The aim of this study was to investigate the association of aortic pulsatility assessed by a non-invasive brachial cuff-based method with coronary atherosclerosis. In total, 139 patients undergoing coronary angiography were included in this cross-sectional study. Aortic blood pressure (BP) indices were recorded invasively by a fluid-filled catheter and non-invasively by a brachial cuff-based oscillometric device. Fractional pulse pressure (FPP) was defined as pulse pressure (PP)/mean BP and pulsatility index (PI) as PP/diastolic BP. Aortic FPP and PI in coronary artery disease (CAD) patients were significantly higher than in non-CAD patients in both invasive and non-invasive methods. Multivariate logistic regression analysis demonstrated that non-invasively measured aortic FPP and PI were associated with CAD risk in patients aged ≥70 years [aortic FPP per 0.1 odds ratio (OR) = 1.66, 95% confidence interval (CI) 1.05–2.64; aortic PI per 0.1 OR = 1.39, 95% CI 1.02–1.88; all p < 0.05], but were not associated with CAD risk in patients aged <70 years. In linear regression analysis, non-invasively measured aortic FPP and PI correlated with SYNTAX and Gensini scores only in patients aged ≥70 years. Aortic FPP and PI measured non-invasively by a brachial cuff-based oscillometric device were associated with coronary atherosclerosis in elderly patients.

**Introduction**

Brachial pulse pressure (PP) is a superior predictor of cardiovascular events and mortality over the steady component of blood pressure (BP), especially in elderly people.[1–3] Brachial PP showed a small early rise in a young population and an accelerated late rise after the fifth decade of life.[4,5] The late rise in brachial PP is thought to be caused by increased large arterial stiffness, which is a strong predictor of future cardiovascular events.[6] Therefore, brachial PP of older patients is a good surrogate measurement for large artery stiffness and can be a predictor of cardiovascular events.

Meanwhile, there is a substantial gradient between brachial and aortic PP (generally called “PP amplification”),[7] which suggests that aortic PP could be a more accurate indicator of loading conditions of target organs, including coronary arteries, than brachial PP. Consistent with this idea, invasively measured (IM) aortic PP and new pulsatile indices, the fractional pulse pressure (FPP), calculated as PP/mean blood pressure (MBP), and the pulsatility index (PI) calculated as PP/diastolic blood pressure (DBP), have been shown to be more closely correlated with the presence and severity of coronary artery disease (CAD) than brachial indices.[8–11] However, invasive measurement of aortic BP is not feasible in daily clinical practice.

Radial applanation tonometry using the SphygmoCor® (AtCor Medical, Sydney, Australia), the most common method for non-invasive estimation of aortic BP,[12] has already shown its validity and clinical effectiveness.[13–15] The relation between aortic pulsatile indices derived from the SphygmoCor and CAD risk has also been investigated,[16,17] but the results are inconsistent. Possible explanations for this inconsistency are the inaccuracy of this device due to operator dependence and substantial differences in patient background, especially age distribution, between these two studies. However, there has been no study using other non-invasive methods. Furthermore, the effect of ageing on the association between aortic pulsatile indices and the risk of CAD has not yet been investigated using both invasive and non-invasive methods.

A novel, validated automated oscillometric brachial cuff-based BP recording device, the Mobil-O-Graph® (IEM, Stolberg, Germany), can non-invasively estimate...
central BPs in an easy-to-use, operator-independent manner. Given the lack of evidence with brachial cuff-based non-invasive devices as to the relation between aortic pulsatile indices and CAD risk, confirming the clinical effectiveness of this device will provide a new strategy in managing patients with cardiovascular diseases. The purpose of this study was to assess the association of aortic pulsatile indices derived from a non-invasive brachial cuff-based method with the presence and severity of CAD. The effect of ageing on the predictive values of aortic pulsatile indices was also investigated.

