Atherosclerotic Plaque Ulceration in the Symptomatic Internal Carotid Artery Is Associated With Nonlacunar Ischemic Stroke

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Background and Purpose—Atherosclerotic carotid plaque ulceration is considered a marker of previous plaque rupture and subsequent thromboembolism. It can be accurately detected with multidetector CTA. We hypothesized that atherosclerotic plaque ulceration is associated with nonlacunar ischemic stroke rather than lacunar stroke.

Methods—Prospectively, 750 consecutive patients with transient ischemic attack or ischemic stroke symptoms in the anterior cerebral circulation were evaluated for the presence of atherosclerotic plaque ulceration in the symptomatic carotid artery with multidetector CTA. Patients with stroke attributable to cardiac embolism or other specific etiologies and patients with amaurosis fugax were excluded. Ischemic strokes in the remaining 534 patients were classified as nonlacunar (n=236) or lacunar (n=298) based on clinical symptoms and multidetector CT of the brain. Ulceration was defined as extension of contrast material beyond the vascular lumen into the surrounding plaque.

Results—Plaque ulceration in the symptomatic carotid artery was more common in nonlacunar strokes (n=47; 20%) as compared to lacunar strokes (n=20; 7%; P<0.001). After adjustment for age, gender, cardiovascular risk factors, and degree of stenosis, ulcerations were independently associated with nonlacunar stroke compared to lacunar stroke (odds ratio, 2.70; 95% confidence interval, 1.43–5.09).

Conclusions—Atherosclerotic carotid plaque ulceration is associated with nonlacunar ischemic stroke, independent of the degree of carotid stenosis. These results suggest that nonlacunar stroke and lacunar stroke are caused by different pathophysiological mechanisms. (Stroke. 2010;41:1151-1156.)

Key Words: atherosclerosis ■ carotid artery ■ computed tomography ■ stroke subtype ■ ulceration

Whereas lacunar strokes are associated with local occlusive disease of the deep perforating arteries at the base of the brain,1 large deep and nonlacunar ischemic strokes are frequently caused by thromboembolism from extracranial arteries or the heart.2 The association of atrial fibrillation and carotid stenosis with nonlacunar stroke3 supports the assumption that this is attributable to (thrombo-) embolism. Atherosclerotic carotid plaque ulceration is considered to be a marker of previous plaque rupture and an influential predictor of ischemic stroke besides degree of stenosis.4,5 Plaque rupture with subsequent thrombus formation and embolization of plaque material or thrombus into the intracranial circulation may cause nonlacunar stroke.

Multidetector computed tomography angiography (MDCTA) has been demonstrated to be effective in the detection of carotid plaque ulceration, with sensitivity and specificity of 94% and 99%, respectively.6 CTA is superior to digital subtraction angiography in detecting ulcerations of the carotid atherosclerotic plaque.7

In the current study, the association between atherosclerotic plaque ulceration in the symptomatic carotid artery and nonlacunar stroke was evaluated by means of MDCTA in a large population of patients with ischemic stroke. If nonlacunar stroke is associated with thromboembolism, then it may also be associated with atherosclerotic plaque ulceration in the symptomatic carotid artery. To test this hypothesis, we compared the prevalence of plaque ulceration by means of MDCTA between patients with lacunar and nonlacunar stroke.

Materials and Methods

Study Population

From a prospective registry of 911 consenting patients with amaurosis fugax, transient ischemic attack, or minor ischemic stroke (Rankin score <4) who underwent MDCTA of the carotid arteries, we selected all patients (n=750) with symptoms in the anterior circulation. Patients were enrolled from a specialized transient ischemic attack/stroke outpatient clinic or the neurology ward. All patients underwent an interview, neurological examination, electro-
cardiography, and laboratory analysis on admission. Medical history and cardiovascular risk factors were recorded. On admission, patients underwent MDCT of the brain and MDCTA of the carotid arteries in a single session. In 3 patients the carotid arteries could not be analyzed because of scan artifacts. Patients with a likely cardiac etiology (n=96) or other specific etiology (n=20) according to the Trial of Oeg 10172 in Acute Stroke Treatment (TOAST) criteria were excluded.8 Subsequently, patients with amaurosis fugax (n=79) were excluded. Amaurosis fugax is often associated with nonatherosclerotic, primary neurological or ophthalmologic origin, and it conveys a different cerebrovascular prognosis.9 The remaining 534 patients were included in the study.

