Innovative Research Journal of **Clinical Sciences** (IRJCS)
2024; 2(2):8-14
DOI: https://doi.org/10.62497//irjcs.107

Research Article

Echocardiographic Assessment of Diastolic Dysfunction in Patients with Poorly Controlled Hypertension

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Citation: Anwar MA, Jabeen F, Aman Y, Umair M, Khan WS. Echocardiographic Assessment of Diastolic Dysfunction in Patients with Poorly Controlled Hypertension. Innov Res J Clin Sci. 2024; 2(2):8-14. DOI: https://doi.org/10.62497//irjcs.107
Available from: https://irjpl.org/irjcs/article/view/107

Article Info
Received:
Revised:
Accepted:

Keywords
Diastolic Dysfunction
Hypertension
Echocardiography
Left Ventricular Function
Cardiovascular Risk

Abstract

Introduction: Diastolic dysfunction is a common cardiac complication in patients with poorly controlled hypertension, contributing to increased morbidity and mortality. Early detection using echocardiography is crucial for effective management and the prevention of heart failure.

Materials and Methods: A cross-sectional study was conducted at the Department of Cardiology, Khyber Teaching Hospital (KTH), Peshawar, from January to December 2023. A total of 118 patients with poorly controlled hypertension were enrolled. Detailed clinical and demographic data were collected, and all participants underwent standardized echocardiographic assessment to evaluate diastolic function. Statistical analyses included chi-square tests, ANOVA, and multivariate logistic regression.

Results: Diastolic dysfunction was identified in 88 patients (74.6%). Grade I dysfunction was most common, observed in 37 patients (31.4%), followed by Grade II in 31 patients (26.3%), and Grade III in 20 patients (16.9%). Significant predictors of diastolic dysfunction included increasing age (OR 1.04, p = 0.008), longer hypertension duration (OR 1.10, p = 0.002), presence of diabetes mellitus (54 patients; 45.8%, OR 2.25, p = 0.023), dyslipidemia (62 patients; 52.5%, OR 1.75, p = 0.031), and elevated systolic blood pressure (OR 1.06, p = 0.015).

Conclusion: Diastolic dysfunction is highly prevalent among patients with poorly controlled hypertension and is associated with several clinical risk factors. Routine echocardiographic evaluation should be considered for early identification and optimal management.

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Introduction

About 1.28 billion adults worldwide suffer with hypertension, a common and chronic health problem, with a large percentage living in nations with low to middle incomes [1]. Often referred to as the "silent killer," uncontrolled hypertension contributes to a wide range of cardiovascular complications, including stroke, myocardial infarction, and heart failure [2]. Among these complications, diastolic dysfunction remains a frequently underdiagnosed yet clinically significant entity that warrants closer attention, especially in patients with poorly controlled blood pressure [3].

If the heart cannot relax and fill with blood normally, this is called diastolic dysfunction, and it frequently results in heart failure marked by normal ejection fraction (HFpEF) [4]. The pathophysiological mechanism primarily involves left ventricular hypertrophy, myocardial fibrosis, and increased arterial hardening, all of which are strongly influenced by long-standing hypertension5. The early stages of diastolic dysfunction are often asymptomatic, making it a covert contributor to progressive cardiac morbidity [6]. Over time, it may lead to overt heart failure, reduced capacity for physical activity and a low standard of living, especially in older adults [7].

Echocardiography has emerged as a cornerstone in the evaluation of diastolic function, offering a non-invasive, accessible, and reliable method to detect subclinical cardiac changes [8]. Fascia Doppler scans, left atrium volume, mitral inflow velocities, and the E/e' ratio are important echocardiographic measures that offer important information about myocardial compliance and left ventricular filling pressures [9].

In patients with poorly controlled hypertension, echocardiographic assessment becomes even more valuable, as it enables early identification of diastolic abnormalities before clinical symptoms emerge [10]. Despite its clinical importance, diastolic dysfunction in hypertensive patients is often overlooked in routine practice, particularly in resource-limited settings where awareness and diagnostic capabilities may be constrained [11].

The link among hypertension and left ventricular diastolic function has been the subject of numerous investigations; however, most have focused on general hypertensive populations without emphasizing the specific subgroup of patients with poorly controlled blood pressure [12]. Moreover, there remains a paucity of regional data, especially from South Asian populations, where hypertension control rates remain suboptimal and cardiovascular disease burden is disproportionately high [13].