**Materials and methods**

**Study population**

Between February 2014 and October 2014, 139 consecutive patients undergoing elective coronary angiography (CAG) for the evaluation of stable CAD \( (n = 74) \) or follow-up of prior percutaneous coronary intervention \( (n = 65) \) at our institution were eligible for the present cross-sectional study. We excluded patients with prior coronary surgical revascularization, haemodynamically significant valvular heart disease, left ventricular outflow tract obstruction and renal insufficiency. Patients with arrhythmias during evaluation were also excluded. The institutional ethics committee approved the study protocol, and written informed consent was obtained from each participant.

Fasting blood samples were taken before CAG for the analysis of total cholesterol, low-density lipoprotein (LDL)-cholesterol, high-density lipoprotein (HDL)-cholesterol, triglyceride, blood glucose, glycosylated haemoglobin (HbA1c) and creatinine levels. Hypertension was defined as brachial systolic blood pressure (SBP) \( > 140 \text{ mmHg} \) and/or diastolic blood pressure (DBP) \( > 90 \text{ mmHg} \), or prescription of antihypertensive drug. The presence of diabetes mellitus was defined as a fasting blood glucose level \( > 126 \text{ mg/dl} \) or use of a hypoglycaemic agent or insulin. Current smoking was defined as smoking any cigarette during the last year before CAG. Glomerular filtration rate (GFR) was calculated according to the Modification of Diet in Renal Disease formula.

**Measurement of haemodynamic indices**

All haemodynamic measurements were performed in the supine position immediately before CAG. Aortic BP was measured invasively using a fluid-filled catheter at the ascending aorta. Aortic MBP was obtained by direct integration of the BP curve. Invasive measurements were performed for at least 10 \( \text{s} \) to derive average values. Concurrently with invasive measurements, aortic and brachial BP was measured non-invasively using the Mobil-O-Graph. This device is a brachial cuff-based oscillometric manometer that yields a simultaneous measure of brachial BP and aortic BP with the inbuilt ARC Solver (Austrian Institute of Technology, Vienna, Austria) algorithm. Brachial MBP and DBP were used for calibration to generate an aortic pulse wave from the brachial waveform by means of the generalized transfer function. In estimating both brachial BP and aortic BP, this apparatus has been validated with acceptable results.

Non-invasive MBP was calculated as \( \frac{1}{3} \times \text{SBP} + \frac{2}{3} \times \text{DBP} \). PP was defined as the difference between SBP and DBP. FPP and PI were defined as PP divided by MBP and DBP, respectively.

**Angiographic evaluation**

CAG was performed through the radial approach by the standard method. CAD was defined as having \( > 50\% \) stenosis in the major epicardial coronary arteries by visual evaluation or having undergone prior percutaneous coronary intervention. The severity of CAD was evaluated by the SYNTAX score and Gensini score for patients without prior percutaneous or surgical revascularization because these scores have been validated in native coronary artery. The Gensini score was calculated according to the described guidelines and the calculation of SYNTAX score was performed with Syntax score calculator 2.1 (www.syntaxscore.com). All coronary angiograms were analysed by at least two experienced cardiologists blinded to the haemodynamic data and a consensus was reached.

**Statistical analysis**

All data were analysed using Stata 13.0 software (StataCorp, College Station, TX). All continuous values are expressed as mean \( \pm \) SD and categorical variables are reported as percentages. Normally continuous variables were assessed by the \( t \) test and non-normally continuous variables by the Mann–Whitney \( U \) test. Pearson’s chi-squared test was used to analyse all categorical variables. Logistic regression analysis was performed to assess the independent association between haemodynamic indices and the presence of CAD. The odds ratios (ORs) and 95\% confidence intervals (CIs) were calculated. The correlation between pulsatile indices and CAD severity (SYNTAX score and Gensini score) was
evaluated by linear regression analysis. Multivariate analysis of logistic and linear regression was performed with a stepwise method, including confounders with \( p \) values <0.15 in each analysis group. All \( p \) values were two tailed, and \( p \) values <0.05 were considered statistically significant.

