

Frequency of Diastolic Dysfunction in Patients With Long-Standing Hypertension Assessed by Clinical and Echocardiographic Parameters

HUMA NAEEM TAREEN¹, AMJAD ALI², AHSAN IQBAL³, MUHAMMAD ALI KHAWAJA⁴, IFTIKHAR HUSSAIN⁵, ZEESHAN FAISAL⁶

¹Associate professor Cardiology BMCH Quetta

²Professor of Medicine Mardan Medical Complex/Bacha Khan Medical College Mardan

³Assistant Professor Cardiology Jinnah Hospital Lahore

⁴Cardiology Ghurki trust teaching hospital Lahore

⁵Assistant Professor Cardiology Niazi Medical and Dental College Sargodha

⁶Assistant Professor Department of Cardiology Sheikh Zayed Medical College /Hospital, Rahim Yar Khan.

Correspondence to: Amjad Ali, Email: dramjadali75@gmail.com

ABSTRACT

Background: Hypertension is a significant healthcare issue on the planet and is one of the primary causes of cardiovascular morbidity and mortality. Prolonged hypertension causes structural and functional changes in the myocardium that causes the impairment of left ventricular relaxation and compliance which results in a diastolic dysfunction. Dysfunction at diastole can be preceded by systolic dysfunction and can go undiagnosed clinically over a long period of time, eventually evolving into heart failure with retained ejection fraction. Echocardiography screening at an early stage is thus required especially in populations where blood pressure has been poorly controlled and where metabolic risk factors are very high.

Methods: The study was a descriptive, cross-sectional, study that was carried out in the Department of Cardiology, Lahore Medical and Dental College from 03-01-2023 to 04-07-2023. Non-probability consecutive sampling was used to enroll 180 adult patients who had a history of hypertension lasting five years and above. All the participants were clinically evaluated and underwent a transthoracic echocardiography. The diastolic functioning was measured by the traditional parameters of Doppler and tissue Doppler imaging, and diastolic dysfunction was rated based on the current parameters. The analysis of the data was done using version 26 of SPSS.

Results: The age of the participants was 56.8 plus or minus 9.7 years. Sixty-two point two percent of the patients had been found to have diastolic dysfunction. Grade I diastolic dysfunction led the pack with Grade II and Grade III coming in the second and third place respectively. Diastolic dysfunction was more frequent as age advanced, hypertension was not well controlled, and diabetes mellitus. The systolic activity of the left ventricle was preserved in every patient.

Conclusion: Diastolic dysfunction has been found to be very common in patients with chronic hypertension and is closely linked with age, years of hypertension and the presence of metabolic comorbidities. It might be possible to detect and promptly intervene in the process of heart failure prevention by having routine echocardiographic evaluation.

Keywords: High blood pressure; Left-sided heart failure; Echocardiography; Heart failure and normal ejection fraction.

INTRODUCTION

Hypertension is among the most common chronic cardiovascular diseases globally and a leading cause of morbidity and mortality especially in under and middle-income nations. Continued increase of blood pressure causes structural and functional changes of myocardium to develop gradually, and patients are predisposed to developing heart diseases of different types. The diastolic dysfunction is one of such, an early and frequently undiagnosed symptom of hypertensive heart disease, occurring before overt systolic dysfunction and clinical heart failure¹.

Chronic hypertension predisposes left ventricular afterload, which leads to compensatory concentric hypertrophy and augmented myocardial rigidity. The result of these changes is the weakening of the relaxation and filling of the ventricles during diastole creating high filling pressures with normal ejection fraction. Diastolic dysfunction can thus be regarded as one of the most important pathophysiological mechanisms connecting chronic hypertension and heart failure with preserved ejection fraction (HFpEF), which is a disease with severe signs, recurrences, and healthcare costs².

Clinically, diastolic dysfunction can be asymptomatic or have uncharacteristic symptoms including exertional dyspnea, fatigue, or loss of exercise tolerance. The symptoms are often overdiagnosed as aging or comorbidity, and thus, they are not diagnosed in time. Due to this, a large proportion of hypertensive patients develop to the further stages of diastolic dysfunction or blatant heart failure, without therapeutic interventions being taken³.

