

Myocardial Performance Index in the Assessment of Ventricular Dysfunction Among Adults with Uncomplicated Hypertension in Lagos, Nigeria

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Abstract

Background

Hypertension can cause changes in cardiac structure and function, even before the development of overt heart failure. The myocardial performance index (MPI) provides a combined assessment of both systolic and diastolic ventricular function. However, its usefulness in assessing ventricular dysfunction in uncomplicated hypertension has not been fully established.

AIM

To assesses the performance of tissue Doppler and pulsed-wave Doppler myocardial performance indices in identifying left ventricular diastolic dysfunction, right ventricular diastolic dysfunction and right ventricular global dysfunction in adults with uncomplicated hypertension in Lagos, Nigeria.

MATERIALS AND METHODS

This was a secondary analysis of prospectively collected data from a case control study conducted at Lagos University Teaching Hospital. Ninety seven adults with uncomplicated hypertension and 96 normotensive controls were included. All of the participants had transthoracic echocardiography done. Tissue Doppler MPI and pulsed-wave Doppler MPI were assessed.

Left ventricular diastolic dysfunction, right ventricular diastolic dysfunction and right ventricular global dysfunction performance were determined using receiver operating characteristic curve analysis

RESULTS

Hypertensive participants had greater interventricular septal and posterior wall thickness, left ventricular mass and relative wall thickness, with higher prevalence of left ventricular hypertrophy compared with controls. LVDD was present in 40 (41.2%) hypertensive participants, while RVDD was present in 23 (23.7%). TDMPI and PDMPI showed poor discrimination for LVDD (AUC 0.553 for both) and RVDD (AUC 0.531 and 0.502, respectively). For right ventricular global dysfunction, TDMPI and PDMPI showed moderate discrimination, with AUCs of 0.735 and 0.769, respectively.

Conclusion

MPI showed limited ability to identify ventricular diastolic dysfunction in adults with uncomplicated hypertension. However, both TDMPI and PDMPI showed moderate ability to identify right ventricular global dysfunction. Further studies are needed to determine the clinical usefulness and prognostic value of MPI in this setting.

BACKGROUND

Hypertension (HTN) is one of the major risk factors for cardiovascular disease globally.^{1–3} According to W.H.O, in 2024, approximately 33% of adults between 30–79 years worldwide had hypertension.⁴ It is a major cause of premature death and a study in 2019 showed that it was responsible for more than 10 million deaths worldwide.^{4,5} Multiple studies have shown that the prevalence of hypertension in Africa is increasing.^{6,7} Nigeria, the continent's most populous country, significantly contributes to this. The estimated age-adjusted prevalence of hypertension in Nigeria increased from 8.5% in 1995 to 32.5% in 2020.²

Arterial hypertension significantly affects left ventricular (LV) geometry and function, even in the early phases of pressure overload. Detecting myocardial dysfunction at an early stage (before the onset of overt heart failure) is essential for guiding patient management, and determining prognosis.⁸ Echocardiography continues to be the primary tool for non-invasive cardiac assessment and has advanced beyond traditional parameters like ejection fraction to incorporate measures that reflect both systolic and diastolic function. An example of such parameter is the myocardial performance index (MPI), also referred to as the Tei index. MPI has been shown to have a stronger correlation with patient outcomes than traditional echocardiographic parameters in various myocardial diseases.^{9,10}

In patients with hypertension, it has been found that there is impairment of both left ventricular systolic and diastolic function and the Myocardial performance index (MPI) is a robust parameter that simultaneously assesses both systolic and diastolic cardiac function.⁹ The myocardial performance index (MPI) has been evaluated in various cardiac conditions like heart failure, myocardial infarction, systemic hypertension, and diabetes mellitus and it has been shown to predict increased morbidity and mortality.^{10–12} With the rising prevalence of hypertensive patients diagnosed with heart failure with preserved ejection fraction,¹³ there has been growing interest in noninvasive methods capable of detecting subtle changes in left ventricular mechanics and research has shown that MPI may be elevated even in hypertensive patients who do not exhibit left ventricular hypertrophy.⁹

Several studies have demonstrated the usefulness of MPI in assessing left ventricular function in patients with uncomplicated hypertension.^{14,15} However, data from low- and middle-income countries, especially in African populations, remain limited. Therefore, this study aims to evaluate the performance of MPI in identifying ventricular dysfunction in patients with uncomplicated hypertension in Lagos. By evaluating the degree of association and identifying possible predictive cut-off values, the research seeks to contribute to early detection strategies for subclinical ventricular dysfunction in hypertensive individuals.

