International Journal of Advanced Research in Medicine

**E-ISSN:** 2706-9575
**P-ISSN:** 2706-9567
IJARM 2022; 4(2): 94-103
Received: 04-07-2022
Accepted: 06-08-2022

**Ramiyaa AB**
Post Graduate, General Medicine, Rajah Muthiah Medical College, Chidambaram, Tamil Nadu, India

**Umarani R**
Professor, General Medicine, Rajah Muthiah Medical College, Chidambaram, Tamil Nadu, India

**Corresponding Author:**
**Ramiyaa AB**
Post Graduate, General Medicine, Rajah Muthiah Medical College, Chidambaram, Tamil Nadu, India

# Prevalence and comparison of left ventricular mass and mass index in patients among stages of hypertension

**Ramiyaa AB and Umarani R**

**DOI:** https://doi.org/10.22271/27069567.2022.v4.i2b.416

**Abstract**
**Introduction:** Hypertension is one of the leading causes of the global burden of disease and is the most important health problem met by general physicians. The development of left ventricular hypertrophy increases with the severity of hypertension. Hypertension causes increase in left ventricular mass. Left ventricular mass index is a surrogate of left ventricular hypertrophy and a predictor of cardiac morbidity and mortality in adults with hypertension.
**Method:** 75 individuals aged from 30 to 60 years enrolled in the study from RMMCH after getting ethical approval. After a Detailed history and thorough clinical examination blood pressure was recorded and the Participants were divided based on JNC 8 guidelines as stage 1 and 2. 2 - D echocardiography was performed and Left ventricular mass (LVM) was recorded even in patients with normal ECG. Left ventricular mass index (LVMI) was calculated after getting body surface area (BSA).
**Result:** Blood pressure changes show marked variation in Left ventricular mass as well as Left ventricular mass index. Hypertensive stage 2 showed increased prevalence of LVH and marked rise in LVM and LVMI in comparison with stage 1 individuals. Blood pressure has strong positive correlation with left ventricular mass and also with ventricular mass index.
**Conclusion:** There is rise in LVM and LVMI and increased prevalence of preclinical target organ damage when blood pressure increased from stage 1 to stage 2. LVMI is strongly related to BP.

**Keywords:** Hypertension, echocardiography, left ventricular mass, left ventricular mass index

## Introduction
Primary hypertension is one of the leading causes of heart disease and stroke in the world and it is no different in India. Epidemiological studies estimate that more than 200 million people suffer from primary hypertension in India alone and this prevalence seems to be increasing [1]. Sustained hypertension causes accelerated atherosclerosis with consequent coronary heart disease (CHD), heart failure, stroke and renal failure. If untreated, approximately 50% of patients develop heart disease, 33% develop stroke and 10%–15% develop renal failure [2]. Hypertension has several complications some of which are left ventricular hypertrophy (LVH) and failure, congestive cardiac failure, cardiac arrhythmias and ischemic heart disease [3]. The main cardiac response to primary hypertension is left ventricular hypertrophy [4]. In hypertensive patients, left ventricular hypertrophy is a powerful independent predictor of morbidity and mortality [5, 6]. The purpose of this study is to investigate the left ventricular mass index, the echocardiographic parameter of hypertensive target organ damage of heart in low cardiovascular risk middle-aged men and women and compare it with different stages of hypertension.

## Materials and methods
### Study design
This is a prospective analytical study conducted in RMMCH, a tertiary care hospital in Cuddalore district, Tamil Nadu during a period of two years spanning from November 2020 and April 2022.

### Inclusion criteria
1. Patients undergoing treatment of hypertension as well as newly detected hypertensives

with systolic BP > 140 mmHg and Diastolic BP > 90 mm Hg (according to JNC-8) even with normal ECG (ECG without LVH findings)
2. Age group of 30 to 60 years.

**Exclusion criteria**
1. Patients with overt proteinuria
2. Patient with congestive cardiac failure
3. Patient with renal failure
4. Patients with Urinary tract infections
5. Patients with Diabetes Mellitus
6. Pregnant women
7. Patients with obstructive uropathy and nephrolithiasis
8. Secondary causes of hypertension
9. Patients who refused to give consent for the study.

**Study Pattern**

The patients admitted in RMMCH with diagnosis of hypertension who meet inclusion and exclusion criteria were selected for this study. Detailed history, thorough clinical examination and relevant investigations including ECG, Thyroid profile, serum electrolytes and renal artery Doppler to rule out renal artery stenosis has been obtained from selected patients. Diabetes mellitus was ruled out by fasting and post prandial blood sugar. Coronary artery disease and stroke was ruled out by history, physical examination and appropriate investigation. Urinary tract infection was ruled out by urine culture and kidney diseases by blood urea and serum creatinine. Study subjects who were anemic and who had fever were excluded from the study.

Once the patient was selected by the above criteria, three BP measurements were recorded, 1–2 min apart, and additional measurements only if the first two readings differ by >10 mmHg. BP is recorded as the average of the last two BP readings by using a standard bladder cuff (12–13 cm wide and 35 cm long) for most patients, but have larger and smaller cuffs available for larger (arm circumference >32 cm) and thinner arms, respectively and was classified according to JNC 8 classification.

**JNC – 8 Staging of Blood Pressure**

| Staging | Systolic BP | Diastolic BP |
|---|---|---|
| Stage 1 Hypertension | 140-159mmHg | 90-99mmHg |
| Stage 2 Hypertension | >160mmHg | >100mmHg |

**Echocardiographic examination**

An Echocardiogram was performed for all the participants by the same person using portable MINDRAY machine and 2-4 MHz mechanical transducer. Detailed structural and functional evaluation of heart was done for each participant. The Interventricular septal thickness (IVSD), left ventricular in cavity dimension (LVIDD), and left ventricle posterior wall thickness (LVPWD) in diastole were measured. All measurements were done on frozen image.

All patients had good quality images suitable for measurement and interpretation were taken. LV mass is assessed with the help of 2-Dimensional Truncated ellipsoid method using the parasternal short axis (at the level of papillary muscle) and apical 4 chambered views [7] (figure VIII and IX) [8].

