The Accuracy of Ankle-Brachial Index Determination Using the Stethoscope to Screen for Peripheral Arterial Disease Among Adults with Type 2 Diabetes Mellitus in Iloilo City

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Abstract

Introduction Peripheral arterial disease (PAD) is a common macrovascular complication of type 2 diabetes mellitus (T2DM) and is associated with increased cardiovascular morbidity and mortality. The ankle-brachial index (ABI) is a simple, non-invasive method for detecting PAD; however, Doppler devices are not always available in primary care and resource-limited settings. This study aimed to determine the diagnostic accuracy of ABI measurement using a stethoscope compared with the Doppler method among adults with T2DM.

Methods A diagnostic accuracy study was conducted among 200 adults with T2DM recruited through convenience sampling from a private outpatient clinic in Iloilo City. ABI measurements were obtained using both the stethoscope and Doppler methods. An ABI of ≤0.90 was considered indicative of PAD. Diagnostic accuracy measures, including sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), overall accuracy, and agreement, were calculated.

Results The prevalence of PAD was 30.5% using the stethoscope method and 35.0% using the Doppler method. Compared with Doppler ABI, the stethoscope method demonstrated an overall accuracy of 94.5%, sensitivity of 85.7%, specificity of 99.2%, PPV of 98.4%, and NPV of 92.8%. Agreement between the two methods was excellent (Cohen's $\kappa = 0.88$, $p < 0.001$).

Conclusion Stethoscope-based ABI determination demonstrated high diagnostic accuracy and excellent agreement with Doppler ABI. Given its low cost, accessibility, and non-invasive nature, it may serve as a practical screening tool for PAD among adults with T2DM, particularly in primary care and resource-limited settings where Doppler devices are unavailable.

Key words: diagnostic accuracy, peripheral arterial disease, ankle-brachial index, stethoscope, Doppler ultrasound, type 2 diabetes mellitus

Diabetes mellitus comprises a group of chronic metabolic disorders characterized by impaired insulin secretion, insulin resistance, and increased hepatic glucose production. It remains a major global health concern and is a significant cause of blindness, cardiovascular disease, stroke, kidney failure, and lower extremity amputation. Established risk factors include advanced age, hypertension, and dyslipidemia. According to the World Health Organization, age-standardized mortality rates due to diabetes increased by 3% between 2000 and 2019.[1]

Data from the International Diabetes Federation showed that in 2021, the prevalence of diabetes among Filipinos aged 20 to 79 years was 6.5%.[1]

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Studies have consistently demonstrated that patients with diabetes are at significantly higher risk of developing peripheral arterial disease (PAD) compared with the general population.[2]

Lower extremity PAD affects approximately 5% of Filipinos aged 40 years and older.[3]

Studies using the ankle-brachial index (ABI), the preferred screening method for PAD, have shown that the prevalence of PAD among patients with diabetes ranges from 20%.[4]

PAD may lead to substantial long-term disability and is associated with symptoms such as intermittent claudication, absent distal pulses, dependent rubor, non-healing ulcers, infection, sepsis, and eventual limb amputation.[5]

According to the American Diabetes Association, approximately one in three individuals with diabetes over 50 years of age has PAD.[6]

However, many patients remain asymptomatic, contributing to delayed diagnosis and treatment. PAD is also associated with increased cardiovascular morbidity and mortality and may significantly impair lower extremity function and quality of life. Patients with diabetes who develop PAD have a significantly increased risk of mortality compared with patients without diabetes.[7]

Various diagnostic modalities, such as computed tomography angiography, magnetic resonance angiography, duplex ultrasound, and digital subtraction angiography, are used to detect PAD. Measuring the ankle-brachial index (ABI) is a simple, non-invasive, and reliable method for diagnosing PAD. Early detection of PAD in the clinical setting may facilitate secondary prevention of cardiovascular disease, reduce complications, lessen hospital admissions, and mitigate the risk of limb amputation.

The ankle-brachial index is one of the clinical tools used to determine the severity of PAD. It is calculated by obtaining the ratio of the systolic blood pressure in the ankle to the systolic blood pressure in the brachial artery.[8] An ABI of ≤ 0.90 indicates lower extremity PAD.[9] In several Asian countries, including the Philippines, 17.7% of patients with type 2 diabetes mellitus were diagnosed with PAD using ABI determination.[10] ABI is a straightforward parameter used to objectively evaluate lower extremity arterial perfusion and diagnose peripheral arterial disease.

