Does the Clinical Examination Predict Lower Extremity Peripheral Arterial Disease?

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Context Lower extremity peripheral arterial disease (PAD) is common and associated with significant increases in morbidity and mortality. Physicians typically depend on the clinical examination to identify patients who need further diagnostic testing.

Objective To systematically review the accuracy and precision of the clinical examination for PAD.

Data Sources, Study Selection, and Data Extraction MEDLINE (January 1966 to March 2005) and Cochrane databases were searched for articles on the diagnosis of PAD based on physical examination published in the English language. Included studies compared an element of the history or physical examination with a reference standard of ankle-brachial index, duplex sonography, or angiogram. Seventeen of the 51 potential articles identified met inclusion criteria. Two of the authors independently extracted data, performed quality review, and used consensus to resolve any discrepancies.

Data Synthesis For asymptomatic patients, the most useful clinical findings to diagnose PAD are the presence of claudication (likelihood ratio [LR], 3.30; 95% confidence interval [CI], 2.30-4.80), femoral bruit (LR, 4.80; 95% CI, 2.40-9.50), or any pulse abnormality (LR, 3.10; 95% CI, 1.40-6.60). While none of the clinical examination features help to lower the likelihood of any degree of PAD, the absence of claudication or the presence of normal pulses decreases the likelihood of moderate to severe disease. When considering patients who are symptomatic with leg complaints, the most useful clinical findings are the presence of cool skin (LR, 5.90; 95% CI, 4.10-8.60), the presence of at least 1 bruit (LR, 5.60; 95% CI, 4.70-6.70), or any palpable pulse abnormality (LR, 4.70; 95% CI, 2.20-9.90). The absence of any bruits (iliac, femoral, or popliteal) (LR, 0.39; 95% CI, 0.34-0.45) or pulse abnormality (LR, 0.38; 95% CI, 0.23-0.64) reduces the likelihood of PAD. Combinations of physical examination findings do not increase the likelihood of PAD beyond that of individual clinical findings. However, when combinations of clinical findings are all normal, the likelihood of disease is lower than when individual symptoms or signs are normal. A PAD scoring system, which includes auscultation of arterial components by handheld Doppler, provides greater diagnostic accuracy.

Conclusions Clinical examination findings must be used in the context of the pretest probability because they are not independently sufficient to include or exclude a diagnosis of PAD with certainty. The PAD screening score using the hand-held Doppler has the greatest diagnostic accuracy.

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CLINICAL SCENARIOS

In the following cases, the clinician would like to know if the patient has peripheral arterial disease (PAD).

Case 1

A 65-year-old man with a history of a myocardial infarction (MI) is referred for problems of deep calf pain in his right leg. This pain occurs when he walks farther than 1 city block and is relieved by rest in less than 10 minutes. On examination, you hear a bruit over his right common femoral artery.

Case 2

A 55-year-old female smoker is admitted to the hospital for a chronic obstructive airways disease exacerbation. Other than her respiratory problem, she has no other complaints. On physical examination, you cannot feel her left dorsalis pedis or posterior tibial pulse.

WHY IS THIS AN IMPORTANT QUESTION TO ANSWER WITH A CLINICAL EXAMINATION?

Lower extremity atherosclerotic PAD affects 12% of older men and women.[1] Among those with advanced age, a history of smoking, and presence of diabetes mellitus, the prevalence of PAD can be as high as 50%.[2]

See also p 547 and Patient Page.

Establishing a diagnosis of PAD is important because of the prognostic and therapeutic implications. PAD is associated with a progressive decline in walking endurance and an increased rate of depression compared with those without PAD.[3-5] Among those with intermittent claudication, 25% experience worsening pain symptoms,[6-8] 5% require revascularization, and 1% to 2%

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will need major amputation.[7,9] PAD is also an indicator of widespread atherosclerosis and increased mortality.[10] Stroke and MI occur 3 times as frequently in those those with PAD compared with those without PAD, even among those with no vascular symptoms.[10]

Proper diagnosis of PAD allows the clinician to select a treatment plan to alleviate pain symptoms, improve functional ability, and reduce the future risk of cardiovascular events among patients.[11] Despite its poor prognosis, PAD is often underdiagnosed.[12] PAD is classically associated with the leg pain features of intermittent claudication as in Case 1. However, most patients with PAD describe other leg pain symptoms, or have no symptoms at all,[12] as in Case 2.

A survey of primary care physicians revealed that they believe in the usefulness of measuring the ankle-brachial index (ABI) for diagnosing PAD.[13] However, the respondents cited a lack of time as a major barrier to systematic screening. Detecting PAD requires screening with the medical history to elicit leg symptoms and identify risk factors, specific physical examination findings, and potential supplemental diagnostic testing. Because physicians largely depend on clinical assessments to determine which patients need further evaluation, determining the accuracy of the clinical examination for PAD is important. We systematically reviewed the diagnostic accuracy and precision of bedside findings for lower extremity PAD for patients with leg pain symptoms and for asymptomatic patients. In particular, we hoped to identify individual symptoms, signs, or combinations of findings that might save time for clinicians by more efficiently targeting patients who require ABI testing.