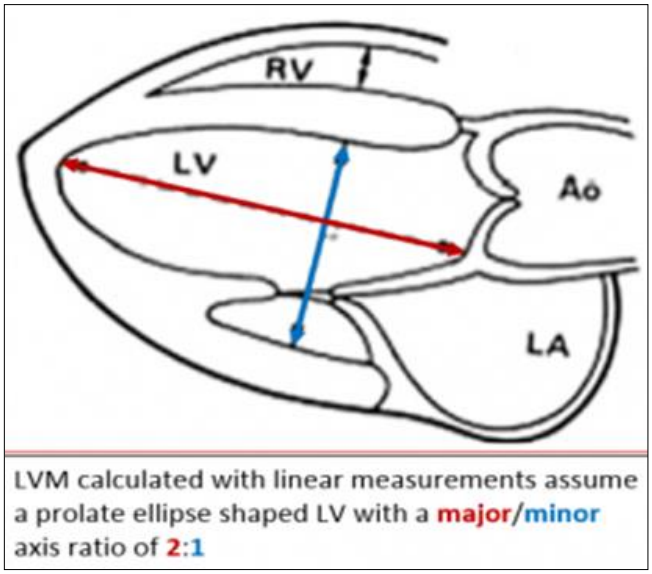


**Fig 1:** LV mass assessment by Truncated Ellipsoid Method

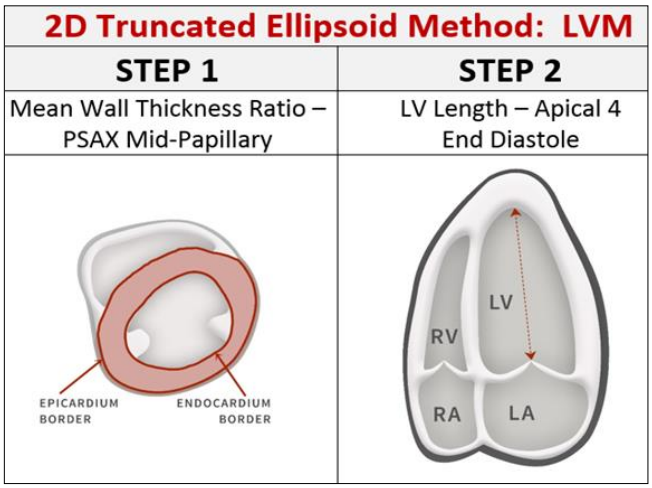


**Fig 2:** Truncated Ellipsoid method

LV MASS (GRAMS) = 0.8 X 1.04 $[(IVSD+LVIDD+PWTD)^3 – (LVDD)^3] + 0.6$

**LV mass was derived using formula by Devereux and Associates [9].**

**LVIDd:** Left ventricular mass internal dimension at end - diastole
**PWTd:** Posterior wall thickness at end – diastole.
**IVSd:** Inter ventricular septal thickness at end - diastole.
Left Ventricular Mass Index was inferred by calculating LV mass for body surface area taken as $1.73m^2$.

