Original Contributions

Carotid Stenosis and Perioperative Stroke Risk in Symptomatic and Asymptomatic Patients Undergoing Vascular or Coronary Surgery

Richard P. Gerraty, MB, BS; Peter C. Gates, FRACP; John C. Doyle, FRACS

Background and Purpose: The management of asymptomatic carotid stenosis found before vascular or coronary surgery is unclear from the literature. We aimed to define the relation of carotid stenosis to perioperative stroke in all patients, symptomatic and asymptomatic, and so determine a policy for the management of asymptomatic carotid stenosis in patients requiring major surgery.

Methods: We conducted a prospective clinical and Duplex ultrasound study of 358 consecutive noncarotid major vascular or coronary artery bypass operations, with a moratorium on endarterectomy for asymptomatic carotid stenosis.

Results: There were 145 vascular and 213 coronary bypass operations. Ten of the 49 cases with prior symptoms of cerebral ischemia (38 carotid, 11 verteobasilar) had symptomatic stenosis of 50% or greater or occlusion, and 3 of these (30%) had ipsilateral perioperative cerebral infarction (95% confidence interval, 6.67% to 65.25%). Two of these occurred ipsilateral to symptomatic carotid occlusions, and 1 occurred ipsilateral to an 80% symptomatic stenosis. One symptomatic patient with bilateral 30% stenosis had a perioperative infarct in the asymptomatic hemisphere. Among the 309 asymptomatic patients, 1 perioperative infarct occurred ipsilateral to carotid stenosis of 30%. In all there were 5 (1.4%) perioperative (within 72 hours) and 2 late (after 18 days) strokes. All strokes were hemisphere infarcts confirmed by computed tomography. There were 53 cases with 50% or greater asymptomatic carotid stenosis or occlusion, including 28 with 80% or greater stenosis or occlusion. None had an ipsilateral perioperative stroke (95% confidence interval, 0% to 6.72%).

Conclusions: We conclude that the risk of perioperative stroke related to symptomatic carotid stenosis may be high, but for asymptomatic carotid stenosis the risk is low and does not justify preoperative prophylactic carotid endarterectomy. (Stroke 1993;24:1115-1118)

Key WORDS • carotid artery diseases • surgery • ultrasonics

The estimated risk of perioperative cerebral infarction distal to asymptomatic carotid stenosis varies from 0.6%1 to 17%.2 Previous studies have either excluded symptomatic patients3,3 or subjected some to carotid endarterectomy without clear explanation.4 Some studies are retrospective,5 and others studied patients with carotid bruit6-7 despite its poor correlation with the severity of carotid stenosis as shown by noninvasive carotid imaging8-10. Rarely is the pathogenesis or severity of stroke discussed.1-5 To determine the relation of perioperative stroke to carotid stenosis, we conducted a prospective clinical and Duplex ultrasound study of all patients, both symptomatic for cerebral ischemia and asymptomatic, undergoing elective peripheral vascular reconstructive or coronary artery bypass graft (CABG) surgery. There was a moratorium on prophylactic carotid endarterectomy of asymptomatic carotid stenosis for the duration of the study.

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Subjects and Methods

Of 452 consecutive patients admitted in a 16-month period for elective peripheral vascular reconstruction, abdominal aortic aneurysm repair, or, during a concurrent 9-month period, CABG surgery, 106 patients were excluded. Four with peripheral vascular disease (PVD) declined to participate, and 102 patients undergoing CABG surgery were excluded: 75 urgent cases requiring glyceryl-trinitrate infusion and cardiac monitoring were excluded for logistical reasons; 18 combined CABG and valve surgery cases were excluded because of the difficulty in determining the mechanism of stroke in valve surgery; the 6 patients of one surgeon were excluded at the outset because he was concerned about the moratorium on prophylactic carotid endarterectomy (which none had); and 3 patients declined to participate. Among these exclusions there was one perioperative stroke: a man without carotid stenosis (examined with Duplex ultrasound after the event) had a minor stroke after combined CABG and valve surgery. There were no other exclusions, so that all eligible patients were included in the study. These 346 patients underwent 358 operations. The study was approved by the St Vincent’s Hospital Human Research Ethics Committee.

All patients had Duplex ultrasonography of both carotid arteries on the day before surgery. In a separate
blinded comparison of Duplex ultrasound with digital subtraction angiography of 136 carotid arteries, using a Diasonics ADA 400 machine, we documented a 93% sensitivity and 96% specificity for the detection of lumen diameter reduction of 50% or greater. There was a 92% sensitivity and 100% specificity for the detection of stenosis of 80% to 99%, and a 100% sensitivity and 95% specificity for detection of carotid occlusion. In 13 cases either one (nine cases) or both carotids (four cases) could not be evaluated because of technical difficulties. These patients remained in the study.

