

Association of Bilateral Brachial-Ankle Pulse Wave Velocity Difference with Peripheral Vascular Disease and Left Ventricular Mass Index

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Abstract

Unequal arterial stiffness had been associated with cardiovascular risks. We investigated whether an association existed between unequal arterial stiffness indicated by bilateral brachial-ankle pulse wave velocity (baPWV) difference and ankle-brachial index (ABI), baPWV, echocardiographic parameters and interarm and interankle systolic blood pressure (BP) differences. A total of 1111 patients referred for echocardiographic examination were included in this study. The BPs, ABI and baPWV were measured simultaneously by an ABI-form device. The Δ baPWV was defined as absolute value of difference between bilateral baPWV. We performed three multivariate analyses for determining the factors associated with a Δ baPWV ≥ 185 cm/s (90 percentile of Δ baPWV) (model 1: significant variables in univariate analysis and ABI < 0.9 and baPWV; model 2: significant variables in univariate analysis and left ventricular mass index [LVMI]; model 3: significant variables in univariate analysis and interankle systolic BP difference ≥ 15 mmHg). The ABI < 0.9 and high baPWV (both $P < 0.001$) in model 1, high LVMI ($P = 0.021$) in model 2 and an interankle systolic BP difference ≥ 15 mmHg ($P = 0.026$) in model 3 were associated with a Δ baPWV ≥ 185 cm/s, but the interarm systolic BP difference ≥ 10 mmHg was not ($P = \text{NS}$). Our study demonstrated ABI < 0.9 , high baPWV, high LVMI and an interankle systolic BP difference ≥ 15 mmHg were associated with unequal arterial stiffness.

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Introduction

Arterial stiffness is an independent predictor for adverse cardiovascular outcomes in various populations [1–3]. Although arterial stiffness exhibits systemic change, there is often unequal progression in different artery territories [4–6]. A recent study demonstrated that arterial stiffness in different regions might have different roles in cardiovascular disease, and showed that arterial stiffening did not occur equally among the arterial regions in patients with ischemic heart disease [4]. However, the exact mechanisms responsible for the correlation between unequal arterial stiffness and adverse cardiovascular outcomes remain unclear.

Previous studies have found there was a significant association of a blood pressure (BP) difference between arms and ankles with peripheral vascular disease, pre-existing coronary artery disease, left ventricular hypertrophy (LVH) and increased cardiovascular mortality and all-cause mortality [7–13]. The large interarm or interankle BP difference might result from unequal limb atherosclerosis and then be associated with peripheral vascular disease, LVH and poor cardiovascular outcomes. The hypothesis that an

association exists between an interarm and interankle BP difference and unequal arterial stiffness has never been examined.

Current technology has allowed for simultaneous BP measurement in 4 limbs, [14] which might provide a comprehensive evaluation of BP differences between 4 limbs, such as ankle-brachial index (ABI) and the interarm and interankle BP differences. A clinical device, ABI-form (Colin VP1000, Komaki, Japan), has been developed to automatically and simultaneously measure BPs in both arms and ankles and record pulse waves of the brachial and posterior tibial arteries using an automated oscillometric method. Using this device, we can easily obtain the values of brachial-ankle pulse wave velocity (baPWV) and ABI, good markers for arterial stiffness and peripheral artery occlusive disease respectively [14,15].

Accordingly, the aims of this study, using a technique of simultaneous BP measurement, are to compare the ABI < 0.9 , baPWV, echocardiographic parameters and an interarm and interankle systolic BP difference between patients with and without unequal arterial stiffness, as indicated by bilateral baPWV difference, and to identify the independent factors associated with a large bilateral baPWV difference.

Subjects and Methods

Study Patients and Design

Study subjects were prospectively included from a group of patients who arranged for echocardiographic examinations at Kaohsiung Municipal Hsiao-Kang Hospital. Patients with significant aortic or mitral valve diseases, atrial fibrillation, or inadequate image visualization were excluded. We did not include all patients consecutively because ABI, baPWV and BPs must be measured within 10 min after the completion of an echocardiographic examination. Finally, 1111 patients (mean age 60.7 ± 13.7 years, 629 males/482 females) were included.

Ethics Statement

The study protocol was approved by the Institutional Review Board of the Kaohsiung Medical University Hospital (KMUH-IRB-20130151). Informed consents have obtained in written form from patients and all clinical investigation was conducted according to the principles expressed in the Declaration of Helsinki. The patients gave consent for the publication of the clinical details.

