Prevalence of and Risk Factors for Abdominal Aortic Aneurysms in a Population-based Study

The Tromsø Study

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In a population-based study of 6,386 men and women aged 25–84 years in Tromsø, Norway, in 1994–1995, the authors assessed the age- and sex-specific distribution of the abdominal aortic diameter and the prevalence of and risk factors for abdominal aortic aneurysm. Renal and infrarenal aortic diameters were measured with ultrasound. The mean infrarenal aortic diameter increased with age. The increase was more pronounced in men than in women. The age-related increase in the median diameter was less than that in the mean diameter. An aneurysm was present in 263 (8.9%) men and 74 (2.2%) women (p < 0.001). The prevalence of abdominal aortic aneurysm increased with age. No person aged less than 48 years was found with an abdominal aortic aneurysm. Persons who had smoked for more than 40 years had an odds ratio of 8.0 for abdominal aortic aneurysm (95% confidence interval: 5.0, 12.6) compared with never smokers. Low serum high density lipoprotein cholesterol was associated with an increased risk for abdominal aortic aneurysm. Other factors associated with abdominal aortic aneurysm were a high level of plasma fibrinogen and a low blood platelet count. Antihypertensive medication (ever use) was significantly associated with abdominal aortic aneurysm, but high systolic blood pressure was a risk factor in women only. This study indicates that risk factors for atherosclerosis are also associated with increased risk for abdominal aortic aneurysm. Am J Epidemiol 2001; 154:236–44.

aneurysm; aorta, abdominal; lipoproteins, HDL cholesterol; prevalence; risk factors; ultrasonography

An abdominal aortic aneurysm presents none or few symptoms until rupture. The risk of rupture increases with the increasing diameter of the aneurysm. In those suffering a ruptured abdominal aortic aneurysm, the mortality is 60–80 percent (30–65 percent if reaching a hospital alive) (1, 2). With an elective operation, the mortality is 3–7 percent (3–7). Death from a ruptured abdominal aortic aneurysm accounts for about 1 percent of all the deaths in the Western world (8).

Several large studies have addressed the epidemiology of abdominal aortic aneurysms (8–16). Atherosclerosis is probably an important factor in the etiology of abdominal aortic aneurysm, although disturbances in the connective tissue metabolism may also be involved (9, 17–22). A number of studies have shown that abdominal aortic aneurysm and atherosclerosis share many risk factors such as age, smoking, hypercholesterolemia, and hypertension (11, 16, 23–26).

Some previous studies of abdominal aortic aneurysm have been population based (8–10, 12, 13, 27), but the definition of abdominal aortic aneurysm has differed, making comparisons of prevalence rates difficult. It has been known for more than 150 years that abdominal aortic aneurysm is four times more frequent in men than in women (28). Thus, several studies have been performed among men only (8, 11, 12, 14). Studies including both genders are important as there may be differences between the genders with regard to risk factors.

Smoking has been emphasized as an independent risk factor for abdominal aortic aneurysm (9, 16, 23, 29, 30), but only two of the larger population-based studies (9, 30) have addressed smoking in detail. The role of high density lipoprotein (HDL) cholesterol in the development of abdominal aortic aneurysm has been the subject of several studies. In most studies, high HDL cholesterol has been found to correlate with a low prevalence of abdominal aortic aneurysm (9, 18, 19, 25, 31–33), but there have also been negative findings (13). It is presently unknown whether hypertension is a risk factor for abdominal aortic aneurysm. Some studies indicate such a relation (16, 27, 29, 30, 34–36), while other studies found no association (5, 13, 14, 24).

The aim of the present report was to study the prevalence of and risk factors for abdominal aortic aneurysm, as well as...
the distribution of infrarenal aortic diameter, in both men and women in a general population.

MATERIALS AND METHODS

Study design

The Tromsø Study was started in 1974 and is a population-based, prospective study of inhabitants in the municipality of Tromsø, Norway. The aims of the study are to investigate the determinants of chronic diseases in order to assess etiologic significance and to investigate potentially modifiable determinants that may be developed into preventive or therapeutic strategies. The main focus is on cardiovascular diseases. The study design includes repeated population surveys to which total birth cohorts and random samples are invited. The regional ethical committee has approved the study.

