Prevalence of Asymptomatic Carotid Artery Stenosis in the General Population
An Individual Participant Data Meta-Analysis

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Background and Purpose—In the discussion on the cost-effectiveness of screening, precise estimates of severe asymptomatic carotid stenosis are vital. Accordingly, we assessed the prevalence of moderate and severe asymptomatic carotid stenosis by age and sex using pooled cohort data.

Methods—We performed an individual participant data meta-analysis (23,706 participants) of 4 population-based studies (Malmö Diet and Cancer Study, Tromsø, Carotid Atherosclerosis Progression Study, and Cardiovascular Health Study). Outcomes of interest were asymptomatic moderate (≥50%) and severe carotid stenosis (≥70%).

Results—Prevalence of moderate asymptomatic carotid stenosis ranged from 0.2% (95% CI, 0.0% to 0.4%) in men aged <50 years to 7.5% (5.2% to 10.5%) in men aged ≥80 years. For women, this prevalence increased from 0% (0% to 0.2%) to 5.0% (3.1% to 7.5%). Prevalence of severe asymptomatic carotid stenosis ranged from 0.1% (0.0% to 0.3%) in men aged <50 years to 3.1% (1.7% to 5.3%) in men aged ≥80. For women, this prevalence increased from 0% (0.0% to 0.2%) to 0.9% (0.3% to 2.4%).

Conclusions—The prevalence of severe asymptomatic carotid stenosis in the general population ranges from 0% to 3.1%, which is useful information in the discussion on the cost-effectiveness of screening. (Stroke. 2010;41:1294-1297.)

Key Words: carotid stenosis ■ epidemiology ■ stroke

Studies have reported an annual stroke risk of approximately 2% to 5% for patients with severe asymptomatic carotid stenosis (ACAS). Two randomized controlled trials in subjects with ACAS showed a benefit from carotid endarterectomy in men, whereas uncertainty persisted in women. These prompted the discussion on noninvasive screening for ACAS in the general population. Because precise and valid prevalence estimates are important for recommendations regarding population-based screening, we initially sought to determine age- and sex-specific prevalence estimates for ACAS through systematic literature review and meta-analysis. However, good stratified estimates appeared difficult to extract due to the variety of definitions used for ACAS. Therefore, we set out to determine the prevalence of moderate and severe ACAS in the general population using individual participant data from 4 population-based cohort studies.

Methods

Data from 4 population-based studies of clinically asymptomatic patients were used; these cohorts have been previously detailed elsewhere. In brief, the Tromsø Study is a population-based prospective study in Tromsø, Norway. All inhabitants aged 55 to 74 years and 5% to 10% samples of other 5-year-age groups aged ≥25 years were invited. In total, 6727 participants (attendance rate 77%) were screened and informed consent was obtained from 6659 participants. In the population-based Malmö Diet and Cancer Study (MDCS), a total of 28,449 participants attended between 1991 and 1996 (attendance rate 41%). A random sample of 6103 (20%) participants had an ultrasound examination. In the Carotid Atherosclerosis Progression Study (CAPS), members of a German primary healthcare scheme were invited of whom 6962 participants (attendance rate 21%) agreed to take part. The Cardiovascular Health Study is a community-based, prospective study of people aged ≥65 years including 5888 subjects (attendance rate 57%).

The following baseline characteristics were recorded: age, sex, history of vascular disease, body mass index, waist–hip ratio, blood pressure, hypertension, diabetes mellitus, smoking status, blood
lipids, and methods of measuring stenosis. Hypertension was defined as ≥140/90 mm Hg or treatment with antihypertensive drugs. Diabetes mellitus was defined as self-reported or fasting blood glucose level ≥7 mmol/L or treatment with insulin or oral glucose-lowering drugs. Hyperlipidemia was defined as total cholesterol ≥5.0 mmol/L, low-density lipoprotein cholesterol ≥3.0 mmol/L, or use of lipid-lowering medication.13 Moderate ACAS was defined as ≥50% stenosis and severe ACAS as ≥70% stenosis measured by Doppler ultrasonography supported by B-mode sound imaging in 3 of the 4 studies (Table). When both carotid arteries were measured, we used the largest stenosis observed.14

