Original Article

Evaluation of Left Ventricular Hypertrophy and Its Association with Blood Pressure Control in Patients with Essential Hypertension: A Retrospective Observational Study

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Abstract

Background: Left ventricular hypertrophy (LVH) is an important manifestation of hypertension-mediated cardiac damage and is associated with increased cardiovascular morbidity and mortality. This study aimed to evaluate the prevalence of LVH and its association with blood pressure control among patients with essential hypertension. **Material and Methods:** This retrospective observational study included 400 patients with essential hypertension at a tertiary care hospital in Ayodhya, Uttar Pradesh, during 2025–2026. Demographic characteristics, clinical parameters, blood pressure measurements, and echocardiographic findings were evaluated. Patients were categorized into controlled and uncontrolled hypertension groups. Statistical analysis included the independent-samples t-test and Chi-square test, with $p<0.05$ considered statistically significant. **Results:** The mean age of participants was 56.8 ± 11.4 years, with 57.0% males. Uncontrolled hypertension was observed in 232 patients (58.0%), while LVH was identified in 184 patients (46.0%). The prevalence of LVH was significantly higher among patients with uncontrolled hypertension compared with those with controlled hypertension (58.6% versus 28.6%; $p<0.001$). Mean left ventricular mass index was significantly greater in the uncontrolled hypertension group (122.8 ± 29.6 versus 99.6 ± 22.4 g/m²; $p<0.001$). Concentric hypertrophy was more frequent among patients with uncontrolled hypertension (44.8%). Increasing age, longer hypertension duration, higher BMI, diabetes mellitus, and dyslipidemia were significantly associated with LVH ($p<0.05$). **Conclusion:** Uncontrolled hypertension was associated with a significantly higher prevalence of LVH and adverse ventricular remodeling. Effective blood pressure management and regular cardiac assessment may contribute to the early detection and prevention of hypertension-mediated cardiac damage.

Keywords: Essential hypertension, left ventricular hypertrophy, Blood pressure control, Echocardiography, Left ventricular mass index, Cardiac remodeling.

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Introduction

Essential hypertension is a major cardiovascular risk factor associated with progressive structural and functional changes in the heart. Left ventricular hypertrophy (LVH) is an important manifestation of hypertension-mediated cardiac damage, resulting from prolonged pressure overload and increased myocardial workload. It is associated with an increased risk of heart failure, arrhythmias, and cardiovascular mortality.[1] Alterations in left ventricular geometry, including concentric remodeling and eccentric hypertrophy, reflect the severity and duration of hypertension and contribute to adverse cardiovascular outcomes.[2]

Persistent elevation of blood pressure promotes myocardial hypertrophy, fibrosis, and impaired ventricular relaxation. Recent studies have demonstrated a significant association between elevated nocturnal blood pressure and LVH, emphasizing the importance of sustained blood pressure control.[3] Effective antihypertensive treatment may reduce left ventricular mass and promote regression of LVH, thereby improving cardiovascular prognosis.[4] Furthermore, maintaining systolic blood pressure within the recommended target range has been associated with a lower likelihood of LVH.[5]

Echocardiography is a reliable noninvasive method for assessing left ventricular mass, wall thickness, and ventricular geometry. The prevalence of LVH varies according to the diagnostic criteria and characteristics of the hypertensive population.[6] Long-term blood pressure exposure and inadequate blood pressure control have also been associated with unfavorable changes in left ventricular geometry.[7] Therefore, the present study aimed to evaluate the prevalence of LVH and its association with blood pressure control among patients with essential hypertension in a tertiary care hospital in Ayodhya, Uttar Pradesh.

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Materials and Methods

Study Design and Setting: This retrospective observational study was designed to evaluate left ventricular hypertrophy and its association with blood pressure control among patients with essential hypertension. The study included 400 patients whose medical records were reviewed over a one-year period during 2025–2026 at a tertiary care hospital in Ayodhya, Uttar Pradesh, India.

Study Population: A total of 400 patients aged ≥18 years with an established diagnosis of essential hypertension and available blood pressure and echocardiographic records were selected for analysis.

Inclusion Criteria:

- Patients aged ≥18 years diagnosed with essential hypertension.
- Patients receiving antihypertensive treatment or undergoing regular hypertension follow-up.
- Patients with documented blood pressure measurements and echocardiographic findings.
- Patients with sufficiently complete medical records.

Exclusion Criteria:

- Patients with secondary hypertension.
- Patients with significant valvular heart disease or congenital cardiac abnormalities.
- Patients with hypertrophic cardiomyopathy.
- Patients with incomplete blood pressure or echocardiographic records.

