Prevalence of Intracranial Atherosclerotic Stenosis Using High-Resolution Magnetic Resonance Angiography in the General Population

The Atherosclerosis Risk in Communities Study

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Background and Purpose—Intracranial atherosclerotic stenosis (ICAS) is a common cause of stroke, but little is known about its epidemiology. We studied the prevalence of ICAS and its association with vascular risk factors using high-resolution magnetic resonance angiography in a US cardiovascular cohort.

Methods—The Atherosclerosis Risk in Communities (ARIC) study recruited participants from 4 US communities from 1987 to 1989. Using stratified sampling, we selected 1980 participants from visit 5 (2011–2013) for high-resolution 3T-magnetic resonance angiography. All images were analyzed in a centralized laboratory, and ICAS was graded as: no stenosis, <50% stenosis, 50% to 69% stenosis, 70% to 99% stenosis, and complete occlusion. We calculated per-vessel and per-person prevalence of ICAS (weighted for n=6538 visit 5 participants) and also estimated the US prevalence. We used multivariable logistic regression to identify variables independently associated with ICAS.

Results—Subjects who had an adequate magnetic resonance angiography (n=1765) were aged 67 to 90 years, 41% were men, 70% were white, and 29% were black. ICAS was prevalent in 31% of participants and 9% had ICAS ≥50%. Estimated US prevalence of ICAS ≥50% for 65 to 90 years old was 8% for whites and 12% for blacks. Older age, black race, higher systolic blood pressure, and higher low-density lipoprotein cholesterol levels were associated with increased odds of ICAS, whereas higher levels of high-density lipoprotein cholesterol and use of cholesterol-lowering medications were associated with decreased odds of ICAS. Body mass index and smoking were not associated with ICAS.

Conclusions—The prevalence of ICAS in older adults is high, and it could be a target for primary prevention of stroke and dementia in this population. **(*Stroke*. 2016;47:1187-1193. DOI: 10.1161/STROKEAHA.115.011292.)**

Key Words: intracranial atherosclerosis stenosis ■ intracranial stenosis ■ magnetic resonance angiography ■ prevalence

Intracranial atherosclerotic stenosis (ICAS) is responsible for ≈8% of ischemic strokes and 34% of dementia diagnoses in the United States[1,2] Despite targeted reduction of LDL-cholesterol using statins, treatment of hypertension, and use of antiplatelet agents, the risk of recurrent ischemic stroke is ≈14% over 1 year for patients with severe ICAS.[3] Intracranial atherosclerosis may also be a major contributor to variations in stroke incidence and mortality[4] and to disparities in stroke burden among minority populations in the United States Among patients with brain ischemic events, Asians[5–7] and blacks[8–10] had disproportionately more intracranial atherosclerosis than Whites. ICAS is also thought to be associated with cognitive deficits of varying severity, including impaired executive function, slowing of activity and thinking, and even anterograde amnesia.[4]

Despite its clinical importance, there is minimal data, especially in the United States, about the prevalence of ICAS. Estimates of the prevalence of ICAS are based either on autopsy series or on the detection of arterial calcification, magnetic resonance angiography (MRA) of selected

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asymptomatic subjects or transcranial Doppler (TCD) studies in population-based surveys.[11] Two Chinese studies have reported population-based prevalence of ICAS based on TCD examination of a single-community door-to-door survey.[12,13] Other Asian and European studies have used MRA, which has better accuracy for identification of ICAS than TCD,[14] but in a selected group of asymptomatic subjects.[15,16] The prevalence of ICAS in the United States may be different from other regions and within various racial and ethnic groups.[17] A small pilot study of 99 US elderly subjects estimated the prevalence of ICAS to be 16%.[18]

Given the paucity of data, and the prominent role of ICAS in ischemic stroke and dementia, we performed a cross-sectional evaluation using MRA in a well-defined community-based cohort. The large sample size and standardized ascertainment of demographic and clinical characteristics of the cohort also allowed an assessment of risk factors for ICAS.

