Hyperdense Sylvian Fissure MCA “Dot” Sign
A CT Marker of Acute Ischemia

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Background and Purpose—The hyperdense appearance of the main middle cerebral artery (HMCA) is now a familiar early warning of large cerebral infarction, brain edema, and poor prognosis. This article describes the hyperdensity associated with embolic occlusion of branches of the middle cerebral artery in the sylvian fissure (MCA “dot” sign). We define it and determine its incidence, diagnostic value, and reliability.

Methods—CT scans performed on patients with acute ischemic stroke within 3 hours of symptom onset were analyzed for signs of thromboembolic stroke and evidence of early CT ischemia. Two neuroradiologists and 2 stroke neurologists initially blinded to all clinical information and then with knowledge of the affected hemisphere evaluated scans for the presence of the MCA dot sign, the HMCA sign, and early MCA territory ischemic changes.

Results—Of 100 consecutive patients who presented within 3 hours of symptom onset, 91 were considered at symptom onset to have anterior circulation stroke syndromes. Early CT ischemia was seen in 74% of these baseline CT scans. The HMCA sign was seen in 5% of CT scans, whereas the MCA dot sign was seen in 16%. All patients then received intravenous tissue plasminogen activator. All 5 patients with an HMCA sign, including 2 with an associated MCA dot sign, were either dead or dependent at 3 months. The 14 patients with an MCA dot sign alone were independent at 3 months in 64% of cases, compared with 50% without the sign (Fisher’s exact test \( P = 0.79 \)). Balanced \( \kappa \) statistics for both the HMCA and the MCA dot sign were in the moderate to good range when the stroke symptom side was given.

Conclusions—The MCA dot sign is an early marker of thromboembolic occlusion of the distal MCA branches seen in the sylvian fissure and is associated with better outcome than the HMCA sign. (Stroke. 2001;32:848-88.)

Key Words: acute ischemic stroke ■ computed tomography ■ middle cerebral artery

Early computed tomographic (CT) ischemic change in the territory of the middle cerebral artery (MCA) has diagnostic and prognostic value.1,2 These changes are subtle, however, and therefore have variable reliability.1–6 Noncontrast CT scans may show a hyperdense MCA (HMCA) sign that represents thromboembolism within the artery and is associated with large MCA territory infarction.7,8 The HMCA sign has been associated with severe neurological deficit, extensive brain damage, and poor clinical outcome.9

In this study, we describe the MCA “dot” sign, a hyperdensity in the distal MCA and its branches seen in the sylvian fissure. The recognition of such vascular information may be important in defining why some patients respond to thrombolysis and others do not and may help in decision making when further interventional therapies are being considered. We define the MCA dot sign and describe its incidence and its association with initial neurological severity and early parenchymal ischemic CT change seen in patients with acute stroke. We report the outcome after treatment with tissue plasminogen activator (tPA). We assumed that the hyperdensity seen within these smaller-caliber vessels is less likely to represent calcified atheromatous plaque than that in larger intracranial vessels, such as the carotid artery, MCA main stem, and basilar artery, as shown in previously detailed pathological studies.10,11

Subjects and Methods
One hundred patients who presented within 3 hours of symptom onset were treated with intravenous tPA between March 1996 and November 1999. Demographic data, stroke risk factors, baseline National Institutes of Health Stroke Scale (NIHSS), and stroke type according to the Oxford Community Stroke Project (OCSP)12 were recorded. The outcome measures were functional outcome defined by the Rankin scale at 3 months, dichotomized into independence (0 to 2), dependence (3 to 5), and death, and symptomatic intracerebral hemorrhage.

Patients had pretreatment noncontrast CT brain scans (baseline) and a second CT at 24 hours. CT scans were performed on a fourth-generation Toshiba Express scanner. Section thickness was 6 mm through the posterior fossa and 6 to 10 mm for the cerebral hemispheres.

All CT scans were independently reviewed by 4 clinicians, 2 neuroradiologists (M.E.H., J.H.W.P.), and 2 stroke neurologists (A.M.D., P.A.B.). One of them had had only 2 months of experience of interpreting CT ischemic changes and applying the Alberta Stroke

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Program Early CT Score (ASPECTS), compared with the 2 years of experience of the others. The scans were initially read with the researchers blinded to all clinical information, the follow-up CT scan, and outcome data. On a separate occasion, they read them again knowing the side of the body of the stroke symptoms. Each scan was assessed specifically for the presence of the following CT signs: an MCA dot sign, an HMCA sign, and evidence of early CT ischemic change. When there was complete disagreement about the presence of a CT sign, a consensus was reached by a panel of CT readers (M.E.H., P.A.B.). The interobserver agreement for the HMCA, the MCA dot sign, and the presence of early CT ischemic change was assessed between each observer. Balanced $\kappa$ statistics, which correct for the prevalence of a particular observation, were used to assess the evidence for agreement between observers.