Materials and Methods

Study design and setting

This study is secondary analysis of data from a prospective, case–control study of ventricular structure and function in hypertensive and normotensive adults carried out at the Lagos University Teaching Hospital (LUTH), Idi-Araba, Lagos, Nigeria. LUTH is one of three public tertiary hospitals serving Lagos, a densely populated commercial city in south-western Nigeria, and provides specialist cardiology services, including transthoracic echocardiography. In the parent study, participants were recruited from the cardiology, renal and family medicine clinics, and all echocardiographic examinations were performed in the hospital’s echocardiography laboratory. The present analysis used clinical and echocardiographic records collected in April 2018.

Study population

Cases were adults with uncomplicated essential hypertension, defined as a physician diagnosis of hypertension of at least one year’s duration in the absence of clinically established cardiovascular disease or other conditions predisposing to cardiac involvement. Participants with comorbidities such as chronic kidney disease, established left- or biventricular heart failure (Framingham criteria), primary valvular heart disease, sustained rhythm disturbances (for example atrial fibrillation or flutter), chronic obstructive or restrictive lung disease, and recognised secondary causes of pulmonary hypertension were excluded.

Controls were age- and sex-comparable adults without hypertension, defined by the absence of a prior diagnosis and a screening blood pressure below 140/90 mmHg. They were drawn from hospital staff and the general population and were subject to the same exclusion criteria as cases. All participants were aged 18 years or older and had given written informed consent at enrolment in the parent study.

Sample size

The sample size was estimated using the formula for the comparison of two means, based on previously reported mean right ventricular dimensions in Nigerian hypertensive and normotensive adults,¹⁶ at a 95% confidence level and 80% power and allowing for attrition, giving a minimum of 100 participants per arm. For the present secondary analysis, all available records meeting the eligibility criteria were included, yielding a final analytic sample of 193 participants (97 cases with uncomplicated hypertension and 96 normotensive controls).

Sampling technique

The parent study used consecutive sampling where all consenting individuals who met the inclusion criteria were enrolled into the relevant arm as they presented. The present study retrospectively analysed these prospectively collected clinical and echocardiographic records, which were retrieved from the echocardiography laboratory of the cardiology clinic.

Data collection

A structured proforma was used at enrolment to record sociodemographic characteristics (age, sex and ethnicity), parental history of hypertension, current antihypertensive therapy and relevant clinical findings, including cardiac auscultation for added heart sounds. All variables analysed in the present study were extracted from these records.

Blood pressure was measured with a digital sphygmomanometer after the participant had rested for at least five minutes in the seated position. Two readings were taken at least two minutes apart in both arms, and the mean of two readings from the arm with the higher value was recorded.

Anthropometric measurements such as weight, height, body mass index, and waist circumference were obtained using a standard protocol.

Echocardiographic assessment

Transthoracic echocardiography was performed with a Sonoscape SSI-8000 series machine and a 3.5 MHz transducer. Measurements were made in accordance with the recommendations of the American Society of Echocardiography (ASE), using the leading-edge-to-leading-edge convention.¹⁷ Participants were examined in the left lateral decubitus position for parasternal long-axis and apical four-chamber views and in the supine position for subcostal views. Studies were acquired and reported by trained operators following a standardised protocol.