Pathophysiological Characteristics of Lower Extremity PAD and the Relationship to Symptoms and Signs

The findings on the medical history and physical examination relate to the pathophysiological characteristics of PAD. Claudication occurs during exertion when blood flow velocity increases across a stenotic lesion. The severity of impaired blood flow, and therefore symptoms, correlates with the flow velocity, degree of stenosis, and number of occlusive lesions.[6-14] However, physically inactive patients with significant stenoses may not have symptoms until they create the demand for increased blood flow to leg muscles. With critical leg ischemia, the stenosis and impaired flow is so severe that no exertion is required to produce symptoms; these patients may have pain at rest that tends to affect the feet as opposed to the legs, and that may resolve by placing the feet in a dependent position.[15,16] Chronically decreased blood flow contributes to the signs of pallor, dependent rubor, atrophic skin and nails, and to the development of ischemic ulcers from areas of minor trauma.[17] Significant narrowing of the blood vessels at the various anatomic segments may also manifest as absent or reduced pulses or arterial bruits.[16]

Diagnostic Reference Standard for PAD

The ABI is a commonly accepted reference standard because it is highly sensitive and specific for diagnosing PAD. Other diagnostic tests are available including duplex ultrasound, contrast-enhanced magnetic resonance angiography, and angiography; but the ABI is widely used because it is noninvasive, less expensive, and readily available. Not only does the ABI effectively identify patients with disease and is an important predictor of future vascular events,[18] but the result also correlates with severity. The bedside ABI serves as the pragmatic reference standard for PAD because it has been validated in clinical epidemiological research.[19] However, the measures performed in a vascular laboratory are likely more precise and are required when considering revascularization. Angiograms outline the anatomy and identify areas of narrowing, but angiography is now primarily used during therapeutic interventions (eg, arterial angioplasty) for patients identified through ABI measurement.

While the methods for calculating the ABI can vary, one commonly accepted calculation is the ratio of the highest ankle systolic pressure divided by the highest brachial systolic pressure.[6] The brachial systolic pressure may be measured with any method (auscultation with a stethoscope, oscillometric, or Doppler ultrasound) as one study showed no large, clinically important differences in ABI values as a function of the method.[20] However, brachial pressures can change slightly as a function of the measurement procedure, so examiners should be consistent when they are monitoring a patient's ABI over time.[21] Because vascular laboratories almost uniformly use the Doppler for brachial systolic pressure, bedside results should better correlate with the values in the vascular laboratory when the same measurement method is used.

With the patient lying supine, a sphygmomanometer cuff, placed 2 to 3 cm above the point of pulse measurement, is inflated above the systolic pressure (FIGURE). As the cuff pressure is slowly released, a handheld Doppler is used for obtaining the systolic pressure at the right and left ankle (either dorsalis pedis artery, posterior tibial artery, or both) and the right and left brachial artery.[22] The systolic pressure is that pressure where the Doppler signal returns.

The ABI accurately diagnoses not just the presence but also the severity of PAD. Using a threshold value of 0.90 or less to indicate an abnormal result, the ABI has a sensitivity of 95% and a specificity approaching 100% for identifying PAD compared with angiography.[23,24] An ABI of 0.71 to 0.90 indicates the presence of mild PAD, an ABI of 0.41 to 0.70 indicates moderate PAD, and an ABI of 0.40 or less indicates severe PAD.[25,26] Pain at rest or severe occlusive disease typically occurs with an ABI of less than 0.50. Ischemic or gangrenous extremities are associated with an ABI of less than 0.20.[22]

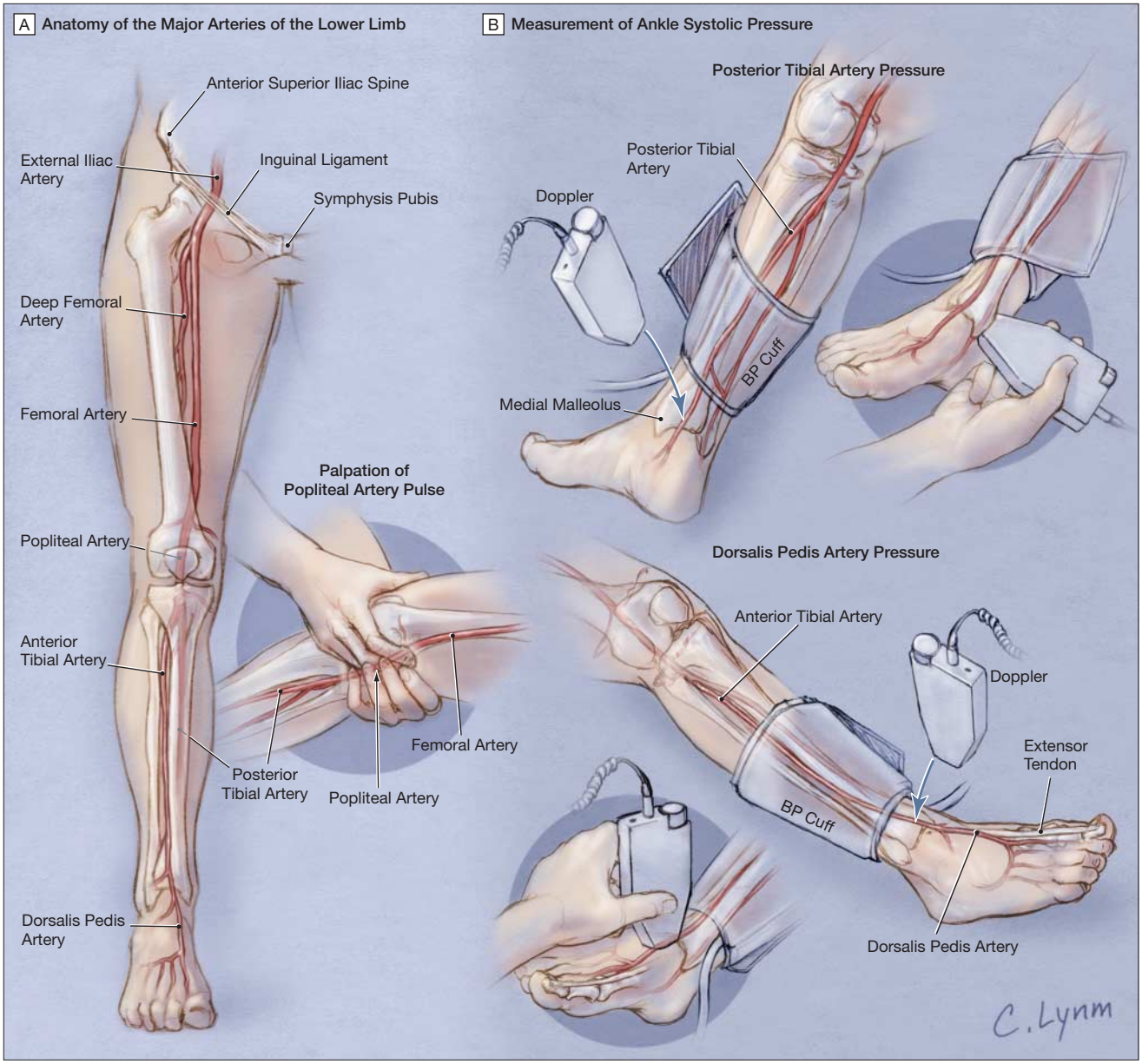
A falsely normal or high ABI occurs when peripheral arteries become