The fourth cross-sectional survey of the Tromsø population started in September 1994 and was completed in October 1995. The study comprised two screening visits 4–12 weeks apart. All inhabitants 25 years or older were invited to the first visit, and 27,159 subjects, 77 percent of the eligible population, participated. A protocol similar to that used in the previous surveys in this population (37) was followed. The examination included standardized measurements of height, weight, blood pressure, nonfasting serum lipids, and blood cell counts. A self-administered questionnaire handed in at the screening examination covered information about current and previous cigarette smoking, physical activity in leisure time, currently or previously treated hypertension, and a medical history of angina pectoris, diabetes mellitus, asthma, myocardial infarction, and stroke. Persons were classified as having low physical activity in leisure time if they denied any high intensity physical activity and had low intensity activity less than 3 hours per week during the last year before the survey.

All subjects aged 55–74 years and a random 5–10 percent sample in the other age groups were eligible for the second visit. Eligible subjects also included a small group of men aged 40–54 years (see below) previously identified as having a high risk of coronary heart disease (38). All eligible subjects who attended the first screening were, at the first screening, invited to the second visit, which comprised inter alia ultrasonographic measurements of aortic diameters, waist and hip circumference, and blood sampling. A total of 6,892 subjects, 79 percent of those who were eligible, were subject to ultrasound measurements of the abdominal aortic diameter. The age-specific attendance rates (based on age by December 31, 1994) were 62, 81, 83, 79, and 58 percent in the age groups 25–44, 45–54, 55–64, 65–74, and 75–84 years, respectively. Thirty-seven attendees who had previously (39) multiplied by the duration of smoking (years) divided by the two last values of blood pressure was used. A venipuncture was performed with the subjects in a sitting position. A short-lasting venous stasis applied to the upper arm was released before blood sampling. Serum total cholesterol and triglycerides were analyzed by enzymatic colorimetric methods with commercial kits (CHOD-PAP for cholesterol and GPO-PAP for triglycerides; Boehringer-Mannheim, Mannheim, Germany). Serum HDL cholesterol was measured after the precipitation of lower density lipoprotein with manganese chloride. Plasma fibrinogen was measured using PT-Fibrinogen reagent (Instrumentation Laboratory, Milan, Italy). Serum creatinine was measured by the HCo Creatinine Jaffè method with a kinetic colorimetric assay on automated clinical chemistry analyzers (Boehringer-Mannheim). Glycated hemoglobin (HbA\textsubscript{1c}) was measured from the hemolysate by a latex-enhanced turbidimetric immunoassay (Unimate 3 HBA1C; Roche Diagnostics Corporation, Indianapolis, Indiana). The analyses were done at the Department of Clinical Chemistry, University Hospital of Tromsø, Norway. Hypertension was defined as a systolic blood pressure of >160 mmHg, a diastolic blood pressure of >95 mmHg, or drug treatment for hypertension (current or previous). Pack-years were calculated as the number of cigarettes smoked per day (previously or currently) multiplied by the duration of smoking (years) divided by 20.

Ultrasonography of the abdominal aorta

The ultrasonographic measurements of the abdominal aorta were performed by four examiners as described previously (39). The subjects were examined in the supine position and/or in the left decubitus position when necessary. No instructions on food or fluid intake were given prior to the examination. The examination was carried out with a 3.5-MHz sector probe (Acuson 128-XP; Acuson Corporation, Mountain View, California). The abdominal aorta was first visualized in the longitudinal plane and was examined from the diaphragm to the bifurcation. The aorta was then examined in the axial plane with scans perpendicular to the longitudinal plane. Aortic diameters were measured at the level of the renal arteries, 1 cm distal to this level, and at the bifurcation level. In addition, the maximal infrarenal aortic diameter was measured. Both transverse and anterior-posterior diameters were measured. The external aortic diameter was measured with electronic calipers in both the anterior-posterior and transverse planes. All the measurements were made before blood sampling in a separate, quiet room with only a nurse present. An automatic device (Dinamap Vital Signs Monitor 1846; Criticon, Inc., Tampa, Florida) was used. After the participant had been seated for 2 minutes, three recordings were made at 2-minute intervals. The lower of the two last values of blood pressure was used.
made online on images that were frozen in systole. The inter- and intraobserver variability was determined at the beginning and at the end of the study. Measurement variability, estimated both as the mean absolute difference between two measurements and as 2 standard deviations of the mean arithmetic difference, was less than 4 mm for measurements of the maximal infrarenal aortic diameter (39).