Evaluation of Cardiac Structure and Function

The echocardiographic examination was performed by one experienced cardiologist with a VIVID 7 (General Electric Medical Systems, Horten, Norway), with the participant respiring quietly in the left decubitus position. The cardiologist was blinded to the other data. Two-dimensional and two-dimensionally guided M-mode images were recorded from the standardized views. The Doppler sample volume was placed at the tips of the mitral leaflets to obtain the left ventricular inflow waveforms from the apical 4-chamber view. All sample volumes were positioned with ultrasonic beam alignment to flow. Pulsed tissue Doppler imaging was obtained with the sample volume placed at the lateral corner of the mitral annulus from the apical 4-chamber view. The wall filter settings were adjusted to exclude high-frequency signals and the gain was minimized. The echocardiographic measurements included left ventricular internal diameter in diastole (LVIDd), left ventricular posterior wall thickness in diastole (LVPWTd), interventricular septal wall thickness in diastole (IVSTd), E-wave deceleration time, transmitral E wave velocity (E) and early diastolic mitral annulus velocity (Ea). Left ventricular systolic function was assessed by left ventricular ejection fraction (LVEF). Left ventricular mass was calculated using Devereux-modified method, i.e. left ventricular mass = $1.04 \times [(IVSTd + LVIDd + LVPWTd)^3 - LVIDd^3] - 13.6$ g [16]. Left ventricular mass index (LVMI) was calculated by dividing left ventricular mass by body surface area. LVH was defined as suggested by the 2007 European Society of Hypertension/European Society of Cardiology guidelines [17]. The left atrial volume was measured by the biplane area-length method [18]. Apical 4- and 2-chamber views were obtained to determine the left atrial area and length (from the middle of the plane of the mitral annulus to the posterior wall). The maximal left atrial chamber area and length were measured before mitral valve opening, excluding the left atrial appendage and pulmonary veins. Left atrial volume index (LAVI) was calculated by dividing left atrial volume by body surface area. The raw ultrasonic data were recorded and analyzed offline by a cardiologist, blinded to the other data, using EchoPAC software (GE Medical Systems).

Assessment of ABI, baPWV and Δ baPWV

The values of ABI and baPWV were measured by one experienced technician with an ABI-form device (VP1000; Colin

Co. Ltd., Komaki, Japan), which automatically and simultaneously measures blood pressures in both arms and ankles using an oscillometric method [14]. The ABI was calculated by the ratio of the ankle systolic BP divided by the higher systolic BP of the arms. After obtaining bilateral ABI values, the lower one was used for later analysis. For measuring baPWV, pulse waves obtained from the brachial and tibial arteries were recorded simultaneously and the transmission time, which was defined as the time interval between the initial increase in brachial and tibial waveforms, was determined. The transmission distance from the arm to each ankle was calculated according to body height. The baPWV value was automatically computed as the transmission distance divided by the transmission time. After obtaining bilateral baPWV values, the higher one was used as representative for each subject. The ABI and baPWV measurements were done once in each patient. The validation of this automatic device and its reproducibility have been previously published [14]. The Δ baPWV was defined as absolute value of difference between bilateral baPWV.

Assessment of BP

To prevent overestimation and observer bias, interarm and interankle difference of BPs should be assessed simultaneously at both arms with one or two automated devices [19]. In our study, the bilateral arm and ankle BP measurements were done simultaneously and automatically using the ABI-form device. The systolic and diastolic BPs were measured by an appropriate cuff and the average of systolic and diastolic BPs of bilateral arms were used for later analysis.

Collection of Demographic, Medical and Laboratory Data

Demographic and medical data including age, gender, smoking history and comorbid conditions were obtained from medical records or interviews with patients. The body mass index was calculated as the ratio of weight in kilograms divided by square of height in meters. Laboratory data were measured from fasting blood samples using an autoanalyzer (Roche Diagnostics GmbH, D-68298 Mannheim COBAS Integra 400). Serum creatinine was measured by the compensated Jaffé (kinetic alkaline picrate) method in a Roche/Integra 400 Analyzer (Roche Diagnostics, Mannheim, Germany) using a calibrator traceable to isotope-dilution mass spectrometry. [20] The value of estimated glomerular filtration rate (eGFR) was calculated using the 4-variable equation in the Modification of Diet in Renal Disease (MDRD) study [21]. Blood samples were obtained within 1 month of enrollment.

Reproducibility

Forty-five patients were randomly selected for evaluation of the reproducibility of right baPWV and left baPWV by two separate measurements at least 5 min apart by the same technician. Mean percent error was calculated as the absolute difference divided by the average of the two observations.

