Effects of age, sex and smoking on ankle-brachial index in a Finnish population at risk for cardiovascular disease

Kari Syvänen MD¹, Pertti Aarnio MD PhD FICA¹, Pekka Jaatinen MD PhD², Päivi Korhonen MD³

K Syvänen, P Aarnio, P Jaatinen, P Korhonen. Effects of age, sex and smoking on ankle-brachial index in a Finnish population at risk for cardiovascular disease. *Int J Angiol* 2007;16(4):128-130.

BACKGROUND: Smoking is a well-known risk factor for peripheral arterial disease (PAD). Data regarding differences in the prevalence of PAD between sexes are somewhat controversial. In addition, most studies indicate that the prevalence of PAD increases with age in both sexes. In the present study, the effects of sex, age and smoking on the ankle-brachial index (ABI) in a Finnish cardiovascular risk population were investigated.

OBJECTIVES: To investigate the relationship between the ankle-brachial index, and age, sex and smoking in a Finnish population at risk for cardiovascular disease.

METHODS: All men and women between 45 and 70 years of age living in a rural town (Harjavalta, Finland; total population 7700) were invited to participate in a population survey (Harmonica study). Patients with previously diagnosed diabetes or vascular disease were excluded. In total, 2856 patients were invited to participate in the

study. From these subjects, a cardiovascular risk population was screened. Complete data were available from 1028 persons. ABI (the ratio between the posterior tibial or dorsalis pedis artery and brachial artery pressures) was measured, and questionnaires were used to detect smoking status and relevant medical history. Only current smoking status was taken into account.

RESULTS: The mean ABI for the entire study population was 1.10 (range 0.56 to 1.64). Current smokers had a lower mean ABI (1.06; $P < 0.001$). There was no statistically significant difference in ABI values among age groups, although the majority of patients with ABI values below 0.9 were older than 60 years of age. There was no statistically significant difference in ABI between sexes.

CONCLUSION: As previously reported, the present study shows the significant effect of smoking in the development of PAD. No statistically significant difference was found among age groups, but the tendency was toward lower ABIs in the oldest age groups. Sex had a minimal effect on the ABI.

Key Words: Age; Ankle-brachial index; Cardiovascular risk; Epidemiology; Sex; Smoking

It has been estimated that for every patient with symptomatic peripheral arterial disease (PAD) there are three to four patients with PAD who do not have classical symptoms of intermittent claudication, rest pain or nonhealing ischemic wounds (1). The prevalence of asymptomatic PAD can only be assessed with noninvasive tests, of which the most widely used is the measurement of ankle-brachial index (ABI). When the ABI is 0.9 or lower, there is hemodynamically significant arterial stenosis and the diagnosis of PAD can be made (2). High ABI values are also related to an increased risk of all-cause and cardiovascular mortality (3). This U-shaped curve is thought to stem from finding that there is a relationship between diabetes and stiffening of blood vessels, as well as the finding that medial arterial calcification creates high ABI values and is associated with diabetes and increased mortality risk (4). Usually, studies exclude patients with high ABI values.

Previous studies have shown that older age, smoking, hypertension, diabetes mellitus, hypercholesterolemia and sedentary life style are the most important risk factors for asymptomatic PAD (5). In some studies, the prevalence of PAD does not vary with sex, but women seem to have more PAD-associated disability and lower quality of life than men (6). On the other hand, there are studies that show that more women in the general population have PAD (7). Follow-up

studies have shown that women develop PAD more often than men (5).

In the present study, we investigated the relationship between the ABI, age, sex and smoking in a Finnish population at risk of cardiovascular disease.

METHODS

All men and women between 45 and 70 years of age from a rural town in Finland (Harjavalta; total population 7700) were invited to participate in a population survey. People with known diabetes and known vascular disease were excluded because they already had systematic follow-up in the Harjavalta health centre. The aim was to detect a cardiovascular risk population. An invitation to participate in the study was mailed to 2856 persons. The invitation included a risk factor survey, a tape measure and the FINnish Diabetes Risk Score (FINDRISC) (8). In the risk factor survey, subjects were asked about their waist circumference measured at the level of navel, their most recent blood pressure result, use of antihypertensive medication, gestational diabetes, hypertension, family history of cardiovascular diseases (parents or siblings having coronary artery disease, myocardial infarction or stroke) and smoking habits. If subjects were willing to participate in the study, they mailed the risk factor survey back to the health

¹Department of Surgery; ²Department of Family Medicine, Satakunta Hospital District; ³Central Satakunta Health Federation of Municipalities, Pori, Finland

Correspondence: Dr Kari Syvänen, Satakunta Central Hospital, Sairaalan tie 3, 28500 Pori, Finland. Telephone 358-50-549-8391, e-mail kari.syvanen@finnet.fi

TABLE 1
Effects of sex and current smoking on ankle-brachial index (ABI)

	n	Mean ABI	P
Sex			
Male	481	1.10	0.185 (NS)
Female	546	1.11	
Current smoker			
Yes	197	1.06	<0.001
No	830	1.11	

NS Nonsignificant

centre. Seventy-three per cent (n=2085) of the invited persons participated. Seventy per cent of responders (n=1496) had at least one risk factor for cardiovascular disease. Waist circumference of 80 cm or greater for women and 94 cm or greater for men, systolic blood pressure of 140 mmHg or greater or diastolic blood pressure of 90 mmHg or greater, or a score of at least 12 points in the FINDRISC were considered to be risk factors, along with any positive answer to questions in the risk factor survey.