Cardiovascular Risk Factors

Hypercholesterolemia was defined as fasting cholesterol >5.0 mmol/L or treatment with cholesterol-lowering medication. Hypertension was defined as a systolic blood pressure >140 mm Hg or a diastolic blood pressure >90 mm Hg during 2 episodes of at least 15 minutes of continuous noninvasive blood pressure measurement or treatment with antihypertensive medication. Diabetes was defined as fasting serum glucose levels >7.9 mmol/L, HbA1c >6.5%, or use of antidiabetic medication.

MDCT and MDCTA Data Acquisition

Imaging was performed with a 16-slice MDCT scanner (Sensation 16; Siemens) or a 64-slice MDCT scanner (Sensation 64; Siemens) with a standardized optimized contrast-enhanced protocol (120 kVp; 180 mAs; collimation 16×0.75 mm or 64×0.6 mm; pitch ≤1).10 The MDCT brain scan ranged from the foramen magnum to the vertex. Image reconstructions were made with a 220-mm field of view, matrix size 512×512 (real in-plane resolution 0.5×0.5 mm), slice thickness 3 to 4.5 mm, and an intermediate reconstruction algorithm.

The MDCTA scan ranged from the ascending aorta to the intracranial circulation (2 cm above the sella turcica). All patients received 80 mL contrast material (iodixanol 320 mg/mL, Visipaque; Amersham Health), followed by a 40-mL saline bolus chaser, both with an injection rate of 4 mL/s. Synchronization between the passage of contrast material and data acquisition was achieved by real-time bolus tracking at the level of the ascending aorta. Image reconstructions were made with a 100-mm field of view, matrix size 512×512 (real in-plane resolution 0.6×0.6 mm), slice thickness 1.0 mm, increment 0.6 mm, and an intermediate reconstruction algorithm.12

MDCT and MDCTA Data Analysis

Relevant cerebral infarctions on MDCT of the brain related to the stroke symptoms were classified as nonlacunar infarction or lacunar infarction. A nonlacunar infarction was defined as an infarction with involvement of the cerebral cortex or a large deep infarction >1.5 cm. A lacunar infarction was defined as an infarction in the deep brain structures (gray or white matter) with a size ≤1.5 cm.

The MDCTA images were sent to a stand-alone workstation (Leonardo; Siemens Medical Solutions) with dedicated 3-dimensional analysis software for further analysis. The symptomatic carotid bifurcation was evaluated with multiplanar reformattting software, which allows reconstruction of sagittal, coronal, and oblique views from axial sections. Two experienced investigators blinded to clinical data and MDCT of the brain analyzed the MDCTA images. Discrepancies were solved by consensus.

First, the degree of stenosis in the symptomatic carotid artery was determined according to the North American Symptomatic Carotid Endarterectomy Trial criteria13 on multiplanar reformattting images perpendicular to the central lumen line. Second, the symptomatic carotid artery was evaluated for the presence of occlusion, atherosclerotic plaque, and atherosclerotic plaque ulceration. Presence of atherosclerotic plaque was defined as thickening of the vessel wall or the presence of calcification. Plaque ulceration was defined as extension of contrast media beyond the vascular lumen into the surrounding plaque.

Stroke Type and Etiology

All patients were analyzed for ischemic stroke etiology. The presence of a likely cardiac etiology or other specific etiology according to the TOAST criteria was determined.8 For the purposes of this study, stroke was defined as ischemic stroke or transient ischemic attack. Based on clinical symptoms, strokes were classified as nonlacunar stroke or lacunar stroke in consensus by 2 experienced neurologists. In patients with a relevant infarction on MDCT of the brain, classification was corrected for imaging results. Nonlacunar ischemic stroke was defined as either ≥2 of the following symptoms: (1) higher cerebral dysfunction (eg, dysphasia, dyscalculia, visuospatial disorder); (2) homonymous visual field defect; and (3) ipsilateral motor or sensory deficit, or higher cerebral dysfunction alone or a motor or sensory deficit more restricted than those classified as lacunar (eg, confined to one limb, face, or hand but not the complete arm). Lacunar ischemic stroke was defined as a pure motor stroke, pure sensory stroke, sensory-motor stroke, dysarthria clumsy hand syndrome, or ataxic hemiparesis without brain stem symptoms.14

Statistical Analysis

Data are presented as mean±SD, medians with interquartile range, or number of patients (%). Differences between categorical data were analyzed with a χ² test or Fisher exact test when appropriate. Differences between continuous data were analyzed with a Mann-Whitney test.