Methods

Study Population

The Atherosclerosis Risk in Communities (ARIC) cohort initially comprised 15 792 participants aged 45 to 64 years recruited in 1987 to 1989 randomly selected from 4 communities: Forsyth County, NC; Jackson, MS; suburban Minneapolis, MN; and Washington County, MD. From 2011 to 2013, the ARIC study conducted the fifth follow-up examination. Among 10 036 participants who were still alive at the time of study, 6538 (65%) took part in visit 5. From those with no known contraindications to MRA, we offered scans to: (1) those who had received an ARIC brain MR scan in 2004 to 2006, (2) those with low-current cognitive test scores or large declines on the longitudinally administered tests, and (3) an age-stratified random sample of the remaining individuals. The goal was to achieve MRA scans in ≈2000 participants. We added high-resolution magnetic resonance imaging (MRI) sequences to identify plaque and measure the intracranial vessel wall, lumen area, and plaque when present. The study was approved by the institutional review board at each field site, and all participants provided written informed consent.

MRA Protocol and Image Analysis

A total of 1959 participants completed the MRA as per protocol. Details of MRI protocol, image analysis, quality control, and reliability have been reported.[19] Percent agreement was 94.4% (inter-reader), 93.8% (intrareader), and 93.2% (interscan) for ordinal stenosis (article submitted and under review). All MRI scans were performed on 3.0T Siemens scanners. High-resolution vascular sequences were acquired at the end of a standardized brain MRI protocol and included a 3-dimensional (3D) time-of-flight MRA. The 3D time-of-flight MRA was acquired in a transverse plane through the circle of Willis, centered to include the distal vertebral artery segments inferiorly and the middle cerebral artery (MCA) branches superiorly. Acquired resolution was 0.50×0.50 mm^2, and slice thickness was 0.55 mm. MRI images were analyzed by 7 certified readers at the MRI reading center without knowledge of the participant characteristics. We excluded studies with poor image quality or poor protocol adherence (n=194). MRA images for the remaining participants had adequate or excellent quality for ICAS identification in the vessels of interest and were included in the current analysis.

Vessel segments analyzed included the supraclinoid and cavernous segments of the internal carotid artery (ICA), MCA (M1–M4 segments), anterior cerebral artery (A1–A3 segments), intracranial segments of the vertebral artery, basilar artery, and posterior cerebral artery (PCA, P1–P3 segments). For each territory, the ordinal degree of narrowing (ie, no detectable stenosis, <50%, 51%–70%, 71%–99%, and occlusion) was recorded for the most stenotic plaque, measured on time-of-flight MRA images using criteria established in the Warfarin–Aspirin Symptomatic Intracranial Disease trial.[20] Since the objective of the study was to report intracranial stenosis prevalence, lesions noted to have plaque but without any measurable stenosis were not included. We identified the most stenotic segment of each vessel analyzed, and used the severity of most stenotic lesion in each participant to determine the per-person prevalence of intracranial stenosis.

Demographic and Clinical Risk Factors

Clinical risk factors were assessed at the time of visit 5 examination and included history of smoking (current, past, or never), use of antihypertensive or cholesterol-lowering medications, body mass index (BMI, kg/m^2), prevalent myocardial infarction, prevalent stroke, systolic blood pressure (SBP), plasma low–density lipoprotein (LDL) cholesterol, plasma high–density lipoprotein (HDL) cholesterol, and plasma triglycerides. We defined hypertension as blood pressure ≥140/90 mm Hg or use of antihypertensive medications and diabetes as fasting glucose ≥126 mg/dL, nonfasting glucose ≥200 mg/dL, use of antidiabetic medications, or a self-reported physician diagnosis of diabetes mellitus.

Analysis

Weights based on the probability of being sampled for the MRI examination were applied to adjust for the stratified sampling design and thus estimate the prevalence of ICAS in all ARIC participants alive at visit 5. To estimate age- and sex-adjusted prevalence of ICAS in the US white and black populations (based on US census, 2010), we extrapolated using the following age groups: 65 to 69, 70 to 74, 75 to 79, 80 to 84, and 85 to 90 years.

