A cute occlusion of the internal carotid artery (ICA) can lead to a large ischemic stroke with severe disability and poor prognosis in the long term. Recanalization after an occlusion of the ICA in the acute stage may occur more commonly than previously assumed. If a high-grade stenosis persists after recanalization, this may have important implications for subsequent treatment because the recurrence rate of ischemic stroke in patients with high-grade stenosis within 7 days is ≈8%. Carotid endarterectomy (CEA) has proven to be beneficial in patients with a ≥70% stenosis without near occlusions, and it is recommended within 2 weeks after the first symptoms.

The combination of noncontrast computed tomography (CT), CT perfusion (CTP), and CT angiography (CTA) is increasingly used to determine the extent and severity of cerebral ischemia and to localize intracranial and extracranial vascular stenosis, occlusion, and recanalization in patients with acute ischemic stroke.

The aim of our study was to determine the frequency of residual high-grade stenosis of ≥70% on follow-up imaging in patients with an acute symptomatic occlusion of the extracranial ICA.
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The Figure shows the proportion of the residual stenosis according to the different categories. A residual stenosis of <30% occurred in 15 (17.4%; 95% CI, 10.8–26.9) patients; a 30% to 49% stenosis in 3 (3.5%; 95% CI, 0.8–10.2) patients; a 50% to 69% stenosis in 2 (2.3%; 95% CI, 0.1–8.6) patients; and a 70% stenosis or occlusion in 2 (2.3%; 95% CI, 0.1–8.6) patients. A Rankin score of 0 to 2 was defined as a good outcome and a score of 3 to 6 as a poor outcome.

Days after stroke onset. Institutional review boards approved the trial, and written informed consent was obtained for each patient. Detailed information on the DUST has been described earlier.9

For the current study, we included patients with signs or symptoms that originated from an ischemic lesion in the supply territory of the ICA and a symptomatic occlusion of the extracranial ICA on the initial CTA. Furthermore, follow-up imaging of the carotid artery with CTA or alternatively magnetic resonance angiography (MRA), duplex ultrasound (DUS), or digital subtraction angiography (DSA) had to be available within 7 days after admission.

Imaging Protocol

The admission CT examination included noncontrast CT, CTP of the brain, and cervical and intracranial CTA. Detailed information on the CT imaging and analysis protocol has been described previously.9 The initial CTA and follow-up imaging (CTA, MRA, DUS, and DSA) were evaluated by a radiologist experienced in neurovascular imaging who was blinded for the clinical features. The carotid arteries were evaluated for the presence and degree of stenosis or occlusion on admission and follow-up imaging.

Clinical Assessment

Information was collected on the patients’ medical history of ischemic stroke or transient ischemic attack, vascular risk factors, and the use of antithrombotic medication. Stroke severity on admission was assessed by means of the National Institute of Health Stroke Scale and stroke subtype by means of the Trial of Org 10172 in Acute Stroke Treatment classification.10 Treatment categories included intravenous recombinant tissue-type plasminogen activator (r-tPA) and endovascular treatment (intra-arterial thrombolysis with r-PA, mechanical clot disruption or retrieval, or a combination of these approaches). Clinical outcome at 3 months was assessed by means of the modified Rankin Scale.11 A Rankin score of 0 to 2 was defined as a good outcome and a score of 3 to 6 as a poor outcome.

Finally, information was collected on subsequent treatment as CEA or carotid stenting after the ischemic stroke.

Outcome Measures

The primary outcome measure was the proportion of patients with a residual high-grade stenosis on follow-up imaging who might be eligible for CEA or carotid artery stenting. A residual high-grade stenosis was defined as a stenosis of ≥70% excluding near occlusions.6,12 It was determined how many patients had complete or partial recanalization of the extracranial ICA on follow-up imaging and what the degree of residual stenosis was according to the following categories: (1) <30%, (2) 30% to 49%, (3) 50% to 69%, (4) ≥70%, (5) near occlusion, and (6) persistent occlusion.11,12 A near occlusion was defined as a severe stenosis with caliber reduction of the ICA distal to the stenosis.13,14 The categories were labeled for the different treatment approaches (eg, intravenous r-PA, endovascular treatment, or conservative treatment).

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics, version 20.

Descriptive analysis was used to determine the frequency of occurrence of categories of residual stenosis with 95% confidence intervals (CIs) on follow-up imaging. Mean values were compared with ANOVA. Differences in proportions were evaluated by the Pearson χ² test. Differences at the level of P<0.05 were considered statistically significant. Finally, for the relationship between residual stenosis and outcome, odds ratios and the corresponding 95% CIs were calculated by means of logistic regression.

Results

From May 2009 to May 2013, 1021 patients were included in DUST. A symptomatic occlusion of the extracranial ICA was found in 126 (12.3%) patients. From these 126, 86 (68.3%) patients with adequate follow-up carotid imaging were included in the analysis. There were no differences in baseline characteristics between patients with and without adequate follow-up. The mean age was 63 (SD±12.9) years, and 74% of the patients were men (Table). The mean time between admission and follow-up imaging was 3.2 (SD±1.6) days. Follow-up imaging consisted of CTA in 83.7%, DUS in 3.5%, MRA in 3.5%, and DSA in 3.5% of the patients.

