Can simple clinical features be used to identify patients with severe carotid stenosis on Doppler ultrasound?

Gillian E Mead, Joanna M Wardlaw, Stephanie C Lewis, Michael McDowall, Martin S Dennis

Abstract

Objectives—Carotid endarterectomy reduces the risk of stroke in symptomatic patients with severe ipsilateral carotid stenosis. Symptomatic patients should therefore undergo carotid Doppler imaging, but in some centres access to imaging is limited. It was therefore investigated whether simple clinical features alone or in combination could be used to identify patients with severe carotid stenosis, so that they could be referred preferentially for carotid imaging.

Methods—1041 patients with acute stroke, cerebral or retinal transient ischaemic attacks, and retinal strokes admitted to Western General Hospital or seen in neurovascular clinics were assessed by a stroke physician. Their carotid arteries were investigated using colour Doppler imaging by a consultant neuroradiologist. Patients with primary intracerebral haemorrhage, total anterior circulation strokes, posterior circulation strokes, or posterior circulation transient ischaemic attacks were excluded because carotid surgery would be inappropriate.

Results—726 patients were used in the analysis. Stepwise logistic regression showed that there were significant positive associations between severe carotid stenosis and an ipsilateral bruit, diabetes mellitus, and previous transient ischaemic attacks; and a negative association with lacunar events. The strategy with the highest specificity (97%) was “any three of these four features” but sensitivity was only 17%. The strategy with the highest sensitivity (99%) was to use one or more of the four features, but specificity was only 22%.

Conclusion—None of the strategies identified all patients with severe carotid stenosis with a reasonable specificity. When access to carotid imaging is severely limited, simple clinical features are of some use in prioritising patients for imaging, but access to carotid imaging should be improved.

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Keywords: carotid stenosis; endarterectomy; Doppler ultrasound

Carotid endarterectomy reduces the risk of stroke in patients with a recent transient ischaemic attack or minor ischaemic stroke and severe ipsilateral carotid stenosis. Therefore, many patients with stroke or transient ischaemic attack should have to have carotid imaging using Doppler ultrasound to select those suitable for surgery, with or without any intervening conventional angiography. However, most patients do not have severe carotid stenosis, so many will undergo carotid imaging to identify relatively few patients who would benefit from carotid endarterectomy. In some hospitals, access to Doppler imaging is limited. In a recent survey of all consultant physicians, geriatricians, and neurologists in the United Kingdom, 20% did not have access to carotid imaging. In other hospitals, patients may require referral to regional centres, where waiting lists may be long. Carotid endarterectomy is almost certainly more effective in stroke prevention if it is performed soon after the ischaemic event. Therefore, a simple method to identify which patients are most likely to have severe stenosis would be useful, so that these patients could be referred preferentially for early duplex imaging.

Patients with carotid bruits are about twice as likely as those without bruits to have severe carotid stenosis, but about a third of patients with significant stenosis do not have carotid bruits, and many patients with bruits do not have carotid stenosis. Therefore, the presence or absence of a carotid bruit alone is a poor predictor of the presence of carotid stenosis. The Oxfordshire Community Stroke Project (OCSP) classification is a simple clinical classification for acute stroke which is of value in predicting recovery and patterns of recurrent stroke. Severe carotid stenosis or occlusion is more common in patients with partial anterior circulation infarcts than those with lacunar, posterior circulation, or total anterior circulation infarcts. However, in one study, the sensitivity of using the partial anterior circulation infarct category to detect severe ipsilateral carotid stenosis was only 76% and specificity was 70%, with wide confidence intervals. Other factors may also be of value in predicting the presence of severe carotid stenosis and several possible risk factors may be present in an individual patient. For example, severe carotid stenosis may be more common in patients with symptoms suggestive of atheroma at other sites—for example, ischaemic heart disease or peripheral vascular disease, than those without such disease.
Identification of severe carotid stenosis using clinical features

The aim of this study was to investigate the value of carotid bruits, the OCSP subtype, risk factors for the development of carotid atheroma (for example, smoking), and the presence of atheroma at other sites (for example, peripheral vascular disease), separately and together, in predicting the presence of severe carotid stenosis in patients with acute stroke, cerebral or retinal transient ischaemic attacks, and retinal strokes to see whether we could develop a simple strategy to select which patients should be referred early for duplex imaging—that is, to identify which patients are most likely to have severe carotid stenosis.