A detailed history was taken, and a neurological examination was performed by a neurological trainee (R.P.G.) on the day before surgery. Symptoms sought included previous monocular blindness, limb weakness, clumsiness or sensory disturbance, speech disturbance, dizziness, and double vision. Isolated vertigo or isolated diplopia was not attributed to cerebral ischemia. Patients were then examined after the operation and daily (R.P.G.) for 4 days after surgery, and again at discharge from the hospital. Perioperative stroke was defined as intraoperative or postoperative stroke occurring within 72 hours. All patients with stroke had computed tomographic (CT) brain scans. The strokes were graded using a stroke severity scale.11 Neither the results of the Doppler studies nor the clinical details elicited by R.P.G. were made available to the clinicians managing the patient.

During the study there was a moratorium on carotid endarterectomy in asymptomatic patients with one exception. A female patient with asymptomatic bilateral 80% carotid stenosis and unilateral vertebral occlusion had unilateral carotid endarterectomy before CABG, which was later performed without any complications. There was not a moratorium on endarterectomy for symptomatic carotid stenosis. Carotid stenosis was deemed symptomatic only when there was a history of ipsilateral carotid territory cerebral ischemic symptoms. Carotid stenosis was considered asymptomatic (1) if contralateral to the symptomatic cerebral hemisphere, (2) in patients with verteobasilar ischemia, or (3) in asymptomatic patients. The overall number of asymptomatic cases of 50% or greater carotid stenosis or occlusion was therefore the sum of these three groups. The 12 patients undergoing two operations (1 symptomatic, 11 asymptomatic) were at risk of stroke during both procedures and were therefore counted twice. Figures and statistics in "Results" therefore refer to the number of operations (358) and not the number of patients (346). All patients undergoing CAGB surgery were fully anticoagulated with heparin while on bypass, and this was reversed with protamine at the conclusion of surgery. All patients with PVD were given 5000 U of intravenous heparin at the time of mobilization of the artery, and this was reversed with protamine at the conclusion of surgery. No patients were given warfarin or dipyridamole.

The 95% confidence intervals (CI) for the observed stroke rates were read from the appropriate table and calculated by the formula provided in the CIBA-GEIGY scientific tables.12 Fisher's Exact Test was used to assess the significance of the difference in stroke rates in the symptomatic and asymptomatic patients. All probability values are two-tailed.

### Chart of Symptomatic and Asymptomatic Carotid Stenosis Cases

<table>
<thead>
<tr>
<th>Carotid Stenosis</th>
<th>Symptomatic Cases*</th>
<th>Asymptomatic Cases†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stenosis (lumen diameter reduction)</td>
<td>Stenosis Ipsilateral to symptoms</td>
<td>Stenosis Contralateral (Asymptomatic)</td>
</tr>
<tr>
<td>Occlusion</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>80—99%</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>50—79%</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>&lt; 50%</td>
<td>14</td>
<td>20</td>
</tr>
<tr>
<td>Normal</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Uninterpretable</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>38</td>
<td>38</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Asymptomatic Carotid Stenoses</th>
<th>Symptomatic Cases*</th>
<th>Asymptomatic Cases†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipsilateral</td>
<td>13</td>
<td>11</td>
</tr>
<tr>
<td>Contralateral</td>
<td>21</td>
<td>188</td>
</tr>
<tr>
<td>Normal</td>
<td>77</td>
<td>125</td>
</tr>
<tr>
<td>TOTAL</td>
<td>322</td>
<td>53</td>
</tr>
</tbody>
</table>

*Symptomatic refers to patients with carotid territory ischemia (see "Subjects and Methods") and does not include the 11 patients with vertebrobasilar ischemia (VBI). †Patients were graded according to the more severe stenosis: two with occlusion had contralateral stenosis; six had bilateral stenosis. Only one patient with VBI had a carotid occlusion. All other stenoses in the asymptomatic group were completely asymptomatic. §Column totals 322 because two patients had stenosis on one side and an uninterpretable Duplex ultrasound on the other. Both sides are recorded at the appropriate levels in the column.

### Results

Three hundred forty-six patients, of whom 270 were men and 76 women, with an average age of 63 years, underwent 358 operations. There were 133 consecutive patients who had 145 PVD procedures (femoropopliteal, iliofemoral, axilllobifemoral bypass, and aortodistal reconstruction or aortic aneurysm resections) and 213 consecutive CABG cases.

Adding to the 45 with asymptomatic carotid stenosis or occlusion (Figure) the 8 cases from the symptomatic group with asymptomatic carotid stenosis (see "Subjects and Methods" for explanation) resulted in 53 patients with 50% or greater asymptomatic carotid stenosis or occlusion. None of these 53 had an ipsilateral perioperative stroke (95% CI, 0% to 6.72% stroke risk). Twenty-eight of the 53 had stenosis of 80% or greater or occlusion, and the 95% CI for the stroke risk of zero in this subgroup is 0% to 12.34%.