The basis of noninvasive evaluation of diastolic functioning is echocardiography. Traditional Doppler parameters such as inflow velocities (E and A waves) transmitted through the septum, E/A ratio, deceleration time and isovolumetric relaxation time are also

useful in determining the ventricular filling patterns. The use of tissue Doppler imaging, especially of early diastolic mitral annular velocity (e') and the E/e' ratio has added to the precision of estimating the filling pressures in the left ventricle as well as the diastolic heart failure grading⁴.

Besides the echocardiographic reports, the development of diastolic dysfunction and its severity in hypertensive patients is also affected by a number of clinical parameters. Risk factors that are well-established are advancing age, duration and poor hypertension control, obesity, diabetes mellitus, and coexisting ischemic heart disease. The combined effect of these influences enhances myocardial remodeling and deteriorates the performance in diastole⁵.

The diastolic dysfunction in long-term hypertension patients is found in a range of 30-70 percent in different studies, and it depends on population factors, diagnostic methods, and echocardiography procedures. Such variation underscores the necessity of region-specific data, especially in South Asian groups where hypertension is likely to manifest at a younger age and has poorly managed the condition⁶.

Clinical significance of early diastolic dysfunction detection of hypertensive patients is that the normalization of blood pressure and control of related risk factors may slow down or reverse disease processes. Furthermore, it is possible that the identification of subclinical cardiovascular involvement will enable the risk stratification of the cardiovascular and more aggressive preventive approaches in high-risk patients^{7,8}.

Objective: To identify the prevalence of diastolic dysfunction among patients with chronic hypertension through clinical and echocardiographic measurements.

MATERIALS AND METHODS

Study Design: The research was performed in the form of a cross-sectional study that was descriptive.

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Study Setting and Duration: The research was conducted in the Department of Cardiology, Lahore Medical and Dental College from 03-01-2023 to 04-07-2023. Clinical assessment and echocardiographic evaluation were also done on all enrolled patients on the same day, and medical records were read to ensure the duration and history of hypertension treatment.

Population and Sample Size of the study: Patients with adult age diagnosed with long-term hypertension who were reported to cardiology outpatient department or the cardiology ward between the study period were taken into consideration. The world health organization sample size calculator was used to calculate the total sample size of 180 patients based on the presumed prevalence of diastolic dysfunction at 50 percent, a confidence level of 95, and a margin of error of 7. The method of non-probability consecutive sampling was used.

Inclusion and Exclusion Criteria: They included patients aged 30 years or older who had a history of hypertension of five years or longer, or had a history of antihypertensive treatment or had a history of uncontrolled hypertension. Patients who had known ischemic heart disease, severe valvular heart disease, cardiomyopathies, congenital heart disease, atrial fibrillation, chronic kidney disease stage IV or V, low left ventricular ejection fraction (<50) were excluded to eliminate confounding variables on the relationship between diastolic and systolic functions.

Data Collection Procedure: Informed consent was received and the identified demographic data, hypertension history, comorbidities, medication history, and clinical results were noted on a structured proforma. The blood pressure was read on a calibrated sphygmomanometer based on the standard guidelines and an average of two readings, separated by a five-minute time interval, was recorded.

Echocardiographic Assessment: Transthoracic echocardiography of all the patients was carried out by a qualified cardiologist on a standard echocardiography machine. The ejection fraction measured left ventricular systolic function and transmitral Doppler parameters (E wave, A wave, E/A ratio, deceleration time) and tissue Doppler parameters (septal and lateral e+ velocities, E/e+ ratio) measured left ventricular diastolic functions. Diastolic dysfunction was rated based on the existing echocardiographic criteria.