The MCA dot sign was defined as the hyperdensity of an arterial structure (seen as a dot) in the sylvian fissure relative to the contralateral side or to other vessels within the sylvian fissure (Figure 1).

The HMCA was defined as an MCA denser than its counterpart. Positive MCA dot and HMCA signs were considered appropriate if associated with CT ischemic change on either the baseline or 24-hour CT scan. Hyperdense signs contralateral to the symptomatic hemisphere or the final area of infarction were considered false-positive by the reading panel.

Early CT ischemic change was considered to be when there was either loss of discrimination between gray and white matter, tissue hypodensity, or swelling of brain tissue resulting in compression of local cerebrospinal fluid spaces relative to other structures or to the contralateral hemisphere. ASPECTS was used to define and quantify early CT ischemic change, and this has been described previously.

ASPECTS was determined from 2 standardized axial CT cuts, 1 at the level of the thalamus and basal ganglia and 1 adjacent to the most superior margin of the ganglionic structures, such that these structures were not visible. The MCA territory is allotted 10 points: caudate nucleus; lentiform nucleus; posterior limb of the internal capsule; insular ribbon; anterior MCA cortex (M1); MCA cortex lateral to the insular ribbon (M2); posterior MCA cortex (M3); and the anterior (M4), lateral (M5), and posterior MCA (M6) territories immediately superior to M1, M2, and M3, rostral to the basal ganglia. A single point was subtracted for an area of early ischemic change, such as focal swelling, or parenchymal hypoattenuation, for each of the defined regions. A normal CT scan received ASPECTS of 10 points. A score of 0 indicated diffuse ischemic involvement throughout the MCA territory. ASPECTS is presented both as ordinal data and dichotomized into $\leq 7$ and $> 7$. Proportions were compared by Fisher’s exact test.

Results

One hundred consecutive patients were assessed. The mean age was 68.6 years (SD 14 years). There were 53 men. For all patients, the median baseline NIHSS was 16. The OCSP stroke classifications were 53 total anterior circulation syndrome (TACS), 31 partial anterior circulation syndrome (PACS), 9 posterior occipital circulation syndrome (POCS), and 7 lacunar anterior circulation syndrome (LACS). Median baseline ASPECTS was 8.5. At 3 months, 51.5% of the patients were independent. There were 8 symptomatic hemorrhages. Seventy-four percent of the baseline CT scans showed evidence of early CT ischemic change. This rose to 85% on the follow-up 24-hour CT scan. MCA dot signs were identified in 16 patients and HMCA signs in 5 (2 of whom had associated MCA dot signs) by the reading panel (Figure 2).

Figure 1. A and B, Baseline CT scan on an 80-year-old woman (patient 74) who presented with aphasia, dense right hemiparesis, and right hemianopia within 3 hours of symptom onset. The CT scan shows a hyperdensity of an M2 branch in the sylvian fissure (MCA dot sign), which also appears plumper than the contralateral side (black arrow). It is associated with loss of gray-white differentiation and parenchymal hypodensity in the temporal and parietal lobes (white arrows). C and D, Area of confirmed infarction at 24 hours. The MCA dot sign remains visible (black arrow).

Figure 2. CT scan at baseline (A, B) and 24 hours (C, D) of a 74-year-old woman presenting with a dense left hemiparesis, neglect, and hemianopia (NIHSS 17). Black arrows demonstrate the HMCA and MCA dot signs (A, B) and residual MCA dot sign (D) on the 24-hour scan.
Balanced $\kappa$ Statistics Between 4 Pairs of Observers for the Sylvian Fissure MCA “Dot” Sign, Hyperdense MCA, and ASPECTS

<table>
<thead>
<tr>
<th>Blind to clinical information</th>
<th>MCA “Dot” Sign</th>
<th>Hyperdense MCA</th>
<th>ASPECTS $\leq 7$ and $&gt; 7$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observer 1 vs observer 2</td>
<td>0.74</td>
<td>0.71</td>
<td>0.67</td>
</tr>
<tr>
<td>Observer 1 vs observer 3</td>
<td>0.88</td>
<td>0.78</td>
<td>0.59</td>
</tr>
<tr>
<td>Observer 1 vs observer 4</td>
<td>0.36</td>
<td>0.69</td>
<td>0.36</td>
</tr>
<tr>
<td>Observer 2 vs observer 4</td>
<td>0.41</td>
<td>0.46</td>
<td>0.35</td>
</tr>
<tr>
<td>Observer 2 vs observer 3</td>
<td>0.56</td>
<td>0.80</td>
<td>0.54</td>
</tr>
<tr>
<td>Observer 3 vs observer 4</td>
<td>0.40</td>
<td>0.57</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Knowledge of stroke side

| Observer 1 vs observer 2      | 0.61           | 0.81          | 0.70                      |
| Observer 1 vs observer 3      | 0.59           | 0.80          | 0.76                      |
| Observer 1 vs observer 4      | 0.56           | 0.54          | 0.44                      |
| Observer 2 vs observer 4      | 0.56           | 0.46          | 0.51                      |
| Observer 2 vs observer 3      | 0.70           | 0.88          | 0.75                      |
| Observer 3 vs observer 4      | 0.63           | 0.47          | 0.63                      |

