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Original Article

Can dobutamine stress echocardiography predict improvement of left ventricular dyssynchrony after coronary artery bypass grafting?

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Abstract

Background: For patients with advanced, diffuse Coronary artery disease (CAD), surgical myocardial revascularization via coronary artery bypass grafting (CABG) continues to represent the gold standard therapeutic approach. Given the paucity of studies demonstrating CABG benefits in patients with significant left intraventricular dyssynchrony (LVD), we conducted this study to evaluate how viable myocardial tissue volume, quantified by dobutamine stress echocardiography (DSE), predicts postoperative LVD improvement.

Methods: This investigation employed a cross-sectional analytical design to assess 30 CABG candidates with moderate-severe ischemic cardiomyopathy. Myocardial viability evaluation utilized dobutamine stress echocardiography, complemented by tissue Doppler Imaging for synchronized assessment of regional LV contractility.

Results: Demographic analysis revealed a study population aged 61.5±7.9 years (range: 47 to 85 years), comprising 73.3% males. Left ventricular ejection fraction (LVEF) measurements improved from 32.2±4.6% at baseline to 39.6±5.2 % following surgical revascularization ($p<0.001$). Postoperative resolution of left ventricular dyssynchrony occurred in 9 patients (30.0 %), whereas 19 patients (63.3 %) showed no improvement ($p<0.001$). Two patients (6.6 %) died due to progressive heart failure and inadequate revascularization.

Conclusion: Our current study demonstrates significant postoperative improvements in LVEF, LVEDD, and left ventricular dyssynchrony. However, given that approximately two-thirds of cases showed only minimal improvement in dyssynchrony, it would be reasonable to consider cardiac resynchronization therapy (CRT) for these patients.

Keywords: Dobutamine stress echocardiography, Coronary artery bypass grafting**,** Left ventricular dyssynchrony.

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Congestive heart failure (CHF) is one of the major causes of death, especially in elderly patients. The main reason for CHF is coronary artery disease (CAD), a condition that predisposes patients to left ventricular dyssynchrony (LVD). Multi-vessel involvement causes more extensive ischemia, which has been proven to significantly contribute to mechanical dyssynchrony (1). In developed countries and some developing ones, CAD is the most common reason for hospitalization, since medical treatments for CAD are largely palliative, alternative procedures such as coronary artery bypass grafting or cardiac resynchronization therapy have been increasingly receiving attention (2, 3). Recent systematic reviews have established a significant correlation between pre-CABG viable myocardium volume and improved long-term survival outcomes. Current evidence indicates that patients with ischemic cardiomyopathy who undergo prompt surgical revascularization experience reduced mortality rates when compared to those receiving solely pharmacological management (4).

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Clinical evidence demonstrates that coronary artery bypass grafting (CABG) enhances disease-free survival among patients experiencing myocardial ischemia with angina pectoris. However, the therapeutic benefits of surgical revascularization for cases presenting with systolic dysfunction and primary dyspnea symptoms continue to be poorly defined. Early observational studies have emphasized the role of viable myocardial tissue as a prognostic marker in patients with systolic dysfunction who are candidate for CABG. Despite these anecdotal reports, many patients with substantial viable myocardial tissue do not experience long-term benefits from surgical revascularization. Alternatively, several investigations have documented enhanced clinical results following revascularization procedures in ischemic heart failure cases, independent of the extent of preserved myocardial viability. This discrepancy underscores the limited predictive value of viable myocardial tissue for postoperative outcomes following CABG (5). Both left intraventricular dyssynchrony (defined as ≥60 ms delay) and significant viable myocardial tissue have independent prognostic values. Contemporary data indicate that mechanical dyssynchrony in the left ventricle demonstrates stronger predictive value for both immediate postoperative complications and extended mortality risk than conventional parameters (6). Given the limited evidence regarding CABG outcomes in patients exhibiting marked left ventricular mechanical dyssynchrony, this investigation was designed to examine whether DSE-quantified viable myocardium predicts postoperative synchrony restoration.

Methods

This investigation employed a cross-sectional analytical design to evaluate 30 individuals diagnosed with moderate-to-severe ischemic cardiomyopathy and scheduled for coronary artery bypass grafting (CABG) at Madani medical center. The investigation adhered strictly to ethical guidelines established by the Helsinki Declarations. Prior to enrollment, all study subjects received detailed information about the research objectives and procedures, following which written informed consent was secured. The institutional review board at Tabriz University granted ethical approval for the study protocol (Tabriz University of Medical Sciences, 90/3-6/13). Exclusion criteria encompassed several cardiac conditions: valvular pathology, non-sinus rhythm, cardiomyopathy of non-ischemic origin, previous CABG procedures, incomplete revascularization, myocardial infarction occurring during the perioperative period, left bundle branch block.

Myocardial viability assessment was conducted using dobutamine stress echocardiography (DSE). Tissue Doppler Imaging was used to measure left ventricular segmental contraction synchrony. Inclusion criteria consisted of: 1) presence of ≥5 viable segments, and 2) left intraventricular dyssynchrony ≥60 ms. All patients underwent re-evaluation with echocardiography and TDI three months post-CABG.