Methods

PATIENT IDENTIFICATION
Patients with acute stroke, transient ischaemic attack, or retinal stroke admitted to our hospital or referred to neurovascular clinics from November 1994 to April 1997 were identified by a stroke physician (either a consultant or research registrar), who assessed each patient. A detailed history was taken, including a history of ischaemic heart disease, diabetes mellitus, peripheral vascular disease, drugs, family history, a transient ischaemic attack at any time before the current event, and a history of smoking. Each patient was carefully examined for the presence or absence of carotid bruits. Patients with acute stroke were classified according to the OCSP into total or partial anterior circulation syndromes, lacunar syndromes, posterior circulation syndromes, or uncertain stroke types. Patients with transient ischaemic attacks were classified as lacunar, cortical, posterior circulation or retinal according to symptoms.

CAROTID IMAGING
The carotid arteries were assessed using colour Doppler ultrasound (Acuson 128XP 10 V) within 3 months of presentation by one of two consultant neuroradiologists or one of two experienced neuroradiographers. Ongoing audit has shown that the results of their ultrasound examinations are valid compared with angiography: in 120 patients who had both ultrasound and angiography during the course of this study, k for 70–99% stenosis was 0.7 to 0.8, indicating good to excellent agreement, even though some patients underwent ultrasound and angiography at different times, which means that a few tight stenoses may have progressed to occlusion by the time angiography was performed. The ultrasonographer was deliberately blinded to the clinical details to ensure that their interpretation of the ultrasound findings was unbiased. The degree of stenosis was assessed using standard velocity criteria and the lesion appearance. Although angiography is the gold standard investigation to assess the severity of carotid disease, patients in our hospital undergo angiography only when the ultrasonographer thinks that the artery is poorly visualised and then only if the patient is suitable for endarterectomy. Therefore, we used the ultrasound assessment of stenosis for this study. Brain CT was performed whenever possible in patients with acute stroke, and only when clinically indicated in transient ischaemic attacks and retinal strokes.

DATA ANALYSES
Clinical and imaging data were prospectively entered onto a local stroke registry (Lothian Stroke Register) for subsequent analysis. We did not use any data retrospectively extracted from case notes. For the purpose of this study, we excluded stroke patients with primary intracerebral haemorrhage because carotid endarterectomy would be inappropriate even if severe stenosis was found. Patients with total anterior circulation syndromes were also excluded because most do not make a good enough recovery for carotid surgery to be worthwhile. Uncertain OCSP stroke types with midline lesions on CT and all patients with posterior circulation events were also excluded.

The prevalence of severe ipsilateral carotid stenosis (70%–99%) in patients both with and without each possible explanatory factor was calculated, and the relationship between 70%–99% stenosis and each factor was determined by using the chi-squared test. If the number of patients with 70%–99% stenosis was less than 10, the exact probability was determined by the binomial distribution.

Table 1 Univariate relation between the presence of possible explanatory factors and the severity of carotid disease

<table>
<thead>
<tr>
<th>Variable</th>
<th>Severity of stenosis (n (%))</th>
<th>Total</th>
<th>OR (p Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ipsilateral carotid bruit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smoker (cigarette or other)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous TIA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The row totals are the number of patients who have each of the possible factors, and the column totals are the number of patients with each of the categories of stenosis. Some patients had more than one risk factor, so the number of risk factors in each column do not add up to the column total. The % are of column totals. The p Values are from the chi-squared test comparing those with 70–99% stenosis to all other patients (<70% stenosis and 100% stenosis combined) for each explanatory factor. Diabetes mellitus was defined as diabetes mellitus at the time of assessment, on diet, or hypoglycaemic drugs or insulin.
individual patient having severe carotid stenosis, and the number of severe stenoses scanned by duplex to detect one severe stenosis was included in the logistic regression model. Results showed no longer significant when complete occlusion included in the severe stenosis group, because occasionally carotid occlusion detected on ultrasound is due to very tight carotid stenosis.

Discussion

Previous studies have shown that severe carotid stenosis is more common in patients with an ipsilateral carotid bruit, and in patients with a partial anterior circulation infarct. This study is the first to our knowledge to systematically investigate other possible clinical predictors of severe carotid stenosis, and to quantify the relation between severe carotid stenosis and these clinical variables.

We have shown that an ipsilateral carotid bruit, a history of diabetes, or any transient ischaemic attack before the current event, are significant predictors of the presence of severe carotid stenosis. We found a negative association between a lacunar event (either stroke or transient ischaemic attack) and severe carotid stenosis, which is in accord with the findings of previous studies. The lower 95% confidence interval (95% CI) of the ORs for diabetes, previous transient ischaemic attacks, and “not a lacunar event” were close to one; whereas, for the OR for an ipsilateral bruit, the lower 95% CI was 7.0, suggesting that an ipsilateral bruit is a much better predictor of the presence of severe carotid stenosis than the other clinical features.