Results

Baseline clinical characteristics

The study group consisted of 139 patients and there were 95 (68\%) significant CAD patients. The baseline characteristics are shown in Table 1. There was no significant difference in the mean ages of patients with CAD and non-CAD. Patients with CAD were more likely to be men and had lower body mass index (BMI) compared with non-CAD subjects. Total cholesterol and LDL-cholesterol levels were significantly lower in CAD patients than in non-CAD patients. Angiotensin-converting enzyme inhibitors/angiotensin receptor blocker, beta-blockers and statins were prescribed more frequently for CAD patients than non-CAD subjects in this study. There were no other significant differences between non-CAD patients and CAD patients regarding baseline characteristics.

Baseline haemodynamic characteristics and the effect of ageing on aortic blood pressure indices

Mean values of haemodynamic indices are shown in Table 2. Among all the patients, non-invasive measurement overestimated aortic SBP and DBP by about 4 mmHg and 15 mmHg, respectively. Accordingly, non-invasively measured (NIM) aortic PP was lower than IM aortic PP by about 11 mmHg. NIM aortic FPP and PI were also lower than IM aortic FPP and PI. When compared with non-CAD patients, only aortic FPP and PI in CAD patients were significantly higher in both invasive and non-invasive methods. IM aortic DBP also showed a significant decrease in CAD patients, whereas NIM aortic DBP did not. There was no significant difference in other indices, including brachial BP indices. Next, we analysed the association between age and aortic BP indices measured with the invasive method in this study population. Aortic SBP increased with age in a non-linear manner and plateaued after about 70 years of age (see Supplementary Figure S1A). Aortic DBP showed an accelerated late fall and aortic MBP exhibited a small decline with age (Supplementary Figure S1B and C). Interestingly, aortic PP increased linearly with age (Supplementary Figure S1D), whereas aortic FPP and PI increased non-linearly with an accelerated late rise in older individuals (Supplementary Figure S1E and F). These data suggest that aortic FPP and PI may

| Table 1. Baseline clinical characteristics of the study population. |
|---|---|---|---|
| Variables | Overall \((n = 139)\) | No CAD \((n = 44)\) | CAD \((n = 95)\) | \(p\) |
| Age (years) | 66.7 ± 12.2 | 65.0 ± 13.7 | 67.5 ± 11.5 | 0.49 |
| Gender (%) | 76.3 | 61.4 | 83.2 | <0.01 |
| BMI (kg/m²) | 24.2 ± 3.8 | 25.8 ± 4.6 | 23.5 ± 3.1 | <0.01 |
| Height (cm) | 162.9 ± 8.8 | 161.3 ± 8.5 | 163.7 ± 8.8 | 0.15 |
| Heart rate (beats/min) | 66.0 ± 11.1 | 68.3 ± 11.9 | 65.0 ± 10.6 | 0.09 |
| Current smokers (%) | 19.4 | 27.3 | 15.8 | 0.11 |
| Hypertension (%) | 72.7 | 68.2 | 74.7 | 0.42 |
| Diabetes (%) | 29.5 | 29.5 | 29.5 | 0.99 |

Laboratory findings

| Total cholesterol (mg/dl) | 180.7 ± 44.1 | 202.8 ± 31.6 | 170.5 ± 45.5 | <0.001 |
| LDL-cholesterol (mg/dl) | 104.6 ± 32.5 | 122.8 ± 26.4 | 96.1 ± 31.7 | <0.001 |
| HDL-cholesterol (mg/dl) | 53.2 ± 14.3 | 57.1 ± 17.7 | 51.4 ± 12.1 | 0.18 |
| Triglyceride (mg/dl) | 165.9 ± 164.6 | 160.9 ± 92.6 | 168.3 ± 189.2 | 0.36 |
| Fasting glucose (mg/dl) | 111.6 ± 29.7 | 109.3 ± 27.7 | 112.5 ± 30.5 | 0.34 |
| Haemoglobin A₁c | 6.1 ± 0.8 | 6.2 ± 0.96 | 6.0 ± 1.0 | 0.37 |
| Creatinine (mg/dl) | 9.9 ± 0.32 | 0.86 ± 0.26 | 0.93 ± 0.34 | 0.24 |
| Estimated GFR (ml/min/1.73 m²) | 67.3 ± 20.7 | 68.0 ± 20.4 | 67.0 ± 21.0 | 0.78 |
| BNP level (pg/ml) | 50.7 ± 62.6 | 49.4 ± 71.9 | 51.3 ± 58.3 | 0.23 |