**Reference value of LVMI**
50–102 – for men
44–88 – for women

## Illustrations

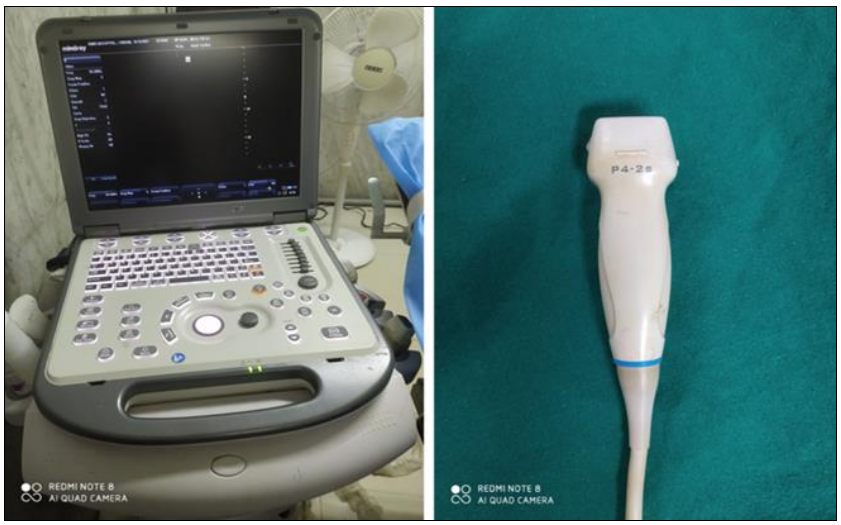

**Fig 3(a):** Portable MINDRAY Echocardiogram Mechine (b) Transducer Probe

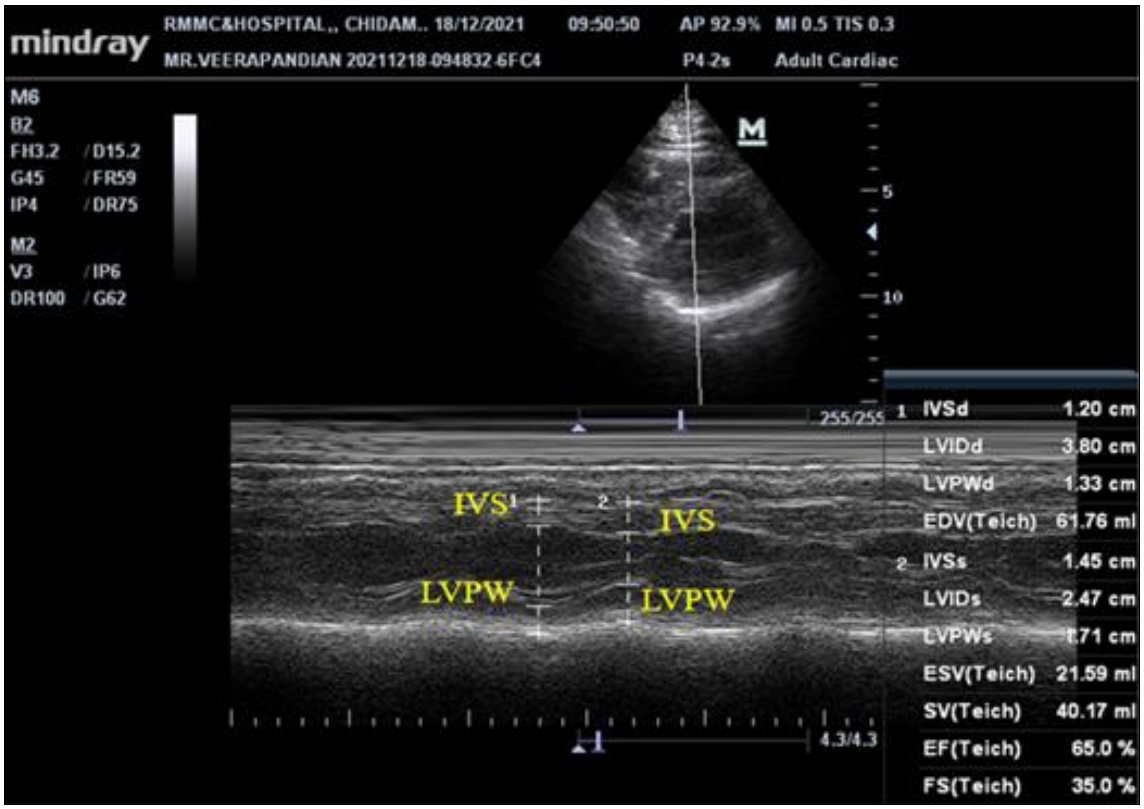


**Fig 4:** Measurements of thickness of interventricular septum (IVS) and Left Ventricular Posterior Wall (LVPW) by Left Ventricular Outflow Tract (LVOT) parasternal long axis view M-mode, measured in systole and diastole

## Observation and analysis

**Table 1:** Sex distribution

| Sex | Cases | |
|---|---|---|
| | No | % |
| Male | 41 | 55 |
| Female | 34 | 45 |
| Total | 75 | 100.0 |

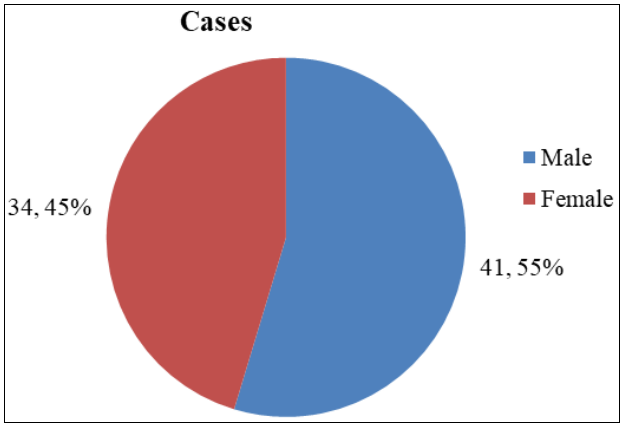


**Fig 5:** Sex distribution

The prevalence of hypertension was more in Males which was 55% compared to female which is 45%. Males were affected more than females in this study

**Table 2:** Age Distribution

| Age (In years) | Cases | |
|---|---|---|
| | No | % |
| 31-40 | 8 | 10.7 |
| 41-50 | 21 | 28 |
| 51-60 | 46 | 61.3 |
| Total | 75 | 100.0 |
| Range | 24-68 years | |
| Mean | 51.8 years | |
| S.D | 9 years | |

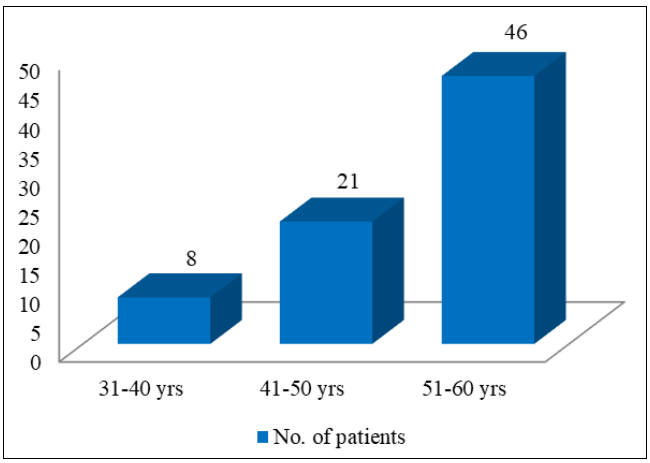


**Fig 6:** Age Distribution

There individuals belonging to age group 51 - 60 were involved more with percentage of 61.3% filled by age group of 41- 50 with percentage of 28% with least involvement in age group 31 - 40 with percentage of 10.7%. There is increasing trend in prevalence of hypertension as age increases.

**Table 3:** Distribution of BMI as per WHO

| BMI | Cases | |
|---|---|---|
| | No | % |
| 18.5 -24.9 Normal | 24 | 32 |
| 25-29.9 overweight | 46 | 61.3 |
| ≥30 obesity | 5 | 6.7 |
| Total | 75 | 100.0 |

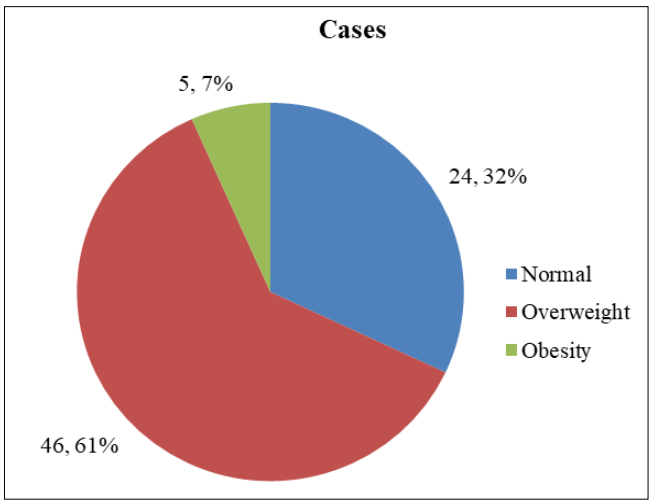


**Fig 7:** Pie chart showing distribution of BMI as per WHO

This study involved 24 (32%) individuals with normal BMI, 46 patients which constituted 61.3% coming under category of overweight and 5 patients which accounted for 6.7% who were obese.