Despite the known cardiovascular risks of uncontrolled hypertension, limited studies have comprehensively evaluated the echocardiographic profile of diastolic dysfunction in this high-risk group highlighting the need to fill this research gap. Consequently, the aim of this research is to evaluate the frequency and echocardiographic features of diastolic dysfunction in patients with poorly controlled hypertension.

Materials and Methods

Study Design

This cross-sectional study was conducted at the Department of Cardiology, Khyber Teaching Hospital (KTH), Peshawar, over a 12-month period from January to December 2023. The primary objective was to evaluate the frequency and echocardiographic features of diastolic dysfunction in patients with poorly controlled hypertension.

Sample Size Calculation

Using OpenEpi version 3.01, the sample size was calculated based on an anticipated prevalence of diastolic dysfunction of 50%, a 95% confidence level, and an 8% margin of error. The minimum required sample size was 114 patients. To compensate for potential dropouts or incomplete data, the final sample size was increased to 118.

Sampling Technique

A non-probability sequential sampling method was employed. All eligible patients presenting to the cardiology outpatient department during the study period were screened and included according to predefined inclusion and exclusion criteria.

Inclusion and Exclusion Criteria

Adults aged 30 to 70 years with a history of hypertension for more than one year and persistently elevated blood pressure (≥140/90 mmHg) despite

ongoing antihypertensive therapy were included. Poor control was confirmed with three separate clinic-based blood pressure readings taken at least one week apart.

Exclusion criteria included known structural or valvular heart disease, ischemic heart disease, cardiac arrhythmias (particularly atrial fibrillation), reduced left ventricular ejection fraction (LVEF <50%), incomplete echocardiographic data, or refusal to provide informed consent.

Data Collection Procedure

After obtaining written informed consent, eligible participants underwent a thorough clinical evaluation. A structured proforma was used to document demographic data, medical history, duration of hypertension, comorbid conditions (such as diabetes and dyslipidemia), and current antihypertensive medications. Blood pressure was measured using a calibrated sphygmomanometer following standardized guidelines, with three readings recorded at one-week intervals.

Echocardiographic Assessment

All patients underwent transthoracic echocardiography performed by a qualified cardiologist using standardized protocols and the same ultrasound machine to ensure consistency. Diastolic function was evaluated based on the recommendations of the American Society of Echocardiography (ASE). Parameters assessed included mitral inflow velocities (E and A waves), E/A ratio, deceleration time (DT), tissue Doppler imaging of early diastolic mitral annular velocity (e'), E/e' ratio, left atrial volume index (LAVI), and tricuspid regurgitation velocity. Diastolic dysfunction was classified as normal, Grade I (impaired relaxation), Grade II (pseudonormal filling), or Grade III (restrictive filling).

Data Analysis

Statistical analysis was conducted using IBM SPSS Statistics version 26. Continuous variables were expressed as means ± standard deviations, while categorical variables were presented as frequencies and percentages. Associations between categorical variables (e.g., presence and grade of diastolic dysfunction with gender or comorbidities) were analyzed using the chi-square test. Independent t-tests and one-way ANOVA were used to compare continuous variables across groups. Multivariate logistic regression was performed to identify independent predictors of diastolic dysfunction, with results presented as odds ratios (ORs) and 95% confidence intervals (CIs).

Ethical Considerations

The study was approved by the Institutional Review Board of Khyber Teaching Hospital. Written informed consent was obtained from all participants prior to inclusion in the study.

Results

The research constitutes of overall118 patients with poorly controlled hypertension, recruited from the cardiology and internal medicine departments at Pakistan Institute of Medical Sciences (PIMS), Islamabad. Subjects ranged in the age range from 28 to 79 years old, with an average age of 53.5 ± 9.3 years. There were 65 males (55%) and 53 females (45%) in the sample. The mean duration of hypertension was 7.8 ± 3.1 years. A history of diabetes mellitus was present in 47 patients (40%), while 47 patients (40%) also had documented dyslipidemia. The average systolic and diastolic blood pressures recorded were 153.4 ± 9.5 mmHg and 94.3 ± 7.2 mmHg, respectively (table 1).