Two patients had cerebral ischemic symptoms in the 6 months before operation: a man in atrial fibrillation had an occipital infarct, and a woman with carotid stenosis had transient ischemic attacks (patient 3, Table; also see below). Three patients had remote (more than 6 months prior) symptoms of cerebral ischemia and ipsilateral stenoses of 50% to 79% that had not been
### Perioperative Strokes

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Surgery type</th>
<th>Stroke severity*</th>
<th>Side</th>
<th>Stenosis grade</th>
<th>Days postop symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>59</td>
<td>M</td>
<td>PVD</td>
<td>5/1</td>
<td>L</td>
<td>100</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>77</td>
<td>M</td>
<td>PVD</td>
<td>5/1</td>
<td>L</td>
<td>100</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>76</td>
<td>F</td>
<td>PVD</td>
<td>10/7</td>
<td>L</td>
<td>80</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>74</td>
<td>M</td>
<td>CABG</td>
<td>2/1</td>
<td>L</td>
<td>30</td>
<td>No</td>
</tr>
<tr>
<td>5</td>
<td>65</td>
<td>M</td>
<td>CABG</td>
<td>2/1</td>
<td>L</td>
<td>30</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>75</td>
<td>M</td>
<td>PVD</td>
<td>8/11</td>
<td>R</td>
<td>100</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>69</td>
<td>M</td>
<td>PVD</td>
<td>5/2</td>
<td>L</td>
<td>30</td>
<td>No</td>
</tr>
</tbody>
</table>

PVD, peripheral vascular disease; CABG, coronary artery bypass graft.

*Stroke severity as used in the Extracranial/Intracranial Bypass Study*: first number refers to the initial deficit, second number to the residual deficit (11=death, ≤4=minimal deficit).

†Stroke occurred immediately after an asymptotic cardiac arrest.

‡This patient had a history of right hemisphere ischemia.

Treated by endarterectomy for a variety of reasons, and none of these had a perioperative stroke. Two had recurrent 50% to 79% stenoses, 2 years after carotid endarterectomy in one case and 4 months in the other. One other patient had declined surgery on the carotid 2 years earlier. In all, 49 patients had a history of cerebral ischemic symptoms a mean of 4.8 years before surgery (range, 6 months to 20 years, with the exception of the 2 patients mentioned above). Twenty-five patients with PVD were on aspirin, 16 of whom had symptoms of cerebral ischemia. Two of the 5 patients with perioperative stroke and 23 of the 353 who did not suffer perioperative stroke were on aspirin.

Seven patients (2%) had strokes (Table). There were 5 perioperative (within 72 hours) and 2 late strokes. Ipsilateral perioperative strokes occurred in 3 of 10 patients (30%) with previously symptomatic carotid stenosis of 50% or greater or occlusion (95% CI, 6.67% to 65.25%). Two of these occurred in the territory of internal carotid artery occlusions previously confirmed by angiography. The other was in the territory of an 80% left carotid stenosis of a 76-year-old woman who had been experiencing recurrent left carotid transient ischemic attacks with episodes of dysphasia and weakness of the right arm and face (symptoms elicited preoperatively by R.P.G.) in the months before surgery. Because of severe foot ischemia a decision was made to proceed with femoropopliteal bypass, and she suffered a left hemisphere infarct associated with postoperative hypotension. In retrospect she should have had an endarterectomy before PVD surgery. Two patients who underwent CABG had small left cerebral infarcts detectable on the day after surgery, and both were associated with asymptomatic carotid stenosis of 30%. None of the patients undergoing two operations and none of the patients with an uninterpretable Duplex ultrasound had strokes. Except for patient 3 (Table), who made a poor recovery, all perioperative strokes improved to grade 1 (residual physical signs without symptoms). One patient with late stroke died (see below). The perioperative stroke risk in the 49 symptomatic patients (either carotid or vertebrobasilar ischemia), regardless of stenosis, was 8.2% (3 had strokes ipsilateral to previous symptoms and 1 contralateral) and in the 309 asymptomatic patients was 0.3% (P=.003; Fisher’s Exact Test). The perioperative stroke risk was 0.9% in the CABG group and 2.1% in the PVD group.

One hundred forty-six patients suffered systolic hypotension (blood pressure less than 95 mm Hg) during the perioperative period. Four of 7 patients with symptomatic 80% to 100% stenosis had hypotension, and 3 of these had perioperative strokes (two were distal to carotid occlusion). One of 3 patients with symptomatic 50% to 79% stenosis had hypotension. None had a perioperative stroke. In the group of 53 patients with asymptomatic stenosis of 50% or greater or occlusion, 22 (11 with 50% to 79% and 11 with 80% to 100% stenosis) had systolic hypotension (blood pressure less than 95 mm Hg) without perioperative stroke. Hypotension occurred in 118 cases with stenosis less than 50% or no stenosis, and there were two strokes. Twelve patients suffered hypertension (defined as a systolic blood pressure greater than 180 mm Hg) in the perioperative period. None of these patients suffered a perioperative stroke.

