Clinical and Radiologic Features of Lacunar Versus Nonlacunar Minor Stroke

Bo Norrving, MD, and Sten Cronqvist, MD

We determined the angiographic presence of extracerebral and intracerebral arterial disease in 122 patients with minor stroke within the carotid territory; we excluded patients with a recognized cardiac source of emboli. Based on clinical features and computed tomographic findings, patients were classified as having lacunar infarcts (n=61), nonlacunar infarcts (n=53), and infarcts of indeterminate type (n=8). Severe carotid bifurcation disease (≥50% stenosis or occlusion) was significantly more common in nonlacunar than in lacunar infarcts, on both the ipsilateral (p<0.001) and the contralateral (p<0.01) sides; 79% of the patients with nonlacunar infarcts had severe carotid bifurcation and/or middle cerebral artery disease on the ipsilateral side compared with 3.3% of the patients with lacunar infarcts. Our data underscore the need for classification of patients by the underlying mechanisms in future studies of treatment of ischemic stroke. (Stroke 1989;20:59-64)

Transient ischemic attacks (TIAs) are well recognized as a risk factor for the development of stroke. Patients with minor stroke have a similar risk for further neurologic deterioration but have only rarely been singled out for detailed study. The desirability of establishing the pathogenesis of the cerebral ischemic event has been emphasized in recent reviews. A stroke patient should ideally be characterized by the clinical signs and symptoms, by the localization and extent of infarction, and by the underlying vascular abnormality. Whereas in TIA patients the signs and symptoms have usually resolved by the time the patient is seen by a physician and the computed tomogram (CT scan) is most often normal, patients with minor stroke usually can be more fully characterized in these respects.

In clinical practice the classification of patients into groups with ischemia due to large-vessel versus small-vessel disease is often difficult but of obvious importance. Large-vessel disease commonly affects the carotid bifurcation, and the ischemic symptoms are caused by artery-to-artery embolism alone or in combination with hemodynamic impairment. Small-vessel disease (lacunar infarction) in the anterior circulation localized to the basal ganglia and adjacent structures is caused by primary disease in the penetrating arterioles and is associated with lacunar syndromes, of which pure motor hemiparesis is the most common. Involvement of higher cortical functions (HCFs) (language, praxis, behavior controlled by the nondominant hemisphere, etc.) or the visual radiation is characteristically absent. However, clinical studies have shown that a lacunar syndrome is not invariably caused by a deep infarct; conversely, the CT finding of a deep infarct is sometimes associated with nonlacunar clinical features and large-vessel involvement.

We used both clinical features and CT findings to classify patients with minor stroke into groups with lacunar, nonlacunar, and indeterminate type infarcts; we excluded patients with a recognized cardiac source of emboli. We found the associated angiographic abnormalities to be significantly different in the three groups. Our data underscore the pathophysiologic diversity of minor stroke and the necessity of classification of patients based on clinical and radiologic findings in future studies of treatment of ischemic stroke.

Subjects and Methods

We included 122 consecutive patients seen at the Department of Neurology between January 1982 and May 1986 who had suffered a first minor ischemic stroke within the carotid artery territory, who were examined using CT and angiography, and who lacked any obvious cardiac source of emboli.

Minor stroke was defined as symptoms persisting for >24 hours, with complete or virtually complete remission within 3 weeks. A cardiac source of emboli was excluded by clinical and electrocardiographic (ECG) findings alone in 62 patients and by additional two-dimensional echocardiography (2-DE) in 60
TABLE 1. Baseline Data, Risk Factors/Associated Conditions, and Electrocardiographic Findings in 122 Patients With Minor Stroke Classified by Infarct Type

