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LEFT ATRIAL STRAIN AS A PREDICTOR OF EARLY DIASTOLIC DYSFUNCTION IN HYPERTENSIVE PATIENTS – A CASE-CONTROL STUDY

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ABSTRACT **Background:** Hypertension is a major risk factor for the development of diastolic dysfunction, often preceding overt heart failure. Left atrial strain, derived from speckle-tracking echocardiography, is a sensitive measure of atrial mechanics and may serve as an early marker of diastolic impairment before conventional parameters become abnormal. **Objective:** This study aimed to evaluate and compare the components of left atrial strain as predictors of early diastolic dysfunction in hypertensive patients compared to non-hypertensive controls. **Methods:** A case-control study was conducted over six months, enrolling 50 participants (25 hypertensive patients and 25 normotensive controls). Individuals with structural heart disease were excluded. All participants underwent a comprehensive echocardiographic examination using a Philips Affinity 50C machine. Two-dimensional speckle-tracking echocardiography was used to analyze the three phasic functions of the left atrium: reservoir strain (LASr), conduit strain (LAScd), and contractile strain (LASct). Conventional Doppler parameters, including mitral inflow E/A ratio, were also assessed. **Results:** The mean ages of the case and control groups were comparable (57.6 ± 8.9 vs. 56.2 ± 7.4 years). The hypertensive group had significantly higher blood pressures. Conventional echocardiography revealed significant diastolic impairment in hypertensives, evidenced by a lower E/A ratio (0.98 ± 0.33 vs. 1.2 ± 0.43; p=0.048). All LA strain parameters were significantly impaired in the hypertensive group. Among these, LA conduit strain (LAScd) demonstrated the highest diagnostic accuracy for identifying early diastolic dysfunction, with an area under the curve (AUC) of 0.82, 80% sensitivity, and 76% specificity. **Conclusion:** Left atrial strain parameters are significantly impaired in hypertensive patients with early diastolic dysfunction. LA conduit strain emerged as the strongest predictor, suggesting its potential as a sensitive, early diagnostic tool for detecting subclinical diastolic impairment in hypertension, which could allow for earlier intervention.

KEYWORDS : Left Atrial Strain, Hypertension, Early Diastolic Dysfunction & India

INTRODUCTION:

One of the most common cardiovascular risk factors in the world and a major cause of morbidity and death is hypertension (1). Left ventricular diastolic dysfunction (LVDD), one of its initial cardiac manifestations, frequently occurs before heart failure with preserved ejection fraction (HFpEF) (2). Therefore, early detection of diastolic dysfunction is essential for directing prompt interventions that could stop the progression of the disease. Diastolic function evaluation frequently uses traditional echocardiographic indices like tissue Doppler imaging (TDI) and transmitral Doppler velocities. These indices, however, may not be sensitive enough to identify subtle, early abnormalities and may be impacted by loading conditions (3). Therefore, in order to identify preclinical dysfunction in hypertensive patients, more sensitive and repeatable markers are required.

By acting as a reservoir, conduit, and booster pump, the left atrium (LA) contributes significantly to left ventricular filling. Atrial remodelling and dysfunction are caused by chronic pressure overload brought on by hypertension, and they frequently appear before the chamber's structural enlargement is noticeable. Because of this, atrial function is a viable target for hypertensive heart disease early detection (4). Left atrial strain, which reflects atrial myocardial deformation, can now be measured thanks to two-dimensional speckle tracking echocardiography (2D-STE). Strain imaging offers a direct, less load-dependent evaluation of intrinsic LA function in contrast to volumetric indices (5). Even in the absence of overt LA enlargement, recent research has shown that decreased LA strain is a sensitive indicator of subclinical LV diastolic dysfunction in hypertensive patients. Furthermore, atrial fibrillation, HFpEF, and mortality are among the negative cardiovascular outcomes that have been connected to impaired LA strain (6,7).

Despite being well-established in the assessment of diastolic function, traditional echocardiographic measures frequently overlook early and subtle abnormalities of ventricular relaxation. A growing body of research indicates that 2D-STE measurement of LA strain offers a more accurate and sensitive way to identify early dysfunction in hypertension. With this background we aimed to assess the left atrial strain as a predictor of early left atrial dysfunction in well controlled hypertension with normal left atrial size.