Most primary care physicians do not routinely use the standard Doppler method because it requires specialized equipment and trained personnel.[11] Doppler devices are not readily available in many primary care clinics and remote areas. This limitation creates challenges for patients, particularly those living in geographically isolated and disadvantaged areas, who may have limited access to diagnostic centers capable of performing ABI determination using Doppler ultrasound. Therefore, identifying a simpler and more accessible screening method for PAD remains clinically important. This study aimed to compare the diagnostic accuracy of determining the ankle-brachial index (ABI) using the stethoscope with the Doppler methods among patients with T2DM.

Methods

The study was approved by the Research Institute for Health Sciences Ethics Review Committee (Code 1793/G/2024/160). This diagnostic accuracy study was conducted in a private outpatient clinic from March to May 2025 in accordance with the Standards for Reporting Diagnostic Accuracy Studies (STARD) 2015 guidelines. A total of 200 adults with T2DM were recruited through convenience sampling.

Eligible participants included adults aged 40 to 70 years with T2DM, regardless of the presence or absence of symptoms suggestive of PAD. Patients with arteriovenous fistula, those undergoing lifelong hemodialysis, individuals with leg amputation, and those with lower extremity infection were excluded from the study. The sample size computation was based on the study which investigated the frequency of PAD diagnosed through ankle-brachial index (ABI) determination among patients with diabetes without intermittent claudication.[12] Using an estimated PAD prevalence of 37%, a 5% level of significance, and a target sensitivity of 95%, the minimum required sample size was calculated to be 197 participants.

The index test consisted of ABI determination using a stethoscope. For brachial systolic pressure measurement, the higher value obtained from either arm was used for ABI computation. For ankle systolic pressure measurement, both the dorsalis pedis and posterior tibial arteries of each lower extremity were assessed. The ABI was computed by dividing the highest ankle systolic pressure by the highest brachial systolic pressure.

The reference standard was ABI determination using a vascular Doppler device. Measurements were obtained using the same protocol applied in the stethoscope method. An ABI of ≤0.90 was considered indicative of PAD, whereas an ABI of >0.90 was classified as normal. Participants with ABI values >1.40, suggestive of arterial calcification or vessel stiffening, were excluded from data analysis and referred for further evaluation and management.

Results

A total of 200 patients in a private outpatient clinic participated in the study. Table 1 summarizes the demographic and clinical characteristics of the study participants.

The mean age of the participants was 56.4 ± 8.2 years. Females comprised the majority of the study population (60.5%), while males accounted for 39.5%. Among the participants, 40.5% reported symptoms suggestive of PAD, whereas 59.5% were asymptomatic. Lower extremity pain (55.6%) and cramping (49.4%) were the most commonly reported symptoms. Mean brachial systolic blood pressure values were higher than mean ankle systolic blood pressure values using both the stethoscope and Doppler methods.

Table 2 shows the number of participants identified to have PAD using ABI determination by the stethoscope and Doppler methods.

The number of true-positive cases was 60, while true-negative cases totaled 129. The prevalence of PAD identified using the stethoscope method was 30.5% (61/200), whereas the prevalence identified using the Doppler method was 35% (70/200). The stethoscope method identified slightly fewer PAD cases compared with the Doppler method.

Table 3 presents the mean ABI values obtained using the stethoscope and Doppler methods, including Cohen's kappa coefficients and p-values for agreement analysis among the overall study population and stratified according to sex and symptom status.

The mean ABI values obtained using the two methods were comparable across all groups. Overall mean ABI values were 0.93 ± 0.08 using the stethoscope and 0.94 ± 0.08 using Doppler. Participants without PAD symptoms demonstrated ABI values within the

Table 1. Demographic and clinical characteristics of participants (n=200).

Variable	Count	Percent
Age (mean ± SD)	56.4 ± 8.2	
Sex		
Male	79	39.5
Female	121	60.5
Symptoms		
Asymptomatic	119	59.5
With symptoms	81	40.5
Lower extremity pain	45	55.6
Cramping	40	49.4
Discoloration	32	39.5
Hair Loss	11	13.6
Non-Healing Sore	11	13.6
Stethoscope Systolic Blood Pressure		
Brachial (mean ± SD)	125.6 ± 11.3	
Ankle (mean ± SD)	115.7 ± 6.8	
Doppler Systolic Blood Pressure		
Brachial (mean ± SD)	126.8 ± 13.0	
Ankle (mean ± SD)	118.0 ± 7.6	

Table 2. Comparison of ABI determination using the stethoscope with ABI determination using the Doppler method.

