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ORIGINAL ARTICLE

The Czech ABI Project – Prevalence of peripheral arterial disease in patients at risk using the ankle-brachial index in general practice (a cross-sectional study)

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Abstract

BACKGROUND: Peripheral arterial disease (PAD) is often under-diagnosed and under-treated. Individuals with symptomatic and even asymptomatic forms of PAD should be identified so that therapeutic interventions could be performed. The aim of this study was to determine the prevalence of PAD, defined as an ABI <0.9, in at-risk consecutive patients visiting their general practitioners (GPs).
METHODS: The ankle-brachial index (ABI) was measured (by an oscillometric method) by 82 GPs in the Czech Republic in 6 885 adults aged 50 years or older with the presence of at least 1 CV risk factor and in all those aged over 60.
RESULTS: In the group of 6 885 patients (mean age 66.4 yrs; 52% of women, 48% of men), the prevalence of PAD was 13.7%. It was increasing progressively with age. Most of the identified patients were asymptomatic (65.5%), with 18.6% and 11.5% being in Fontaine´s stages IIa and IIb, respectively; 4.5% had more advanced limb ischemia. Hypertension was present in 89.2% of patients, dyslipidemia in 74.3%, diabetes in 44.4%, smoking (current or former) in 46.3%. Coronary heart disease had been diagnosed in 29.3%, and cerebrovascular disease in 13.1%.
CONCLUSIONS: ABI determination by GPs is a feasible method substantially improving detection of the early phase of atherosclerosis in the primary care setting. The prevalence of PAD in the population at risk is 13.7% and most patients are asymptomatic.

Abbreviations:

ABI	- ankle-brachial index
BMI	- body mass index
CV	- cardiovascular
CVD	- cardiovascular disease
ECG	- electrocardiogram
GP	- general practitioner
OGTT	- oral glucose tolerance test
PAD	- peripheral arterial disease
SPCC	- Spill Prevention Control Countermeasures (software)
WHO	- World Health Organization

INTRODUCTION

Peripheral arterial disease (PAD) is one of the most common manifestations of atherosclerosis affecting a significant number of individuals. It causes a significant disability related to limb symptoms ranging from impaired walking capacity, through typical claudication pain, rest pain in the acral parts of extremities, to gangrenes. The diagnosis of PAD is associated with a general fear of amputation but the real issue of PAD consists in substantially elevated CV morbidity and mortality, which is 2–4 times higher in patients with PAD than in those of the same age without it (Criqui *et al.* 1992; Hirsch *et al.* 2001; Welten *et al.* 2008). The problem of early diagnosis of PAD is caused by overlooking very mild impairment of walking capacity by elderly patients or their symptoms are not correctly evaluated by physicians or the patients do not report atypical pain at all. Although the condition is well described, PAD continues to be under-diagnosed and thus under-treated. The main reason for it is that more than half of PAD patients are asymptomatic. Diehm and colleagues (2009), confirming similar findings by Hooi *et al.* (2004), demonstrated that asymptomatic PAD conferred a risk of CV morbidity and mortality largely similar to that of symptomatic PAD.

Determination of the ankle-brachial index (ABI) is a simple and inexpensive test, symptom-independent, that has been available for many years. Ankle-brachial index determination can identify PAD patients quickly, in a cost-effective manner, with high sensitivity and specificity. Despite these advantages, the test is still underused.

To increase the possibility of early diagnosing the PAD in the Czech Republic, we designed a general practitioner (GP)-based study that would determine the prevalence of PAD in patients at risk for atherosclerosis. The measurement of ABI was a part of general preventive screening (not only for the presence of risk factors of atherosclerosis but, also, for other diseases such as cancer, diabetes, nephropathy etc.).

METHODS

The Czech ABI Project was a national, multicentre, cross-sectional prevalence study based on real-life clinical practice conditions. Investigators were GPs, and the study was conducted during the year 2011. In some patients, this examination was performed as part of their periodic preventive check-up.

Patients were recruited consecutively if they were over 50 with at least 1 CV risk factor (smoking, hypertension, dyslipidemia, diabetes mellitus) or all aged over 60 regardless their risk.