To determine the independent associations of demographic and clinical variables with any-ICAS or ICAS >50% (compared with no ICAS), we computed odds ratios (ORs) using logistic regression. We examined the following variables in the regression analysis: age, sex, race (white and black), BMI, hypertension, diabetes mellitus, LDL-cholesterol, smoking status, SBP, use of antihypertensive medication, triglycerides, HDL-cholesterol, and use of cholesterol-lowering medications. Because the definition of hypertension was based on SBP and use of antihypertensive medications, to avoid collinearity in analysis we excluded hypertension from the primary model. All analyses were done using SAS version 9.3 (SAS Institute, Cary, NC) and R version 3.0.2.[21] R package survey[22] and SAS PROC SURVEYLOGISTIC were used to adjust for stratification weights for all regression analysis.

Results

The mean age (±SD) of the 1765 participants with adequate quality MRA was 76±5 years, 732 (41%) were men, 1242 (70%) were white, 520 (29%) were black, and 3 were categorized as other races. Sixty (3%) participants had history of stroke and 164 (9%) had history of myocardial infarction. Compared with participants who had adequate quality MRA, participants with inadequate quality MRA (n=194) were more likely to be women and white, to have a higher BMI, and to have diabetes mellitus or hypertension (Table I in the online-only Data Supplement). There was no statistically significant difference between the 2 groups in regard to smoking status, LDL levels, history of myocardial infarction, or history of stroke.

Per-person prevalence (Table 1) of ICAS ≥50% was 9% (95% confidence interval, 8%–10%) and ICAS ≥70% was 5% (95% confidence interval, 4%–5%). After excluding subjects with history of stroke (n=60), prevalences of ICAS ≥50% and ≥70% were 9% and 4%, respectively. Among all vessels included in the analysis, ICAS was most prevalent in ICA (16%). However, ICAS ≥50% was most commonly identified in PCA (4%). About 52% of the participants with any-ICAS had >1 lesions (Figure). After age and sex adjustment to the 2010 US population[23] by direct

Table 1. Counts and Weighted Prevalence (To the Entire ARIC Visit 5 Cohort, 2011–2013) Per-Vessel Type of ICAS, According to Severity of Stenosis Identified, in n=1765 Participants

	≥50% Stenosis (%)	51%–69% Stenosis (%)	71%–99% Stenosis (%)	Total Occlusion (%)
MCA	38 (1.7)	28 (1.1)	8 (0.6)	2 (0.1)
ICA	31 (1.5)	25 (1.2)	2 (0.1)	4 (0.3)
BA	15 (0.7)	12 (0.6)	2 (0.1)	1 (0.03)
VA	49 (2.4)	11 (0.5)	16 (0.6)	22 (1.2)
ACA	19 (0.9)	10 (0.4)	9 (0.5)	0 (0)
PCA	86 (4.0)	45 (2.1)	37 (1.8)	4 (0.2)
Total	188 (9.0)	94 (4.2)	64 (3.1)	30 (1.7)

ACA indicates anterior cerebral artery (A1 segment); ARIC, Atherosclerosis Risk in Communities; BA, basilar artery; ICA, intracranial segment of internal carotid artery (intracranial segments); ICAS, intracranial atherosclerotic stenosis; MCA, middle cerebral artery (M1–M3 segments); PCA, posterior cerebral artery (P1–P3 segments); and VA, vertebral artery (intracranial segment).

standardization,[24] the estimated prevalence of ICAS ≥50% for the US population aged 65 to 90 years was 8% for whites and 12% for blacks.

Table 2 shows the prevalence of ICAS according to demographic characteristics and vascular risk factors. Patients with ICAS were more likely to be older, men, and black; and more likely to have diabetes mellitus, hypertension, and treatment for hypertension. BMI, SBP, triglycerides, and LDL-cholesterol were higher; and HDL and cholesterol medication use were lower in those with ICAS. There was no statistically significant difference in the cigarette smoking status between those with and without ICAS. The odds of ICAS were 1.9× higher in those with a history of myocardial infarction and 4.3× higher in those with a history of stroke, compared with their counterparts without these disease histories.

