Hide and Seek: Does the Toe-brachial Index Allow for Earlier Recognition of Peripheral Arterial Disease in Diabetic Patients?

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WHAT THIS PAPER ADDS
Arterial stiffness in diabetics may render the ankle-brachial index (ABI) unreliable, even below the guideline recommended threshold for a falsely elevated ABI of > 1.4. Consequently, the use of the toe-brachial index (TBI) is advocated in the initial vascular examination of diabetics. However, there is no evidence that the TBI yields additional information compared with the ABI in diabetic patients if the ABI is not obviously elevated.

Objective/Background: Arterial calcification may render the ankle-brachial index (ABI) unreliable in diabetic patients. Although guidelines recommend the toe-brachial index (TBI) for patients with falsely elevated ABI arbitrarily defined as an ABI > 1.4, arterial calcification is also common among diabetic patients with an ABI ≤ 1.4. This could result in a “falsely normalized” ABI and under-diagnosis of peripheral arterial disease (PAD). We investigated whether diabetes invalidates the ABI as opposed to the TBI, and if the TBI may therefore be more suitable for detecting PAD in diabetic patients.

Methods: The difference between ABI and TBI was compared between diabetic and non-diabetic patients with an ABI ≥ 1.4 referred to the vascular laboratory. A Bland–Altman plot was constructed to assess whether ABI–TBI differences were dependent on the magnitude of the measurements. Subgroup analyses were performed for patients with a normal ABI, and for patients with critical ischemia.

Results: The population comprised 161 diabetic (252 limbs) and 160 non-diabetic (253 limbs) patients (mean age 67). Median ABIs (0.79 vs. 0.80) were similar, while median TBI was 0.07 higher in diabetics (p = 0.024). The ABI–TBI difference in diabetics and non-diabetics was similar (0.32 vs. 0.35; p = .084), and was also similar for patients with a normal ABI. Moreover, ABI–TBI differences in diabetic- and non-diabetic patients overlapped, irrespective of the magnitude of the measurements. Diabetes was not associated with larger differences between ankle and toe pressures (mean difference −0.9 mmHg, 95% confidence interval −15 to 13 mmHg) among patients with critical ischemia.

Conclusion: No evidence was found that the TBI may overcome the potentially invalidated ABI in diabetic patients with an ABI ≤ 1.4. ABI and TBI are strongly associated, and this relationship is not influenced by diabetes. Therefore, the TBI does not allow for earlier detection of ischemia in diabetes.

INTRODUCTION
Background
Lower extremity peripheral arterial disease (PAD) ranges in severity from asymptomatic to critical limb ischemia with tissue loss. Early detection of PAD is crucial, not only to provide symptomatic patients with adequate therapy, but also to guide the intensity of secondary prevention for these patients, who are at high risk of subsequent cardiovascular (CV) morbidity and mortality.1,2 PAD is particularly common among patients with diabetes, who have more severe disease and worse outcomes than those without diabetes.2,3 The ankle-brachial index (ABI) is widely recommended in the initial assessment of lower extremity perfusion, based on a substantial body of evidence linking low ABI to imaging-confirmed PAD, and increased CV morbidity and mortality.4 However, the sensitivity of the ABI may be lower in diabetic patients, presumably as a result of the high prevalence of medial arterial calcification (MAC) and the resulting arterial stiffening.5–9 Clinical guidelines recognize that the ABI may be unreliable in diabetic patients and recommend alternative tests, such as the toe-brachial index (TBI) for patients suspected of having a falsely elevated ABI. The threshold for a falsely elevated ABI is
often arbitrarily set at 1.3—1.4. However, MAC is also frequently observed in the ankle arteries of patients with an ABI below this threshold, and imaging-confirmed arterial stenosis is common among diabetic patients with an ABI within the normal reference range.\textsuperscript{8,10–14} Based on the assumption that the toe arteries are less susceptible to MAC, it is frequently suggested that assessment of the TBI in addition to the ABI may enable earlier detection of PAD in the initial vascular examination of diabetic patients, even when the ABI is not obviously falsely elevated.\textsuperscript{8,10–14}

**Objectives**

The aim of the study was to investigate if the ABI underestimates the severity of ischaemia in diabetic patients, even below the recommended threshold for falsely elevated pressures of 1.4, and whether it is useful to include assessment of the TBI in the initial vascular examination of diabetic patients. The difference between the ABI and the TBI was therefore compared between diabetic and non-diabetic patients, for whom the ABI has been validated, in a population with suspected PAD referred to the vascular laboratory.