Statistical Analysis

Statistical analysis was performed using SPSS 15.0 for windows (SPSS Inc. Chicago, USA). Data were expressed as percentages, mean \pm standard deviation or median (25th–75th percentile) for Δ baPWV, interarm and interankle systolic BP differences and triglyceride. The differences between groups were checked by Chi-square test for categorical variables or by independent *t*-test for continuous variables. Multiple logistic regression analysis was used to identify the factors associated with a Δ baPWV ≥ 185 cm/s (90 percentiles of Δ baPWV). Significant variables in univariate

analysis were selected as covariates for multivariate analysis. A difference was considered significant if the *P* value was less than 0.05.

Results

The mean age of the 1111 patients was 60.7 ± 13.7 years. The median (25th–75th percentile) of bilateral Δ baPWV was 50 (22–102) cm/s. The mean value of baPWV at right side and left side was 1722.3 ± 427.6 and 1695.1 ± 426.9 cm/s respectively ($P < 0.001$). The 90 percentile of Δ baPWV was 185 cm/s. The mean percent errors for right baPWV and left baPWV measurements were 4.0 ± 3.4 and $3.4 \pm 3.1\%$ respectively. The differences between patients with and without a Δ baPWV ≥ 185 cm/s are shown in Table 1. Compared with patients with a Δ baPWV < 185 cm/s, patients with a Δ baPWV ≥ 185 cm/s were found to have older age, higher prevalence of diabetes mellitus (DM), hypertension and coronary artery disease, higher systolic BP, higher heart rate, higher prevalence of ABI < 0.9 ($P < 0.001$), higher baPWV ($P < 0.001$), higher interankle systolic BP difference ($P < 0.001$), higher prevalence of an interankle systolic BP difference ≥ 15 mmHg ($P < 0.001$) [22], higher fasting glucose, lower hematocrit and lower prevalence of eGFR ≥ 60 mL/min/1.73 m². In addition, patients with a Δ baPWV ≥ 185 cm/s had higher LAVI ($P < 0.001$), higher LVMI ($P < 0.001$), higher prevalence of LVH ($P = 0.004$), lower LVEF ($P = 0.046$) and higher E/Ea ($P < 0.001$). However, interarm systolic BP difference and the prevalence of an interarm systolic BP difference ≥ 10 mmHg [7] were not significantly different between these two groups.

Table 2 displays the odds ratio (OR) estimates of ABI < 0.9 , baPWV, LVMI and interankle systolic BP difference ≥ 15 mmHg for a Δ baPWV ≥ 185 cm/s in all study patients with adjustment for demographic, clinical and biochemical parameters. We performed three multivariate analyses. In the first multivariate analysis (covariates included age, sex, diabetes, hypertension, coronary artery disease, systolic blood pressure, heart rate, ABI < 0.9 , baPWV, fasting glucose, hematocrit and eGFR ≥ 60 mL/min/1.73 m²), the ABI < 0.9 (OR, 33.001; $P < 0.001$) and baPWV (per 10 cm/s; OR, 1.019; $P < 0.001$) were associated with a Δ baPWV ≥ 185 cm/s. In the second multivariate analysis (covariates included age, sex, diabetes, hypertension, coronary artery disease, systolic blood pressure, heart rate, fasting glucose, hematocrit, eGFR ≥ 60 mL/min/1.73 m² and LVMI), LVMI was associated with a Δ baPWV ≥ 185 cm/s (OR, 1.006; $P = 0.021$). Besides, in the third multivariate analysis (covariates included age, sex, diabetes, hypertension, coronary artery disease, systolic blood pressure, heart rate, interankle systolic BP difference ≥ 15 mmHg, fasting glucose, hematocrit and eGFR ≥ 60 mL/min/1.73 m²), interankle systolic BP difference ≥ 15 mmHg was associated with a Δ baPWV ≥ 185 cm/s (OR, 2.016; $P = 0.026$).

In addition, we performed analyses using 85 percentile (Δ baPWV ≥ 140 cm/s) or 95 percentile (Δ baPWV ≥ 269 cm/s) as a cut-off value of bilateral baPWV difference. Multivariate analysis showed the association of ABI < 0.9 ($P < 0.001$) and high baPWV ($P < 0.001$) with bilateral baPWV difference ≥ 85 percentile still existed, but the association of LVMI ($P = 0.493$) and interankle systolic BP difference ≥ 15 mmHg ($P = 0.125$) did not reach statistical significance. Besides, the association of ABI < 0.9 ($P < 0.001$), high baPWV ($P < 0.001$) and interankle systolic BP difference ≥ 15 mmHg ($P < 0.001$) with bilateral baPWV difference ≥ 95 percentile still existed, but the association of LVMI ($P = 0.274$) did not reach statistical significance.

