Cavitation After Acute Symptomatic Lacunar Stroke Depends on Time, Location, and MRI Sequence

Francois Moreau, MD; Shiel Patel, BSc; M. Louis Lauzon, PhD; Cheryl R. McCreary, PhD; Mayank Goyal, MD, FRCP; Richard Frayne, PhD; Andrew M. Demchuk, MD, FRCP; Shelagh B. Coutts, MD, FRCP; Eric E. Smith, MD, MPH, FRCP

Background and Purpose—Definitions for chronic lacunar infarcts vary. Recent retrospective studies suggest that many acute lacunar strokes do not develop a cavitated appearance. We determined the characteristics of acute lacunar infarcts on follow-up MRI in consecutive patients participating in prospective research studies.

Methods—Patients with acute lacunar infarction on diffusion-weighted imaging were selected from 3 prospective cohort studies of minor stroke imaged within <24 hours of onset. Follow-up MRI was performed at 30 days (Vascular Imaging of Acute Stroke for Identifying Predictors of Clinical Outcome and Recurrent Ischemic Events [VISION] study, n=21) or 90 days (VISION-2 and CT and MRI in the Triage of TIA and Minor Cerebrovascular Events to Identify High Risk Patients [CATCH] studies, n=34). Evidence of cavitation on MRI was rated separately on fluid-attenuated inversion recovery, T1, and T2 sequences by 2 independent study physicians; discrepant readings were resolved by consensus.

Results—Probable or definite cavitation on any sequence was more common at 90 days compared with 30 days (P≤0.001 for all sequences). At 90 days, evidence of cavitation was seen on at least 1 sequence in 33 of 34 patients (97%). The T1-weighted sequence was most sensitive to the presence of cavitation (94% at 90 days). By contrast, the fluid-attenuated inversion recovery sequence frequently failed to show evidence of cavitation in the brain stem or thalamus (only 10 of 18 [56%] showed cavitation).

Conclusions—MRI scanning at 90 days with T1-weighted imaging reveals evidence of cavitation in nearly all cases of acute lacunar infarction. By contrast, reliance on fluid-attenuated inversion recovery alone will miss many cavitated lesions in the thalamus and brain stem. These factors should be taken into account in the development of standardized criteria for lacunar infarction on MRI. (Stroke. 2012;43:1837-1842.)

Key Words: acute stroke □ lacunar infarcts □ lacunes □ magnetic resonance imaging

Acute symptomatic lacunar stroke provides a prototypical model of lacunar lesion evolution because it allows precise identification of the time of onset of the lesion, its location, and the clinical mechanism (that is, infarction). Surprisingly, a recent study suggested that the majority of symptomatic lacunar infarctions do not evolve into a cavitated appearance on MRI but rather evolve into a nonspecific white matter hyperintensity.11 This finding, if confirmed, has major implications for the diagnosis and classification of cerebral small vessel disease and vascular cognitive impairment. Epidemiological studies have typically classified lacunar lesions separately from white matter lesions (WMLs) or subcortical gray matter T2 hyperintensities to investigate risk factors and consequences of these lesions.8–10 If WML and lacunar infarction are indeed less distinct than origi-
nally conceived, then the epidemiological findings may be biased by misclassification.

In this study, we used data from 3 prospective longitudinal MRI research studies of stroke to investigate the process of lacunar lesion evolution. Our objective was to determine the proportion of acute lacunar infarcts that evolved into a cavitated appearance on follow-up MRI and to identify the determinants of MRI-defined cavitation, including MRI sequence type, lesion location, and patient characteristics.