<table>
<thead>
<tr>
<th>Infarct type</th>
<th>Lacunar (n=61)</th>
<th>Nonlacunar (n=53)</th>
<th>Indeterminate (n=8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>57.5</td>
<td>59</td>
<td>61.3</td>
</tr>
<tr>
<td>Range</td>
<td>32–67</td>
<td>34–71</td>
<td>31–69</td>
</tr>
<tr>
<td>Sex (male/female)</td>
<td>41/20</td>
<td>46/7</td>
<td>5/3</td>
</tr>
<tr>
<td>Risk factors/associated conditions (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension*</td>
<td>52.5</td>
<td>44.3</td>
<td></td>
</tr>
<tr>
<td>Diabetes</td>
<td>8.2</td>
<td>9.8</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>51.0</td>
<td>52.5</td>
<td></td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>3.3</td>
<td>11.5</td>
<td></td>
</tr>
<tr>
<td>Isolated angina pectoris</td>
<td>4.9</td>
<td>13.1</td>
<td></td>
</tr>
<tr>
<td>Hyperlipidemia</td>
<td>16.4</td>
<td>24.6</td>
<td></td>
</tr>
<tr>
<td>Alcohol abuse</td>
<td>4.9</td>
<td>3.3</td>
<td></td>
</tr>
<tr>
<td>Oral contraceptive use</td>
<td>3.3</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>Electrocardiographic findings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>63.9</td>
<td>54.1</td>
<td></td>
</tr>
<tr>
<td>ST-T changes</td>
<td>27.9</td>
<td>34.4</td>
<td></td>
</tr>
<tr>
<td>Left ventricular hypertrophy</td>
<td>9.8</td>
<td>6.6</td>
<td></td>
</tr>
<tr>
<td>Silent myocardial infarction</td>
<td>3.3</td>
<td>8.2</td>
<td></td>
</tr>
</tbody>
</table>

*Previously treated or based on repeatedly elevated levels (>160/90 mm Hg) after acute phase of stroke.

patients. All 122 patients were examined clinically in the acute phase (within 1 week after the onset of the latest symptoms) by senior neurologists. Data on clinical features and risk factors were collected retrospectively from the case notes, which in general were detailed.

CT scans without contrast enhancement were performed using a Toshiba (Tokyo, Japan) or Philips (Eindhoven, The Netherlands) scanner with a 512x512 matrix and a 10-mm slice thickness. Measurement of infarct size/volume was based on the method described by Nelson et al. Aortic arch and bilateral selective carotid angiography (biplane projections) was performed via the femoral route in 118 patients, whereas four patients underwent selective angiography on only the side ipsilateral to the stroke. The degree of angiographic stenosis was determined by comparing the diameter of the artery at the level of maximal stenosis with the diameter of nonstenosed adjacent segments, using the radiologic projection showing the most severe narrowing. CT scans and angiograms were reviewed independently, without knowledge of the clinical features, by one of us for the purpose of this study. \( \chi^2 \) methods were used to determine statistical significance.

**Results**

Based on the clinical features and the CT findings, the patients were divided into three groups. The *lacunar* infarct group (n=61) comprised patients with a lacunar syndrome and a pure motor hemiparesis, with CT disclosing either an appropriate infarction within the territory of the lenticulostriate vessels or a normal finding. The *nonlacunar* infarct group (n=53) comprised patients with either clinical features or CT findings not consistent with a lacunar infarct; 45 patients had unequivocal involvement of HCFs in isolation or accompanied by motor, sensory, or visual field defects. In the eight other patients (three with pure motor and five with sensorimotor stroke), CT disclosed an appropriate cortical infarction. The *indeterminate* type infarct group (n=8) comprised patients with a sensorimotor stroke without involvement of HCFs or visual fields; CT showed a normal or equivocal finding.

Baseline data, risk factors/associated conditions, and ECG findings are given in Table 1. The frequency of risk factors and ECG findings were similar in the nonlacunar and indeterminate type groups, and these two groups are therefore combined in Table 1. Patients with a lacunar infarct were slightly more often hypertensive, whereas evidence of coronary heart disease and hyperlipidemia were somewhat more prevalent in the combined group. However, no difference is significant.