An abdominal aortic aneurysm was present if one or more of the following criteria were met: 1) the aortic diameter at the renal level was equal to or greater than 35 mm in either the anterior-posterior or the transverse plane; 2) the infrarenal aortic diameter was $\geq 5$ mm larger than the renal aortic diameter in either plane; and/or 3) a localized dilatation of the aorta was present. If an abdominal aortic aneurysm was suspected to be present, the patients were examined by computed tomography and referred to the Department of Cardiovascular Surgery for clinical evaluation and follow-up.

Statistical analysis

Age-adjusted characteristics of men and women with and without an abdominal aortic aneurysm were calculated using analysis of variance. Associations between abdominal aortic aneurysm and cardiovascular risk factors as well as prevalent cardiovascular diseases were determined by using multiple logistic regression. Age was included in the analysis as age at the ultrasound examination. Ninety-five percent confidence intervals were calculated. Two-sided $p$ values were used throughout, and $p < 0.05$ was considered to indicate statistical significance. The SAS software package was used (40).

RESULTS

Figure 1 summarizes descriptive measures of maximal infrarenal aortic diameter in the anterior-posterior plane measured with ultrasound. The mean maximal infrarenal anterior-posterior diameter was 22.5 (standard deviation, 5.4) mm in men and 19.1 (standard deviation, 3.3) mm in women. The difference in diameter between the genders was statistically significant ($p < 0.001$). The mean aortic diameter increased with age in both men and women ($p < 0.001$), although the increase was more pronounced in men. The median, however, did not increase much after the age of 55 years (figure 1). From the age of 55 years, there was a pronounced increase in standard deviation and skewness, particularly in men (data not shown).

An abdominal aortic aneurysm, as defined in our study, was present in 263 (8.9 percent) men and in 74 (2.2 percent) women (table 1; figure 2). The prevalence in men and women differed significantly ($p < 0.001$). Only 46 men (1.6 percent) and eight women (0.2 percent) had abdominal aortic aneurysm solely defined as a visible localized aortic dilatation, and 21 men (0.7 percent) and seven women (0.2 percent) had abdominal aortic aneurysm solely defined as a renal aortic diameter greater than 34 mm. Thus, the majority of the cases of abdominal aortic aneurysm had an infrarenal diameter of $\geq 5$ mm larger than the aortic diameter at the level of renal arteries. The prevalence of abdominal aortic aneurysm defined as a maximal infrarenal aortic diameter of $>29$ mm or $>39$ mm was 8.2 percent and 1.7 percent in men and 2.3 percent and 0.4 percent in women, respectively (table 1). There was no abdominal aortic aneurysm in subjects under the age of 48 years, and no persons under the age of 55 years had an aortic diameter above 39 mm. The prevalence of abdominal aortic aneurysm increased with age in both men and women ($p < 0.001$). Men had a 4–6 times higher prevalence of abdominal aortic aneurysm than did women, depending on the definition of abdominal aortic aneurysm (table 1).

The mean age and age-adjusted characteristics of men and women with and without abdominal aortic aneurysm are summarized in table 2. In both men and women, age and age-adjusted mean levels of waist/hip ratio, serum HDL cholesterol, serum triglycerides, plasma fibrinogen, white blood cell count, previous or present use of antihypertensive medication, physical activity in leisure time during the last
Prevalence and Predictors of Aortic Aneurysms


TABLE 1. Percentage of subjects with abdominal aortic aneurysm, maximal aortic diameter of >29 mm, and maximal aortic diameter of >39 mm by sex and age, The Tromsø Study, 1994–1995