**METHODS**

**Design**

A retrospective cross-sectional study was performed to compare the differences between the ABI and TBI among diabetic and non-diabetic patients referred to the vascular laboratory of the Academic Medical Center (AMC), Amsterdam, the Netherlands, for a non-invasive vascular examination of the lower extremities. The current article was written in accordance with the STROBE statement for cross-sectional studies, which is a checklist to ensure accurate and complete conduct and reporting of observational studies.\textsuperscript{15} Ethical approval from the local institutional review board is not necessary for retrospective chart reviews.

**Patient selection.** The vascular laboratory of the AMC serves as the primary diagnostic unit for non-invasive vascular examination for all in- and outpatients at the tertiary hospital. A sample of consecutive patients referred for non-invasive vascular examination was taken from the 10,464 measurements performed between 1993 and 2005. Patients were included if ankle, toe, and brachial blood pressures were simultaneously obtained during a single visit, irrespective of other characteristics, to assure that the sample reflected the population referred to the vascular laboratory. Patients with acute limb ischemia were excluded, as were patients with unknown diabetes status, an ABI > 1.4, or measurement results deemed unreliable by the vascular technician owing to the inability to comply with the measurement protocol. Patients were identified using unique identifying numbers, and only the first measurement was included.

As this was an exploratory study, the sample size required to detect a clinically relevant difference in ABI—TBI between diabetic and non-diabetic patients could only be estimated tentatively. A study by Brooks et al. reported an ABI—TBI difference for diabetic patients of 0.37, with an SD of 0.15.\textsuperscript{16} Including 222 measurements in the diabetic and in the non-diabetic group provides 80% power to detect a 10% difference in the mean ABI—TBI between diabetic and non-diabetic patients at a two-sided significance level of 0.05. A margin of 15% was taken to improve the statistical power, and data on 505 measurements were included.

**Measurements.** Experienced vascular technicians from the vascular laboratory at the AMC carried out all measurements. Great toe blood pressures were obtained using a photoplethysmograph (Nicolet VasoGuard; VIASYS Healthcare, Madison, WI, USA). Ankle systolic blood pressures (SBPs) in both the posterior tibial and the dorsalis pedis arteries were obtained using a Doppler device (Nicolet VasoGuard; VIASYS Healthcare). Prior to 2005, ankle SBPs were measured using an 8-MHz Doppler probe (Stöpler; PV Lab, Electronic Diagnostic Instruments, Burbank, CA, USA) and a 12-cm cuff just proximal to the ankle, and toe SBPs were measured by photoplethysmography (Stöpler; PV Lab) and a digital cuff with a width depending on the diameter of the toe (1.9 or 2.5 cm). The ABI and TBI were calculated by dividing the highest systolic ankle or toe blood pressure by the highest of both systolic brachial artery blood pressures. For the ABI, values between 0.91 and 1.4 were considered within the normal range.

All measurement results and baseline characteristics were documented on examination and subsequently validated by checking the medical charts. A patient was considered to have diabetes or hypertension if this was documented in the patient chart, or if the patient was prescribed antidiabetic or antihypertensive drugs, respectively. Smoking was defined as smoking within the last 5 years, or a history of > 15 pack years. End stage renal disease, defined as dialysis dependence or history of kidney transplantation, and clinical disease stage (i.e., asymptomatic, intermittent claudication, rest pain, or tissue loss), were considered potential effect modifiers. Age at examination was considered a potential confounder as it is a known predictor of arterial calcification and may be influenced by the presence of diabetes.\textsuperscript{17}

**Statistical methods**

Continuous values were expressed as means and SD, or medians and interquartile ranges, where appropriate. Baseline characteristics of diabetic and non-diabetic patients were displayed as differences with 95% confidence intervals (CIs) and analyzed statistically using chi-square tests or two-sampled Student t tests/Mann—Whitney U tests, depending on the normality of the data.