Methods

We identified participants with acute lacunar stroke from 3 prospective studies of ischemic stroke and transient ischemic attack with MRI <24 hours after onset: Vascular Imaging of acute Stroke for Identifying predictors of clinical Outcome and recurrent ischemic eveNts (VISION study; enrolling patients with any National Institutes of Health Stroke Scale severity).12-14 Evaluation of magnetic resonance Imaging as a potential Surrogate end point for future stroke intervention trials when compared to clinical Outcomes in Nondisabling minor stroke and TIA (VISION-2; enrolling patients with National Institutes of Health Stroke Scale ≤5), and CT And MRI in the Triage of TIA and minor Cerebrovascular events to Identify high risk patients (CATCH; enrolling patients with National Institutes of Health Stroke Scale ≤3).15 Full study inclusion and exclusion criteria are provided in the online-only Data Supplement. All 3 studies included a baseline MRI done within 24 hours and either a 30-day (VISION) or 90-day (VISION-2 and CATCH) follow-up MRI. Baseline demographics, details of the clinical assessment, and stroke type were prospectively recorded in study case report forms.

Eligibility for this study was based on an MRI-confirmed clinical diagnosis of acute lacunar infarction, defined as:1) baseline MRI showing restricted diffusion in a deep brain region, corresponding to the presumed territory of a single penetrating artery; (2) maximum diameter ≤25 mm; (3) absence of multiple lesions that could suggest embolic infarctions; and (4) a confirmatory clinical impression of acute lacunar infarction based on all neuroimaging and clinical information prospectively recorded as a diagnosis of acute lacunar stroke in the CATCH study when compared to clinical Outcomes in Nondisabling minor stroke and TIA (VISION-2; enrolling patients with National Institutes of Health Stroke Scale ≤5), and CT And MRI in the Triage of TIA and minor Cerebrovascular events to Identify high risk patients (CATCH; enrolling patients with National Institutes of Health Stroke Scale ≤3).15 Full study inclusion and exclusion criteria are provided in the online-only Data Supplement. All 3 studies included a baseline MRI done within 24 hours and either a 30-day (VISION) or 90-day (VISION-2 and CATCH) follow-up MRI. Baseline demographics, details of the clinical assessment, and stroke type were prospectively recorded in study case report forms.

All MR images were acquired on the same General Electric 3.0 T scanner (Signa VH/GE Healthcare, Waukesha, WI). MRI sequences were similar across all 3 studies and included diffusion-weighted imaging (repetition time, TR, 7000–16 000 ms; echo time, TE, 100–200 ms), T1-weighted imaging, T2-weighted imaging (TR 22 ms; TE 3.2 ms; slice thickness 5 mm), and FLAIR sequence (TR 2560 ms; TE 98 ms; matrix 512×512; slice thickness 3.5 mm). T2*-weighted gradient-recalled echo (TR 256–2562 ms; slice thickness 2.0 mm) sequences. By comparison, at 90 days, cavitation was seen on 25% on T2-weighted, and 10 of 19 (53%) on T1-weighted studies. The acute lacunar infarct was located in the lobar white matter (not involving the basal ganglia or internal capsule) in 12 (22%), internal capsule in 11 (20%), globus pallidus or striatum with adjacent white matter in 6 (11%), thalamus in 9 (16%), and brain stem in 17 (31%) patients. Other characteristics of the study population are shown in Table 1.

All patients had MRI FLAIR at follow-up but some patients were missing other MR sequences: 3 were missing the T1-weighted sequence, 4 were missing the T2-weighted sequence, and 15 were missing the gradient-recalled echo sequence. A hyperintensity was visible on the follow-up FLAIR in 52 of 55 patients (95%). Probable or definite cavitation was less frequently present in the patients scanned at 30 days compared with 90 days (Table 2). At 30 days, cavitation was seen in 4 of 20 (25%) on FLAIR, 4 of 20 (25%) on T2-weighted, and 10 of 19 (53%) on T1-weighted sequences. By comparison, at 90 days, cavitation was seen on 26 of 34 (76%) FLAIR, 24 of 30 (80%) T2-weighted, and 30 of 32 (94%) T1-weighted sequences (P=0.001 for all comparisons with 30 days). Cavitation was seen on at least 1 of the 3 sequences at 90 days in 33 of 34 (97%). The proportion with cavitation at 90 days was higher on the T1-weighted sequence than FLAIR (P=0.01), driven by a lack of cavitation on the FLAIR sequence compared with the T1-weighted sequence in brain stem and thalamic lacunes (16 of 18
Table 1. Characteristics of the Study Cohort

