



Association of Grades of Diastolic Dysfunction with Severity of Systemic Hypertension

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(Received: 16 September 2024

Revised: 11 October 2024

Accepted: 11 December 2024)

KEYWORDS

Systemic Hypertension, Diastolic Dysfunction, Heart Failure

ABSTRACT:

Background: Diastolic dysfunction refers to the impairment of ventricular relaxation or filling, regardless of ejection fraction. This study was conducted to examine the association between the grades of diastolic dysfunction and the severity of systemic hypertension.

Objectives: To determine the prevalence of diastolic dysfunction in systemic hypertension and to investigate the relationship between the grades of diastolic dysfunction and the severity of systemic hypertension.

Methods: This hospital-based cross-sectional study was conducted over a period of two years at the outpatient and inpatient departments of General Medicine at Aarupadai Veedu Medical College, Puducherry. A sample of 110 patients with systemic hypertension was selected. Demographic data, hypertension stage, and echocardiographic findings were collected. Inferential statistics, including the Chi-square test, were used to analyze the correlation between diastolic dysfunction and stages of systemic hypertension.

Results: Stage I hypertension, observed in 32.4% of participants, represents the initial phase of elevated blood pressure. Stage II hypertension, the most prevalent at 44.1%, indicates moderate severity and is commonly associated with early signs of organ dysfunction and damage, including changes in cardiac structure and function. Stage III hypertension, seen in 23.4% of participants, reflects severe hypertension with significant cardiovascular risk and advanced end-organ damage. Diastolic dysfunction (DD) was classified into grades to reflect the severity of the condition. Grade II DD, the most common, was present in 41.4% of participants, indicating moderate dysfunction. Grade I DD, reflecting mild dysfunction, was found in 32.4% of participants. Grade III DD, indicating more severe dysfunction, affected 18.9% of participants, while Grade IV DD, the most severe form, was observed in 7.2% of participants. The statistical analysis revealed a significant association between the stages of systemic hypertension and the grades of diastolic dysfunction ($p=0.0027$), indicating a strong relationship.

Conclusion: The study underscores the prevalence of diastolic dysfunction in patients with systemic hypertension and highlights a significant association between the severity of diastolic dysfunction and the stages of systemic hypertension.



Introduction

Systemic hypertension is a major etiological factor associated with a wide range of cardiac abnormalities in cardiovascular medicine.(1) Notably, it has been recognized for its role in the development of diastolic dysfunction, a condition characterized by the heart's diminished ability to relax and fill during diastole.(2) Diastolic dysfunction encompasses a spectrum of alterations in diastolic filling and myocardial relaxation.

The relationship between systemic hypertension and diastolic dysfunction is complex, involving a range of adaptive and maladaptive cardiac responses to high blood pressure, which warrants further investigation.(3) This condition is often considered a precursor to heart failure with preserved ejection fraction (HFpEF), a clinical syndrome that is increasingly prevalent and associated with high morbidity and mortality rates.(4) The link between systemic hypertension and diastolic dysfunction is mediated by intricate mechanistic pathways, including neurohormonal activation, myocardial fibrosis, and changes in the structural and functional properties of the heart.(5) These pathways illustrate the complex process of cardiac remodeling in response to chronic pressure overload.(6)

The motivation for this study arises from the hypothesis that there is a direct correlation between the progression of diastolic dysfunction and the severity of systemic hypertension. If validated, this association could provide insight into the pathological mechanisms underpinning the development of hypertensive heart disease and its progression toward HFpEF.(7) Such findings would emphasize the importance of early detection and aggressive treatment of systemic hypertension to prevent the onset of advanced diastolic dysfunction. Clinically, understanding the relationship between the severity of systemic hypertension and the grades of diastolic dysfunction could significantly impact patient management strategies.(8) This research aims to clarify an important aspect of hypertensive heart disease by examining the relationship between hypertension severity and diastolic dysfunction grades. The study seeks to advance clinical practice, enhance our understanding of the continuum from hypertension to heart failure, and pave the way for innovative therapies to improve outcomes for this high-risk patient population.

