Prevalence of peripheral arterial disease and its association with smoking in a population-based study in Beijing, China

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Objective: Although the prevalence of peripheral arterial disease (PAD) and its association with smoking in Western populations has been extensively studied, little information is available in China. The objective of this study was to determine the age-standardized prevalence of PAD and examine the relationship between smoking, quitting, and PAD in elderly Chinese.

Methods: We conducted a population-based cross-sectional study in an urban Beijing sample of 2334 subjects aged ≥60 years (943 men and 1391 women) in 2001 to 2002. PAD was assessed by symptoms of intermittent claudication (IC) as measured by the WHO/Rose questionnaire and an ankle-arm systolic blood pressure index (AAI) of <0.90.

Results: The prevalence of PAD defined by IC was 11.3% (men, 8.0%; women, 13.6%); 15.3% (men, 11.7%; women, 17.7%) by AAI, and 19.8% (men, 14.7%; women, 23.2%) by both criteria. After adjusting for age, gender, marital status, education, alcohol drinking, exercise, body mass index, and histories of hypertension and diabetes mellitus, the odds ratios and 95% confidence intervals of PAD for current smokers vs never smokers were 1.54 (1.12 to 2.11) and 1.28 (0.91 to 1.79) for former smokers (stopped smoking for at least 2 years). There was a dose-response relation between the number of cigarettes smoked and increasing risk of PAD. Quitting for ≥10 years nearly eliminated excess risk associated with smoking.

Conclusions: PAD is common in elderly Chinese and the prevalence is higher in women than in men. About 40% of PAD patients were asymptomatic and unaware of their condition. Cigarette smoking is a major risk factor for PAD, and smoking cessation substantially reduces the risk. (J Vasc Surg 2006;44:333-8.)

The presence of peripheral arterial disease (PAD) indicates significant atherosclerosis, and it has been associated with substantially increased morbidity, disability, and mortality in the elderly. A rapidly ageing population in China has led to increased prevalence of atherosclerotic disease (eg, coronary heart disease and stroke) in the past two decades. Compared with other areas of cardiovascular research, there were limited data, especially population-based, on the prevalence and risk factors of PAD in China. Furthermore some studies showed that smoking is a major avoidable risk factor for PAD in Western countries, but no epidemiologic reports were found on the association of smoking and PAD in China. Additionally, data show that excess risk of coronary heart disease and stroke diminish rapidly after cessation of smoking, but this effect has not been investigated for PAD. The purpose of this study was to determine the age-standardized prevalence of PAD, and examine the relation between smoking and PAD in a population-based survey of elderly Chinese in Beijing, China.

METHODS

Identification of participants. This study was a population-based cross-sectional survey of the elderly individuals living in the Wanshoulu Community of Haidian District in Beijing, China, a representative metropolitan area of the geographic and economic characteristics, such as income levels, residential status, and lifestyle factors. A two-stage stratified sampling method was used. First, nine residential communities or streets (about 300 to 600 households) were randomly selected from the 94 residential communities in the Wanshoulu Area. Second, all individuals were chosen from the selected streets. Between April 2001 and March 2002, 2680 people aged ≥60 years were selected and invited for screening. Of these, 2334 subjects (943 men and 1391 women) completed the survey, yielding a response rate of 87.1% (83.5% in men, 89.7% in women), and they accounted for 11.4% of elderly residents in the Wanshoulu Area.

Collection of data. We identified eligible individuals by their age and documents of residence and invited them to a community clinic by letter or telephone. Participants were interviewed, and each completed a questionnaire covering a range of demographic factors, aspects of medical history, and lifestyle. All survey interviewers and physicians were trained in the standardized procedure in the Department of Epidemiology of Chinese PLA General Hospital. The committee for
medical ethics of the Chinese PLA General Hospital approved
the study, and each participant signed an informed consent
form before completing the questionnaire.

