Compatibility of renal resistive index value and left ventricular mass index value in hypertension patients

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ABSTRACT

25 **Background and Objectives**. Hypertension causes damage to various organs such as the kidneys and heart. The effects of hypertension on the heart are often found in patients with 30 Left Ventricular Hypertrophy (LVH) which can be measured by the Left Ventricular Mass Index (LVMI). The effects of hypertension on the kidneys can cause renal vascular resistance which can be measured by the Renal Resistive Index (RRI). 1 This study aims to determine the correspondence between RRI and LVMI in hypertensive patients.

14 **Materials and Methods**. This was an analytical observational study using a cross-sectional design by examining RRI and LVMI values in patients who have been diagnosed with hypertension 1 at Dr. Wahidin Sudirohusodo Hospital and Hasanuddin University Hospital from March 2024 to August 30, 2024. RRI measurements were taken using Intrarenal Artery Doppler USG, and LVMI measurements were taken using ultrasound. Data were analyzed using the 35 chi-square test, Spearman correlation, and independent sample t-test.

Results. A total of 54 hypertensive patients were collected, most of whom were > 60 years old (53.7%) and female (51.9%). LVMI had a significant relationship with RRI ($p <, 001$). 16 There was a positive and moderate correlation between RRI and LVMI values ($r = 0.480$; $p <0.001$). RRI ≥ 0.7 was found to be significantly higher in LVH (100%) compared to non-LVH (0%) ($p < 0.05$).

Conclusions. There was a correlation between the increase in RRI values and the increase in LVMI in hypertensive patients.

Keywords: hypertension, Left Ventricular Mass Index, Renal Resistive Index

Abbreviations:

LVH – Left Ventricular Hypertrophy,

LVMI – Left Ventricular Mass Index,

RRI – Renal Resistive Index,

HMOD – Hypertension-Mediated Organ Damage,

SBP – systolic blood pressure,

DBP – diastolic blood pressure,

ASE – American Society of Echocardiography

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INTRODUCTION

Hypertension is one of the diseases that cause high morbidity and mortality rates worldwide (Mills *et al.*, 2016). In 2010 it was reported that around 1.39 billion people in the world were diagnosed with hypertension, of which 349 million were from high-income countries and 1.04 billion came from low-middle-income countries (Mills *et al.*, 2016; Irianto *et al.*, 2021). Data from 2016 shows that hypertension is the cause of death globally in 10.4 million patients per year (Stanaway *et al.*, 2018). In Indonesia, based on the 2018 Basic Health Research (Riskesdas), the prevalence of hypertension reached 34.1%, this data increased when compared to the prevalence of hypertension in 2013 which was 25.8% (Kementerian Kesehatan Republik Indonesia, 2018).

Hypertension affects almost every organ in the body at both the micro and macrovascular levels. There are many specific organ changes caused by hypertension that lead to Hypertension-Mediated Organ Damage (HMOD). HMOD is a structural or functional change in the arterial blood vessels and the organs they supply due to increased blood pressure. The damage includes the brain, central and peripheral arteries, eyes, heart, and kidneys (Unger *et al.*, 2020).

The primary organ directly impacted by hypertension is the heart. Left Ventricular Hypertrophy (LVH) is the most prevalent consequence of hypertension on the heart in hypertensive patients. LVH is thought to affect 36-41% of all hypertension patients (Nadar and Lip, 2021). The Left Ventricular Mass Index (LVMI) can be measured during an echocardiography test to assess LVH; if the LVMI is greater than 115 g/m2 for men and greater than 95 g/m2 for women, LVH is considered to be present (Lang *et al.*, 2015). Essential hypertension occasionally results in poor renal function in addition to heart issues. This is so because systemic blood pressure and renal vascular resistance interact to determine renal blood flow. The Renal Resistive Index (RRI) is a test that can assess renal vascular resistance (Sveceny *et al.*, 2022).

Several studies have shown a relationship between RRI and systemic circulation, where the study analyzed the relationship between RRI and arterial stiffness, central and peripheral pressure, and right ventricular flow. In contrast to renal vascular resistance, RRI was found to be significantly impacted by pulse pressure and vascular filling in earlier research. This suggests that RRI represents a complex interplay between systemic circulation and renal microcirculation, which may serve as a marker of cardiovascular risk.

