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ASSESSING THE RELATIONSHIP BETWEEN LEFT VENTRICULAR HYPERTROPHY (LVH) AND ANTIHYPERTENSIVE TREATMENT OUTCOMES IN HYPERTENSIVE PATIENTS

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Abstract

Objective: The aim of this study was to determine the prevalence rate of left ventricular hypertrophy (LVH) in hypertensive patients and assess the usefulness of antihypertensive therapies in preventing the progression of LVH.

Study Design: Observational

Place and Duration: This study was conducted at, People's University of Medical and Health Sciences Nawabshah (PUMHS) for a period of 1 year from March 2024 to March 2025.

Methods: In this study 250 hypertension patients were included; 125 of them had regulated blood pressure (≤130/80 mm Hg) and 125 had uncontrolled blood pressure (≥140/90 mm Hg). Using transthoracic echocardiography, echocardiographic parameters such as left ventricular mass (LVM), interventricular septum (IVS), posterior wall thickness (PWT), and left ventricular internal diameter (LVID) were evaluated. Data were analyzed using SPSS version 26.0, with comparisons made using the Student's t-test.

Results: In the uncontrolled hypertension group, the mean LVM was 155 g, significantly higher than the controlled group's 55 g ($p < 0.001$). Other parameters, such as LVMI (87 g/m² vs. 70 g/m²), IVS (11.1 mm vs. 5.5 mm), PWT (11.1 mm vs. 3.6 mm), and EF% (40% vs. 45%), also showed significant differences (all $p < 0.05$). While the uncontrolled group received CCBs more often (40%)

than the controlled group (20%), the controlled group was prescribed ACE inhibitors/ARBs more frequently (60%) than the uncontrolled group (40%).
Conclusion: The study demonstrated that uncontrolled hypertension is strongly associated with LVH, with significantly higher LVM and adverse echocardiographic outcomes. ACE inhibitors/ARBs were effective for the controlled hypertensive group, and CCBs were used regularly in the uncontrolled hypertensive group. Blood pressure control, coupled with medication and lifestyle interventions, can significantly help in the prevention of LVH progression.

Keywords: *Left Ventricular Hypertrophy, Hypertension, Echocardiography, Calcium Channel Blockers, ACE inhibitors.*

Introduction

Hypertension continues to be a major contributor to cardiovascular morbidity and mortality, with left ventricular hypertrophy (LVH) identified as an important indicator of target organ damage [1]. a common consequence of chronic hypertension, is characterized by thickening of the left ventricular wall due to increased cardiac workload [2]. It has also been reported that LVH is prevalent in 30% of hypertension patients and is more prevalent in patients with poorly controlled hypertension or with longer disease duration [3]. In a population-based study, the age-standardized prevalence of LVH was reported at 9%, with elevated rates noted among individuals with uncontrolled hypertension [4]. This structural remodeling is an independent risk factor for cardiovascular events, including heart failure, arrhythmias, and sudden cardiac death, amplifying the urgency for effective antihypertensive management [3]. Older adults, individuals with diabetes mellitus, those who have been smoking, and those who fail to take anti-hypertensive medications, are more susceptible to LVH [3, 5].

The development of LVH due to hypertension is a multi-factorial progressive process involving adaptive and maladaptive cardiovascular remodeling [2]. In cases where the left ventricle experiences concentric hypertrophy because of chronic hypertension, the heart wall thickens in an effort to adapt and overcome extra increased afterload. The purpose of this adaptation is to stabilize the cardiac output and minimize pressure on the walls to maintain cardiovascular capabilities [6]. At the cellular level, cardiomyocyte hypertrophy is observed, and the level of extracellular matrix components increases, which is then followed by myocardial fibrosis [7]. The harmful effects of prolonged LVH as a form of compensation encompass diastolic dysfunction, myocardial firmer caused by fibrosis and collagen deposition [7]. This interferes with the process of ventricular relaxation, raising the susceptibility of heart failure with preserved ejection fraction (HFpEF) [8].

Echocardiography is the gold standard of LVH diagnosis. It provides a precise assessment of left ventricular mass, chamber shape and wall thickness [9]. Echocardiography plays a particularly important role in establishing the presence of other potential abnormalities. It contributes to directing management, particularly in hypertensive individuals who are at a higher risk of developing associated cardiovascular complications [10]. It offers better sensitivity and specificity than electrocardiography (ECG), which has narrow significance in diagnosing LVH [11].

