Original Article

Role of Dobutamine Stress Test and Speckle Tracking in Ischemic Heart Disease, Comparative Study

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Abstract

Background: Coronary artery disease (CAD) is a major cause of cardiovascular mortality. Echocardiography plays a vital role in early detection and treatment. **Objectives:** We investigated the use of speckle tracking during dobutamine stress echocardiography (DSE) to diagnose CAD in moderate-risk patients. **Materials and Methods:** A 4-month cross-sectional study enrolled 42 moderate-risk patients without prior CAD history. Data included questionnaires, echocardiographic measurements, and SPSS analysis. **Results:** Patients were divided into CAD-negative (66.7%) and CAD-positive (33.3%) groups based on coronary angiography. Speckle tracking during stress correlated better with angiography (kappa = 0.78) than at rest (kappa = 0.21) or stress visualization (kappa = 0.66). Sensitivity and specificity were 71.4% and 92.8% (stress test), 57.1% and 85.7% (speckle at rest), and 85.7% and 92.8% (speckle during stress), respectively. **Conclusion:** Speckle tracking during DSE is a promising approach for diagnosing CAD in moderate-risk patients, enhancing early intervention possibilities.

Keywords: Coronary artery disease, dobutamine stress, echocardiography, global longitudinal strain, moderate risk, noninvasive imaging, speckle tracking

Introduction

Ischemic heart disease remains the leading cause of morbidity and mortality worldwide. The prevalence of patients with ischemic cardiomyopathy and heart failure is on the rise, and chronic heart failure, primarily caused by coronary artery disease (CAD), accounts for a significant proportion of left ventricular (LV) dysfunction cases.[1] The socioeconomic burden of ischemic heart failure is substantial, affecting approximately 126 million individuals globally.[2,3] Both low-income and high-income countries experience disability-adjusted life years due to CAD, with significant mortality rates reported in various regions.[4]

LV function serves as a crucial prognostic factor for patients with CAD, impacting their survival, hospitalization, and overall quality of life. Identifying individuals who may benefit from revascularization strategies is imperative, especially for those with severe LV impairment, as long-term survival rates are generally poor.[5]

Various risk factors contribute to an elevated risk of heart attack, including modifiable factors such as hypertension, diabetes, hyperlipidemia, and nonmodifiable factors like age, gender, family history, and ethnicity.[6]

The pathogenesis of ischemic heart disease involves the accumulation of atherosclerotic plaque in the epicardial arteries, leading to obstructed blood flow and impaired myocardial perfusion.[7,8] The resulting ischemia triggers a cascade of events, leading to various clinical markers of ischemia, with regional malperfusion considered the most sensitive indicator.[9]

Diagnosing CAD often involves resting a 12-lead electrocardiogram, but it may not always provide a

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Submission: 28-Aug-2023 **Accepted:** 05-Sep-2023 **Published:** 24-Sep-2024

How to cite this article: Kadhim MM, AL-Saad SF, Al-Jumaily HS, Hassan ZF. Role of dobutamine stress test and speckle tracking in ischemic heart disease, comparative study. Med J Babylon 2024;21:621-6.

Access this article online	
Quick Response Code:	**Website:** https://journals.lww.com/mjby
	DOI: 10.4103/MJBL.MJBL_1300_23

definitive diagnosis.[10] Echocardiography, particularly stress echocardiography, is a valuable noninvasive technique for detecting CAD and assessing global and regional systolic function.[11,12]

Stress echocardiography, performed with physical or pharmacological stress, induces transient changes in LV regional function during stress, aiding in the detection of myocardial ischemia.[13,14] Dobutamine stress echocardiography (DSE) is commonly used, involving the infusion of dobutamine, a sympathomimetic agent, to increase heart rate and myocardial contractility.[15] It provides valuable diagnostic information in cases where exercise stress testing is contraindicated or yields inconclusive results.[16-19]

To enhance diagnostic accuracy and overcome the limitations of visual assessment, 2D-speckle tracking echocardiography (STE) has emerged as a promising technique. STE enables the assessment of myocardial strain and strain rate in multiple dimensions, providing valuable information about myocardial function.[20-25]

In this context, our study aims to examine the feasibility and diagnostic accuracy of using speckle tracking during DSE in patients with moderate risk for CAD. We will investigate the role of longitudinal strain as an early marker of ischemia and its potential to improve sensitivity and specificity in detecting CAD.