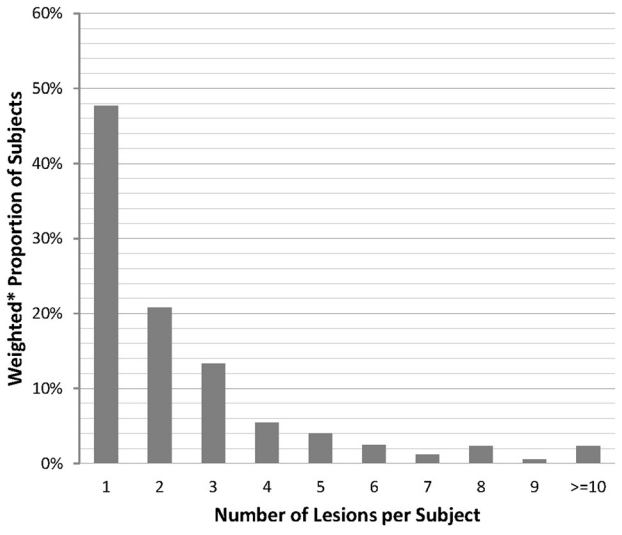

Figure. Per-person number of ICAS lesions (all vessels) in participants with at least 1 lesion (n=641), Atherosclerosis Risk in Communities (ARIC), 2011 to 2013. *Weighted to all ARIC visit 5 participants.

Risk factors association with any-ICAS and ICAS ≥50% after multiple logistic regression analysis are shown in Table 3. Odds of any-ICAS were higher for greater age, black race (compared with whites), greater SBP, greater LDL, and lesser HDL. Inclusion of field center (after excluding race) in regression model did not affect the association of other variables. In separate analysis (not shown), after excluding the use of antihypertensive medication and including hypertension, odds of any-ICAS were >30% in those with hypertension. After excluding LDL and HDL, the use of cholesterol-lowering medication was significantly associated with lower odds of any-ICAS (OR, 0.69; 95% confidence interval, 0.52–0.92). There was no change in association of LDL and HDL after excluding cholesterol-lowering medications.

Age and race were more strongly associated with ICAS ≥50% than to any-ICAS. Association of other variables with ICAS ≥50% was similar to any-ICAS. We also repeated the regression model after excluding participants with previous history of myocardial infarction or stroke and noted no change in associations.

Discussion

In this general population study of 4 US communities, the prevalence of ICAS in at least 1 artery was 31%, and 9% of participants had ICAS with 50% or more stenosis. Age, black race, diabetes mellitus, hypertension, greater LDL-cholesterol levels, greater triglyceride levels, and lesser HDL levels were associated with the presence of ICAS. Smoking status was not associated with prevalent ICAS.

Prevalence of ICAS

The 31% prevalence of ICAS—a common cause for ischemic stroke[1,25]—is much higher than that reported in other studies, which all used TCD.[12,13,15,18] Wong et al found the prevalence of ICAS in a door-to-door survey of inhabitants ≥40 years in a Chinese village to be 6.9%.[12] Huang et al,[13] in a larger (n=1068) and similar study, reported a prevalence of ICAS in the MCA of 5.9%. We performed a small (n=99) population-based study in the Twin Cities (mean age of 72 years) and noted the prevalence of ICAS to be 16%, and ICAS ≥50% was 6%.[18] Recently, Lopez-Cancio et al[15] studied the prevalence of ICAS in a Spanish cardiovascular cohort participants (n=933, mean age 66 years) with vascular risk factors. ICAS was identified in 8.6%, and 3.3% had moderate–severe stenosis. Although participants in this study were selected using a stratified random sampling from a cardiovascular cohort, they were not selected based on their vascular risk factors or history of cardiovascular disease. Our sample was older than previous studies and expected to have higher prevalence of ICAS. The accuracy of 1.5T-MRA is better than TCD for detecting ICAS.[14] The reported accuracy of 3T-MRA for ICAS, using digital subtraction angiography as gold-standard, is even higher than 1.5T-MRA.[14,26] To further improve the accuracy of our image analysis, we excluded all MRAs for which quality was considered inadequate. In addition, we were able to include vessel segments that are small and distal and cannot be investigated with TCD techniques. Thus, the prevalence