**Table 4:** Distribution according stage of BP

| Staging | Cases | |
|---|---|---|
| | No | % |
| I | 30 | 40 |
| II | 45 | 60 |
| Total | 75 | 100.0 |

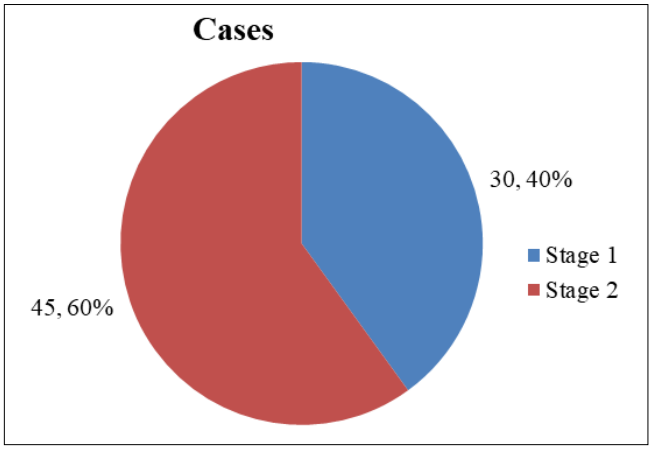


**Fig 8:** Pie chart showing distribution according stage of BP

In this study 30 patients which was 40% were in stage 1 category and 45 patients which was 60% were in the stage 2 category of hypertension according to JNC 8 classification

**Table 5:** SBP wise distribution

| SBP | Cases | |
|---|---|---|
| | No | % |
| < 140 | 2 | 2.7 |
| 140 - 149 | 12 | 16 |
| 150 - 159 | 16 | 21.3 |
| >160 | 45 | 60 |
| Total | 75 | 100.0 |

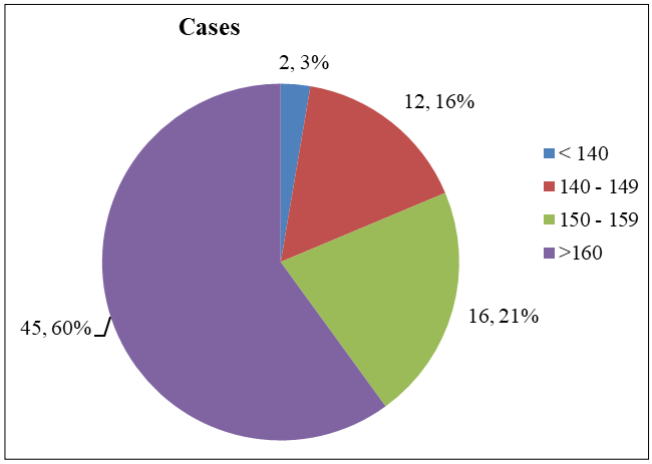


**Fig 9:** Pie chart showing SBP wise distribution in Number of cases

45 patients had presented with SBP >160 which accounted 60% followed by 16 patients had presented with SBP of 150- 159 which accounted for 21.3% followed by 12 patients who had presented with SBP of 140 - 149 which was 16%. There is more percentage of patients who presented with SBP > 160.

**Table 6:** DBP wise distribution

| DBP | Cases | |
|---|---|---|
| | No | % |
| < 90 | **20** | **26.7** |
| 90-99 | 30 | 40.3 |
| >99 | 25 | 33 |
| Total | 75 | 100.0 |

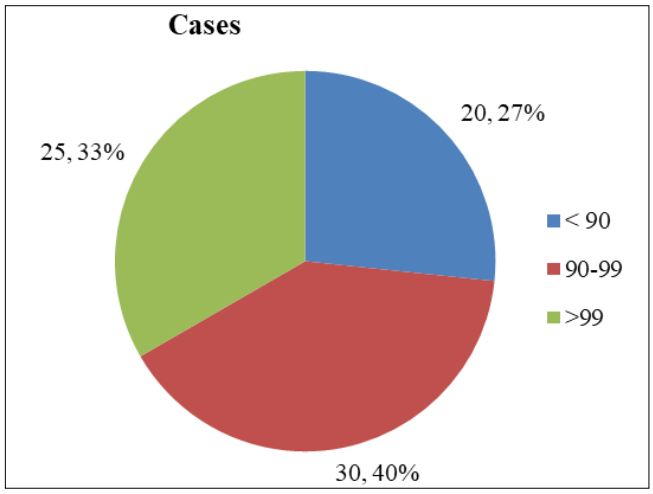


**Fig 10:** Pie chart showing DBP wise distribution in Number of cases

In this study, 25 patients had presented with DBP >99 which accounted 33.33% followed by 30 patients had presented with DBP of 90 - 99 which accounted for 40%. There is more percentage of patients who presented with DBP with 90 - 99 in this study.

**Table 7:** Prevalence of LVH according to LVMI

| LVH according to LVMI | Cases | |
|---|---|---|
| | No | % |
| Positive | 39 | 52 |
| Negative | 36 | 48 |
| Total | 75 | 100.0 |

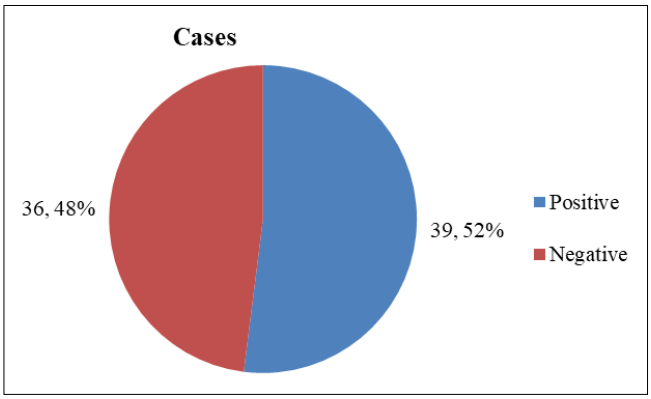


**Fig 11:** Prevalence of LVH according to LVMI

The Prevalence of LVH in hypertensive patient is 52% in this study.