Epidemiological studies have suggested the presence of a latent period during which diastolic dysfunction develops and worsens before heart failure symptoms appear. Approximately 21% of individuals have mild left ventricular diastolic dysfunction (LV DD) without symptoms, while 7% exhibit moderate or severe dysfunction.(9) Early intervention during this asymptomatic phase could potentially prevent the progression to symptomatic heart failure. A mortality benefit has been observed in individuals whose diastolic dysfunction improved, compared to those whose condition remained the same or worsened, suggesting the potential efficacy of targeted therapies.(10)

Against this background, the aim of the present study was to determine the prevalence of diastolic dysfunction in systemic hypertension and to investigate the relationship between the grades of diastolic dysfunction and the severity of systemic hypertension.

Materials and Methods

A cross-sectional study was conducted from June 2022 to June 2024 in the Department of General Medicine at Aarupadai Veedu Medical College and Hospital, involving both inpatient and outpatient participants. Prior to participation, all study subjects provided written informed consent. Ethical approval for the study was granted by the Institutional Human Ethics Committee of Aarupadai Veedu Medical College and Hospital (Ethical Approval No: IHEC NO:AV/IHEC/2022/091). The study included individuals aged 33 to 80 years with a known diagnosis of systemic hypertension.

Exclusion criteria for the study included the absence of clinical, electrocardiographic, or echocardiographic evidence of secondary hypertension, valvular heart disease, congenital heart disease, ischemic heart disease, renal disease, or stage IV heart failure. Patients with chronic kidney disease, thyrotoxicosis, hyperaldosteronism, pheochromocytoma, Cushing's syndrome, obstructive sleep apnea, or hyperparathyroidism were also excluded.

The sample size of 110 was determined based on a similar study by Sammar et al. (2021), which reported a prevalence of diastolic dysfunction of 35.6% among patients with systemic hypertension. Detailed demographic data were collected, and patients were categorized according to the stages of hypertension based



on the American Heart Association's 2017 hypertension guidelines. Echocardiography was performed on all participants to assess the grade of diastolic dysfunction.

Statistical analysis: Data analysis was performed using SPSS (IBM SPSS Statistics for Windows, Version 26.0, Armonk, NY: IBM Corp., 2019) and Microsoft Excel for data entry. Continuous variables were summarized using the mean (standard deviation) or median (interquartile range), depending on the data distribution, which was tested using the Kolmogorov-Smirnov test and the Shapiro-Wilk test. To assess statistical significance, the Chi-square test or Fisher's exact test was used.

Results

The frequency and percentage distribution of age groups ranging from 30 to 80 years are presented. The participants are categorized into five age groups: ≤ 35 years, 36–45 years, 46–55 years, 56–65 years, and >65 years. Among the total sample, 2 individuals (1.8%) fall into the ≤ 35 years group, 21 individuals (18.9%) are in the 36–45 years group, 34 individuals (30.6%) are in the 46–55 years group, another 34 individuals (30.6%) are in the 56–65 years group, and 20 individuals (18.0%) are in the >65 years group. Gender distribution among the 110 participants is almost evenly split, with males representing 50.5% of the sample and females representing 49.5%. This balance ensures that the study's findings are not biased toward one gender, allowing for a more balanced analysis of health variables across both sexes.

Participants are classified into different stages of systolic hypertension (SHTN), which reflects the severity of their condition. Stage II SHTN is the most prevalent, affecting 44.1% of participants, indicating a significant portion of the study population with moderate hypertension. Stage I SHTN is observed in 32.4% of participants, suggesting early-stage hypertension in nearly one-third of the sample. Stage III SHTN, the most severe form, is present in 23.4% of participants, highlighting a substantial group with advanced hypertension. Diastolic dysfunction (DD) is graded to reflect the severity of the condition among participants. Grade II DD is the most common, affecting 41.4% of the population, indicating moderate dysfunction. Grade I DD is present in 32.4% of participants, representing mild dysfunction. Grade III DD, indicating more severe dysfunction, affects 18.9% of participants, while Grade IV DD, the most severe form, is observed in 7.2% of participants.