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>No. of subjects examined</th>
<th>Abdominal aortic aneurysm*</th>
<th>Maximal aortic diameter of &gt;29 mm</th>
<th>Maximal aortic diameter of &gt;39 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men (%)</td>
<td>Women (%)</td>
</tr>
<tr>
<td>25–44</td>
<td>214</td>
<td>282</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>45–54</td>
<td>156</td>
<td>199</td>
<td>2.6</td>
<td>0.5</td>
</tr>
<tr>
<td>55–64</td>
<td>1,394</td>
<td>1,477</td>
<td>6.2</td>
<td>0.7</td>
</tr>
<tr>
<td>65–74</td>
<td>1,117</td>
<td>1,370</td>
<td>14.1</td>
<td>4.2</td>
</tr>
<tr>
<td>75–84</td>
<td>81</td>
<td>96</td>
<td>19.8</td>
<td>5.2</td>
</tr>
<tr>
<td>Total</td>
<td>2,962</td>
<td>3,424</td>
<td>8.9</td>
<td>2.2</td>
</tr>
</tbody>
</table>

* *Abdominal aortic aneurysm* was defined as a renal aortic diameter of ≥35 mm, an infrarenal aortic diameter of ≥5 mm larger than the renal level, or localized infrarenal dilation of the aorta.

year, and smoking were statistically significantly associated with abdominal aortic aneurysm. The mean weight, body mass index, serum total cholesterol, and serum creatinine were statistically significantly associated with abdominal aortic aneurysm in men only. Blood pressure was associated with the risk of abdominal aortic aneurysm in women only. In both men and women, there was no statistically significant association between the risk of abdominal aortic aneurysm and height, HbA1c, and blood platelet count.

In the multivariate model, we included variables found to be associated with the risk of abdominal aortic aneurysm with $p < 0.1$ after adjustment for age in either sex. Two variables were not, however, included: weight (correlated with body mass index, $r = 0.77$) and diastolic blood pressure (correlated with systolic blood pressure, $r = 0.72$). Systolic blood pressure and ever use of antihypertensive medication were moderately correlated ($r = 0.26$ (men) and $r = 0.37$ (women)) and were both included in the model.

The risk of abdominal aortic aneurysm increased strongly with age in the multivariate model (table 3). The waist/hip ratio was positively related to the risk of abdominal aortic aneurysm. The point estimate was higher in women but not statistically significantly different from that in men ($p > 0.2$). High serum total cholesterol was a relatively weak risk factor for abdominal aortic aneurysm, whereas high HDL cholesterol was strongly associated with a low risk of abdominal aortic aneurysm in both genders. We found that systolic blood pressure was a risk factor in women only ($p < 0.001$). As the risks of abdominal aortic aneurysm for previous and current use of antihypertensive medication were similar (results not shown), the two dichotomous variables were combined. Ever use of antihypertensive medication was associated with increased risk of abdominal aortic aneurysm in both genders (table 3) even when adjusted for current systolic blood pressure. The effect of ever use of antihypertensive medication was found in both low (systolic blood pressure of $<140$ mmHg) and high (systolic blood pressure of $\geq 140$ mmHg) blood pressure groups in both genders. We found no relation between pulse pressure and the risk of abdominal aortic aneurysm (results not shown).

Smoking, particularly current smoking, was a strong risk factor for abdominal aortic aneurysm in both genders, with a 6–7 times increased risk of abdominal aortic aneurysm in current smokers. In men, a high plasma fibrinogen level and a low blood platelet count increased the risk of abdominal aortic aneurysm significantly. Nonfasting serum triglycerides were not associated with the risk of abdominal aortic aneurysm in the multivariate model, and the association between the level of serum triglycerides and abdominal aortic aneurysm prevalence in the age-adjusted analysis was entirely explained by the inverse correlation ($r = -0.41$) with HDL cholesterol (results not shown). Body mass index, serum creatinine, white blood cell count, and physical activity in leisure time were not statistically significantly associ-