Table 1: Demographic and Clinical Characteristics of Study Participants

Variable	Mean ± SD / n (%)
Age (years)	53.5 ± 9.3
Gender (Male)	65 (55%)
Gender (Female)	53 (45%)
Duration of HTN (years)	7.8 ± 3.1
Diabetes (Yes)	47 (40%)
Dyslipidemia (Yes)	47 (40%)
Systolic BP (mmHg)	153.4 ± 9.5

Diastolic BP (mmHg)	94.3 ± 7.2

Echocardiographic assessment demonstrated that a significant proportion of the study population exhibited diastolic dysfunction. Out of 118 patients, 88 (74.6%) were found to have some degree of diastolic dysfunction, whereas 30 patients (25.4%) maintained normal diastolic function. Among those with dysfunction, Grade I (impaired relaxation pattern) was the most prevalent, affecting 37 patients (31.4%). This was followed by Grade II (pseudonormal filling pattern) in 31 patients (26.3%) and Grade III (restrictive filling pattern) in 20 patients (16.9%). These findings indicate a notable burden of subclinical cardiac involvement in patients with poorly controlled hypertension (figure 1).

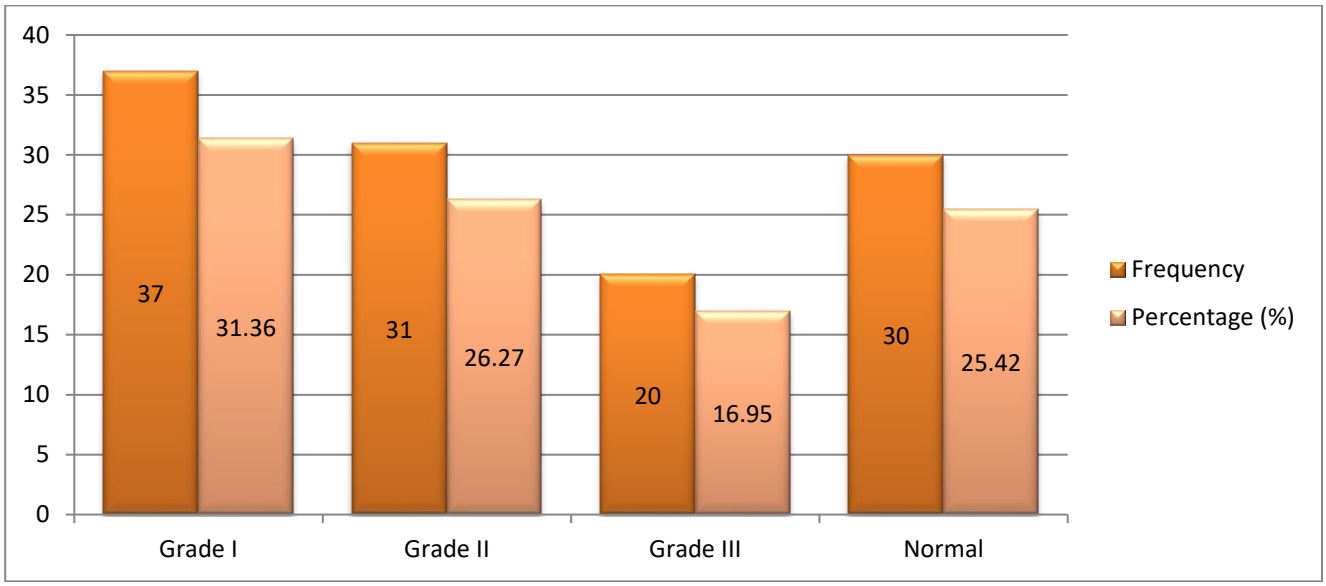

Figure 1: Frequency of Diastolic Dysfunction Grades

The gender-based distribution of diastolic dysfunction was analyzed using the chi-square test to determine any significant associations. Although variations in the distribution were noted between males and females, the findings lacked in statistical importance ($\chi^2 = 1.84$, $p > 0.05$). Among male patients (n = 65), Grade I dysfunction was the most common, observed in 21 individuals, while Grade II and III dysfunctions were present in 11 and 8 patients, respectively. In contrast, among female patients (n = 53), Grade II dysfunction was more prevalent, occurring in 20 individuals, followed by Grade I in 16 and Grade III in 12. Interestingly, the number of patients with normal diastolic function was equal in both genders, with 15 cases each. These patterns suggest subtle gender-related trends in diastolic dysfunction, although without statistical significance (table 2).

