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Association of Hypertension Severity and Duration with Left Ventricular Diastolic Dysfunction

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Abstract

Background: Left ventricular diastolic dysfunction (LVDD) is a common yet often underdiagnosed consequence of chronic hypertension. Early identification of diastolic dysfunction in hypertensive patients can prevent progression to heart failure. This study aimed to assess the association between the severity and duration of hypertension and the presence and grade of LVDD. ***Methods:*** This cross-sectional study at Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, from January 2020 to December 2020. Included 80 hypertensive patients aged 52 to 90 years. Participants underwent comprehensive echocardiographic evaluation, including diastolic function grading. Patients were stratified based on hypertension stage (Stage I–III) and duration of hypertension. Associations between clinical variables and LVDD were analyzed using appropriate statistical tests. ***Results:*** The mean age of the participants was 68.9 ± 11.9 years, with 55% females. Diastolic dysfunction was present in 77.5% of the patients, predominantly Grade I (55%), followed by Grade II (16.3%) and Grade III (6.3%). A significant correlation was observed between LVDD and both the severity ($p < 0.05$) and duration of hypertension ($p < 0.05$). Patients in Stage II and III hypertension, as well as those with longer hypertension duration, exhibited higher grades of LVDD. ***Conclusion:*** LVDD is highly prevalent among

hypertensive individuals and shows a significant association with both hypertension severity and duration. These findings underscore the importance of routine echocardiographic screening in hypertensive patients for early detection of subclinical myocardial dysfunction and timely therapeutic intervention.
Keywords: Hypertension, Diastolic dysfunction, Echocardiography, Left ventricular function, Heart failure.

INTRODUCTION

Hypertension, defined as persistently elevated arterial pressure, is one of the most prevalent non-communicable diseases, affecting over one billion people globally and contributing significantly to cardiovascular morbidity and mortality [1]. The burden of hypertension continues to rise, particularly in low- and middle-income countries, where healthcare systems may lack adequate screening and control strategies [2]. Long-standing hypertension exerts adverse effects on multiple organ systems, with the cardiovascular system bearing the brunt of this chronic hemodynamic stress. Among the spectrum of hypertensive heart disease, left ventricular diastolic dysfunction (LVDD) occupies a critical yet often underrecognized position [3]. LVDD refers to the impaired ability of the left ventricle to relax and fill during diastole, resulting in elevated left atrial pressure and pulmonary venous congestion [4]. This abnormality can occur despite preserved systolic function and often precedes the clinical onset of heart failure with preserved ejection fraction (HFpEF)—a condition increasingly recognized for its high prevalence and poor outcomes [5]. The pathogenesis of LVDD in hypertension involves complex interactions, including pressure overload-induced myocardial hypertrophy, interstitial fibrosis, microvascular dysfunction, and abnormal calcium handling [6,7]. These changes result in impaired ventricular relaxation and increased stiffness, ultimately compromising diastolic filling. Echocardiography, particularly when enhanced by tissue Doppler imaging (TDI) and pulsed Doppler techniques, offers a non-invasive means of detecting and grading diastolic dysfunction even before the emergence of overt heart failure symptoms [8]. However, despite the availability of such diagnostic tools, routine assessment of diastolic function in hypertensive patients remains limited in clinical practice, especially in resource-constrained settings [9]. Multiple studies have demonstrated the relationship between elevated blood pressure and LVDD [10,11]. However, there is a paucity of data specifically delineating how the severity (i.e., blood pressure stage) and duration of hypertension independently contribute to the development and progression of LVDD. Moreover, gender-specific differences in hypertensive heart disease, though increasingly observed, remain underexplored [12]. Understanding these associations is vital, not only for identifying high-risk individuals but also for developing early intervention strategies aimed at preventing the transition from subclinical myocardial dysfunction to symptomatic HFpEF. This study, therefore, sought to assess the prevalence of LVDD in a cohort of hypertensive patients and examine its relationship with both the severity and duration of hypertension, with the goal of informing risk stratification and screening guidelines.

METHODS

Study Design and Participants

This cross-sectional observational study was conducted at Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh, from January 2020 to December 2020. Included 80 hypertensive patients aged between 52 and 90 years. Inclusion criteria were known hypertensive patients on treatment for at least one year. Patients with significant valvular disease, congenital heart disease, or reduced ejection fraction were excluded.

Data Collection

Data on demographics, clinical history, duration of hypertension, and blood pressure readings were recorded. Echocardiographic assessment was performed using standard protocols, including pulsed Doppler and tissue Doppler imaging, to assess diastolic function based on the American Society of Echocardiography (ASE) guidelines.

Statistical Analysis

Data were analyzed using SPSS version 26. Continuous variables were expressed as mean ±standard deviation (SD), and categorical variables as frequencies and percentages. Chi-square tests and independent t-tests were used to compare groups. A p-value < 0.05 was considered statistically significant.

