

ORIGINAL RESEARCH

Unveiling the Hidden Burden: Prevalence and Patterns of Diastolic Dysfunction among Hypertensive Individuals from a tertiary care centre in South India

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ABSTRACT

Background: Diastolic dysfunction, a precursor to heart failure often underestimated in hypertensive patients, warrants early detection and management to mitigate cardiovascular morbidity and mortality. Previous studies primarily relied on the transmitral low-velocity curve, which has limitations, especially in cases with a pseudo normal pattern. This study combines transmitral flow velocity curves and pulmonary venous Doppler analysis to assess diastolic function in hypertensive individuals with preserved left ventricular systolic function to estimate the prevalence of diastolic dysfunction among hypertensive patients. **Methods:** This study was conducted at Government Sivagangai Medical College, South India, during September and October 2021 among 150 hypertensive patients from the non-communicable disease clinic. Patients with certain cardiac complications, diabetes, alcoholism, cirrhosis, chronic kidney disease, or an ejection fraction below 50% were excluded. Diastolic function was assessed using transmitral flow velocity curves, employing an E/A ratio cut-off value of 1.0. Pseudo normal patterns were identified via Δd fraction analysis, while ECG findings were also evaluated. **Result:** In this study, 43% of participants exhibited abnormal E/A ratios indicative of diastolic dysfunction. Subsequent Δd fraction analysis identified a subset of patients with a pseudo normal pattern, resulting in 62% of patients having diastolic dysfunction. ECG findings revealed left atrial enlargement (38%), left ventricular hypertrophy (33%), and left axis deviation (24%) as common abnormalities. Correlations emerged between diastolic dysfunction and age, sex, duration of hypertension, systolic/diastolic blood pressure, and ECG abnormalities. **Conclusion:** This study underscores the underrecognized prevalence of diastolic dysfunction among hypertensive patients without clinical heart disease. Combining transmitral flow velocity curves and Δd fraction analysis improves diagnostic accuracy, particularly in pseudo normal patterns. ECG findings emphasize diverse cardiac manifestations linked to hypertension. Comprehensive cardiovascular assessments in hypertensive patient management are crucial. Early detection and management can mitigate cardiovascular risks, necessitating further research into underlying mechanisms and risk factors.

Key words: Diastolic dysfunction, hypertensive patients, transmitral flow velocity curves, pulmonary venous Doppler analysis, ECG abnormalities.

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INTRODUCTION

Cardiovascular diseases (CVDs), with hypertension as a prominent contributor, have emerged as a pressing global health concern. In India, the epidemiological landscape of CVDs has witnessed an alarming rise, coinciding with significant demographic and lifestyle transitions.¹ Projections suggest that by the year 2020,

CVDs will account for more than one-third of all deaths in India.² Hypertension, characterized by persistently elevated blood pressure, plays a pivotal role in fuelling this growing health crisis. A comprehensive understanding of the pathophysiology of hypertension is imperative, given its multifactorial nature, involving dysregulation of systems such as the

renin-angiotensin-aldosterone system, heightened sympathetic nervous system activity, endothelial dysfunction, and genetic predisposition, among other factors.³ Prolonged exposure to elevated blood pressure leads to vascular remodelling, increased arterial stiffness, and endothelial dysfunction, collectively driving the progression of hypertension.⁴ Concurrently, diastolic dysfunction, marked by impaired relaxation and compliance of the left ventricle during its filling phase, presents another facet of the CVD challenge. This condition encompasses complex alterations in myocardial structure and function, resulting in decreased ventricular compliance, impaired relaxation, and heightened ventricular stiffness.⁵ The underlying pathophysiology of diastolic dysfunction encompasses processes such as cardiomyocyte hypertrophy, fibrosis, impaired calcium handling, and changes in myocardial energetics. Understanding both the pathophysiology of hypertension and diastolic dysfunction is crucial for developing effective strategies to address the escalating burden of cardiovascular diseases in India and globally. In hypertensive patients, left ventricular (LV) diastolic dysfunction can occur independently of changes in systolic function. This dysfunction is characterized by specific alterations in LV hemodynamic, including decreased early diastolic filling (E) velocity, increased atrial contraction (A) velocity, and a reduced E/A ratio. This "abnormal relaxation" pattern, seen in 30% to 50% of hypertensive patients, is indicative of diastolic dysfunction. As hypertension progresses, it may also involve reduced LV compliance, leading to elevated LV filling pressure and further E/A ratio increases. Assessing diastolic function based solely on trans-mitral flow velocity may lead to misclassification, missing patients with diastolic dysfunction. Thus, a comprehensive approach is necessary to accurately identify and manage diastolic dysfunction in hypertensive individuals.⁶ Diastolic dysfunction, often underestimated yet clinically significant, can precede heart failure and early detection and management hold potential to modify cardiovascular morbidity and mortality. Given regional variations, investigating its prevalence in hypertensive patients is vital. While prior studies mainly assessed diastolic dysfunction in hypertensive patients using the trans-mitral low-velocity curve alone, this approach has limitations, particularly with pseudo normal patterns.⁷ Incorporating pulmonary venous Doppler analysis improves precision by examining pulmonary vein blood flow during diastole, enhancing the evaluation's depth and suitability for investigating diastolic dysfunction in hypertensive individuals.⁸ Hence, this hospital-based cross-sectional study was conducted to determine diastolic dysfunction prevalence among hypertensive patients with preserved left ventricular systolic function, employing a comprehensive approach that combines

