Vertebral Artery Stenosis: Long-Term Follow-Up

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SUMMARY Ninety-six patients with ≥50% unilateral vertebral artery (VA) stenosis were followed up for an average of 4.6 years. In 89 patients (93%) at least one VA origin was involved, while the intracranial VA was affected in 3 patients (3%). Seventy-four patients (77%) had ≥50% stenosis of at least one internal carotid artery, of whom 52 underwent carotid endarterectomy. None of the patients had definite vertebrobasilar transient ischemic attacks (VB TIA). Nineteen patients (19.8%) experienced nonlocalizing symptoms possibly compatible with VB TIA, none of whom had a stroke. Twenty-three patients (24%) had strokes. The only two patients (2%) who sustained a brainstem infarction had fatal strokes and both were known to have basilar artery stenosis in addition to their VA stenosis. The observed stroke rate was 8.5 times the expected infarction rate for a normal population. Forty patients died during follow up. The observed 5-year survival rate was 60% compared to 87% in a matched normal population. Eight deaths (20% of all deaths) were caused by stroke and 21 deaths (52.5% of all deaths) were cardiac related. VA stenosis is most frequently located at the VA origin (93%), and is associated with a low incidence of brainstem infarction.

THE PRESENT STUDY describes the stroke and survival rates in a group of patients with angiographically proven vertebral artery (VA) stenosis. Little information is available regarding the natural history of patients with VA occlusive disease. Previous studies suggest that stenosis of the distal VA is more dangerous than stenosis at the VA origin, and that hemodynamic factors may be more important than emboli in producing vertebrobasilar (VB) ischemia. However, lack of precise information about the prognosis in these patients makes recommendations for treatment difficult. The problem is further complicated since the clinical symptoms of VB ischemia are often difficult to define, and non-localizing events such as isolated vertigo may be erroneously labeled as "VB ischemia".

Methods
The records of patients who underwent aortic arch and/or selective vertebral artery angiography at the Cleveland Clinic between 1974 and 1978 were reviewed. The angiographic films of all patients with reported stenosis of at least 1 VA were examined. Ninety-eight patients with ≥50% unilateral or bilateral VA stenosis were selected for follow up. Patients with unilateral or bilateral VA occlusion only and patients who underwent VA operative procedures were excluded. Fifty-two patients who underwent carotid endarterectomy (CE) were included in follow up since the benefit of CE in VB ischemia is doubtful. These cases were analyzed separately. Follow up was accomplished using a standardized questionnaire and telephone interviews. End points were death or stroke. Vertebrobasilar transient ischemic attacks (VB TIA) were noted but were not sufficient reason for stopping follow up. The recommendations of the ad hoc NINCDS Committee were followed in defining VB TIA. Only crossed or bilateral symptoms or combinations of symptoms localizing to the brainstem were considered definite evidence of VB TIA. Transient unsteadiness, blurred vision, lightheadedness, vertigo and other non-localizing symptoms occurring in isolation were considered as possibly indicative of VBI.

Actuarial methods were used to calculate the net survival during follow up. The Kaplan-Meier product limit method in which an estimate is calculated at each unique time of stroke, was used to determine cumulative stroke risk. The expected mortality rates were based on the USNCHS life tables with age and sex matching. The expected stroke rates were based on age and sex matched data reported by Matsumoto et al.

Results
Follow up averaged 4.6 years and was achieved in 96 patients (98%). The mean age of the 77 males and 19 females at the time of angiography was 62 years. A list of associated conditions in our population is given in table 1.

Angiography was done in 28 patients for asymptomatic carotid bruits, in 26 for hemispheric TIA's, in 21 for hemispheric strokes, in 18 for suspected vertebrobasilar disease and in 3 for other reasons (table 2). Seventy-four patients had more than 50% stenosis of at least one internal carotid artery, of whom 52 underwent CE. Seventy-five patients (78%) had unilateral and 21 patients (22%) had bilateral VA stenosis. In 89 patients (93%) at least one VA origin was involved (table 3). The distal VA and the basilar artery were visualized in 22 patients and there was ≥50% stenosis of the distal VA in 3 and of the basilar in 5.

During follow up none of the patients had definite VB TIA. Nineteen patients (19.8%) experienced non-localizing symptoms possibly compatible with VB TIA, none of whom had a stroke. Twenty-three patients (24%) had strokes. The only two patients (2%) who sustained a brainstem infarction had fatal strokes and both were known to have basilar artery stenosis in addition to their VA stenosis. Of the 21 hemispheric strokes, 13 were due to spontaneous infarction (3 fa-
VERTEBRAL ARTERY STENOSIS/Moufarrij et al

TABLE 1  Vertebral Artery Stenosis: Associated Conditions in 96 Patients

<table>
<thead>
<tr>
<th>Condition</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary artery disease</td>
<td>64</td>
</tr>
<tr>
<td>Hypertension (≥ 150/90)</td>
<td>53</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>52</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>19</td>
</tr>
</tbody>
</table>

Tatal); 7 happened as a complication of a major operative procedure (2 fatal); and 1 hypertensive putaminal hemorrhage was fatal. The total average stroke rate per year was 5.25% but decreased to 3.85% when perioperative strokes were excluded. These rates are respectively 8.5 times and 6.2 times the expected stroke rates for a matched normal population.