Left ventricular (LV) structural parameters such as interventricular septal thickness in diastole (IVSD), LV posterior wall thickness in diastole (LVPWD), and LV internal diameters in diastole and systole (LVIDd, LVIDs) were obtained by two-dimensional-guided M-mode imaging in the parasternal long-axis view. LV mass was estimated using the Devereux formula and indexed to body surface area to derive the LV mass index (18). Relative wall thickness (RWT) was calculated, and LV geometry was classified as normal, concentric remodeling, concentric hypertrophy or eccentric hypertrophy on the basis of LV mass index and RWT, following ASE criteria.¹⁹

LV systolic function was assessed by ejection fraction, and by fractional shortening. LV diastolic function was assessed from transmitral pulsed-wave Doppler early (E) and late (A) velocities and the E/A ratio, supplemented by tissue Doppler indices; diastolic dysfunction was defined according to ASE criteria.¹⁷

The myocardial performance index (MPI) was derived by two methods. For the pulsed-wave Doppler MPI (PDMPI), the combined isovolumic contraction and isovolumic relaxation times were obtained as the interval between cessation and onset of ventricular inflow (a) minus the ejection time (b) measured from the outflow Doppler tracing, and MPI was calculated as $(a - b)/b$, equivalent to $(ICT + IRT)/ET$. For the tissue Doppler MPI (TDMPI), the same intervals were measured from a single tissue Doppler tracing at the atrioventricular annulus, and MPI was calculated as $(\text{valve closure} - \text{opening time} - \text{ejection time})/\text{ejection time}$.

Right ventricular (RV) assessment included RV wall thickness, RV dimensions and functional indices, in accordance with ASE recommendations. RV hypertrophy was defined by an increased RV free-wall thickness.

Statistical analysis

Data were analysed using IBM SPSS Statistics version 26. Continuous variables were summarised as mean $\pm$ standard deviation and categorical variables as frequencies and percentages. Cases and controls were compared using the independent-samples t-test for continuous variables and the chi-square test for categorical variables. The diagnostic performance of PDMPI and TDMPI for identifying LV diastolic dysfunction, RV diastolic dysfunction and RV global dysfunction was evaluated by receiver operating characteristic (ROC) curve analysis. For each outcome, the area under the curve (AUC) was computed, and the optimal cut-off, with the corresponding sensitivity and specificity, was identified using the Youden index. A p-value of less than 0.05 was taken as statistically significant.

Results

A total of 193 participants were included in the study. Cases with uncomplicated hypertension comprised 97 participants (50.3%) and controls without hypertension comprised 96 (49.7%). The majority of participants were in the 50–59 year age range ($n = 62$, 32.1%), followed by those aged 40–49 years ($n = 57$, 29.5%). The majority of participants were females (104, 53.9%), and Yoruba ethnic group ($n = 121$, 62.7%). Most participants were overweight ($n = 76$, 39.6%), while 51 (26.6%) were obese and only four (2.1%) were underweight (Table 1).

Table 1
Sociodemographic characteristics of all participants
(N = 193)

Variable	n (%)
Group	
Control (no hypertension)	96 (49.7)
Case (uncomplicated hypertension)	97 (50.3)
Age range (years)	
< 30	5 (2.6)
30–39	24 (12.4)
40–49	57 (29.5)
50–59	62 (32.1)
60–69	34 (17.6)
≥ 70	11 (5.7)
Sex	
Male	89 (46.1)
Female	104 (53.9)
Ethnicity	
Yoruba	121 (62.7)
Igbo	57 (29.5)
Hausa	5 (2.6)
Others	10 (5.2)
BMI category	
Underweight	4 (2.1)
Normal	61 (31.8)
Overweight	76 (39.6)
Obese	51 (26.6)
BMI = body mass index	

There was no significant difference between the age distribution and sex of cases and controls ($p = 0.993$ and $p = 0.938$, respectively). However, ethnicity was significantly associated with hypertension

status ($\chi^2=15.076$, $p = 0.002$), and BMI ($\chi^2=11.631$, $p = 0.009$). A positive parental history of hypertension was more prevalent among cases than controls and statistically significant ($p < 0.001$). Added heart sounds were significantly more frequent among cases ($p < 0.001$), and cases had significantly higher mean systolic blood pressure (143.53 ± 20.12 mmHg) than control group (123.26 ± 9.60 mmHg, $p < 0.001$) (Table 2).