Respondents with at least one risk factor for cardiovascular disease were invited for further examination, and if they were diagnosed with hypertension, diabetes, impaired glucose tolerance or the metabolic syndrome, or if the total cardiovascular risk was 5% or more based on the Systematic COronary Risk Evaluation (SCORE) system, physical examination by a doctor was completed.

All ABI measurements were performed by a doctor or a trained nurse. ABI was determined from blood pressure measurements in both upper limbs and ankles, with subjects in a supine position. Systolic blood pressure from the brachial artery in the antecubital fossa was measured using a blood pressure cuff and Doppler instrument (UltraTec PD1v [United Kingdom] with a 5 MHz probe). In the lower limbs, systolic blood pressure from the posterior tibial or dorsalis pedis arteries was measured with Doppler detection by placing a blood pressure cuff just above the malleoli at the ankle. ABI was the lowest systolic blood pressure from the ankle divided by the highest systolic brachial blood pressure. ABI measurements and smoking status were determined in 1028 subjects (69%).

Statistical analysis

Data were analyzed using SPSS for Windows 15.0 (SPSS Inc, USA). Using the database, descriptive analyses were performed. Statistical significance between groups was calculated using cross-tabulation and the χ^2 test; means were compared using Student's *t* test or ANOVA.

The study protocol and consent forms were reviewed and approved by the ethics committee of Satakunta hospital district (Finland). All participants provided written, informed consent for the project and subsequent medical research.

RESULTS

In total, there were 1028 participants (547 women, 481 men), and the mean age was 59 years (range 45 to 70 years). The mean ABI was 1.10 (range 0.56 to 1.64). The number of patients who had an ABI lower than 0.9 (indicating PAD) was 30 (3%). Of these 30 patients, only two (7%) were younger than 60 years of age, and 19 were men (63%). Three

TABLE 2
Ankle-brachial index (ABI) in different age groups

Age group, years	Mean ABI	P
45–49	1.11	0.248 (NS)
50–54	1.10	
55–59	1.11	
60–64	1.10	
65–70	1.09	

NS Nonsignificant

patients had ABIs higher than 1.5. In total, 197 of the subjects were current smokers (19%). There was a statistically significant difference between ABI values in current smokers and nonsmokers. The mean ABIs of smokers and nonsmokers were 1.06 and 1.11, respectively ($P<0.001$). Women seemed to have a lower mean ABI, but the difference was not statistically significant. The mean ABI was 1.10 in women and 1.1 in men ($P=0.185$) (Table 1). There were no statistically significant differences between ABI values in different age groups, although older age groups showed a trend toward a lower ABI. The mean ABI was 1.11 in patients 45 to 49 years of age, and 1.09 in those 65 to 70 years of age ($P=0.248$) (Table 2).

DISCUSSION

The prevalence of PAD in our study was 3%. That is lower than in the study by Carbayo et al (9) but in line with Framingham offspring study (10). Our study was based on individuals drawn from a population survey who were at risk of cardiovascular disease. All of the subjects in our study had at least one cardiovascular risk factor. Therefore, the estimated prevalence of PAD may have been higher than in random population samples.

In the present study, we found an expected difference between ABI values in smokers and nonsmokers. However, we took into account only current smoking status, and former smokers were considered to be nonsmokers. Obviously, this is a limitation, because we could not study differences between nonsmokers, former smokers and current smokers. In previous studies (9–11), pack-years smoked and smoking history were related to the risk of developing PAD. Our study is in line with those findings, because current smokers had lower ABI values.

In the study by Carbayo et al (9), the mean ABI was significantly higher in men 40 to 59 years of age than in women of the same age, and this trend was reversed in those older than 70 years. The prevalence of PAD almost doubled after the age of 70 years compared with the 60- to 70-year age group for both sexes. The mean ABI, however, stayed above normal level. In our study, only two patients with an ABI of less than 0.9 were younger than 60 years of age. The mean ABI values in the oldest age group were lower than in youngest group. However, no statistically significant trend was found between age and ABI.

As discussed earlier in some studies (6,12), the prevalence of PAD does not vary with sex. Collins et al (6) also demonstrated that risk factors for PAD were the same for both women and men. In our study, 63% of patients with an ABI less than 0.9 were men. There was no statistically significant difference between sex and ABI. This finding is in agreement with previously mentioned studies.