Methodology:

A Case-control study was carried out in the Department of Cardiology at Tertiary care Hospital in chennai, utilizing a Philips Affinity 50C echocardiography machine. A total of fifty (50) patients with 25 hypertensive and 25 Non-hypertensive patients were enrolled in the study. The duration of the study was 6 months. Enrollment was based strictly on predefined inclusion and exclusion criteria. The inclusion criteria comprised adults aged 30 to 70 years with a diagnosis of hypertension, as well as common comorbidities including Diabetes Mellitus, Dyslipidemia, and a family history of Coronary Artery Disease (CAD). Key exclusion criteria were applied to eliminate confounding variables, including the presence of any Structural Heart Disease, pregnancy, and diagnosed psychiatric issues.

The study procedure involved a comprehensive echocardiographic examination. Using the Philips Affinity 50C machine, an ECG-gated study was performed to acquire standard two-dimensional, M-mode, and speckle-tracking images. All standard views were obtained, including the parasternal long and short axes, apical 4-chamber, apical 2-chamber, apical 3-chamber, and sub-costal views. The primary focus of the analysis was on left atrial function assessed via two-dimensional speckle-tracking echocardiography. Specifically, the following Reservoir, Conduit and Booster Strain components of left atrial strain were measured and analyzed to evaluate distinct phases of atrial function:

RESULTS:

Table 1: Characteristics Of Patients

Characteristics	Hypertensive (n=25)	Non hypertensive (n=25)
Age (years)	57.6 ± 8.9	56.2 ± 7.4
Male	14 (56)	13 (52)
Female	11 (44)	12 (48)
SBP (mmHg)	139 ± 6	118 ± 7
DBP (mmHg)	87 ± 5	75 ± 4

The mean & SD of age among our participants in cases & Controls are 57.6 ± 8.9 and 56.2 ± 7.4 years respectively. The majority of the

participants were males. The hypertensive group demonstrated a mean systolic blood pressure of 139 mmHg, which is 21 mmHg higher than the mean of 118 mmHg observed in the non-hypertensive group. This pattern is consistent for diastolic blood pressure, with a difference of 12 mmHg between the hypertensive group's mean of 87 mmHg and the non-hypertensive group's mean of 75 mmHg.

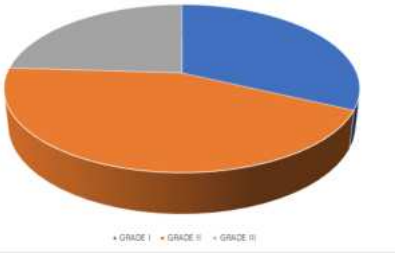

Figure 1: Grades of Hypertension

The figure.1 illustrates the distribution of patients based on the grades of diastolic dysfunction. Grade II diastolic dysfunction constituted the largest proportion, accounting for nearly half of the cases. Grade I was the next most common, followed by Grade III, which represented the smallest proportion.

Table 2: Representation Of E/A ratio

Variables	Hypertensive (n=25)	Non hypertensive (n=25)	p-value
E (M/S)	0.8 ± 0.3	0.7 ± 0.23	0.192
A (M/S)	0.8 ± 0.12	0.6 ± 0.34	***0.007****
E/A	0.98 ± 0.33	1.2 ± 0.43	***0.048****

There is a statistically significant difference in the late diastolic (A wave) filling velocity between the two groups (Hypertensive: 0.8 ± 0.12 m/s vs. Non-hypertensive: 0.6 ± 0.34 m/s; p-value = 0.007). The key ratio of early to late diastolic filling (E/A) is also significantly different (Hypertensive: 0.98 ± 0.33 vs. Non-hypertensive: 1.2 ± 0.43; p-value = 0.048). A ratio of less than 1 in the hypertensive group is a classic indicator of abnormal diastolic function,

Table 3: Representation Of Strain Deformation

LA Strain	Hypertensive (n=25)	Non-Hypertensive (n=25)	p-value
LA Reservoir Strain (%)	33.5 ± 6.73	38.2 ± 8.6	0.036*
LA Conduit Strain (%)	13.3 ± 5.43	18.3 ± 6.54	0.005*
LA Contraction Strain (%)	14. 7 ± 4.71	17.4 ± 4.23	0.038*

Hypertensive patients show significantly impaired function in all three phases of left atrial mechanics. The LA Reservoir function is reduced (33.5% vs. 38.2%), indicating increased atrial stiffness. LA Conduit function is the most affected (13.3% vs. 18.3%), pointing to impaired passive ventricular filling. LA Contractile function is also weaker (14.7% vs. 17.4%), suggesting a failing compensatory "booster pump" mechanism.