Lims were used as the unit of analysis. The ABI—TBI difference was compared between diabetic and non-diabetic patients using a Student t test. A Bland—Altman plot was constructed to assess whether the difference between the ABI and TBI was dependent on the magnitude of the pressure values for diabetic and non-diabetic patients. Lines for the 95% limits of agreement were constructed...
using the ABI—TBI differences obtained from non-diabetic patients, for whom the ABI has been extensively validated and who therefore served as the reference group.

Two subgroup analyses were performed. The first was for patients with an ABI between 0.91 and 1.4, to compare the differences between ABI and TBI for diabetic and non-diabetic patients who would currently not be recognized as having PAD. The other subgroup included only patients with ischemic rest pain or tissue loss, and the difference between absolute ankle- and toe pressures rather than the ABI—TBI difference was compared. If age was unevenly distributed, an additional subgroup analysis would be performed for patients aged 50–65 years.

\( p < .05 \) was considered statistically significant. Statistical analyses were performed using SPSS version 20.0 (IBM Statistics, Armonk, NY, USA).

**RESULTS**

**Baseline characteristics**

Baseline characteristics for the 161 diabetic patients (252 limbs) and 160 non-diabetic patients (253 limbs) are shown in Table 1. Notably, age and sex were equally distributed between both groups, whereas hypertension was more common among diabetics and (history of) smoking among non-diabetics. Moreover, diabetic patients more often presented with tissue loss. The majority of diabetic patients (77%) had type 2 diabetes (Table 1). Approximately half of diabetic patients used insulin, and the median duration of diabetes was 11 years. The proportion of men was somewhat higher among patients with an ABI ≤ 0.9 than among patients with an ABI > 0.9 (35% vs. 25%).

**Pressure measurements**

Median ABI values did not differ between diabetic and non-diabetic patients, while diabetic patients had a significantly higher median TBI value (Table 2). Consequently, the mean difference ABI—TBI tended to be smaller in diabetic patients, although the difference between both groups was not statistically significant.

In the subgroup of patients with an ABI within the normal range (0.91–1.4), neither the ABI and TBI nor the difference between the two significantly differed between diabetic and non-diabetic patients (Table 2). The differences between ABI and TBI according to clinical disease stage are given in Table 3. Among patients with rest pain or tissue loss, no significant differences were found in the absolute ankle and toe pressures between diabetic and non-diabetic patients (mean difference = 0.9 mmHg, 95% CI = 15 to 13 mmHg; \( p = .897 \) (Fig. 1).

The Bland–Altman plot shows that the ABI values were systematically higher (0.32) than the TBI values across the range of measurements (Fig. 2). Overall, ABI—TBI differences were large: 95% of these differences were between 0.00 (i.e., TBI = ABI) and 0.76 (i.e. ABI > TBI). The observed

