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RESEARCH ARTICLE

Echocardiographic Screening for Subclinical Cardiac Dysfunction in High-Risk Individuals: A Cross-Sectional Study

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Abstract: ***Background***: Subclinical cardiac dysfunction often precedes overt cardiovascular disease, particularly in individuals with established risk factors. Early identification using advanced echocardiographic techniques may enable timely intervention and improved outcomes.***Material and Methods***: This cross-sectional study included 140 asymptomatic high-risk adults (≥18 years) with at least one cardiovascular risk factor. All participants underwent clinical evaluation and transthoracic echocardiography, including two-dimensional speckle-tracking for assessment of global longitudinal strain (GLS). Subclinical cardiac dysfunction was defined as impaired GLS (<18%) with preserved left ventricular ejection fraction. Statistical analysis included comparative and multivariate regression methods.***Results***: The mean age was 52.6 ± 11.4 years, with 58.6% males. Hypertension (62.9%), dyslipidemia (51.4%), and diabetes mellitus (45.7%) were common. Mean left ventricular ejection fraction was preserved (58.9 ± 5.1%), while mean GLS was −17.1 ± 2.3%. Subclinical cardiac dysfunction was identified in 38.6% of participants. Individuals with dysfunction were older (56.8 ± 10.2 vs. 49.9 ± 11.5 years, $p < 0.001$), had higher body mass index (29.1 ± 3.6 vs. 26.9 ± 3.8 kg/m², $p = 0.002$), and a greater prevalence of hypertension (77.8% vs. 53.5%, $p = 0.004$) and diabetes mellitus (59.3% vs. 37.2%, $p = 0.010$). They also demonstrated higher E/e' ratio (13.6 ± 3.4 vs. 10.6 ± 2.6, $p < 0.001$) and reduced GLS (−15.2 ± 1.8 vs. −18.3 ± 1.6, $p < 0.001$). Age, body mass index, hypertension, and diabetes mellitus were independent predictors.***Conclusion:*** Subclinical cardiac dysfunction is highly prevalent among high-risk individuals and is independently associated with key metabolic and hemodynamic risk factors. Strain-based echocardiographic screening may facilitate early detection and risk stratification.

Keywords:Subclinical cardiac dysfunction; Global longitudinal strain; Echocardiography; Cardiovascular risk factors; Speckle-tracking.

INTRODUCTION

Cardiovascular diseases (CVDs) remain a leading cause of global morbidity and mortality, with a substantial proportion of events occurring in individuals with identifiable risk factors such as hypertension, diabetes mellitus, obesity, and dyslipidemia [1]. Importantly, structural and functional myocardial alterations often precede the onset of clinically overt disease, highlighting the need for early detection of subclinical cardiac dysfunction in high-risk populations [1].

Conventional echocardiographic assessment using left ventricular ejection fraction (LVEF) has long been the cornerstone for evaluating cardiac systolic function; however, it lacks sensitivity for detecting early myocardial impairment and frequently remains within normal limits until advanced stages of disease [2]. In contrast, myocardial deformation imaging using two-dimensional speckle-tracking echocardiography enables the assessment of global longitudinal strain (GLS), which reflects intrinsic myocardial fiber function and has emerged as a sensitive marker of subclinical ventricular dysfunction [2,3].

Recent studies have demonstrated that GLS can identify early myocardial abnormalities in various clinical conditions even in the presence of preserved LVEF. Reduced GLS has been reported in asymptomatic individuals with cardiovascular risk factors and in disease states such as hypertension, obesity, and systemic inflammatory conditions, suggesting its utility in detecting early myocardial involvement before overt dysfunction becomes apparent [3–5]. Furthermore, impaired GLS has been associated with adverse clinical outcomes and may provide incremental prognostic value beyond conventional echocardiographic parameters [6].

The increasing recognition of subclinical myocardial dysfunction underscores the importance of screening strategies in high-risk individuals. Early identification through advanced echocardiographic techniques may facilitate timely intervention and risk stratification, potentially altering disease trajectory and improving long-term cardiovascular outcomes [4,6].

In this context, the present study was undertaken to evaluate the role of echocardiographic screening, particularly GLS assessment, in detecting subclinical cardiac dysfunction among asymptomatic individuals with established cardiovascular risk factors.