Medications

| ACE-I or ARB (%) | 53.2 | 36.4 | 61.1 | <0.01 |
| Beta-blockers (%) | 36.7 | 18.2 | 45.3 | <0.01 |
| Calcium antagonists (%) | 47.5 | 45.5 | 48.4 | 0.75 |
| Nitrates (%) | 10.1 | 15.9 | 7.4 | 0.12 |
| Diuretics (%) | 20.1 | 27.3 | 16.8 | 0.15 |
| Statins (%) | 66.2 | 45.5 | 75.8 | <0.001 |

All values are expressed as mean ± SD or frequencies.

CAD: coronary artery disease; BMI: body mass index; LDL: low-density lipoprotein; HDL: high-density lipoprotein; GFR: glomerular filtration rate; BNP: brain natriuretic peptide; ACE-I: angiotensin-converting enzyme inhibitor; ARB: angiotensin receptor blocker.
Table 2. Baseline haemodynamic characteristics of the study population.

| Variable | Overall (n = 139) | No CAD (n = 44) | CAD (n = 95) | p | Odds ratios (95% confidence intervals) for the association of aortic fractional pulse pressure (aFPP) and aortic pulsatility index (aPI) with the presence of coronary artery disease. |
|----------|------------------|----------------|-------------|---|----------------------------------------------------------------------------------|
| Brachial BP indices | | | | | |
| bSBP | 140.8 ± 22.6 | 140.6 ± 23.1 | 140.9 ± 22.6 | 0.95 | All patients (n = 139) |
| bDBP | 87.0 ± 12.4 | 89.7 ± 14.2 | 85.8 ± 11.7 | 0.14 | NIM aFPP per 0.1 |
| bMBP | 104.9 ± 14.8 | 106.6 ± 16.4 | 104.3 ± 14.0 | 0.51 | NIM aPI per 0.1 |
| bFPP | 53.8 ± 16.2 | 59.2 ± 14.1 | 55.1 ± 17.0 | 0.27 | NIM aFPP per 0.1 |
| bPI | 0.51 ± 0.13 | 0.48 ± 0.11 | 0.53 ± 0.13 | 0.06 | NIM aPP per 0.1 |
| bPP | 63.0 ± 19.0 | 65.8 ± 20.0 | 60.2 ± 18.0 | 0.06 | NIM aPI per 0.1 |

Non-invasively measured aortic BP indices

| Variable | Overall (n = 139) | No CAD (n = 44) | CAD (n = 95) | p | Odds ratios (95% confidence intervals) for the association of aortic fractional pulse pressure (aFPP) and aortic pulsatility index (aPI) with the presence of coronary artery disease. |
|----------|------------------|----------------|-------------|---|----------------------------------------------------------------------------------|
| NIM aSBP | 149.5 ± 25.6 | 146.2 ± 24.4 | 151.0 ± 26.1 | 0.35 | All patients (n = 139) |
| NIM aPP | 89.2 ± 12.5 | 91.3 ± 14.0 | 88.2 ± 11.7 | 0.27 | NIM aFPP per 0.1 |
| NIM aMBP | 109.3 ± 15.3 | 109.6 ± 16.4 | 109.2 ± 14.8 | 0.98 | NIM aPI per 0.1 |
| NIM aFPP | 63.0 ± 20.1 | 54.9 ± 16.5 | 62.8 ± 21.2 | 0.06 | NIM aFPP per 0.1 |
| NIM aPI | 0.55 ± 0.14 | 0.50 ± 0.12 | 0.57 ± 0.15 | 0.009 | NIM aPP per 0.1 |
| NIM aPI | 68.6 ± 23.0 | 60.6 ± 18.0 | 72.7 ± 25.0 | 0.008 | NIM aPI per 0.1 |