<table>
<thead>
<tr>
<th>Variable</th>
<th>DM+ (n=252)</th>
<th>DM— (n=253)</th>
<th>Difference</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male (%)</td>
<td>31.0</td>
<td>31</td>
<td>0.5</td>
<td>−0.076 to 0.086</td>
</tr>
<tr>
<td>Age, y (mean ± SD)</td>
<td>68 ± 13</td>
<td>66 ± 15</td>
<td>1.4</td>
<td>−0.971 to 3.814</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>82.0</td>
<td>54.0</td>
<td>28.0</td>
<td>0.202–0.358</td>
</tr>
<tr>
<td>Unknown</td>
<td>2.7</td>
<td>6.3</td>
<td>3.5</td>
<td>−0.072 to 0.001</td>
</tr>
<tr>
<td>ESRD (%)</td>
<td>7.9</td>
<td>5.1</td>
<td>2.8</td>
<td>−0.015 to 0.071</td>
</tr>
<tr>
<td>Smoking (%)</td>
<td>39</td>
<td>58</td>
<td>18.4</td>
<td>−0.270 to −0.098</td>
</tr>
<tr>
<td>Unknown</td>
<td>12.0</td>
<td>11.0</td>
<td>0.8</td>
<td>−0.047 to 0.063</td>
</tr>
<tr>
<td>Previous vascular intervention (%)</td>
<td>16</td>
<td>24</td>
<td>8.2</td>
<td>−0.152 to −0.013</td>
</tr>
<tr>
<td>No symptoms</td>
<td>26.0</td>
<td>34.0</td>
<td>8.2</td>
<td>−0.162 to −0.002</td>
</tr>
<tr>
<td>Intermittent claudication</td>
<td>19.0</td>
<td>27.0</td>
<td>8.6</td>
<td>−0.160 to −0.013</td>
</tr>
<tr>
<td>Rest pain</td>
<td>6.7</td>
<td>10.0</td>
<td>3.5</td>
<td>−0.084 to 0.014</td>
</tr>
<tr>
<td>Tissue loss</td>
<td>25.0</td>
<td>11.0</td>
<td>14.0</td>
<td>0.077–0.210</td>
</tr>
<tr>
<td>Unknown</td>
<td>23.0</td>
<td>17.0</td>
<td>6.0</td>
<td>−0.010 to 0.131</td>
</tr>
<tr>
<td>DM characteristics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type 1</td>
<td>7.9</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Type 2</td>
<td>77.0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Unknown type</td>
<td>15.0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>IDDM</td>
<td>46.0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>NIDDM</td>
<td>51.0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Unknown</td>
<td>3.0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Duration of DM (median ± IQR)</td>
<td>11.0</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>ABI ≤ 0.90</td>
<td>60.0</td>
<td>59.0</td>
<td>0.6</td>
<td>−0.080 to 0.093</td>
</tr>
<tr>
<td>0.91–1.40</td>
<td>41.0</td>
<td>40.0</td>
<td>0.6</td>
<td>−0.093 to 0.080</td>
</tr>
</tbody>
</table>

**Note.** DM = diabetes mellitus; DM+ = DM positive; DM— = DM negative; CI = confidence interval; ESRD = end stage renal disease; IDDM = insulin dependent diabetes mellitus; NIDDM = non-insulin dependent diabetes mellitus; IQR = interquartile range; ABI, ankle-brachial index; NA = not applicable.
Earlier Recognition of Peripheral Arterial Disease in Diabetic Patients?

DM frequently encountered among diabetic patients. MAC is Berg of 1.4 was not confirmed. Therefore, the hypothesis that diabetes in similar between diabetics and non-diabetics with rest pain. Similar finding was irrespective of the magnitude of the pressure measurements. Likewise, the difference between absolute ankle and toe pressures was similar between diabetics and non-diabetics with rest pain or tissue loss. Therefore, the hypothesis that diabetes invalidates the ABI as opposed to the TBI even below the guideline recommended threshold for falsely elevated ABIs of 1.4 was not confirmed.

It is widely assumed that MAC, also known as Mönckeberg’s sclerosis, is responsible for the falsely elevated ABI frequently encountered among diabetic patients. MAC is particularly common among diabetic patients and results in stiffening of the arterial wall, thereby increasing the pressure required for compression of the ankle arteries, which may falsely elevate the ABI. Aside from diabetes, an association has been demonstrated between MAC and peripheral neuropathy, male sex, advancing age, renal insufficiency, and genetic factors.

Several explanations may account for the observed lack of divergence between the ABI and TBI in diabetic patients in this study. First, it is possible that in diabetic patients with an ABI ≤ 1.4 the ankle vessels are not stiffened to a degree that would falsely elevate the ABI. However, several studies have indicated a high prevalence of MAC among diabetic patients with an ABI ≤ 1.4, and increased arterial stiffness can be observed even among pre-diabetic patients, in whom severe MAC is less likely. Second, the recommendation that the TBI may be more sensitive for the detection of limb ischemia is based on the assumption that the toe arteries are less susceptible to MAC. However, this assumption is largely based on a single study in which a declining gradient of the prevalence of MAC from the ankle vessels to the toe vessels was observed on plain radiographs. Plain X-rays may have limited sensitivity for detecting calcification of the toe arteries, and calcification of the toe arteries was still observed in 24−40% of diabetic patients with neuropathy. Third, it has been suggested that the distal distribution of atherosclerosis in diabetic patients may partially contribute to the unreliability of the ABI in diabetic patients. At least in theory, very distally located lesions could cause significant ischemia of parts of the foot,