RESULTS:

The study included 80 hypertensive patients, among them echocardiography parameters of diastolic dysfunction were assessed.

Table 1. Demographic Characteristics of the Study Subjects (n = 80)

Variable	Mean ± SD / Frequency (%)
Age (years)	68.9 ± 11.9
Sex (Male)	36 (45%)
Sex (Female)	44 (55%)

This table illustrates the basic demographic profile of the study population. The mean age was approximately 69 years, indicating an older cohort, which is relevant as age is an independent factor affecting diastolic function. There was a slight female predominance (55%).

Table 2. Distribution of Study Subjects by Previous History (n = 80)

Clinical History	Frequency (n)	Percentage (%)
Dyslipidemia	44	55.0
Smoking	43	53.8
Previous history of heart failure	8	10.0

This table reflects common cardiovascular risk factors present in the study population. A high prevalence of dyslipidemia and smoking further compounds the risk of diastolic dysfunction. Only 10% had a known history of heart failure, suggesting most cases of LVDD were previously undetected.

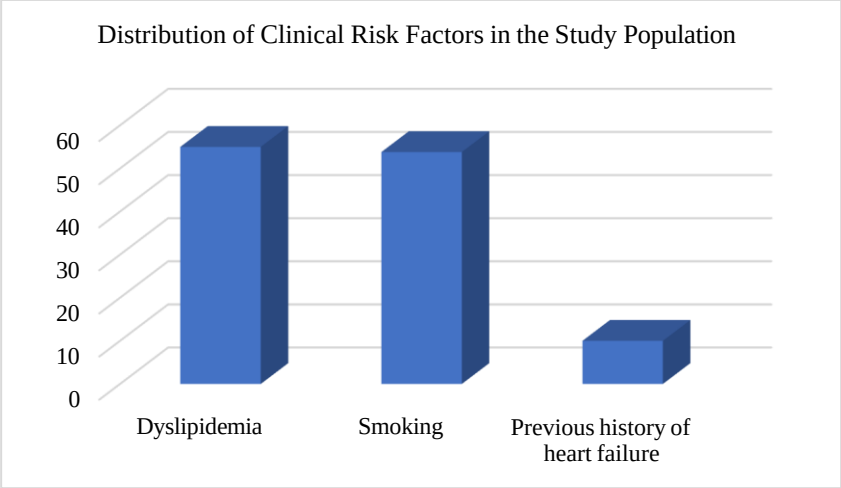

Figure I: Line Chart Showed Distribution of Clinical Risk Factors in the Study Population

Table 3. Sex Distribution of the Study Subjects (n = 80)

Sex	Frequency (n)	Percentage (%)
Male	36	45.0
Female	44	55.0

This table reiterates the sex distribution of the study participants, showing a female predominance which reflects general healthcare-seeking behavior in older populations in many regions.

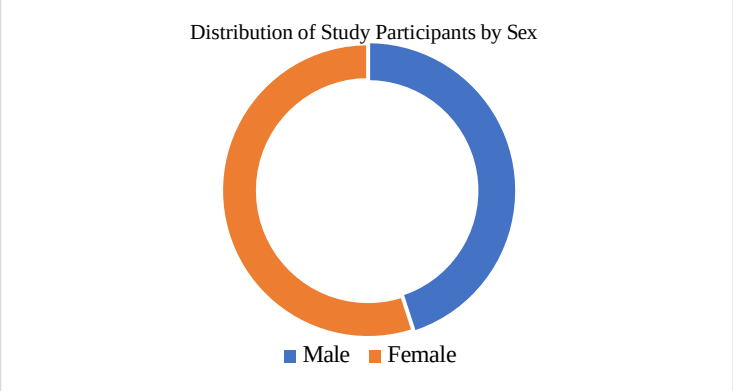

Figure II: Pie Chart Showed Distribution of Study Participants by Sex

Table 4. Comparison of Duration of Hypertension Between Male and Female Participants (n = 80)

Sex	Mean Duration ± SD (years)	p-value
Male	10.2 ± 1.19	< 0.05
Female	9.50 ± 1.13	

Male participants had a significantly longer duration of hypertension compared to females ($p < 0.05$), which may partially explain a greater burden of myocardial remodeling observed in men. This difference could have implications for personalized hypertension management strategies.

Table 5. Hypertension Stage Distribution Among Study Subjects (n = 80)

Hypertension Stage	Frequency (n)	Percentage (%)
Stage I	65	81.3
Stage II	9	11.3
Stage III	6	7.5

Most patients were categorized under Stage I hypertension. However, patients with Stage II and III hypertension were observed to have more severe diastolic dysfunction, supporting the hypothesis that higher blood pressure levels have a more detrimental effect on cardiac compliance.