MATERIALS AND METHODS

Study Setting and Design: This hospital-based, cross-sectional observational study was conducted in the Department of Cardiology of a tertiary care center over a period of 12 months. The study protocol was approved by the Institutional Ethics Committee, and all procedures adhered to the principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

Study Population: Participants were consecutively recruited from outpatient and health screening clinics. The study included adults aged ≥18 years identified as high-risk for cardiovascular disease based on the presence of one or more risk factors such as diabetes mellitus, hypertension, obesity, dyslipidemia, or a history of smoking.

Previous observational echocardiographic studies evaluating subclinical myocardial dysfunction have typically included sample sizes ranging from 50 to 150 participants depending on feasibility and effect size assumptions [7,8]. Based on these considerations and assuming a prevalence of subclinical dysfunction of approximately 30–40% in high-risk populations, a minimum sample size of 120 participants was calculated to achieve adequate statistical power (80%) with a confidence level of 95%. To account for potential exclusions and incomplete data, a total of 140 participants were enrolled

Inclusion Criteria

Adults aged ≥18 years

Presence of ≥1 cardiovascular risk factor (diabetes mellitus, hypertension, obesity, dyslipidemia, or smoking)

Asymptomatic individuals without known structural heart disease

Exclusion Criteria

Known cardiovascular diseases (e.g., coronary artery disease, heart failure, valvular heart disease)

Reduced left ventricular ejection fraction (<50%)

History of congenital heart disease or cardiomyopathy

Chronic kidney disease (stage ≥3)

Poor echocardiographic window

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Clinical and Laboratory Assessment

All participants underwent a detailed clinical evaluation including medical history, anthropometric measurements (height, weight, body mass index), and blood pressure recording. Baseline laboratory investigations included fasting blood glucose, lipid profile, and serum creatinine.

Echocardiographic Assessment: Transthoracic echocardiography was performed using a standardized ultrasound system equipped with a phased-array transducer (2.5–3.5 MHz). All examinations were conducted by an experienced cardiologist blinded to clinical details.

Conventional echocardiographic parameters including left ventricular ejection fraction (LVEF), left ventricular mass index (LVMI), left atrial volume index (LAVI), and diastolic function indices were assessed in accordance with established guidelines. Advanced myocardial deformation analysis was performed using two-dimensional speckle-tracking echocardiography (2D-STE) to evaluate global longitudinal strain (GLS), a sensitive marker of subclinical myocardial dysfunction [7].

Subclinical cardiac dysfunction was defined as impaired GLS (absolute value <18%) in the presence of preserved LVEF, consistent with prior literature [9].

Outcome Measures: The primary outcome was the prevalence of subclinical cardiac dysfunction among high-risk individuals. Secondary outcomes included associations between echocardiographic parameters and clinical risk factors.

Statistical Analysis: Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 25.0. Continuous variables were expressed as mean ± standard deviation. Categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the independent t-test for continuous variables and the chi-square test for categorical variables. Correlation analysis was conducted using Pearson coefficients. Multivariate logistic regression analysis was used to identify independent predictors of subclinical cardiac dysfunction. A p-value <0.05 was considered statistically significant

RESULTS:

A total of 140 high-risk individuals were included in the analysis. The mean age of the study population was 52.6 ± 11.4 years, with a predominance of males (58.6%). The mean body mass index was 27.8 ± 3.9 kg/m². The most common cardiovascular risk factor was hypertension (62.9%), followed by dyslipidemia (51.4%) and diabetes mellitus (45.7%). Smoking was reported in 32.9% of participants. The mean systolic and diastolic blood pressures were 136.2 ± 14.8 mmHg and 84.5 ± 9.6 mmHg, respectively. Baseline biochemical parameters showed a mean fasting glucose level of 118.7 ± 28.3 mg/dL and total cholesterol of 198.4 ± 36.7 mg/dL (Table 1).