heavily calcified and noncompressible. The noncompressibility, generally occurring in older individuals and those with diabetes mellitus or end-stage renal disease, leads to ABI values well above normal (>1.30). Very high ABI values are associated with increased mortality, similar to patients with PAD,[27] and should prompt other noninvasive testing (ie, duplex ultrasonography or toe-brachial index) at a vascular laboratory to diagnose PAD.[22]

Symptoms of PAD

When assessing the patient with leg complaints, a clinician should consider PAD in the differential diagnosis (BOX 1). PAD is commonly believed to be present in patients with symptoms of ischemic intermittent claudication (ie, reproducible leg pain that occurs with exercise, does not occur at rest, and is relieved within 10 minutes of rest).[28] While the preva-

Figure. Normal Arterial Anatomy of the Lower Limb and Positioning for Measurement of Ankle Systolic Pressure Used for Determining the Ankle-Branchial Index (ABI)



A, Normal arterial anatomy of the right lower limb in anterior view and palpation of the popliteal pulse with the examiner's hands tucked into the popliteal fossa (inset, posteromedial view). B, To obtain ankle systolic pressure for calculating the ABI using the posterior tibial artery (B, top) or the dorsalis pedis artery (B, bottom), the blood pressure cuff is placed above the pulse. The Doppler probe is positioned over the area of the arterial pulse.

lence of intermittent claudication varies depending on the population studied, these classic symptoms occur in the minority of patients with PAD. In community cohort studies, patients with PAD report symptoms of intermittent claudication less often (6%-9%).[29,30] In 2 primary care clinic studies, patients with PAD more commonly reported exertional leg pain atypical for claudication (46%-48%) or no symptoms at all (20%-48%).[12,31] The Rose Questionnaire, a symptom inventory used to identify and characterize claudicatory symptoms, identifies patients with PAD but is confounded by common comorbid conditions that also cause leg discomfort.[32] Unfortunately, relying on the presence of intermittent claudication alone to make a diagnosis of PAD, or even as the screening criteria to perform a further detailed examination, would miss the majority of patients.

Box 1. Differential Diagnoses for Leg Discomfort*

Arteritis
Arthritis of knees or hips
Ischemic intermittent claudication
Lymphangitis
Mechanical muscle pain
Myositis
Nerve root pain, sciatica, neurogenic pseudoclaudication (spinal stenosis)
Peripheral nerve pain (eg, diabetic neuropathy)
Phlebitic syndrome after deep venous thrombosis
Reflex sympathetic dystrophy
Thromboangiitis obliterans (Buerger disease)
Venous claudication

*Clinicians should be aware that multiple causes could be present. Based on data from the Transatlantic Intersociety Consensus document on peripheral arterial disease.[6]

Signs of PAD

Skin Examination. Abnormalities in skin coloration (pallor, red, blue, or dusky purple), atrophy of skin or nails (dry, brittle skin and nails), cool skin, and absence of hair on the toes are often associated with insufficient arterial blood supply.[17,33] Severe ischemia produces ulcers that usually occur at the lateral malleolus, tips of the toes, metatarsal heads, or bunion area. The ulcers tend to be dry and painful and may progress to gangrene. Venous stasis ulcers are usually distinguishable from ischemic ulcers because they tend to occur on the medial malleolus and are more typically painless.

Pulse Examination. Any of the femoral, popliteal, posterior tibial, or dorsalis pedis pulses may be absent or diminished in PAD. The femoral artery is palpated just below the inguinal ligament, halfway between the anterosuperior iliac spine and the symphysis pubis.[16] The popliteal artery is palpated with the examiner's fingers tucked into the patient's popliteal space with the patient's knee extended (Figure). If the popliteal pulse cannot be felt, the clinician may attempt to palpate with the patient's knees and hips partially flexed. The posterior tibial artery pulsation can be palpated below and behind the medial malleolus.[33] While the location of the dorsalis pedis artery can be variable, it is usually felt halfway down the dorsum of the foot, just lateral to the extensor tendon of the first toe. Slight dorsiflexion of the foot may aid in eliciting the dorsalis pedis pulse.[16,33]

The handheld Doppler can localize the pulse, characterize the arterial signals, and measure the ABI. To localize the pulse, place a pea-sized amount of conductivity gel over the area of the arterial pulse, then, place the tip of the Doppler probe into the conductivity gel, making full contact with the skin surface. To obtain the number of audible components, or if there is difficulty in localizing the pulse, adjust the probe angle between 30° and 60° and/or the probe position from side to side until the sound is clearly optimized. Some Doppler devices are directional and require placement of the Doppler at a specified angle to the artery, others are nondirectional and the sound can be heard with the device at any angle. It is important to apply only light pressure with the Doppler probe as heavy pressure may extinguish one or all of the arterial signals. In individuals with severe PAD, the signal may be soft and difficult to distinguish between a vein or arterial Doppler sound. The arterial signal is pulsatile and follows the cardiac cycle unlike a vein or background static.