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Aneurysm present</th>
<th>Aneurysm absent</th>
<th>p value</th>
<th>Aneurysm present</th>
<th>Aneurysm absent</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>66.4 (6.1)</td>
<td>60.8 (10.0)</td>
<td>&lt;0.001</td>
<td>69.4 (5.4)</td>
<td>61.2 (10.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>175.2 (6.5)</td>
<td>171.5 (6.8)</td>
<td>0.7</td>
<td>162.1 (4.9)</td>
<td>161.5 (6.3)</td>
<td>0.4</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>81.7 (12.8)</td>
<td>79.4 (11.8)</td>
<td>0.003</td>
<td>67.8 (12.9)</td>
<td>67.6 (11.7)</td>
<td>0.9</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>26.6 (3.7)</td>
<td>25.9 (3.3)</td>
<td>0.001</td>
<td>25.8 (4.6)</td>
<td>25.9 (4.4)</td>
<td>0.7</td>
</tr>
<tr>
<td>Waist/hip ratio</td>
<td>0.94 (0.06)</td>
<td>0.92 (0.06)</td>
<td>&lt;0.001</td>
<td>0.85 (0.08)</td>
<td>0.82 (0.07)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Serum cholesterol (mmol/liter)</td>
<td>6.65 (1.13)</td>
<td>6.47 (1.19)</td>
<td>0.02</td>
<td>7.02 (1.38)</td>
<td>6.93 (1.34)</td>
<td>0.5</td>
</tr>
<tr>
<td>Serum HDL† cholesterol (mmol/liter)</td>
<td>1.28 (0.37)</td>
<td>1.42 (0.39)</td>
<td>&lt;0.001</td>
<td>1.46 (0.42)</td>
<td>1.68 (0.43)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Serum triglycerides (mmol/liter)</td>
<td>1.97 (1.07)</td>
<td>1.75 (1.12)</td>
<td>0.002</td>
<td>1.89 (1.39)</td>
<td>1.56 (0.94)</td>
<td>0.003</td>
</tr>
<tr>
<td>HbA1c† (%</td>
<td>5.48 (0.65)</td>
<td>5.47 (0.67)</td>
<td>0.7</td>
<td>5.56 (0.57)</td>
<td>5.48 (0.64)</td>
<td>0.4</td>
</tr>
<tr>
<td>Serum creatinine (mmol/liter)</td>
<td>91.1 (23.4)</td>
<td>87.8 (22.3)</td>
<td>0.02</td>
<td>71.9 (13.0)</td>
<td>70.2 (12.9)</td>
<td>0.3</td>
</tr>
<tr>
<td>Plasma fibrinogen (mmol/liter)</td>
<td>3.72 (0.91)</td>
<td>3.32 (0.88)</td>
<td>&lt;0.001</td>
<td>3.77 (0.68)</td>
<td>3.43 (0.80)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Blood platelet count (10⁹/liter)</td>
<td>232.8 (47.9)</td>
<td>239.4 (58.4)</td>
<td>0.08</td>
<td>255.4 (57.4)</td>
<td>256.0 (59.7)</td>
<td>0.9</td>
</tr>
<tr>
<td>White blood cell count</td>
<td>7.43 (1.84)</td>
<td>7.01 (1.92)</td>
<td>&lt;0.001</td>
<td>7.69 (1.95)</td>
<td>6.78 (1.78)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>83.9 (13.1)</td>
<td>82.6 (12.0)</td>
<td>0.09</td>
<td>82.1 (13.0)</td>
<td>79.1 (12.8)</td>
<td>0.04</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>143.4 (22.6)</td>
<td>142.4 (20.3)</td>
<td>0.4</td>
<td>151.3 (25.5)</td>
<td>141.4 (23.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Antihypertensive medication</td>
<td>29.1</td>
<td>17.4</td>
<td>&lt;0.001</td>
<td>36.8</td>
<td>18.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>(previous or present) (%)</td>
<td>57.4</td>
<td>66.0</td>
<td>0.006</td>
<td>40.8</td>
<td>52.3</td>
<td>0.05</td>
</tr>
<tr>
<td>Physical activity in leisure</td>
<td>41.8</td>
<td>48.9</td>
<td>0.03</td>
<td>17.4</td>
<td>26.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Previous smoking (%)</td>
<td>51.6</td>
<td>31.6</td>
<td>&lt;0.001</td>
<td>65.6</td>
<td>30.2</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* Values are means with standard deviation in parentheses or percentages.
† HDL, high density lipoprotein; HbA1c, glycated hemoglobin.

We found that the multivariate-adjusted odds ratio for abdominal aortic aneurysm increased from 1.4 (95 percent CI: 0.8, 2.4) (1–20 years) to 8.0 (95 percent CI: 5.0, 12.6) (>40 years) when never smokers were the reference group. When adjusted for duration of smoking, there were no significant associations between the number of cigarettes smoked per day and the risk of abdominal aortic aneurysm (results not shown).