trans-mitral flow velocity curve and pulmonary venous Doppler analysis.

MATERIALS AND METHODS

This cross-sectional study was conducted at Government Sivagangai Medical College, Sivagangai, a well-established tertiary care medical institution located in South India. The hospital provides comprehensive healthcare services, to a diverse patient population. This study was conducted during the months of September and October 2021. The study population comprised individuals with a confirmed diagnosis of hypertension who attended the non-communicable disease (NCD) clinic at the Outpatient Department (OPD) of Government Sivagangai Medical College.

All patients attending the NCD clinic for routine medication refills from the surrounding community were approached for study participation and recruited upon obtaining informed consent. Inclusion criteria encompassed registered hypertensive patients with a minimum of 6 months of follow-up at the clinic who willingly consented to partake in the study. Exclusion criteria comprised patients who: a) who are unable to comprehend, b) recently diagnosed hypertension cases (<6 months), and c) exhibited concurrent cardiac complications such as congestive cardiac failure, coronary heart disease, valvular heart disease, cardiomyopathy, diabetes mellitus, alcoholism, cirrhosis, chronic kidney disease, or an ejection fraction (EF) of less than 50%. The exclusion of these individuals aimed to mitigate potential influences on the prevalence of diastolic dysfunction and minimize the introduction of selection bias.

The sample size was determined using the formula $Z\alpha/22 * p * (1 - p) / d^2$, with the prevalence (p) of diastolic dysfunction of 12.3%, the absolute precision (d) was set at 5%, and a confidence level of 95% and 80% power was considered. The final sample size after rounding off came to be 160. A comprehensive enumeration was conducted for all patients attending the NCD clinic throughout the study period. After evaluating their eligibility, those who willingly provided informed consent were included in the study. Ethical approval for the research was obtained from the Institutional Ethical Committee, and all study procedures strictly adhered to the ethical principles outlined in the Helsinki Declaration of 1975, as revised in 2000.

The data collectors were doctors who went through an extensive two-day training program on research methodologies and data collection techniques, which was conducted by the investigators themselves. A pre-tested semi-structured questionnaire was used to obtain basic demographic details. This was followed by physical and systemic examination and followed by investigations to detect diastolic dysfunction. The following investigations were done : 12 lead ECG, haematological examination, biochemical investigations including, hemoglobin concentration,

blood sugars, blood urea and serum creatinine. Echocardiographic studies were performed by a cardiologist. Ambulatory asymptomatic patients diagnosed to have hypertension (grade I & II) for minimum period of 6 months on any class of antihypertensives were included in the study. Two-dimensional and M- mode Echocardiography was performed. Left ventricular diastolic dysfunction was determined by decreased E/A ratio (trans mitral low velocity curve). Normal E/A ratio was defined as E/A ratio \geq age and sex adjusted mean value -2SD. Abnormal E/A ratio was defined as E/A ratio $<$ age and sex adjusted mean value -2SD. All the data collected were password protected and were accessible only to the investigators.