Demographic characteristics. The average age was 68.5
± 5.4 years (range, 60 to 95 years). The sample was stratified
by age into three groups: 60 to 69, 70 to 79, and ≥80 years.
Categories of educational attainment included: 0 years, never
attended primary school; ≤6 years, only attended primary
school; ≤9 years, completed middle school; ≤12 years, com-
pleted high school or the equivalent; and ≥13 years, com-
pleted a university or other tertiary degree. Marital status was
classified as single, married, divorced, or widowed.

Definition of risk factors. The categories of smoking
were never smoked, former smoker, and current smoker. An
ever-smoker was defined as one who had smoked at least one
cigarette daily for ≥1 year. Current smokers were ever-smok-
ers who were still smoking at the time of the interview, and
former smokers were those who had stopped for at ≥2 years.
Pack-years of smoking were calculated by multiplying the
average number of cigarettes smoked daily by the number of
years of smoking and dividing by 20. Current drinking was
defined as average alcohol consumption of >10 g of absolute
alcohol per day for >1 year in the past 5 years.

Hypertension was defined as diastolic blood pressure of
≥90 mm Hg, systolic blood pressure of ≥140 mm Hg, or
current medication for hypertension as defined by the World
Health Organization (WHO) in 1999. Other disease histories
included coronary heart disease, stroke, and diabetes mellitus.
Coronary heart disease and stroke were defined using the
WHO Monitoring of Trends and Determinants in Cardiovas-
cular Diseases (MONICA) criteria.9 The information was
verified by hospital reviewing. Subjects with a fasting plasma
cholesterol 5.2 mmol/L, or both during an oral glucose tolerance test in this
WHO/Rose questionnaire were diagnosed with diabetes mellitus.

Physical examinations. Height was measured in meters
(without shoes), and weight in kilograms (with heavy clothing
removed and 1 kg deducted for remaining garments). Body
mass index (BMI) was calculated (kg/m2). Blood biochemis-
try included liver and kidney function and plasma lipoprotein
total cholesterol, triglycerides, and high-density and low-
density lipoprotein cholesterol.

Measurement of ankle-arm systolic blood pressure
index. The ratio of systolic blood pressure at the ankle (mea-
sured by an 8-MHz continuous wave Doppler probe at the
dorsal pedal artery or the posterior artery) and at the arm
(measured by a standard mercury sphygmomanometer at the
brachial tree) was calculated for each leg. The lowest of the
ankle-arm index (AAI) was used in the analysis. Subjects with
a large left-right difference (a sign of possible vascular disease
in the brachial tree) and with an AAI >1.5 were excluded from
these analyses to avoid affecting the reliability of the AAI.
Measurement of all subjects was done by a trained research
nurse and a physician. The quality control procedures showed
good agreement in AAIs between the two observers and the
two measurements 20 days apart, with κ statistics of 0.78 and
0.82 (P < .01).

Diagnosis criteria of peripheral arterial disease. The
diagnostic criteria for PAD was positive intermittent claudica-
tion (IC) defined by the WHO/Rose questionnaire (ie, the
subject with a pain in the calf while walking which disappeared
when the patient was standing still and which was not present
when the patient was resting10) or an AAI index <0.9.

Statistical analysis. Data were entered (double entry)
and managed by Access 2000 software (Microsoft, Redmond,
Wash). The crude, age-specific, and age-standardized preva-
ence of PAD and corresponding 95% confidence intervals
(CI) were calculated by the WHO/Rose questionnaire or
AAI, or both. Standardization used the direct method and
weights from Beijing urban district standard population in
year 2000. The t test and χ2 test were used to compare
differences in continuous and categoric variables, respectively,
between men and women. Logistic regression was used to
calculate odds ratios (OR) and 95% CIs. The statistical analysis
was performed with SPSS 12.0 software (SPSS, Inc, Chicago,
Ill).

RESULTS

Table I describes the general characteristics of the 2334
subjects (943 men, 1391 women) by categories of PAD.
Significant differences were found between the subjects with
PAD and without PAD in age, gender, marital status, educa-
tion, BMI, systolic blood pressure, low-density lipoprotein
cholesterol, AAI, and histories of smoking, hypertension, di-
babetes mellitus, and coronary heart disease. The distribution of
AAI values (Fig 1) is skewed to the left. The mean and
median AAI in men (1.05 and 1.06) were higher than that in
women (0.99 and 1.00).