The balanced $\kappa$ statistic is a measure of agreement between the 2 observers (stroke neurologists and experienced neuroradiologists). A $\kappa$ value of 0 indicates agreement no better than chance, and a value of 1 indicates perfect agreement. Values of 0 to 0.2 indicate poor agreement; 0.21 to 0.40, fair agreement; 0.41 to 0.61, moderate agreement; 0.61 to 0.81, good agreement; and 0.81 to 1.0, excellent agreement.13

Two more cases of MCA dot signs were considered by some of the independent readers to probably represent false-positive signs, because they were not associated with CT ischemic change on the 24-hour scan or were not related to the anatomic locality of the patient’s symptoms. The interobserver reliability for the MCA dot sign and HMCA sign and the recognition of early CT ischemic change are summarized in the Table.

This table shows that the reliability with ASPECTS improves when clinical information is available. It reveals that observer 4 has less experience than the others with this method of interpretation. The recognition of the HMCA sign did not change when clinical information was provided. The scores converge when clinical information is available during the assessment of the MCA dot sign, suggesting that it helps the less experienced. For cases in which an MCA dot sign was identified, the artery was considered “plumper” by the observers in 12 of the 16 cases.

The median NIHSS was 15 for patients with an MCA dot sign, 15 when no occlusion was identified, and 18 for an HMCA sign (comparisons between groups were not statistically significant). The OCSP stroke types were 7 TACS and 9 PACS. As expected, the presence of an MCA dot sign was strongly associated with cortical symptoms and signs (TACS or PACS versus POCS and LACS, $P<0.001$).

In addition, there is no significant difference between patients with the MCA dot sign and patients in whom no occlusion was seen in terms of functional outcome at 3 months (Fisher’s exact test $P=0.56$). The presence of an HMCA sign was not statistically associated with a greater probability of dependence or death than when no hyperdense artery sign was seen or an MCA dot sign was present (Fisher’s exact test $P=0.054$). This may relate to the small number of HMCA signs seen in this study. All 5 of these patients were dead or dependent at 3 months. However, an MCA dot sign was associated with better outcomes at 3 months than an HMCA sign was (Fisher’s exact test $P=0.033$).

We also found that the presence of either an MCA dot sign or an HMCA sign correlated well with the degree of CT ischemia quantified by ASPECTS (dichotomized score $\leq 7$ versus $> 7$).2 Three of 14 patients with MCA dot signs had ASPECTS $\leq 7$, compared with 5 of 5 with HMCA signs (Fisher’s exact test $P=0.005$). No statistical difference was seen for ASPECTS when the MCA dot sign was compared with the group in which no vascular occlusion was identified (Fisher’s exact test $P=1.0$). The clinical characteristics and 24-hour cerebral infarcts of patients with an MCA dot are presented in Figure 3.

These results of this figure are summarized for pattern recognition in Figure 4.

Discussion

Early CT ischemic change has been shown to have prognostic use in predicting functional outcome and symptomatic intracerebral hemorrhage before thrombolyis is administered.1,2 It can also provide information regarding vascular thromboembolic occlusions.7 Much has been written about the HMCA sign and its association with large MCA infarction.7,9 The reliability of this sign is uncertain. Thrombosis can be confused with calcified artery walls, particularly in the elderly, and with a slice showing the MCA very well in the symptomatic hemisphere but not so ideally on the opposite side. Consequently, the incidence of the HMCA sign has been reported to be as high as 41%,7 but others found the hyperdense artery sign in only 5% of patients with acute ischemic stroke.14

In this study, we describe the phenomenon of hyperdensity of the MCA branches observed within the sylvian fissure, the MCA dot sign. Previous pathological studies suggest that atherosclerosis mainly affects the larger extracranial and intracranial cerebral vessels, and therefore hyperdensity within the smaller sylvian M2 branches is more likely to be representative of embolic material than calcified atheromatous plaque.10,11 The incidence of the MCA dot sign in this group of consecutive patients treated with thrombolysis was 16%, a finding similar to the incidence of “distal” MCA branch (M2 or M3 segments) in the analysis of CT findings from ECASS I.9 The frequency of the MCA dot sign in this study was greater than that of the HMCA sign; the dot sign, therefore, may be a more useful indicator of thromboembolic stroke.