STATISTICAL ANALYSIS

Data was entered in Microsoft excel and analysis was conducted using STATA version 14 software (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP). Normality of the data was checked statistically by Shapiro Wilk test. Continuous data was represented by mean (SD) or Median (IQR) based on the normality of the data and the categorical variables were represented by frequency and percentages. The proportion of diastolic dysfunction was calculated. Chi-square test and t-test will be used to find the association between the categorical variables and the quantitative variables respectively. Correlation test was done using Pearman's correlation (r) test between two quantitative variables after assessing the normality of the data and after excluding collinear variables. Variables with p-value less than 0.05 was considered statistically significant.

RESULT

A total of 400 hypertensive patients were contacted during the study period and were screened based on the eligibility criteria and of them, 376 agreed to participate in this study. Of them 160 satisfied the eligibility criteria and finally the complete data were collected for 150 patients as shown in Figure 1.

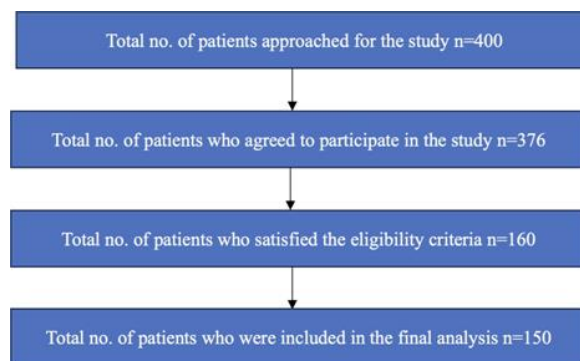


Figure 1: Flow of study participants

Of the total 150 patients, 56.7% were males and 43.3% were females. The median age in this study was 33.4 (IQR- 24.5,61.2) and most of them belong to the age group of 41 to 60 years

(54%). The patient's age ranged from 31 to 64 years. The median duration of hypertension in this study was 4.4 years (IQR- 2,5). More than half of the patients (54%) were hypertensive for more than 4 years and 33.3% of patients were hypertensive for 2-4 years as shown in Table 1. The mean (SD) systolic blood pressure (SBP) was 154.3 (13.2) and the mean (SD) diastolic blood pressure (DBP) was 86.7 (8.7) respectively. The mean SBP and DBP were higher among males when compared to females as shown in Table 2.

Table 1. Distribution of the participants based on demographic details (N=150)

S.No.	Characteristics	Frequency(%)	p-value*
1.	Age(in years)		0.09
	30-40	32 (21.3)	
	41-60	81 (54)	
	>60	37 (24.6)	
2.	Sex		0.03
	Male	85 (56.7)	
	Female	65 (43.3)	
3.	Durationofhypertension		0.02
	2-4years	81 (54%)	
	>4years	69 (46%)	

*p-value was calculated using chi-square test.

Table 2: Distribution of the participants based on blood pressure (N=150)

S.No.	Characteristics	Mean \pm SD	Male (mean \pm SD)	Female (mean \pm SD)	p-value*
1.	SBP	154.3 \pm 13.2	159.2 \pm 12.7	152.3 \pm 10.2	0.03
2.	DBP	86.7 \pm 8.7	90.2 \pm 8.7	85.4 \pm 10.2	0.04

*p-value was calculated using t-test.

We found that a considerable portion of the patient cohort exhibited distinct patterns in their antihypertensive medication regimens. Among the patients included in the study, a majority of them 83 patients (55.3%) were effectively managed with a single antihypertensive drug, with amlodipine being the most frequently prescribed medication in this category. Furthermore, 44 patients (29.3%) were found to benefit from a combination of two antihypertensive drugs, while a subset of 23 patients (15.4%) required a more complex regimen involving three antihypertensive medications to achieve optimal blood pressure control as shown in Table 3.

Table 3: Distribution of participants based on antihypertensive medication regimens

S.No.	Medication Regimen	Number of Participants	Percentage(%)
1.	Single Drug(e.g.,amlodipine)	83	55.3%
2.	Two Drugs	44	29.3%
3.	Three Drugs	23	15.4%

With respect to the ECG findings, we observed a spectrum of cardiac electrical alterations among the hypertensive patients under investigation. Notably, left atrial enlargement emerged as the most prevalent ECG abnormality, affecting 38% of the study participants. Following which, left ventricular hypertrophy was identified in 33% of the patients, while left axis deviation was noted in 24% of the participants as shown in Figure 2. These findings provide valuable insights into the diverse cardiac manifestations associated with hypertension and underscore the importance of comprehensive cardiovascular assessments in hypertensive patient management.