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value (N=55)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>64.9±10.7</td>
</tr>
<tr>
<td>Male</td>
<td>36 (66%)</td>
</tr>
<tr>
<td>DWI diameter, mm</td>
<td>10 [7, 16]</td>
</tr>
<tr>
<td>FLAIR diameter, mm</td>
<td>10 [7, 16]</td>
</tr>
<tr>
<td>DWI volume, cm³</td>
<td>0.7 [0.3, 1.2]</td>
</tr>
<tr>
<td>FLAIR volume, cm³</td>
<td>0.7 [0.3, 1.0]</td>
</tr>
<tr>
<td>FLAIR diameter, follow-up</td>
<td>11 [8, 17]</td>
</tr>
<tr>
<td>FLAIR volume, follow-up</td>
<td>0.8 [0.4, 1.8]</td>
</tr>
<tr>
<td>Atrophy scale score</td>
<td>1 [1, 2]</td>
</tr>
<tr>
<td>Fazekas WML score</td>
<td>2 [2, 4]</td>
</tr>
<tr>
<td>Acute lacunar infarct location</td>
<td></td>
</tr>
<tr>
<td>Basal ganglia/internal capsule</td>
<td>17 (31%)</td>
</tr>
<tr>
<td>Subcortical white matter</td>
<td>12 (22%)</td>
</tr>
<tr>
<td>Thalamus</td>
<td>9 (16%)</td>
</tr>
<tr>
<td>Brainstem</td>
<td>17 (31%)</td>
</tr>
<tr>
<td>Chronic lacunes</td>
<td>24 (44%)</td>
</tr>
<tr>
<td>Microbleeds</td>
<td>14 (29%)</td>
</tr>
<tr>
<td>Smoker</td>
<td>11 (20%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>33 (60%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>10 (18%)</td>
</tr>
</tbody>
</table>

Values are mean±standard deviation or median [25th percentile, 75th percentile] unless otherwise noted.

DWI indicates diffusion-weighted imaging; FLAIR, fluid-attenuated inversion recovery; WML, white matter lesion.

Table 2. Frequency of Cavitation on MRI Sequences in Patients Scanned at Either 30 Days or 90 Days

<table>
<thead>
<tr>
<th>Timing of Follow-Up</th>
<th>No Cavitation</th>
<th>Probable Cavitation</th>
<th>Definite Cavitation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 d</td>
<td>17 (81)</td>
<td>3 (14)</td>
<td>1 (5)</td>
<td>21</td>
</tr>
<tr>
<td>FLAIR</td>
<td>16 (76)</td>
<td>4 (19)</td>
<td>1 (5)</td>
<td>21</td>
</tr>
<tr>
<td>T1</td>
<td>9 (47)</td>
<td>9 (47)</td>
<td>1 (5)</td>
<td>19</td>
</tr>
<tr>
<td>90 d</td>
<td>8 (24)</td>
<td>9 (26)</td>
<td>17 (50)</td>
<td>34</td>
</tr>
<tr>
<td>FLAIR</td>
<td>6 (20)</td>
<td>5 (17)</td>
<td>19 (63)</td>
<td>30</td>
</tr>
<tr>
<td>T2-weighted</td>
<td>2 (6)</td>
<td>5 (16)</td>
<td>25 (78)</td>
<td>32</td>
</tr>
</tbody>
</table>

Numbers in parentheses are row percentages. See text for definitions of “probable” and “definite” cavitation.