Invasively measured aortic BP indices

| Variable | Overall (n = 139) | No CAD (n = 44) | CAD (n = 95) | p | Odds ratios (95% confidence intervals) for the association of aortic fractional pulse pressure (aFPP) and aortic pulsatility index (aPI) with the presence of coronary artery disease. |
|----------|------------------|----------------|-------------|---|----------------------------------------------------------------------------------|
| IM aSBP | 145.6 ± 26.7 | 143.8 ± 27.2 | 146.5 ± 26.6 | 0.69 | All patients (n = 139) |
| IM aPP | 74.2 ± 13.6 | 77.8 ± 13.1 | 72.5 ± 13.5 | 0.03 | NIM aFPP per 0.1 |
| IM aMBP | 102.3 ± 16.6 | 104.8 ± 16.7 | 101.1 ± 16.5 | 0.29 | NIM aPI per 0.1 |
| IM aFPP | 71.4 ± 22.9 | 65.9 ± 21.4 | 74.0 ± 23.3 | 0.13 | NIM aFPP per 0.1 |
| IM aPI | 0.70 ± 0.19 | 0.63 ± 0.17 | 0.73 ± 0.19 | 0.003 | NIM aPP per 0.1 |
| IM aPI | 1.00 ± 0.37 | 0.86 ± 0.30 | 1.06 ± 0.39 | 0.004 | NIM aPI per 0.1 |

All values are expressed as mean ± SD.

Discussion

To our knowledge, this is the first study showing the relation between CAD and the pulsatile components of aortic BP measured with a brachial cuff-based device. We also showed that age-related changes in aortic FPP and PI were more prominent in older patients, and these indices were sensitive markers of the presence and severity of CAD in elderly patients. In elderly people, risk prediction and stratification with non-invasive methods are essential to clinical decisions because they frequently have underlying or coexisting diseases, for example renal insufficiency. Therefore, our findings may provide useful suggestions for deciding strategies to detect CAD, including coronary angiography, in elderly patients.

We showed the significant association between CAD risk and IM aortic pulsatile components of BP, similarly to previous reports.[8–11] Meanwhile, consistent results have not yet been obtained with non-invasive methods. Wykretowicz et al. showed that NIM aortic FPP was associated with the presence of CAD.[16] However, Cho et al. demonstrated that NIM aortic FPP and PI were not related to CAD risk,[17] although IM indices were related. The small sample size of the latter study and differences in baseline characteristics between the two studies are possible reasons for this inconsistency. For example, ethnic biases between participants are sure to exist because these

be more sensitive markers of arterial stiffness and atherosclerosis in older patients.

Aortic pulsatile components and the presence and severity of coronary artery disease

In multivariate logistic regression analysis, aortic FPP and PI measured with both methods were related to the presence of CAD in all patients (Table 3). To examine the effect of ageing on predictive values, we performed logistic regression analyses in patients <70 years of age (n = 72) and ≥70 years of age (n = 67) separately, considering the accelerated rise of aortic FPP and PI around 70 years of age. There was no difference in the prevalence of CAD between the two groups (70.8% vs 65.7%, p = 0.51). Aortic FPP and PI were not independently associated with the presence of CAD in patients <70 years of age. In contrast, aortic FPP and PI remained independent markers of CAD risk in patients ≥70 years of age. No other haemodynamic indices showed significant associations with the presence of CAD in each age group (see Supplementary Table S1 and S2). Next, we examined the correlation between the extent of CAD and NIM aortic FPP or PI. SYNTAX and Gensini scores were calculated as indicators of the CAD severity for patients without prior percutaneous revascularization in this study (n = 74). Univariate linear regression analysis showed that aortic FPP and PI were closely correlated with both SYNTAX and Gensini scores only in patients ≥70 years of age (Figures 1 and 2). In multivariate linear regression analysis, the correlations remained significant (Tables 4 and 5).
studies were performed at hospitals in Europe and Asia, respectively. In respect of age distribution, the participants in the latter study were substantially older (63 ± 10.8 years) than those in the former study (53 ± 0.9 years). However, the present study was conducted in Asia, as was the latter study, and we showed that the discriminative power of aortic FPP and PI is large in elderly people. The inconsistency cannot be explained by differences in patient background.

