doi:10.1093/fampra/cmn035 Family Practice Advance Access published on 20 June 2008

Ankle–brachial index measured by palpation for the diagnosis of peripheral arterial disease

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Migliacci R, Nasorri R, Ricciarini P and Gresele P. Ankle–brachial index measured by palpation for the diagnosis of peripheral arterial disease. *Family Practice* 2008; **25**: 228–232.

Background. The ankle–brachial index (ABI), i.e. the ratio of the ankle to brachial systolic blood pressure, is the golden standard for the diagnosis of peripheral arterial disease (PAD) and is a highly specific method for the assessment of vascular risk in otherwise asymptomatic patients.

Objective. To assess the diagnostic accuracy of the ABI measured by palpation in patients at increased cardiovascular risk in a primary care setting.

Methods. Twenty-four GPs enrolled 10 consecutive patients each, at intermediate cardiovascular risk, based on age >55 and <65 years and one or two associated major cardiovascular risk factors or age >65 and <80 years without associated cardiovascular risk factor. Clinical data recording and measurements of the ABI were performed. The design of the study was a prospective, blind comparison between the ABI measured by palpation by the GP and simultaneously by Doppler ultrasound by an angiologist (reference test).

Results. Out of 240 enrolled patients, 205 completed the study (35 lost to follow-up); in 9, ABI by palpation was not measurable. Out of the remaining 196 assessable patients, 8 (4.08%) had PAD. Sensitivity of the palpation method was 88% (95% confidence intervals: 65–100), specificity 82% (77–88), positive predictive value 18% (6–29), negative predictive value 99% (98–100), positive likelihood ratio = 4.98 (3.32–7.48) and negative likelihood ratio = 0.15 (0.02–0.95).

Conclusions. The measurement of ABI by palpation in the setting of primary care, in patients at intermediate cardiovascular risk, is a sufficiently sensitive method to consider its use as a screening test for the exclusion of PAD.

Keywords. Ankle–brachial index, cardiovascular risk, doppler ultrasound, peripheral arterial disease, primary care.

Introduction

The ankle–brachial index (ABI), i.e. the ratio of the ankle to brachial systolic blood pressure, is the golden standard for the diagnosis of peripheral arterial disease (PAD) and is a highly specific, although poorly sensitive, method for the assessment of vascular risk in otherwise asymptomatic patients.[1]

This has been demonstrated not only in specialized clinical settings or in population-based studies[2] but also in primary care, where patients with an ABI $\leqslant 0.9$ were shown to have a substantially increased risk of death and severe vascular events.[3]

While in most epidemiological studies the ABI has been measured by Doppler ultrasound,[3,4] which represents the gold diagnostic standard, a substudy of the Heart Outcomes Prevention Evaluation Study (HOPE) trial showed that the ABI is a strong predictor for future cardiovascular events and for all-cause mortality even when measured simply by palpation of the foot arteries.[5]

The potential use of the ABI, as measured by palpation of the foot arteries, in primary care has not been properly assessed and it requires validation of its diagnostic accuracy; indeed, if validated, the ABI by palpation could provide a simple to perform,

Received 23 November 2007; Revised 16 May 2008; Accepted 22 May 2008.
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noninvasive, inexpensive and rapid method for PAD detection and vascular risk stratification in primary care.

Aim of our study was to evaluate, in a typical primary care setting, the diagnostic accuracy of the ABI measured by palpation in comparison with the gold standard ABI measured by Doppler ultrasound.

Methods

Twenty-four GPs of the Val di Chiana area, Tuscany, Central Italy, participated in the study. In total, the practices had a population of 20 000 patients. The study population comprised patients registered with these practitioners in 2004 and having the following characteristics: age between 55 and 65 years and one or two additional major cardiovascular risk factors (type II diabetes mellitus, hypertension, smoking, dyslipidemia) or age between 65 and 80 and no additional risk factors. Exclusion criteria were previous clinically apparent ischemic cardiovascular disease, a previous diagnosis of PAD, the concomitant presence of three or more risk factors, refusal to give written, informed consent. All the practitioners participated, before the start of the study, in a 3-h session of training given by a specialized angiologist (RM) on the methodology of ABI measurement by palpation of the foot arteries. The first 10 patients seen by each GP after the start of the study, and satisfying enrolment criteria, were asked to sign an informed consent and to come back on a later occasion for the measurement of ABI.

On the study day, each patient underwent the measurement of ABI bilaterally by pulse detection of the posterior tibial and dorsalis pedis arteries of the right lower limb, of the right and left brachial artery, of the posterior tibial and dorsalis pedis arteries of the left lower limb and again of the right and left brachial artery. The ABI was calculated from the average of two determinations as the ratio between the highest systolic blood pressure of the ankle and the highest systolic blood pressure of the upper limbs. Blood pressure measurements were taken on patients in a supine position, resting for at least 10 min, by detection of either the posterior tibial or of the dorsalis pedis artery during deflation of an appropriately sized cuff placed around the ankle. Pressure readings were taken at reappearance of the foot pulse and approximated to 2 mmHg; when only one of the two foot arteries was palpable, this was used for pressure measurement. Measurements were carried out simultaneously by the GP, by palpation of the posterior tibial artery and by an experienced angiologist, by Doppler ultrasound of the dorsalis pedis using an attached stethoscope in order to prevent the Doppler signal to be heard by the GP (Fig. 2); the sequence of the measurements on the foot arteries by the GP and angiologist was then inverted. Brachial blood pressures were taken, again simultaneously by the GP and by the angiologist, by palpation of the radial pulse (GP) and by ultrasound Doppler of the brachial artery (angiologist), respectively. The angiologist and the GP were blinded to one another as regards the results obtained in each patient.