Table 3. Characteristics of Patients Scanned at 90 Days With and Without FLAIR Cavitation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>FLAIR Cavitation Present (n=26)</th>
<th>FLAIR Cavitation Absent (n=8)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, mean±SD</td>
<td>65.5±11.9</td>
<td>62.3±8.9</td>
<td>0.49</td>
</tr>
<tr>
<td>Male sex</td>
<td>16 (62%)</td>
<td>7 (88%)</td>
<td>0.23</td>
</tr>
<tr>
<td>Baseline lesion size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DWI diameter, mm</td>
<td>12 (9–15)</td>
<td>12 (9.8–15.6)</td>
<td>0.70</td>
</tr>
<tr>
<td>DWI volume, cm³</td>
<td>0.5 (0.3–0.9)</td>
<td>0.6 (0.2–1.0)</td>
<td>0.89</td>
</tr>
<tr>
<td>FLAIR diameter, mm</td>
<td>9 (6–15)</td>
<td>10.5 (6.7–15.6)</td>
<td>0.58</td>
</tr>
<tr>
<td>FLAIR volume, cm³</td>
<td>0.4 (0.1–0.7)</td>
<td>0.6 (0.2–0.9)</td>
<td>0.66</td>
</tr>
<tr>
<td>Follow-up lesion size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLAIR diameter at follow-up, mm</td>
<td>11.0 (7–14)</td>
<td>7.7 (5.4–10.5)</td>
<td>0.13</td>
</tr>
<tr>
<td>FLAIR volume at follow-up, cm³</td>
<td>0.6 (0.4–1.4)</td>
<td>0.1 (0.1–0.4)</td>
<td>0.01</td>
</tr>
<tr>
<td>Baseline scan—other lesions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chronic lacunes</td>
<td>11 (42%)</td>
<td>4 (50%)</td>
<td>0.99</td>
</tr>
<tr>
<td>Microbleeds</td>
<td>10 (38%)</td>
<td>1 (13%)</td>
<td>0.23</td>
</tr>
<tr>
<td>Atrophy scale score</td>
<td>1 (1–2)</td>
<td>1 (0.5–2)</td>
<td>0.85</td>
</tr>
<tr>
<td>Fazekas score</td>
<td>3 (2–5)</td>
<td>2 (1–2)</td>
<td>0.009</td>
</tr>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Basal ganglia/internal capsule</td>
<td>7 (27%)</td>
<td>0 (0%)</td>
<td>0.005</td>
</tr>
<tr>
<td>Subcortical white matter</td>
<td>9 (35%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Thalamus</td>
<td>3 (12%)</td>
<td>5 (63%)</td>
<td></td>
</tr>
<tr>
<td>Brain stem</td>
<td>7 (27%)</td>
<td>3 (38%)</td>
<td></td>
</tr>
<tr>
<td>Medical history</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smoker</td>
<td>5 (19%)</td>
<td>2 (25%)</td>
<td>0.99</td>
</tr>
<tr>
<td>Hypertension</td>
<td>14 (54%)</td>
<td>7 (88%)</td>
<td>0.12</td>
</tr>
<tr>
<td>Diabetes</td>
<td>2 (8%)</td>
<td>1 (13%)</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Numbers in parentheses are percentages or interquartile ranges, as appropriate.

DWI indicates diffusion-weighted imaging; FLAIR, fluid-attenuated inversion recovery.