The association between degree of stenosis and plaque ulceration was evaluated in a multivariable logistic model adjusted for age and gender. The association between age, gender, cardiovascular risk factors, degree of stenosis, and plaque ulceration with nonlacunar stroke (with lacunar stroke as reference) was first evaluated in a univariable logistic regression model. Thereafter, a multivariable logistic regression analysis was performed to identify variables independently associated with nonlacunar stroke after adjustment for all variables. Patients with a symptomatic occluded carotid artery, in which assessment of atherosclerotic plaque morphology was not possible, were not included in this analysis.

A multivariable logistic regression analyses was repeated with nonlacunar infarctions (vs lacunar infarctions) on MDCT of the brain to confirm the association of plaque ulcerations with clinically defined stroke subtype. Adjustments were made for age and gender plus the 6 variables, with the strongest association in the univariable analysis. Statistical analyses were performed using SPSS software (version 15.0, SPSS). P<0.05 was considered statistically significant.

Results

Patients Characteristics

Excluded patients with a likely cardiac etiology or other specific etiology (n=116) had less hypertension (56% vs 71%; P=0.002) and smoked less often (28% vs 39%; P=0.02) than included patients in the analysis. In this group, plaque ulceration in the symptomatic carotid artery was present in 9 patients (8%). Excluded patients with amaurosis fugax (n=79) smoked less often (28% vs 39%; P=0.04) and less often had a previous ischemic stroke (5% vs 14%; P=0.02) than included patients. Plaque ulceration in the symptomatic carotid artery was present in 7 patients (7%) with amaurosis fugax.

In the remaining 534 patients, nonlacunar stroke was present in 236 patients and lacunar stroke was present in 298 patients. The mean age of the study population was 62±13 years and 56% of the patients were male. In 355 (66%) patients the index event was an ischemic stroke, whereas 179 (34%) patients had a transient ischemic attack. Patients with nonlacunar stroke were significantly older than patients with
Diabetes mellitus 50 (21%) 55 (18%) 0.43

Disease

History of ischemic heart

Previous intracerebral hemorrhage

Previous TIA

Smoking

Hypertension

Hypercholesterolemia

Male

Age, yr

Data are means ± SD or number of patients (%).

Plaque ulceration 47 (20%) 20 (7%) <0.001

Plaque ulceration in Ischemic Stroke Subtypes

Table 1. Characteristics of Patients With Nonlacunar and Lacunar Ischemic Stroke

<table>
<thead>
<tr>
<th></th>
<th>Nonlacunar Stroke</th>
<th>Lacunar Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, yr</td>
<td>64±13</td>
<td>61±13</td>
</tr>
<tr>
<td>Male</td>
<td>128 (54%)</td>
<td>170 (57%)</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>174 (74%)</td>
<td>215 (72%)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>167 (71%)</td>
<td>212 (71%)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>50 (21%)</td>
<td>55 (18%)</td>
</tr>
<tr>
<td>Smoking</td>
<td>82 (35%)</td>
<td>126 (42%)</td>
</tr>
<tr>
<td>Peripheral arterial disease</td>
<td>17 (7%)</td>
<td>17 (6%)</td>
</tr>
<tr>
<td>Previous ischemic stroke</td>
<td>31 (13%)</td>
<td>42 (14%)</td>
</tr>
<tr>
<td>Previous TIA</td>
<td>36 (15%)</td>
<td>42 (14%)</td>
</tr>
<tr>
<td>Previous intracerebral hemorrhage</td>
<td>4 (2%)</td>
<td>5 (2%)</td>
</tr>
<tr>
<td>History of ischemic heart disease</td>
<td>37 (16%)</td>
<td>42 (14%)</td>
</tr>
</tbody>
</table>

Risk Factors for Nonlacunar Ischemic Stroke

Oclusions of the symptomatic carotid artery were significantly more prevalent in patients with nonlacunar stroke as compared to patients with lacunar stroke (8% vs 1%; P<0.001). Normal symptomatic carotid arteries were significantly less prevalent in patients with nonlacunar stroke as compared to patients with lacunar stroke (20% vs 34%; P<0.001; Table 2).

Stenosis of ≥50% of the symptomatic carotid artery in patients with nonlacunar stroke was significantly more prevalent than in patients with lacunar stroke. Plaque ulceration in the symptomatic carotid artery was more common in nonlacunar strokes (n=47; 20%) as compared to lacunar strokes (n=20; 7%; P<0.001).

