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Prevalence and risk factors of symptomatic carotid stenosis in patients with recent transient ischaemic attack or ischaemic stroke in the Netherlands

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Abstract

Introduction: Literature on prevalence of symptomatic internal carotid artery stenosis is scarce and heterogeneous. Prevalence may have decreased in recent years due to improved management of cardiovascular risk factors. We aim to estimate current prevalence and identify risk factors of ipsilateral internal carotid artery stenosis in patients with recent hemispheric transient ischaemic attack or ischaemic stroke in the Netherlands.

Patients and methods: We included consecutive adult patients admitted to two large hospitals in the Netherlands in 2014 who suffered from amaurosis fugax, retinal ischaemia, transient ischaemic attack or ischaemic stroke in the vessel territory of the internal carotid artery. Primary outcome was presence of ipsilateral internal carotid artery stenosis (degree subdivided following NASCET criteria), as assessed with duplex ultrasonography, computed tomography angiography and/or magnetic resonance angiography. We used univariable and multivariable logistic regression to identify risk factors for the presence of a 50–100% internal carotid artery stenosis.

Results: We analysed 883 consecutive patients with recent transient ischaemic attack or ischaemic stroke. Of these, 110 (12.5%) had 50–99% ipsilateral internal carotid artery stenosis. Subgroup analyses showed higher prevalence of any degree of internal carotid artery stenosis for male sex and White patients. In adjusted analyses, higher age (odds ratio 1.4/10 years; 95% confidence interval 1.16–1.63), male sex (odds ratio 2.8; 95% confidence interval 1.83–4.19), retinal ischaemia (odds ratio 2.5; 95% confidence interval 1.32–4.76) and current smoking (odds ratio 1.8; 95% confidence interval 1.09–2.79) were statistically significant risk factors for 50–100% internal carotid artery stenosis.

Conclusion: The prevalence of internal carotid artery stenosis seems to be lower in patients with recent transient ischaemic attack or ischaemic stroke than stated in previous studies. We found that higher age, male sex, White ethnicity, retinal ischaemia and current smoking were important risk factors for symptomatic internal carotid artery stenosis.

Keywords

Carotid artery, stenosis, stroke, cerebral infarction, transient ischaemic attack, prevalence, epidemiology, ethnicity

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Introduction

Patients with recent transient ischaemic attack (TIA) or ischaemic stroke are at high risk for early stroke recurrence.[1] Comparing the five different etiological subtypes of ischaemic stroke, the highest risk for early recurrent stroke was found in patients with large-artery atherosclerosis, which includes the internal carotid artery (ICA).[2]

Studies on ICA stenosis in patients with TIA and ischaemic stroke report a prevalence ranging from 12% to 25%.[3–5] We hypothesise that the prevalence of ICA stenosis has decreased in the recent years due to better management of cardiovascular risk factors, but literature is scarce and no recent studies have elaborated on this topic. Moreover, literature on prevalence is heterogeneous: some results are based on reports from patients in a specific age category[3,5] or on studies that excluded patients with disabling ischaemic stroke.[3,4] Additionally, these studies used various cut points on degree of ICA stenosis to determine the prevalence.[5] In most studies it is not clear whether they report on stenosis of the ICA or also the common carotid artery (CCA)[3,4] and whether the ICA stenosis is located intracranially or extracranially.[3–5] A reliable and current prevalence is essential to perform statistical power analysis for future research.

To improve prevention strategies, it is important to identify risk factors for ICA stenosis. In 2009, a study in two large hospitals in Amsterdam showed an association between White patients and the presence of ipsilateral or contralateral ICA stenosis.[6] A pooled study containing four population-based studies of asymptomatic individuals found that smoking, higher age, male sex, increasing blood pressure, hyperlipidaemia and diabetes mellitus were associated with an increased prevalence of both $\geq$50% and $\geq$70% ICA stenosis.[7] ICA stenosis in patients with ipsilateral TIA was associated with male sex and age above 60 years in two studies.[8,9]

The aim of this study is to estimate the current prevalence and identify risk factors of symptomatic ipsilateral ICA stenosis in patients with recent TIA and ischaemic stroke.