Table II shows that prevalence of PAD tended to increase
with age. Approximately 43% (n = 198) of PAD patients were
asymptomatic and detected by AAI, and only 34% of PAD
cases identified by AAI were also detected by the WHO/Rose
questionnaire (n = 158) in the present study. The age stan-
dardized prevalence of PAD was 11.9% (95% CI, 10.6% to
13.2%) by WHO/Rose questionnaire for IC, 16.0% (95% CI,
14.5% to 17.5%) by measured AAI <0.90, and 20.7% (95% CI,
19.1% to 22.3%) by IC or with AAI <0.9. The prevalence
of PAD was substantially higher in women than in men.

When participants were stratified by smoking status, a
clear increase in the prevalence of PAD between the never,
former, and current smokers was observed for IC, AAI <0.90,
or either criteria for both men and women (Fig 2).

Table III shows the odds ratios of PAD defined by either
IC or AAI <0.90 according to smoking status. Compared
with never smokers, a significantly increased risk of PAD was
observed in current smokers in both men and women after
adjusting for age, marital status, education, exercise, BMI,
hypertension, diabetes mellitus, and family histories of coro-
nary heart disease or stroke. Further adjustment for blood
lipsids and fibrinogen did not appreciably alter the results. The
increased risk for former smokers was limited to recent quitters
(2 to 9 years), and the excess risk was nearly abolished after
quitting for ≥10 years. A dose-response relation was found
between the amount of cigarettes smoked and risk of PAD (P
for trend < .001, men and women combined).
In separate analyses, the multivariate adjusted ORs (95% CI) of the IC and AAI \(0.90\) were \(1.96\) (1.34 to 2.86) and \(1.53\) (1.08 to 2.17) for current smokers, and \(1.02\) (0.65 to 1.58) and \(1.47\) (1.02 to 2.11) for former smokers.

Finally, in multivariable adjusted analyses, the ORs (95% CI) of PAD were \(1.06\) (1.04 to 1.08) for 1-year increment in age, \(1.05\) (1.02 to 1.08) for each 1 kg/m\(^2\)-increment in BMI, \(1.30\) (1.04 to 1.61) for hypertension, and \(1.54\) (1.18 to 2.02) for diabetes mellitus.

DISCUSSION

To the best of our knowledge, this is the first study to report the prevalence of PAD and its association with smoking and quitting in a population-based study in China. This investigation focused on Chinese men and women aged \(\geq 60\) or more, a group at higher risk of developing cardiovascular disease. The sample was randomly selected from a cluster sample of similar residential communities, and the response
fraction was relatively high. Approximately 13% of eligible subjects had moved from their original residence or failed to complete interviews or examinations, or both. However, the differences between the responders and nonresponders for factors such as age, gender, and locations of residence were not statistically significant. Consequently, the prevalence of PAD and associated risk factors can be generalized with confidence to similar populations in urban Beijing, China.

Prevalence of PAD is known to vary by diagnostic criteria and population.2-6 Our results showed that PAD was common in elderly Chinese men and women, with a prevalence similar to that of Western populations in the same age groups. Consistent with the literature,11 symptomatic PAD in our study was diagnosed from positive results on the WHO/Rose questionnaire, and asymptomatic PAD from an AAI >0.90. Both methods are noninvasive, quick, easy to perform, and thus suitable for large-scale surveys.