Listen for a pulsating whooshing sound, the arterial signal that indicates the presence of an arterial pulse. Typically, the normal pulse creates 3 (triphasic) audible arterial components, although patients without PAD may have a diphasic posterior tibial artery (only 2 audible components). The initial component produces the loudest sound, followed by the perception of a slight pause and then a slightly softer second component. The third component rapidly follows the second and is the least intense of the 3 components. As a stenosis worsens, the number of sounds decreases to 1 (monophasic) and then 0 with complete occlusion.

Auscultation for Bruits. Auscultation for systolic bruits requires only light pressure with either the bell or diaphragm of the stethoscope, as compression of the artery induces a bruit in individuals without PAD.[33,34] Auscultation should include the iliac (located on both sides of the umbilicus, 2-cm lateral from the midline and halfway between the umbilicus and inguinal ligament), femoral, and the popliteal areas.

Table 1. Characteristics of Primary Diagnostic Accuracy Studies

Source	Quality Level*	Total No. of Participants	No. (%) With Disease	Setting	Reference Standard	Symptoms vs Screening†
Stoffers et al,[39] 1997	1	2455	287 (12)	Primary care clinic	ABI <0.90	Symptoms
Boyko et al,[35] 1997	1	631	46 (7)	Internal medicine clinic patients with diabetes mellitus	ABI ≤0.50	Screening
Criqui et al,[40] 1985	1	575	65 (11)	Lipid clinic study participants	ABI ≤0.80	Screening
Nicholson et al,[41] 1993	2	37	25 (68)	Vascular surgery clinic	Angiogram	Symptoms
Carter,[42] 1981	3	458	309 (67)	Vascular surgery clinic	ABI <0.97	Symptoms
Hiatt et al,[43] 1990	1	950	130 (14)	Diabetic and nondiabetic cohort	ABI <0.94	Screening
Christensen et al,[44] 1989	1	132 (249 limbs)	176 limbs (71)	Surgery clinic	ABI <0.90	Symptoms
Moffatt and O'Hare,[45] 1995	3	462 (533 limbs)	93 limbs (17)	Primary care clinic patients with leg ulcers	ABI <0.90	Screening
Tan et al,[46] 1982	3	254	83 (33)	Medical and orthopedic inpatients with diabetes mellitus	ABI <0.94	Screening
Kazmers et al,[47] 1996	3	100	40 (40)	Vascular laboratory	ABI ≤0.82	Symptoms
Farkouh et al,[48] 2002	1	218	51 (23)	Internal medicine clinic	ABI ≤0.90	Screening

Abbreviation: ABI, ankle-brachial index.
*Based on previously developed checklists.[49]
†Symptom studies identified patients with leg complaints compatible with peripheral arterial disease. Screening studies identified patients without regard to symptoms compatible with peripheral arterial disease.

Table 2. Interobserver Agreement for Diagnostic Precision of Pulse Palpation

Pulse Palpation	No. of Participants	Type of Clinician	κ Statistic
Palpable vs absent	25	Vascular laboratory personnel (n = 3)[55]	0.68
		Vascular surgeons (n = 3)	0.38
		Medical students (n = 3)	0.47
	44	Vascular surgeons (n = 6)[50]	0.52-0.53
	5	Vascular surgeons (n = 2)[51]	0.80-1.00
	84	Generalist physicians (n = 3)[54]	0.27-0.43
	27	Generalist physicians (n = 2)[53]	0.72-0.80
Reduced vs absent	44	Vascular surgeons (n = 6)[50]	0.01-0.15
Absent, just perceptible, perceptible, easily perceptible, or very easily perceptible	63	Clinical preceptors (n = 3)[52]	0.20-0.72

Other Physical Examination Findings

Ancillary physical examination techniques for PAD include capillary refill time, the Buerger test, and venous filling time. To determine capillary refill time, the examiner applies firm pressure to the plantar aspect of the great toe for 5 seconds. After releasing the great toe, if it takes longer than 5 seconds for normal skin color to return, this is considered abnormal.[35] For the Buerger test, the clinician examines for development of pallor with the patient's leg elevated to 90° with the patient lying supine. The leg is then lowered slowly and the angle at which the reddish hue returns is known as the "angle of circulatory sufficiency"; the result is positive if the angle is less than 0° (ie, hangs below the examining table).[36] After identifying a visible vein at the ankle area with the patient supine, the examiner can assess for venous filling time. The examiner lifts the patient's leg 45° above the examining table for 1 minute while observing the vein for a normal collapse. With the patient then positioned to sitting and dangling his/her legs, the examiner measures the length of time it takes for the vein to refill; an abnormal venous filling time is longer than 20 seconds.[35]

METHODS

Data Sources and Study Selection

Using MEDLINE (January 1966 to March 2005) and the Cochrane Database of Systematic Reviews, we sought to retrieve all relevant articles published in the English language on the bedside diagnosis of PAD. The following Medical Subject Headings were used: (EXP *peripheral vascular disease* or EXP *arterial occlusive disease* or EXP *arteriosclerosis obliterans* or EXP *intermittent claudication* or EXP *thromboangitis obliterans*) and (EXP *leg/*). To complete the search, the authors reviewed bibliographies from these articles and from 4 physical examination textbooks.[17,33,37,38] Articles were included if they fulfilled all of the following criteria: (1) the physical examination maneuvers were clearly described and could be accomplished at the bedside; (2) there was an independent comparison between the experimental test and either the ABI, angiography, or duplex sonography as the reference standard; and (3) data could be extracted and used to construct 2×2 tables. Of the 51 articles retrieved and reviewed, 11 articles[35,39-48] on diagnostic accuracy (**TABLE 1**) and 6 articles[50-55] on precision (**TABLE 2**) were included in this study. Of the studies excluded, 20 were not examining a bedside maneuver, 5 had incomplete data, 3 had identified patients improperly (ie, all free of PAD or all with PAD), and 6 had used unacceptable reference standards.