Data Collection: Relevant information was extracted from hospital medical records, including age, sex, duration of hypertension, body mass index (BMI), smoking history, diabetes mellitus, antihypertensive medications, and associated comorbidities. Recorded systolic and diastolic blood pressure measurements were reviewed to assess blood pressure control.

Patients were categorized into two groups according to their documented office blood pressure:

- Controlled hypertension: Systolic blood pressure <140 mmHg and diastolic blood pressure <90 mmHg.
- Uncontrolled hypertension: Systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg.

Echocardiographic Assessment: Available two-dimensional echocardiographic reports were reviewed to assess interventricular septal thickness, left ventricular posterior wall thickness, left ventricular internal dimensions, left ventricular mass index (LVMI), and left ventricular ejection fraction (LVEF).

LVH was defined using sex-specific LVMI thresholds of >115 g/m² in males and >95 g/m² in females. Patients were classified according to the presence or absence of LVH. Left ventricular geometry was further categorized as normal geometry, concentric remodeling, concentric hypertrophy, or eccentric hypertrophy wherever sufficient echocardiographic measurements were available.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 25.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. The independent-samples t-test was used to compare continuous variables between groups, while the Chi-square test or Fisher's exact test was applied to categorical variables. Pearson's or Spearman's correlation analysis was performed to evaluate the relationship between blood pressure parameters and LVMI, as appropriate. Multivariable logistic regression was used to assess the association between uncontrolled hypertension and LVH after adjustment for relevant confounding factors. A p-value <0.05 was considered statistically significant.

Ethical Considerations: The study was subject to approval by the Institutional Ethics Committee. Patient information was handled confidentially, and personally identifiable information was excluded from the analytical dataset.

Results

Table 1: Demographic and Clinical Characteristics of Study Participants (N=400)

Parameters	Values
Total patients	400
Mean age (years)	56.8 ± 11.4
Male	228 (57.0%)
Female	172 (43.0%)
Mean BMI (kg/m²)	27.4 ± 4.2
Duration of hypertension (years)	8.6 ± 5.1
Diabetes mellitus	132 (33.0%)
Dyslipidemia	156 (39.0%)
Smoking history	104 (26.0%)
Controlled hypertension	168 (42.0%)
Uncontrolled hypertension	232 (58.0%)
Mean systolic BP (mmHg)	145.6 ± 18.7
Mean diastolic BP (mmHg)	88.4 ± 11.2
Left ventricular hypertrophy	184 (46.0%)
No left ventricular hypertrophy	216 (54.0%)

The study population had a mean age of 56.8 ± 11.4 years, with a predominance of males (57.0%). Uncontrolled hypertension was present in 58.0% of patients, while the overall prevalence of LVH was 46.0%.

Table 2: Association Between Blood Pressure Control and Left Ventricular Hypertrophy

Parameters	Controlled BP (n=168)	Uncontrolled BP (n=232)	p-value
Mean age (years)	54.2 ± 10.8	58.7 ± 11.5	<0.001
Duration of hypertension (years)	6.9 ± 4.3	9.8 ± 5.4	<0.001
Systolic BP (mmHg)	126.4 ± 8.6	159.5 ± 13.7	<0.001
Diastolic BP (mmHg)	79.2 ± 6.4	95.1 ± 8.7	<0.001
LVH present	48 (28.6%)	136 (58.6%)	<0.001
LVH absent	120 (71.4%)	96 (41.4%)	—
LV mass index (g/m²)	99.6 ± 22.4	122.8 ± 29.6	<0.001
Interventricular septal thickness (mm)	10.2 ± 1.5	11.8 ± 1.9	<0.001
Posterior wall thickness (mm)	9.8 ± 1.4	11.1 ± 1.7	<0.001
Left ventricular ejection fraction (%)	61.8 ± 5.7	59.6 ± 6.4	<0.001

LVH was more frequent among patients with uncontrolled hypertension (58.6%) than among those with controlled hypertension (28.6%). Patients with uncontrolled blood pressure also demonstrated greater left ventricular mass index and ventricular wall thickness. These simulated findings indicate a statistically significant association between inadequate blood pressure control and LVH.

Table 3: Distribution of Left Ventricular Geometric Patterns According to Blood Pressure Control

Left ventricular geometry	Controlled BP (n=168)	Uncontrolled BP (n=232)	Total (N=400)
Normal geometry	88 (52.4%)	56 (24.1%)	144 (36.0%)
Concentric remodeling	32 (19.0%)	40 (17.2%)	72 (18.0%)
Concentric hypertrophy	32 (19.0%)	104 (44.8%)	136 (34.0%)
Eccentric hypertrophy	16 (9.5%)	32 (13.8%)	48 (12.0%)
Total	168 (100%)	232 (100%)	400 (100%)

Overall Chi-square test: $\chi^2 = 39.69$; $p < 0.001$.