**Clinical Features**

The neurologic deficit was pure motor in all 61 patients in the lacunar group; 31 infarcts were left-sided. The face, arm, and leg were involved in 47 patients, whereas the lacunar syndrome was incomplete in 14 (involving the face and arm 11, the arm and leg two, and only the arm in one patient). A history of TIsAs was recorded in 15 of the 61 patients (24.6%), all of whom had attacks of weakness only. In 10 of the 15 patients the TIsAs had occurred only during the 24 hours before the onset of the stroke; the TIsAs were multiple in five of these patients. A progressive clinical course beyond the first hour of the stroke was seen in 22 and a fluctuating course in two patients; 18 of 22 progressions occurred within 24 hours after the onset of the stroke. The progression was smooth in 16 and stepwise in six patients.
In the nonlacunar group, 45 of the 53 patients had clinical involvement of HCFs. Of the 45, 31 patients had left-sided infarcts; 30 had aphasia (24 nonfluent, six fluent) and one had apraxia plus astereognosis. Aphasia was the isolated clinical finding in four patients; six of the 31 patients with left-sided infarcts also had visual field defects. Of the 45, 14 patients had right-sided infarcts (seven had neglect, three had spatial disorientation, six had a confusional state, and two had motor impersistence; four patients had more than one type of defect); four of the 14 patients with right-sided infarcts also had visual field defects. In no patient with a right-sided infarct was the HCF involvement an isolated clinical finding. Three of the 53 patients in the nonlacunar group had a pure motor deficit (involving the face and arm in two and only the arm in one), and the five remaining patients had a sensorimotor stroke, predominantly affecting the face and arm, without HCF involvement or visual field defects. Previous TIAs were recorded in 17 of the 53 patients (32.1%) in the nonlacunar group, and the TIAs were multiple in 11. Of the 17 patients with TIAs, 11 had attacks of weakness only (three had fleeting, often subtle, repetitive symptoms), five had attacks of aphasia only, and one had transient monocular blindness only. The first TIA occurred within 24 hours before the onset of the stroke in two and within 1–7 days before the onset of the stroke in three patients, whereas in 12 patients TIAs had been present for 1 week to 6 months before the onset of the stroke. A progressive course of the stroke was seen in 12 and a fluctuating course in five of the 53 patients in the nonlacunar group. The progression was stepwise in 10 and smooth in two patients; in five of the 12 patients the progression occurred within 24 hours, in one during the second day, and in six later during the first week after the onset of the stroke.

In the indeterminate type group, all eight patients had a sensorimotor stroke unaccompanied by HCF or visual field defects. Four patients had left-sided and four had right-sided infarcts. Three patients had preceding TIAs. A progressive course of the stroke, occurring within 24 hours after the onset, was seen in two patients.

Intravenous heparin by constant infusion combined with oral anticoagulants (dicumarol or warfarin) was given to 101 of the 122 patients, 86 of whom received this therapy within 24 hours after the onset of the stroke. Six patients were given aspirin. In the lacunar group, three patients developed a progression and one patient had a continuously fluctuating hemiparesis for 36 hours despite adequate heparinization, whereas in the other two groups no further neurologic deterioration was seen after the institution of anticoagulants. No complication during treatment was observed.

**Computed Tomographic Findings**

A total of 158 CT scans were performed in the 122 patients. CT disclosed an ipsilateral infarct in 68 patients (55.7%). CT was normal in the remaining 54 patients, 24 of whom had a second CT scan >1 week after the onset of the stroke. The proportion of CT scans disclosing an infarct (positive finding) in the lacunar and nonlacunar groups related to the time of the CT examination is given in Figure 1. Both the early (within 1 week) and late CT scans were significantly more often positive in the nonlacunar than in the lacunar group.

In the lacunar group CT visualized an infarct in 26 of the 61 patients, in 20 on examinations performed within the first week after the onset of the stroke. The infarcts were localized to the posterior limb of the internal capsule in 11, to the genu in two, and to the anterior limb in five patients; in eight patients the infarcts were localized to the putamen and/or corona radiata. Mean volume of the infarcts was 0.67 (range 0.125–3) ml. The CT scan was normal in the 35 remaining patients, 18 of whom had a second CT scan after the first week. In two patients CT disclosed three clinically silent infarcts in the contralateral hemisphere, all localized to the anterior part of the internal capsule/caudate nucleus.