Quality Review

Two investigators (N.A.K. and S.A.R.) independently reviewed each of the

articles for inclusion and for quality review. Any discrepancies were resolved by discussion. We used the quality checklists previously developed for the Rational Clinical Examination series.[49]

Data Analysis

There are 2 commonly encountered yet distinct clinical settings in which physicians suspect PAD: those in which a patient seeks medical attention for leg complaints; and those in which a patient does not have a specific leg complaint but the clinician conducts a screening for PAD based on the patient's risk factor profile. Therefore, to provide clinicians with the evidence for the clinical examination for these 2 patient profiles, we categorizied the studies as symptomatic or screening. Symptomatic studies refer to those in which the study population was identified from a group of patients known to have leg complaints or claudication (eg, surgical or vascular laboratory patients). Screening studies refer to those in which patients were identified before the investigators were aware of any leg complaints (eg, primary care clinics or medical clinics in which leg symptom status was unknown before the patients were enrolled in the study). For the symptomatic studies, in which one is interested in case detection, investigators assessed disease in the individual limb. In screening studies, disease was evaluated for each patient.

Because lower ABI thresholds indicate greater severity of arterial obstruction, we also evaluated the accuracy of the clinical examination for a diagnosis of any degree of PAD (ie, ABI levels $\leq$0.97) and for moderate to severe PAD (ie, ABI levels $<$0.50). Prevalence, sensitivity, specificity, κ scores, likelihood ratios (LRs), and 95% confidence intervals (CIs) were calculated using conventional definitions.[56] Summary measures pooled all the data using a random-effects model, which considers both within- and between-study variances.[57] We also tested for heterogeneity between studies using the Mantel-Haenszel Q-statistic and evaluated studies to look for explanations of heterogeneity. While there was evidence for statistical heterogeneity with several of the pooled results, the studies were clinically homogeneous and the diagnostic point estimates were qualitatively similar. Therefore, we presented the pooled LRs and their corresponding 95% CI because this would provide clinicians with the best available estimates for diagnostic accuracy. We calculated the summary estimates assuming a random-effects model using the Comprehensive Meta Analysis software version 1 (Biostat Inc, Englewood, NJ).

RESULTS

Symptoms of Intermittent Claudication

Four studies examined the accuracy of intermittent claudication in diagnosing PAD.[35,40,43,46] The presence of claudication increases the likelihood of PAD (LR, 3.30; 95% CI, 2.30-4.80). The LRs were similar (P=.22 for heterogeneity) across a range of ABI thresholds (0.50 for moderate to severe disease to 0.94 for any disease). No study found that the absence of claudication helps lower the likelihood of PAD (ABI $<$0.94; LR, 0.89; 95% CI, 0.78-1.00; P=.02 for heterogeneity; TABLE 3). However, the absence of claudication lowers the likelihood of moderate to severe PAD (LR, 0.57; 95% CI, 0.43-0.76).

Signs of Intermittent Claudication

Skin Changes. One large study evaluated skin changes among symptomatic patients.[39] The presence of skin being cooler to the touch in the affected leg is most useful with an LR of 5.90 (95% CI, 4.10-8.60), although discolored skin also increases the likelihood of PAD (LR, 2.80; 95% CI, 2.40-3.30). Wounds or sores increase the likelihood of PAD, but occur less frequently, resulting in wide 95% CIs (LR, 5.90; 95% CI, 2.60-13.40). The absence of cool skin, wounds, or sores does not clinically lessen the likelihood of PAD. Normal skin color lowers the likelihood of PAD, although only to a small extent (LR, 0.74; 95% CI, 0.69-0.79).

A large study among asymptomatic patients with diabetes mellitus[35] evaluated the association between the presence of abnormal skin and moderate to severe PAD (ABI $\leq$0.50). The presence of atrophic skin, cool skin, blue/purple skin, or absence of lower limb hair each possesses limited utility for identifying moderate to severe PAD (LR, 1.50; 95% CI, 1.20-1.70). Likewise, the absence of these signs has minimal impact on the likelihood of moderate to severe PAD (LR, 0.81; 95% CI, 0.72-0.92).

Bruits. The presence of at least 1 bruit at rest (iliac, femoral, or popliteal) increases the likelihood of PAD (LR, 5.60; 95% CI, 4.70-6.70).[39,41,42] Although finding just 1 bruit is useful, clinicians should confirm the absence of a bruit in all 3 arteries of symptomatic patients to lower the likelihood of PAD (LR, 0.39; 95% CI, 0.34-0.45). Auscultation of the femoral artery alone and finding no bruit is inadequate because it provides little information (LR, 0.74; 95% CI, 0.70-0.78).

From the study of asymptomatic patients,[40] the presence of a femoral bruit increases the likelihood of PAD (LR, 4.80; 95% CI, 2.40-9.50) while the absence of a femoral bruit creates little effect on the likelihood of PAD (LR, 0.83; 95% CI, 0.73-0.95).