Smoking was assessed using the WHO definition. A person was considered to be a current smoker if smoking at least 1 cigarette per day. Hypertension was defined as blood pressure ≥140/90 mmHg or current treatment with antihypertensive drugs. Dyslipidemia was defined as total cholesterol ≥5 mmol/l or LDL-cholesterol ≥3 mmol/l or HDL-cholesterol <1 mmol/l in men and <1.2 mmol/l in women or triglycerides ≥1.7 mmol/l or use of lipid-lowering drugs. Diabetes mellitus was defined by fasting glucose ≥7.0 mmol/l or 2-h postload glucose ≥11.1 mmol/l during an oral glucose tolerance test (OGTT) or casual glycemia (any time of the day without regard since last meal) ≥11.1 mmol/l or drug treatment for diabetes.

The examination consisted of medical history, basic anthropometric parameters [height and body weight; body mass index (BMI) was calculated as the weight divided by the height squared (kg/m^2); waist circumference], blood pressure measurement, 12-lead resting ECG, and ABI determination. An ECG was considered to be abnormal if any of the following were present: significant ST-segment depressions (≥0.2 mV), T-wave inversions, Q waves, left bundle branch block, 2nd or 3rd degree atrioventricular blocks or atrial fibrillation/flutter. The examination was complemented by assessment of laboratory parameters as shown in Table 1.

Total cardiovascular risk was estimated using the country-specific SCORE chart for the Czech Republic (Cífková *et al.* 2005).

The ankle-brachial index was determined using the oscillometric method with a Boso ABI-System 100 device (BOSCH + SOHN GmbH u. Co. KG, Jungingen, Germany) which enables simultaneous measurement of systolic blood pressure on all four extremities. Fluctuations in the individual measurement duration are reduced to a minimum through the simultaneous pump system and regulation of release speed. After measuring, the values are transmitted to a PC, where the application software automatically calculates the ABI. The diagnosis of PAD was based on an ABI value of less than 0.9.

Statistical analysis was carried out using SPSS software for Windows. Data were summarized using mean, median, standard deviation, and range for continuous parameters, and counts and percentages for categorical

Tab. 1. Medical history, examination and laboratory assessment.

Medical history	Examination	Laboratory assessment
Previous CVD Current CVD symptoms CV risk factors Current medication for CVD	Height Weight Body Mass Index Waist circumference Blood pressure ECG ABI CV risk estimation	Fasting glycemia Glycosylated Hb* Total cholesterol LDL-cholesterol HDL-cholesterol Triglycerides

CVD – cardiovascular disease; CV – cardiovascular; ABI – ankle-brachial index; Hb – hemoglobin
*Glycosylated hemoglobin determined only in diabetics.

parameters. To find any potential significant differences between categories, advanced statistical techniques, e.g., the statistical hypothesis test (*t*-test) were used.

RESULTS

A total of 6 885 individuals were recruited during the year 2011 by 82 GPs, evenly distributed in the Czech Republic. In Table 2, selected characteristics of the study population are given for all screened individuals (6 885 men and women) and separately for patients with PAD in whom the diagnosis was based on an ABI <0.9 (941 patients). Peripheral arterial disease was found in 13.7% of all examined patients. The prevalence of PAD was higher in men (15.5%) than in women (11.9%), but the difference did not reach statistical significance (p=0.124). A clear-cut increase in the prevalence of PAD with age was observed in both men and women, ranging from 4.5% in those aged 50–55 to 20.4% in the age group above 90.

Among the 941 patients with the diagnosis of PAD based on an ABI <0.9, 616 (65.5%) were completely free from typical symptoms of the disease, and 325 (34.5%) were symptomatic (at the time of examination or before). Among all PAD patients, 18.6% were classified as being in Fontaine´s stage IIa (claudication distance over 200 m), 11.5% in IIb (claudication distance less than 200 m), 3.2% in stage III with some rest pain, and 1.2% in stage IV.

Hypertension was present in 89.2% of patients with PAD, dyslipidemia in 74.3%, diabetes in 44.4% (15.1% treated by diet only, 67% on oral hypoglycemic agents, and 18% on insulin therapy), smoking (current or former) in 46.3%, and impaired renal function in 10.3%. Coronary heart disease was previously diagnosed in 29.3%, and cerebrovascular disease in 13.1% of all PAD patients.