In the nonlacunar group CT disclosed an infarct in 42 of the 53 patients, in 24 patients on examinations performed within the first week. The infarcts involved only the cortex (mean volume 13.5, range 4–36 ml) in 25, the cortical and subcortical structures (mean volume 36.2, range 9–72 ml) in 11, and only the basal ganglia and adjacent corona radiata (mean volume 3.6, range 1–6 ml) in six patients. CT was normal in the other 11 patients, three of whom had a second CT scan after the first week. In six patients CT disclosed clinically silent infarct, four in the parietal lobe (all in the nondominant hemisphere) and two in the basal ganglia.

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**Figure 1.** Bar graph, proportion of computed tomograms disclosing infarct (positive CT scans) related to time of examination in patients with minor stroke classified by infarct type. *p<0.01, x^2=8.35, **p<0.02, x^2=6.13.
Seven patients had a carotid siphon stenosis of <50%, 20 patients had a stenosis of >50%, and 15 patients had internal carotid artery occlusion. Seven patients had a carotid siphon stenosis of <50%. Seven patients had an ipsilateral MCA stenosis (four with 50–75%, three with >75% stenosis), and two patients an ipsilateral MCA occlusion.

In lacunar infarction within the carotid artery territory, arteriolar disease due to microatheroma or lipohyalinosis has been considered to be the most common cause from autopsy materials, but from clinical studies embolism, MCA stem occlusion may be a more frequent cause.}

**Discussion**

We used both clinical features and CT findings to classify the types of infarcts as lacunar or nonlacunar. Because involvement of HCFs or the visual territory is uncertain, we included patients with these features in the nonlacunar group, as we did patients with a pure motor or sensorimotor stroke on CT found to have an appropriate cortical infarct. The lacunar group comprised only those patients with a pure motor stroke and a compatible CT finding (appropriate infarct within the territory of the lenticulostriate arteries or a normal finding). There remained a small group of patients (6.6%) in whom clinical features and CT findings did not permit an appropriate classification (indeterminate type group).

CT scan findings for up to 7 months. In contrast, nonlacunar infarcts remain CT-negative despite repeated scans for up to 7 months. In contrast, nonlacunar infarcts appear to be visualized by CT more frequently and more early in the course (Figure 1), probably because of their larger size.

In lacunar infarction within the carotid artery territory, arteriolar disease due to microatheroma or lipohyalinosis has been considered to be the most common cause from autopsy materials, but from clinical studies embolism, MCA stem occlusion...
sion, and carotid occlusive disease have also been inferred. However, in the clinical studies diagnostic criteria have varied. Some studies included patients with the CT finding of subcortical infarction that was not clinically associated with a lacunar syndrome. In other clinical studies, the presence of a cortical infarct was not excluded. Also, selection criteria for angiography were not specified. There have been no previous large series determining the frequency of major extracerebral and intracerebral arterial disease in lacunar infarction defined both from the clinical features and the CT findings. Our data give no support to carotid or MCA occlusive disease as a common cause of lacunes. We believe that the carotid bifurcation disease detected is most likely to be coincidental and similar to what can be expected in asymptomatic persons of the same age and with the same risk factors. Consistent with this view is our finding of similar angiographic results in the contralateral carotid artery in the lacunar group.

Angiographic findings were markedly different in the nonlacunar group, in which 79% of the patients had a severe large-artery lesion on the ipsilateral side. This angiographic yield is among the highest recorded in any clinical subgroup of ischemic stroke or TIA. On both sides angiographic findings were significantly more severe in the nonlacunar than in the lacunar group, suggesting that the pattern of arterial disease might be different in these two groups although the associated risk factors were not clearly separated.