Pulse Palpation. Any palpable pulse abnormality (absent or reduced femoral, popliteal, dorsalis pedis, or posterior tibial arteries) increases the likelihood of PAD (LR, 4.70, 95% CI, 2.20-9.90; $P<$.001 for heterogeneity).[39,44,45,47] The wide 95% CI indicates the magnitude of diagnostic accuracy varied across studies. However, all of the individual studies demonstrated a significant association between pulse abnormality and PAD and their corresponding lower boundaries of the 95% CIs were all greater than 2.00, suggesting that abnormal pulse palpation at least moderately increases the likelihood of PAD. The absence of any palpable pulse abnormality decreases the likelihood of PAD (LR, 0.38; 95% CI, 0.23-0.64; $P<$.001 for heterogeneity). Each of the studies and their associated 95%

Table 3. Positive and Negative Likelihood Ratios for Various Symptoms or Signs, Stratified by Symptomatic or Screening Studies

Type of Study	Severity	Symptom or Sign	Likelihood Ratio (95% CI)	
			Positive	Negative
Claudication				
Screening	Any disease[31,38,49,56]	"Definite" or "probable" claudication	3.30 (2.30-4.80)*	
	Moderate to severe[31]†	No claudication		0.57 (0.43-0.76)
	Any disease[38,49,56]	No claudication		0.89 (0.78-1.00)‡
Skin changes				
Symptomatic	Any disease[57]	Cooler to touch	5.90 (4.10-8.60)	0.92 (0.89-0.95)
		Wounds or sores	5.90 (2.60-13.40)	0.98 (0.97-1.00)
		Discoloration	2.80 (2.40-3.30)	0.74 (0.69-0.79)
Screening	Moderate to severe[31]†	Either hair, temperature, color, or atrophic change	1.50 (1.20-1.70)*	0.81 (0.72-0.92)*
Bruits				
Symptomatic	Any disease[40,43,57]	At least 1 bruit (iliac, femoral, popliteal)	5.60 (4.70-6.70)*	0.39 (0.34-0.45)*
	Any disease[57]	Femoral bruit	5.70 (4.70-7.00)	0.74 (0.70-0.78)
Screening	Any disease[49]	Femoral bruit	4.80 (2.40-9.50)	0.83 (0.73-0.95)
Pulse palpation				
Symptomatic	Any disease[39,40,42,43,46,57]	Any palpable pulse abnormality	4.70 (2.20-9.90)‡	0.38 (0.23-0.64)‡
Screening	Moderate to severe[31]†	Any palpable pulse abnormality	3.00 (2.30-3.90)	0.44 (0.30-0.66)
	Any disease[31,38,49]	Any palpable pulse abnormality	3.10 (1.40-6.60)§	0.48 (0.22-1.04)
	Any disease[49]	Absence of any palpable abnormality from a lipid research clinic study		0.27 (0.16-0.44)
	Any disease[38]	Absence of any palpable abnormality in high prevalence of diabetes		0.87 (0.79-0.97)

Abbreviation: CI, confidence interval.
*Results statistically homogeneous (all $P>.20$).
†Studies that identified patients with moderate to severe peripheral arterial disease required patients to have an ankle-brachial index of 0.50 or less to be considered "diseased."
‡Results have sufficiently narrow 95% CIs to assess the utility of the finding, although the results are statistically heterogenous ($P = .02$ for claudication; $P<.001$ for pulse palpation).
§Results are statistically heterogeneous with broad 95% CIs ($P<.001$). However, we included studies that used a threshold for mild disease along with studies that used a lower threshold for identifying only patients with moderate to severe disease.

Table 4. Likelihood Ratios of Combinations of Clinical Findings

Clinical Finding	Likelihood Ratio (95% CI)		
	Diabetes Cohort, ABI ≤0.50 (n = 31)	Lipid Study Cohort, ABI ≤0.80 (n = 39)	High-Prevalence Diabetes Cohort, ABI <0.94 (n = 36)
Claudication and abnormal pulse*	6.50 (3.80-11.00)	8.10 (2.70-24.00)	
Claudication or abnormal pulse*	2.10 (1.50-2.90)	4.60 (3.50-6.10)	
Absent pedal pulse or femoral bruit			6.30 (3.70 to 10.00)
No claudication or abnormal pulse*	0.24 (0.13-0.46)	0.21 (0.12-0.38)	
No claudication, absent pedal pulse, or femoral bruit			0.42 (0.30-0.60)

Abbreviations: ABI, ankle-brachial index; CI, confidence interval.
*Reduced or absent pulse.

CIs demonstrated this association, suggesting that the absence of a pulse abnormality at least moderately decreases the likelihood of PAD.

Just as in symptomatic patients, any pulse abnormality in asymptomatic individuals increases the likelihood of PAD in all primary studies (LR, 3.10; 95% CI, 1.40-6.60; $P<.001$ for heterogeneity).[35,40,43] In the single study evaluating moderate to severe disease, any pulse abnormality increased the likelihood that the patient would have an ABI of 0.50 or less (LR, 3.00; 95% CI, 2.30-3.90).

One study evaluated the contribution of each peripheral pulse in the clinical examination. An abnormality in the femoral (LR, 7.20; 95% CI, 2.70-19.00) or posterior tibial artery (LR, 8.10; 95% CI, 5.80-11.00) has equivalent importance for detecting the presence of an ABI of 0.80 or less, but finding an abnormal dorsalis pedal pulse is not as useful (LR, 1.90; 95% CI, 1.30-2.50).[39] An abnormal dorsalis pedal pulse has a lower specificity for identifying PAD compared with an abnormal femoral or posterior tibial artery pulse, so including patients with abnormal dorsalis pedal pulse dilutes the LRs associated with an isolated femoral or posterior tibial artery abnormality.[40,43]

Patients with palpably normal pulses are less likely to have moderate to severe PAD (LR, 0.44; 95% CI, 0.30-0.66). However, the importance of palpably normal pulses for confirming normality varies with the patient population. In patients derived from a lipid clinic study, normal pulses lower the likelihood of PAD (LR, 0.27; 95% CI, 0.16-0.44).[57] In a different population with a high prevalence of diabetes mellitus, a normal pulse was not informative for identifying PAD (LR, 0.87; 95% CI, 0.79-0.97).[43]

Provocative Maneuvers. Abnormal capillary refill time (LR, 1.90; 95% CI, 1.20-3.20) is associated with moderate to severe PAD (LR, 0.80; 95% CI,

0.70-1.00), but the strength of the findings suggests that this sign has little clinical utility among asymptomatic patients with diabetes mellitus.[35] Prolonged venous filling time increases the likelihood of moderate to severe PAD (LR, 3.60; 95% CI, 1.90-6.80), but a normal venous filling time is not informative (LR, 0.80; 95% CI, 0.70-1.00). No studies that evaluated the accuracy of the Buerger test met our inclusion criteria. The impact of exercise on the intensity of bruits has been evaluated,[42] but the small sample size and possible selection bias make it impossible to make conclusions about the utility of this maneuver.