**Table 2. Measurement results and difference ankle-brachial index (ABI)—toe-brachial index (TBI).**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall</th>
<th>DM+</th>
<th>DM−</th>
<th>p</th>
<th>ABI 0.91−1.40</th>
<th>DM+</th>
<th>DM−</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median ABI (IQR)</td>
<td>0.79 (0.50)</td>
<td>0.80 (0.59)</td>
<td>0.582&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.06 (0.15)</td>
<td>1.07 (0.16)</td>
<td>0.259&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.64 (0.29)</td>
<td>0.66 (0.30)</td>
</tr>
<tr>
<td>Median TBI (IQR)</td>
<td>0.44 (0.38)</td>
<td>0.37 (0.47)</td>
<td>0.024&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.35 (0.23)</td>
<td>0.38 (0.26)</td>
<td>0.084&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.29 (0.24)</td>
<td>0.24 (0.27)</td>
</tr>
<tr>
<td>Mean difference ABI−TBI (SD)</td>
<td>0.32 (0.24)</td>
<td>0.35 (0.23)</td>
<td>0.846&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.43 (0.24)</td>
<td>0.45 (0.26)</td>
<td>0.484&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. DM = diabetes mellitus; DM+ = DM positive; DM− = DM negative; IQR = interquartile range.*

<sup>a</sup> Mann–Whitney U test.

<sup>b</sup> Student t test.

**DISCUSSION**

This study shows that diabetic patients, compared with patients without diabetes, with an ABI ≤ 1.4 do not have a lower TBI at similar ABIs. This finding was irrespective of the magnitude of the pressure measurements. Likewise, the difference between absolute ankle and toe pressures was similar between diabetics and non-diabetics with rest pain or tissue loss. Therefore, the hypothesis that diabetes invalidates the ABI as opposed to the TBI even below the guideline recommended threshold for falsely elevated ABIs of 1.4 was not confirmed.

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**Table 3. Measurement results and differences for each clinical disease stage.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>No symptoms</th>
<th>Intermittent claudication</th>
<th>Rest pain</th>
<th>Tissue loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABI, median (IQR)</td>
<td>1.03 (0.24)</td>
<td>0.63 (0.32)</td>
<td>0.52 (0.34)</td>
<td>0.54 (0.61)</td>
</tr>
<tr>
<td>TBI, median (IQR)</td>
<td>0.61 (0.29)</td>
<td>0.38 (0.26)</td>
<td>0.24 (0.27)</td>
<td>0.26 (0.47)</td>
</tr>
<tr>
<td>Mean ± SD difference ABI−TBI</td>
<td>0.37 ± 0.23</td>
<td>0.23 ± 0.22</td>
<td>0.29 ± 0.20</td>
<td>0.18 ± 0.24</td>
</tr>
<tr>
<td>Highest absolute ankle blood pressure (mmHg), median (IQR)</td>
<td>152 (42)</td>
<td>114 (43)</td>
<td>83 (54)</td>
<td>66 (58)</td>
</tr>
<tr>
<td>Absolute toe blood pressure (mmHg), median (IQR)</td>
<td>95 (50)</td>
<td>62 (50)</td>
<td>35 (40)</td>
<td>33 (61)</td>
</tr>
<tr>
<td>Mean difference ankle-toe blood pressure (mmHg), mean (SD)</td>
<td>56 (36)</td>
<td>36 (35)</td>
<td>46 (32)</td>
<td>28 (37)</td>
</tr>
</tbody>
</table>

*Note. DM = diabetes mellitus; DM+ = DM positive; DM− = DM negative; ABI = ankle-brachial index; IQR = interquartile range; TBI = toe-brachial index.*
while the arteries supplying the ankle and toe remain patent. In addition, the limited reproducibility of ankle and toe pressure measurements could mask a potential association between diabetes and ABI—TBI differences.23

If the lack of divergence between ABI and TBI in diabetics as found in our study could be explained by either falsely elevated TBI or distally located lesions, then both measures would underestimate the true extent of ischemia and one would expect higher readings of both measurements at similar clinical stages in diabetic patients compared with non-diabetics. Indeed, diabetic patients were characterized by a slightly higher ABI and TBI than non-diabetics at each clinical disease stage (Table 3).