Table 2. Association of Demographic and Clinical Variables With ICAS, ARIC, 2011 to 2013

	No ICAS*†	Any-ICAS*†	Any vs No ICAS; *P* Value	ICAS ≥50%*†	≥50% vs No ICAS; *P* Value
Age (mean±SD)	75±5	76±5	<0.0001	78±5	<0.0001
Sex					
Men	67%	33%	Reference	10%	Reference
Women	71%	29%	<0.0001	8%	0.005
Race					
White	71%	29%	Reference	8%	Reference
Black	63%	37%	<0.0001	12%	<0.0001
Other	67%	33%	0.4	0%	0.3
Body mass index (mean±SD, kg/m^2)	28±5	28±6	0.05	29±6	0.01
Diabetes mellitus					
No	71%	29%	Reference	8%	Reference
Yes	64%	36%	<0.0001	11%	0.0013
Hypertension					
No	77%	23%	Reference	6%	Reference
Yes	67%	33%	<0.0001	10%	<0.0001
SBP (mean±SD, mm Hg)	129±17	133±20	<0.0001	135±19	<0.0001
Use of antihypertensive medication					
No	73%	27%	Reference	7%	Reference
Yes	68%	33%	<0.0001	10%	0.0004
Triglycerides (mean±SD, mg/dL)	124±53	133±71	<0.0001	142±89	<0.0001
LDL-cholesterol (mean±SD, mg/dL)	106±35	108±36	0.11	108±37	0.39
HDL-cholesterol (mean±SD, mg/dL)	54±15	50±12	<0.0001	51±15	<0.0001
Use of cholesterol-lowering medication in past 4 wk					
No	68%	32%	Reference	9%	Reference
Yes	71%	30%	0.01	9%	0.6
Cigarette smoking status					
Never	70%	30%	Reference	9%	Reference
Past	70%	30%	0.8	9%	0.6
Current	71%	29%	0.8	9%	0.9
Prevalent myocardial infarction					
No	71%	30%	Reference	9%	Reference
Yes	56%	44%	<0.0001	13%	0.01
Prevalent stroke					
No	70%	30%	Reference	9%	Reference
Yes	33%	67%	<0.0001	26%	<0.0001
Field center					
Forsyth Co, NC	71%	30%	…	7%	…
Jackson, MS (blacks)	63%	37%	…	13%	…
Minneapolis suburbs	70%	30%	…	8%	…
Washington Co, MD	73%	27%	…	9%	…

ARIC indicates Atherosclerosis Risk in Communities; HDL, high-density lipoprotein cholesterol; ICAS, intracranial atherosclerotic stenosis; LDL, low-density lipoprotein; and SBP, systolic blood pressure.

*For categorical variables—prevalence of ICAS per-person (based on most stenotic lesion) weighted for all ARIC visit 5 participants.

†For continuous variables—weighted mean±SD.

Table 3. Odds Ratios (OR) and 95% Confidence Intervals of Any-ICAS and ICAS ≥50% for Selected Risk Factors in Logistic Regression Analysis (Weighted for Entire ARIC Visit 5 Cohort, 2011–2013)