**Table 8:** Comparison between AGE and LVH

| AGE | LVH | | Total | P value |
|---|---|---|---|---|
| | Positive | Negative | | |
| | N (%) | N (%) | | |
| 31 - 40 | 3 (37.5%) (7.7%) | 5 (62.5%) (13.9%) | 8 | 0.332 |
| 41 - 50 | 9 (42.9%) (23.1%) | 12 (57.1%) (33.3%) | 21 | >0.05 |
| 51-60 | 27 (58.7%) (69.2%) | 19 (41.3%) (52.8%) | 46 | |
| Total | 39 | 36 | 75 | |

*P value <0.05 significant (S) using Chi Square Test/ Fischer Exact Test

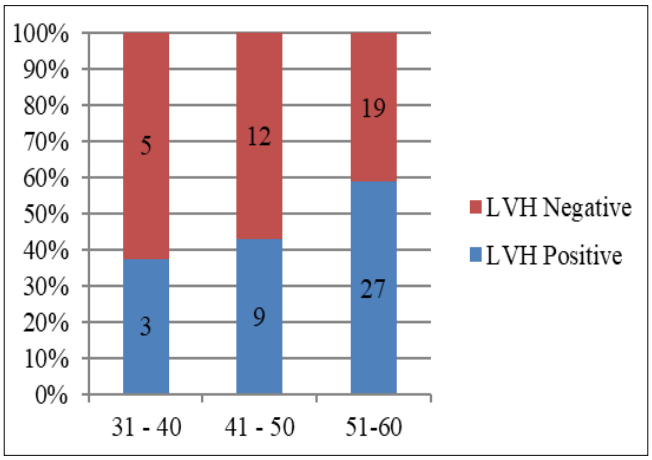


**Fig 12:** Comparison between AGE and LVH

This study shows prevalence of LVH in age group between 51 -60 was present in 27 patients which was 58.7% which was found to be high followed by 9 patients in age group 41-50 involving 42.9% patients which was followed by the age group 31 – 40 which also had prevalence of 37.5%.

**Table 9:** Comparison between BMI and LVH

| BMI | LVH | | Total | P value |
|---|---|---|---|---|
| | Positive | Negative | | |
| | N (%) | N (%) | | |
| Normal | 15, (62.5%), (38.5%) | 9, (37.5%), (25%) | 24 | 0.381 >0.05 |
| Obese | 21, (45.7%), (53.8%) | 25, (54.3%) (69.4%) | 46 | |
| Overweight | 3, (60%), (7.7%) | 2, (40%), (5.6%) | 5 | |
| Total | 39 | 36 | 75 | |

*P value <0.05 significant (S) using Chi Square Test/ Fischer Exact Test

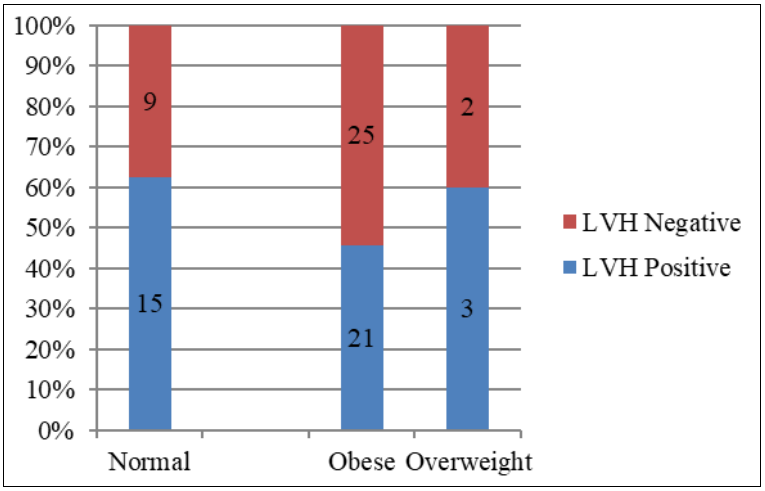


**Fig 13:** Comparison between BMI and LVH

The above table shows that majority (62.5%) of the normal healthy subjects had LVH, the percentage of Positivity for left ventricular hypertrophy was also observed more among them.

**Table 10:** Association of Sex and LVH

| Sex | LVH | | Total | P value |
|---|---|---|---|---|
| | Positive | Negative | | |
| | N (%) | N (%) | | |
| Male | 24 (58.5%) (61.5%) | 17 (41.5%) (47%) | 41 | 0.332 >0.05 |
| Female | 15 (44.1%) (38.5%) | 19 (55.8%) (53%) | 34 | |
| Total | 39 | 36 | 75 | |

*P value <0.05 significant (S) using Chi Square Test/ Fischer Exact Test

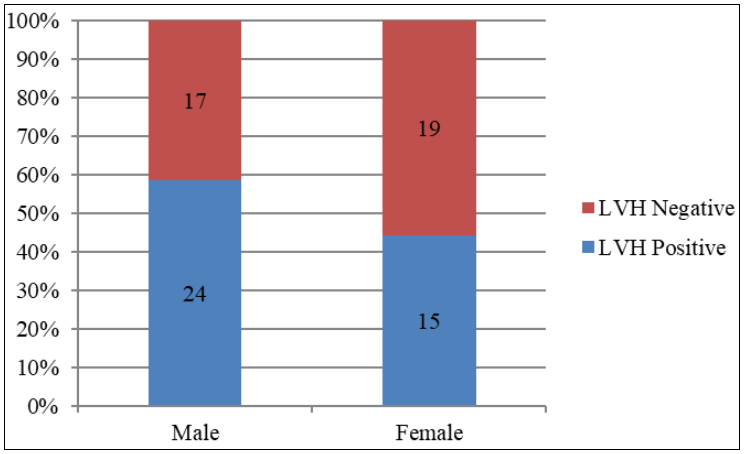


**Fig 14:** Association of Sex and LVH

The study shows that out of 41 males 24 had left ventricular hypertrophy (58.5%) where as it was only 15 out of 34 females (44.1%). Regarding the relationship between sex and left ventricular hypertrophy our study showed a more positivity with male gender.

**Table 11:** Comparison Grading of BP and LVH+

| BP | LVH | | Total | P value |
|---|---|---|---|---|
| | Positive | Negative | | |
| | N (%) | N (%) | | |

| | | | | |
|---|---|---|---|---|
| Stage 1 | 9 (30%) (23.1%) | 21 (70%) (58.3%) | 30 | <0.05* |
| Stage 2 | 30 (66.7%) (76.9%) | 15 (33.3%) (41.7%) | 45 | |
| Total | 39 | 36 | 75 | |