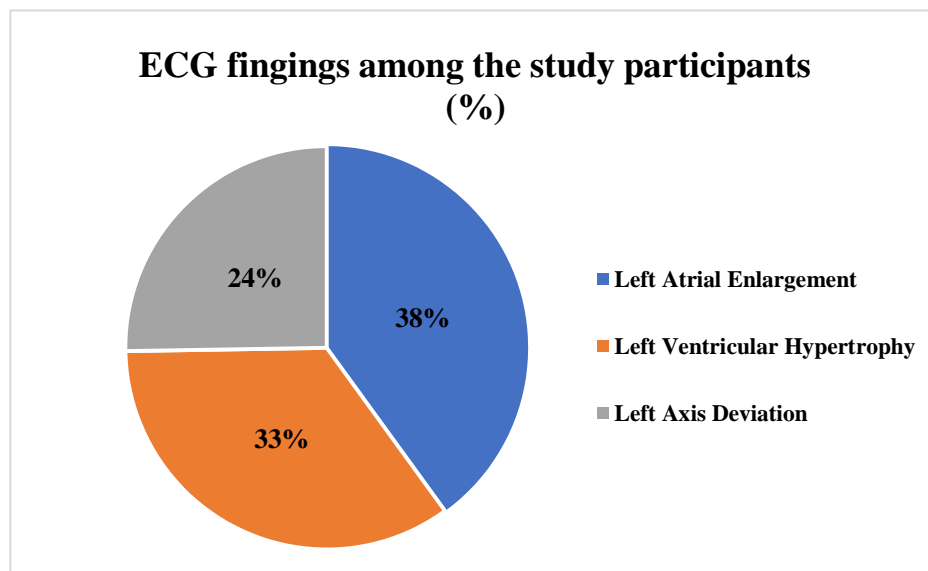


Figure 2: Distribution of study participants based on ECG changes

In our study, we established a critical E/A ratio cut-off value of 1.0 as a benchmark for assessing left ventricular (LV) diastolic dysfunction. Within our cohort of 150 patients, a noteworthy 43% exhibited an abnormal E/A ratio, signifying impaired diastolic function (E/A ratio < 1), while the remaining 57% maintained an E/A ratio greater than 1, which is typically indicative of normal diastolic function. To further refine our diagnostic accuracy, we introduced the Δd fraction analysis to distinguish between true normal and pseudo normal cases among those initially categorized as having a normal E/A ratio. Surprisingly, our in-depth evaluation revealed that a subset of patients, initially considered to have normal diastolic function based on E/A ratio alone, fell into the category of pseudo normal when subjected to Δd fraction assessment. This novel approach enabled us to identify an additional 27 cases of diastolic dysfunction that would have otherwise remained undetected. This distinct group, characterized by a normal E/A ratio but an abnormal Δd fraction, was deemed to exhibit a "pseudo normal pattern" of diastolic dysfunction. Consequently, in our study, an overall majority of 62% of the 150 patients were found to have LV diastolic dysfunction. These findings underscore the importance of a comprehensive diastolic assessment that extends beyond traditional E/A ratio measurement, thus enhancing our ability to identify diastolic dysfunction in hypertensive patients more accurately as shown in Table 4.

Table 4: Comprehensive overview of the diastolic dysfunction assessment (N=150)

Diastolic dysfunction assessment(E/A)	Number of Participants*	Percentage(%)
Abnormal E/ARatio (< 1.0)	65	43%

Normal E/ARatio(≥ 1.0)	85	57%
Pseudo Normal Pattern(Δd Fraction)	27	18%
Overall Left Ventricular Diastolic Dysfunction	93	62%

*Numbers are not mutually exclusive

In our study, we identified a noteworthy and statistically significant correlation between age and diastolic dysfunction (p-value<0.001). This implies that as individuals advance in age, there is a discernible decline in LV relaxation and filling capabilities. Also, our investigation unveiled another compelling correlation, this time pertaining to gender and diastolic dysfunction, which was also statistically significant (p-value-0.01). We found a significant correlation between the duration of hypertension and the prevalence of diastolic dysfunction (p-value-0.02). We also found a significant correlation between diastolic blood pressure and diastolic dysfunction (p-value 0.04). Also we found a statistically significant

correlation between the grade of systolic blood pressure (SBP) and diastolic dysfunction (p-value of 0.01). Also, our study discerned that diastolic dysfunction was more prevalent among male participants when compared to their female counterparts as shown in Table 5. The prevalence of diastolic dysfunction was significantly higher among patients with a prolonged history of hypertension. Our data demonstrated that the prevalence of diastolic dysfunction increases concomitantly with higher grades of diastolic blood pressure. However, we did not observe a significant correlation between left ventricular hypertrophy (LVH) and diastolic dysfunction.