Materials and Methods

Study design and patients

The study was a cross-sectional study conducted at Shaheed-Al Mehraab Cardiac Center in Hilla City from February 2023 to June 2023 on individuals with a moderate probability of CAD. A cross-sectional study was conducted with patients with a moderate risk of CAD who had resting normal wall motion. The study included patients with a moderate risk of CAD and good LV systolic function with LV ejection fraction (EF) ≥53% and no regional wall motion abnormalities at rest. Patients with left bundle branch block were also included.

The patients with undefined results of the treadmill test or who were unable to exercise were considered for inclusion. Patients with acute coronary syndrome, prior percutaneous coronary intervention or coronary artery bypass grafting, unstable angina, LV EF <53%, history of cardiovascular, significant valvular heart disease, prosthetic valves, or congenital heart disease were excluded from the study. Patients with permanent atrial fibrillation, atrioventricular block, complex ventricular arrhythmias, hypersensitivity to contrast agents, severe renal impairment, or advanced liver disease were also excluded. Patients with a poor acoustic window preventing proper evaluation of all myocardial segments were not included.

A self-constructed survey form was used to collect data from patients or their relatives, including information about age, sex, weight, past medical history (diabetes, hypertension), and personal habits like smoking. Body mass index (BMI) was calculated using weight and height data. Transthoracic echocardiography was performed using GE Vivid E9 ultrasound system equipment with an M5S-D probe. Echocardiographic imaging included 2D images and speckle tracking with DSE.

Statistical analysis

All values are expressed as mean ± standard deviation. Data were analyzed by SPSS version 27 (SPSS, IBM Company, Chicago, llinois) and Microsoft Excel. Categorical variables were analyzed by Chi-square test. Student *t* test was used for comparing means between two groups, with a *P*-value of ≤0.05 considered significant. Inter-rater agreement was evaluated using Kappa (κ) to compare DSE or global longitudinal strain (GLS) analysis with coronary angiography, considered the gold standard, with κ of 1 indicating perfect agreement.

Ethical approval

The study was conducted following ethical principles based on the Helsinki Declaration, with official permission obtained from relevant health offices and hospitals and verbal informed consent obtained from patients. The study protocol, the subject information, and the consent form were reviewed and approved by a local committee on publication ethics at Babil Health Directorate under reference no. 368 on July 22, 2022.

Results

A total of 57 patients with chronic stable angina were scheduled for DSE to investigate suspected CAD. Fifteen patients were excluded for difficulty in follow-up, poor image quality, or nonconclusive test results, leaving 42 patients enrolled in the study [Table 1].

These patients were divided into two groups based on CATH results: the CAD-negative group (28 patients, 66.7%) and the CAD-positive group (14 patients, 33.3%). The mean age ± SD of the CAD-negative group

Table 1: Demographic and clinical variables of the study group (n = 42)

		NO CAD (n = 28)	CAD (n = 14)	P value
Age (years)	Mean ± SD	66.7 ± 7.2	64.2 ± 11.6	0.41
	Range	50-85	41-84	
Gender, n (%)	Male	6 (21.4)	8 (57.1)	0.03
	Female	22 (78.6)	6 (42.9)	
BMI	Mean±SD	25.64 ± 2.24	25.78 ± 1.71	0.84
Past medical history, n (%)	HTN	18 (64.2)	10 (71.4)	0.57
	DM	9 (32.1)	5 (35.7)	0.49
	Family HX	7 (25)	1 (7.14)	0.06
	Smoking	2 (7.14)	2(14.28)	0.17

was 66.7 ± 7.2 years, and the CAD-positive group was 64.2 ± 11.6 years. Gender distribution showed a significant association with the study group ($P < 0.03$), with 78.6% females in the CAD-negative group and 42.9% females in the CAD-positive group Figure 1.