Risk factors associated with nonlacunar stroke (as opposed to lacunar stroke) in univariable and multivariable analysis are provided in Table 3. In univariable analysis, age, degree of stenosis, and plaque ulceration were found to be significantly associated with nonlacunar stroke, whereas smoking was found to be associated with lacunar stroke. Risk factors independently associated with nonlacunar stroke in multivariable analysis were degree of stenosis (OR, 1.19; 95% CI, 1.07–1.32) and plaque ulceration (OR, 2.70; 95% CI, 1.43–5.09).

As illustrated by the forest plot in the Figure, multivariable analysis revealed an independent association between plaque ulceration and nonlacunar stroke after adjustment for age and gender; age, gender, and all cardiovascular risk factors; degree of stenosis alone; and age, gender, all cardiovascular risk factors, and degree of stenosis.

Risk Factors for Nonlacunar Infarction on MDCT of the Brain

An infarction on MDCT of the brain was found in 162 patients (30%), including 82 patients with nonlacunar infarction and 80 patients with lacunar infarction. The median time

Table 3. Univariable and Multivariable OR for Association Between Nonlacunar Stroke (vs Ischemic Lacunar Stroke) and Cardiovascular Risk Factors, Degree of Stenosis, and Plaque Ulceration

<table>
<thead>
<tr>
<th></th>
<th>Univariable Analysis</th>
<th>Multivariable Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per decade)</td>
<td>1.23 (1.08–1.40)*</td>
<td>1.11 (0.96–1.29)</td>
</tr>
<tr>
<td>Male</td>
<td>0.84 (0.59–1.20)</td>
<td>0.70 (0.48–1.02)</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>1.02 (0.69–1.51)</td>
<td>0.86 (0.56–1.33)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.98 (0.66–1.44)</td>
<td>0.75 (0.48–1.15)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.27 (0.82–1.95)</td>
<td>1.24 (0.77–1.98)</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.68 (0.47–0.98)*</td>
<td>0.73 (0.49–1.19)</td>
</tr>
<tr>
<td>Peripheral arterial disease</td>
<td>1.04 (0.49–2.19)</td>
<td>0.81 (0.36–1.87)</td>
</tr>
<tr>
<td>Previous ischemic stroke</td>
<td>0.89 (0.53–1.49)</td>
<td>0.81 (0.46–1.42)</td>
</tr>
<tr>
<td>Previous TIA</td>
<td>1.17 (0.71–1.94)</td>
<td>1.05 (0.61–1.82)</td>
</tr>
<tr>
<td>Previous intracerebral hemorrhoma</td>
<td>1.09 (0.29–4.09)</td>
<td>1.07 (0.27–4.27)</td>
</tr>
<tr>
<td>History of ischemic heart disease</td>
<td>1.23 (0.75–2.00)</td>
<td>1.09 (0.63–1.89)</td>
</tr>
<tr>
<td>Degree of stenosis (per 10%)</td>
<td>1.27 (1.16–1.40)*</td>
<td>1.19 (1.07–1.32)*</td>
</tr>
<tr>
<td>Plaque ulceration</td>
<td>3.79 (2.17–6.61)*</td>
<td>2.70 (1.43–5.09)*</td>
</tr>
</tbody>
</table>

Data are OR (95% CI). In multivariable analyses, adjustments were made for all variables.

*Significant relation.
between the index event and acquisition of the MDCT of the brain was 5 days (interquartile range 1–14 days). In patients with nonlacunar infarction as compared to patients with lacunar infarction, a higher prevalence of atherosclerotic plaques (n=60; 73% vs n=65; 81%) and occlusions (n=10; 12% vs n=1; 1%; P=0.02) was observed in the symptomatic carotid artery. Plaque ulceration in the symptomatic carotid artery was more common in nonlacunar infarction (n=23; 28%) as compared to lacunar infarction (n=7; 9%; P=0.002).

Risk factors associated with nonlacunar infarction (as opposed to lacunar infarction) in univariable and multivariable analysis are provided in Table 4. Atherosclerotic plaque ulceration was independently associated with nonlacunar infarction in multivariable analysis (OR, 3.88; 95% CI, 1.39–10.84).