Patients and methods

Patient domain and study design

We retrospectively reviewed prospectively collected databases comprising data of one academic centre (Erasmus MC, University Medical Center Rotterdam) and one large general hospital (St. Antonius Ziekenhuis Nieuwegein) in The Netherlands. These databases include all consecutive patients with TIA or ischaemic stroke admitted to one of these large stroke centres. Inclusion criteria for the current study were an age of 18 years or over, a TIA or ischaemic stroke in one of the ICA territories, and an event between January 2014 and December 2014. Final diagnosis of stroke or TIA was determined by the treating neurologist. We excluded patients with vertebrobasilar ischaemic stroke, carotid artery dissection and previous carotid endarterectomy or stenting. The ethics committee waived the need for written informed consent because this is a retrospective analysis of anonymised data.

Definitions

Baseline patient characteristics were collected and included age, sex, ethnicity, history of atrial fibrillation, diabetes mellitus, hypertension, symptomatic peripheral vascular disease, hyperlipidaemia, prior use of statins and smoking status. Ethnic origin was self-identified by patients since this is the most reliable form of ethnic identification.[10] Ethnicity was dichotomised into 'White ethnicity' and 'non-White ethnicity' of which the latter group included Black, Asian, north-African and mixed ethnicity. Symptomatic peripheral vascular disease was defined as intermittent claudication or ischaemia of the lower limbs. Hyperlipidaemia, diabetes mellitus, atrial fibrillation and hypertension were scored present when reported in medical history or conclusion of discharge note. Smoking status was obtained from discharge notes or the medical file. Final diagnosis and location of TIA and ischaemic stroke were determined according to the information on the discharge notes. ICA stenosis was defined as atherosclerotic luminal narrowing in the proximal extracranial ICA or at the location of the carotid bifurcation. Degree of stenosis was subdivided into four groups: <50%, 50–69%, 70–99% and 100% (occlusion), following NASCET criteria.[11] Near-occlusion was included in the 70–99% stenosis group. Arterial calcifications and arterial wall thickening without a stenosis of the arterial lumen were classified as <50% stenosis. Guidelines state that severe comorbidities or limited life expectancy are reasons to not perform diagnostic imaging for ICA stenosis. The decision whether to perform imaging or not was a clinical decision made by the treating neurologist, and could therefore differ from the guidelines.

Methods of measurement

The degree of ICA stenosis was measured by experienced radiologists, clinical neurophysiologists or technicians using either duplex ultrasonography (DUS), computed tomography angiography (CTA) or magnetic resonance angiography (MRA). In all centres in the

Netherlands, validation of own diagnostic accuracy and thresholds is mandatory. Using DUS, the degree of ICA stenosis was based on a combination of the presence of plaque and the flow rate defined as peak systolic velocity (PSV). A PSV of <125 cm/s in absence of visible plaque or intimal thickening was considered normal. When a plaque or intimal thickening was visible in the ICA, a PSV of <125 cm/s was diagnosed as stenosis of <50%, a PSV of 125–230 cm/s as stenosis of 50–69% and a PSV above 230 cm/s as stenosis of 70–99%. Near-occlusion was defined as a considerably narrowed lumen with either a high, low or undetectable PSV. When near-occlusion was suspected on DUS, a CTA was performed to confirm this diagnosis according to the guidelines in the Netherlands. Complete occlusion of ICA was diagnosed when no patent lumen and no detectable flow was visible on DUS.[12] Using CTA and MRA, the degree of ICA stenosis was measured by millimetre measurement of the stenosis on maximum intensity projection (MIP) reconstructions. Stenosis percentages were calculated following NASCET criteria, using the narrowest part of the ICA stenosis and a normal vessel distal to the stenosis.[11] In the Netherlands, both DUS and CTA are commonly preferred primary tests for detecting ICA stenosis. If patients underwent carotid imaging with more than one modality, the results of CTA were used in the analysis followed by MRA and DUS.