If all patients with an ischaemic stroke or transient ischaemic attack who might be suitable for surgery were referred for imaging in centres where resources for imaging were limited, this would overload the system and lead to long waiting lists. This delay in imaging and any surgical intervention would reduce the effectiveness of surgery as some patients may have a stroke while awaiting surgery. Alternatively, selecting patients for duplex imaging who for clinical reasons are more likely to have severe stenosis and would be eligible for surgery might reduce the waiting time for imaging and enhance the effectiveness of surgery. However, unless the clinical criteria are sensitive, too many patients with potentially correctable carotid lesions would be missed and the efficacy of the stroke prevention programme would be reduced.

Table 3 shows that as sensitivity rises, specificity tends to fall. Other than scanning all patients, the strategy with the highest sensitivity (99%) was to refer patients with any one of the above clinical features (ipsilateral bruit, previous transient ischaemic attack, diabetes mellitus, and “not a lacunar event”). This strategy would mean referring 80% of patients, which is at least better than referring all patients, and only 1% of stenoses would be missed. However, seven patients would still...
Table 4 Predicted and observed risk of having severe carotid stenosis

<table>
<thead>
<tr>
<th>Clinical Risk Factor</th>
<th>Predicted Risk</th>
<th>Observed Risk</th>
<th>Number of Patients in Risk Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>6%</td>
<td>6%</td>
<td>335</td>
</tr>
<tr>
<td>*Bruit only</td>
<td>43%</td>
<td>44%</td>
<td>70</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>13%</td>
<td>13%</td>
<td>32</td>
</tr>
<tr>
<td>Previous TIA only</td>
<td>13%</td>
<td>15%</td>
<td>39</td>
</tr>
<tr>
<td>Lacunar event only</td>
<td>3%</td>
<td>1%</td>
<td>142</td>
</tr>
<tr>
<td>Bruit + diabetes</td>
<td>64%</td>
<td>38%</td>
<td>8</td>
</tr>
<tr>
<td>Bruit + previous TIA</td>
<td>63%</td>
<td>75%</td>
<td>16</td>
</tr>
<tr>
<td>Bruit + lacunar event</td>
<td>26%</td>
<td>39%</td>
<td>18</td>
</tr>
<tr>
<td>Diabetes + previous TIA</td>
<td>25%</td>
<td>10%</td>
<td>10</td>
</tr>
<tr>
<td>Diabetes + lacunar event</td>
<td>7%</td>
<td>18%</td>
<td>17</td>
</tr>
<tr>
<td>Previous TIA + lacunar event</td>
<td>6%</td>
<td>4%</td>
<td>28</td>
</tr>
<tr>
<td>Bruit + diabetes + previous TIA</td>
<td>80%</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Bruit + lacunar event</td>
<td>45%</td>
<td>0%</td>
<td>1</td>
</tr>
<tr>
<td>Bruit + previous TIA + lacunar event</td>
<td>43%</td>
<td>20%</td>
<td>5</td>
</tr>
<tr>
<td>Diabetes + previous TIA + lacunar event</td>
<td>13%</td>
<td>50%</td>
<td>4</td>
</tr>
<tr>
<td>All four factors</td>
<td>64%</td>
<td>-</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: *Bruit refers to ipsilateral bruit.

These strategies were developed using our particular data set, which means that the results may not be generalisable. For example, our patients were examined by a stroke physician or research registrar who was experienced in the detection of carotid bruits. Less experienced clinicians may miss typical bruits and report bruits when the findings are not typical of a carotid stenotic bruit. Furthermore, our case mix may differ from other centres. We probably see a larger proportion of patients with minor strokes or transient ischaemic attacks than other hospitals because we have a specialised neurovascular outpatient clinic, although we admit patients with acute stroke directly from their general practitioners. We found severe carotid stenosis in 13% of our patients. The proportion of patients with severe carotid stenosis may be different in other centres, which may alter the predictive value of clinical features in the detection of severe stenosis.

Although our clinical strategies are better than nothing when attempting to prioritise patients for carotid imaging, none of them reliably identified most of the patients with severe carotid stenosis and also had a high specificity. Therefore, access to Doppler imaging should be improved so that all patients with acute stroke who make a reasonable recovery, and all those with transient ischaemic attacks, should have access to early carotid imaging, providing that carotid surgery would be a clinically suitable option acceptable to the individual patient concerned.

This study would not have been possible without the hard work of all involved in collecting data for the Lothian Stroke Register. The Stroke Association funded the Lothian Stroke Register from 1990–1. The register is now funded by the Medical Research Council and the Scottish Office Home and Health Department. JMW and SCL are funded by the Medical Research Council. We are grateful to Professor CP Warlow for his helpful comments on the manuscript.

1 European Carotid Surgery Trialists’ Collaborative Group. MRC European Carotid Surgery Trial: interim results for symptomatic patients with severe (70–99%) or with mild (0–29%) carotid stenosis. Lancet 1991;337:1235–43.
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