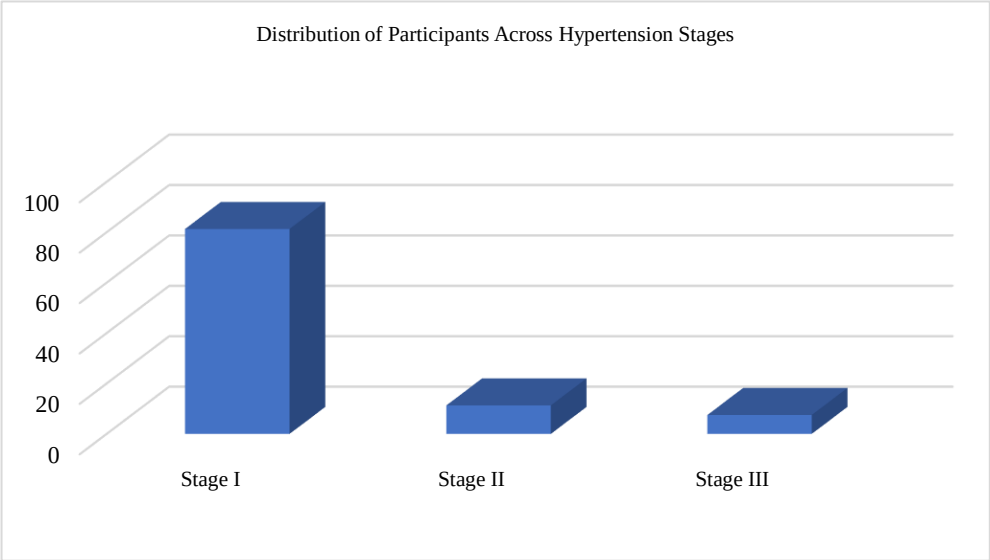

Figure III: Line Chart Showed Distribution of Participants Across Hypertension Stages

Table 6. Grading of Diastolic Dysfunction (n = 80)

Diastolic Dysfunction Grade	Frequency (n)	Percentage (%)
Normal (No Dysfunction)	18	22.5
Grade I	44	55.0
Grade II	13	16.3
Grade III	5	6.3

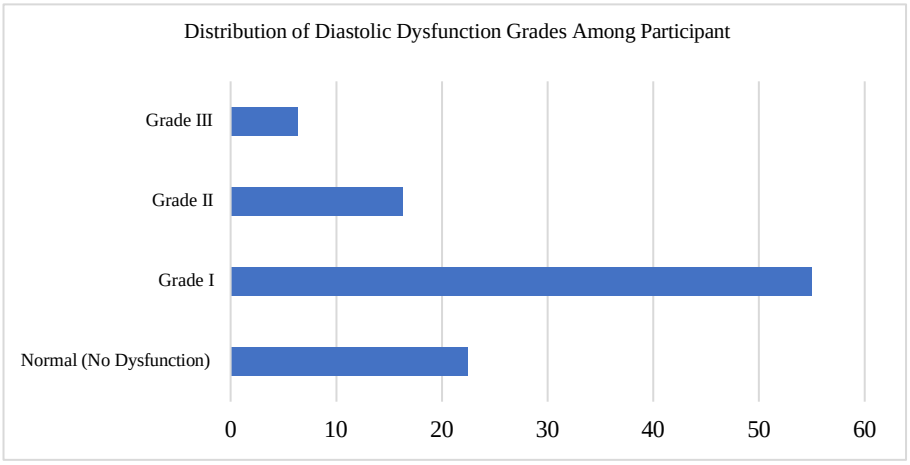

Figure IV: Bar Chart Showed Distribution of Diastolic Dysfunction Grades Among Participant

Table 7. Overall Prevalence of Diastolic Dysfunction

Diastolic Function Status	Frequency (n)	Percentage (%)
Normal	18	22.5
Any Diastolic Dysfunction	62	77.5

This table emphasizes the high prevalence of diastolic dysfunction (77.5%) among hypertensive patients, most of whom were asymptomatic. These findings underscore the importance of echocardiographic screening in seemingly stable hypertensive individuals.