Reducing blood pressure has played a determining role in LVH regression, which is a significant process to stem the risks of cardiovascular diseases in patients with hypertension [12, 13]. Antihypertensive treatment, especially renin-angiotensin system (RAS) blockers, has been found to cause LVH regression and consequently significantly decrease the risk of unfavorable cardiovascular incidents [14]. Angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs) are more effective in reducing left ventricular mass than beta-blockers, calcium channel blockers (CCBs) and diuretics [15]. In a meta-analysis, ARBs showed a stronger effect on the regression of LVH than other classes, and beta-blockers showed the least effect [16]. ACEIs and ARBs inhibit angiotensin II-mediated hypertrophy, and both ACEIs/ARBs plus thiazide diuretic or CCB combination therapy similarly reduce LVH independent of any blood pressure lowering effect [17].

In spite of all these advancements, challenges still persists, including inconsistency with patient responses due to age, comorbidities, and compliance, that demand personalized drug therapy [14]. In Pakistan, the problem is compounded by the lack of awareness, poor screening, and healthcare facilities. Since LVH is highly prevalent among hypertensive patients in Pakistan, the study will fill this gap by determining the incidence of LVH in hypertensive patients through transthoracic echocardiography as well as measuring the effectiveness of antihypertensive treatment in thwarting the progression of LVH.

Methodology

The study employed observational research design to investigate the cardiac parameters in hypertensive patients. This research was conducted to compare the echocardiographic measurements of patients with controlled and uncontrolled hypertension. Data were collected in the outpatient department (OPD) of the hospital using its resources. The research involved 250 patients with hypertension, including 125 patients in each group (controlled vs. uncontrolled).

The primary variables measured were the posterior wall thickness (PWT), left ventricular mass (LVM), the left ventricular internal diameter (LVID), and interventricular septum (IVS). All these variables were quantified on a GE-Vivid S60N Sonography machine during transthoracic echocardiography. M-mode and 2-D echocardiography were also used and measured in parasternal short axis and parasternal long axis view. Informed consent was granted by all the participants before the procedure. Standardized data collection processes reduced bias by using random selection of participants to lessen selection bias. The population studied consisted of 250 participants, with an equal number in each hypertension group to facilitate meaningful comparison.

Descriptive statistics were used to analyze quantitative variables, such as BMI, echocardiographic measurements, and blood pressure, with results presented as means ± standard deviations or percentages, where appropriate. The study adhered to ethical standards, with informed consent secured from all participants and approval obtained from the hospital's ethics review board.

Data analysis was conducted using SPSS version 26.0. Baseline characteristics and echocardiographic measurements were summarized with descriptive statistics. Differences between controlled and uncontrolled hypertension groups were assessed using the Student's t-test. The effectiveness of antihypertensive therapy in both groups was presented in percentages.

Results

A total of 250 hypertension patients were included in the research. Of them, 125 had blood pressure levels that were regulated (≤130/80 mm Hg) and 125 had blood pressure levels that were uncontrolled (≥140/90 mm Hg). Participants were getting their follow-up care in the cardiac outpatient department. Women made up most of the uncontrolled hypertension group, with a ratio of 3:1 female to male and an average age of 60 ± 10 years. This group had a mean body mass index (BMI) of 27 ± 10 kg/m2, suggesting that some of the people included were overweight or obese.

Table 1: Clinical Characteristics of Patients

Variables	Uncontrolled BP (N=125)	Control BP (N=125)	P-Value
Mean Age (years)	60 ± 20	55 ± 20	0.100
Gender: Female	92 (73.6%)	88 (70.4%)	0.100
Gender: Male	33 (26.4%)	37 (29.6%)	0.100
Mean Systolic BP (mmHg)	141 ± 20	130 ± 10	0.001
Mean Diastolic BP (mmHg)	91 ± 11	80 ± 10	0.001
Body Mass Index (kg/m²) Normal (18 - 23)	37 (29.6%)	43 (34.4%)	0.001
Body Mass Index (kg/m²) Overweight (23 - 29)	44 (35.2%)	44 (35.2%)	0.001
Body Mass Index (kg/m²) Obese (29 or above)	44 (35.2%)	38 (30.4%)	0.001

The LVM, LVMI, IVS, PWT, LVID, and EF% mean values in the uncontrolled hypertension group were significantly greater than those in the managed hypertension group. The uncontrolled hypertension group had a significantly higher LVM (mean 155 g) compared to the managed group (mean 55 g), as shown by a p-value < 0.001. Additional echocardiographic metrics, including EF%, LVID, PWT, and IVS, also revealed statistically significant ($p < 0.05$) differences between the two groups.

Table 2: Echocardiographic M-mode Findings

Variables	Uncontrolled BP (N=125)	Control BP (N=125)	P-Value
Echocardiography: EF (%)	40 ± 5	45 ± 5	0.001
Echocardiography: LVM (gm)	155 ± 36	55 ± 20	0.001
Echocardiography: LVM index (g/m²)	87 ± 21	70 ± 10	0.050
Echocardiography: PWT (mm)	11.1 ± 0.6	3.6 ± 0.6	0.050
Echocardiography: IVS (mm)	11.1 ± 0.5	5.5 ± 0.5	0.001
Echocardiography: LVID (mm)	55.5 ± 4	54.0 ± 4	0.050

ACE inhibitors and ARBs were given at lower rates in the group with uncontrolled hypertension than in the group with controlled hypertension (40 vs. 60%) but more likely to be prescribed in the uncontrolled group than calcium channel blockers (CCBs) (40 vs. 20%) in the controlled group. The use of beta-blockers and combination therapy was lower in both groups.