The present findings as to the non-divergence of ABI and TBI in diabetic patients with an ABI ≤ 1.4 are in line with previous studies.16,24–26 However, those studies did not include patients referred to the vascular laboratory, or they only reported the overall correlation between the ABI and TBI for diabetic and non-diabetic patients. Several other studies have reported on the agreement between the TBI and ABI in categorizing patients according to PAD status using a variety of diagnostic limits for the TBI, with different conclusions on the additional value of the TBI.11,13,16,25–28 The various cut off values for the TBI used in these studies reflect the lack of agreement on the optimal diagnostic limits in diagnosing PAD.29

In the current study, the TBI and the ABI were used, rather than the absolute systolic blood pressures, to allow categorization of patients into PAD categories, as recommended by clinical guidelines using the ABI, and to account for possible differences in the prevalence of hypertension between diabetic and non-diabetic patients. However, for patients with rest pain or tissue loss, the differences in absolute ankle and toe blood pressures were compared, as guidelines recommend the use of absolute pressures in these patients. Diagnostic limits of 50 mmHg for the ankle blood pressure and 30 mmHg for the toe blood pressure have been shown to predict wound healing in patients with tissue loss. Our results indicate that among patients with an ABI ≤ 1.4, the ABI—TBI differences between diabetics and non-diabetics did not change substantially across the range of ankle and toe pressures. The present study did not include patients with an ABI > 1.4, as the high likelihood of a falsely elevated ABI and the high prevalence of PAD among these patients mandates additional tests, irrespective of the presence of diabetes.27,30 Although a number of studies have indicated that the TBI may provide a more adequate estimate of limb ischemia in these patients, its sensitivity for detecting PAD remains to be established.26,29,30

A number of limitations of the current study should be taken into consideration. As data were obtained in clinical practice, missing data and coding imperfections could have limited the reliability of the results. However, data were prospectively documented and could be validated using the patients’ medical charts. Yet, it was not possible to take into account all known predictors of MAC, perhaps most importantly the presence of neuropathy. Hence, the possibility that the conclusions are not applicable to patients with severe neuropathy cannot be excluded. In addition, the severity of MAC is likely to depend on glycemic control and
the duration of diabetes. It was not possible to take into account glycemic control. The sample size in the present study was insufficient to reliably determine whether the similarity in the ABI—TBI difference between diabetic and non-diabetic patients is dependent on the duration of diabetes. The high proportion of women in the study population cannot be accounted for. However, no apparent discrepancies in ABI—TBI differences were found between men and women in the overall group or within the group of patients with an ABI within the normal reference range. In addition, the sex distribution was not different for diabetic and non-diabetic patients. Considering that the purpose of the study was to assess whether the TBI might overcome potentially flawed ABIs in diabetic patients, imaging studies were not performed. Therefore, it was not possible to assess the diagnostic accuracy of ABI or TBI for the assessment of PAD.

Implications for practice and further studies

The findings of this study indicate that diabetes does not falsify the ABI any more than the TBI in patients with an ABI ≤ 1.4. As such, the TBI is not capable of overcoming the potentially invalidated results of the ABI in diabetic patients with an ABI ≤ 1.4, and the widely held belief that assessment of the TBI in the initial vascular examination of diabetic patients may allow for earlier detection of PAD is not valid. Although the TBI is widely used, and its application is recommended by clinical guidelines, more research is needed to validate the TBI against imaging-confirmed PAD, and the optimal cut-off values remain to be established.

CONFLICT OF INTEREST

None.

FUNDING

None.

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