We determined the prevalence of moderate and severe ACAS by age and sex in the complete data set and among those without a history of coronary heart disease or cerebrovascular disease. We assessed whether the overall prevalence estimates differed among current smokers, hyperlipidemic, hypertensive, and diabetic subjects or the combination of ≥1 of these vascular risk factors compared with those without risk factors.

## Results

General characteristics are shown in the Table. In men, the prevalence of moderate ACAS increased with age from 0.2% (95% CI, 0.0% to 0.4%) to 7.5% (5.2% to 10.5%); for severe ACAS, the prevalence increased from 0.1% (0.0% to 0.3%) to 3.1% (1.7% to 5.3%); Figure 1; Supplemental Table I, available at http://stroke.ahajournals.org). For women, the prevalence of moderate ACAS increased from 0% (0.0% to 0.2%) to 5.0% (3.1% to 7.5%); for severe ACAS, this prevalence increased from 0% (0.0% to 0.2%) to 0.9% (0.3% to 2.4%). The prevalence estimates were similar in participants without a history of vascular disease until the age of 60 years. In participants without a history of vascular disease aged ≥60 years the prevalence of severe stenosis was lower. (Supplemental Table II, available at http://stroke.ahajournals.org). The prevalence of severe ACAS was higher in participants with vascular risk factors (Figure 2).

### Discussion

The prevalence of moderate ACAS varied from 0% to 7.5% and the prevalence of severe ACAS from 0% to 3.1%. Prevalence estimates increased with age and were slightly higher in men.

Age- and sex-specific estimates in the present study are smaller than the prevalence estimates reported in our previous literature-based meta-analysis.7 These differences in prevalence may have been introduced by the selection process of individual papers in the literature-based meta-analysis. Only a few studies reported age- and sex-specific data.7 These aspects were overcome in the present analyses in which a large number of persons was involved, giving us the ability to present a precise estimate of the ACAS prevalence by age and sex. This study has some limitations. Our meta-analysis suffers from nonparticipation in the individual cohorts. When nonresponse is related to the more sick or high-risk patients, which is supported by the nonparticipant analyses in the MDCS cohort,15 our estimates reflect an underestimation of the actual ACAS prevalence. The volunteer approach in CAPS, however, did not select participants with a particularly low vascular risk.16 Although differences exist in the methods for determination of stenosis degree between studies,9–11 the regression analyses using the Tromsø data indicated that