Damage to cardiorenal structure and hemodynamic brought on by hypertension is associated with RRI, LVMI, hypertrophy, and diastolic dysfunction (Darabont, Mihalcea and Vinereanu, 2023). Even when the glomerular filtration rate remains within normal bounds, worse renal function is linked to higher RRI. RRI is additionally linked to extrarenal organ alterations like LVH in hypertensive patients (Granata *et al.*, 2014; Sveceny *et al.*, 2022).

According to Tedesco et al.'s research, which involved 556 hypertensive individuals, the LVMI increased with the RRI score (Tedesco *et al.*, 2007). When comparing essential hypertension patients with target organ damage (carotid wall thickening, LVH, and albuminuria) to those without, Doi et al.'s retrospective study of 288 patients revealed that the former group's RRI values significantly increased. A 47% increase in LVH occurrences will result from every RRI increase, according to multiple logistic regression analysis (Doi *et al.*, 2012). When assessing cardiovascular risk in hypertension patients, it can be helpful to comprehend target organ damage. In addition, research on the conformity between RRI and LVMI values in hypertensive patients in Indonesia has never been conducted before. This study aims to determine the conformity between RRI and LVMI values in hypertensive patients.

MATERIALS AND METHODS

Patient Population

This study was an analytical observational study with a cross-sectional method. The population of this study was all patients diagnosed with hypertension at the Kidney Hypertension outpatient department of Dr. Wahidin Sudirohusodo Hospital and Hasanuddin University Hospital from March 2024 to August 30, 2024. The study participants were patients who met the inclusion criteria. All participants received information about the study's objectives, and their anonymity, confidentiality, voluntary nature of participation, and the right to refuse or withdraw consent at any moment were assured without consequence. This allowed them to clarify any questions they had about their involvement. Thus, all participants provided their free and informed consent in writing.

Inclusion and exclusion criteria

Inclusion criteria were adult patients diagnosed with hypertension aged 18-65 years and willing to participate in the study. Post-kidney transplant patients either as donors or recipients, aortic valve structural abnormalities, secondary hypertension, and chronic kidney disease were excluded.

Clinical data and data collection

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Sampling was carried out by consecutive sampling. The diagnosis of hypertension was made when systolic blood pressure (SBP) was ≥140 mmHg and/or diastolic blood pressure (DBP) ≥90 mmHg on at least three visits in accordance with the International Society of Hypertension Global Hypertension Practice Guideline 2020 (Unger *et al.*, 2020), or when antihypertensive therapy was present. Blood pressure was measured by mercury sphygmomanometer applied around the nondominant arm.

RRI measurement using Intrarenal Artery Doppler USG, where the patient is examined in a supine position. The transducer is placed on the lumbar region. Intrarenal arteries (segmental/interlobar) are visualized with Color-Doppler Sonography, then RRI is calculated using the following formula: peak systolic velocity - end-diastolic velocity) / peak systolic velocity. RRI examination is performed using a GE Voluson P6 BT15 ultrasound machine (Boston, Massachusetts, USA) and this examination is carried out by 1 operator. Normal upper limit was found to be 0,70, the patients were divided in two groups: <0.7 and ≥0.7. LVMI measurements were performed by 1 operator, using the Philips Ultrasound System 3300 (Bothell, Washington, USA), where the patient was examined in the supine position. The transducer was placed in the Parasternal (long and short axis images) and Apical (2 and 4 chamber images). LVMI (g/m2) was calculated using the formula from the American Society of Echocardiography (ASE) (Lang *et al.*, 2015; Grebe *et al.*, 2020). LVH: LVMI >95 g/m^2 in women or >115 g/m^2 in men.

Statistical analysis

The analysis of the data was done with SPSS version 25 (Armonk, NY: IBM Corp.). The frequency distribution, standard deviation (SD), and mean value are determined statistically. They used the independent sample t-test, correlation Spearman, and chi-square. Significant results are obtained from the statistical test if the test p-value is less than 0.05.