Statistical analysis

We used R studio, version 3.6.1 software to perform statistical analyses. If baseline characteristics were continuous and normally distributed, mean and standard deviation were presented. If not normally distributed, median and interquartile range were presented. Categorical variables were presented as frequencies and percentages.

First, the prevalence of ICA stenosis in patients with TIA or ischaemic stroke was calculated. To test the association of sex and ethnicity on the different degrees of stenosis, subgroup analyses were performed. Second, the relation of all potential risk factors for a 50–100% ICA stenosis, used in this study as an indicator of significant atherosclerosis in the ICA, was analysed by univariable analysis. Categorical variables with more than two groups were dichotomised based on clinical relevance. Missing values were excluded from our model if the percentage of missing values was <5%. Variables with a p value of <0.10 in univariable analysis were added to the multivariable logistic regression model. The model was then investigated for multicollinearity with variation inflation factors (VIFs).

Results

We included 883 patients. The median age was 70 years and slightly more men were included (55.2%) (Table 1). Most patients were diagnosed with ischaemic stroke (65.2%), followed by TIA (28.3%). Retinal ischaemic stroke or retinal TIA was diagnosed in 6.4% of individuals. The vascular imaging modality most often used to assess ICA stenosis was DUS (52.3%; 512/979), followed by CTA (45.6%; 446/979) and MRA (2.1%; 21/979). In 96 patients, multiple modalities were used (see supplement S1 for similarities and discrepancies between different modalities). A ≥50% ICA stenosis was found in 19.3% of the patients examined with DUS (99/512), 27.4% examined with CTA (122/446) and 47.6% examined with MRA (10/21). Information on ethnicity was available for 584 individuals (66.1%), of which the majority (83.9%) was of White ethnicity. Smoking status was known for 853 patients (96.6%) of which 28.6% were current smokers. With 469 patients (53.2%) having hypertension in their medical history, this was the most common comorbidity. The least reported comorbidity was symptomatic peripheral vascular disease (7.5%). All variables except ethnicity had <3.5% missing data. 5.9% (55/938) of carotid territory stroke or TIA patients were excluded from analysis because imaging results about ICA stenosis were missing. Reasons for not performing carotid imaging were registered for 45% of these patients (25/55) and the most common reasons were limited life expectancy or death.

Prevalence

Among all 883 individuals, 110 patients (12.5%; 95% CI 10.4–14.9) had an ICA stenosis of 50–99%. Occlusion was detected in 46 patients (5.2%; 95% CI 3.9–6.9). An ICA stenosis of 50–99% was found in 80 men (16.4%; 95% CI 13.3–20.1) and in 30 women (7.6%; 95% CI 5.3–10.8). Subgroup analyses showed that ICA stenosis was more prevalent in White patients and male sex in every range of degree of stenosis (Table 2).

After dichotomising the total cohort based on degree of stenosis, patients with a 50–100% stenosis had a higher median age (73 vs. 69 years), included more men (114/156; 73.1% vs. 373/727; 51.3%) and included more patients of White ethnicity (107/156; 68.6% vs. 383/727; 52.7%) (Table 1). The percentage of patients with a final diagnosis of ischaemic stroke was similar in both groups (102/156; 65.4% vs. 474/727; 65.2%). Relatively more patients suffered from comorbidities in the group with a 50–100% stenosis. This was the case for all comorbidities except for atrial fibrillation diagnosed during work-up.

Table 1. Baseline characteristics of included patients, stratified by degree of stenosis.