The PAD patients were significantly older, with larger waist circumference, had higher systolic blood pressure, more of them had hypertension, diabetes, dyslipidemia, were current or former smokers, and a higher proportion of them had a history of cardiovascular disease (angina, myocardial infarction, and stroke). Coronary revascularization was twice as common in the PAD patients. Likewise, they had more often an abnormal electrocardiogram (Table 2).

Presence of abnormal ABI: abnormal ABI (<0.9) was seen in 941 (13.7%) of all those examined. The aver-

Tab. 2. Study population characteristics.

Characteristic	Total n=6 885	ABI <0.9 n=941	ABI ≥0.9 n=5 944	*p*-value*
Age, years	66.4±9.23	70.4±9.4	65.7±9.03	p<0.01
Men, %	3329 (48.4%)	517 (54.5%)	2812 (47.3%)	NS
Body mass index, kg/m^2	29.2±5.0	29.1±5.3	29.2±5.0	NS
Waist circumference, cm	97.6±13.4	99±13.7	97.3±13.3	p<0.01
Systolic blood pressure, mmHg	138.5±16.1	144±18.5	137.6±15.5	p<0.01
Diastolic blood pressure, mmHg	81.6±8.8	81.3±9.7	81.6±8.6	NS
Hypertension, %	5582 (81.1%)	839 (89.2%)	4743 (79.8%)	p<0.01
Diabetes mellitus, %	2252 (32.7%)	418 (44.4%)	1834 (30.9%)	p<0.01
Dyslipidemia, %	4690 (68.1%)	699 (74.3%)	3991 (67.1%)	p<0.01
Smoking, %				
Current	1349 (19.6%)	274 (29.1%)	1075 (18.1%)	p<0.01
Former	1070 (15.5%)	174 (18.5%)	896 (15.1%)	p<0.01
Total cholesterol, mmol/l	5.3±1.1	5.2±1.2	5.4±1.1	NS
LDL-cholesterol, mmol/l	3.2±1.0	3.1±1.0	3.2±1.0	NS
HDL-cholesterol, mmol/l	1.4±0.4	1.3±0.4	1.4±0.4	NS
Triglycerides, mmol/l	1.8±1.1	1.8±1.1	1.8±1.1	NS
History of angina, %	762 (11.1%)	193 (20.5%)	569 (9.6%)	p<0.01
History of myocardial infarction, %	574 (7.9%)	150 (15.9%)	397 (6.7%)	p<0.01
History of stroke, %	500 (7.3%)	123 (13.1%)	377 (6.3%)	p<0.01
History of coronary revascularization, %	476 (6.9%)	137 (14.6%)	339 (5.7%)	p<0.01
Abnormal ECG, %	1272 (19.1%)	291 (32.2%)	981 (17.1%)	p<0.01

Values are given as mean ± SD.; **p*-value for ABI <0.9 vs ABI ≥0.9.

age ABI values in patients was 0.77 (±0.27) for the left lower extremity and 0.79 (±0.24) for the right lower extremity.

Prevalence of peripheral arterial disease based on an ABI <0.9 and total cardiovascular risk: Based on country-specific SCORE charts used by GPs, only half (49.6%) of patients with diagnosed PAD based on a pathological ABI value were scored as having a 10-year risk of fatal cardiovascular disease (CVD) >10%, the risk was 6–10% in 28.4%, and the risk for fatal CVD <5% was in as many as even 22%.

Most patients were receiving some type of CV medication (Table 3). We focused on antihypertensive agents, lipid-lowering drugs, antiplatelet agents, and vasodilating agents. Antihypertensive therapy was common in both groups – at-risk (total screened) and PAD patients. Among those receiving antihypertensives, two thirds were receiving an angiotensin-converting enzyme inhibitor. Lipid-lowering agents (almost exclusively statins) were prescribed to two-thirds of PAD patients and fewer than half of those without PAD. Antiplatelet therapy was twice as common in PAD patients as in those without PAD. Less than 30% of all patients with PAD were being treated by vasodilating agents.

DISCUSSION

A number of studies have suggested that PAD is widely under-diagnosed, and even after establishing the diagnosis, PAD often remains an under-treated condition, in contrast to coronary heart disease. This was why the Czech Society of Angiology started, in 2008, long-term training of hundreds of GPs across the Czech Republic in diagnosing peripheral arteriopathy along with instructions for best behavior and medical treatment of even early stages of PAD.