Data Analysis: The SPSS version 26 was used to enter and analyze data. Age and period of hypertension were quantitative variables and were reported as a mean and standard deviation whereas gender and the presence of a diastolic dysfunction were qualitative variables and were discussed in terms of frequencies and percentages. The stratification was done to determine the impact of age, gender and the duration of hypertension on the prevalence of diastolic dysfunction.

RESULTS

The final analysis involved 180 patients who had long-term hypertension. The average age of the research participants was 56.8 years with a standard deviation of 9.7 (range was 32 to 78 years). Most of the patients fell in the 51-60 years category. It consisted of 104 (57.8%) males and 76 (42.2%) females, with a male to female percentage ratio of 1.4:1. The average years of diagnosed hypertension were found to be 9.6 3.8 years and 61.1% of the patients had over 8 years of hypertension. Table 1 presents a summary of baseline demographic and clinical characteristics.

The presence of diastolic dysfunction was observed in 112 patients (62.2%), and the normal diastolic function was found in 68 patients (37.8%). Grade I (impaired relaxation) was the commonest among the patients with diastolic dysfunction and found in 66 patients (58.9%), Grade II (pseudonormal filling) in 34 patients (30.4%), and Grade III (restrictive filling) in 12 patients (10.7%). Table 2 shows the distribution and grading of the diastolic dysfunction.

A major correlation was noted between the age and the existence of diastolic dysfunction. The prevalence of diastolic dysfunction was significantly high among patients 60 years and

older than it was among those younger than 60 years (78.3% vs. 49.2%, respectively). On the same note, the prevalence of diastolic dysfunction also rose gradual with the duration of hypertension with highest prevalence being recorded among patients whose hypertension length exceeds 10 years (81.5%). Table 3 describes these associations.

The clinical factors were worse blood pressure control, diabetes mellitus, and higher body mass index that were more frequently seen among patients having diastolic dysfunction. The echocardiographic data revealed that patients with diastolic dysfunction experienced much lower mean septal e 7 velocity and mean E/e 7 ratio than normal patients. Left ventricular ejection fraction was maintained at a mean in both the groups. Table 4 gives comparative findings of echocardiography.

Figure 1 shows that diastolic dysfunction is more common with increased length of time with hypertension with an evident upward trend and an improvement in patients with 5-7 years of hypertension to those with over 10 years of hypertension.

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n = 180)

Variable	Frequency (%) / Mean ± SD
Age (years)	56.8 ± 9.7
Age group 30-40 years	18 (10.0%)
Age group 41-50 years	42 (23.3%)
Age group 51-60 years	64 (35.6%)
Age >60 years	56 (31.1%)
Male	104 (57.8%)
Female	76 (42.2%)
Duration of hypertension (years)	9.6 ± 3.8
Diabetes mellitus	62 (34.4%)
Poor BP control	98 (54.4%)

Table 2: Frequency and Grading of Diastolic Dysfunction (n = 180)

Diastolic Function Status	Frequency (%)
Normal diastolic function	68 (37.8%)
Diastolic dysfunction (overall)	112 (62.2%)
Grade I diastolic dysfunction	66 (36.7%)
Grade II diastolic dysfunction	34 (18.9%)
Grade III diastolic dysfunction	12 (6.6%)

Table 3: Association of Diastolic Dysfunction with Age and Duration of Hypertension

Variable	Diastolic Dysfunction Present	Diastolic Dysfunction Absent
Age <60 years (n = 124)	61 (49.2%)	63 (50.8%)
Age ≥60 years (n = 56)	44 (78.3%)	12 (21.7%)
Hypertension 5-7 years (n = 52)	22 (42.3%)	30 (57.7%)
Hypertension 8-10 years (n = 61)	38 (62.3%)	23 (37.7%)
Hypertension >10 years (n = 67)	52 (77.6%)	15 (22.4%)

Table 4: Comparison of Echocardiographic Parameters Between Patients With and Without Diastolic Dysfunction