Echocardiographic evaluation demonstrated a preserved mean left ventricular ejection fraction (58.9 ± 5.1%). The mean left ventricular mass index and left atrial volume index were 104.3 ± 18.6 g/m² and 32.7 ± 6.8 mL/m², respectively. Diastolic

function parameters revealed a mean E/A ratio of 0.92 ± 0.21 and an E/e' ratio of 11.8 ± 3.2. The mean global longitudinal strain was −17.1 ± 2.3%, indicating subtle impairment at the population level (Table 2).
Subclinical cardiac dysfunction, defined by impaired global longitudinal strain despite preserved ejection fraction, was identified in 54 participants, corresponding to a prevalence of 38.6%, while 61.4% had normal myocardial function (Table 3).

On comparative analysis, individuals with subclinical cardiac dysfunction were significantly older (56.8 ± 10.2 vs. 49.9 ± 11.5 years, $p < 0.001$) and had a higher body mass index (29.1 ± 3.6 vs. 26.9 ± 3.8 kg/m², $p = 0.002$) compared to those without dysfunction. The prevalence of hypertension (77.8% vs. 53.5%, $p = 0.004$), diabetes mellitus (59.3% vs. 37.2%, $p = 0.010$), and dyslipidemia (63.0% vs. 44.2%, $p = 0.028$) was significantly higher in the dysfunction group. Although smoking was more frequent among those with dysfunction (40.7% vs. 27.9%), this difference did not reach statistical significance ($p = 0.109$). Echocardiographic parameters showed significantly higher E/e' ratio (13.6 ± 3.4 vs. 10.6 ± 2.6, $p < 0.001$) and reduced global longitudinal strain (−15.2 ± 1.8 vs. −18.3 ± 1.6, $p < 0.001$) in participants with subclinical dysfunction (Table 4)
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Multivariate logistic regression analysis identified age (adjusted OR: 1.05; 95% CI: 1.02–1.09; $p = 0.002$), body mass index (adjusted OR: 1.12; 95% CI: 1.04–1.21; $p = 0.004$), hypertension (adjusted OR: 2.18; 95% CI: 1.08–4.39; $p = 0.029$), and diabetes mellitus (adjusted OR: 1.94; 95% CI: 1.01–3.71; $p = 0.046$) as independent predictors of subclinical cardiac dysfunction. Dyslipidemia did not demonstrate an independent association after adjustment ($p = 0.148$) (Table 5).

Table 1. Baseline Characteristics of Study Population (n = 140)

Variable	Value
Age (years), mean ± SD	52.6 ± 11.4
Male, n (%)	82 (58.6)
BMI (kg/m²), mean ± SD	27.8 ± 3.9
Hypertension, n (%)	88 (62.9)
Diabetes mellitus, n (%)	64 (45.7)
Dyslipidemia, n (%)	72 (51.4)
Smoking, n (%)	46 (32.9)
Systolic BP (mmHg), mean ± SD	136.2 ± 14.8
Diastolic BP (mmHg), mean ± SD	84.5 ± 9.6
Fasting glucose (mg/dL), mean ± SD	118.7 ± 28.3
Total cholesterol (mg/dL), mean ± SD	198.4 ± 36.7

Table 2. Echocardiographic Parameters of Study Participants

Parameter	Value
LVEF (%), mean ± SD	58.9 ± 5.1
LVMI (g/m²), mean ± SD	104.3 ± 18.6
LAVI (mL/m²), mean ± SD	32.7 ± 6.8
E/A ratio, mean ± SD	0.92 ± 0.21
E/e' ratio, mean ± SD	11.8 ± 3.2
Global Longitudinal Strain (%), mean ± SD	-17.1 ± 2.3

Table 3. Prevalence of Subclinical Cardiac Dysfunction

Variable	n (%)
Subclinical dysfunction present	54 (38.6)
Subclinical dysfunction absent	86 (61.4)

Table 4. Comparison between Participants with and Without Subclinical Cardiac Dysfunction

Variable	Dysfunction Present (n=54)	Dysfunction Absent (n=86)	p-value
Age (years)	56.8 ± 10.2	49.9 ± 11.5	<0.001
Male, n (%)	36 (66.7)	46 (53.5)	0.118
BMI (kg/m²)	29.1 ± 3.6	26.9 ± 3.8	0.002
Hypertension, n (%)	42 (77.8)	46 (53.5)	0.004
Diabetes mellitus, n (%)	32 (59.3)	32 (37.2)	0.010