		Symptomatic ICA stenosis	
	Total ($n = 883$)	<50% or no stenosis ($n = 727$)	50–100% stenosis ($n = 156$)
Age, median (IQR)	70 (60–79)	69 (59–79)	73 (66–81)
Male sex, *n* (%)	487 (55.2%)	373 (51.3%)	114 (73.1%)
Ethnicity, *n* (%)			
• White	490 (55.5%)	383 (52.7%)	107 (68.6%)
• Non-White	94 (10.6%)	83 (11.4%)	11 (7.1%)
• Unknown	299 (33.9%)	261(35.9%)	38 (24.4%)
Diagnosis, *n* (%)			
• TIA	250 (28.3%)	214 (29.4%)	36 (23.1%)
• Ischaemic stroke	576 (65.2%)	474 (65.2%)	102 (65.4%)
• Amaurosis fugax	47 (5.3%)	31 (4.3%)	16 (10.3%)
• Retinal ischaemic stroke	10 (1.1%)	8 (1.1%)	2 (1.3%)
Atrial fibrillation, *n* (%)			
• Yes, history	107 (12.1%)	86 (11.8%)	21 (13.5%)
• Yes, diagnosed during work-up	38 (4.3%)	35 (4.8%)	3 (1.9%)
• No	736 (83.6%)	605 (83.2%)	131 (84.0%)
Diabetes mellitus, *n* (%)	186 (21.2%)	148 (20.4%)	38 (24.7%)
Hyperlipidaemia, *n* (%)	324 (36.8%)	256 (35.3%)	68 (43.9%)
Statin use, *n* (%)	345 (39.2%)	271 (37.3%)	74 (47.7%)
Hypertension, *n* (%)	469 (53.2%)	375 (51.7%)	94 (60.3%)
Symptomatic peripheral vascular disease, *n* (%)	66 (7.5%)	37 (5.1%)	29 (18.8%)
Smoking, *n* (%)			
• Yes	244 (28.6%)	196 (28.0%)	48 (31.6%)
• Stopped	184 (21.6%)	140 (20.0%)	44 (29.0%)
• No	425 (49.8%)	365 (52.1%)	60 (39.5%)

IQR: interquartile range; ICA: internal carotid artery; TIA: transient ischaemic attack.

Table 2. Absolute numbers and percentages of internal carotid artery (ICA) stenosis in the total cohort and subgroups (men vs. women and Whites vs. non-Whites).

Degree of stenosis	Total $N = 883$	Men $N = 487$	Women $N = 396$	White $N = 490$	Non-White $N = 94$
50–69%, *n* (%; 95% CI)	39 (4.4; 3.2–6.1)	28 (5.7; 3.9–8.3)	11 (2.8; 1.5–5.1)	24 (4.9; 3.2–7.3)	3 (3.2; 0.8–9.7)
50–99%, *n* (%; 95% CI)	110 (12.5; 10.4–14.9)	80 (16.4; 13.3–20.1)	30 (7.6; 5.3–10.8)	72 (14.7; 11.7–18.2)	8 (8.5; 4.0–16.6)
70–99%, *n* (%; 95% CI)	71 (8.0; 6.4–10.1)	52 (10.7; 8.2–13.9)	19 (4.8; 3.0–7.5)	48 (9.8; 7.4–12.9)	5 (5.3; 2.0–12.6)
100%, *n* (%; 95% CI)	46 (5.2; 3.9–6.9)	34 (7.0; 5.0–9.7)	12 (3.0; 1.7–5.4)	35 (7.1; 5.1–9.9)	3 (3.2; 0.8–9.7)

Risk factors

In the univariable analysis, the group with 50–100% ICA stenosis was older (odds ratio [OR] (per 10 years) 1.26; 95% confidence interval [CI] 1.10–1.45), included more men (OR 2.58; 95% CI 1.77–3.81), was more likely to be treated with statins (OR 1.53; 95% CI 1.08–2.18) and suffered more from comorbidities such as hypertension (OR 1.42; 95% CI 1.00–2.03), hyperlipidaemia (OR 1.43; 95% CI 1.01–2.04) and symptomatic peripheral vascular disease (OR 4.30; 95% CI 2.53–7.24). Lastly, patients with a retinal neurological event more often had a significant stenosis (OR 2.30: 95% CI 1.25–4.08) (Table 3). None of the variables had a VIF higher than 2. Even though symptomatic peripheral vascular disease did not have an increase in VIF, it was excluded from the multivariable analysis due to the suspicion of collinearity with statin use and hyperlipidaemia.