The ABI is a standard measure of PAD. Variation of method for measurement of brachial artery pressure significantly affects

ABI values. For example, measurement of ABI using an automated blood pressure monitor can have a mean difference of 0.15 compared with Doppler-recorded ABI values (13). In this study, ABI values were higher when measured by nurses than doctors. In our study, we used only two measurers, one doctor and one trained nurse, to minimize the bias caused by multiple analyzers. We also used Doppler instruments. Three patients had ABI values higher than 1.5, perhaps indicating noncompressible vessels as previously published by McDermott et al (14).

In 1992, Criqui et al (15) published a 10-year follow-up study of mortality in patients with PAD. In their study, 61.8% of men and 33.3% of women with large-vessel PAD died during follow-up, compared with 16.9% of men and 11.6% of women without PAD. This indicates that large-vessel PAD has a RR of 3.1 for dying from all causes, 5.9 for all deaths from cardiovascular disease and 6.6 for deaths from coronary artery disease. In patients with symptomatic PAD, there is a 15-fold increase in rates of mortality due to cardiovascular disease or coronary artery disease. It seems that the RR of death from causes other than cardiovascular disease is not significantly increased among patients with PAD.

According to the recently published TransAtlantic Inter-Society Consensus (TASC) II for the management of PAD (2), the ABI should be taken to detect PAD in patients with exertional leg symptoms, patients between 50 and 69 years of age with a cardiovascular risk factor (particularly diabetes or smoking), patients older than 70 years of age despite the risk status and patients with a Framingham risk score of 10% to 20%. The ABI confirms the diagnosis of PAD and also detects PAD in asymptomatic patients. It can be used to make a differential diagnosis between vascular and other etiologies of leg symptoms. Our study confirms the importance of the ABI measurement in these patient groups.

CONCLUSIONS

Our study is a preliminary study from our database of Finnish patients with one or more cardiovascular risk factors. It showed that smoking was a crucial risk factor for PAD. In addition, age was not statistically significantly related to the ABI, but the majority of patients with PAD were in the oldest age group. Sex had no effect on ABI, which is in line with previous findings from other studies.

REFERENCES

1. Hiatt WR. Medical treatment of peripheral arterial disease and claudication. *N Engl J Med* 2001;344:1608-21.
2. Norgren L, Hiatt WR, Dormandy JA, Nehler MR, Harris KA, Fowkes FG; TASC II Working Group. Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). *J Vasc Surg* 2007;45(Suppl S):S5-67.
3. Resnick HE, Lindsay RS, McDermott MM, et al. Relationship of high and low ankle brachial index to all-cause and cardiovascular disease mortality. The Strong Heart Study. *Circulation* 2004;109:733-9.
4. Quigley FG, Faris IB, Duncan HJ. A comparison of Doppler ankle pressures and skin perfusion pressure in subjects with and without diabetes. *Clin Physiol* 1991;11:21-5.
5. Hooi JD, Kester ADM, Stoffers HE, et al. Incidence of and risk factors for asymptomatic peripheral arterial occlusive disease: A longitudinal study. *Am J Epidemiol* 2001;153:666-72.
6. Collins TC, Suarez-Almazor M, Bush LR, et al. Gender and peripheral arterial disease. *J Am Board Fam Med* 2006;19:132-40.
7. He Y, Jiang Y, Wang J, et al. Prevalence of peripheral arterial disease and its association with smoking in a population-based study in Beijing, China. *J Vasc Surg* 2006;44:333-8.
8. Lindström J, Tuomilehto J. The diabetes risk score: A practical tool to predict type 2 diabetes risk. *Diabetes Care* 2003;26:725-31.
9. Carbayo JA, Divisón JA, Escibano JL, et al. Using ankle-brachial index to detect peripheral arterial disease: Prevalence and associated risk factors in a random population sample. *Nutr Metab Cardiovasc Dis* 2007;17:41-9.
10. Murabito JM, Evans JC, Nieto K, et al. Prevalence and clinical correlates of peripheral arterial disease in the Framingham Offspring Study. *Am Heart J* 2002;143:961-5.
11. Weitz JI, Byrne J, Clagett GP, et al. Diagnosis and treatment of chronic arterial insufficiency of the lower extremities: A critical review. *Circulation* 1996;94:3026-49.
12. McDermott M, Greenland P, Liu K, et al. Sex differences in peripheral arterial disease: Leg symptoms and physical functioning. *J Am Geriatr Soc* 2003;51:222-8.
13. Jeelani NUO, Braithwaite BD, Tomlin C, et al. Variation of method for measurement of brachial artery pressure significantly affects ankle-brachial pressure index values. *Eur J Vasc Endovasc Surg* 2000;20:25-8.
14. McDermott MM, Greenland P, Liu K, et al. Leg symptoms in peripheral arterial disease: Associated clinical characteristics and functional impairment. *JAMA* 2001;286:599-606.
15. Criqui MH, Langer RD, Fronek A, et al. Mortality over a period of 10 years in patients with peripheral arterial disease. *N Engl J Med* 1992;326:381-6.