*P value <0.05 significant (S) using Chi Square Test/ Fischer Exact Test

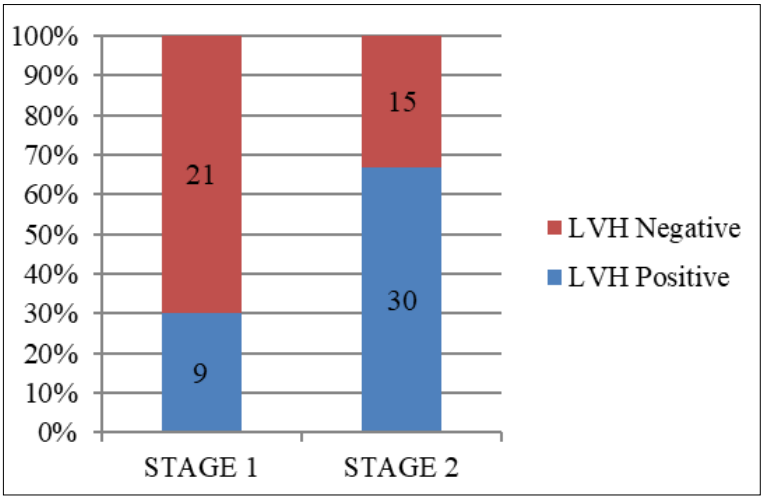


**Fig 15:** Comparison Grading of BP and LVH+

Among 75 patients, 45 patients were in stage II hypertension among them 30 patients (66.7%) had left ventricular hypertropy. 30 patients were in stage I hypertension among them 9 patients (30%) had left ventricular hypertrophy. There is a strong positive association between stage of Hypertension and LVH.

**Table 12:** Distribution of LVH and SBP

| SBP | LVH | | Total | P value |
|---|---|---|---|---|
| | Positive | Negative | | |
| | N (%) | N (%) | | |
| 140 | **0** | **2 (5.6)** | **2** | <0.05* |
| 140 - 149 | 4 (33.3%) (10.3%) | 8 (66.7%) (22.2%) | 12 | |
| 150 - 159 | 5 (31.3%) (12.8%) | 11 (68.7%) (30.6%) | 16 | |
| >160 | 30 (66.7%) (76.9%) | 15 (33.3) (41.7%) | 45 | |
| Total | 39 | 36 | 75 | |

*P value <0.05 significant (S) using Chi Square Test/ Fischer Exact Test

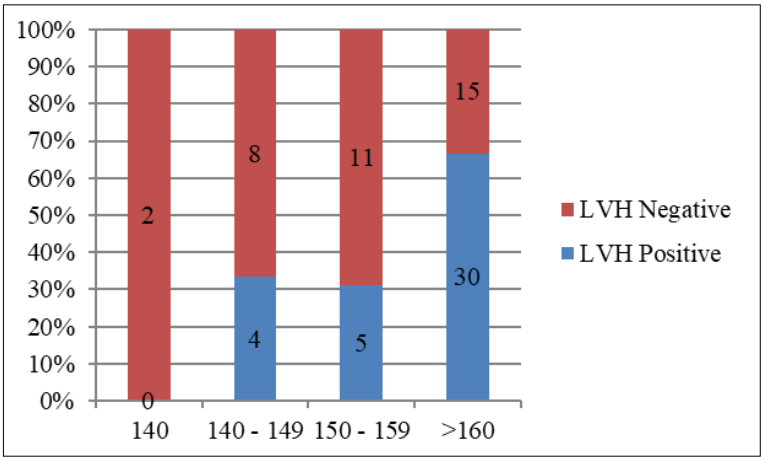


**Fig 16:** Distribution of LVH and SBP

Out of 39 subjects who had left ventricular hypertrophy, 4 had systolic blood pressure between 140 to 149 (10.3%), 5 had systolic blood pressure between 150 to 159 (12.8%) and 30 had systolic blood pressure of > 160 which accounted for 76.9%.

**Table 13:** Distribution of LVH and DBP

| DBP | LVH | | Total | P value |
|---|---|---|---|---|
| | Positive | Negative | | |
| | N (%) | N (%) | | |

| | | | | |
|---|---|---|---|---|
| 90 | 7 (35%) (18%) | 13 (65%) (36.1%) | 20 | |
| 90 – 99 | 10 (33.3%) (25.6%) | 20 (66.7%) (55.6%) | 30 | |
| >99 | 22 (88%) (56.4%) | 3 (12%) (8.3%) | 25 | <0.05* |
| Total | 39 | 36 | 75 | |

*P value <0.05 significant (S) using Chi Square Test/ Fischer Exact Test

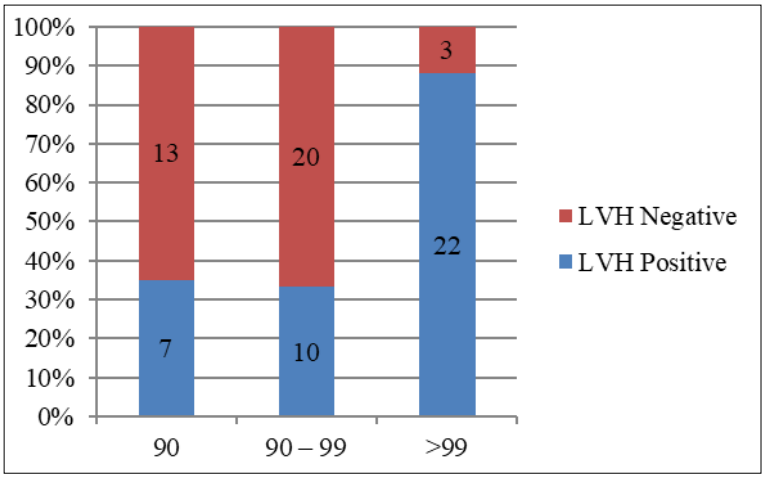


**Fig 17:** Distribution of LVH and DBP

Out of 39 subjects who had left ventricular hypertrophy, 7 had diastolic blood pressure < 90 (18%), 10 had diastolic blood pressure between 90to 99 (25.6%) and 30 had systolic blood pressure of > 99 which accounted for 56.4%.There was a constant increase in the left ventricular hypertrophy Positivity with the increase in diastolic blood pressure and it is significant.

**Table 14:** Distribution of Mean age with Grading of hypertension

| Parameter | Stage 1 | Stage 2 | T score | P value |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | | |
| Age | 48.4 ± 6.3 | 50.7 ± 6.3 | 1.58 | >0.05 (NS) |

*p*<0.05 (NS) –Not Significant by Applying Students T –Test.