Table 3: Outcome Data for Anti-Hypertensive Drug Therapy Usage

Variables	Uncontrolled BP (N=125)	Control BP (N=125)	P-Value
Combination anti-hypertensive therapy	12 (9.6%)	6 (4.8%)	0.001
Beta-blockers (BB)	13 (10%)	19 (15%)	0.001
Calcium channel blockers (CCB)	50 (40%)	25 (20%)	0.001
ACE-Inhibitors/ARB	50 (40%)	75 (60%)	<0.001

Discussion

The aim of the study was to determine the incidence of LVH and the quality of antihypertensive treatment among individuals with hypertension. Our findings indicate significant differences between the two groups. The uncontrolled BP group, predominantly female with a mean age of 60 ± 20 years and a higher prevalence of overweight or obesity (mean BMI 27 ± 10 kg/m²), exhibited significantly higher left ventricular mass (LVM; 155 ± 36 g vs. 55 ± 20 g), left ventricular mass index (LVMI; 87 ± 21 g/m² vs. 70 ± 10 g/m²), interventricular septum (IVS; 11.1 ± 0.5 mm vs. 5.5 ± 0.5 mm), posterior wall thickness (PWT; 11.1 ± 0.6 mm vs. 3.6 ± 0.6 mm), and left ventricular internal diameter (LVID; 55.5 ± 4 mm vs. 54.0 ± 4 mm), with a lower ejection fraction (EF; 40 ± 5% vs. 45 ± 5%) compared to the controlled BP group (all $p < 0.05$).

These findings are consistent with the existing evidence, meaning that the presence of untreated hypertension is a predisposing factor to the development of LVH. This is consistent with a study by Yang et al. (2023), which revealed that there was significantly more LVH risk in older adults with uncontrolled hypertension in comparison to individuals with controlled hypertension [18]. In Ethiopia, a study report demonstrated that LVH was common among Hypertensive patients in the country, which was 30.7%, and having uncontrolled blood pressure led to the greatest increase in LVM [3]. Consistent with this, higher LVM in our study in uncontrolled participants (155 g) is comparable to previous reports by the Valsartan Antihypertensive Long-Term Use Evaluation (VALUE) trial that documented LVH in 40 percent of hypertensive patients, related to poor myocardial microcirculation and augmented cardiovascular event risks [19].

In the current study, CCBs were more utilized in the uncontrolled hypertension group, and ACE inhibitors/ARBs in the controlled group were more common. In a study conducted by Arshad et al. (2023), CCBs were the most frequently used drug to address hypertension, with 33-72 percent of their usage wide across studies [20]. This observation concurs with our findings, as a higher proportion reported the use of CCBs in non-controlled hypertension (40%) than in the controlled group (20%). ACE inhibitors and ARBs, however, are common in patients who have controlled blood pressure because they have been found to be effective in preventing cardiovascular complications and guarding organs [21]. Contrarily, CCBs (particularly dihydropyridines like amlodipine) are recommended to manage hypertension as first-line therapy, and they are often combined with other medications to provide optimal blood pressure control [22]. In addition, the reduced prescription rates of beta-blockers and combination therapies in both groups align with current recommendations. Because of the limited impact on stroke incidence and absence of mortality benefit compared with other antihypertensive agents, beta-blockers are no longer advocated as first-line therapy among the general hypertensive population [23].

There are limitations to this study. The technique of echocardiography is very effective in diagnosis, but the results may vary on several factors, such as the competency of the operator as well as the quality of the machine, which can affect the precision of the measurements. In addition, the study of hypertensive patients already taking antihypertensive medication may lead to selection bias, which makes the generalizability of findings limited to a wider population of hypertensive patients. Future studies could consider employing additional diagnostic tools, larger and more heterogeneous sample populations, and prospective designs better help us understand left ventricular hypertrophy in hypertension patients in more depth.

Conclusion

Echocardiography is a major diagnostic tool in the early detection of LVH, which may lead to heart failure if left untreated. It helps identify left ventricular enlargements and is a useful aid in understanding how the heart is functioning. Lifestyle modification, accompanied by antihypertensive medication, is an important part of managing uncontrolled hypertension, especially in patients with symptoms of edema and dyspnea. A main target of ACE inhibitors or ARBs is regression of left ventricular mass, which further illustrates the importance of the medicines in treating hypertension. This interventional combination is a critical variable that can improve patient outcomes.

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