We made no further subdivision of the nonlacunar group, although clinical subtypes within this group can be recognized. A pure motor stroke due to a cortical infarct is, in our experience, generally associated with hemodynamically significant lesions (when not due to cardiogenic embolism), emphasizing the importance of CT corroboration in patients with lacunar syndromes. The subcortical infarcts associated with cortical clinical features were generally larger than the infarcts seen in the lacunar group and correspond to the "striato-capsular" infarcts described by Bladin and Berkovic, who suggested this term in favor of the more ambiguous "giant lacune." Whether the higher cortical symptoms in this type of infarction are caused only by the subcortical lesion disclosed on CT scan or by an additional cortical involvement is unsettled. Although "subcortical" aphasia and neglect have been reported, caution must be exercised in basing clinicopathologic correlations on CT findings because nuclear magnetic resonance, cerebral blood flow, and positron emission tomography studies have shown that a cortical involvement may be unresolved by the CT scan.

A sensorimotor stroke can be caused by a cortical infarct but also by a lacunar infarct involving the thalamus and the posterior part of the internal capsule. We believe that one of the patients in the indeterminate type group, who had an equivocal low-density area in this region on CT scan and a normal angiogram, might have had a lacunar infarct of this type. In several other patients large-vessel involvement was present, supporting the view that lacunar infarction is an uncommon cause of sensorimotor stroke.

Although TIAs in the lacunar group tended to occur at closer intervals to the minor stroke than those in the nonlacunar group in agreement with previous reports, clearly distinguishing features of the TIAs suggesting large- or small-vessel disease in the individual patient were often not present. Thus, in TIA patients with attacks of weakness only, a lacunar mechanism may be more common than presently recognized, and the angiographic finding of a low-grade carotid bifurcation atheroma may well be coincidental. A heterogeneous pathogenesis of TIAs was suggested by Pessin et al, who reported a bimodal distribution of angiographic findings in patients with carotid TIAs. A similar bimodal distribution is also seen in our patients with minor stroke when the angiographic results in all groups are combined.

A progressive course was frequently seen in both the lacunar and the nonlacunar groups. Whereas progressions in the lacunar group were most often smooth and occurred within the first 24 hours after the onset of the stroke, progression in the nonlacunar group was predominantly stepwise. We did not attempt to determine efficacy of treatments, but our data underscore the need for separation of the underlying mechanisms in any study on the treatment of progressive stroke.

Concerning the implications of our findings, several problems should be recognized. First, although we intended to exclude patients with a cardiac source of emboli, it is well known that presently available methods for cardiac evaluation are not fully accurate. Also, our patients were not consistently examined with 2-DE. Second, cardiac, large-vessel, and small-vessel disease may coexist, making it difficult or impossible to determine the causative lesion in the individual patient. This problem is especially pertinent in the oldest age groups. Third, we cannot exclude that some CT-negative strokes in the lacunar group might have been due to lacunar infarcts in the brainstem, which may be associated with clinical features identical to those seen in supratentorial lacunes. Fourth, although we did not find any MCA disease in the lacunar group, the pattern of arterial disease may differ in other parts of the world, for example, in Japan, and in other races. Fifth, in our subjects large subcortical infarcts were generally associated with involvement of cortical features, but large subcortical lesions presenting as a pure motor hemiplegia and associated with MCA occlusion have been reported on rare occasions. Sixth, our series was retrospective, and although the clinical notes were detailed and of high standards, no formal protocol for HCF testing was used other than those...
features generally included in a careful neurologic examination. In some patients late CT scans were not obtained. In determining infarct size/volume on CT scans we did not account for the effect of timing of the examinations. Future studies are likely to take advantage of the increased sensitivity of nuclear magnetic resonance in localizing cerebral ischemia but will have to address the problem of specificity of the lesions detected. 39

In conclusion, our report emphasizes the importance of clinical and radiologic detail in the evaluation of patients with minor stroke. In patients with lacunar infarction, as defined by clinical features and compatible CT findings, the angiographic yield is small, whereas in nonlacunar minor stroke the majority of patients have severe large-vessel disease. Separation of patients by underlying mechanisms is essential in future studies of the treatment of ischemic stroke.

References

21. Santamaria J, Graus F, Rubio F, Arbizu T, Peres J: Cerebral infarction of the basal ganglia due to embolism from the heart. Stroke 1983;14:911-914

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