**Discussion**

In the current study, patients with ischemic cerebrovascular symptoms were classified according to presumed stroke etiology. Besides degree of stenosis, atherosclerotic carotid plaque ulceration was shown to be independently associated with nonlacunar stroke. This relation between plaque ulceration and clinically defined nonlacunar stroke was confirmed by an independent association between the presence of atherosclerotic carotid plaque ulceration and nonlacunar infarction on MDCT of the brain.

**Etiology of Ischemic Stroke Subtypes**

The association of various risk factors with subtypes of ischemic stroke has been studied extensively. Differences in cardiovascular risk factor profile would support a distinct arterial pathological process underlying different types of stroke. Previous studies have suggested lacunar strokes to be predominantly associated with hypertension and diabetes mellitus. However, in a review by Jackson et al., only a marginal increase was shown in the prevalence of hypertension in patients with lacunar stroke as compared to nonlacunar stroke. In the present study, a risk factor-free stroke subtype classification was used and stroke subtypes were differentiated based on clinical symptoms and MDCT imaging of the brain. In concordance with Jackson et al, no significant difference in cardiovascular risk factors was observed between patients with nonlacunar and lacunar ischemic stroke. To further elucidate the pathophysiological mechanisms associated with subtypes of ischemic stroke, we evaluated the relation between parameters of carotid atherosclerosis as assessed by MDCTA of the symptomatic carotid artery.

**Table 4. Univariable and Multivariable OR for Association Between CT-Confirmed Nonlacunar Infarctions (vs Lacunar Infarctions) and Cardiovascular Risk Factors, Degree of Stenosis, and Plaque Ulceration**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Univariable Analysis</th>
<th>Multivariable Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (per decade)</td>
<td>0.90 (0.69–1.18)</td>
<td>0.81 (0.60–1.10)</td>
</tr>
<tr>
<td>Male</td>
<td>1.16 (0.61–2.20)</td>
<td>0.88 (0.43–1.80)</td>
</tr>
<tr>
<td>Hypercholesterolemia</td>
<td>0.70 (0.32–1.53)</td>
<td>0.76 (0.33–1.78)</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.60 (0.28–1.31)</td>
<td>0.45 (0.19–1.09)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.48 (0.72–3.03)</td>
<td>2.04 (0.92–4.55)</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.95 (0.50–1.80)</td>
<td></td>
</tr>
<tr>
<td>Peripheral arterial disease</td>
<td>0.97 (0.35–2.67)</td>
<td></td>
</tr>
<tr>
<td>Previous ischemic stroke</td>
<td>1.47 (0.64–3.39)</td>
<td>1.44 (0.58–3.60)</td>
</tr>
<tr>
<td>Previous TIA</td>
<td>0.99 (0.38–2.58)</td>
<td></td>
</tr>
<tr>
<td>Previous intracerebral hematoma</td>
<td>1.10 (0.07–17.89)</td>
<td></td>
</tr>
<tr>
<td>History of ischemic heart disease</td>
<td>1.11 (0.45–2.75)</td>
<td></td>
</tr>
<tr>
<td>Degree of stenosis (per 10%)</td>
<td>1.23 (1.05–1.44)*</td>
<td>1.18 (0.98–1.43)</td>
</tr>
<tr>
<td>Plaque ulceration</td>
<td>4.83 (1.92–12.12)*</td>
<td>3.88 (1.39–10.84)*</td>
</tr>
</tbody>
</table>

Data are OR (95% CI). In multivariable analyses, adjustments were made for age, gender, hypercholesterolemia, hypertension, diabetes mellitus, previous ischemic stroke, degree of stenosis, and plaque ulceration.

*Significant relation.
Relation of Carotid Artery Stenosis and Plaque Ulceration With Nonlacunar Stroke

The relation of degree of stenosis and plaque ulceration with any ischemic stroke has been previously studied using conventional angiographic studies. Previous studies relating degree of stenosis with specific stroke subtypes have identified an association with nonlacunar stroke.\(^3\)\(^,\)\(^7\)\(^,\)\(^8\) Accordingly, in the current study, a significant relation was observed between the severity of carotid stenosis and presence of nonlacunar stroke. Plaque ulceration in the symptomatic carotid artery of patients with ischemic stroke has been shown to be independently associated with an increased risk of recurrent ipsilateral ischemic stroke in patients using medical treatment in the North American Symptomatic Carotid Endarterectomy Trial and European Carotid Surgery Trial (ECST) study.\(^2\)\(^,\)\(^3\)\(^,\)\(^5\) However, no previous studies have evaluated the association of plaque ulceration with nonlacunar stroke in particular.