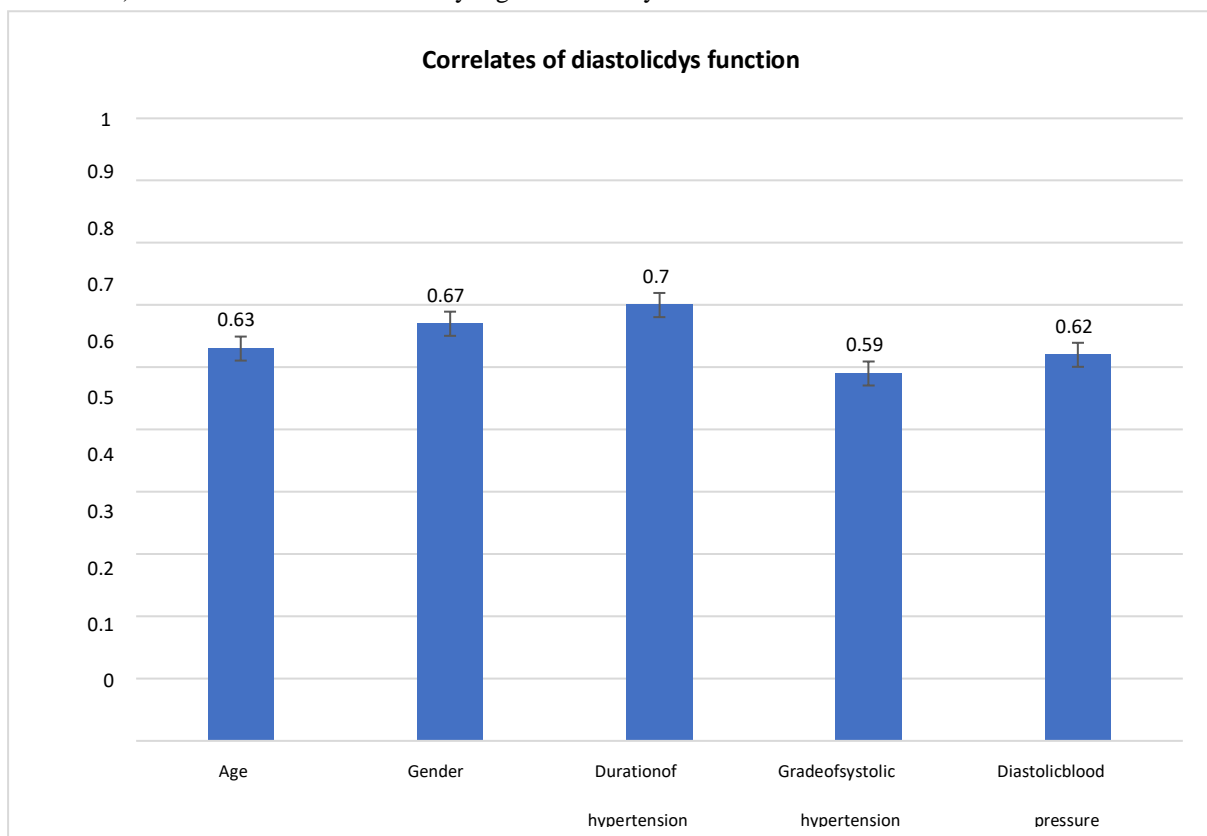


Figure 3: Correlation Analysis of various factors with Diastolic Dysfunction

Among all the cases analyzed, we observed that the E/A ratio fell within the normal range in 57 cases, constituting 38% of the total study population. These findings suggested that a substantial portion of the study participants, approximately 38%, maintained what is considered normal diastolic function based on this metric. However, in 66 cases, the E/A ratio fell below the age-adjusted normal range, signifying an abnormal diastolic function. These cases represented 44% of the study cohort, highlighting a significant

proportion with impaired diastolic function. Furthermore, within our examination of the E/A ratio, we identified an additional subset of 27 cases, accounting for 18% of the total cases. These cases exhibited an seemingly normal E/A ratio but were characterized by an abnormal Δd parameter, signifying an underlying diastolic dysfunction. This distinct pattern, known as the "pseudo normal pattern," underscores the importance of a more comprehensive diastolic function assessment.