The WHO/Rose questionnaire has 60% sensitivity for PAD, and the AAI is both sensitive and specific for PAD.12 Bernstein et al13 report that AAI >0.9 has a sensitivity of 95% and a specificity of 100% in detecting PAD compared with the gold standard of angiography. We found that an AAI >0.9 was a more sensitive test for PAD than the WHO/Rose questionnaire, with only 34% of PAD cases identified by AAI also detected by the WHO/Rose questionnaire in the present study. These results are consistent with other data.14 Both IC and AAI were used to identify prevalent PAD in most of studies.1-4,6,11 If only AAI criteria were used, the specificity of the PAD diagnosis would be increased, but the sensitivity would be decreased, leading to increased false-negatives. In present study, the definitions of PAD do not include critical limb ischemia because there were few cases (9 in men, 6 in women), and the prevalence of PAD was thus likely to be slightly underestimated.

PAD was asymptomatic in 43% of patients in this study, suggesting that the disease has been underdiagnosed and undertreated15 in elderly Chinese. There was some evidence that asymptomatic PAD was associated with future risk of developing more severe symptoms (eg, intermittent claudication) and cardiovascular mortality.5,16-18 Our data suggest that measuring the AAI is appropriate for detecting asymptomatic PAD in epidemiologic studies and is suitable for use in primary care.19

Our results show that more women in the general population have PAD than do men, and it could be due to the higher proportion of asymptomatic PAD in women (18.8%) than in men (12.1%). A prospective report from the Limburg Study in 2001 showed a 73% higher incidence of PAD in women (14.2/1000 person-years) than in men (8.2/1000 person-years).4 Hiatt et al20 proposed that the differences of PAD prevalence between men and women was because healthy women have lower AAI than healthy men, and thus the use of separate cutoff points to define PAD by the AAI for women and men may be necessary.

Table II. Gender and age-specific and age-standardized prevalence of peripheral arterial disease

<table>
<thead>
<tr>
<th>Age groups (years)</th>
<th>Subjects (n)</th>
<th>Cases (n)</th>
<th>Prevalence (%)</th>
<th>95% CI</th>
<th>Cases (n)</th>
<th>Prevalence (%)</th>
<th>95% CI</th>
<th>Cases (n)</th>
<th>Prevalence (%)</th>
<th>95% CI</th>
<th>Cases (n)</th>
<th>Prevalence (%)</th>
<th>95% CI</th>
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<tbody>
<tr>
<td>Male</td>
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<tr>
<td>60-69</td>
<td>596</td>
<td>16</td>
<td>2.7</td>
<td>1.4-4.0</td>
<td>34</td>
<td>5.7</td>
<td>3.8-7.6</td>
<td>20</td>
<td>3.4</td>
<td>1.9-4.8</td>
<td>70</td>
<td>11.7</td>
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<td>70-79</td>
<td>309</td>
<td>12</td>
<td>3.9</td>
<td>1.7-6.0</td>
<td>23</td>
<td>7.4</td>
<td>4.5-10.4</td>
<td>21</td>
<td>6.8</td>
<td>4.0-9.6</td>
<td>56</td>
<td>18.1</td>
<td>13.8-22.4</td>
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<tr>
<td>≥80</td>
<td>38</td>
<td>2</td>
<td>5.3</td>
<td>1.8-12.4</td>
<td>8</td>
<td>21.1</td>
<td>8.1-34.0</td>
<td>4</td>
<td>10.5</td>
<td>0.8-20.3</td>
<td>14</td>
<td>36.8</td>
<td>21.5-52.1</td>
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<tr>
<td>Total</td>
<td>943</td>
<td>30</td>
<td>3.2</td>
<td>2.1-4.3</td>
<td>65</td>
<td>6.9</td>
<td>5.3-8.5</td>
<td>45</td>
<td>4.8</td>
<td>3.4-6.1</td>
<td>140</td>
<td>14.8</td>
<td>12.4-17.0</td>
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<td>Age-standardized</td>
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<td>3.3</td>
<td>2.2-4.4</td>
<td>7.2</td>
<td>5.6-8.8</td>
<td>4.9</td>
<td>3.5-6.3</td>
<td>14.8</td>
<td>12.5-17.1</td>
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<td>Female</td>
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<tr>
<td>60-69</td>
<td>914</td>
<td>46</td>
<td>5.0</td>
<td>3.6-6.5</td>
<td>84</td>
<td>9.2</td>
<td>7.3-11.1</td>
<td>45</td>
<td>4.9</td>
<td>3.5-6.3</td>
<td>175</td>
<td>19.1</td>
<td>16.6-21.7</td>
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<td>70-79</td>
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<td>24</td>
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<td>3.5-8.0</td>
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<td>9.4</td>
<td>6.6-12.2</td>
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<td>9.6-16.0</td>
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<tr>
<td>≥80</td>
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<td>7.0-25.3</td>
<td>15</td>
<td>24.2</td>
<td>13.5-34.9</td>
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<td>37.6-62.4</td>
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<td>Total</td>
<td>1391</td>
<td>76</td>
<td>5.5</td>
<td>4.3-6.7</td>
<td>133</td>
<td>9.6</td>
<td>8.0-11.1</td>
<td>113</td>
<td>8.1</td>
<td>6.7-9.6</td>
<td>322</td>
<td>23.1</td>
<td>20.9-25.3</td>
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<tr>
<td>Age-standardized</td>
<td></td>
<td>5.7</td>
<td>4.5-6.9</td>
<td>9.8</td>
<td>8.2-11.4</td>
<td>9.0</td>
<td>7.5-10.5</td>
<td>24.4</td>
<td>22.1-26.7</td>
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<tr>
<td>Total (M+F)</td>
<td>2334</td>
<td>106</td>
<td>4.5</td>
<td>3.7-5.3</td>
<td>198</td>
<td>8.5</td>
<td>7.4-9.6</td>
<td>158</td>
<td>6.8</td>
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<td>462</td>
<td>19.8</td>
<td>18.2-21.4</td>
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<tr>
<td>Age-standardized</td>
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<td>4.7</td>
<td>3.8-5.6</td>
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<td>7.2</td>
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<td>20.7</td>
<td>19.1-22.3</td>
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</table>