In this present study, NIM aortic BP indices were obtained in an automatic and operator-independent manner using the Mobil-O-Graph, in contrast to the two previous reports using the SphygmoCor.[16,17] Although the SphygmoCor has been widely used as a

Figure 1. Correlation of non-invasively measured aortic fractional pulse pressure (FPP) and pulsatility index (PI) with SYNTAX score in: (A) patients <70 years of age (n = 38) and (B) patients ≥70 years of age (n = 36).

Figure 2. Correlation of non-invasively measured aortic fractional pulse pressure (FPP) and pulsatility index (PI) with Gensini score in: (A) patients <70 years of age (n = 38) and (B) patients ≥70 years of age (n = 36).
Aortic pulsatility index. NIM: non-invasively measured; aFPP: aortic fractional pulse pressure; aPI: aortic pulsatility index.

These facts potentially explain the inconsistent results of the previous studies using the SphygmCor.[16,17] In contrast, the Mobil-O-Graph is a brachial cuff-based oscillometric device which yields aortic BP indices in an easy-to-use, operator-independent way and has been validated with acceptable results.[18] Moreover, this device enables ambulatory aortic BP monitoring to be performed, and its clinical effectiveness has been validated by investigating the association between 24 h ambulatory aortic BP indices and left ventricular hypertrophy.[25] Ambulatory aortic BP monitoring may also improve the predictive value of aortic FPP and PI for the presence and severity of CAD, but further investigation is needed.

Brachial PP shows a small early rise in young people and an accelerated late rise after the fifth decade of life.[4,5] Brachial PP in younger patients is largely determined by stroke volume, while late increases in older patients are determined by aortic stiffening.[4,5,26] These findings are likely reasons why brachial PP is a more sensitive predictor of coronary mortality in elderly people than in young people.[1–3] In contrast, we showed that aortic PP rose linearly with age, consistent with a previous report.[5] The linear rise in aortic PP may be determined by increased wave reflection, because aortic PP depends on the reflection wave in addition to stroke volume and aortic stiffness. Considering the consistent linear rise with ageing and the recent findings that aortic PP provides a better marker for risk and prognosis of cardiovascular disease than brachial BP values,[14,27] aortic PP was expected to be a good marker for CAD risk even in young subjects. However, we did not observe a significant association between aortic PP and coronary atherosclerosis in younger and even in older subjects.

On the other hand, aortic FPP and PI were confirmed as superior predictors to aortic PP for cardiovascular events.[27] In addition, we showed that aortic FPP and PI, as well as brachial PP, exhibited accelerated late rises in elderly people.[4,5] These data suggest that aortic FPP and PI may show good correlations with CAD risk, especially in elderly people. Lu et al. also showed that aortic FPP was a powerful predictor of restenosis after coronary angioplasty in patients aged >70 years compared to patients aged between 60 and 70 years.[28] Consistent with this idea, we demonstrated that aortic FPP and PI were closely associated with the presence and severity of CAD in patients ≥70 years of age. Aortic FPP and PI were probably marked sensitive indicators of large artery stiffness in subjects with increased aortic stiffness, such as the elderly population. This has important clinical implications because aortic FPP and PI are easily obtainable and can improve the sensitivity of aortic PP as an indicator of progressive coronary artery atherosclerosis. However, aortic FPP and PI cannot complement the drawback of brachial PP as a predictor in younger subjects, probably owing to a remaining large contribution of stroke volume to aortic PP. We should take age into consideration when assessing aortic pulsatile values as well as brachial values.

We found that aortic SBP measured with both invasive and non-invasive methods was higher than NIM brachial SBP, which was inconsistent with the general understanding that brachial SBP is higher than aortic SBP.[7] Similar findings were observed in several studies, including the validation study of the Mobil-O-Graph device.[12,18] The paradoxical reversal of brachial and aortic SBP is probably due to a substantial underestimation of brachial SBP when measured with a cuff-based oscillometric method.[29–31]

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**Table 4. Linear regression analysis of the severity of coronary artery disease expressed as SYNTAX score.**

| Variable | Univariate analysis | Multivariate analysis |
|----------|-------------------|----------------------|
|          | Pearson’s correlation coefficient | Standardized β regression coefficients |
| Patients aged <70 years (n = 38) | | |
| NIM aFPP | 0.18 | 0.28 | – | – |
| NIM aPI | 0.17 | 0.30 | – | – |
| Patients aged ≥70 years (n = 36) | | |
| NIM aFPP | 0.60 | <0.001 | 0.50 | <0.001 |
| NIM aPI | 0.60 | <0.001 | 0.50 | <0.001 |

NIM: non-invasively measured; aFPP: aortic fractional pulse pressure; aPI: aortic pulsatility index.