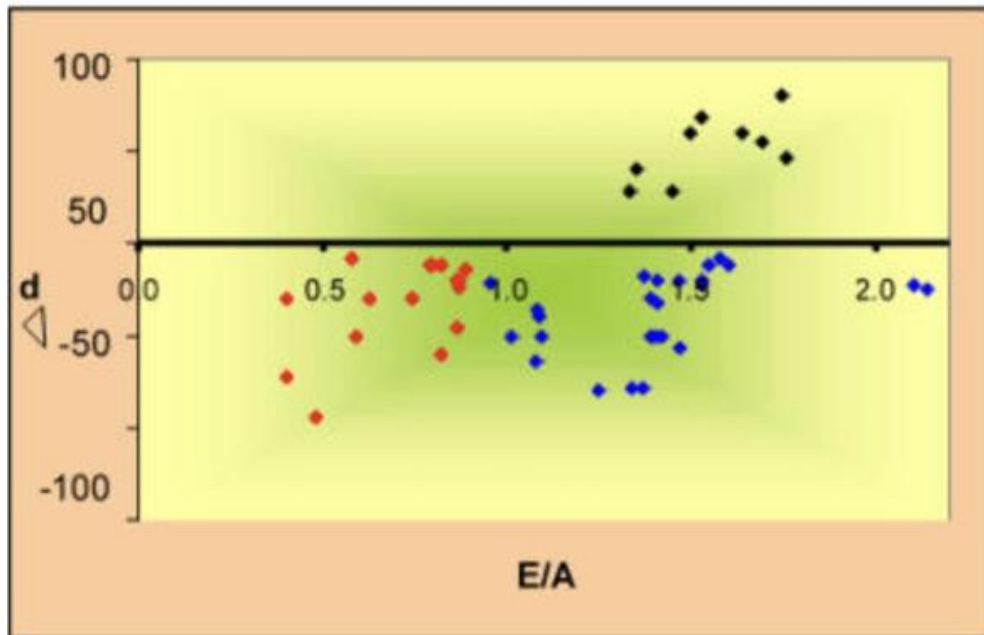


Figure 4: Relation between E/A ratio and Δd in cases with normal diastolic function (blue), cases with pseudo normal pattern (black) and cases with abnormal diastolic function (red)

We found that ejection fraction remained within the normal range across all groups of cases, indicating preserved systolic function of the left ventricle. However, a more nuanced picture emerged when we examined the structural dimensions of the left ventricle. Specifically, both the left ventricular internal diameter in systole (LVIDS) and the left ventricular internal diameter in diastole (LVIDD) exhibited notable variations among the different

groups of cases. These variations were statistically significant, with a p-value < 0.001 for each parameter. We also observed that LVIDS and LVIDD were at their maximum in the group characterized by abnormal diastolic function. Conversely, in the group exhibiting the pseudo normal pattern, both LVIDS and LVIDD were at their minimum, indicating smaller left ventricular dimensions during systole and diastole as shown in Table 5.

Table 5: Echo Parameters among participants diagnosed with Diastolic Dysfunction

Echo parameters Mean \pm SD (Min- Max)	Normal diastolic function(n=57)	Diastolicdys function		p-value
		Pseudo normal (n=27)	Abnormal(n=66)	
EjectionFraction(%)	63.26 \pm 4.47	61.33 \pm 1.58	65.09 \pm 4.63	0.075
LVIDS	2.44 \pm 0.30	2.05 \pm 0.51	2.84 \pm 0.47	<0.001
LVIDD	4.13 \pm 0.38	3.61 \pm 0.74	4.47 \pm 0.47	<0.001

DISCUSSION

The primary objective of this study was to estimate the prevalence of diastolic dysfunction among hypertensive patients who presented with normal ejection fraction (EF). We employed a multifaceted approach, including the examination of transmitral pressure gradients and a thorough Doppler study of the pulmonary vein. While previous studies had largely focused on the transmitral flow velocity curves alone, we recognized the importance of a more detailed assessment to unveil subtle signs of diastolic dysfunction. Diastolic function is a multifaceted aspect of cardiac performance influenced by a combination of modifiable and non-modifiable risk factors. Factors such as sex, age, duration of hypertension, and the presence of left ventricular (LV) hypertrophy exert a significant influence on the afterload experienced by the heart. Notably, as

individuals age, there are physiological alterations that occur, leading to limitations in transmitral flow velocity curves, even in the absence of other cardiac pathologies.⁹