During DSE, the CAD-negative group showed a significant decrease from rest to peak dose dobutamine test in EDV, ESV, ESD, and EDD ($P < 0.001$, [Table 2]) and a significant increase in EF and GLS at peak dose ($P < 0.001$, $P < 0.005$, respectively, [Table 2]). The CAD-positive group had a significant association with increased ESV, WMI, and TID mean ± SD ($P < 0.033$, $P < 0.003$, $P < 0.02$, respectively, [Table 2]) and a significant decrease in EF and GLS at peak dose ($P < 0.019$, $P < 0.003$, respectively, [Table 2]).

All patients had normal BP and HR at the beginning of the examination, with no significant difference in DBP and HR growth between the CAD-positive and CAD-negative groups [Table 2]. However, SBP in the CAD-positive group significantly increased from rest to peak stress ($P < 0.008$, [Table 2]).

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Among the study group, 73.8% of patients didn't develop any complications during DSE, while 11.9% experienced chest pain, 4.7% had hypotension, 4.7% developed hypertension, and 2.4% had arrhythmia [Table 3].

GLS results at rest showed that 80% of participants had normal resting GLS, while 14.2% had LAD and 2.4% had LMCA, 2.4% had 3VD [Figure 2]. After DSE, 76.1% were normal, 16% had LAD, and 2.4% had LMCA and 3VD [Figure 3].

After the DES test, GLS shows that among 42 participants, 71.4% of them had normal WMA, 19% had LAD, and 2.4% had LMA, 3VD, RCA, and CIRX, respectively [Figure 4]. Catheterization results showed normal findings in 66.7% of participants, 21.4% had LAD, 4.8% had RCA, while 2.4% had CIRX, LMCA, and 3 VD each [Table 4].

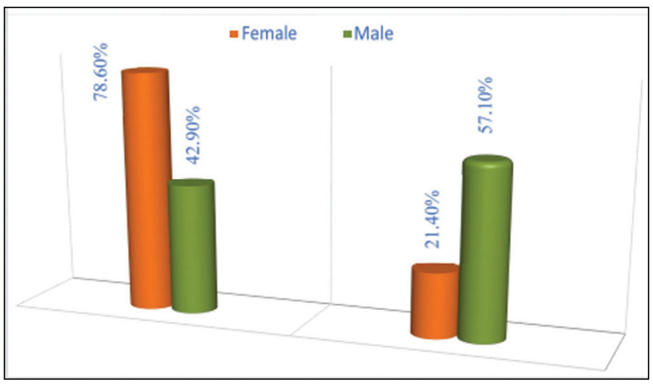

Figure 1: Gender distribution of the study sample

Table 3: Clinical complications during DSE

Complications	No.	%
None (*N*/%)	31	73.8
H.T (*N*/%)	2	4.7
Hypotension (*N*/%)	2	4.7
Chest pain (*N*/%)	5	11.9
SOB (*N*/%)	1	2.4
Bigeminy, arrhythmia (*N*/%)	1	2.4

Table 2: Echocardiographic variables comparison of each group during rest and stress test

	No CAD ($n = 28$)				*P* Value	CAD ($n = 14$)				*P* value
	Rest		Peak dose			Rest		Peak dose		
	Mean	± SD	Mean	± SD		Mean	± SD	Mean	± SD	
Heart rate (BPM)	71.9	9.6	124.3	9	0.001*	68.9	7.6	124.1	9.8	0.001*
Systolic BP (mmHg)	141	12	141	24	0.826	140	22	157	20	0.008
Diastolic BP (mmHg)	81	10	80	13	0.799	80.7	12	85	14	0.102
EF%	0.59	0.02	0.63	0.03	0.001*	0.57	0.02	0.51	0.07	0.019
EDV	99.5	14.6	84.4	13	0.001*	97	17	103.1	15.5	0.260
ESV	41.5	8.2	31.5	7.9	0.001*	39.3	9.7	49.6	13.5	0.033
EDD	46.4	3	43.5	3	0.001*	44.9	6.7	47	2.5	0.203
ESD	33.8	3	30.7	3.2	0.001*	34.7	3.4	33	10.7	0.591
GLS	-19.9	1.6	-20.4	1.7	0.005	-17.3	1.6	-15.1	2.3	0.001*
WMI	1	0	1.01	0.2	0.161	1	0	1.24	0.18	0.003*