PAD, Peripheral arterial disease; AAI, ankle-arm systolic blood pressure index; IC, intermittent claudication.
In present study, the mean and median AAI in men were higher than in women, and when the AAI cutoff points were defined by a low-risk group consisting of 296 men and 477 women, with normal glucose tolerance, no symptoms of angina or claudication, no previous history of cardiovascular disease, and either never smokers or former smokers, the prevalence of gender-specific AAI cut points at the percentile of 2.5, 5, 10 and 15 in men was 4.0%, 7.1%, 14.0%, and 18.5%. However, because published reports have widely used the same cutoff point of AAI of 2.5, 5, 10 and 15 in men was 4.0%, 7.1%, 14.0%, and 18.5%. However, because published reports have widely used the same cutoff point of AAI <0.90 in both men and women, we also used this cutoff point to facilitate comparisons between our study and the published reports.

Our results on smoking and PAD are consistent with those from previous Western studies as well as a Hong Kong hospital-based study in Chinese subjects with a mean age of 72 years. Our data show that smoking cessation is associated with decreased risks of PAD—further evidence that the association between smoking and PAD is causal and that quitting smoking is beneficial. Excess risk of PAD was nearly eliminated after stopping smoking for >10 years.

Smoking status was assessed via self-report. Less than 3% of cases and controls had missing data on smoking status. The prevalence of smoking was 29.6% in cases and 25.2% in controls. A total of 458 cases and controls with complete smoking status data were included in the analysis. The prevalence of smoking was 29.6% in cases and 25.2% in controls. A total of 458 cases and controls with complete smoking status data were included in the analysis.

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results suggest that stopping smoking confers significant benefit in the elderly.

**AUTHOR CONTRIBUTIONS**

Conception and design: YH, JW, XYL, LF
Analysis and interpretation: YH, YJ, JW
Data collection: YH, YJ, JW
Writing the article: YH, FBH
Critical revision of the article: YH, XYL, LF, FBH
Final approval of the article: YH, FBH
Statistical analysis: YH, YJ
Obtained funding: YH, XYL, FBH
Overall responsibility: YH, FBH

**REFERENCES**


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