The risk of abdominal aortic aneurysm decreased slowly after the cessation of smoking, and the reduction in risk was mainly due to the reduced duration of smoking. When adjusting for smoking duration, the risk of abdominal aortic aneurysm even 20 years after the cessation of smoking was not statistically significantly different from the risk for current smokers.

Subjects with abdominal aortic aneurysm were more likely to have a self-reported history of myocardial infarction, angina pectoris, or hypertension, but no relations were found with self-reported diabetes mellitus, asthma, or stroke (results not shown).

In a subgroup analysis, we included 2,336 men and 2,998 women who reported no history of myocardial infarction, angina pectoris, stroke, or diabetes. There were 158 men and 152 women with abdominal aortic aneurysm.
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49 women with abdominal aortic aneurysm. The results from this stratified analysis confirmed the strong associations of serum HDL cholesterol and smoking with the risk of abdominal aortic aneurysm in both genders, with plasma fibrinogen and blood platelet count in men, and with systolic blood pressure in women. The impact of physical activity in leisure time in men was somewhat stronger in this stratified analysis (odds ratio = 0.64; 95 percent CI: 0.45, 0.92).

**DISCUSSION**

Most previous studies on abdominal aortic aneurysm were performed among middle-aged and elderly men. Our study covered all men and women aged 55–74 years and random 5–10 percent samples of subjects aged 25–54 and 75–84 years. We confirm that abdominal aortic aneurysm is a disease with a more than four times higher prevalence in men than women and that the prevalence increases with age (10, 15).

The complex pathogenesis of abdominal aortic aneurysm is still under debate. Conventionally, the development of abdominal aortic aneurysm has been attributed to atherosclerotic degeneration of the vessel wall (21). Atherosclerosis may increase the pressure load on the vessel and decrease the capacity of the wall to bear that load, leading to the formation of an abdominal aortic aneurysm (17). Louwrens et al. (19) concluded, however, that dilating and stenosing diseases are two distinct pathologic entities. Our results indicate that the risk factors for the development of abdominal aortic aneurysm and atherosclerosis are overlapping, but they should be confirmed in a prospective study design.

All aneurysms included in our analysis were previously unknown. Thus, knowledge of abdominal aortic aneurysm has probably not influenced the risk factor levels, although some persons may have been aware of the high risk of cardiovascular diseases and changed their living habits accordingly. The results were, however, unchanged when we restricted the analysis to subjects without known cardiovascular diseases. If an abdominal aortic aneurysm persists over years, it will cause turbulence of the blood flow, which may stimulate the blood platelets and the coagulation system.
Thus, the existence of an abdominal aortic aneurysm may have increased fibrinogen and reduced platelet count. The increased plasma fibrinogen in subjects with abdominal aortic aneurysm may reflect this. A direct relation cannot, however, be excluded.

A striking finding in the present study is the highly significant relation between low HDL cholesterol and the risk of abdominal aortic aneurysm. Similar and less pronounced relations have been found in some (9, 18, 25, 31, 33), but not all (13), previous studies. The risk of having an abdominal aneurysm was 70 percent lower in subjects with a serum HDL cholesterol level of >1.79 mmol/liter compared with subjects with a serum HDL cholesterol level of <1.20 mmol/liter. It seems therefore likely that a low serum HDL cholesterol level, as a part of the atherogenic process, is a risk factor for developing an abdominal aortic aneurysm.

The blood sample was nonfasting, which has influenced the serum triglyceride level. As the misclassification is non-differential, this has attenuated any relation between serum triglycerides and the risk of abdominal aortic aneurysm. In the multivariate analysis (table 3), we found no relation between the serum triglyceride level and abdominal aortic aneurysm risk.

Smoking is strongly associated with the risk of abdominal aortic aneurysm (table 3). The duration of smoking was the most important smoking variable associated with the risk of abdominal aortic aneurysm. The number of cigarettes per day or pack-years were not statistically significantly associated with abdominal aortic aneurysm risk when adjusted for duration. Cessation of smoking reduces the risk of abdominal aortic aneurysm slowly and mainly due to the reduced duration of smoking. The present findings are in accordance with those reported by Wilmink et al. (23) in a nested case-control study and several previous studies (9, 11, 16, 17, 25–27, 41, 42), but, in a recent population-based study by Vardulaki et al. (30), the level of cigarette use was reported as a stronger risk indicator than was duration of smoking.