Since a low ABI might diminish baPWV accuracy, [23] we further performed a subgroup analysis after excluding 56 patients

with ABI < 0.9 . We found LVMI was still independently associated with a Δ baPWV ≥ 185 cm/s after adjusting for demographic, clinical and biochemical factors (OR, 1.007; $P = 0.019$).

Discussion

In the present study, using a simultaneous measurement technique, we found that ABI < 0.9 , high baPWV, high LVMI and an interankle systolic BP difference ≥ 15 mmHg were independently associated with a large bilateral baPWV difference, but an interarm systolic BP difference ≥ 10 mmHg was not. The relation between Δ baPWV ≥ 185 cm/s and high LVMI still existed even after excluding patients with ABI < 0.9 .

Arterial stiffness measured by pulse wave velocity (PWV) in different segments appeared to be differentially associated with micro- and macro-vascular complications [24]. Pannier et al. revealed that aortic PWV, but not femorotibial PWV, was an independent predictor for cardiovascular death in hemodialysis patients [6]. Kim et al. had also shown that diabetic retinopathy was closely associated with heart-femoral PWV, but not carotid-brachial PWV [25]. Besides, Hatsuda et al. found the PWVs of different segments correlated with each other in patients without ischemic heart disease, but less impressive in those with ischemic heart disease [4]. This finding suggested that unequal arterial stiffness might be related to ischemic heart disease. One important finding of our study was that there was a significant association of ABI < 0.9 and high baPWV with a large bilateral baPWV difference. The reason for the association of ABI < 0.9 and larger bilateral baPWV difference may be related to a lower baPWV value at the side of ABI < 0.9 [23], which contributed to larger bilateral baPWV difference. The ABI < 0.9 and baPWV are good markers of peripheral artery occlusive disease and arterial stiffness respectively [2,15,26–28]. A lower ABI and high baPWV show strong powers in predicting the mortality in various populations [29–32]. Hence, unequal arterial stiffness indicated by a large bilateral baPWV difference may be associated with peripheral vascular disease and have a potential to become a useful parameter in predicting adverse cardiovascular events.

Arterial stiffness may contribute to LVH independently of BP [33,34]. Some studies have reported a positive correlation between PWV and increased LVMI and LVH [35–37]. Arterial stiffness is associated with hypertrophy and atherosclerosis within the capacitance arteries that result in an increase in PWV and consequent alterations in the pressure waveform and increases in systolic and pulse pressure. Alterations in wave reflections combined with increased stiffness may also contribute to LVH [33,38,39]. Previous studies using different measurement methods of arterial stiffness have shown increased arterial stiffness was independently associated with LVH in a variety of populations [35,36,40–42]. Our study showed that a large bilateral baPWV difference was associated with LVMI. The relationship between a large bilateral baPWV difference and LVMI still existed even after excluding patients with ABI < 0.9 . This is the first study to show the association between unequal arterial stiffness with LVMI. Hence, LVH might represent a causal intermediary between unequal arterial stiffness and poor cardiovascular outcomes.

Several studies have reported that an interarm BP difference is associated with subclavian stenosis diagnosed by angiography, peripheral artery disease by ABI and LVH by echocardiography [11,43]. Furthermore, an interarm BP difference is strongly associated with increased cardiovascular mortality and all-cause mortality [43]. Besides, Sheng et al. have recently found an interankle systolic BP difference predicts mortality in the elderly

Table 1. Comparison of baseline characteristics between patients with and without a ΔbaPWV ≥ 185 cm/s.