FIGURE 1 *Example of the simultaneous measurement of ABI by palpation (GP) and by Doppler ultrasound (angiologist) on a patient of the study*

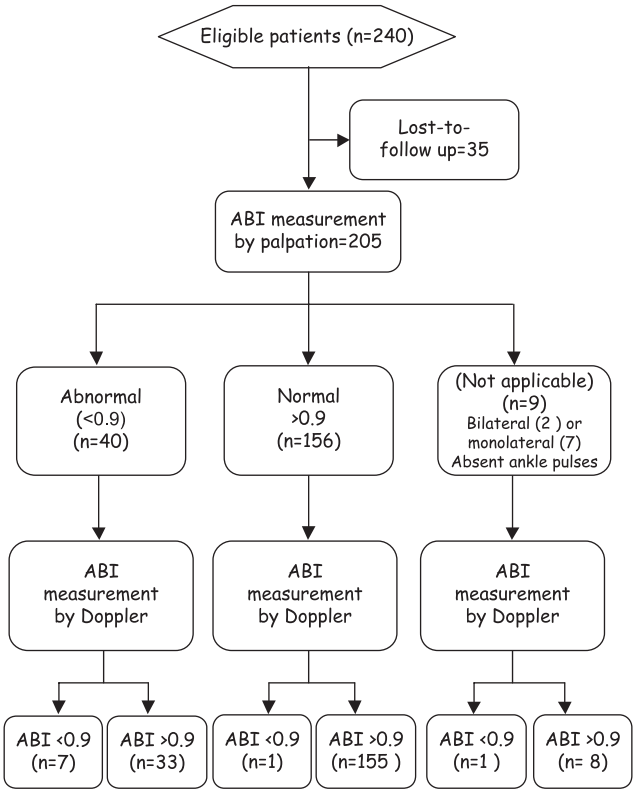

FIGURE 2 *Flow diagram of the study*

Diagnostic accuracy of the ABI measurement by pulse palpation was calculated versus the gold standard (ABI measured by Doppler ultrasound) according to the Standards for Reporting of Diagnostic Accuracy (STARD) initiative rules.[6]

All statistical analyses were carried out using the CAT-maker software, according to the instructions downloaded from the Center for Evidence-Based Medicine (http://www.cebm.net/).

Results

The 24 GPs identified their respective10 patients to be enrolled in an average time of 2.7 days. Of the 240 patients who accepted to participate, 205 came back for the study (85%). Patients' mean age was 64.5 years (55–80), 51.6% were female, 11% had diabetes mellitus, 43% hypertension, 11% were smokers and 16% were dyslipidemic.

Out of the 205 assessable patients, 9 had an ABI ⩽0.9 at Doppler measurement (PAD prevalence = 4.37%). In 9 out of 205 patients, ankle pulses were both not detectable on palpation, either bilaterally (two cases) or in one leg (seven cases), and thus, ABI by palpation was not applicable. In these nine patients, ABI by Doppler was <0.9 in one and normal in the other eight. Of the remaining 196 patients, eight (4.08%) had an ABI ⩽0.9; of these, seven were correctly classified by palpation while one was mistakenly classified as normal (ABI = 0.93); furthermore, 33 patients with a Doppler ABI >0.9 were erroneously classified as affected by PAD (ABI ⩽ 0.9) (Fig. 2). Taking the Doppler measurement of ABI as the gold standard, the palpation method had a sensitivity of 88% [95% confidence intervals (CIs) = 65–100], specificity 82% (77–88), positive predictive value 18% (6–29), negative predictive value 99% (98–100), positive likelihood ratio 4.98 (3.32–7.48) and negative likelihood ratio 0.15 (0.02–0.95) (Table 1).

Discussion

We have validated the measurement of ABI by palpation in a typical primary care setting in Central Italy. The target patient population selected was patients at intermediate cardiovascular risk: in these patients, the yield of ABI as a screening test is expected to be higher than in the general population[7,8] and the finding of a pathologic ABI may allow to identify those cases with a worse cardiovascular prognosis. We have shown that the ABI measured by the GP has a sensitivity of 88%, a specificity of 82%, a positive predictive value of 18% and a negative predictive value of 99% in detecting PAD.

