general population. Available data on the incidence of aneurysms have been acquired to date from autopsy series, and these statistics are quite variable. Reasons for this variability include: inherent bias of any autopsy series along with reasons for the examination, population and demographic differences, methods of data accumulation, and the interest of the pathologist.

The asymptomatic aneurysm of clinical concern has been identified incidentally by angiography. Therefore, it is important to know the frequency of this finding in patients undergoing angiography for symptoms other than those related to a possible aneurysm. The purpose of this study was to obtain this information, which may be more relevant clinically than that extrapolated from autopsy studies.

Clinical Material and Methods

Cerebral angiograms performed from January, 1980, through December, 1986, were reviewed. Patients undergoing angiography for suspected or known intracranial or extracranial vascular disease were excluded from initial consideration because some vascular diseases may predispose to the development of aneurysms. Thus, from the 9295 studies performed during this period of time, 2309 remained as a possible sample. Of these, 1752 were excluded because the minimum required film sequences of bilateral anteroposterior and lateral internal carotid injections were not performed. An additional 56 digital subtraction studies were excluded since the detection of small aneurysms could be difficult on such films. In the remaining group, computerized tomography (CT) scans performed prior to angiography were reviewed and 119 cases were excluded for the following reasons: nine patients had CT evidence suggestive of parenchymal or subarachnoid blood; three patients had CT evidence suggestive of arteriovenous malformation (AVM) or other vascular malformation; and 107 had CT evidence of basilar or sylvian cistern exophytic masses, some of which might conceivably have been aneurysmal. Finally, 23 patients were excluded because of a history compatible with old or recent subarachnoid hemorrhage (SAH) and 81 because of a history and/or a preangiography CT scan suggestive of a pituitary tumor, which may be confused with an aneurysm in some instances.

Following the above exclusions, a total of 278 patients were thought to have minimal bias toward the
**TABLE 1**  
Indications for angiography: classification of 278 patients in this series

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Total Cases</th>
<th>Sex Distribution</th>
<th>Age Range (yrs)</th>
<th>Mean Age (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>metastasis</td>
<td>39</td>
<td>25M, 14F</td>
<td>31-81</td>
<td>58</td>
</tr>
<tr>
<td>meningioma</td>
<td>73</td>
<td>26M, 47F</td>
<td>25-81</td>
<td>57</td>
</tr>
<tr>
<td>glioma</td>
<td>103</td>
<td>64M, 39F</td>
<td>9-83</td>
<td>53</td>
</tr>
<tr>
<td>subdural hematoma acute</td>
<td>5</td>
<td>4M, 1F</td>
<td>22-59</td>
<td>39</td>
</tr>
<tr>
<td>chronic</td>
<td>9</td>
<td>8M, 1F</td>
<td>50-71</td>
<td>51</td>
</tr>
<tr>
<td>pineal region tumor</td>
<td>10</td>
<td>5M, 5F</td>
<td>15-69</td>
<td>44</td>
</tr>
<tr>
<td>other diseases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>epidermoid cyst</td>
<td>1</td>
<td>1F</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>lipoma</td>
<td>1</td>
<td>1M</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>colloid cyst</td>
<td>3</td>
<td>1M, 2F</td>
<td>26-58</td>
<td>37</td>
</tr>
<tr>
<td>lymphoma</td>
<td>5</td>
<td>3M, 2F</td>
<td>60-76</td>
<td>65</td>
</tr>
<tr>
<td>glomus tumor</td>
<td>7</td>
<td>4M, 3F</td>
<td>24-55</td>
<td>37</td>
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<tr>
<td>acoustic schwannoma</td>
<td>1</td>
<td>1M</td>
<td>68</td>
<td></td>
</tr>
<tr>
<td>chordoma</td>
<td>5</td>
<td>1M, 4F</td>
<td>50-60</td>
<td>56</td>
</tr>
<tr>
<td>other schwannoma</td>
<td>2</td>
<td>2M</td>
<td>19-50</td>
<td>34</td>
</tr>
<tr>
<td>cylindroma</td>
<td>1</td>
<td>1F</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>papilloma</td>
<td>1</td>
<td>1F</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>abscess</td>
<td>1</td>
<td>1M</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>arachnoid cyst</td>
<td>1</td>
<td>1F</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>encephalitis</td>
<td>1</td>
<td>1M</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>meningial carcinomatosis</td>
<td>2</td>
<td>2M</td>
<td>56-62</td>
<td>59</td>
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<tr>
<td>germinoma</td>
<td>2</td>
<td>1M, 1F</td>
<td>6-27</td>
<td>16</td>
</tr>
<tr>
<td>ependymoma</td>
<td>1</td>
<td>1F</td>
<td>55</td>
<td></td>
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<tr>
<td>medulloblastoma</td>
<td>1</td>
<td>1M</td>
<td>16</td>
<td></td>
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<tr>
<td>unknown</td>
<td>3</td>
<td>1M, 2F</td>
<td>45-77</td>
<td>59</td>
</tr>
<tr>
<td>totals</td>
<td>278</td>
<td>153M, 125F</td>
<td>1-83</td>
<td>53</td>
</tr>
</tbody>
</table>