	OR (95% Confidence Interval)	
	Any-ICAS	ICAS ≥50%
Age (every 1 y greater)	1.06 (1.03–1.09)	1.11 (1.08–1.15)
Sex (vs men)	0.83 (0.61–1.12)	0.69 (0.44–1.07)
Black and others (vs whites)	1.46 (1.07–1.98)	1.70 (1.09–2.64)
BMI (every 5 kg/m^2 greater)	1.02 (0.89–1.18)	1.19 (0.98–1.44)
Diabetes mellitus (vs no)	1.21 (0.88–1.66)	1.12 (0.71–1.78)
SBP (every 10 mm Hg greater)	1.11 (1.02–1.20)	1.10 (0.99–1.23)
Use of antihypertensive medication	1.17 (0.85–1.60)	1.17 (0.74–1.86)
Triglycerides (every 10 mg/dL greater)	1.01 (0.99–1.04)	1.05 (1.00–1.09)
LDL-cholesterol (every 10 mg/dL greater)	1.05 (1.00–1.09)	1.02 (0.95–1.09)
HDL-cholesterol (every 10 mg/dL greater)	0.87 (0.77–0.97)	0.98 (0.81–1.19)
Use of cholesterol-lowering medication (vs no)	0.79 (0.59–1.07)	0.96 (0.61–1.50)
Cigarette smoking status		
Current vs never	0.91 (0.50–1.65)	1.25 (0.50–3.16)
Past vs never	0.96 (0.72–1.27)	0.92 (0.62–1.38)
Prevalent myocardial infarction (vs no)	1.47 (0.93–2.31)	1.10 (0.60–2.02)
Prevalent stroke (vs no)	4.64 (2.25–9.55)	3.04 (1.43–6.44)

Models included all the variables in the table simultaneously. ARIC indicates Atherosclerosis Risk in Communities; HDL, high-density lipoprotein cholesterol; ICAS, intracranial atherosclerotic stenosis; LDL, low-density lipoprotein; and SBP, systolic blood pressure.

of ICAS noted in our study was not only expected to be higher but also more accurate than previously reported.

We estimated the prevalence of ICAS to be 29% and 37% for US elderly whites and blacks, respectively. This is the first large study to estimate the prevalence of ICAS among different races in the United States. Baker et al[17] studied intracranial atherosclerosis in 3942 autopsies in Minneapolis, MN. More than 90% of specimens, for subjects aged 70 to 90 years, were noted to have some degree of intracranial atherosclerosis. McGarry et al[8] inspected 1093 randomly selected specimens in New Orleans, LA. For those aged 65 to 69 years, on average, whites had 8%, black men had 32%, and black women had 20% of intracranial vasculature covered with plaque. Intracranial atherosclerosis detected in these studies includes both stenotic and nonstenotic plaques, whereas we measured only stenotic intracranial atherosclerosis with MRA. Therefore, these studies cannot be used to estimate the prevalence of stenotic intracranial atherosclerosis, and cannot be directly compared with our study. In addition, because of increased mortality in subjects with ICAD,[4] the autopsy studies are biased toward artifactually higher prevalence of intracranial atherosclerosis. Other US-based studies investigating the prevalence of ICAS were limited because of selection bias or small samples.[18,27,28]

Per-Vessel Prevalence of ICAS

There are limited data about the per-vessel prevalence of intracranial atherosclerosis. In an autopsy study, Baker et al[29] noted that the most common locations for intracranial atherosclerosis were the basilar artery and ICA, followed by the PCA. Homburg et al[27] studied ICAS in patients with brain ischemic events and noted that the PCA was one of the most common location for ICAS. Our observation was similar to these studies. ICAS was more common in vessels with known larger diameters[30]—the ICA followed by MCA, vertebral artery, and basilar artery. However, the high prevalence of ICAS noted in PCA, in our and in previous studies, is an exception to this observation. It seems that the PCA has a higher predilection for ICAS compared with other intracranial vessels.

Association of ICAS With Demographic and Vascular Risk Factors

Vascular risk factors were associated with ICAS in the expected directions. Blacks had higher odds of ICAS compared with whites. Sacco et al[1] noted that pathogenesis for stroke is more likely to be ICAS in blacks compared with whites. Waddy et al[31] compared the incidence of stroke between white and black patients enrolled in the Warfarin-Aspirin Symptomatic Intracranial Disease (WASID) trial. Blacks were 50% more likely to have an ischemic stroke during follow-up than whites. Our study suggests that an important reason why blacks have higher odds of stroke compared with whites is their higher prevalence of ICAS.