Discussion

In this study we found that radiographic cavitation after acute lacunar infarction is incomplete at 30 days but almost always present at 90 days (33 of 34 patients) when evaluated using a comprehensive MRI acquisition. However, we found that the sensitivity of FLAIR for cavitation was considerably lower than for T1-weighted sequences and that the probability of FLAIR cavitation varied by lesion location, lesion evolution, and severity of WML.
Our findings contrast with 2 recently published studies of the evolution of acute lacunar stroke on CT or MRI. In 1 study, only 25 of 90 patients (28%) showed evidence of evolution into a cavitated lesion, including only 14 of 33 (42%) of patients with an MRI-confirmed acute infarct and a follow-up MRI. Longer time to follow-up was associated with an increased likelihood of cavitation (median time 228 days in patients with cavitation versus 72 days in patients without cavitation), similar to our study. In another study, cavitation was seen on 23 of 38 MRI (61%) and 50 of 70 CT (70%). There were some methodological limitations of these previous studies, however. The timing of follow-up ranged widely (6 days to >4 years) because follow-up was nonconsecutive and done for clinical indications, raising the possibility of bias. Follow-up was available in only 75 of 250 consecutive cases (30%) in the study that reported the rate of follow-up. The exact sequences and parameters used to determine cavitation in each individual were not given. A reliance on FLAIR alone could partially explain the lower rate of apparent cavitation compared with our study, because we have demonstrated that FLAIR is significantly less sensitive than the T1-weighted sequence. Other methodological differences compared with our study include the retrospective designs, use of multiple 1.5-T scanners (compared with a single 3.0-T scanner in our study), enrollment in the subacute phase of stroke in some cases (median time to baseline imaging was 10–18 days in 1 study), and use of a clinical definition of lacunar stroke with normal MRI in 23% of the patients in 1 of the studies. Although MRI is not perfectly sensitive for lacunar stroke, the inclusion of cases without MRI confirmation may be problematic given that CT is much less sensitive than MRI and the specificity of the clinical diagnosis of lacunar stroke is poor. By contrast, in our study we were able to use data from 3 prospective longitudinal studies with MRI confirmation of acute lacunar stroke in the acute period followed by study-mandated follow-up.

Despite evidence of cavitation on the T1-weighted sequence, the FLAIR sequence frequently failed to show evidence of cavitation. One possible reason is that the slice thickness was higher on the FLAIR than the T1-weighted sequence, which may have led to more partial volume averaging with normal tissue. However, we identified other characteristics associated with the lack of FLAIR cavitation. Although all of the basal ganglia and white matter lacunar infarcts showed evidence of cavitation on FLAIR, only 10 of 18 thalamic and brain stem infarcts showed evidence of cavitation on FLAIR, only 10 of 18 thalamic and brain stem infarcts showed cavitation on FLAIR. The lack of apparent cavitation on FLAIR, despite clear evidence of cavitation on other sequences, has previously been observed in thalamic lacunes. The partial or absent central hypointensity on FLAIR, despite clear hypointensity on the T1-weighted sequence (Figure 2), probably reflects incomplete suppression of the cavity fluid by the inversion pulse. Lack of fluid suppression could potentially result from a difference in the T1 relaxation time of the intralacunar fluid compared with CSF or lack of penetration of the radiofrequency pulse (dielectric effect). Thalamic and
brain stem lacunar infarcts were smaller at follow-up and occurred in patients with lower WML scores. WML may be associated with the appearance of cavitation on FLAIR because they reflect lack of tissue integrity, which promotes evolution into a larger lacunar lesion, which was also associated with a cavitated appearance on FLAIR. We failed to confirm a previous finding of greater likelihood of FLAIR lacunar infarct cavitation in the absence of diabetes.11

Only 2 patients (6%) had no cavitated appearance on the T1-weighted sequence when imaged at 90 days. In these 2 cases, the lacunar infarction may have been incomplete, corresponding to a Type Ib lacune in the modified version of the original small vessel disease classification system by Poirier and Desrouesne (in which the classic cavitated lacune is classified as Type Ia). A limitation of our study is that we do not have pathological correlation of our observed MRI findings. Previously published MRI pathology correlations have mainly focused on differentiating lacunes from Virchow-Robin spaces without comprehensively evaluating the appearance of lacunes across MRI sequences.23–26