Parameter	Diastolic Dysfunction (n = 112)	Normal Diastolic Function (n = 68)
LVEF (%)	58.6 ± 4.9	60.1 ± 5.1
Septal e' (cm/s)	6.1 ± 1.4	9.3 ± 1.8
Lateral e' (cm/s)	7.4 ± 1.6	11.2 ± 2.0
Mean E/e' ratio	15.8 ± 3.6	9.4 ± 2.1
Left atrial diameter (mm)	41.6 ± 4.8	36.2 ± 3.9

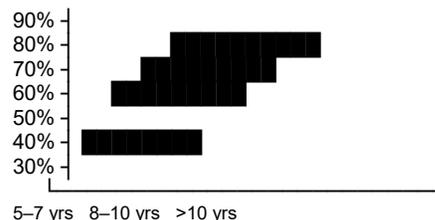


Figure 1: Frequency of Diastolic Dysfunction According to Duration of Hypertension

Figure 1 demonstrates a progressive increase in the frequency of diastolic dysfunction with increasing duration of hypertension, with the highest prevalence observed in patients hypertensive for more than 10 years.

DISCUSSION

The current study has revealed a very high prevalence of the overall diastolic dysfunction (DD) of 62.2 percent in patients with long-term hypertension. This rate is more than a number of reports that reported more moderate rates but is in line with other cohort studies that indicated a high burden of DD in hypertensive cohorts. To illustrate, a big community hypertension group published a high level of LV diastolic malformations as well as the prognostic significance of subclinical DD in hypertensive groups⁹.

In our data age was a good correlate of DD: patients aged 60 years and older had a much higher frequency of DD (78.3%), than younger patients. This increase in diastolic impairment with age reflects the clear evidence that progressive impairment of LV relaxation and increased filling pressures with no overt cardiovascular disease occur with the progression of age. Much of this effect is probably due to age-related effects on myocardial stiffness and arterial stiffening¹⁰.

DD was both associated with blood pressure control and time of hypertension in our sample. The prevalence of DD was linked to poor management of blood pressure and length of hypertension (>10 years) (77.6%). This observation is consistent with previous studies that diastolic parameter improvement is dependent on blood-pressure and that chronic hypertension enhances maladaptive remodelling which causes relaxation impairment. Current and early BP management has been demonstrated to produce or avert deterioration of the diastolic indices, which supports the clinical significance of vigorous BP management¹¹.

Our measured tissue- Doppler velocities and E/e ratios are put in an echocardiographic context of thresholds and normative ranges. Mean septal e was lower (6.1 cm/s) and mean E/e was higher (15.8) in patients with DD in our cohort of patients with DD that are consistent with the cutoffs of guidelines suggesting abnormal relaxation and increased filling pressures. These tissue Doppler thresholds are used to identify pathologic diastolic function and to grade the severity through reference datasets and normative values developed as a result of the guidelines¹².

Patterns of comorbidity in our DD group: particularly, increased incidence of diabetes mellitus and elevated BMI coincide with mechanistic and clinical research demonstrating that diabetes alone increases diastolic mechanics via myocardial fibrosis, microvascular dysfunction and changes in myocardial energetics. A number of studies have reported a lower LA and LV diastolic index in hypertensive patients with underlying diabetes than those without diabetes. Those pathophysiologic relations are supported by our finding that diabetes was associated with more adverse e' and increased E/e'¹³.

Left atrial enlargement (LAE) and left-atrial diameter rise in patients with DD in our cohort are indicators of the chronic augmentation of left-sided filling pressures; LA remodelling is an established prognostic and compensatory ectoparathyroid indicator of diastolic diseases. The clinical summaries and reviews focus on the fact that the LA size and functionality are related to the chronicity and severity of the diastolic burden and are independently associated with such outcomes as atrial arrhythmia and heart failure symptoms. Our differences in the LA diameter between the DD and non-DD groups are then biologically and clinically realistic¹⁴.