This cross-sectional study, the Czech ABI Project, was designed to investigate the prevalence of both symptomatic and asymptomatic forms of PAD in the patient population older than 50 years with at least 1 CV risk factor and in all those examined over 60 years of age (both men and women). The criteria for defining at-risk patients were chosen on the basis of well-recognized risk factors that are easy to detect. We found the prevalence to be 13.7%, with a steep increase with age. This study is the first performed in the Czech Republic by GPs only. The GPs were asked to invite pre-specified groups of patients and the examination was performed concomitantly with other preventive check-ups performed routinely every two years. The estimated prevalence of PAD in the Czech population is in good agreement with some similar studies such as the Rotterdam Study, the Edinburgh Artery Study, the French study of Boccalon or the Framingham Study (Meijer *et al.* 1998; Fowkes *et al.* 1991; Boccalon *et al.* 2000; Murabito *et al.* 2003); in some studies, the prevalence was even higher (Cacoub *et al.* 2009; Mourad *et al.* 2009), above 20%. In the Peripheral Arterial Disease Detection, Awareness and Treatment in Primary Care (PARTNERS) study (Criqui *et al.* 1992), conducted also across a number of primary care sites in the USA, a high prevalence – 29% – was found in higher-risk patients. By contrast, lower prevalence rates were reported by other studies conducted in Spain such as the ESTIME study with a prevalence of 8.03% in the same age group (Blanes *et al.* 2009) or 4.5% in 35–79-year group in the Girona study (Ramos *et al.* 2009). The proportion between symptomatic and asymptomatic patents with PAD in the Czech ABI Project is consistent with the findings of other authors, i.e., only one in three PAD patients is usually symptomatic.

The ABI at rest is one of the options for detecting arterial stenosis or even occlusion, and a most valuable tool for discovering atherosclerosis as early as possible in the primary prevention setting. It is particularly the asymptomatic form of PAD resulting from risk exposure and genetic susceptibility, which may be useful in improving CV risk stratification, risk modification, and

Tab. 3. Selected classes of drugs for cardiovascular disease.

Medication	Total n=6 885	ABI <0.9 n=941	ABI ≥0.9 n=5 944	*p*-value*
Antihypertensive agents	5454 (79.2%)	814 (86.5%)	4640 (78.1%)	$p<0.01$
ACE inhibitors	3518 (64.5%)	564 (69.3%)	2954 (63.7%)	$p<0.01$
ARBs	1300 (23.8%)	198 (24.3%)	1102 (23.8%)	$p=0.72$
Diuretics	2467 (45.2%)	426 (52.3%)	2041 (44.0%)	$p<0.01$
Calcium-channel blockers	2427 (44.5%)	420 (51.6%)	2007 (43.3%)	$p<0.01$
Beta-blockers	2178 (39.9%)	353 (43.4%)	1825 (39.3%)	$p<0.05$
Other	919 (16.9%)	173 (21.3%)	746 (16.1%)	$p<0.01$
Lipid-lowering drugs	3537 (51.4%)	622 (66.1%)	2915 (49.0%)	$p<0.01$
Antiplatelets	2208 (32.1%)	522 (55.5%)	1686 (28.4%)	$p<0.01$
Vasodilating agents	658 (9.6%)	259 (27.5%)	399 (6.7%)	$p<0.01$

implementation of adequate therapeutic strategies. The method now commonly applied is one measurement of ABI at a single time point. Price *et al.* set the cut-off ABI value in a very large population-based cohort. A resting ABI below 0.9 is widely considered to be abnormal (Price *et al.* 2008). Ankle-brachial index measurement involves the recording of systolic blood pressure in the brachial artery and in the posterior tibial and the dorsalis pedis arteries at each ankle. The result is reported as a ratio of the ankle systolic pressure in the numerator over the higher brachial pressure in the denominator. The ABI is calculated for each leg separately and the lower of the two values is taken as a result for the patient. Numerous methods of calculating the ABI have been described, i.e., the current method using the higher of the two ankle systolic arterial pressures (so called high ankle pressure); however, some studies have reported also a low ankle pressure, in some epidemiological studies, the average of the two ankle systolic pressure values were taken as the numerator, and a few studies have used the posterior tibial artery systolic pressure to calculate ABI. A high level of specificity (83.3–99.0%) and accuracy (72.1–89.2%) for an ABI ≤0.9 in detecting ≥50% stenosis was reported in a review addressing this topic, with a large variation in the level of sensitivity (15–79%). Sensitivity was lower especially in elderly individuals and patients with diabetes. The authors concluded that, in populations between 40 and 75 years of age with at least 1 CV risk factor, ABI could be reliably used for the diagnosis of PAD (Dachun *et al.* 2010). There is also a consistent series of prospective epidemiological studies indicating that an abnormal ABI predicts CVD. A systematic review and meta-analysis including 7 population-based studies with a total of 28 679 patients found a consistent relationship between a low ABI and an unfavorable CV prognosis (Doobay & Anand 2005).

