The relationship between cerebrovascular disease and stroke complicating coronary artery bypass graft (CABG) surgery is controversial. Neurologists are often consulted regarding the risk of stroke in patients requiring elective myocardial revascularization in the presence of internal carotid artery (ICA) stenosis or occlusion. In an attempt to reduce the risk of perioperative stroke, some centers screen neurologically asymptomatic patients with carotid non-invasive tests to identify candidates for angiography and staged or combined carotid and coronary operations. Presently there is insufficient data to determine the stroke risk posed by ICA stenosis or occlusion in patients undergoing cardiac or other surgical procedures because no study employing cerebral angiography has addressed factors related to brain infarction, such as hypotension and cardiac sources of emboli, were noted.

Methods
We identified 144 patients who underwent CABG surgery at the Cleveland Clinic from 1973 through 1983 with known, unoperated ≥50% ICA stenosis or occlusion of at least one ICA as documented by intraarterial angiography. Of these 144 patients, 115 were collected from a previously published series of combined coronary and carotid operations at our institution and represent a subset in which only unilateral endarterectomy was performed despite the presence of bilateral ≥50% ICA lesions. An additional 29 patients who did not undergo combined carotid surgery were identified by cross-referencing our angiographic and surgical records. Most of these patients had intracranial ICA stenosis or ICA occlusion. In this group 18 patients had unilateral ICA lesions and 11 had bilateral ICA lesions.

Charts were reviewed for evidence of perioperative focal brain infarction. Stroke laterality and potential causes related to brain infarction, such as hypotension and cardiac sources of emboli, were noted.

Results
Cerebral angiography was performed in 73 patients because of an asymptomatic carotid bruit, and in 71 patients because of a history of transient ischemic attacks or stroke. The mean age was 59 years.

The distribution of ICA lesions and their correlation with perioperative infarcts involving the ipsilateral cerebral hemisphere are given in table 1. A total of 9 cerebral infarcts occurred (6%), including 5 minor strokes and 4 moderate to severe strokes. Only 3 strokes (2%) involved a cerebral hemisphere ipsilateral...
to a nonoperated ICA lesion. Two of these strokes occurred intraoperatively and 1 postoperatively; there was no unusual hypotension or other obvious precipitating factor in these cases. Among the 29 patients not undergoing combined carotid surgery there was 1 stroke (3%) and it was ipsilateral to an ICA occlusion. Eight strokes (7%) occurred among the 115 patients with bilateral ICA lesions who underwent combined coronary bypass and unilateral carotid surgery, and 6 of these were ipsilateral to the carotid endarterectomy. Seven of the 9 strokes were in patients with asymptomatic carotid disease.

**Discussion**

In a prospective study reported from our institution, there was a 5% rate of focal brain or ocular infarction complicating CABG surgery, with a major stroke rate of 2%. The etiology of stroke in this setting was often embolic, although carotid occlusive disease seemed to play a role in some patients. Our present study indicates that asymptomatic unilateral 50%-90% ICA stenosis or ICA occlusion does not increase the risk of ipsilateral brain infarction in patients undergoing CABG surgery. Whether severe stenosis (> 90%) poses an increased stroke risk cannot be precisely determined from our data. Because of a traditional bias in our institution for surgical management of high-grade asymptomatic carotid stenosis in this setting, we were unable to identify enough patients with > 90% ICA stenosis who had not undergone endarterectomy prior to CABG surgery to allow statistical comparisons.

The risk of stroke was greater among patients with bilateral ICA disease who underwent combined coronary and unilateral carotid surgery, but 6 of the 8 infarctions in this group involved the cerebral hemispheric ipsilateral to the side of carotid endarterectomy. Conclusions concerning the risk of uncorrected bilateral ICA lesions are difficult to draw from our data because it is impossible to determine how many of the 107 who had successful unilateral combined operations might have sustained strokes if they had undergone CABG surgery alone. Of the 29 patients in this study who did not have combined procedures, 11 with bilateral carotid lesions had no perioperative neurologic complications, but this group is too small for statistical analysis.

Several studies have concluded that the presence of an asymptomatic carotid bruit does not increase the risk of perioperative stroke during cardiovascular or other major surgical procedures. More recently, preoperative carotid non-invasive tests have been used to screen asymptomatic patients for hemodynamically significant ICA lesions regardless of the presence of a bruit. Neither Turnipseed et al. nor Breslau et al. could correlate abnormal preoperative Doppler studies with perioperative stroke risk during cardiac or peripheral vascular surgery. On the other hand, Kartchner and McRae reported a 17% rate of ischemic stroke among 41 patients with an abnormal pre-cardiovascular surgery oculoplethysmogram (OPG) compared to a 1% rate among 192 patients with a normal OPG but the locations of the strokes are not given. Because none of these non-invasive studies has angiographic confirmation, they do not fully clarify the relationship between ICA disease and perioperative stroke. Studies employing non-invasive tests have detected "hemodynamically significant" ICA stenosis in 6% to 31% of patients undergoing cardiovascular surgery. Kartchner and McRae have reported an accuracy of 89% for detecting greater than 40% ICA stenosis with OPG, but accuracy rates for non-invasive tests vary widely. Using the duplex scan, Keagy et al. found that this technique was inaccurate 64% of the time for detecting 50% or more reduction in ICA diameter in a group of patients undergoing CABG surgery. The accuracy of duplex scanning was increased to 92% if testing was limited to patients with carotid bruits. At the Cleveland Clinic, combined carotid endarterectomy has been performed in only 1.7% of all patients undergoing CBG surgery, yet our stroke rate is low and comparable to other centers. This suggests that studies using non-invasive tests overestimate the prevalence of hemodynamically significant asymptomatic ICA lesions in asymptomatic CABG patients, or that, bolstered by our angiographic data, such lesions do not significantly increase stroke risk during surgery. We do not routinely perform preoperative carotid non-invasive tests on all patients undergoing CABG, as others have recommended.

It remains probable that an occasional patient undergoing CABG surgery harbors an asymptomatic ICA lesion which does increase the risk of ipsilateral stroke during sufficient hemodynamic stress. Presently there is no reliable way to identify such patients preoperatively. In most patients with ICA occlusion or severe stenosis cerebral blood flow (CBF) is matched to the metabolic demands of the tissue, and CBF changes cannot be predictably correlated with the degree of ICA obstruction. However, recent positron emission tomography (PET) studies suggest that some patients with ICA disease have a decreased perfusion reserve. CBF ipsilateral to an ICA occlusion may be inappropriately low but compensated for by an increased oxygen extraction fraction. In some patients CBF and oxygen metabolism are normal but cerebral blood volume is increased implying a compensatory vasodilatation. Possible defects in perfusion reserve may be elicitable only with 5% CO2 inhalation. These early PET results may lead to the development of a reliable test of cerebral perfusion reserve, but have yet
to be correlated with stroke risk during hemodynamic stress such as cardiopulmonary bypass, especially in patients with asymptomatic ICA lesions. It should be emphasized that carotid non-invasive test results have not been correlated with CBF or perfusion reserve in asymptomatic patients.

Acknowledgment
The authors would like to thank Norman Hertzer, M.D. for assistance in the preparation of this manuscript.

References
Risk of stroke during coronary artery bypass graft surgery in patients with internal carotid artery disease documented by angiography.
A J Furlan and A R Craciun

Stroke. 1985;16:797-799
doi: 10.1161/01.STR.16.5.797

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