**Results**

The 278 patients consisted of 153 males and 125 females with an age range of 1 to 83 years (mean 53 years). The patients were placed into six categories based on their diagnosis. These data are summarized in Tables 1 and 2.

Incidental intracranial aneurysms were identified in three (1.08%) of the 278 patients. None of the aneurysms was depicted by CT scan alone, and since they were not suspected special CT procedures to locate them were not performed. A summary of these three cases is given in Table 3.

**Discussion**

*Rationale of Methods*

Patients who are asymptomatic, without any signs of disease, or who are not followed for certain disease processes rarely undergo angiography. Therefore, it is impossible to construct a totally bias-free sample; nevertheless, working within the limits of established medical practice, such a sample can be reasonably approached. Since bilateral carotid angiograms are performed more frequently than three- or four-vessel angiograms at our institution, a higher yield and therefore a greater statistical significance was obtainable by confining our study to the anterior circulation. Aneurysm distribution percentages are already known from previous clinical series, and approximately 90% of aneurysms are found in the anterior circulation.1 Accordingly, we decided to limit this study to anterior circulation aneurysms. For this, complete anterior circulation views were a prerequisite.

Few patients undergo angiography prior to CT scanning, which is usually performed with contrast enhancement, and yet numerous reports have emphasized the sensitivity of CT for the diagnosis of aneurysms. The resolution of CT scans, the temporal profile of contrast enhancement, and the size of the aneurysm are important determinants for detection of an aneurysm by CT.3, 12, 28, 33 It was difficult to exclude the test, which clearly biases preangiographic information, because all but a few patients underwent CT scanning prior to angiography. Therefore, the detection of aneurysms by CT scanning was considered irrelevant for inclusion or exclusion as long as the patient fulfilled the other criteria and as long as the aneurysm was not thought to be responsible for the patient’s symptoms. If there was any possibility based on the location and size of the aneurysm that it may have caused the presence of aneurysms. These cases form the sample for this study.

**TABLE 3**  
Clinical summary of three patients with incidental aneurysms

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Diagnosis</th>
<th>Angiographic Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>61, F</td>
<td>bronchogenic cancer metastasis to rt thalamus</td>
<td>one 5- to 6-mm aneurysm on superior extradural internal carotid artery near ophthalmic artery</td>
</tr>
<tr>
<td>2</td>
<td>57, F</td>
<td>parasagittal meningioma near coronal suture</td>
<td>two small carotid ophthalmic aneurysms (&lt; 5 mm)</td>
</tr>
<tr>
<td>3</td>
<td>41, M</td>
<td>metastasis to midpetrous ridge</td>
<td>three aneurysms: small lt &amp; rt middle cerebral artery aneurysms (&lt; 5 mm) &amp; one 5- to 6-mm anterior communicating artery aneurysm</td>
</tr>
</tbody>
</table>
In the literature, incidence of 0.3%. Grkalp, discovered four incidental tumors over a 17-year period of giant aneurysms associated with intracranial tumors undergoing surgery for aneurysms, and Okada, five incidental tumors (0.7%) among 747 patients untreated with aneurysms. Sayama, et al., concluded that the frequency of aneurysms in patients with exophytic masses within the basilar or sylvian cisterns were excluded because aneurysms may be in the clinic and/or radiological differential diagnosis.