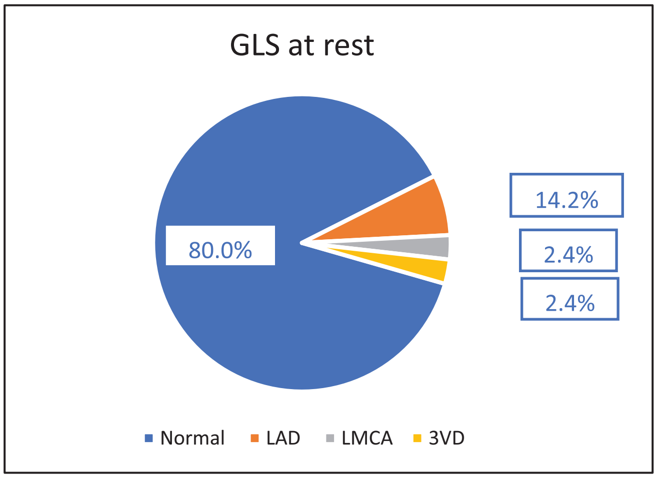

Figure 2: Results of GLS at rest

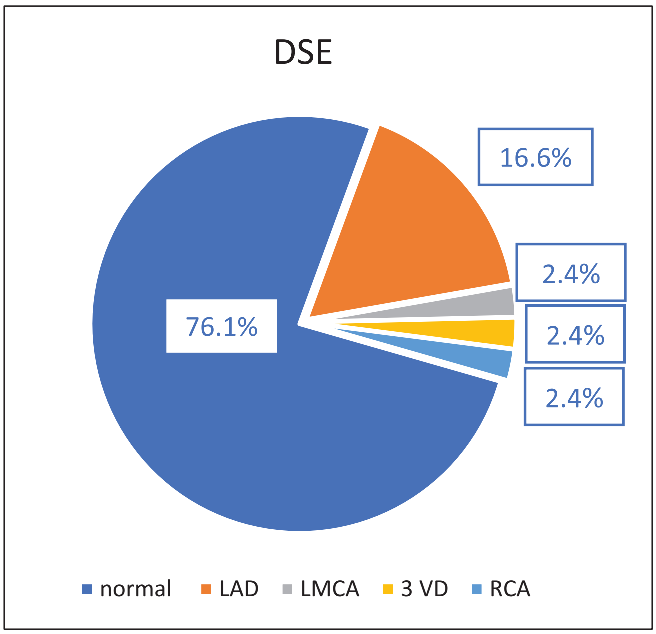

Figure 3: Results of DSE

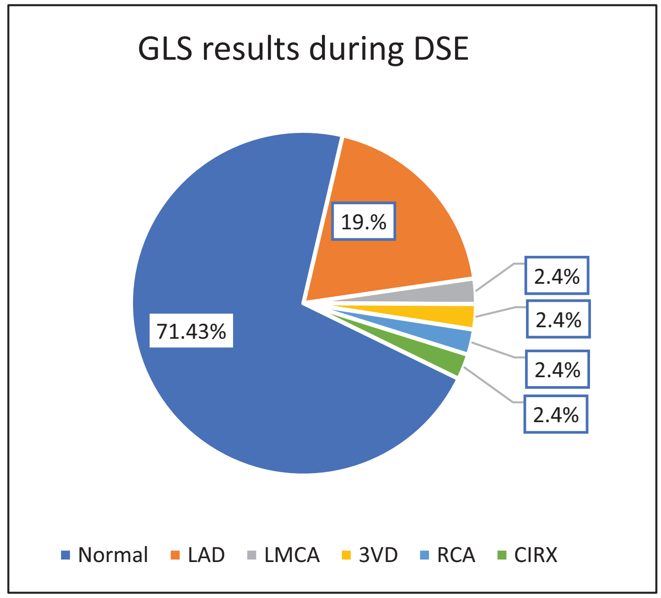

Figure 4: GLS results during DSE

Table 4: Catheterization results of the study group (n = 42)

Cath. results	Frequency	Percent
Normal	28	66.7
CIRX	1	2.4
RCA	2	4.8
LAD	9	21.4
LMCA	1	2.4
3 VD	1	2.4
Total	42	100.0