There are some additional caveats that should be considered when interpreting our findings. The sample was small but well characterized. MRI sequences were reviewed simultaneously; therefore, the lesion appearance on 1 sequence might have biased the interpretation of other sequences. Our study design required a cohort with symptomatic acute lacunar infarction but 2 of the studies only enrolled patients with mild stroke severity; therefore, it is possible that the study findings may not be representative of either asymptomatic (silent) lacunar infarcts or more clinically severe larger lacunar infarcts if the pathogenesis is different. Silent lacunar infarcts likely differ in location and could differ in the severity of ischemia (possibly resulting in a higher proportion of incomplete Type Ib versus cavitated Type Ia infarcts). Acute lacunar infarction is presumed to be caused by vascular occlusion but other causative mechanisms for silent infarction may exist, including blood–brain barrier breakdown or inflammation.28 Furthermore, the pathogenesis may vary by location because subcortical incident lacunes frequently develop within existing WMH.29 However, incident silent lacunes cannot be detected acutely because the lesion is asymptomatic or minimally symptomatic; therefore, selecting patients with acute lacunar stroke remains the only practical way of identifying the radiological evolution of lacunar infarction from the acute to the chronic stage.

The main implication of our findings is that the sensitivity of MRI for detection of chronic lacunar infarction depends on the type of MRI sequences used and analyzed. This highlights the need for standards for acquiring, analyzing, and reporting MRI data relevant to cerebral small vessel disease.6 A reliance on FLAIR alone without whole-brain T1-weighted imaging, as may be done in clinical protocols, will have substantially lower sensitivity for identifying chronic lacunar infarcts and will misclassify many infarcts as either WML or subcortical gray matter T2 hyperintensities. Sensitivity of FLAIR is particularly poor in the thalamus, a critically

Figure 2. Acute lacunar infarct in the left thalamus (A, DWI) followed at 90 days by absence of cavitation on FLAIR (B) despite definite cavitation on the T2-weighted (C) and T1-weighted (D) sequences. DWI indicates diffusion-weighted imaging; FLAIR, fluid-attenuated inversion recovery.
important region where small strategic infarctions are sufficient to cause vascular cognitive impairment. This has implications for both clinical care and research. Clinically, lack of recognition of chronic lacunar infarcts, including strategically located thalamic infarcts, may lead to underrecognition of vascular cognitive impairment. In research, misclassification of chronic lacunar infarction as WML or gray matter T2 hyperintensities will tend to obscure differences in pathogenesis, risk factors, and consequences of these lesion types. Furthermore, because the incidence and prevalence of chronic lacunar infarction will depend on the MRI acquisition protocol, it is critically important that the MRI acquisition methods be specified when reporting results. We recommend that high-resolution T1-weighted MRI with whole brain coverage be incorporated into clinical and research protocols for cerebrovascular disease to maximize sensitivity for chronic lacunar infarction and minimize misclassification of lacunar infarction as other lesions.

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Disclosures

None.

References

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Study Inclusion and Exclusion Criteria

Prospective study inclusion and exclusion criteria were similar across the 3 studies and consisted of:

A. Vascular Imaging of acute Stroke for Identifying predictors of clinical Outcome and recurrent ischemic events (VISION) Study

**Inclusion Criteria**
1. Age $\geq$ 18.
2. TIA with focal weakness or speech disturbance lasting $\geq$ 5 minutes or
   Ischemic stroke with any NIHSS severity
3. Presentation to hospital emergency department within 12 hours of symptom onset.
4. Study MRI could be completed within 24 hours (the scanner was not available during night hours).

**Exclusion Criteria**
1. Pre-morbid modified Rankin scale $\geq$ 2.
2. Treatment with IV rt-PA.
3. Serious co-morbid illness likely to result in death in 3 months.