The distribution of DD grades across different SHTN stages shows significant variation. Grade I DD is most prevalent in Stage II SHTN (21.6%), indicating that moderate dysfunction is common in individuals with moderate hypertension. Grade IV DD is primarily seen in Stage I (5.4%), suggesting that severe dysfunction can occur even at early stages of hypertension. The chi-square test reveals a significant association between DD grades and SHTN stages ($p = 0.0027$), highlighting a strong relationship between the severity of diastolic dysfunction and hypertension.

Discussion

Left ventricular (LV) diastolic dysfunction (LVDD) is characterized by alterations in LV diastolic filling, which may include impairments in myocardial relaxation and abnormal distensibility of the myocardium. Krishnan et al.(11) investigated how diastolic dysfunction is affected by hypertension. Per the research, people with heart failure with a normal or nearly normal left ventricular ejection fraction are more likely to die since hypertension is a major source of diastolic dysfunction. The research emphasised the need of proficiently managing hypertension to avert the advancement of diastolic dysfunction and enhance patient consequences.

The incidence of left ventricular diastolic dysfunction in newly diagnosed Nigerian patients with systemic hypertension was the main emphasis of Adamu et al.(12) By using pulsed wave Doppler echocardiography, the researchers were able to determine that diastolic dysfunction was present in 62% of these individuals, with the most frequent characteristic being poor relaxation. Due to the high incidence, it is imperative that diastolic dysfunction in hypertension patients be identified and treated as soon as possible in order to avoid developing new cardiovascular problems. Pavlopoulos and colleagues examined whether individuals with diastolic dysfunction who were hypertensive also have longitudinal systolic dysfunction.(13) Longitudinal systolic dysfunction was observed to be prevalent in the research, particularly when septal E/a was less than 5.9 cm/s. According to Pavlopoulos et al.,(13) there was a strong correlation between the modified segmental relaxation pattern and longitudinal systolic dysfunction, indicating that diastolic dysfunction and systolic dysfunction often coexist in hypertension individual.



The age distribution of the study population provides valuable insights into the demographics most affected by SHTN and Diastolic dysfunction. The majority of participants are within the age ranges of 46-55 years and 56-65 years, each comprising 30.6% of the total sample. This observation aligns with the findings of Gautam et al.,(14) who reported a significant prevalence of Diastolic dysfunction among middle-aged and older adults. The study indicated that prolonged exposure to hypertension and other cardiovascular risk factors in these age groups contributes to the development of Diastolic dysfunction. The presence of 18.9% of participants aged 36-45 years and 18% over 65 years further underscores the age-related increase in the risk of developing Diastolic dysfunction and its complications.

Gender distribution in the study is nearly equal, with 50.5% males and 49.5% females. This balanced distribution is crucial for analysing gender-specific differences in the presentation and progression of SHTN and Diastolic dysfunction. Previous studies, such as those by Nazário Leão and Marques da Silva, have highlighted significant gender differences in cardiovascular disease outcomes.(15) They noted that males and females might exhibit different physiological responses to hypertension, which could influence the development and severity of DD. In this study, the association between gender and DD grades was not statistically significant ($p=0.125$), suggesting no substantial gender difference in DD progression. This balanced gender distribution allows for meaningful comparisons and enhances the generalizability of the study findings.

The classification of SHTN into three stages (Stage I, Stage II, and Stage III) provides a structured framework for assessing the severity of hypertension and its correlation with DD. Stage I hypertension, affecting 32.4% of participants, represents the initial phase of elevated blood pressure. This stage is often characterized by mild symptoms and minimal end-organ damage. Stage II hypertension, the most prevalent at 44.1%, indicates moderate severity and is commonly associated with early signs of organ damage, including changes in cardiac structure and function. Stage III hypertension, observed in 23.4% of participants, reflects severe hypertension with significant cardiovascular risk and advanced end-organ damage.