Table 5: Validity of DSE and STE (at rest and stress) for detecting the presence of CAD

Variable	SN (%)	SP (%)	PPV (%)	NPV (%)	KAPPA	*P* value
DSE	71.4	92.8	83.3	86.6	0.66	<0.001
STE at rest	57.1	85.7	66.6	80	0.46	<0.001
STE at stress	85.7	92.8	85.7	92.8	0.78	<0.001

The sensitivity and specificity of DSE were 71.4% and 92.8%, respectively, with positive and negative predictive values of 83.3% and 86.6%. The sensitivity and specificity of STE at rest were 57.1% and 85.7%, respectively, and at stress, they were 85.7% and 92.8%, respectively ($P < 0.001$, [Table 5]).

Discussion

DSE has been widely used as a sensitive diagnostic tool for detecting inducible ischemia in patients with suspected CAD. However, its subjective nature has limitations, primarily relying on the operator's experience in image acquisition and interpretation. To address this, STE has emerged as an objective method for assessing regional wall function, providing quantifiable data, and potentially improving the objectivity of DSE in revealing inducible ischemia.[26,27]

The results of our study showed that measuring GLS during DSE proved to be a suitable method for detecting myocardial ischemia, with a better agreement (kappa = 0.78) than the traditional DSE visualization approach and GLS at rest, along with good sensitivity and specificity. This is consistent with recent studies suggesting that STE can enhance the sensitivity of DSE in detecting myocardial ischemia.[26,27]

In our study, we performed coronary angiography (CATH) in all patients to validate the DSE results. Among patients with a negative DSE result, there were a few cases of false-negative results, likely due to global LV hyperkinesia induced by stressors, leading to the masking of minor wall motion hypokinesia. Collateral circulation growth may also contribute to the underestimation of ischemia under certain circumstances. On the other hand, in patients with a positive DSE result, there were a couple of cases of false-positive results with intact coronary arteries. Mechanisms contributing to false-positive stress echo results include wall motion disturbance of adjacent regions, disturbances of regional/global loading conditions, and microvascular abnormalities.[18,19]

Comparing our DSE results with CATH, we found a sensitivity of 71.4% and specificity of 92.8%, with positive and negative predictive values of 83.3% and 86.6%, respectively. These results align with other studies, which have reported sensitivities ranging from 79% to 83% using the wall motion abnormality index during DSE.[28] However, the use of strain and strain rate analysis during DSE might further increase sensitivity up to 90.9%, as suggested by discriminant function analysis.

Resting echocardiography revealed no statistically significant difference between the CAD-positive and CAD-negative groups, except for GLS results, which were lower among patients with significant CAD. GLS showed sensitivity and specificity of 57.1% and 85.7%, respectively, using a cutoff value of >-17.9 (according to ASE guidelines). These findings are in line with previous studies, which have consistently demonstrated significantly lower GLS values among patients with significant CAD, showing sensitivities ranging from 51% to 74% and specificities ranging from 58% to 81%.[29,30]

During DSE, GLS dynamics showed a minor drop in the CAD-positive group, while it significantly increased in the CAD-negative group. At peak stress, GLS demonstrated sensitivity and specificity of 85.7% and 92.8%, respectively. These results are consistent with other studies that have also reported comparable sensitivities and specificities of GLPS at peak stress during DSE.[31,32] Furthermore, adding STE to DSE has been shown to increase sensitivity and specificity, emphasizing the potential value of combining these two techniques for enhanced diagnostic accuracy.[33]

Our study has certain limitations, including its small sample size and predominance of LAD disease, which may limit the generalizability of the findings to other CAD pathomorphological types. ADditionally, technical issues during STE, such as suboptimal visualization in cases with high heart rates and the lack of defined cutoff values for confident use, remain potential limitations of the technique.

In conclusion, our study highlights the potential of GLS measured during DSE as a reliable method for detecting myocardial ischemia in patients with suspected CAD. Combining DSE and STE may offer a more objective and accurate approach in the diagnosis of inducible ischemia. Further research with larger sample sizes and standardized cutoff values for STE analysis is warranted to validate these findings and establish its clinical utility.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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