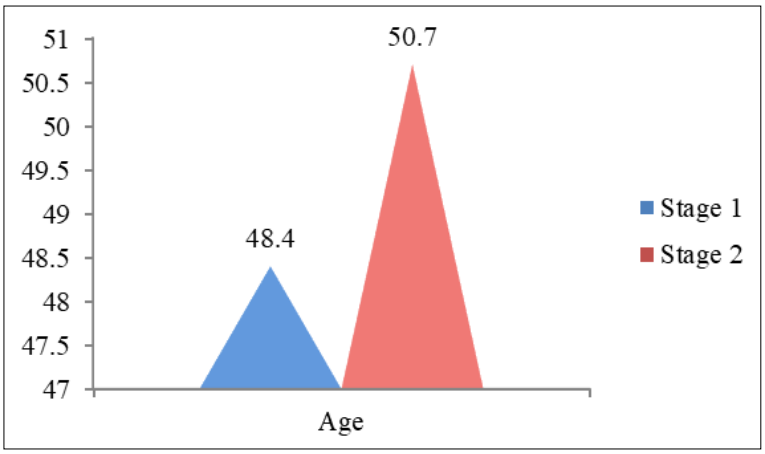


**Fig 18:** Distribution of Mean age with Grading of hypertension

**Table 15:** Distribution of Mean LVM with Grading of hypertension

| Parameter | Stage 1 | Stage 2 | T score | P value |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | | |
| LVM | 164.4 ± 39 | 216.8 ± 145 | 2.2 | <0.05* |

**p*<0.05 – Significant by Applying Students T –Test

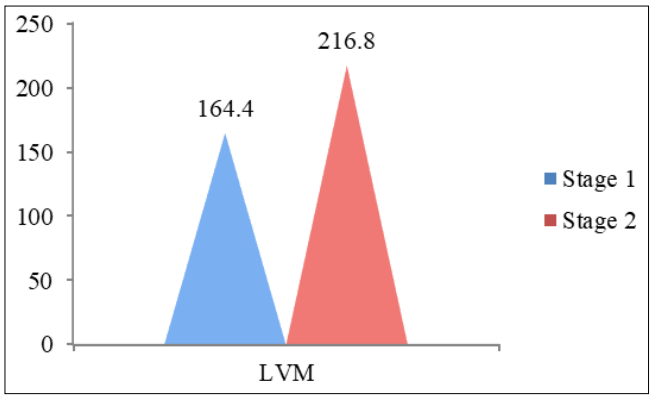


**Fig 19:** Distribution of Mean LVM with Grading of hypertension

**Table 16:** Distribution of Mean LVMI with Grading of hypertension

| Parameter | Stage 1 | Stage 2 | T score | P value |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | | |
| LVMI | 90.9 ± 23.3 | 107.4 ± 25.1 | 2.89 | <0.05* |

* $p$<0.05 – Significant by Applying Students T –Test

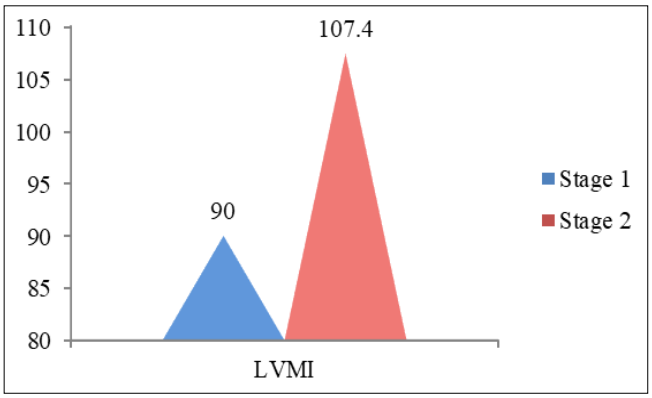


**Fig 20:** Distribution of Mean LVMI with Grading of hypertension

**Table 17:** Distribution of Mean BMI with Grading of hypertension

| Parameter | Stage 1 | Stage 2 | T score | P value |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | | |
| **BMI** | **24.9 ± 2.9** | **26.2 ± 3.3** | 0.661 | **>0.05 (NS)** |

$p$<0.05 (NS) –Not Significant by Applying Students T –Test

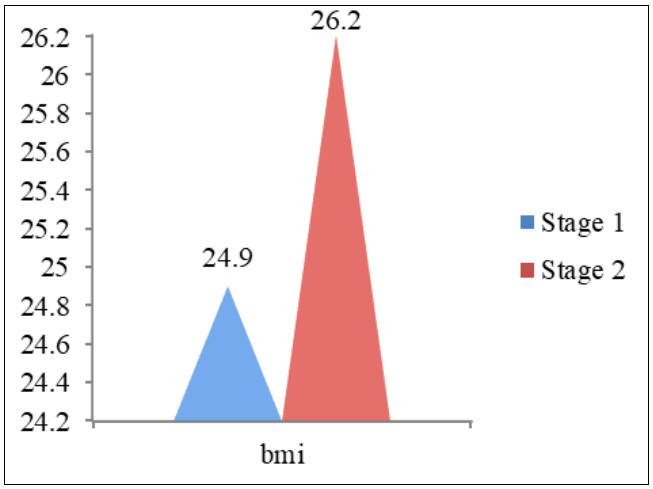


**Fig 21:** Distribution of Mean BMI with Grading of hypertension

## Discussion

Present study which analyzed the data of 75 subjects with hypertension including patients without any LVH in ECG reveals that there is relationship between blood pressure and echocardiographic parameters involving left ventricular mass and mass indexes. Hence Echocardiography is the best predictor of Left ventricular mass index. This Study also reveals the highly significant positive relation between BP with LVM and LVMI. Similar studies reported by Rowlands *et al*., studied 45 subjects found the positive correlation (r= 0.45; $p$<0.01) and Deveureux *et al*., studied 100 subjects (r=0.24; $p$<0.001). A number of previous studies have related BP values with LVH and organ damage [10-12]. Study reported by "STRONG" [10] on a heterogeneous cohort of 2585 participants found 32% participants hypertensive and BP was closely related to LVMI and the correlation (r=0.396) of the BP values was higher than that of the PP. Similar data was found in a study conducted in Taiwan with 1272 subjects, found 34% untreated hypertensive individuals and BP was also more closely related to LVMI (r=0.410) [11].