Table 4: Diagnostic Accuracy Of LA Strain

Parameter	Cut-off Value	Sensitivity (%)	Specificity (%)	AUC (95% CI)	p-value
LA Reservoir Strain (%)	≤35%	76	72	0.78 (0.65 – 0.91)	0.002*
LA Conduit Strain (%)	≤15%	80	76	0.82 (0.70 – 0.94)	<0.001*
LA Contraction Strain (%)	≤15%	72	68	0.74 (0.60 – 0.88)	0.005*

LA Conduit Strain showed the best diagnostic accuracy, with an AUC of 0.82, sensitivity of 80%, and specificity of 76%, making it the strongest predictor of early diastolic dysfunction in hypertensive patients. LA Reservoir Strain also demonstrated good accuracy (AUC = 0.78), while LA Contraction Strain had moderate diagnostic utility (AUC = 0.74).

DISCUSSION:

The current case-control study shows that hypertensive patients have significantly worse left atrial (LA) strain, particularly in the reservoir, conduit, and contractile phases, when compared to non-hypertensive controls. Evidence currently describing LA strain parameters as sensitive, early indicators of diastolic dysfunction is supported by the finding that hypertensive patients have lower LA strain parameters.

A cross-sectional study by Miljković et al. reported that LA strain had the highest diagnostic accuracy for detecting diastolic dysfunction in hypertensive patients, with a cut-off value of 24.27% yielding an AUC of 0.885, sensitivity of 78.9%, and specificity of 84.6%—metrics closely matching the current study's results for LA conduit strain (AUC 0.82, sensitivity 80%, specificity 76%). Both studies conclude that LA strain is a robust, independent marker for early diastolic dysfunction and recommend its inclusion in standard echocardiographic evaluations for at-risk patients (8). A study by Chopra E et al demonstrated that LA reservoir strain (LASr) was significantly reduced across all grades of diastolic dysfunction, with a strong inverse correlation between LASr and diastolic dysfunction severity (Spearman's $\rho = -0.82$, $p<0.001$). LASr <24% was predictive of diastolic dysfunction with excellent diagnostic accuracy, complementing and enhancing conventional parameters like E/A ratio and E/e' which is consistent with our study results (9). A similar study by Seçkin Ö et al showed the mean & sd of LASr and LAScd among dipper Hypertension group are 34.4 ±3.9 and 18.5 ±3.7, respectively, whereas in our study LA Reservoir Strain (%) and LA Conduit Strain (%) are 33.5 + 6.73 and 13.3 + 5.43 which is close to the previous study results (10).

The conventional Doppler echocardiographic findings of a significantly increased late diastolic (A wave) filling velocity (0.8±0.12 m/s vs. 0.6±0.34 m/s, p-value = 0.007) and a reduced early-to-late diastolic filling ratio (E/A ratio) of 0.98±0.33 in the hypertensive group are consistent with a pattern of impaired relaxation, a classic hallmark of Grade I diastolic dysfunction. This aligns with extensive literature, such as the work of Ikejder Y et al. (11), which has established the A-wave as a compensatory mechanism where the left atrium contracts more forcefully to "kick" blood into a stiffened left ventricle, thereby maintaining stroke volume. The reduced E/A ratio in our hypertensive cohort further supports this pathophysiological model. The LA reservoir strain in our investigation demonstrated the best sensitivity and specificity in separating hypertensive from normotensive patients with early diastolic dysfunction. This is in line with research by Morris et al. (12) and Cameli et al. (13), which found that the most reliable and repeatable metric for identifying diastolic dysfunction and forecasting unfavourable cardiovascular outcomes is LA reservoir strain.

Notwithstanding these advantages, our research has some drawbacks. The results may not be as broadly applicable as they could be due to the small sample size. We excluded longitudinal follow-up to determine whether a lower LA strain is predictive of future clinical outcomes like heart failure or atrial fibrillation. Furthermore, vendor-specific software and image quality may have an impact on strain measurements, which calls for standardisation in subsequent research.

CONCLUSION:

This study demonstrates that in hypertensive patients, left atrial (LA) strain—specifically, LA conduit strain—is a highly sensitive and specific early indicator of diastolic dysfunction. The reserve, conduit, and contractile functions of LA mechanics are all significantly compromised in hypertensive patients, which is indicative of weakening compensatory mechanisms, increased atrial stiffness, and impaired passive ventricular filling. LA conduit strain was a strong predictor of early diastolic dysfunction and showed the highest diagnostic accuracy, outperforming conventional metrics like the E/A ratio. According to these results, LA strain assessment should be incorporated into routine echocardiographic evaluation in order to facilitate earlier identification and more accurate risk stratification of diastolic dysfunction in hypertension, which could lead to better clinical management and results.

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Conflict Of Interest: Nil

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