Study protocol: All enrolled participants received comprehensive cardiac imaging evaluations, including both standard echocardiography and tissue Doppler imaging (TDI), within 48 hours preceding their coronary artery bypass graft surgery. These assessments measured multiple cardiac parameters: left ventricular volumetric measurements, ejection fraction quantification, dimensional analysis, and, synchronization patterns.

Additionally, dobutamine stress echocardiography was administered to determine myocardial tissue viability. The imaging protocol utilized the GE Vingmed Vivid 7 ultrasound platform (Horten, Norway) featuring specialized 2.5-MHz transducer technology. Quantitative analysis of ventricular volume, and pump function employed the apical four-chamber and two-chamber views with biplane volumetric calculation methodology. Ventricular synchrony patterns were characterized through pulsed-wave tissue Doppler analysis. For viability assessment, the left ventricle was systematically divided into 16 distinct regions (comprising 4 apical, 6 mid-ventricular, and 6 basal segments) for detailed evaluation.

Assessment of left ventricular dyssynchrony by tissue doppler imaging: The assessment of left ventricular mechanical dyssynchrony was performed through pulsed-wave tissue Doppler analysis. This technique involved precise measurement of temporal intervals between QRS complex initiation and maximal systolic contraction velocities across twelve distinct ventricular regions-comprising six basal and six mid-ventricular sections from various myocardial walls (inferolateral, inferoseptal, anterior, posterior, anteroseptal, and lateral). Methodological protocol required acquisition of data across three complete cardiac cycles for each myocardial segment, with subsequent calculation of mean values.

Quantitative analysis focused on determining inter-segmental timing disparities by computing the temporal difference in peak systolic velocities between the most rapidly contracting (Tf) and most delayed (Ts) segments within the basal and mid-ventricular regions (expressed as Tf-Ts interval). Based on established clinical criteria, mechanical dyssynchrony was considered hemodynamically significant when this septal-to-lateral delay exceeded 60 milliseconds (7).

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Assessment of myocardial viability by DSE: Patients underwent DSE after a 5-hour fast while continuing all prescribed medications. Standard echocardiographic views (apical 4-, 2- and 3-chamber plus midventricular short axis) were digitally archived. A graduated dobutamine infusion protocol was initiated (starting at 5 µg/kg/min, increasing by 5 µg/kg/min increments every 3 minutes to a maximum of 20 µg/kg/min). Pre-dose escalation imaging captured all standardized views.

Continuous ECG monitoring and tri-minute blood pressure measurements ensured patient safety. Rest and stress images were compared simultaneously in the same views by a single operator. Wall motion analysis was performed according to the standardized 16-segment model endorsed by the American Society of Echocardiography. Segmental systolic function was graded using a four-tier scoring system:

1= Normal/hyperkinetic contraction
2= Reduced wall thickening (hypokinesis),
3= Absent thickening (Akinesis),
4= Paradoxical motion (dyskinesis) (8, 9).

Ventricular function was quantified using Simpson's biplane technique, measuring ejection fraction both at baseline and during pharmacologic stress with dobutamine. Significant contractile reserve was identified when ≥ 5 neighboring segments demonstrating baseline dysfunction showed enhanced systolic thickening during stress.

Statistical analysis: Descriptive statistics presented categorical data as counts (percentage) and continuous variables as mean±SD. Comparative analyses employed:

- Independent samples t-test for normally distributed continuous variables
- Fisher's exact or chi-square tests for categorical comparisons (SPSS v22; IBM Crop). Statistical significance threshold was set at $p<0.05$

Results

The study population had an average age of 61.5 years (SD±7.9), with ages ranging from 47 to 85 years. Males constituted approximately 73 % of the participants. The most common presenting symptom was chest discomfort (86.7%), followed by dyspnea (13.3%). Comorbidities included hypertension (50%), diabetes (23.7%), and hypercholesterolemia (10%). Nearly all patients (96.7%) had documented evidence of previous myocardial infarction (MI). Coronary artery disease severity distribution was as follows: three-vessel disease (63.3%), two-vessel disease (33.3%), and one-vessel disease (3.3%). The mean number of affected vessels was 2.6±0.56. Coronary artery involvement patterns showed the following distribution among patients: Left main (6.7 %), left anterior descending (93.3 %), left circumflex (83.3 %), and right coronary artery (73.3 %) (table 1).