RESULTS

This study collected 54 hypertensive patients consisting of 26 male participants (48.1%) and 28 female participants (51.9%) aged between 26-80 years, with an average age in this study of <60 years as many as 25 participants (46.3%), and >60 years as many as 29 participants (53.7%). From 54 hypertensive participants, the average SBP value was 142.4, DBP value 79.2, and Pulse Pressure was 63.2.

The results showed that there was a significant positive correlation between the RRI value and LVMI ($p < 0.001$), where the higher the RRI value, the higher the LVMI value (red line in the image below). The correlation coefficient value (r) obtained was 0.480 (Figure 1) which indicates the closeness of the relationship between RRI and LVMI in the moderate category (r <0.500).

In this study, a significant relationship was found between RRI and LVMI (p<0.01) as seen in Table 1 where the mean LVMI value was found to be significantly higher in RRI ≥ 0.7 (144.57) compared to RRI < 0.7 (111.93). This means that LVMI has a significant relationship with RRI.

The proportion of hypertensive patients was found to be higher with LVH (72.2%) compared to non-LVH (27.8%), which can also be seen in Table 2 where RRI ≥ 0.7 was found to be significantly higher in LVH (100%) compared to non-LVH (0%).

DISCUSSION

According to the study's findings, RRI and LVMI have a positive link, with a correlation coefficient of 0.480. This result comes from earlier research by Tedesco et al., who studied 566 individuals with essential hypertension and discovered a favorable association between RRI and LVMI (correlation coefficient of 0.37) (Tedesco *et al*., 2007). In a similar result, Doi et al. discovered a substantial link between RI and LVMI in a univariate analysis of 288 essential hypertension patients in both men and women, with a correlation coefficient of 0.21 in women and 0.30 in men (Doi *et al*., 2012).

According to these findings, the larger the left ventricular mass, the higher the vascular resistance in the kidneys, as indicated by the elevated RRI value. Blood pressure, heart rate, and other systemic hemodynamic variables are significant drivers of RRI (Heine *et al*., 2005). RRI was also found to be significantly correlated with age, pulse pressure, and eGFR in the Doi et al. study (Doi *et al*., 2012). According to research by Yan Li et al., arterial stiffness and RRI were found to correlate with the ambulatory arterial stiffness index, which was determined using 24-hour ambulatory blood pressure in cases of essential hypertension (Li *et al*., 2006). As a result, RRI is regarded as an indicator of systemic atherosclerotic vascular injury.

These results indicate that the higher the vascular resistance in the kidneys as reflected by the increased RRI value, the greater the left ventricular mass. Systemic hemodynamic factors such as blood pressure and heart rate are important determinants of RRI (Heine *et al*., 2005). In the study by Doi et al., a significant relationship between RRI and age, pulse pressure, and eGFR was also found (Doi *et al*., 2012). A study by Li et al found that, in essential hypertension, the ambulatory arterial stiffness index, calculated based on 24-hour ambulatory blood pressure, was found to correlate with arterial stiffness which was also related to RRI (Li *et al.*, 2006). Therefore, RRI is considered a marker of systemic atherosclerotic vascular damage. As a result of increased cardiac workload as a compensatory mechanism for high vascular resistance, hypertensive individuals with high RRI had higher LVMI, according to the study's findings (Darabont, Mihalcea and Vinereanu, 2023).

The average LVMI value was found to be considerably greater in the RRI > 0.7 group than in the RRI < 0.7 group. According to Tedesco et al., who studied 556 hypertension patients, patients with RRI ≥ 0.7 had a significantly higher LVMI than those with RRI ≥ 0.7 (228 patients) and over 0.7 (110 patients) (Tedesco *et al.*, 2007). In a study of 48 kids with recently diagnosed hypertension, Cilsal et al. discovered a correlation between LVMI and RRI levels (Cilsal and Koc, 2019).

These results indicate that a high Renal Restrictive Index is associated with a large flow difference between systolic and diastolic phases that depend on peripheral arterial stiffness. Increased RRI reflects not only changes in intrarenal perfusion but also systemic hemodynamics and the presence of subclinical atherosclerosis. This condition also affects the volume load and stress on the ventricular wall that can cause LVH (Tedesco *et al.*, 2007; Cilsal and Koc, 2019).