In the multivariable model, for each increase of 10 years in age, the adjusted odds ratio (aOR) of

Table 3. Univariable and multivariable analyses: unadjusted and adjusted associations between variables and internal carotid artery (ICA) stenosis of 50–100%.

Total $n = 883$	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Age (per 10 years)	1.26 (1.10–1.45)[a]	1.37 (1.16–1.63)
Male sex	2.58 (1.77–3.81)[a]	2.75 (1.83–4.19)
Ethnicity		
• White	2.11 (1.13–4.31)[a]	1.90 (0.97–4.02)
• Non-White	Reference	Reference
• Unknown	1.10 (0.55–2.34)	–
Location of ischaemia		
• Cerebral	Reference	Reference
• Retinal	2.30 (1.25–4.08)[a]	2.54 (1.32–4.76)
Atrial fibrillation	0.92 (0.56–1.45)	–
Diabetes mellitus	1.27 (0.84–1.90)	–
Hyperlipidaemia	1.43 (1.01–2.04)[a]	1.12 (0.75–1.66)
Statin use	1.53 (1.08–2.18)[a]	1.39 (0.94–2.04)
Hypertension	1.42 (1.00–2.03)[a]	1.36 (0.91–2.03)
Symptomatic peripheral vascular disease	4.30 (2.53–7.24)[a]	–
Smoking		
• Yes	1.49 (1.23–2.95)[a]	1.75 (1.09–2.79)
• Stopped	1.91 (0.98–2.26)[a]	1.59 (1.00–2.52)[b]
• No	Reference	Reference

Cerebral diagnosis: TIA or ischaemic stroke, retinal diagnosis: amaurosis fugax or retinal ischaemic stroke.
[a]$p < 0.10$ and included in multivariable analysis, except symptomatic peripheral vascular disease due to the suspicion of collinearity with statin use and hyperlipidaemia.
[b]Lower 95% CI = 0.998.

having ICA stenosis was 1.37 (95% CI 1.16–1.63). Men more often had ICA stenosis compared to women (aOR 2.75; 95% CI 1.83–4.19) and it was more often seen in patients with retinal ischaemia compared to cerebral ischaemia (aOR 2.54; 95% CI 1.32–4.76). Also, current smoking was associated with ICA stenosis (aOR 1.75; 95% CI 1.09–2.79). Finally, a non-significant association was found for ICA stenosis and White patients (aOR 1.90; 95% CI 0.97–4.02), use of statins (aOR 1.39; 95% CI 0.94–2.04) and previous smoking (aOR 1.59; 95% CI 1.00–2.52) (Table 3).

Discussion

This study revealed up-to-date prevalences of different degrees of ICA stenosis in Dutch patients with a recent TIA or ischaemic stroke. A 50–99% ICA stenosis was found in 12.5% of included patients. Risk factors for ≥50% ICA stenosis were age, male sex, retinal ischaemia and current smoking.

Comparison of our results with previous literature was difficult due to widely varying patient characteristics and clinical findings in previous studies.[3–5] Details of these studies are shown in Supplement S2. The results of the current study are consistent with findings in the Oxfordshire Primary Care Trusts (OPTC) cohort.[4] Although the authors of this study used the same inclusion criteria and showed similar prevalences for different degrees of stenosis, it was impossible to apply their numbers to any stroke population because ICA stenosis was not their primary endpoint and patient demographics, location of stenosis and exclusion criteria were not specified. A second cohort in this same study, the Oxford Vascular Study (OXVASC), reported a lower prevalence of patients with ICA stenosis (50–100% ICA stenosis: 14.6%), which could be due to the exclusion of patients with a disabling event (defined as a modified Rankin scale score higher than 2).[4] In contrast to these findings, a different study found a slightly higher prevalence (50–99% ICA stenosis: 14.2%), despite excluding patients with a higher stroke severity (NIHSS higher than 7).[3] This could be explained by the inclusion of patients with not only extracranial stenosis but also patients with intracranial stenosis. The highest prevalence of ICA stenosis was reported in the oldest study, dating from 1991 (75–100% ICA stenosis: 24.6%).[5] A possible explanation might be that secondary prevention was not yet introduced at that point. Furthermore, the authors excluded patients with an age below 65 years and included not only patients with a stenosis in the ICA, but also in the CCA, which contributes to an even higher prevalence.