Table 2: Diastolic Dysfunction by Gender

Dysfunction Grade	**Male (n=65)**	**Female (n=53)**
Grade I	21	16
Grade II	11	20
Grade III	8	12
Normal	15	15

To explore the relationship between diastolic dysfunction severity and patient demographics, Systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean age were compared among the various dysfunction classes using a one-way ANOVA test. While age differences among the sets were not noticeable quantitatively ($p = 0.18$), both systolic and diastolic blood pressures revealed a notable variance ($p = 0.03$ and $p = 0.04$, respectively). The highest mean SBP was observed in

patients with Grade III dysfunction (154.8 mmHg), followed closely by Grade II (154.5 mmHg) and Grade I (151.1 mmHg), compared to 154.0 mmHg in those with normal diastolic function. Mean DBP values also followed a similar trend, with Grade II showing the highest mean (95.3 mmHg), followed by Grade I (94.7 mmHg), Grade III (94.3 mmHg), and the normal group (92.8 mmHg). Although age did not differ significantly, the findings underscore a notable association among high blood pressure levels and the severity of diastolic dysfunction (figure 2).

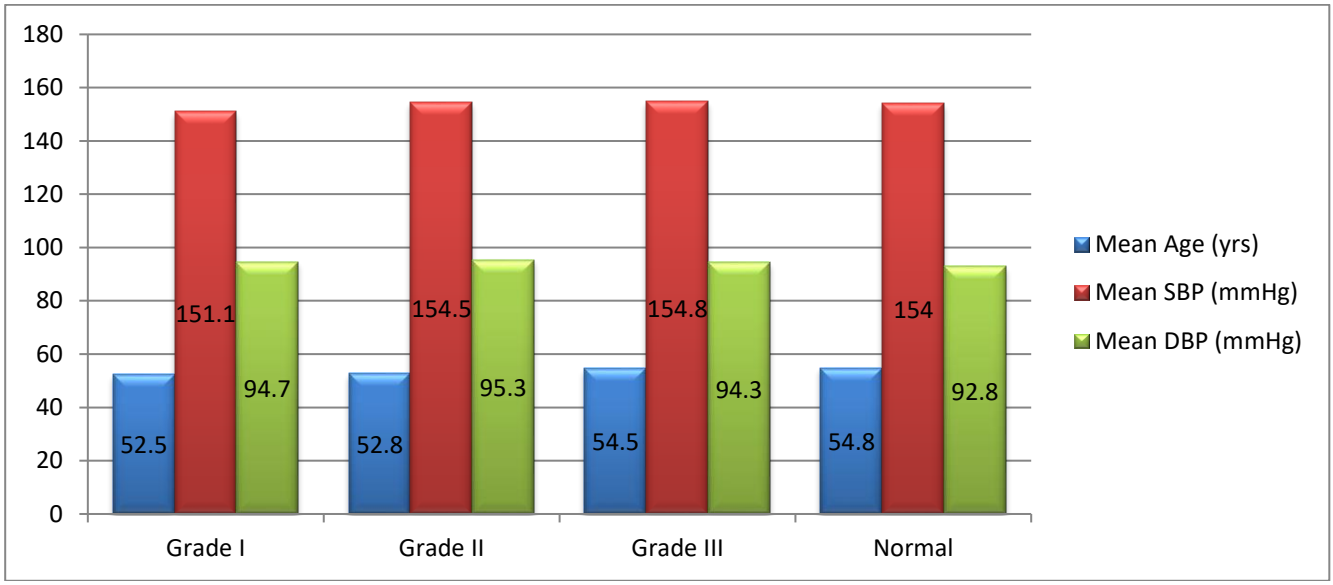

Figure 2: Mean Age and Blood Pressure by Dysfunction Grade

In patients with poorly managed hypertension, multivariate logistic regression analysis was used to find distinct indicators of diastolic dysfunction. The Models' Primary factors consisted of age, duration of hypertension, diabetes status, dyslipidemia, and systolic blood pressure (SBP). The results demonstrated that several factors substantial correlation with a higher risk of diastolic dysfunction. Specifically, the increasing age showed an odds ratio (OR) of 1.04 (p = 0.008), suggesting a 4% rise in risk per additional year. Longer duration of hypertension emerged as a strong predictor with an OR of 1.10 (p = 0.002), indicating a 10% increase in odds for each additional year of hypertension. The presence of diabetes (OR: 2.25, p = 0.023) and dyslipidemia (OR: 1.75, p = 0.031) were also statistically significant predictors. Furthermore, higher risks of diastolic dysfunction were linked to increasing systolic blood pressure (OR: 1.06, p = 0.015), underscoring the crucial part of effective blood pressure control. These results underscore how diastolic dysfunction is a complex condition and highlight key clinical parameters that may guide risk stratification and early intervention (table 3).

Table 3: Multivariate Logistic Regression for Predictors of Diastolic Dysfunction

Predictor	Odds Ratio	95% CI	p-value
Age (years)	1.04	1.01–1.07	0.008
Duration of Hypertension	1.10	1.04–1.17	0.002
Diabetes	2.25	1.11–4.58	0.023
Dyslipidemia	1.75	1.02–3.02	0.031
Systolic BP (mmHg)	1.06	1.01–1.11	0.015

Discussion

This study demonstrated an increased risk (74.6%) of diastolic dysfunction in patients with poorly controlled hypertension, with Grade I dysfunction being the most common pattern. The strong

correlation between increasing age and diastolic dysfunction, longer duration of hypertension, diabetes, dyslipidemia, and elevated systolic blood pressure underscores the multifactorial nature of cardiac impairment in hypertensive patients. The results of the echocardiogram highlight the significance of regular diastolic function assessments in this high-risk population.