Table 1. Characteristics of patients

Characteristics	Value
Mean age (years)	61.5±7.9
Male	73.3%
Chest discomfort	86.7%
Dyspnea	13.3%
Hypertension	50%
Diabetes	23.7%
Hypercholesterolemia	10%
Previous myocardial infarction	96.7%
Three-vessel disease	63.3%
Two-vessel disease	33.3%
One-vessel disease	3.3%
Left main coronary artery involvement	6.7%
Left anterior descending coronary artery involvement	93.3%
Left circumflex coronary artery involvement	83.3%
Right coronary artery involvement	73.3%

Preoperative evaluation revealed a mean left ventricular ejection fraction (LVEF) of 32.2±4.6 %, which showed significant improvement to 39.6±5.2 % post-CABG ($p<0.001$). Cardiac dimensions demonstrated notable changes following surgical intervention, with left ventricular end-diastolic diameter (LVEDD) reducing from 5.6±0.6 cm preoperatively to 5.2±0.7 cm postoperatively ($P<0.001$). Similarly, left ventricular end-systolic diameter (LVESD) measurements decreased from 4.5±0.6 cm before surgery to 4.1±0.8 cm after the procedure ($p<0.001$). Table 2 summarizes echocardiographic findings before and after CABG. In 9 patients (30.0 %), left ventricular dyssynchrony resolved after CABG, whereas in 19 patients (63.3 %), there was no change ($p<0.001$). Two patients (6.6%) died due to progressive heart failure and unsuccessful revascularization

Table 2. Echocardiographic findings before and after CABG

Variable	Pre-CABG	Post-CABG	P-value
LVEF*(%)	32.20±4.67	39.68±5.20	<0.001
LVEDD(cm)**	5.61±0.61	5.21±0.72	<0.001
LVESD*(cm)**	4.56±0.66	4.10±0.82	<0.001
LVD**(msec)**	138.6±55	119.8±58.6	<0.001

*Left Ventricular Ejection Fraction, **Left Ventricular End Diastolic Diameter, ***Left Ventricular End Systolic Diameter, ****Left ventricular dyssynchrony

Discussion

In ischemic CHF, impaired cardiac contractility progresses to intraventricular dyssynchrony, characterized by uncoordinated segmental contraction. This mechanical dyssynchrony progressively worsens left ventricular systolic function and ejection fraction, resulting in diminished systemic perfusion and aggravated angina symptoms (1, 10). Patients with multivessel coronary artery disease continue to drive superior long-term survival benefits from coronary artery bypass grafting (CABG), maintaining its status as the gold-standard revascularization approach. Given its associated surgical risks, appropriate patient selection is paramount, with studies consistently demonstrating that myocardial viability is a key predictor of postoperative functional recovery. In systolic heart failure, early revascularization correlates with improved survival. Although CABG offers established advantages for ischemic cardiomyopathy patients experiencing angina, its efficacy remains uncertain in asymptomatic cases (11). This may be related to the fact that relying solely on the amount of viable myocardium to predict CABG benefit could be misleading (12). Our investigation assessed dobutamine stress echocardiography´s predictive capacity for left ventricular synchrony restoration following coronary artery bypass surgery. The cohort comprised predominantly male participants (73.3 %) with a mean age of 61.5±7.9 years. The sixth decade represents the peak age for ischemia-induced heart failure, a condition consistently shown to be more prevalent in males across most studies (13). Nearly all participants (96.7%) in the investigation reported prior myocardial infarction. Hypertension, diabetes, and hypercholesterolemia were present in 50%, 23.7%, and 10% of patients, respectively, which is consistent with other studies (14). The study revealed coronary artery involvement patterns with the following distribution: left main (6.7%), left anterior descending (93.3%), left circumflex (83.3 %), and right coronary artery (73.3%). These prevalence rates correlate with existing literature reports (15). Our analysis demonstrated a marked postoperative elevation in left ventricular ejection fraction (LVEF) accompanied by decrease in both end-diastolic and end-systolic dimensions. Notably, 30 % of cases achieved complete resolution of left ventricular dyssynchrony. Consistent with our findings, Babaee Beigi et al. reported significant improvements in LV dyssynchrony and both systolic and diastolic function following CABG in cardiomyopathy patients (16). Gibson et al. demonstrated that while CABG fails to induce lasting modification in isovolumic ventricular performance, regional hypokinesis, or wall motion abnormalities, it achieves significant reduction in ejection-phase mechanical asynchrony. This selective improvement suggests ejection-phase asynchrony serves as a specific marker of preoperative coronary perfusion deficits (17). As in our study, a comparable pattern of dyssynchrony improvement after CABG was noted in these reports.

In the present study, we highlight several key findings: First, we evaluated the impact of viable myocardial tissue volume (quantified by dobutamine stress echocardiography) on LV dyssynchrony improvement post-CABG in patients with significant preoperative dyssynchrony-a previously unexplored relationship in this field. Second, significant improvements in LVEF (from 32.2±4.6% to 39.6±5.2 %, p<0.001) and reductions in LVEDD were observed at 3-month follow-up. Third, while LV dyssynchrony resolved in 9 patients (30 %), it persisted in 19 (63.3 %). Two patients (6.7 %) died from progressive heart failure and inadequate revascularization. Although postoperative LVD improvement was statistically significant (p<0.001), approximately two-thirds of patients showed no functional recovery- a clinically substantial proportion. Both viable myocardium volume and left intraventricular dyssynchrony serve as critical prognostic markers in CABG candidates. Our findings reveal

significant postoperative enhancement of LVEF, LVEDD, and LV dyssynchrony. However, since LV dyssynchrony improved minimally in 67 % of patients, CRT should be considered as adjunctive therapy in this subset.

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