All patients with pituitary tumors were excluded. Those with chromophobe adenomas were excluded because angiograms are usually performed to rule out aneurysm; however, all tumor cases were excluded because patients with pituitary adenomas may have an increased frequency of aneurysms. Wakai, et al., found a 7.4% incidence of aneurysms in reviewing 95 cases of pituitary adenoma. Jakubowski and Kendall reviewed 150 pituitary adenomas and 33 craniopharyngiomas and demonstrated 11 incidental aneurysms. Encasement of the vessels was found unusually often. Both of these studies suggest a higher incidence of aneurysms with growth hormone-secreting tumors, and Handa and coworkers thought it was related to the associated hypertension and diabetes in these patients. Pia, et al., found only a 1% frequency in over 2200 pituitary adenomas, and Laws reported a frequency of five aneurysms in approximately 500 pituitary adenoma cases he reviewed (ER Laws, personal communication, 1988). Nevertheless, because of possible concerns, all patients with pituitary tumors were omitted.

There are many case reports of various tumors and associated aneurysms, but most reviews suggest they are within the realm of chance occurrence, with the possible exception of pituitary tumors. Wakai, et al., found an aneurysm frequency of 1.1% in 349 cases of intracranial tumors. Sakai and coworkers found 138 cases of brain tumor associated with intracranial aneurysm in the literature. The frequency of this association varied between 0.3% and 0.7% in different series. Pia, et al., found an incidence of less than 0.5% and concluded that the frequency of aneurysms in patients with tumors was probably no higher than that in the general population.

The converse has been recorded regarding incidental tumors with aneurysms. Sayama, et al., discovered five incidental tumors (0.7%) among 747 patients undergoing surgery for aneurysms, and Okada, et al., discovered four incidental tumors over a 17-year period during which they had treated 1280 aneurysms, for an incidence of 0.3%. Gökşalp, et al., found only five cases of giant aneurysms associated with intracranial tumors in the literature.

The above studies suggest that the frequency of aneurysms for certain tumors may be higher than for others, but the overall frequency is low and, according to Taylor, any apparent association is only on the basis of chance. Therefore, we believe our group of patients selected for study is a relatively unbiased sample.

**Aneurysm Statistics**

**Clinical Incidence of Subarachnoid Hemorrhage.** In Rochester, Minnesota, the incidence of stroke decreased during the period from 1945 to 1974 but no definite trend was noted in the incidence of SAH. Most studies use an average annual incidence of 10 to 11 ruptured aneurysms per 100,000 population per year and these statistics have remained relatively static over time.

**Autopsy Series Statistics.** The use of autopsy series to correlate the incidence of incidental aneurysms in the population at large can be extremely misleading. In evaluating autopsy series, consideration of the percentage of autopsies on adults is very important because cerebral aneurysms have never been recorded as prevalent in the young. Although it may seem obvious, only autopsies where the brain is examined should be included, and whether or not a neuropathologist is present can be significant. Autopsy series are extremely variable in incidence figures depending on their bias, and thus are subject to misrepresentation. The extreme variability of the findings in autopsy series reflects a lack of consistency and represents both ends of the spectrum: low and high incidence. Housepian and Pool quoted a 1.3% overall incidence in 8762 postmortem brain examinations, while McCormick reported a 7.9% incidence in 1587 brain examinations. Housepian and Pool pointed out that these facts can be manipulated within a study. There were 8762 brain examinations among 13,704 autopsies in their series. Using the number of aneurysms per total number of autopsies, the incidence falls to 0.8%. If 3000 children (in whom no aneurysms were detected) are omitted, leaving 5762 adults, the figure rises to 2.1%. Therefore, because of the variability and lack of consistency within and among autopsy series, statistics may be quoted to support either a low or high incidence of aneurysms.

Another major point for consideration is what constitutes an aneurysm. In the series of Stehbens, an incidence of 5.6% is quoted among 1364 autopsies. The vast majority of his patients were elderly, which skews his statistics toward the presence of aneurysms. He included aneurysms of any visible size including those that were "little more than a filling out of the apical angle."

The most important issue regarding the incidence of aneurysms is whether or not autopsy series are representative of the population at large. An important selection bias for autopsy is whether death occurred in the hospital. A hospital population is affected by the presence of neurological or neurosurgical services. The
percentage of hospital deaths that go to autopsy has declined in recent years, and the majority of patients submitted to postmortem examination are elderly, introducing another bias for a higher frequency of aneurysms.

Autopsy series are important for aneurysm detection, specifically with regard to death from SAH and the anatomic correlation of aneurysm size at autopsy with location and frequency of aneurysms. However, they clearly are not appropriate to use for an estimate of incidence of asymptomatic aneurysms simply because autopsy subjects are not representative of the general population.