The observed prevalence of diastolic dysfunction aligns closely with previous studies that report rates between 60% and 80% in hypertensive cohorts, reflecting the well-known impact of chronic hypertension on left ventricular compliance and relaxation [14]. The predominance of Grade I dysfunction corresponds with early-stage diastolic impairment typically seen in hypertensive patients before progression to more severe grades [15]. Similar to our findings, prior research has consistently highlighted age and duration of hypertension as significant predictors, suggesting cumulative myocardial remodeling and fibrosis over time [16]. The role of comorbid diabetes and dyslipidemia in exacerbating diastolic dysfunction also confirms existing evidence linking metabolic disturbances to myocardial stiffness through mechanisms such as micro vascular disease and low-grade inflammation [17].

Elevated systolic blood pressure as an independent risk factor concurs with studies indicating that persistent pressure overload increases left ventricular wall thickness and impairs relaxation [18]. However, the non-significant difference in age across dysfunction grades in our sample may reflect a relatively narrow age range or other confounding factors, which some literature also notes [19]. Taken together, these results reinforce the notion that diastolic dysfunction in hypertensive patients is a complex interplay of hemodynamic stress and metabolic comorbidities. The findings support current clinical recommendations to include echocardiographic evaluation of diastolic function as part of comprehensive cardiovascular risk assessment.

Limitations and Future Suggestions

There are various limitations to this research. Foremost, because study was only carried out at one tertiary care facility, the findings might not be as applicable to larger populations. It is difficult to determine causality or monitor the development of diastolic dysfunction over time due to the cross-sectional design. Additionally, other potential confounders such as medication adherence, lifestyle factors, and detailed renal function were not extensively evaluated. Longitudinal studies should be taken into account in future study with larger, multicenter cohorts to evaluate the temporal evolution of diastolic dysfunction in hypertensive patients. Investigations into the impact of specific antihypertensive regimens on diastolic parameters and exploration of novel biomarkers for early detection could provide valuable insights. Integrating strain imaging and advanced echocardiographic techniques may also enhance sensitivity in identifying subtle myocardial dysfunction.

Conclusion

Diastolic dysfunction is highly prevalent among patients with poorly controlled hypertension, with early-stage impairment being the most common. Age, duration of hypertension, diabetes, dyslipidemia, and elevated systolic blood pressure are significant predictors of diastolic dysfunction. Regular evaluation of diastolic function with echocardiography in hypertensive subjects is essential for timely detection and management to prevent progression to heart failure. Further longitudinal studies are needed to explore effective interventions and improve cardiovascular outcomes in this population.

Conflict of interest

The authors declared no conflict of interest.

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