Table 2
Comparison of sociodemographic and clinical parameters between cases and controls

Variable	Control n = 96	Case n = 97	χ^2 / t	p value
Age group				
< 30	2 (40.0%)	3 (60.0%)	0.470	0.993
30–39	13 (54.2%)	11 (45.8%)		
40–49	28 (49.1%)	29 (50.9%)		
50–59	31 (50.0%)	31 (50.0%)		
60–69	17 (50.0%)	17 (50.0%)		
≥ 70	5 (45.5%)	6 (54.5%)		
Sex				
Male	44 (49.4%)	45 (50.6%)	0.006	0.938
Female	52 (50.0%)	52 (50.0%)		
Ethnicity				
Yoruba	68 (56.2%)	53 (43.8%)	15.076	0.002
Igbo	24 (42.1%)	33 (57.9%)		
Hausa	4 (80.0%)	1 (20.0%)		
Others	0 (0%)	10 (100%)		
BMI category				
Underweight	4	0	11.631	0.009
Normal	36	25		
Overweight	38	38		
Obese	17	34		
Parental history of hypertension				
None	73	45	20.548	< 0.001
Father only	8	23		
Mother only	13	36		
Both parents	2	16		
Added heart sounds				

Variable	Control n = 96	Case n = 97	χ^2 / t	p value
No	94	67	29.024	< 0.001
Yes	2	30		
Continuous clinical parameters, mean $\pm$ SD				
SBP (mmHg)	123.26 $\pm$ 9.60	143.53 $\pm$ 20.12	-8.83	< 0.001
DBP (mmHg)	76.19 $\pm$ 7.67	87.16 $\pm$ 11.75	-7.72	< 0.001
Weight (kg)	72.50 $\pm$ 13.61	78.15 $\pm$ 15.38	-2.68	0.008
BMI (kg/m ²)	25.60 $\pm$ 6.30	28.24 $\pm$ 5.14	-3.19	0.002
Waist circumference (cm)	92.49 $\pm$ 10.49	97.77 $\pm$ 12.72	-3.14	0.002

SBP = systolic blood pressure; DBP = diastolic blood pressure; BMI = body mass index.

On echocardiographic assessment, left ventricular hypertrophy (LVH) was present in 65 cases (67.0%, $p < 0.001$), and concentric LVH was the most common geometric pattern among cases ($n = 20$). Cases demonstrated significantly greater interventricular septal thickness in diastole (IVSD: 1.050 ± 0.196 cm vs. 0.865 ± 0.167 cm, $p < 0.001$), LV posterior wall thickness (LVPWD: 0.993 ± 0.203 cm vs. 0.856 ± 0.166 cm, $p < 0.001$), LV mass (171.63 ± 55.30 g vs. 135.53 ± 41.03 g, $p < 0.001$), and relative wall thickness. However, the LV ejection fraction ($66.87 \pm 9.33\%$ vs. $66.98 \pm 8.87\%$, $p = 0.931$) and fractional shortening ($35.57 \pm 6.37\%$ vs. $35.32 \pm 5.58\%$, $p = 0.777$) were not statistically different between groups. The mitral E/A ratio was significantly lower in cases (1.008 ± 0.314) than controls (1.189 ± 0.332 , $p < 0.001$), indicating early diastolic impairment. LV diastolic dysfunction was present in 40 cases (41.2%) compared to 16 controls (16.7%, $p < 0.001$), and RV diastolic dysfunction was more prevalent in cases ($p = 0.014$) (Table 3).

Table 3
Comparison of echocardiographic parameters between cases and controls

Parameter	Control (n = 96) Mean $\pm$ SD	Case (n = 97) Mean $\pm$ SD	Mean diff.	p value
LV structural parameters				
IVSD (cm)	0.865 $\pm$ 0.167	1.050 $\pm$ 0.196	-0.185	< 0.001
LVPWD (cm)	0.856 $\pm$ 0.166	0.993 $\pm$ 0.203	-0.137	< 0.001
LVIDd (cm)	4.674 $\pm$ 0.540	4.675 $\pm$ 0.726	-0.002	0.987
LVIDs (cm)	2.973 $\pm$ 0.459	3.003 $\pm$ 0.540	-0.030	0.680
LVRWT	0.374 $\pm$ 0.077	0.451 $\pm$ 0.115	-0.076	< 0.001
LV mass (g)	135.53 $\pm$ 41.03	171.63 $\pm$ 55.30	-36.10	< 0.001
LV mass index – Devereux (g/m ²)	73.59 $\pm$ 21.25	91.92 $\pm$ 26.32	-18.33	< 0.001
LV mass index – Troy (g/m ²)	33.57 $\pm$ 10.99	43.48 $\pm$ 13.14	-9.90	< 0.001
LV systolic function				
LVEF (%)	66.98 $\pm$ 8.87	66.87 $\pm$ 9.33	+ 0.11	0.931
LVFS (%)	35.32 $\pm$ 5.58	35.57 $\pm$ 6.37	-0.24	0.777
LV diastolic function				
Mitral E/A ratio	1.189 $\pm$ 0.332	1.008 $\pm$ 0.314	+ 0.181	< 0.001
LV diastolic dysfunction, n (%)	16 (16.7%)	40 (41.2%)	—	< 0.001
LV geometry, n (%)				
Normal geometry	67 (69.8%)	32 (33.0%)	—	< 0.001
Concentric remodelling	22 (22.9%)	36 (37.1%)		
Concentric LVH	2 (2.1%)	20 (20.6%)		
Eccentric LVH	5 (5.2%)	9 (9.3%)		
RV parameters, n (%)				