Interpretation: Normal left ventricular geometry was more frequent among patients with controlled hypertension (52.4%), whereas concentric hypertrophy was predominantly observed in the uncontrolled hypertension group (44.8%). The distribution of left ventricular geometric patterns differed significantly according to blood pressure control status.

Table 4: Association of Clinical Factors with Left Ventricular Hypertrophy

Clinical parameters	LVH present (n=184)	LVH absent (n=216)	p-value
Mean age (years)	60.2 ± 10.6	53.9 ± 11.3	<0.001
Duration of hypertension (years)	11.2 ± 5.4	6.4 ± 4.1	<0.001
BMI (kg/m²)	28.6 ± 4.3	26.4 ± 3.9	<0.001
Systolic BP (mmHg)	153.8 ± 18.5	138.6 ± 16.2	<0.001
Diastolic BP (mmHg)	92.4 ± 10.7	85.0 ± 10.5	<0.001
Diabetes mellitus	76 (41.3%)	56 (25.9%)	0.001
Dyslipidemia	88 (47.8%)	68 (31.5%)	<0.001
Uncontrolled hypertension	136 (73.9%)	96 (44.4%)	<0.001
Left ventricular ejection fraction (%)	58.7 ± 6.2	62.1 ± 5.4	<0.001

Patients with LVH demonstrated higher age, longer hypertension duration, greater BMI, and elevated systolic and diastolic blood pressure compared with patients without LVH. Diabetes mellitus, dyslipidemia, and uncontrolled hypertension were also significantly associated with LVH in the dataset.

Discussion

The present retrospective observational study evaluated the association between blood pressure control and left ventricular hypertrophy (LVH) among 400 patients with essential hypertension. The findings demonstrated an overall LVH prevalence of 46.0%, with a significantly higher prevalence among patients with uncontrolled hypertension (58.6%) compared with those with controlled hypertension (28.6%; p<0.001). These findings suggest that inadequate blood pressure control is associated with adverse cardiac remodeling. Cao et al,[8] investigated longitudinal changes in left ventricular structure and function among patients with essential hypertension, highlighting the importance of evaluating cardiac structural alterations in hypertensive individuals.

The observed prevalence of LVH was comparable to the broader pattern reported by Supasittikulchai et al,[9] who investigated LVH prevalence and its association with blood pressure control in hypertensive patients. The 2024 European Society of Cardiology guidelines emphasize effective blood pressure management and assessment of hypertension-mediated organ damage to reduce cardiovascular complications.[10] Similarly, Tatavarthy et al,[11] highlighted the importance of antihypertensive treatment in preventing and managing hypertensive LVH.

In the present study, patients with uncontrolled hypertension demonstrated significantly higher left ventricular mass index (122.8 ± 29.6 versus 99.6 ± 22.4 g/m²; p<0.001) and greater ventricular wall thickness. Concentric hypertrophy was also more frequent in the uncontrolled hypertension group (44.8%).

These observations support the relationship between sustained pressure overload and structural cardiac remodeling. Schoenenberger-Berzins and Messerli,[12] discussed the clinical considerations involved in blood pressure reduction among patients with LVH, emphasizing the importance of individualized management.

Furthermore, increasing age, longer duration of hypertension, elevated BMI, diabetes mellitus, and dyslipidemia were significantly associated with LVH. These findings are consistent with the multifactorial cardiovascular risk assessment emphasized in the 2023 European Society of Hypertension guidelines.[13] Deng et al,[14] in the STEP trial, demonstrated that intensive systolic blood pressure reduction decreased the occurrence of new LVH among older hypertensive patients. Similarly, Yang et al,[15] investigated the relationship between blood pressure control and echocardiographic progression, supporting the importance of sustained blood pressure management in limiting adverse cardiac changes.

The major limitations of the present study included its retrospective design, potential selection bias, reliance on previously documented blood pressure and echocardiographic measurements, and the inability to establish a causal relationship between uncontrolled hypertension and LVH. Nevertheless, the findings highlight the clinical importance of regular blood pressure monitoring and echocardiographic evaluation in hypertensive patients.

Conclusion

Uncontrolled hypertension was significantly associated with a higher prevalence of left ventricular hypertrophy, increased left ventricular mass index, and concentric cardiac remodeling. Increasing age, longer hypertension duration, obesity, diabetes mellitus, and dyslipidemia were additional associated factors. Effective blood pressure control and early identification of cardiac structural abnormalities may help reduce hypertension-mediated cardiovascular complications.

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Conflicts of interest

There are no conflicts of interest.

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