*Confounders with p values <0.15 in each analysis group were included in the initial model.

**Table 5. Linear regression analysis of the severity of coronary artery disease expressed as Gensini score.**

| Variable | Univariate analysis | Multivariate analysis |
|----------|-------------------|----------------------|
|          | Pearson’s correlation coefficient | Standardized β regression coefficients |
| Patients aged <70 years (n = 38) | | |
| NIM aFPP | 0.27 | 0.11 | – | – |
| NIM aPI | 0.26 | 0.12 | – | – |
| Patients aged ≥70 years (n = 36) | | |
| NIM aFPP | 0.52 | <0.01 | 0.42 | <0.01 |
| NIM aPI | 0.53 | <0.01 | 0.43 | <0.01 |

NIM: non-invasively measured; aFPP: aortic fractional pulse pressure; aPI: aortic pulsatility index.

*Confounders with p values <0.15 in each analysis group were included in the initial model.
However, further investigation is needed to exclude the possibility of a device-specific problem.

In the present study, the severity of CAD was assessed by two popular indices, SYNTAX and Gensini scores, with consistent results. To the best of our knowledge, it is the first to demonstrate a significant association between aortic pulsatile indices and SYNTAX scores, because most previous studies expressed the extent of CAD by the number of diseased coronary vessels.[8,9,11] Cho et al. showed a correlation between invasively measured aortic pulsatile components and Gensini score; however, it was not applicable to non-invasive measurement.[17] The SYNTAX score is a helpful tool for therapeutic decision making regarding the complexity of CAD, and it has prognostic implications in terms of death, cardiac death and cardiovascular events in various clinical settings.[32] The Gensini score attempts to quantify the overall coronary atherosclerosis burden,[21] and it could be used to predict the cardiovascular prognosis in combination with classical risk factors and clinical variables as well as SYNTAX score.[33] We showed that aortic pulsatile indices were closely associated with both SYNTAX and Gensini scores in elderly people. Moreover, they were applicable to non-invasive measurement. Our consistent findings raise the possibility that aortic pulsatile values obtained by a non-invasive method can be useful markers for risk stratification.

There are several limitations to the present study. Firstly, the study population was small in number. In particular, a larger sample size would be required to demonstrate the significant relation between NIM aortic FPP and the extent of coronary angiography in a young group because our finding was inconsistent with the previous study reporting that IM FPP was related to Gensini score even after adjustment for age.[34] Secondly, the frequency of significant CAD was very high in this study because we included patients who received follow-up CAG for prior coronary intervention. In addition, after the prior percutaneous coronary intervention, most of these patients started to receive medical interventions including dietary counselling and cardiovascular drugs. In fact, paradoxically, the BMI, total and LDL-cholesterol levels of CAD patients were lower than those of non-CAD patients. Thirdly, the high frequency of taking medication which affects haemodynamic indices may affect the accuracy of estimating aortic BP non-invasively. However, a majority of patients undergoing CAG are taking drugs in daily clinical practice. Our results are likely to be applicable to patients with suspected CAD. Finally, we used a fluid-filled system to record the ascending aortic pressure. The use of a high-fidelity pressure transducer would increase the accuracy of the recorded pressure waveform.

In conclusion, this study demonstrated that NIM aortic pulsatile indices measured with a brachial cuff-based device were independent markers for coronary atherosclerosis in the older, but not younger, patients. Although a larger population is needed to confirm the significant relation between NIM aortic pulsatile indices and coronary atherosclerosis in younger patients, NIM aortic pulsatile indices may be novel risk stratification tools for CAD, at least in high-risk populations such as elderly people.

Disclosure statement
The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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