Parameter	Control (n = 96) Mean $\pm$ SD	Case (n = 97) Mean $\pm$ SD	Mean diff.	p value
RV hypertrophy	18 (18.8%)	47 (48.5%)	—	< 0.001
RV diastolic dysfunction	10 (10.4%)	23 (23.7%)	—	0.014
RV global dysfunction	53 (55.2%)	71 (73.2%)	—	0.015
MPI parameters, mean $\pm$ SD				
PDMPI	0.607 $\pm$ 0.162	0.643 $\pm$ 0.204	-0.037	0.171
TDMPI	0.577 $\pm$ 0.160	0.634 $\pm$ 0.188	-0.058	0.023

IVSD = interventricular septal thickness in diastole; LVPWD = LV posterior wall thickness in diastole; LVIDd = LV internal diameter in diastole; LVIDs = LV internal diameter in systole; LVRWT = LV relative wall thickness; LVEF = LV ejection fraction; LVFS = LV fractional shortening; LVH = left ventricular hypertrophy; PDMPI = pulsed wave Doppler myocardial performance index; TDMPI = tissue Doppler myocardial performance index.

Among the 97 hypertensive participants analysed for MPI performance, 23 (23.7%) had right ventricular diastolic dysfunction (RVDD) and 40 (41.2%) had left ventricular diastolic dysfunction (LVDD). Tissue Doppler MPI (TDMPI, mean 0.63 $\pm$ 0.11) and pulsed wave Doppler MPI (PDMPI, mean 0.64 $\pm$ 0.20) were both poor predictors of LVDD (TDMPI AUC 0.553; PDMPI AUC 0.553) and RVDD (PDMPI AUC 0.502; TDMPI AUC 0.531). For RV global function, PDMPI showed moderate discriminatory ability (AUC 0.769) while TDMPI performed similarly (AUC 0.735) (Table 4).

Table 4
Diagnostic performance of MPI for predicting ventricular dysfunction among hypertensive participants (n = 97)

Outcome	MPI type	AUC	Optimal cut-off	Sensitivity	Specificity
LV diastolic dysfunction	TDMPI	0.553	0.582	0.650	0.536
LV diastolic dysfunction	PDMPI	0.553	0.604	0.575	0.518
RV diastolic dysfunction	TDMPI	0.531	0.623	0.522	0.608
RV diastolic dysfunction	PDMPI	0.502	—	—	—

AUC = area under the receiver operating characteristic curve; LV = left ventricular; RV = right ventricular; TDMPI = tissue Doppler MPI; PDMPI = pulsed wave Doppler MPI.

Discussion

The prevalence of LV diastolic dysfunction within the hypertensive population in this study was 41.2% and 23.7% for RV diastolic dysfunction. These proportions were significantly higher than in those without hypertension. This study also demonstrates that individuals with hypertension were more likely to have worse metrics in parameters assessing left ventricular structure. LVPWD, IVSD, LVRWT, LV mass and LV mass index were all higher than that of the control group. The prevalence of RVH was 48.5% while that of LVH was 67%. This is comparable with multiple studies (20,21) but significantly higher than the 32.4% prevalence reported in another study population of a Nigerian tertiary hospital.²⁰⁻²² This may have been due to the demographic difference among the participants.