Atherosclerotic carotid plaque ulcerations are thought to be a marker of previous plaque ruptures.\(^9\) After plaque rupture, thrombogenic material is exposed to blood, initiating platelet aggregation and thrombus formation, ultimately leading to thromboembolism or local carotid artery occlusion.\(^2\)\(^0\) Emboli from ruptured atherosclerotic carotid plaques may occlude the intracranial cerebral arteries, resulting in ischemia of cortical and subcortical brain tissue. Accordingly, Lovett et al.\(^2\)\(^1\) observed a strong correlation between atherosclerotic plaque ulceration in the carotid artery and histological characteristics of plaque instability, including plaque rupture, intraplaque hemorrhage, and large lipid core. The results of the present study support this underlying mechanism by revealing an independent association between plaque ulceration in the symptomatic carotid artery and nonlacunar stroke. In addition, current results suggest a different pathophysiological mechanism in nonlacunar and lacunar stroke subtypes.

Clinical and Research Implications

Recent research on atherosclerosis has shifted from severity of stenosis toward parameters of plaque vulnerability. Plaque surface morphology and plaque ulcerations may be a reflection of plaque vulnerability. Plaque surface evaluation of the symptomatic carotid artery has been recommended in an algorithm for clinical decision-making concerning carotid endarterectomy.\(^2\)\(^2\) That particular algorithm is based on the results of the North American Symptomatic Carotid Endarterectomy Trial and ECST data, in which plaque surface morphology was evaluated using conventional arterial angiography. However, in current clinical practice conventional angiography is increasingly replaced by noninvasive imaging modalities such as MDCTA and MRA. Both techniques provide accurate noninvasive evaluation of carotid artery stenosis. In addition, MDCTA provides supplementary information on plaque surface morphology as compared to MRA.\(^7\) Accordingly, for individual risk stratification assessment of plaque surface morphology could be based on MDCTA rather than conventional angiography. This study further supports the importance of etiologic stroke subtype assessment in stroke patients and the evaluation of plaque morphology in patients with nonlacunar stroke. Furthermore, future studies evaluating the relation between atherosclerotic disease in the carotid bifurcation and clinical events or brain tissue damage should take into account the heterogeneity of stroke etiologies.

Study Limitations

The current study is based on carotid analysis by MDCTA, and findings were not confirmed by histological specimens. Thus far, MDCTA has been validated for detection of plaque ulceration in 1 study.\(^9\) The good accuracy observed in that particular study remains to be confirmed. The applied stroke subtype classification was based on clinical symptoms and corrected for relevant infarctions seen on MDCT of the brain. In patients with a transient ischemic attack in whom the diagnosis is often solely based on the patients’ history, subtype classification may be less accurate. MRI of the brain, especially when combined with diffusion-weighted imaging, can better-detect and localize infarcts resulting in an improved classification of stroke subtypes. Furthermore, stroke classification based on clinical symptoms alone may lead to misclassification of stroke subtype in 25% of the patients.\(^2\)\(^3\) In the current study, the clinical classification of stroke subtypes was corrected for relevant infarctions seen on MDCT of the brain. This refinement has likely improved the accuracy of stroke subtype classification. However, relevant infarctions on MDCT of the brain were absent in 70% of the patients. Accordingly, an overall misclassification of stroke subtype may be possible in up to \(\approx 20\%\) of the study population. Of note, the current study results were confirmed by a subanalysis in patients with relevant brain infarction on MDCT, in which an independent association was found between carotid plaque ulceration and nonlacunar infarction. It should be acknowledged that given the limited total number of relevant infarctions, this analysis was based on a small number of ulcerations (23 in nonlacunar infarctions compared to 7 in lacunar infarctions).

Finally, the present study has a cross-sectional design. Therefore, the prognostic value of carotid plaque ulcerations in different stroke subtypes remains to be determined in follow-up studies.

Conclusion

Atherosclerotic plaque ulceration of the symptomatic carotid artery is strongly related to nonlacunar ischemic events as compared to lacunar ischemic events, independently of severity of stenosis. This finding was confirmed by an independent association between the presence of atherosclerotic carotid plaque ulceration and nonlacunar infarctions on MDCT of the brain. These results suggest that nonlacunar ischemic stroke and lacunar stroke are caused by different pathophysiological mechanisms. Plaque ulceration is an important factor to evaluate in future prognostic and therapeutic studies of patients with carotid atherosclerotic disease.

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Disclosures

None.
References

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