The very low probability of having PAD in a patient with an ABI >0.9 by palpation (posttest probability = 0.45%) allows to consider the test adequate as a first screening for PAD identification and to exclude the need of further testing. On the other hand, the low positive predictive value (18%) does not allow to use the test as a conclusive diagnostic test. Patients identified by palpation as possibly affected by PAD (ABI ⩽ 0.9), or those not suitable for ABI measurement by palpation (4.4% of total in our study), should be further evaluated by Doppler ultrasound. The prevalence of PAD in our population was lower (4.37%) than that reported in previous epidemiological studies in primary care[3,4]; however, in those studies, the population included patients at high risk or with previous clinically evident atherosclerotic disease[3,4] while our patients were selected as a population at intermediate risk, based on age >55 and <65 with one or two associated risk factors or age >65 and no associated risk factors. To the best of our knowledge, our study is the first to report the prevalence of asymptomatic PAD in this intermediate risk population.

A previous study, with a design similar to ours, attempted to validate the auscultatory method for the diagnosis of PAD in comparison with the Doppler method, but found a lower positive likelihood ratio as compared with our method (2.7, CIs 1.9–3.9) and a much lower percentage of assessable patients (60.5%) as a compared with ours (95.6%).[9]

The most important step for the reduction of cardiovascular morbidity and mortality in patients with PAD is disease recognition[7,10] and an ABI ⩽0.9 is the main parameter for PAD diagnosis.[1]

PAD is very infrequently diagnosed in primary care due to the need to perform measurements requiring a specialized equipment, an appropriate training and a relatively time-consuming procedure. In Italy, for

TABLE 1 *Sensitivity, specificity and predictive values of ABI by palpation versus ABI by Doppler ultrasound*

		ABI by Doppler		Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	Negative predictive value (%)	Positive predictive value (%)
		Positive	Negative				
ABI by palpation	Positive	7	33	88% (95% CI = 65–100)	82% (95% CI = 77–88)	99% (98–100)	18% (6–29)
	Negative	1	155				

instance, Doppler measurement is not usually performed by GPs as this diagnostic procedure is not among those reimbursed to the GPs by the National Health System and most patients with suspected PAD are referred to specialized Centers. This creates problems with the waiting lists and with the cost burden for the National Health System. The palpation approach to the measurement of ABI should allow to reduce substantially the burden of Doppler ultrasound measurements required (a 78% reduction from our study population); given the cost of Doppler measurement in referral centres in secondary care, this would imply a substantial cost reduction.

A simple, fast and inexpensive method for the measurement of ABI, which requires no special equipment or special training, is represented by the blood pressure measurement in the arm and foot by palpation of the arterial pulses.[5] ABI measurement by palpation has been proven to be a prognostic factor for ischemic cardiovascular events in the setting of a prospective clinical trial,[5] but its value in primary care is not defined yet. The validation of its diagnostic accuracy in primary care, with reference to the golden standard represented by ABI measurement by Doppler ultrasound, is preliminary to the evaluation of its prognostic role.

Clinical examination alone does not allow to confirm or exclude the diagnosis of PAD and thus cannot be used for clinical decision making.[11] In fact, both our data and previous studies[12] show that the absence of ankle pulses is not a sufficiently sensitive criterium to exclude asymptomatic PAD. The systematic evaluation of ABI by palpation, therefore, can substantially improve the negative predictive value of physical examination and may allow to exclude the presence of PAD in a significant number of patients. For example, ABI measurement by palpation as a screening test is simpler and faster than ambulatory blood pressure measurement, considering that the exclusion of hypertension requires repeated blood pressure measurements.[13] Finally, it should not be forgotten that given that the measurement of ABI by palpation involves touch, this is likely to enhance the doctor to patient relationship and, thus, to reinforce the compliance of the patient to the doctor's advice.[14]

The possible substantial reduction of costs for the Health Care System is an argument in favor of a generalized screening of PAD in primary care, a procedure recommended by several authorities.[7,8] The low cost and the inexpensive equipment required for the screening of ABI by palpation may be of particular importance for developing countries where the prevalence of atherosclerotic disease is in great expansion.[15] The cost–benefit ratio of an alternative strategy, i.e. that of providing all GPs with the appropriate equipment and the training for ABI measurements by Doppler Ultrasound, is likely to be disadvantageous.

A prospective assessment of the prognostic value of a low ABI by palpation on cardiovascular events in primary care is now warranted.

Acknowledgements

We thank the practitioners of the Cooperativa 'Etruria Medica' and the Members of the Palpazione Indice E Doppler Indice study group (P. Angori, G. Argirò, A. Brocchi, D. Brocchi, M. Burbi, F. Calzini, I. Calzolari, G. Chiavini, G. Cianti, R. Cottini, M. Failli, U. Faralli, G. Franceschini, S. Lovari, G. Lovrencie, A. Mariangeloni, A. Melacci, M. Pellegrini, R. Reali, F. Rinchi, I. Santeramo and U. Santiccioli) for actively participating in the study. We are grateful to Dr G. Guglielmini for help with some parts of the statistical analysis and to Mrs M. Sensi for secretarial assistance.

Declaration

Ethical approval: The study was approved by the local Ethical Committee (Comitato Etico Locale, USL 8, Arezzo).
Funding: No external funding was provided for the study.
Competing interests: All authors have reported no competing financial interests.
Conflicts of interest: No conflict of interest reported.

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