In this study, the analysis of the patient group with RRI ≥0.7 was found to be significantly higher in participants with LVH (100%) compared to non-LVH (0%). The results of this study are from previous studies by Doi et al. of 288 hypertensive patients, where patients with RRI ≥ 0.69 (male) and RRI ≥ 0.72 (female) were more likely to experience LVH with a prevalence of 67.4% in patients with LVH compared to those with lower RRI (Doi *et al.*, 2012). A study by Bots et al. found that RRI had an inverse relationship with diastolic blood pressure and a positive correlation with systolic blood pressure. This suggests that higher renovascular resistance is linked to higher systemic pulse pressure, which is a known indicator of increased arterial bed stiffness (Bots *et al.*, 1996). A study by Mimran et al. revealed a correlation between elevated RRI and atherosclerosis, suggesting intrarenal atherosclerosis (Mimran, Ribstein and DuCailar, 1994).

These findings are explained by the fact that elevated arterial stiffness can impact heart and kidney circulation, making them more vulnerable to elevated hemodynamic pressure and, consequently, high vascular resistance (Kahan and Bergfeldt, 2005). This implies that greater renal vascular resistance, as indicated by elevated RRI, is linked to left ventricular hypertrophy in hypertension (Darabont, Mihalcea and Vinereanu, 2023).

The strength of this study is that it is the first study to analyze the correlation between RRI and LVMI in hypertensive patients. The limitations of this study are that it did not assess blood pressure control, duration of hypertension, and type of hypertension medication and used a small participants size.

CONCLUSION

The increase in RRI value corresponds to the increase in LVMI in hypertensive patients. These results imply that it is necessary to evaluate RRI as a parameter in detecting changes in LVMI, especially in the context of hypertension.

CONFLICT OF INTEREST: None declared

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INFORMED CONSENT: Informed consent was obtained from all participants in the study.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE: The study was approved by the Ethics Review Committee of the Faculty of Medicine, Hasanuddin University, Makassar, Indonesia under reference number 542/UN4.6.4.5.31/PP36/2024.

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Figure:

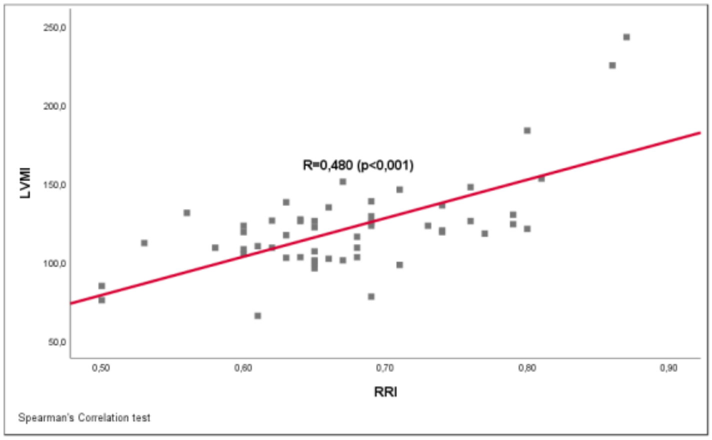

Figure 1. Correlation of RRI with LVMI
Note: RRI, Renal Resistive Index; LVMI, Left Ventricular Mass Index.

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TABLES

Table 1. Relationship between Renal Restrictive Index and Left Ventricular Mass Index

Variable	RRI	n	Mean	SD	p
LVMI	< 0.7	38	111.93	18.11	0.001
	≥ 0.7	16	144.57	39.96	

Note: RRI, Renal Resistive Index; LVMI, Left Ventricular Mass Index.

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Table 2. Comparison of Renal Restrictive Index and Left Ventricular Mass Index values

RRI		LVMI		Total	p-value
		LVH	Non LVH		
< 0.7	n	23	15	38	0.002
	%	60.5	39.5	100.0	
≥ 0.7	n	16	0	16	
	%	100.0	0.0	100.0	
Total	n	39	15	54	
	%	72.2	27.8	100.0	

Note: RRI, Renal Resistive Index; LVMI, Left Ventricular Mass Index.