Present study observed that the patients with the high SBP as in stage 2 hypertension had a two times greater risk of LVH compared to SBP of 140 – 159 and the risk of LVH increases three times with DBP stage 2 Hypertension compared to stage1 hypertension. There is significant rise in both LVM and LVMI and also increased prevalence of LVH in stage 2 hypertension. This was similiar to Akasheh A *et al*., [13] studied 344 subjects and concluded that Diastolic (DBP) compared to systolic BP (SBP) was more strongly associated with LVMI (beta = 0.714 vs. 0.379, both P = 0.02). J.C.N. Mbanya *et al*. [14] conducted a cross sectional study. It was found that diastolic blood pressure was significantly higher in the patients with ventricular hypertrophy, and shortening fraction was negatively correlated with diastolic blood pressure (r = -0.40; p = 0.01) but not with systolic blood pressure.

This study did not show any significant correlation between increase in BMI and LVH. Rosa *et al*. [15] conducted a study including 544 hypertension patients and concluded that Left ventricular hypertrophy (LVH) has been underestimated in the obese with the use of LVM/BSA because this index considers obesity as a physiological variable. Indexing by height2 allows differences between BMI subgroups to become apparent and seems to be more appropriate for detecting LVH in obese populations.

There are too much controversies regarding relationship between gender and LVH. There are studies that showed that females have a positive association with LVH. However, other studies confirmed the reverse of this. At the same time, another series showed that there is no difference between gender and LVH [16]. This study revealed more positivity for LVH in male gender.

## Limitations

The inclusion of autonomic function testing with echocardiography for better prediction of LVH & LVMI as the response of BP to activated sympathetic outflow is one of the primary determinants of left ventricular hypertrophy in hypertension. They refer to a population with low prevalence of elderly (<10%), diabetes mellitus and obesity and should not be extended to other populations with different demographic and clinical features. The present analysis was restricted to LVH and did not examine other relevant markers of cardiac (ie, LV systolic/diastolic function, left atrial size) and extracardiac organ damage (ie, microalbuminuria, carotid intima-media thickness, and

carotid-femoral pulse wave velocity) and, more importantly, the association between new-onset LVH and cardiovascular events.

## Conclusion

In conclusion, this study found a high prevalence of LVH (52%) in hypertensive patients and strong linear relationship between BP with LVM and LVMI. Both SBP and DBP had strong association with increased LVM and LVMI. Based on the known strong association of LVMI with cardiovascular outcomes and our finding of a strong linear association of BP and LVMI, the clinical and public health implications to optimally control BP is substantial.

## References


1. Hypertension epidemiology in India: emerging aspects. Gupta R, Ram CV. Curr Opin Cardiol. 2019;34(4):331–341.
2. Kaplan NM; Systemic hypertension; Mechanism and diagnosis, in Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine 7thed. Zipes DP, Libby P, Bonow R, and Braunwald E, editos. Philadelphia, PA; Elsevier Saunders, 2004, 967.
3. Edward DF, Carl A, AramV C, Richard BD, Harriet PD, Victor D *et al*. The Heart in Hypertension. NEJM. 1992;327:1000-1008.
4. Böhm M, Laragh JH, Zehender M, editors. From Hypertension to Heart Failure. Berlin: Springer Verlag, 1998, 93.
5. Frey N, Katus HA, Olson EN, Hill JA. Hypertrophy of the Heart: Anew Therapeutic Target? Circulation 2004;109(13):1580-1589.
6. Vakili BA, Okin PM, Devereux RB. Prognostic Implications of Left Ventricular Hypertrophy. Am Heart J. 2001;141(3):334-341.
7. Menhel Kinno, Alfonso H. Waller, Julius M. Gardin**.** Approaches to Echocardiographic Assessment of Left Ventricular Mass: What Does Echocardiography Add? American College of Cardiology. [cited 2021 Oct 3]. Available from:https://www.acc.org/.
8. Burkule N, Bansal M, Mehrotra R, Venkateshvaran A. Indian academy of echocardiography performance standards and recommendations for a comprehensive transthoracic echocardiographic study in adults. J Indian Acad Echocardiogr Cardiovasc Imaging 2017;1(1):1-17.
9. Roberto Lang M, Luigi Badano P, Victor Mor-Avi, Jonathan Afilalo, Anderson Armstrong, Laura Ernande, Frank Flachskamp F A, *et al*. Recommendations for Cardiac Chamber Quantification by Echocardiography in Adults: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging, European Heart Journal - Cardiovascular Imaging. 2015;16(3):233–271,
10. Huang Y, Wang S, Cai X, Mai W, Hu Y, Tang H, *et al*. Prehypertension and incidence of cardiovascular disease: a meta-analysis. BMC Med. 2013;11(1):177.
11. Lorber R, Gidding SS, Daviglus ML, Colangelo LA, Liu K, Gardin JM. Influence of systolic blood pressure and body mass index on left ventricular structure in healthy African-American and white young adults: the CARDIA study. J Am Coll Cardiol.
12. Post WS, Larson MG, Levy D. Impact of left ventricular structure on the incidence of hypertension. The Framingham Heart Study. Circulation. 1994;90(1):179-85.
13. Akasheh A, Wu Y, Li Y, Dustin LD, Wong ND, Gardin JM, *et al*. Association of blood pressure with left ventricular mass in untreated hypertensives in rural Yunnan Province. Am J Hypertens. 2009 Jul;22(7):730-4. Doi: 10.1038/ajh.2009.75. Epub 2009 Apr 23. PMID: 19390514.
14. Mbanya JCN, Sobngwi E, Mbanya DS, Ngu KB. Left ventricular mass and systolic function in African diabetic patients: association with microalbuminuria. Vol 27, N° 3 - juin 2001 p. 378. DOI: DM-06-2001-27-3-1262-3636-101019- ART10.
15. Rosa Eduardo Cantoni, *et al*. Left Ventricular Hypertrophy Evaluation in Obese Hypertensive Patients: Effect of Left Ventricular Mass Index Criteria. Arquivos Brasileiros de Cardiologia [online]. 2002;78(4):347-351. [Accessed 15 November 2022]. Available from: <https://doi.org/10.1590/S0066-782X2002000400001>. Epub 31 Jan 2007. ISSN 1678-4170. https://doi.org/10.1590/S0066-782X2002000400001.
16. Khaznadar AA, Ahmed FJ, Tahir K, Kakamad FH. Left ventricular hypertrophy in hypertensive patients: Prevalence and diagnosis. Edorium J Cardiol. 2018;4:100008C03AK2018.