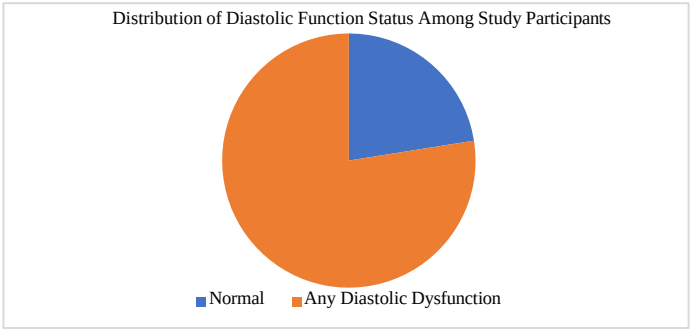

Figure V: Pie Chart Showed Distribution of Diastolic Function Status Among Study Participants)

Table 8. Correlation of Diastolic Dysfunction with Clinical Parameters (n = 80

Parameter	Correlation with Diastolic Dysfunction	p-value	Significance
Duration of Hypertension	Positive correlation	< 0.05	Significant
Systolic Blood Pressure	Positive correlation	< 0.05	Significant
Hypertension Stage	Positive association	< 0.05	Significant

A statistically significant correlation was observed between diastolic dysfunction and three major clinical parameters: duration of hypertension, systolic blood pressure, and hypertension stage. These correlations suggest a cumulative effect of elevated blood pressure over time on diastolic function.

DISCUSSION

This study underscores the high prevalence of left ventricular diastolic dysfunction (LVDD) among hypertensive patients, with 77.5% of our study population demonstrating evidence of diastolic impairment. The predominance of Grade I LVDD (55%) in our cohort reflects the early-stage myocardial remodeling associated with chronic pressure overload—a finding consistent with earlier reports [13,14]. Our results reveal a statistically significant correlation between LVDD and both the severity and duration of hypertension, thereby affirming the progressive nature of hypertensive cardiac remodelling. Chronic elevation of systolic pressure increases left ventricular afterload, prompting compensatory myocardial hypertrophy. Over time, this hypertrophy, combined with interstitial collagen deposition, reduces myocardial compliance, impairs active relaxation, and ultimately leads to elevated left ventricular end-diastolic pressures [6,15]. The greater prevalence of higher-grade diastolic dysfunction in patients with Stage II and Stage III hypertension highlights the dose-dependent impact of pressure overload on myocardial function. This finding supports the notion that more aggressive blood pressure control may mitigate the development of irreversible myocardial damage and the evolution toward HFpEF [16]. Additionally, patients with longer durations of hypertension had more advanced LVDD, suggesting a cumulative effect of long-term exposure to elevated pressures. This aligns with data from the Framingham Heart Study, which reported a higher incidence of diastolic dysfunction in individuals with prolonged hypertensive exposure [10]. Interestingly, our study also revealed sex-related differences in hypertension duration, with males exhibiting a slightly longer average duration of disease. While the clinical significance of this finding requires further exploration, it suggests that gender-specific factors—possibly hormonal or behavioral—may influence the natural history of hypertensive cardiac remodeling [17]. Previous work has shown that female patients may develop concentric remodeling and diastolic dysfunction more readily in response to hypertension, potentially contributing to the observed higher prevalence of HFpEF in women [18]. The implications of our findings are far-reaching. Firstly, they emphasize the need for routine echocardiographic assessment of diastolic function in hypertensive patients, especially those with longstanding or severe hypertension. Secondly, our data support the integration of diastolic function screening into hypertension management protocols, particularly for early identification and intervention. Finally, these results highlight the potential utility of echocardiographic grading of diastolic dysfunction as a surrogate marker for subclinical cardiac damage in this population. Despite the strengths of our study—including standardized echocardiographic evaluation and clearly defined inclusion criteria—it is not without limitations. As a cross-sectional study, causal relationships cannot be definitively established. The sample size was relatively modest and drawn from a single center, limiting generalizability. Additionally, important confounding factors such as left ventricular mass index, renal function, and medication adherence were not analyzed.

Future research should aim to validate our findings in larger, multicenter cohorts and explore whether early therapeutic interventions guided by diastolic function grading can improve clinical outcomes in hypertensive populations.

CONCLUSION

The present study demonstrates a strong association between the severity and duration of hypertension and the development of left ventricular diastolic dysfunction (LVDD). A significant proportion of hypertensive patients had subclinical diastolic dysfunction, with higher dysfunction grades observed in those with longer-standing and more severe hypertension. These findings emphasize the importance of early and routine echocardiographic assessment in hypertensive individuals, even in the absence of symptoms, to detect early myocardial changes and guide timely therapeutic interventions aimed at preventing the progression to heart failure.

Limitations

This study has some limitations. Being cross-sectional, causality cannot be inferred. The relatively small sample size and single-center data limit generalizability. Other potentially confounding factors such as renal function, BMI, medication adherence, and biochemical markers were not considered.

Recommendations

- Routine echocardiographic screening should be included in the management protocol for hypertensive patients.
- Optimal antihypertensive therapy should be ensured to prevent cardiac remodeling.
- Patient education on lifestyle modification should be emphasized.
- Regular follow-up with echocardiographic assessment is recommended in patients with LVDD.
- Further large-scale multicenter studies are warranted.

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