Cardiac arrest occurred in three patients during the perioperative period. Two were fatal, and one was associated with a stroke in a previously symptomatic patient (patient 1, Table). A further uncomplicated cardiac arrest occurred 11 days after surgery in a patient who subsequently suffered a stroke 8 days after the cardiac arrest (patient 7, Table).

There were eight death within 30 days of surgery (2.2% mortality), four in the PVD group and four in the CABG group. One patient died of pneumonia after right hemisphere cerebral infarction (patient 6, Table), and one patient died of pulmonary embolism 14 days after abdominal aneurysm resection. Five deaths resulted from cardiac events and occurred within days of surgery. One woman died suddenly in a nursing home 28 days after femoropopliteal bypass.

### Discussion

The most striking feature of these results is that none of 53 patients with asymptomatic carotid stenosis of 50% or greater or occlusion suffered an ipsilateral perioperative stroke (95% CI, 0% to 6.72% stroke risk) despite suffering a period of hypotension with a systolic blood pressure of 90 mm Hg or less.

The study of Barnes et al11 used very nearly the same methodology as the present study except for the exclusion of patients with a history of cerebral ischemia and patients admitted on the weekend. They recorded a similar prevalence of asymptomatic carotid disease and a similar perioperative ipsilateral stroke risk for asymptomatic carotid disease. Only one patient suffered a stroke ipsilateral to a significant stenosis (percent stenosis not clearly defined) in the setting of a cardiac arrest and hypoxia. Other studies of the perioperative risk of stroke have many methodological flaws, and these have been discussed elsewhere.13

Unlike most previous studies we found that a history of symptoms of cerebral ischemia was associated with a significant increase in risk of perioperative stroke. The influence of previous cerebral ischemic symptoms on perioperative stroke risk is likely to have been obscured in earlier studies for a number of reasons. Many prospective studies have not included symptomatic patients, and many symptomatic patients in other studies have had carotid endarterectomy. In previous studies...
examining both PVD and CABG surgery, at least half of the periopeative strokes have occurred in the CABG group,1,2,7,14 where the mechanism is usually attributed to embolism. In the present study there were only two strokes of this type (0.9% of 213 CABG patients), and most strokes occurred in the PVD group (Table). The combination of previous ischemic neurological symptoms and severe ipsilateral carotid disease accounted for all three periopeative strokes in the PVD group. (This is a small number, and two of the three cases involved angiographically confirmed carotid occlusions, so that a high periopeative stroke risk for symptomatic severe carotid stenosis cannot definitely be concluded from these results.) In a recent case-control study of the periopeative stroke risk in CABG, Reed et al15 have shown that previous transient ischemic attack or stroke is a significant risk factor.

It is doubtful whether there is a subgroup of asymptomatic patients with extremely tight carotid stenosis (greater than 80%) who have a high risk of periopeative stroke. Only two studies2,3 support the contention, and telling criticisms can be made of each. With positron emission tomography, Powers et al16 have shown that the degree of carotid stenosis need have no bearing on the hemodynamic status of the distal cerebral hemisphere. Meningeal or ophtalmic collaterals were the only predictors of reduction in cerebral blood flow or cerebral perfusion pressure in their study. It could be argued that the number of patients in our study with 80% to 99% stenosis (n=16) is too few to draw valid conclusions and that this is a subgroup that requires further study. Our finding of no ipsilateral periopeative stroke in 53 patients with significant asymptomatic carotid disease indicates that if there is an increased risk it is small and not likely to be greater than the risk of endarterectomy. Since the completion of this study two recent trials, the Medical Research Council European Carotid Surgery Trial17 and the North American Symptomatic Carotid Endarterectomy Trial (NASCET),18 have demonstrated a benefit of endarterectomy for symptomatic stenosis of 70% or greater, although there may be a time after symptoms beyond which the benefit of endarterectomy is reduced.17,19 So far there is no randomized trial evidence in favor of endarterectomy of asymptomatic carotid stenosis.

Our study suggests that the presence of symptoms is a good indicator of the risk of periopeative stroke in patients with carotid disease and that a careful inquiry regarding transient cerebral ischemic symptoms should be made in all patients requiring major vascular surgery. Whatever the long-term risk of stroke related to asymptomatic carotid stenosis,20 the periopeative risk is low and does not justify prophylactic carotid endarterectomy when cardiac or major peripheral vascular surgery is planned.

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References
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