Radiographic Series. There are other angiographic series in tumor patients that report incidental asymptomatic aneurysms. In all the occurrence is low, and the findings are consistent in their incidence results. However, bilateral angiograms are performed in the minority of cases, and for some tumors angiography is performed to rule out aneurysms, which produces a potential bias. Du Boulay\(^7\) reported a series of 1144 cases with “normal” angiograms or angiograms documenting tumor and found four asymptomatic aneurysms; however, only 160 (13.9\%) of the angiograms were bilateral. Wakai, et al.,\(^31\) found an aneurysm frequency of 1.1\% in 349 cases of intracranial tumors other than pituitary tumors, but further tumor or angiographic information was not described. Pia, et al.,\(^21\) reviewed case reports and many personal communications from a large number of neurosurgeons. From 23,876 cases of verified brain tumors, they found 116 cases of coexistent aneurysms, a frequency of less than 0.5\%. However, 30\% of these patients may have had symptoms from the aneurysm alone prior to angiography, making possible the diagnosis of incidental tumor coexistent with an aneurysm in that group of patients. The authors indicated that the vast majority of angiograms were performed only on the side of the tumor; thus the frequency of these aneurysms is about half that of the other studies.

Significance and Treatment of Asymptomatic Aneurysms

The present study suggests that the radiographic frequency of incidental aneurysms of the anterior circulation is about 1\%. This study does not address the posterior circulation but, since anterior circulation aneurysms represent the vast majority of all intracranial aneurysms, extrapolation produces a total angiographic frequency of incidental aneurysms estimated as slightly over 1\%. Although angiographic criteria are less well defined, other previously reported angiographic series suggest that the incidence of aneurysms is low, and the studies are consistent with each other. Our study supports the observation that aneurysms are low in incidence.

Clinical decisions for patients with aneurysms require a definitive diagnosis, and angiographic visualization remains the definitive method for diagnosis. Approximately 20,000 aneurysms rupture per year in the United States.\(^2,13,27\) About 8\% of these patients are dead before reaching the hospital and half will die within the first 30 days after rupture. A large percentage of the remainder die or suffer major disability without definitive treatment.\(^2,22,25,32\)

There is a direct correlation between the size of an aneurysm and the risk for SAH. Locksley\(^14\) and McCormick and Acosta-Rua\(^16\) found no hemorrhages from aneurysms less than 3 mm in size. McCormick and Acosta-Rua pointed out that the aneurysm size at autopsy may be 30\% to 60\% smaller than its in vivo size because of the lack of perfusion pressure. Wiebers, et al.,\(^24\) also noted a larger angiographic size for asymptomatic aneurysms that later bleed. This correlates well with the sensitivity of angiography in detecting aneurysms of a size significant enough to become symptomatic. It would seem that most asymptomatic aneurysms large enough to pose a risk for SAH should be identifiable on angiography. Reasons for nonvisualization, such as vasospasm or acute thrombosis,\(^19\) are unlikely to be present in asymptomatic aneurysms.

Radiographic and autopsy series concur that aneurysms are distinctly uncommon in the young and have an increasing incidence with age; therefore, aneurysm formation is an acquired phenomenon regardless of the etiology. This study is as bias-free as possible for detection of asymptomatic aneurysms but suffers to some extent in the same way as autopsy series, in that it is not representative of the age distribution in the United States. According to 1980 United States statistics,\(^30\) the 40- to 79-year age group represents about 35\% of the white population, and in this angiographic series this age group represents about 80\% of the sample. Because the older population is over-represented in this series, the actual angiographic incidence of asymptomatic aneurysms in the United States population is probably less than 1\%.

The treatment of asymptomatic aneurysms remains controversial. Studies using current SAH statistics and quoting a small number of autopsy series with a high incidence of aneurysms suggest that aneurysms are plentiful in the general population and only a small percentage of aneurysms ever go on to rupture.\(^34\) Therefore, it is inferred that identification and management of incidental aneurysms is of minor significance. The incidence of asymptomatic aneurysms of any significant size seems very low and, if applied to current United States population statistics, is probably much less than 1\%. This contrasts sharply with reports quoting high incidence statistics, and significantly alters the concept of this disease. Aneurysmal rupture is a devastating event and when it occurs there is a high risk of mortality and severe morbidity in survivors. Only diagnosis and management with low surgical morbidity and mortality rates prior to aneurysmal hemorrhage will change these dismal aneurysm statistics.

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Angiographic rate of anterior circulation aneurysms


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