Research has shown that higher stages of hypertension are linked to increased left ventricular mass and impaired diastolic function. For instance, Ravi et al.(16) found that 62 out of 85 hypertensive patients had Diastolic dysfunction, with some also exhibiting left ventricular hypertrophy. This highlights a strong association between the severity of hypertension and the progression of DD. In our study, higher SHTN stages correlate with more severe DD grades, reinforcing the importance of early detection and management of hypertension to prevent the progression of cardiac dysfunction. Our statistical analysis reveals a significant association between SHTN stages and Diastolic dysfunction grades, indicating a strong relationship. This reinforces the clinical relevance of closely monitoring hypertensive patients for DD, particularly as hypertension progresses.(17)

The grading of DD into four categories—Grade I (32.4%), Grade II (41.4%), Grade III (18.9%), and Grade IV (7.2%)—facilitates a nuanced analysis of its progression and severity. Grade I DD, often referred to as mild diastolic dysfunction, is characterized by early abnormalities in ventricular relaxation. Grade II, or moderate diastolic dysfunction, involves more pronounced impairments, including elevated filling pressures. Grade III, or severe diastolic dysfunction, is marked by significantly impaired relaxation and restrictive filling patterns. Grade IV, or advanced diastolic dysfunction, represents the most severe form, often associated with marked clinical symptoms and poor prognosis.

The prevalence and severity of in diastolic dysfunction hypertensive patients underscore the clinical importance of closely monitoring and managing both conditions. Andor et al.(18) highlighted that a significant proportion of hypertensive patients exhibit varying degrees of DD, with more severe hypertension associated with higher DD grades. This association is consistent with the findings of our study, where higher grades of DD are observed in patients with more severe stages of hypertension. The statistically significant association underscores the importance of early detection and intervention.

The relationship between DD and hypertension is complex and multifaceted. Tsai et al.(19) discussed the post systolic strain index (PSI) as a marker for delayed



diastolic lengthening and DD in untreated hypertension. Their study emphasized the need for early intervention to prevent the progression of DD in hypertensive patients. This finding is particularly relevant to our study, where even early stages of hypertension (Stage I) are associated with significant DD (Grade I). Furthermore, the impairment of diastolic function in metabolic syndrome, as noted by Cavalcante et al.,(20) is not solely a consequence of hypertension. Their research highlighted the role of epicardial fat volume (EFV) in contributing to DD, suggesting that metabolic factors also play a significant role in the development and progression of diastolic dysfunction.(20) This underscores the importance of a comprehensive approach to managing hypertension and its related metabolic disorders.

Conclusion

This study highlights the prevalence of diastolic dysfunction in systemic hypertension and significant association between the grades of diastolic dysfunction and the severity of systemic hypertension. The findings emphasize the need for early intervention and aggressive management of hypertension to mitigate the progression of diastolic dysfunction, thereby reducing cardiovascular morbidity and mortality. Understanding these relationships will inform clinical practice and guide the development of more effective treatment strategies for patients with hypertension and diastolic dysfunction.

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Table 1: Characteristics of study participants

		Number	Percentage
Age distribution	≤35 years	2	1.8
	36 – 45 years	21	18.9
	46 – 55 years	34	30.6
	56 – 65 years	34	30.6
	>65 years	20	18.0
Gender	Male	56	50.5
	Female	54	49.5
Systemic hypertension	Stage I	36	32.4
	Stage II	49	44.1
	Stage III	26	23.4
Diastolic dysfunction	Grade I	36	32.4
	Grade II	46	41.4
	Grade III	21	18.9
	Grade IV	8	7.2

Table 2: Association between diastolic dysfunction and systemic hypertension

Diastolic dysfunction	Systemic hypertension			Total n (%)
	Stage I n (%)	Stage II n (%)	Stage III n (%)	
Grade I	8 (7.2)	24 (21.6)	4 (3.6)	36 (32.4)
Grade II	14 (12.6)	18 (16.2)	14 (12.6)	46 (41.4)
Grade III	8 (7.2)	5 (4.5)	8 (7.2)	21 (18.9)
Grade IV	6 (5.4)	2 (1.8)	0 (0.0)	8 (7.2)
Total	36 (32.4)	49 (44.1)	26 (23.4)	111 (100)

Chi-Square Test: 20.02; P-value: 0.0027