Our study showed that important risk factors for ICA stenosis in patients with recent TIA and ischaemic

stroke were age, male sex, retinal ischaemia and current smoking. Previous population based studies in slightly different populations showed similar results. One study aimed to predict the probability of having asymptomatic ICA stenosis in the general population using individual participant data of over 23,000 participants and found that age, male sex and current smoking were independent risk factors.[7] Two other studies in patients with TIA showed that symptomatic ICA stenosis was significantly associated with male sex, amaurosis fugax and age above 60 years.[8,9]

An interesting finding of our study was that White patients more often had stenosis in the crude analysis but after adjustment for patient-related factors, this association was not statistically significant anymore. It is unclear to what extent adjustments should be made in terms of ethnicity, because varying lifestyle in different ethnicities may be related to cardiovascular risk factors. Within this context, we think that crude estimates are just as informative as are the adjusted estimates. Other findings that confirm the results of the crude analysis were the results from subgroup analysis. As shown in Table 2, ICA stenosis was more prevalent in White patients compared to other non-White patients, in all ranges of degree of stenosis. Furthermore, the association between White patients and the presence of symptomatic ICA stenosis was found in previous literature.[6]

Major strengths of this study are first of all the strict and clear definitions we maintained for our patient groups. In order to obtain clinically relevant results, we focused on extracranial ICA stenosis only. Second, the patients were selected from hospitals that serve as acute stroke centres for all patients in their respective regions. Since stroke care is organised accordingly in other parts of the Netherlands, we assume this cohort is representative for the general stroke population in the Netherlands. Third, nearly all patients with TIA or ischaemic stroke in the vessel territory of the ICA underwent imaging: 94.1% (883/938). A limitation of this study is the diagnostic modalities used to measure degree of stenosis. CTA, for example, is expected to have a relatively low sensitivity for detecting ICA stenosis but comparing literature is difficult due to large heterogeneity. However, we chose CTA as primary diagnostic modality because it had the highest specificity.[13] Another limitation is the absence of strict definitions for the assessment of comorbidities. Instead, comorbidities were identified by reviewing patient history and discharge notes. Although strict definitions could possibly contribute to less heterogeneity, we did not use them since some comorbidities change during the first weeks after a stroke (e.g. blood pressure levels), vary during the day or change depending on the use of medication (e.g. blood lipid levels). The assumption that comorbidities were not present in individual patients when they were not reported in patient history or conclusion could have led to an underestimation of comorbidities, but we assume that this possible underestimation is equal in both groups since there was no difference in reporting medical history and conclusion between both groups. Although this study shows ethnicity is a possible risk factor, investigating ethnicity generates some inevitable limitations. Dividing people into ethnic categories will never truly represent reality because ethnicity is not defined by phenotype or the language people speak. However, in order to reduce these limitations, we used self-identification to categorise people, which is currently the best method for ethnic identification.[10]

One interpretation of our findings on prevalence could be that the prevalence of ICA stenosis is overestimated in previous literature, but this is difficult to conclude due to heterogeneity. A probable explanation for a decrease in prevalence could be the change of several risk factors concerning TIA and ischaemic stroke in the past years. We speculate that a possible decrease in prevalence can largely be attributed to the start of secondary prevention after cardiovascular events with platelet aggregation inhibiting drugs and statins, increasing awareness and better treatment of risk factors. Since these factors were all present in our cohort (e.g. 39.2% used statins at baseline), the prevalence shown in this study can be of great value for calculating power analyses for future studies.