Our study revealed various cardiac electrical abnormalities in hypertensive patients, with left atrial enlargement being the most prevalent ECG abnormality (38% of participants), followed by left ventricular hypertrophy (33%) and left axis deviation (24%), as depicted in Figure 2. These findings align with similar studies in the field, such as those by Mottram et al.¹⁰ and Yamamoto et al.¹¹, which also reported a high incidence of cardiac abnormalities in hypertensive populations. These results underscore the consistent need for comprehensive cardiovascular assessments in the management of hypertension to detect and address these potential complications at an early stage. To determine impairment of relaxation,

we utilized the E/A ratio as a key parameter. Previous studies have consistently demonstrated that E/A ratio decreases as age advances.¹² However, the E/A ratio values observed in the hypertensive group (abnormal E/A ratio; 0.80 ± 0.22) were significantly lower than those in the control group. It's important to note that control subjects' E/A ratio values, which were derived from age-specific reference values, played a crucial role in our analysis. These reference values were particularly valuable given the variations in E/A ratio associated with age.

Our study population consisted predominantly of males (58%), aligning with the male preponderance observed in several earlier studies.¹³ The mean age of the cases in our study was 45.70 ± 11.12 years, a finding comparable to mean age values reported in earlier Asian studies, such as Masliza et al.¹⁴, where the mean age was 43.1 ± 5.7 years. In contrast, some Western studies had enrolled older cases, emphasizing the variability in demographics across different regions.¹⁰ In our study, we identified diastolic dysfunction, as defined by the E/A ratio, in 44% of cases. This finding is consistent with the observations made by Mottram et al.¹⁰, who reported an abnormal E/A ratio in 40% of their patients, aligning closely with our results. However, it's worth noting that other investigators have reported a lower proportion of cases with an abnormal E/A ratio in their respective study groups. Interestingly, while the sex ratio in the abnormal E/A ratio group was nearly equal (50% male and 50% female), our study revealed that a higher percentage of females tended to have a normal E/A ratio (62% female vs. 48% male). This contrasts with the findings of Mottram et al.¹⁰, who identified female sex as an independent predictor of diastolic dysfunction. In our study, the prevalence of diastolic dysfunction was predominantly observed among males. These variations underscore the complexity of diastolic dysfunction and highlight the potential influence of sex-specific factors in its manifestation, warranting further investigation.

Our study, consistent with existing literature, revealed significant correlations associated with diastolic dysfunction in hypertensive patients. Notably, advancing age exhibited a robust and statistically significant relationship with diastolic dysfunction ($p < 0.001$), aligning with the recognized age-related decline in left ventricular relaxation and filling capabilities. Gender also played a role, with a significant correlation observed ($p = 0.01$), echoing similar findings in prior research.¹⁰ Furthermore, we identified significant correlations between the duration of hypertension, diastolic blood pressure, and the grade of systolic blood pressure (SBP) with diastolic dysfunction ($p = 0.02$, $p = 0.04$, $p = 0.01$, respectively). Intriguingly, we did not detect a significant link between left ventricular hypertrophy (LVH) and diastolic dysfunction, contrary to some earlier studies.¹⁴ In summary, our findings emphasize the importance of early hypertension management,

particularly among older individuals and males, to mitigate the risk of diastolic dysfunction and related cardiovascular issues.

We also observed a significant correlation between an abnormal E/A ratio and diastolic blood pressure (DBP) levels ≥ 90 mm Hg. Additionally, we found a correlation between normal diastolic function, as defined by the E/A ratio, and DBP levels < 80 mm Hg ($p=0.004$). This aligns with the findings of Mottram et al., who also identified DBP as significantly associated with diastolic dysfunction, mirroring our study results. Furthermore, our study revealed associations between an abnormal E/A ratio and the duration of hypertension, as well as both systolic and diastolic blood pressure. It's noteworthy that, apart from Masliza's study, no other investigation had previously established an association between systolic blood pressure, the duration of hypertension, and diastolic dysfunction. These findings emphasize the intricate relationship between blood pressure parameters and the duration of hypertension in the context of diastolic dysfunction, underscoring the multifactorial nature of this condition.