Previous studies noted higher magnitude of association of ICAS with hypertension (OR, 1.8–9.2) than identified in our study.[12,13,15] There was also a strong association of diabetes mellitus (2.9–5.9) to ICAS in these studies, whereas we failed to identify an association. This could be because of differences in race, community, and age compared with our study. In addition, many ARIC hypertensives were treated to normal blood pressure and the sample had a high prevalence of lipid-lowering medication, all of which could reduce the ORs for hypertension and diabetes mellitus. Higher LDL and lower HDL-cholesterol were independently associated with the presence of ICAS. These associations were not identified in previous studies. Again, this could be because of difference in population characteristics, but a larger sample size and a higher prevalence of ICAS in our sample, compared with previous studies, also increases the power of our study to identify associations of smaller magnitude.

After excluding LDL and HDL, use of cholesterol-lowering medications was independently associated with 31% lower odds of ICAS in our study. Use of statins has been shown to slow the progression, and even cause regression of atherosclerosis in noncerebral circulations.[32–34] Statins have been shown to reduce stroke incidence in clinical trials[35] and may prevent ICAS.

Surprisingly, cigarette smoking status was not associated with ICAS. Because our study population was elderly, the sample size of current smokers was small (only 5%) and

selective attrition of smokers before old age may play a role. Also, among former smokers, there is a wide variation in the time because they quit smoking, thus affecting the risk factor exposure. Our study sample had only 5% subjects who are current smokers when compared with the 9.5% of US population aged ≥65 years in 2010.[36] It is possible that we could not find an association with smoking because of selection bias, that is, subjects who are smokers and had ICAS were more sick and were unable to come for the examination. Interestingly, Lopez-Cancio et al,[15] Wong et al,[12] and Huang et al[13] also did not find any association of smoking with ICAS.

Despite lower prevalence of ICAS ≥50% (9%) compared with any-ICAS (31%), associations of age and race were stronger with ICAS ≥50%. Because ICAS ≥50% is a more specific and severe outcome measure, this adds credibility to these associations. Associations of other variables remained similar but lost statistical significance in some, likely because of loss of power and broadening of confidence interval.

Limitations

Although the original ARIC cohort was a population sample of 4 US communities, most of the blacks (93%) were from Jackson, MS. The prevalence of diabetes mellitus and hypertension in our sample was similar to what has been reported for the US elderly population.[37,38] However, participants included in the analysis tended to have fewer risk factors for ICAS than those excluded for an inadequate MRA. ARIC cohort was not designed to estimate prevalence of disease in the US population. Because there were no good estimates of ICAS in the US population, we used age and sex adjustment to best estimate the prevalence of ICAS in the United States. Risk factor associations were based on cross-sectional analyses and may not reflect those that might be obtained prospectively and especially in a sample never treated with antihypertensive or antihyperlipidemic medications. We reported ORs as magnitudes of association. However, as the prevalence of any-ICAS was high (31%), ORs would markedly overestimate the prevalence ratios. Compared with digital subtraction angiography, MRA can overestimate degree of stenosis in the cavernous segment of ICA, distal ICA bifurcation, or MCA bifurcation area.[26] We did not perform digital subtraction angiography to validate stenosis measurements. Our MRA scans were acquired at 3T using a relatively high-resolution technique (0.5 mm×0.5 mm×0.55 mm), minimizing the effects of dephasing artifacts that would exaggerate stenosis. Furthermore, unlike MRA studies, there are no population studies based on DSA measurements that we could use to reference our reported measurements. We did not study concurrent extracranial carotid stenosis, and based on our study, cannot comment if risk factor profile for intra- and extracranial stenosis is different.

Conclusions

This is the first study to estimate the burden of ICAS (9% prevalence for ICAS ≥50%) and study the association of main risk factors associated with ICAS in a large US population–based sample of older adults. The higher prevalence of ICAS in blacks helps to explain the higher likelihood of ICAS being the cause of stroke compared with whites. Finding the use of cholesterol-lowering medications to carry 31% lower odds of ICAS, compared with nonuse, raises the possibility of a protective role for statins, which needs further study.

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Disclosures

Owner ship interest by Dr Wasserman: 3-dimensional black blood MRI technique used (patent pending No. 13/822,111). There has been no royalties or licensing derived from this pending application. The other authors report no conflicts.

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