ABI Determination through the Stethoscope	ABI Determination Using the Doppler Method		TOTAL
	(+) PAD	(-) PAD	
(+) PAD	60	1	61
(-) PAD	10	129	139
Total	70	130	200

normal range, whereas symptomatic participants had lower ABI values suggestive of PAD. Cohen's kappa analysis demonstrated almost perfect agreement between the two methods overall ($\kappa = 0.88$), with high agreement observed among both males and females. Agreement between the stethoscope and Doppler methods was statistically significant ($p < 0.001$). For symptom-stratified analysis, Fisher's exact test was used because the assumptions required for Chi-square testing were not met.

Table 4 presents the diagnostic accuracy of the stethoscope method compared with the Doppler method stratified according to symptom status. Overall diagnostic accuracy was 94.5%, with sensitivity of 85.7% and specificity of 99.2%. The positive predictive value (PPV) was 98.4%, while the negative predictive value (NPV) was 92.8%. Among asymptomatic participants, diagnostic accuracy was 98.3%, with high specificity and NPV. Among symptomatic participants, specificity and PPV reached 100%, indicating excellent ability of the stethoscope method to confirm PAD in symptomatic individuals.

Table 5 shows the diagnostic accuracy of the stethoscope method compared with the Doppler method in identifying an ABI of <0.90, indicative of PAD. The stethoscope method demonstrated an overall accuracy of 94.5%. Sensitivity was 85.7%, while specificity was 99.2%. The PPV was 98.4%, and the NPV was 92.8%.

Table 6 presents the agreement analysis between ABI determination using the stethoscope and Doppler methods. The overall Cohen's kappa coefficient was 0.88, indicating strong agreement between the two methods beyond chance. Agreement between the methods was statistically significant ($p < 0.001$).

Discussion

The study cohort had a mean age of 56.4 years, representing a predominantly middle-aged to older-adult population, which is consistent with the age group at increased risk for vascular complications associated with T2DM. A substantial proportion of participants were asymptomatic, emphasizing the

Table 3. ABI as measured by the stethoscope, doppler, stratified according to sex and the presence or absence of symptoms.

Population	Mean ABI		Cohen's Kappa		
	Stethoscope	Doppler	Agreement	Kappa	p-value
Sex					
Male	0.93 ± 0.08	0.93 ± 0.08	92.41	0.8217	< 0.001
Female	0.93 ± 0.11	0.94 ± 0.08	95.87	0.9084	< 0.001
Symptoms					
Without	0.97 ± 0.07	0.98 ± 0.07	97.48	0.5587	< 0.001
With	0.86 ± 0.06	0.86 ± 0.04	90.12	0.7286	< 0.001
Total	0.93 ± 0.08	0.94 ± 0.08	94.50	0.8754	< 0.001

Table 4. Measures of diagnostic accuracy for the stethoscope method compared with the Doppler method, stratified by symptom status.

Measure	Total	Without Symptoms	With Symptoms
Accuracy	94.5 (90.4 – 97.2)	98.3 (94.1 – 99.8)	90.1 (81.5 – 95.6)
Sensitivity	85.7 (75.3 – 92.9)	75.0 (19.4 – 99.4)	87.9 (77.5 – 94.6)
Specificity	99.2 (95.8 – 99.9)	99.1 (95.2 – 99.9)	100 (78.2 – 100)
Positive Predictive Value	98.4 (89.5 – 99.8)	75.0 (28.2 – 95.8	100 (93.84 – 100)
Negative Predictive Value	92.8 (87.9 – 95.8)	99.1 (95.4 – 99.8)	65.2 (49.5 – 78.2)

Note. Accuracy = proportion of correct classifications; Sensitivity = proportion of true positives correctly identified; Specificity = proportion of true negatives correctly identified; PPV = positive predictive value; NPV = negative predictive value.