Conclusion

We conclude that the current prevalence of clinically significant ICA stenosis in patients with recent TIA or ischaemic stroke seems to be lower than stated in previous studies. Important risk factors for symptomatic ICA stenosis in this study are age, male sex, White ethnicity, retinal ischaemia and current smoking.

Trial registration

Not applicable because this is a retrospective study of patient's records.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical approval

Ethical approval for this study was waived by Medical Ethics Review Committee of the Academic Medical Centre (Amsterdam) because this is a retrospective study of patient's records. This study was completed in accordance with the Helsinki Declaration as revised in 2013.

Informed consent

Informed consent was not sought for the present study, because the data was collected retrospectively and is not reducible to individual persons.

Guarantor

PN

Contributorship

PN conceived the study. MB collected data, performed analysis and wrote the first draft of the manuscript. LK performed analysis and edited the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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Supplemental Material

Supplemental material for this article is available online.

References

1. Benjamin EJ, Muntner P, Alonso A, et al. Lic VS on behalf of the AHAC on E and PSC and SSS. Heart disease and stroke statistics – 2019 update: a report from the American Heart Association. *Circulation* 2019; 139: e1–e473.
2. Lovett JK, Coull AJ and Rothwell PM. Early risk of recurrence by subtype of ischemic stroke in population-based incidence studies. *Neurology* 2004; 62: 569–573.
3. Ois A, Cuadrado-Godia E, Rodríguez-Campello A, et al. High risk of early neurological recurrence in symptomatic carotid stenosis. *Stroke* 2009; 40: 2727–2731.
4. Fairhead JF, Mehta Z and Rothwell PM. Population-based study of delays in carotid imaging and surgery and the risk of recurrent stroke. *Neurology* 2005; 65: 371–375.
5. Admani AK, Mangion DM and Naik DR. Extracranial carotid artery stenosis: prevalence and associated risk factors in elderly stroke patients. *Atherosclerosis* 1991; 86: 31–37.
6. Wolma J, Nederkoorn PJ, Goossens A, et al. Ethnicity a risk factor? The relation between ethnicity and large- and small-vessel disease in White people, Black people, and Asians within a hospital-based population. *Eur J Neurol* 2009; 16: 522–527.
7. De Weerd M, Greving JP, Hedblad B, et al. Prediction of asymptomatic carotid artery stenosis in the general population: identification of high-risk groups. *Stroke* 2014; 45: 2366–2371.
8. Al-Khaled M and Scheef B. Symptomatic carotid stenosis and stroke risk in patients with transient ischemic attack according to the tissue-based definition. *Int J Neurosci* 2016; 126: 888–892.
9. Mannu GS, Kyu MM, Bettencourt-Silva JH, et al. Age but not ABCD2 score predicts any level of carotid stenosis in either symptomatic or asymptomatic side in transient ischaemic attack. *Int J Clin Pract* 2015; 69: 948–956.
10. Tang H, Quertermous T, Rodriguez B, et al. Genetic structure, self-identified race/ethnicity, and confounding in case-control association studies. *Am J Hum Genet* 2005; 76: 268–275.
11. Ferguson GG, Eliasziw M, Barr HWK, et al. The North American Symptomatic Carotid Endarterectomy Trial – surgical results in 1415 patients. *Stroke* 1999; 30: 1751–1758.
12. Grant EG, Benson CB, Moneta GL, et al. Carotid artery stenosis: gray-scale and Doppler US diagnosis – Society of Radiologists in Ultrasound Consensus Conference. *Radiology* 2003; 229: 340–346.
13. Wardlaw JM, Chappell FM, Stevenson M, et al. Accurate, practical and cost-effective assessment of carotid stenosis in the UK. *Health Technol Assess*. 2006; 10(30): iii–182. doi:10.3310/hta10300.