B. eValuation of magnetic resonance Imaging as a potential Surrogate endpoint for future stroke Intervention trials when compared to clinical Outcomes in Nondisabling minor stroke and TIA (VISION-2) Study

**Inclusion Criteria**
1. Age $\geq$ 18.
2. TIA with focal weakness or speech disturbance lasting $\geq$ 5 minutes or
   Minor ischemic stroke with NIHSS $\leq$ 5
3. Presentation to hospital emergency department within 12 hours of symptom onset.
4. Study MRI could be completed within 24 hours (the scanner was not available during night hours).

**Exclusion Criteria**
1. Pre-morbid modified Rankin scale $\geq$ 2.
2. Treatment with IV rt-PA.
3. Serious co-morbid illness likely to result in death in 3 months.
C. CT And MRI in the Triage of TIA and minor Cerebrovascular events to identify High risk patients (CATCH) Study

Inclusion Criteria
1. Age ≥18.
2. TIA with focal weakness or speech disturbance lasting ≥5 minutes or Minor ischemic stroke with NIHSS ≤3
3. Presentation to hospital within 24 hours of symptom onset.
4. Study MRI could be completed within 24 hours (the scanner was not available during night hours).

Exclusion Criteria
1. Pre-morbid modified Rankin scale ≥2.
2. Treatment with IV rt-PA.
3. Serious co-morbid illness likely to result in death in 3 months.
急性期症候性ラクナ脳卒中後の空洞形成は時間、局在、およびMRIシーケンスに依存する

Cavitation After Acute Symptomatic Lacunar Stroke Depends on Time, Location, and MRI Sequence

Francois Moreau, MD1,2; Shiel Patel, BSc1; M. Louis Lauzon, PhD3; Cheryl R. McCreary, PhD3; Mayank Goyal, MD, FRCPC3,4; Richard Frayne, PhD3,4; Andrew M. Demchuk, MD, FRCPC1,3,4; Shelagh B. Coutts, MD, FRCPC1,3,4; Eric E. Smith, MD, MPH, FRCPC1,3,4

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Abstract

背景および目的：慢性期ラクナ梗塞の定義は定まっていない。最近の後ろ向き研究から、多くの慢性期ラクナ脳卒中では空洞化は生じないことが示唆されている。我々は、前向き研究において、連続患者の追跡MRIで急性期ラクナ梗塞の特徴を評価した。

方法：発症から24時間未満の間に検査された軽度な脳卒中中の3件の前向きコホート研究から、拡散強調画像で急性期ラクナ梗塞を認めた患者を選択した。追跡MRIを30日時点（VISION研究、n=21）または90日時点（VISION-2研究およびCATCH研究、n=34）で行った。MRIでの空洞形成のエビデンスを、独立した2名の研究担当医がFLAIR、T1およびT2シーケンスについて別々に評価した。認識が一致すると場合は合意により解決した。

結果：すべてのシーケンスでのほぼ全例または確認された空洞形成は、90日時点で30例より多くみられた（全シーケンスでp<0.001）。90日時点では、34例の患者のうち33例（97%）で少なくとも1つのシーケンスに空洞形成のエビデンスが認められた。空洞形成の存在に対して最も高頻度であったのはT1強調シーケンスである（90日時点で94%）。これとは対照的に、FLAIRシーケンスでは脳幹または視床の空洞形成のエビデンスが認められないことが多かった（空洞形成が認められたのは18例中10例（56%）のみ）。

結論：T1強調画像法による90日時点のMRIスキャンでは、急性期ラクナ梗塞のほぼすべての症例に空洞形成のエビデンスが認められる。これとは対照的に、FLAIRのみを使用した場合には、視床および脳幹の多くの空洞化に関与される。MRIでのラクナ梗塞に関する標準的な基準の開発ではこれらの要因を考慮に入れるべきである。

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図2 左側の急性期ラクナ梗塞（A、DWI）の90日時点の追跡調査で、FLAIRでは空洞形成が認められないが（B、T2強調）、（C）およびT1強調（D）シーケンスでは確定的に空洞形成が認められる。DWI：拡散強調画像、FLAIR：fluid-attenuated inversion recovery.