Concentric hypertrophy was the most prevalent pattern of left ventricular geometry among affected participants, occurring in 20.6% of cases. This finding is consistent with a study conducted in northern Nigeria, although with a higher prevalence of 37%.²³ Furthermore, concentric remodeling was found in over an additional one-third. This finding raises concerns about the insidious changes that are already taking place in individuals with hypertension before they develop overt complications. This study set out to evaluate the degree of ventricular dysfunction among individuals with uncomplicated hypertension in order to identify potential parameters that could be useful for early detection and management. A Korean study conducted among participants recruited from tertiary centres confirmed that treatment with appropriate antihypertensives can cause a regression in LVH, highlighting the fact that reducing the afterload leads to a reversal of adverse cardiac remodeling.²⁴ They also demonstrated that the reduction in BP was proportional to the reduction in LVMI.²⁴

Our research is crucial due to the growing interest in detecting changes in ventricular function among hypertensive patients before they progress to heart failure and the paucity of data from low- and middle-income countries, like Nigeria. LVDD arises in hypertension due to a complex interplay between elevated arterial blood pressure, neurohormonal factors and changes in cardiac structure and function.²⁵ An Egyptian study reported the prevalence of left ventricular diastolic dysfunction among hypertensive to be 72%,¹⁴ much higher than the 41.2% found in this study. A Chinese community study discovered that 12.3% of participants with uncomplicated hypertension had LVDD, and that it was a strong predictor of multiple adverse cardiac events (MACE) independent of age.²⁶ This is most likely due to differences in study population characteristics among the research population. However, a northern Nigerian study reported an LVDD prevalence of 62% among treatment-naïve hypertensive patients.²⁷

Finally, this study revealed that MPI was a poor predictor of LV diastolic dysfunction in uncomplicated hypertension. The MPI or Tei index has documented usefulness in evaluating global LV function in heart failure because it assesses both systolic and diastolic function.^{28,29} Systolic function did not differ significantly between both groups of participants in this study. The study demonstrated that both TDMPI and PDMPI exhibited low sensitivity and specificity for the detection of diastolic dysfunction. This finding is consistent with the results of a previous study conducted among patients with isolated diastolic dysfunction, which, despite reporting relatively higher sensitivity and specificity values, similarly concluded that these indices possess limited diagnostic accuracy.³⁰

The cross-sectional nature of this study limits the determination of a causal relationship between a higher MPI and the eventual development of heart failure. Nevertheless, evidence from previous diagnostic and longitudinal studies supports this association. Gaibazzi et al ³¹ evaluated patients with heart failure and demonstrated a significant correlation between PWDMPI and TDIMPI, with both indices exhibiting high diagnostic accuracy for the identification of heart failure. This study, however, establishes the existence of diastolic impairment among individuals with uncomplicated hypertension, and the findings could serve as a basis for the development of clinical guidelines for early detection and monitoring of therapy response in hypertension with ventricular dysfunction.

Conclusion

Uncomplicated hypertension was associated with significant changes in left ventricular structure and diastolic function, as well as a higher prevalence of right ventricular dysfunction. Both tissue Doppler and pulsed-wave Doppler myocardial performance indices showed poor performance in identifying left and right ventricular diastolic dysfunction. However, both indices demonstrated moderate discriminatory ability for right ventricular global dysfunction, with pulsed-wave Doppler MPI showing the better performance. These findings suggest that although MPI has limited value in detecting diastolic dysfunction in patients with uncomplicated hypertension, it may have a role in assessing overall ventricular function. Further studies are needed to evaluate its clinical and prognostic values

Declarations

Ethical considerations

Ethical approval for the parent study was granted by the Health Research Ethics Committee of the Lagos University Teaching Hospital, and written informed consent was obtained from every participant. All records were de-identified before analysis, and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request

Competing interests

Authors declare no competing interests

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Authors' contributions

RM conceptualised and designed the study; RM coordinated the data collection; AOB analysed the data; MA, IO, AA, TO, MA and AOB write initial draft of manuscript; AM, CC, EOI, OO, OO, FD AA revised the manuscript. All authors review the final draft of manuscript and approved for publication.

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