The method of ABI determination used in this study was not the gold standard of Doppler probe-assisted ABI determination but oscillometric measurement automatically calculating ABI after placement of four cuffs of the Boso ABI-System 100 device. The detection of peripheral pulses by Doppler may require a certain degree of expertise that has precluded its widespread use in the primary care setting. The main advantages of the Boso-ABI System 100 device used in our study are that it can be operated by a nurse and the measurement is faster, taking only a few minutes to be completed. Diehm compared these two methods of ABI determination and found an overall good correlation between oscillometric and Doppler ABI determination. The correlation was limited in diabetic patients and in patients with critical limb ischemia (Diehm *et al.* 2009). In our patient population, we found the oscillometric method convenient for the patient because it causes minimal discomfort during cuff inflation, and feasible for the medical staff given its simplicity and rapidity. These are the most important advantages allowing to introduce the method into routine practice. At the end of the study, where each GP had examined on average 70 patients during regular preventive medical check-ups, the GPs reported that ABI determination using this method is suitable and feasible for the primary care setting as it is not time-consuming and requires only little training.

The unique role of ABI determination as a marker of atherosclerosis becomes clearly evident when correlated with cardiovascular events in different studies. The ABI Collaboration project found that inclusion of the ABI into the widely used Framingham Risk Score reclassified 19% of men and 36% of women into another category of risk (Fowkes 2008). In the Czech ABI Project, the risk was classified in all examined individuals using SCORE charts for countries at high CVD risk (based on age, sex, smoking, systolic blood pressure, and total cholesterol). Surprisingly, only half of patients with a documented low ABI have a 10-year risk for fatal CVD event above 10% (very high risk), less than one third (28.4%) of these with PAD were scored as being at high risk (6–10%) and as many as 22% of those with established PAD are in the intermediate/low-risk group (<5%). The addition of ABI determination to CV risk estimation could thus reclassify a patient´s risk and change the view of importance for CV preventive measures in individual patients.

The measurement of the ABI in patients without symptoms of PAD was somewhat controversial. However, getABI, a similar German epidemiological study clearly showed that 21% of subjects screened had PAD, and the presence of PAD was associated with a >2-fold adjusted risk of death or severe vascular events. In persons with PAD, the risk of death or a severe coronary or cerebral vascular event was three times that of a peripheral vascular event (Diehm *et al.* 2009). Their findings reinforce the concept that the measurement of ABI in selected patients as part of primary care practice would identify a significant number of persons at elevated risk for CV morbidity and mortality.

One limitation of our study is the fact that we did not assess individuals with an ABI >1.3 as abnormal and did not evaluate them further. The ABI may be elevated falsely in elderly people, patients with renal disease and especially in those with diabetes. In these cases, PAD could be confirmed or excluded non-invasively by measuring the toe-brachial index. We did not perform this examination because it requires special equipment unavailable in the primary care setting. This fact may contribute to some degree of underestimation of the prevalence of the disease.

Both aims of the Czech ABI study were achieved: 1) to include measurement of the ABI as a tool for diagnosing PAD (as a marker of generalized atherosclerosis) into regular preventive check-ups by the GP; 2) to estimate the prevalence of PAD in patients at risk.

Eighty-two GPs became familiar with the oscillometric method of ABI determination in the Czech

Republic within one year. Using this method, they were able to examine a total of 6 885 individuals during regular preventive check-ups. They were advised to be aware of the technical limitations of this method, especially in individuals with high or low ABI, and these cases have to be assessed carefully by vascular specialists.

The Czech ABI Project is a study reporting the prevalence of PAD in an East European country supposed to have a clearly increased risk of CVD; however the figures obtained show that the prevalence of PAD in the Czech Republic is similar to that of Germany and even lower than in France.

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