It is at present not clarified whether hypertension increases the risk of abdominal aortic aneurysm (13, 14, 16, 24, 25, 27, 30, 34, 35). We found a significant relation between systolic blood pressure and abdominal aortic aneurysm in women but not in men. Ever use of antihypertensive medication was significantly associated with the risk of abdominal aortic aneurysm in both genders in our study, which supports a role of hypertension, as the use of antihypertensive medication probably is a proxy measure for long-term hypertension.

Some previous reports have indicated that the diameter of the abdominal aorta increases throughout life (43, 44). Recently, it has been suggested that the diameter of the infrarenal aorta increases only in a part of the population (45). As we do not have longitudinal data, we are not able to address this question properly. However, as the median maximal infrarenal aortic diameter increases only marginally with age from the age of 55 years, our data may give some support to the notion that a substantial increase in diameter with increasing age is found in a minority of the population. The 75th percentile does, however, increase considerably with age in men. Therefore, this minority cannot be negligible.

Because of the different criteria used for the definition of abdominal aortic aneurysm, it is difficult to compare the prevalence of abdominal aortic aneurysm in different epidemiologic studies. In the present study, the criteria for the diagnosis were set to give a high sensitivity for finding an abdominal aortic aneurysm. In spite of this, we found no persons with abdominal aortic aneurysm who were aged less than 48 years. As shown in table 1, the prevalence of abdominal aortic aneurysm in men was reduced from 8.9 percent to 8.2 percent and 2.3 percent if the criteria are set to >29 mm or >39 mm of maximal infrarenal aortic diameter, respectively. In women, the abdominal aortic aneurysm prevalence was reduced from 2.2 percent to 1.7 percent and 0.4 percent, respectively, if the criteria are similarly altered. In order to compare the prevalence of abdominal aortic aneurysm from different studies, it is important that the criteria for diagnosis are given and that the measurements of the abdominal aorta are done with a high degree of precision.

In our study, the attendance rate was relatively high as the aortic diameter was measured in 79 percent of the eligible persons. However, the attendance rate in the 25–44 and 75–84 year age groups was 62 percent and 58 percent, respectively. Although the overall attendance rate is higher than in most of the published studies, still a significant number did not attend the survey. Under the age of 55 years (with a total attendance rate of 71 percent), abdominal aortic aneurysms are very rare in our population, and the low number of invited subjects precludes a more detailed analysis of possible nonresponse bias. However, such bias should not influence our finding of a low prevalence.

The majority of our subjects were aged 55–74 years. The subjects who came to the first screening of the study, but did not attend ultrasound examination, had slightly higher levels of some, but not all, cardiovascular risk factors (low HDL cholesterol and current smoking, but similar blood pressure and lower total cholesterol) than those who attended the ultrasound examination (results not shown). However, because only 11 percent of those who attended the first screening did not attend the ultrasound examination, the mean values of risk factors were very similar in those who were examined with ultrasound and those who attended the first screening only. The major possible nonresponse bias is thus connected to the 9 percent of the eligible persons who never were examined. We find it unlikely that this relatively small group of subjects can seriously bias our findings.

The lower attendance rate by subjects aged over 74 years is of some greater concern as this age group has the highest prevalence of abdominal aortic aneurysm. However, the number of subjects invited was low, and the confidence intervals were wide. Thus, bias can hardly change the finding of a high prevalence of abdominal aortic aneurysm in old people, and the relatively few subjects included in these age groups cannot materially influence the analysis of risk factors for abdominal aortic aneurysm.

In conclusion, our study shows that abdominal aortic aneurysm is a disease of the elderly that is 4–6 times more prevalent among men than women. Tobacco smoking and low concentrations of serum HDL cholesterol are strong independent risk factors for abdominal aortic aneurysm.
both genders. Our results also indicate a significant effect of blood pressure on the risk of developing abdominal aortic aneurysm.

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