Table 5. Diagnostic accuracy comparing the stethoscope and the Doppler in recognizing an ankle-brachial index of < 0.90

Measure of Diagnostic Accuracy	Value (%)	95% Confidence Interval (CI)
Accuracy	94.5	90.4 – 97.2
Sensitivity	85.7	75.3 – 92.9
Specificity	99.2	95.8 – 99.9
Positive Predictive Value	98.4	89.5 – 99.8
Negative Predictive Value	92.8	87.9 – 95.8

Table 6. Diagnostic accuracy measures comparing ABI determination by stethoscope and by Doppler.

Stethoscope	Doppler		Row Total	Diagnostic Measure	Value (%)
	(+) PAD	(-) PAD			
(+) PAD	60	1	61	Sensitivity	85.7
(-) PAD	10	129	139	Specificity	99.2
Total	70	130	200	Positive Predictive Value (PPV)	98.4
				Negative Predictive Value (NPV)	92.8
				Cohen's kappa	0.8754
				p-value	< 0.001

importance of PAD screening even in the absence of clinical symptoms. More than half of the participants were asymptomatic (59.5%, n = 119), while 40.5% (n = 81) reported symptoms suggestive of PAD. Among symptomatic participants, lower extremity pain (55.6%) and cramping (49.4%) were the most frequently reported manifestations, which are recognized clinical features of PAD.[13]

The sex distribution of PAD reported in previous studies has been variable. In the present study, females comprised 60.5% of the study population. This finding may reflect greater health-seeking behavior and participation in healthcare-related activities among women. One study likewise reported that the prevalence of PAD among women was similar to or higher than that observed among men.[14]

The prevalence of PAD detected using the stethoscope method was 30.5% (61/200), compared with 35.00% (70/200) using the Doppler method. Previous studies reported a PAD prevalence of approximately 30% among patients with T2DM, which is consistent with the findings of the present study.[15]

The stethoscope method demonstrated high diagnostic performance, with an overall accuracy of 94.5%. Sensitivity was 85.7%, indicating good ability to correctly identify patients with PAD, while specificity was 99.2%, demonstrating strong ability to correctly classify patients without disease. The high specificity observed suggests that ABI determination using a stethoscope may be a useful screening approach for PAD, particularly in primary care and resource-limited settings.

Predictive value analysis further supported the diagnostic utility of the stethoscope method. The positive predictive value was 98.4%, indicating that most participants identified as positive using the stethoscope method were likewise positive using the Doppler method. The negative predictive value was 92.8%, indicating strong ability of the method to identify individuals without PAD.

Stratified analysis according to symptom status demonstrated similarly favorable diagnostic performance. Among asymptomatic participants, the stethoscope method demonstrated high accuracy and negative predictive value, suggesting good screening capability in patients without overt symptoms. Among symptomatic participants, specificity and positive predictive value were notably high, indicating strong confirmatory value among clinically suspected cases. Agreement analysis further demonstrated strong concordance between the stethoscope and Doppler methods. The overall Cohen's kappa coefficient was 0.88, indicating almost perfect agreement beyond chance. Values greater than 0.80 are generally interpreted as excellent agreement. Agreement between the two methods was statistically significant ($p < 0.001$), supporting the reliability of the stethoscope method in ABI determination.

Taken together, these findings suggest that stethoscope-based ABI determination may serve as a clinically useful and accessible screening tool for PAD among patients with T2DM. Early identification of PAD in primary care settings may facilitate timely intervention and potentially reduce complications such as cardiovascular events, lower extremity amputation, and mortality. Given its low cost, portability, and non-invasive nature, the stethoscope method may be particularly valuable in geographically isolated and resource-limited settings where Doppler devices are not readily available.[16]

However, several limitations of the stethoscope method should be acknowledged. Low-flow states and weak arterial signals may result in false-negative findings. Reduced peripheral perfusion, arterial calcification, and examiner-related variability in auscultation may impair accurate detection of arterial flow return, potentially leading to falsely normal ABI values. These limitations highlight the need for careful technique and consideration of confirmatory testing in selected cases.

Overall, the study supports the potential role of stethoscope-based ABI determination as a practical screening and triaging tool for PAD among patients with T2DM. Although Doppler ultrasound remains the preferred reference standard, the stethoscope method demonstrated strong diagnostic performance and may provide a feasible alternative in settings where Doppler assessment is not readily accessible.

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