Box 2. Calculating the Peripheral Arterial Disease Score*

Definition

The number of auscultated components (right posterior tibial artery + left posterior tibial artery; range of 0 for none heard to 3 for normal for each artery)

plus

The grade of palpated posterior tibial artery (right posterior tibial artery + left posterior tibial artery; 2 for normal, 1 for palpated but abnormal, 0 for not palpable for each artery)

plus

A history of myocardial infarction (1 for none, 0 for prior myocardial infarction)

Normal Score

Ten when considering both legs (eg, screening the asymptomatic patient; the likelihood of having peripheral arterial disease [PAD] increases for a patient with a score of <6 [likelihood ratio {LR}, 7.80; 95% confidence interval {CI}, 4.80-12.70]; the likelihood of having PAD decreases for a patient with a score of ≥6 [LR, 0.20; 95% CI, 0.10-0.40]).

Five when considering only 1 leg (eg, a patient with unilateral symptoms; the LR for a patient with a score of <4 is 4.80-5.00; for a score ≥4, the LR is 0.10).

*Based on data from Farkouh et al.[48] Listen to a recording of a doppler auscultation of the posterior tibial artery at http://jama.com/cgi/content/full/295/5/536/DC1.

Combinations of Clinical Findings

For identifying affected patients, combinations of clinical abnormal findings do not work much better than individual abnormalities. However, when combinations of findings are all normal, the likelihood of disease is lower than when the individual symptoms or signs are present. The presence of normal pulses without claudication has a similar LR for moderate to severe PAD among patients with diabetes (LR, 0.24; 95% CI, 0.13-0.46) and PAD of any severity among participants of a lipid clinic study (LR, 0.21; 95% CI, 0.12-0.38; TABLE 4).

Marcon et al[58] developed and validated a clinical decision rule to identify those that require noninvasive diagnostic testing to determine PAD status. With a "normal" clinical examination (not fully defined by the authors) and absence of all risk factors (diabetes mellitus, current or ever smoker, dyslipidemia, age <40 years, cerebrovascular disease [including abnormal carotid artery evaluation]), no further testing was required. This decision rule and the combination of clinical factors are promising and provide additional accuracy over single physical examination maneuvers.

Use of a Bedside Doppler

As handheld Dopplers are increasingly available and simple to use, clinicians can easily incorporate the Doppler as a part of the bedside examination. Although time constraints are often considered a significant barrier to performing a complete ABI measurement,[13] Farkouh et al[48] evaluated a rapid clinical prediction rule using arterial Doppler signals. From 218 individuals older than 55 years and presenting to general medical clinics, the investigators derived a score based on the number of auscultated arterial components, grade of the peripheral pulse, and history of MI that are all determined at the bedside (BOX 2 and audio supplement at http://jama.com/cgi/content/full/295/5/536/DC1). With a score of less than 6, the likelihood of having disease increases (LR, 7.80; 95% CI, 4.80-12.70) and with a score greater or equal to 6, the likelihood of disease significantly decreases (LR, 0.20; 95% CI, 0.10-0.40). Using a threshold of 6 points, this screening tool efficiently and effectively separated those who require ABI measurement from those who do not. For those with unilateral leg symptoms, the scoring system can be modified whereby one adds the audible components and pulse palpation grade only on the leg in question, combined with the MI history (1 for none and 0 for prior MI). With the unilateral leg score, a threshold of 4 points optimally separated those with PAD compared with those without disease (score of <4: LR of 4.80 to 5.00; score of ≥4: LR of 0.10). The area under the receiver operating characteristic curve for both models was 0.91 to 0.92, respectively, suggesting the overall accuracy was high. Use of these scoring systems provides greater accuracy for identifying those who require bedside ABI assessment compared with single clinical examination maneuvers.

Precision of Symptoms and Signs

Six studies examined the precision in measuring lower limb pulses in patients suspected of having PAD.[50-55] Interobserver agreement ranged from fair to high (κ: 0.27-1.00) when determining whether a pulse is absent or present (Table 2). Discriminating between reduced and normal pulsations, however, showed only marginal reproducibility[50,52] compared with dichotomous assessments (present vs ab-

Table 5. Prevalence of Peripheral Arterial Disease According to Patient Characteristics for Symptomatic Patients and the General Population

Characteristic	Prevalence, % (95% CI)	
	Symptomatic*	General Population†
Age, y		
60-80	15 (13-16)	
60-69		5 (3-7)
70-79		12 (8-16)
Male sex	12 (10-13)	5 (3-6)
Ischemic heart disease	19 (17-21)	13 (7-20)
Stroke	26 (20-31)	15 (5-25)
Hypercholesterolemia	15 (12-18)	6 (4-8)
Diabetes mellitus	18 (15-22)	11 (3-18)
Smoking (current or quit in last 5 y)	11 (9-12)	7 (4-10)
Hypertension	12 (11-14)	7 (5-9)

Abbreviation: CI, confidence interval.
*Estimates were derived from a community cohort of patients with leg complaints.[39]
†Estimates were derived from the National Health and Nutrition Examination Survey for 1999-2000.[63,64]

sent). Precision also appeared to increase with experience.[52,55] In a study of 25 vascular surgery patients, investigators found that those with the most experience (ie, vascular laboratory personnel) had greater precision compared with medical students or vascular surgeons.[55] A study of 9 general internists found that assessment of the ABI and the number of auscultated arterial components using a handheld Doppler had excellent precision.[59] No data were found on the reproducibility of the other physical examination maneuvers.