The characteristics of the MCA dot sign have not been described previously. We defined the sign as the hyperdensity of MCA branches (either M2 or M3) beyond the MCA bifurcation seen in the sylvian fissure compared with other arteries in the contralateral sylvian fissure. The dot sign is characteristically associated with confirmed infarction typically affecting the insular cortex in 12 of our patients and

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[1] Fisher’s exact test

[2] Balanced $\kappa$ statistic

[3] OCSP stroke types

[4] PACS versus POCS and LACS

[5] NIHSS

[6] ASPECTS

[7] ECASS I

[8] HMCA sign

[9] MCA dot sign

[10] Hyperdense MCA


[12] MCA branches

[13] Stroke neurologists and experienced neuroradiologists

[14] Hyperdense artery sign
adjacent temporal and frontal parietal cortices, corresponding to the ASPECTS areas M2 and M5 (Figures 1, 3, and 4).

Many of the cases in which isolated MCA dot signs were present produced infarction in the basal ganglia (most commonly the lentiform nucleus). There are 3 possible explanations for this: first, the thrombus caused proximal MCA occlusion, resulting in reduced blood flow in the lenticulostriate arteries, and later migrated to a more distal position; second, an associated HMCA occlusion was not visible for technical reasons (eg, slice thickness); and third, the lateral lenticulostriate vessels may originate distal to the MCA bifurcation. We observed on occasion that the thrombosed artery appeared to be not only more hyperdense but also plumper than adjacent arteries in the sylvian fissure and the contralateral side. This may be due to clot within the vessel, distending it.

Two cases that were considered by some of the independent observers to show MCA dot signs were later labeled as false-positives by the panel of CT readers, because the signs were not related to the area of ischemia. One was in the contralateral hemisphere and the other in the brain stem. Neither was associated with ipsilateral CT ischemic change on the follow-up CT. One case, however, in which an MCA dot sign was observed contralateral to the symptomatic side, produced confirmed infarction in the basal ganglia on the follow-up CT scan. This patient was in atrial fibrillation and developed bilateral hemispheric strokes of cardioembolic origin.

The presence of the MCA dot sign was associated with severe stroke (median NIHSS 15). Although the natural history of the sign cannot be commented on because all patients received intravenous tPA, the functional outcome with treatment is generally good, with 64% independent at 3 months. This contrasts with the 5 patients with HMCA signs who died or were dependent at 3 months. This may support the concept that branch MCA occlusions (of either the M2 or M3 branches) respond better to intravenous thrombolysis than larger vessels, such as the MCA.15

The interobserver reliability for the sign was in the moderate to good range. The poorer results were associated with observer 4, who was the least experienced of the readers. It is hoped that the recognition of the MCA dot sign, with its

Figure 3. CT scan findings with hyperdense sylvian fissure MCA dot sign. Associated HMCA signs (patients 48 and 88), baseline NIHSS, and functional outcome are labeled for each case.

Figure 4. The pattern of CT infarction at 24 hours in cases in which an MCA dot sign was observed. The sign is most commonly associated with CT infarction in the insula \( n = 12 \), M2 \( n = 11 \), and M5 \( n = 9 \) regions, according to the ASPECTS system.
associated pattern of infarction, most commonly the insular cortex, and the ASPECTS cortical areas M2 and M5 (Figure 4), will help the less experienced to detect ischemia on the baseline CT scan.

The weakness of this study is the absence of a “gold standard.” Therefore, we were unable to calculate the sensitivity or specificity of the sign. Further studies should attempt to validate this CT finding with either high-resolution MR angiography of the distal MCA branches or formal angiography. As with the HMCA sign, the sensitivity of the MCA dot sign is likely to be poor.

It is necessary to develop reliable and accessible noninvasive imaging modalities in acute ischemic stroke, such as MR angiography, CT angiography, and transcranial Doppler. Understanding why acute ischemic stroke resolves rapidly in some patients but not in others is of importance when considering acute stroke therapies, such as thrombolysis. Intravenous tPA is an important therapeutic option that may be appropriate for some occlusive disease, such as MCA branch occlusions, whereas other large-artery occlusions may not be as responsive. The identification of thromboembolic occlusions has become even more pertinent after the publication of the positive PROACT II trial. Because time is of the essence in the treatment of acute ischemic stroke, it is reassuring for the treating clinician that an occlusive lesion can be identified rapidly and noninvasively. The MCA dot sign can facilitate this process.

We conclude that the recognition of the MCA dot sign may help in the diagnosis and treatment of thromboembolic MCA branch occlusion and CT infarction. This sign is not infrequently seen in hyperacute stroke, and it has a better prognosis than the HMCA sign.

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References

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