| Characteristics | All patients (n = 1111) | Difference <185 cm/s (n = 1000) | Difference ≥ 185 cm/s (n = 111) |
|--|-------------------------|---------------------------------|---------------------------------|
| ΔbaPWV (cm/s) | 50 (22–102) | 43 (20–79) | 268 (215–432)** |
| Age (year) | 60.7±13.7 | 59.6±13.3 | 70.4±13.1** |
| Male gender (%) | 56.6 | 56.6 | 56.8 |
| Smoking history (%) | 15.1 | 15.6 | 10.7 |
| Diabetes mellitus (%) | 27.5 | 25.6 | 44.1** |
| Hypertension (%) | 68.9 | 67.5 | 82.0* |
| Coronary artery disease (%) | 18.5 | 17.3 | 29.4* |
| Systolic BP (mmHg) | 135.7±20.9 | 134.6±20.0 | 145.6±25.7** |
| Diastolic BP (mmHg) | 77.6±12.0 | 77.4±11.7 | 79.0±14.6 |
| Heart rate (beats/min) | 69.7±12.4 | 69.3±12.1 | 73.3±14.4* |
| Body mass index (kg/m ²) | 26.0±3.9 | 26.0±3.9 | 25.9±4.3 |
| ABI <0.9 (%) | 5.0 | 2.0 | 32.4** |
| baPWV (cm/s) | 1756.2±448.4 | 1705.5±405.5 | 2217.1±544.9** |
| Interarm systolic BP difference (mmHg) | 3 (2–5) | 3 (1–5) | 3 (2–5) |
| Interarm systolic BP difference ≥10 mmHg (%) | 7.2 | 7.2 | 8.1 |
| Interankle systolic BP difference (mmHg) | 6 (3–10) | 6 (3–10) | 10 (5–27)** |
| Interankle systolic BP difference ≥15 mmHg (%) | 13.5 | 10.9 | 36.4** |
| Laboratory parameters | | | |
| Fasting glucose (mg/dL) | 113.4±40.1 | 111.4±36.4 | 132.8±62.9* |
| Triglyceride (mg/dL) | 124 (85.5–184.5) | 123 (85–184) | 138 (87–186) |
| Total cholesterol (mg/dL) | 192.3±43.8 | 192.9±43.9 | 187.4±42.6 |
| Hematocrit (%) | 40.4±6.3 | 40.8±6.3 | 37.7±5.5** |
| eGFR ≥60 mL/min/1.73 m ² (%) | 50.7 | 53.7 | 25.0** |
| Echocardiographic data | | | |
| LAVI (ml/m ²) | 35.0±15.2 | 34.1±14.7 | 43.1±17.3** |
| LVMI (g/m ²) | 134.5±45.2 | 132.3±44.1 | 154.1±50.6** |
| LVH (%) | 59.4 | 58.0 | 72.1* |
| LVEF (%) | 63.1±13.2 | 63.4±12.8 | 60.2±16.4* |
| E/Ea | 9.6±5.2 | 9.3±4.9 | 12.9±6.7** |
| E-wave deceleration time (ms) | 202.7±63.8 | 201.6±61.6 | 212.6±80.6 |

Abbreviations. baPWV, brachial-ankle pulse wave velocity; blood pressure; ABI, ankle-brachial index; eGFR, estimated glomerular filtration rate; LAVI, left atrial volume index; LVMI, left ventricular mass index; LVH, left ventricular hypertrophy; LVEF, left ventricular ejection fraction; E, transmitral E wave velocity; Ea, early diastolic mitral annulus velocity.

*P<0.05, **P<0.001 compared patients with a bilateral baPWV difference <185 cm/s.

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[12]. Our recent study has also reported that a difference in systolic BP ≥ 15 mmHg or diastolic BP of ≥ 10 mmHg between ankles is associated with atherosclerosis and increased risk for overall and cardiovascular mortality in hemodialysis patients [13]. Unequal limb atherosclerosis may represent a causal intermediary between an interarm or interankle systolic BP difference and poor cardiovascular outcomes, but it has never been validated. Our present study showed that a large interankle, but not interarm, systolic BP difference was associated with a large bilateral baPWV difference. It might imply only patients with an interankle systolic BP difference ≥ 15 mmHg had a significantly unequal arterial stiffness indicated by large ΔbaPWV. Hence, the association between interankle systolic BP difference and poor cardiovascular outcomes may be explained by unequal arterial stiffness. However, the same mechanism may not be able to explain the association between interarm systolic BP difference and poor cardiovascular outcomes. In addition, there was a lot more overlap of artery

territory in calculating ΔbaPWV and interankle systolic BP difference than in calculating ΔbaPWV and interarm systolic BP difference, which might explain why a large interankle, but not interarm, systolic BP difference was associated with a large ΔbaPWV in the present study. However, the influence of the asymmetrical aortic arch geometry on the bilateral baPWV difference could not be excluded, even though an interarm systolic BP difference was not related to bilateral baPWV difference.