Participants with normal E/A ratios underwent further evaluation to identify the presence of a pseudo normal pattern of diastolic function, as defined by Δd , which serves as an indicator of left ventricular (LV) filling and diastolic function. Remarkably, 18% of cases in our study, initially categorized as having a normal E/A ratio, were found to exhibit a pseudo normal pattern of diastolic function, characterized by a normal E/A ratio but abnormal Δd . Our findings align with those of previous studies that have also investigated diastolic function using Δd . A study by Yamamoto et al.¹¹ in 2011 reported a pseudo normal pattern in 23% of cases, while Mottram et al.¹⁰ identified it in 13% of their study participants. Importantly, both left ventricular internal diameter in diastole (LVIDD) and left ventricular internal diameter in systole (LVIDS) were significantly higher in the group with abnormal diastolic function and significantly lower in patients exhibiting a pseudo normal pattern of diastolic function. While both groups exhibited varying degrees of diastolic dysfunction, increased LVIDD and LVIDS typically signify LV dilatation, whereas decreased LVIDD and LVIDS are indicative of reduced LV compliance. Mottram et al.¹⁰ also reported that elevated diastolic blood pressure was significantly associated with diastolic dysfunction, corroborating our findings. These observations underscore the value of considering multiple parameters in the assessment of diastolic function, as they provide insights into the nuanced aspects of LV function and compliance.

While earlier studies had established a correlation between left ventricular hypertrophy (LVH) and diastolic dysfunction, recent investigations, including our own, have failed to confirm this association. Masliza et al.¹⁵ also did not find a correlation between LVH and diastolic dysfunction, suggesting that

compensatory physiological mechanisms may be at play in response to pressure load during early hypertension, even before the onset of demonstrable LVH. Our study's primary finding underscores the higher prevalence of left ventricular (LV) diastolic dysfunction than initially anticipated, impacting a considerable portion (62%) of hypertensive individuals without overt clinical heart disease. Additionally, our investigation identified a noteworthy subgroup (18%) displaying a pseudo normal diastolic pattern when assessed using Δd , consistent with findings from earlier studies. Notably, Mottram et al.¹⁰ and Yamamoto et al.¹¹ reported abnormal diastolic function in 53% and 55% of cases, respectively, aligning closely with the results of our study.

STRENGTHS AND LIMITATIONS

This study offers several notable strengths. It employs a comprehensive approach to evaluate diastolic dysfunction in hypertensive patients by combining transmitral flow velocity curves and Δd fraction analysis, enhancing diagnostic accuracy. With a substantial sample size of 150 hypertensive patients and its location in a diverse tertiary care medical institution, the study's findings are both statistically robust and relevant to a broad patient population. Comparative analysis with prior research enriches the existing understanding of diastolic dysfunction in hypertensive patients. Additionally, the study carefully selected a relatively uniform and ambulant group of hypertensive patients to minimize confounding variables and enhance internal validity. Nonetheless, limitations exist. The cross-sectional design precludes causal relationships, necessitating future longitudinal investigations. The study's single-institution focus may not fully represent the broader population, calling for multi-center studies. While it sheds light on diastolic dysfunction in hypertensive patients, further exploration of contributing factors and comorbidities is needed. The reliance on echocardiographic assessments may introduce variability based on equipment and operator skills.

CONCLUSION

Our study underscores the substantial prevalence of left ventricular diastolic dysfunction (62%) among hypertensive individuals, even in the absence of clinically detectable heart disease. The adoption of a comprehensive diagnostic approach, combining transmitral flow velocity curves and Δd fraction analysis, revealed that diastolic dysfunction affects a significant majority of hypertensive patients (62%). Moreover, a notable subset of subjects (18%) exhibited a pseudo normal pattern of diastolic function, further highlighting the complexity of this condition. These findings emphasize the critical importance of regular cardiovascular assessments in hypertensive individuals to facilitate early detection

and management of diastolic dysfunction, potentially altering the course of cardiovascular morbidity and mortality. We recommend that healthcare providers incorporate these comprehensive diagnostic methods into routine care for hypertensive patients to improve the detection of diastolic dysfunction and enhance clinical decision-making. Future research should delve deeper into the underlying mechanisms and risk factors contributing to diastolic dysfunction in hypertensive patients to enhance our understanding and inform more targeted interventions.

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