Absence of a Dorsalis Pedis or Posterior Tibial Pulse

A number of studies among healthy participants revealed that the dorsalis pedis pulse was not palpable in 8.1% of cases and the posterior tibial pulse was not palpable in 2.9% of cases.[54,55,59] In most cases, however, the Doppler detected the pulse. Congenital absence of either or both dorsalis pedis and posterior tibial pulse was uncommon (<2%).[60,61]

Ways to Improve Elicitation of Signs for PAD

Palpation of lower extremity pulses can be challenging. Appropriate localization and training may aid in detection of these pulses. Mowlavi et al[62] increased detection of the dorsalis pedis pulse using a boney landmark (tuberosity of the navicular bone) and searched for the dorsalis pedis pulse in an arc over the dorsum of the foot toward the lateral malleolus in a posterior-lateral direction.

Lawson et al[52] found that training improved precision of pulse palpation. The steps of training included (1) by lamp or flashlight, adequately illuminate for inspection of pulse; (2) have the patient lie supine; (3) examine the right pulse while standing to the right side of the patient and the left pulse while standing to the left side of the patient; (4) palpate with the fingers that one is most comfortable in using for palpating pulses; (5) palpation should last up to a slow count of 3. As a part of training, examiners also practiced their pulse palpation technique in the presence of others and any disagreement prompted reexamination until consensus was achieved.

Clinicians may listen to their own posterior tibial artery for practicing Doppler placement to detect sounds. Concentrating on the time immediately following the second component focuses attention on the third, softest sound. However, the third component may not be audible even among healthy individuals. The 3 components should always be heard over the radial artery, a good location for practicing auscultation.

Estimating Pretest Probabilities

For patients with leg complaints, the pretest probability is estimated from the patient's risk factors for PAD (TABLE 5) as well as the differential diagnosis for their leg complaint (Box 1). For patients without leg complaints, the pretest probability is estimated by the presence of risk factors for PAD.

Typically, patients with PAD have at least 1 cardiovascular risk factor. For patients with 1 risk factor, the prevalence of disease ranges from 10% to 25%. Patients with multiple coexistent risk factors have an even higher prevalence of disease.[65]

SCENARIO RESOLUTION

Case 1

The first scenario describes a man with known cardiovascular disease who presents with typical intermittent claudication. Because of his known ischemic heart disease, advanced age, and medical history compatible with intermittent claudication, his pretest probability for PAD is estimated to be high (approximately 40%). The LR for PAD in the presence of a bruit in a symptomatic individual is 5.60. Therefore, his posttest probability is 79%, and he most likely has PAD. Alternatively, with a handheld Doppler, the patient scored 3 points on the unilateral PAD scoring system (1 point for arterial signal + 2 points for normal pulse palpation of right posterior tibial artery + 0 points for previous MI). Given this score, the corresponding LR is 4.80 and the posttest probability for PAD is 76%.

Case 2

The second scenario describes a female smoker who has an incidental finding of absent pedal pulses. Given her smoking history and the absence of other risk factors, she has a low to intermediate pretest probability of having PAD (approximately 10%). Although she does not complain of leg pain, the absence of both of her pedal pulses favors a diagnosis of PAD even among asymptomatic populations (LR is 3.10 in asymptomatic individuals). Her posttest

probability is approximately 25%. With a handheld Doppler, her PAD score is 3 (2 points for 1 arterial signal in each posterior tibial pulse + 0 points for pulse palpation +1 point for no prior MI). Given the PAD score of 3, the LR is 7.80, corresponding with a posttest probability of 46%, so there is a strong enough suspicion to warrant further noninvasive testing.

BOTTOM LINE

Physicians largely rely on the clinical examination to identify those needing further testing to diagnose PAD. This systematic overview identified several high-quality studies on physical examination maneuvers and scoring systems. For screening patients who require further testing to diagnose PAD, the most useful individual symptoms and signs are: asking about the presence of claudication, listening for a femoral bruit, and palpating for a pulse abnormality. No clinical examination feature helped to reduce the likelihood of PAD. However, the absence of claudication and the presence of normal pulses decreases the likelihood of moderate to severe disease.

When considering patients who are symptomatic with leg complaints, the most useful individual findings are the presence of cool skin, the presence of at least 1 bruit, and any palpable pulse abnormality. The absence of any bruit (iliac, femoral, and popliteal) and the presence of normal peripheral pulses reduces the likelihood of PAD.

The pooled LR of these individual findings must be used in context with the pretest probability because none of the symptoms or signs is independently sufficient to diagnose or rule out PAD with certainty. Although the presence of an abnormal pulse moderately increases the likelihood of PAD, the precision of pulse palpation ranges from fair to high. The data suggest that this precision can be improved with training. Capillary refill, a commonly taught physical examination maneuver, has poor diagnostic accuracy. Combinations of physical examination findings do not increase the likelihood of PAD beyond that of individual findings. However, when combinations of findings are all normal, the likelihood of disease is lower than when individual symptoms or signs are present.

Clinicians who measure the ABI should listen and notice the number of auscultated components. Use of the handheld Doppler to auscultate the number of arterial components that are used in a PAD scoring system yields greater diagnostic accuracy for PAD compared with individual or combinations of clinical findings. By systematically recording the PAD score and then measuring the ABI, clinicians can determine for themselves whether the score helps save time in identifying patients who will have a normal ABI score.

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Study concept and design: Khan, Rahim, Panju.
Acquisition of data: Khan, Rahim.
Analysis and interpretation of data: Khan, Rahim, Anand, Simel, Panju.
Drafting of the manuscript: Khan, Rahim, Anand, Simel, Panju.
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Audio Supplement

Listen to a recording of a doppler auscultation of the posterior tibial artery at http://jama.com/cgi/content/full/295/5/536/DC1.