## Table. General Characteristics of the Study Population by Cohort

<table>
<thead>
<tr>
<th></th>
<th>Tromsø</th>
<th>MDCS</th>
<th>CAPS</th>
<th>CHS</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of participants</td>
<td>6659</td>
<td>6103</td>
<td>5056</td>
<td>5888</td>
<td>23 706</td>
</tr>
<tr>
<td>Mean age, years (SD)</td>
<td>60.2 (10.2)</td>
<td>57.5 (5.9)</td>
<td>50.1 (13.1)</td>
<td>72.8 (5.6)</td>
<td>60.5 (12.1)</td>
</tr>
<tr>
<td>Male sex, no. (%)</td>
<td>3298 (49.5)</td>
<td>2572 (42.1)</td>
<td>2471 (48.9)</td>
<td>2495 (42.4)</td>
<td>10836 (45.7)</td>
</tr>
<tr>
<td>History of disease, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coronary heart disease, no. (%)</td>
<td>822 (12.4)</td>
<td>102 (1.7)</td>
<td>108 (2.1)</td>
<td>1553 (32.8)</td>
<td>2585 (11.5)</td>
</tr>
<tr>
<td>Cerebrovascular disease, no. (%)</td>
<td>182 (2.7)</td>
<td>69 (1.2)</td>
<td>52 (1.0)</td>
<td>349 (5.9)</td>
<td>652 (2.8)</td>
</tr>
<tr>
<td>Body mass index, mean kg/m² (SD)</td>
<td>26.1 (4.0)</td>
<td>25.9 (4.0)</td>
<td>26.6 (4.1)</td>
<td>26.7 (4.7)</td>
<td>26.3 (4.2)</td>
</tr>
<tr>
<td>Waist–hip ratio, mean (SD)</td>
<td>0.87 (0.08)</td>
<td>0.85 (0.09)</td>
<td>0.95 (0.11)</td>
<td>0.93 (0.09)</td>
<td>0.90 (0.10)</td>
</tr>
<tr>
<td>Hypertension, no. (%)</td>
<td>2257 (33.9)</td>
<td>2659 (43.6)</td>
<td>706 (14.0)</td>
<td>2511 (42.7)</td>
<td>8133 (34.3)</td>
</tr>
<tr>
<td>Mean systolic blood pressure (SD)</td>
<td>145 (23)</td>
<td>141 (19)</td>
<td>128 (17)</td>
<td>137 (22)</td>
<td>138 (21)</td>
</tr>
<tr>
<td>Mean diastolic blood pressure (SD)</td>
<td>83 (13)</td>
<td>87 (9)</td>
<td>77 (10)</td>
<td>71 (11)</td>
<td>80 (13)</td>
</tr>
<tr>
<td>Diabetes, no. (%)</td>
<td>217 (3.3)</td>
<td>244 (4.2)</td>
<td>134 (2.7)</td>
<td>722 (12.3)</td>
<td>1317 (5.6)</td>
</tr>
<tr>
<td>Current smoking, no. (%)</td>
<td>2116 (31.8)</td>
<td>1618 (28.1)</td>
<td>1055 (20.9)</td>
<td>700 (11.9)</td>
<td>5489 (23.5)</td>
</tr>
</tbody>
</table>

LDL indicates high-density lipoprotein; LDL, low-density lipoprotein; NR, not reported.

Lipids, mean (SD)

| Total cholesterol, mmol/L | 6.8 (1.3) | 6.2 (1.1) | NR | 5.5 (1.0) | 6.2 (1.3) |
| HDL cholesterol, mmol/L  | 1.5 (0.4) | 1.4 (0.4) | 1.5 (0.4) | 1.4 (0.4) | 1.5 (0.4) |
| LDL cholesterol, mmol/L  | NR | 4.2 (1.0) | 3.4 (0.9) | 3.4 (0.9) | 3.6 (1.0) |
| Triglycerides, mmol/L     | 1.7 (1.1) | 1.4 (0.8) | 1.5 (1.0) | 1.6 (0.9) | 1.6 (0.9) |

Methods of measure stenosis

| Duplex ultrasonography | Yes | Yes | Yes | No |
| Lumen diameter method  | Yes | Yes | No |
| Cross-sectional lumen method | Yes | No | Yes |
different approaches were unrelated to the prevalence estimate of moderate ACAS. Therefore, it is unlikely that the different methods used to measure stenosis degree have affected our results.

For the discussion about the feasibility and cost-effectiveness of screening the general population for ACAS, our findings are important. Some reported that screening for severe ACAS was cost-effective when the prevalence of severe ACAS was at least 20%.17 Using that cutoff point and given our estimates, population screening is unlikely to become worthwhile. Yet, we recommend the development of a prediction rule estimating the risk of having severe carotid stenosis to evaluate whether we can select a high-risk group of participants that might benefit from screening.

In conclusion, the prevalence of severe ACAS in the general population ranges from 0% to 3.1%. Its prevalence increases with age and with risk factor levels. These results are of relevance for the discussion on screening for severe ACAS.

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Disclosures
None.

References
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