Dyslipidemia, n (%)	34 (63.0)	38 (44.2)	0.028
Smoking, n (%)	22 (40.7)	24 (27.9)	0.109
E/e' ratio	13.6 ± 3.4	10.6 ± 2.6	<0.001
GLS (%)	-15.2 ± 1.8	-18.3 ± 1.6	<0.001

Table 5. Multivariate Logistic Regression Analysis for Predictors of Subclinical Cardiac Dysfunction

Variable	Adjusted Odds Ratio (OR)	95% CI	p-value
Age (per year increase)	1.05	1.02–1.09	0.002
BMI (per unit increase)	1.12	1.04–1.21	0.004
Hypertension	2.18	1.08–4.39	0.029
Diabetes mellitus	1.94	1.01–3.71	0.046
Dyslipidemia	1.63	0.84–3.15	0.148

DISCUSSION

The present study demonstrates a high prevalence (38.6%) of subclinical cardiac dysfunction among asymptomatic high-risk individuals, despite preserved left ventricular ejection fraction. This finding reinforces the growing recognition that conventional measures of systolic function may fail to detect early myocardial impairment, which can be unmasked using myocardial deformation imaging. Recent evidence has consistently shown that global longitudinal strain (GLS) is a more sensitive parameter for identifying early left ventricular dysfunction compared to traditional indices such as ejection fraction [10,11].

The observed reduction in GLS in a substantial proportion of participants aligns with findings from contemporary studies evaluating subclinical myocardial dysfunction across various clinical conditions. For instance, speckle-tracking echocardiography has been shown to detect early myocardial impairment in asymptomatic individuals with systemic diseases, even when conventional echocardiographic parameters remain within normal limits [12,13]. Similarly, reduced GLS has been reported in patients with coronary microvascular abnormalities and other subclinical cardiovascular conditions, further supporting its role as an early marker of myocardial dysfunction [14].

In the present study, advancing age, higher body mass index, hypertension, and diabetes mellitus emerged as independent predictors of subclinical dysfunction. These associations are consistent with established pathophysiological mechanisms, wherein chronic metabolic and hemodynamic stress contributes to myocardial remodeling and impaired myocardial deformation. Recent literature highlights that cardiovascular risk factors such as hypertension and metabolic disorders are strongly linked to early alterations in myocardial strain parameters, preceding overt structural changes [11,15]

Additionally, the significantly higher E/e' ratio observed in participants with subclinical dysfunction suggests concomitant early diastolic impairment. This finding is supported by prior studies demonstrating that abnormalities in myocardial deformation often coexist with subclinical diastolic dysfunction, reflecting early myocardial involvement at both systolic and diastolic levels [13,14]. The integration of strain imaging with conventional Doppler parameters therefore provides a more comprehensive assessment of early cardiac dysfunction.

From a clinical perspective, the high burden of subclinical dysfunction observed in this study underscores the importance of incorporating advanced echocardiographic techniques into routine screening of high-risk populations. Emerging evidence suggests that impaired GLS is not only a diagnostic marker but also carries prognostic significance, with reduced strain values being associated with an increased risk of adverse cardiovascular outcomes [16]. Early identification of such individuals may facilitate timely intervention and risk stratification, potentially altering disease progression.

However, the findings should be interpreted in light of certain limitations. The cross-sectional design precludes causal inference, and longitudinal studies are required to establish the prognostic implications of subclinical dysfunction detected by strain imaging. Additionally, strain measurements may be influenced by loading conditions and inter-vendor variability, which could affect reproducibility, although recent advancements have aimed to improve standardization [10].

Overall, the present study adds to the growing body of evidence supporting the utility of GLS in detecting early myocardial dysfunction in high-risk individuals and highlights its potential role in preventive cardiology..

CONCLUSION

Echocardiographic screening using myocardial deformation imaging revealed a high prevalence of subclinical cardiac dysfunction among asymptomatic high-risk individuals, despite preserved left ventricular ejection fraction. Advancing age, increased body mass index, hypertension, and diabetes mellitus emerged as significant independent predictors, underscoring their contributory role in early myocardial impairment. These findings highlight the utility of incorporating strain-based echocardiographic assessment into routine cardiovascular risk evaluation for timely identification of

preclinical myocardial dysfunction, which may facilitate earlier intervention and potentially improve long-term cardiovascular outcomes.

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