There were several limitations to this study. First, this study was cross-sectional, so the causal relationship and long-term clinical outcomes could not be confirmed. Future prospective studies are needed to address the issues. Second, as no studies have documented the reliable abnormal values of a bilateral baPWV difference, we used 90 percentile of bilateral baPWV difference to classify our study patients. Third, we had no data of direct comparison between bilateral baPWV and carotid-femoral PWV difference. Fourth, the travelled path was longer at the right than

Table 2. Determinants of ΔbaPWV ≥ 185 cm/s in all study patients.

| Parameter | Multivariate: Model 1 | | Multivariate: Model 2 | | Multivariate : Model 3 | |
|--|------------------------|--------|-----------------------|--------|------------------------|--------|
| | OR (95% CI) | P | OR (95% CI) | P | OR (95% CI) | P |
| Age (per 1 year) | 0.998 (0.968–1.029) | 0.898 | 1.054 (1.029–1.079) | <0.001 | 1.044 (1.019–1.070) | <0.001 |
| Male gender | 0.932 (0.500–1.738) | 0.825 | 0.862 (0.497–1.493) | 0.596 | 0.969 (0.556–1.687) | 0.911 |
| Diabetes mellitus | 0.991 (0.480–2.048) | 0.981 | 1.132 (0.606–2.117) | 0.697 | 1.284 (0.682–2.418) | 0.439 |
| Hypertension | 1.666 (0.730–3.804) | 0.225 | 1.755 (0.847–3.636) | 0.130 | 1.662 (0.781–3.536) | 0.188 |
| Coronary artery disease | 1.891 (0.906–3.948) | 0.090 | 2.234 (1.189–4.199) | 0.013 | 2.263 (1.191–4.297) | 0.013 |
| Systolic blood pressure (per 1 mmHg) | 1.001 (0.984–1.019) | 0.898 | 1.021 (1.008–1.035) | 0.002 | 1.023 (1.009–1.036) | 0.001 |
| Heart rate (per beat/min) | 1.006 (0.979–1.033) | 0.682 | 1.027 (1.005–1.049) | 0.016 | 1.025 (1.002–1.048) | 0.034 |
| ABI <0.9 | 33.001 (12.879–84.605) | <0.001 | – | – | – | – |
| baPWV (per 10 cm/s) | 1.019 (1.011–1.028) | <0.001 | – | – | – | – |
| Interankle systolic BP difference ≥15 mmHg | – | – | – | – | 2.016 (1.085–3.744) | 0.026 |
| Laboratory parameters | | | | | | |
| Fasting glucose (mg/dL) | 1.006 (1.000–1.013) | 0.052 | 1.009 (1.003–1.015) | 0.002 | 1.005 (0.999–1.011) | 0.088 |
| Hematocrit (per 1%) | 0.982 (0.923–1.046) | 0.577 | 0.970 (0.920–1.023) | 0.260 | 0.966 (0.915–1.020) | 0.211 |
| eGFR ≥60 mL/min/1.73 m ² | 0.906 (0.459–1.787) | 0.775 | 0.819 (0.449–1.496) | 0.517 | 0.704 (0.374–1.323) | 0.275 |
| Echocardiographic data | | | | | | |
| LVMI (per 1 g/m ²) | – | – | 1.006 (1.001–1.011) | 0.021 | – | – |

Values expressed as odds ratio (OR) and 95% confidence interval (CI). Abbreviations are the same as in Table 1.

Covariates in the basic model included age, sex, diabetes, hypertension, coronary artery disease, systolic blood pressure, heart rate, fasting glucose, hematocrit and eGFR ≥60 mL/min/1.73 m².

Covariates in the model 1 included covariates in the basic model+ABI <0.9 and baPWV.

Covariates in the model 2 included covariates in the basic model+LVMI.

Covariates in the model 3 included covariates in the basic model+interankle systolic BP difference ≥15 mmHg.

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at the left body side [44], which might contribute to the bilateral baPWV difference. Finally, since the subjects of this study were already being evaluated for heart disease by echocardiography, it was susceptible to selection bias, making findings potentially less generalized.

In conclusion, our results demonstrated that ABI <0.9, high baPWV and high LVMI were significantly correlated with unequal arterial stiffness. In addition, interankle, but not interarm, systolic BP difference was associated with unequal arterial stiffness.

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Author Contributions

Conceived and designed the experiments: SCC HMS. Performed the experiments: HMS THL PCH WHL CYC SCC CSL WCV WTL SHS. Analyzed the data: SCC HMS. Contributed reagents/materials/analysis tools: HMS THL PCH WHL CYC SCC CSL WCV WTL SHS. Wrote the paper: SCC HMS.

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