Forty-seven (54.7%) patients were treated with intravenous r-tPA and 11 (12.8%) patients underwent endovascular treatment. The baseline characteristics stratified for the different treatment modalities are presented in Table I in the online-only Data Supplement. The majority of ICA occlusions (76.7%) was considered to be caused by large artery atherosclerosis, whereas 16.3% was attributed to carotid dissection. Cardiac embolism and unknown cause each accounted for 3.5%.

In 34 (39.5%; 95% CI, 29.9–50.1) of the 86 patients, the occluded extracranial ICA was completely or partially recanalized at follow-up. Near occlusions were not included in this group. Characteristics of patients with a near or persistent occlusion (n=52) and patients with an open extracranial ICA at follow-up (n=34) are shown in Table. In the group with CTA follow-up only, the occluded carotid artery recanalized in 40.3%. For the remaining follow-up imaging modalities together, this was 35.7% (P=0.75).

The Figure shows the proportion of the residual stenosis according to the different categories. A residual stenosis of <30% occurred in 15 (17.4%; 95% CI, 10.8–26.9) patients; a 30% to 49% stenosis in 3 (3.5%; 95% CI, 0.8–10.2) patients; a 50% to 69% stenosis in 2 (2.3%; 95% CI, 0.1–8.6) patients; and a 70% stenosis or occlusion in 2 (2.3%; 95% CI, 0.1–8.6) patients.
a residual high-grade stenosis of ≥70% in 14 (16.3%; 95% CI, 9.8–25.6) patients; a near occlusion was found in 3 (3.5%; 95% CI, 0.8–10.2) patients, and a persistent occlusion in 49 (57.0%; 95% CI, 46.4–66.9) patients.

With regard to acute treatment, a residual high-grade stenosis of the extracranial ICA was found in 2 (7.1%; 95% CI, 0.9–23.7) of the 28 untreated patients and in 11 (23.4%; 95% CI, 13.5–37.4) of the 47 patients treated with intravenous rtPA. In 1 (9.1%; 95% CI, −0.6 to 40.0) of the 11 patients with endovascular treatment, a residual high-grade stenosis was present, but this patient also underwent stenting of the occluded extracranial ICA during endovascular treatment.

Of the 14 patients with a residual high-grade stenosis, 8 were later treated with CEA. Two patients were diagnosed with carotid artery dissection and, therefore, they were not eligible for CEA. The 2 patients with a residual stenosis of 50% to 69% did not undergo CEA.

Good clinical outcome (modified Rankin Scale, ≤2) 3 months after stroke did not differ significantly in patients with either a residual high-grade stenosis (odds ratio, 2.1; 95% CI, 0.6–7.1; P=0.23) or patients with a residual stenosis <70% (odds ratio, 1.3; 95% CI, 0.5–3.7; P=0.64) compared with patients with a near or persistent occlusion.

Discussion

In 1 of 6 patients with an occlusion of the extracranial ICA in the acute stage of ischemic stroke, a residual high-grade stenosis remains after recanalization. Our findings have implications for secondary prevention because CEA or stenting might be indicated in a selected group of these patients.

The proportion of patients with ischemic stroke and acute carotid occlusion in our study concurs with findings in previous studies in which rates between 6% and 15% have been reported.12,15 Our recanalization rate of acute carotid occlusion (39.5%) also falls within the range (15.8%–62.5%) described in other studies.2,16-18 The rate of recanalization is dependent on several factors, such as the type of acute treatment and the segment affected.17,19

This is the first study with a prospective design on the occurrence of a residual high-grade stenosis after recanalization of an extracranial ICA occlusion in the acute stage of cerebral ischemia. One previous retrospective study showed that a high-grade stenosis remained in 13 (25%) of 52 patients with an acute occlusion.18 Two smaller studies reported a residual high-grade stenosis in 1 of 12 (8.3%) patients and 2 of 20 (10.0%) patients, respectively.2,16 More than half of the patients with a residual high-grade stenosis in our study population underwent CEA or carotid stenting. In addition, CEA could also be considered in patients with a residual stenosis of 50% to 69%.6 This emphasizes the importance of follow-up imaging of a carotid artery that is found to be occluded in the acute phase.

Our study has several strengths, including the prospective design, the use of a standardized CTA imaging protocol, and review of the imaging data, blinded to clinical findings. A possible limitation might be that the baseline and follow-up imaging were not performed in all patients with a carotid occlusion. This was because of a contraindication for iodinated contrast administration at the baseline of follow-up, early discharge of the patients, or no permission to perform a follow-up CTA. However, baseline characteristics did not differ between patients with and without follow-up imaging. Furthermore, DUST was designed as a diagnostic and prognostic observational study on the value of CTA and CTP in acute ischemic stroke. There was no standardized collection of recurrent strokes, additional therapeutic strategies, or outcome other than the modified Rankin Score. In addition, follow-up examinations consisted of 4 different modalities (CTA, MRA, DUS, and DSA). Although standardization of the follow-up imaging would have increased the validity of our study, previous
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Disclosures

None.

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Merel J.A. Luitse, Birgitta K. Velthuis, Meenakshi Dauwan, Jan Willem Dankbaar, Geert Jan Biessels and L. Jaap Kappelle
on behalf of the Dutch Acute Stroke Study Group

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