Concerning diagnostic outcomes of E/e and tissue Doppler outcomes, our findings that show that E/e was much greater in the DD group are consistent with findings in the literature that E/e is a useful noninvasive surrogate of left-sided filling pressure. Guideline analyses and meta-analyses state that there is a reasonable E/e-diagnostic accuracy when used alongside other parameters, but also warn of the weaknesses in some clinical situations. We thus

used E/e 7 and transmitral inflow alongside the metrics of LA in conjunction with clinical data when grading DD¹⁵.

The pattern of DD grading in this study (preponderance of Grade I and then Grade II and fewer Grade III) is similar to recent series of DD grading in hospitals: the earlier stages of DD (impaired relaxation) are usually the most large sub-group in outpatient cohorts of hypertension, and more advanced (pseudonormal and restrictive) patterns are less common and found in more patients with a longer disease history or comorbidities. This is in line with the opinion that a large number of hypertensive patients have subclinical or early diastolic anomalies that can be followed before severe haemodynamic abnormalities¹⁶.

The high correlation between hypertension duration and DD (steady increase between 57 years and over 10 years) is in agreement with a number of cross-sectional studies, which revealed that DD prevalence increased with duration. Multiple series and registry studies have replicated this pattern of concentric remodelling, interstitial fibrosis and LA enlargement due to long term pressure overload, which increases the cumulative worsening of diastolic filling. These time effects help in the significance of early detection and long-term BP management¹⁷.

Compared with other prevalence studies, our 62.2% rate certainly falls on the higher side of the range of reported. Recent hospital-based series and registry studies have prevalence estimates of 30-50% range, and others, especially those with older and more comorbid patients, report higher prevalence of over 60%. Much of this variability is due to differences in sampling frame (community vs tertiary referral), echocardiographic criteria on which DD is based and the burden of comorbid disease. We would expect higher DD prevalence in our sample, which will be based on a tertiary cardiology setting that represents long-term hypertensive patients and high rate of poor BP control^{18,19}.

Last but not least, the clinical implications that result out of these comparisons are two-fold. One, tissue Doppler indices and E/e+ can continue to be used as a screening instrument to identify the presence of subclinical DD in hypertensive patient and to determine patients who might be able to receive a more aggressive BP and risk-factor intervention. Second, age, length of duration, diabetes, and poor BP control with DD were also clustered in our and other studies which supports the idea of integrated care pathways through earlier detection and multifactorial risk modification to avoid progression to symptomatic HFpEF. These points are highlighted in recent reviews of outpatient screening of echocardiography in hypertensive groups²⁰.

Limitations: There are a number of limitations of this study. First, it is cross-sectional and hence cannot be used to make a causal conclusion regarding the temporal order of hypertension duration, control, and diastolic deterioration. Second, as a one-centre, tertiary study, with consecutive sampling, spectrum bias could have overstated prevalence in comparison to community samples. Third, the echocardiographic examinations were conducted by skilled operators and the results were conducted by using guideline-based criteria; there was no interobserver variation of diastolic grading despite the advanced measurements of the LA strain or invasive hemodynamic correlation that would substantiate borderline cases. Fourth, drug compliance was evaluated based on records and patient report and not on objective tests which can give a false classification of BP control. At last, the fourth limitation is that the study only included patients without atrial fibrillation and significant valve disease, which enhances internal validity of pure hypertensive DD, but reduces the generalizability to more real-world populations where the comorbidities are prevalent.

CONCLUSION

This research illustrates the high incidence of diastolic dysfunction in patients with long-standing hypertension and almost 2/3 of the research population has indicated echocardiographic evidence of impaired diastolic heart function despite intact systolic cardiac performance. The intensity of the diastolic dysfunction rose with age, hypertension duration, inadequate blood pressure regulation,

and the existence of metabolic comorbid conditions, having a cumulative impact of prolonged pressure overload on myocardial relaxation and compliance. The preponderance of parsimonious diastolic dysfunction highlights the unsensible character of the disease and the possibility of its early detection during the regular echocardiographic check-up. The results support the need to recognize hypertension early, achieve effective blood pressure management, and implement a multifactorial methodology to avoid the development of symptomatic heart failure and minimize cardiovascular morbidity in hypertensive patients.

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