There were 40 deaths (41.7%) during follow up. The observed 5-year survival rate on an actuarial basis was 60% compared to 87% in a matched normal population (fig 1). Eight deaths (20% of all deaths) were caused by stroke and twenty-one deaths (52.5% of all deaths) were known to be cardiac related.

Table 4 gives the stroke and death rates in subgroups of patients depending on the severity of co-existent carotid artery disease and whether CE was performed. Figures 2 and 3 illustrate the cumulative stroke and survival rates in these subgroups. Although the differences are not statistically significant, patients with VA stenosis only had lower stroke and death rates than patients with co-existent CA disease. Patients undergoing CE had the highest long-term stroke rates, while patients with carotid artery occlusion or unoperated ≥50% stenosis had the highest death rate.

Discussion

We found that atherosclerotic stenosis of the vertebral artery is most frequent at the origin, which agrees with previously reported postmortem and angiographic studies. Imparato described the gross and microscopic features of VA stenosis in 58 patients who underwent cervical vertebral angioplasty. The plaques were usually fibrous and smooth with no evidence of ulceration, and intramural hemorrhages were not encountered. Fisher et al found that the severity of atherosclerosis in the vertebral arteries is less than in the aorta, coronary arteries and carotid arteries but about equal to the cerebral arteries. The Joint Study of Extracranial Arterial Occlusion as a Cause of Stroke reported that the frequency of atherosclerotic plaques in patients with brain ischemia was highest at the carotid artery bifurcation and at the VA origin in a 2:1 ratio.

52.5% of all deaths were cardiac related which is similar to the cardiac mortality in patients with extracranial or intracranial atherosclerosis in other locations. Furlan et al reported that 57% of the deaths were cardiac related in patients with carotid artery occlusion, and Marzewski et al reported that 55% of all deaths were cardiac related in patients with intracranial internal carotid artery stenosis.
TABLE 4  Vertebral Artery Stenosis: Stroke and Death Rates in Relation to the Status of the Carotid Arteries in 96 Patients*

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of patients</th>
<th>Person-years</th>
<th>Number of strokes</th>
<th>Stroke rate†</th>
<th>Number of deaths</th>
<th>Mortality rate†</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) VA stenosis with ≤ 50% stenosis in either carotid</td>
<td>22</td>
<td>113</td>
<td>2</td>
<td>1.77</td>
<td>7</td>
<td>6.19</td>
</tr>
<tr>
<td>2) VA stenosis with unoperated ≥ 50% stenosis or occlusion in either carotid</td>
<td>22</td>
<td>75</td>
<td>4</td>
<td>5.33</td>
<td>12</td>
<td>16.00</td>
</tr>
<tr>
<td>3) VA stenosis with at least one carotid endarterectomy</td>
<td>52</td>
<td>250</td>
<td>17</td>
<td>6.80</td>
<td>21</td>
<td>8.40</td>
</tr>
<tr>
<td>Total</td>
<td>96</td>
<td>438</td>
<td>23</td>
<td>5.25</td>
<td>40</td>
<td>9.13</td>
</tr>
</tbody>
</table>

*The p-values obtained by comparing the groups (1,2); (1,3) and (2,3) for the survival rates are 0.048, 0.497 and 0.060 respectively, and for the stroke rates are 0.385, 0.106 and 0.842 respectively.
†% per 100 person-years of observation.

Little information is available about the stroke rate in patients with known VA stenosis. Fisher in 1965 stated that occlusion of the VA in the neck commonly produces transient symptoms but rarely brainstem infarction, which happens more frequently with an intracranial VA occlusion. More recently, Caplan presented a follow-up analysis of 4 patients with vertebral artery and 6 patients with basilar artery occlusion and demonstrated a benign outcome. Imparato et al found a 1.2% stroke rate in 58 patients followed 1 to 14 years after vertebral angioplasty. The five-year survival reported in that series was 93%, which is considerably better than our rate of 60% and suggests the two series are not comparable. The average annual stroke rate in our study was 5.25%. Since many of our patients had carotid endarterectomy, this figure might be an underestimate. However, patients with carotid endarterectomy had the highest stroke rate when compared to the other patients with VA stenosis, which possibly reflects the widespread nature of their atherosclerotic disease. Our data does cast further doubt on the effectiveness of CE in improving VB ischemia since clear-cut brainstem ischemia was uncommon in any of our patient subgroups during follow up. No patients had

![Figure 2](http://stroke.ahajournals.org/)

**Figure 2.** Vertebral artery stenosis: cumulative stroke risks based on severity of coexistent carotid artery disease.

![Figure 3](http://stroke.ahajournals.org/)

**Figure 3.** Vertebral artery stenosis: survival curves based on severity of coexistent carotid artery disease.
definite VB TIA's and both patients with brainstem infarction had coexistent severe basilar artery stenosis. Since only three patients had VA stenosis intracranially, we could not make any correlation between the site of stenosis and prognosis. However, our findings suggest that stenosis of the VA origin is a benign lesion when it occurs without basilar artery disease. Caution should be exercised in ascribing ongoing brainstem ischemia to isolated stenosis of the VA origin.

Acknowledgements
The authors are indebted to Miss Judy Adams, B.S. for her help in the statistical analysis of the data and to Miss Geneva Phillips for secretarial assistance.

References
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N A Moufarrij, J R Little, A J Furlan, G Williams and D J Marzewski

Stroke. 1984;15:260-263
doi: 10.1161/01.STR.15.2.260
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

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