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ORIGINAL ARTICLE

Comparison of Dobutamine and Treadmill Exercise Echocardiography in Detecting and Predicting the Extent of Coronary Artery Disease

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Abstract

Background: Coronary artery disease (CAD) continues to be a major cause of morbidity and mortality worldwide. Timely and precise detection is essential for appropriate intervention and management. Two commonly used non-invasive diagnostic techniques for detecting coronary artery disease are dobutamine stress echocardiography and treadmill exercise echocardiography. This study aimed to compare the effectiveness of dobutamine and treadmill exercise echocardiography for detecting coronary artery disease. Methods: This prospective observational study was conducted at the Department of Cardiology, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh from January 2000 to December 2021. As study subjects, a total of 77 suspected patients of coronary artery disease were enrolled by using a purposive sampling technique. For data analysis MS Office tools and SPSS Version 23.0 were used. Results: In comparing the peak hemodynamic data during dobutamine echocardiography and treadmill exercise electrocardiography, we found statistically significant differences (p<0.05). Additionally, significant differences were observed between the procedures in HR (beats/min), SBP (mm Hg), DBP (mm Hg), mean BP (mm Hg), % max HR, and PRR (mmHg)× HR/100. Significant differences were also found in both maximal and submaximal stress assessments (p<0.001). Conclusion: Echocardiography performed immediately after treadmill exercise induces a greater ischemic burden than dobutamine-atropine infusion. Therefore, in clinical settings where it is feasible, exercise echocardiography should be preferred over dobutamine echocardiography for diagnosing ischemia.

Keywords: Dobutamine, Treadmill exercise echocardiography, Coronary artery disease.

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Introduction

Although it is suggested that dobutamine stress causes ischemia similar in degree and extent to that caused by treadmill exercise, a direct comparison with treadmill exercise, the most common form of exercise, has not been performed.[1] The use of two-dimensional echocardiography for the non-invasive diagnosis of coronary artery disease during exercise[2] and dobutamine infusion has been extensively studied using various stress techniques.[3] Identifying transient regional myocardial dysfunction in the left ventricle through echocardiography provides an earlier and more sensitive indication of myocardial ischemia than electrocardiographic (ECG) changes or chest pain alone.[4]

The two most frequently used stress methods combined with echocardiographic imaging are dobutamine and treadmill exercise.[5] While treadmill exercise remains the

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most popular form of exercise and provides the best workload,[6] dobutamine has become the most widely used pharmacologic stressor. Both treadmill exercise and dobutamine can be combined with cross-sectional echocardiography to enhance the predictive accuracy of stress tests for detecting myocardial ischemia.[1] Each method has its own pros and cons in clinical practice. Dobutamine stress testing is easier to perform, suitable for patients unable to exercise, and permits continuous imaging throughout the procedure. It also provides valuable information on myocardial viability when necessary. However, it requires the insertion of an intravenous cannula, making it a semi-invasive test that can cause unpleasant side effects and often results in uninterpretable ECG readings.[7] On the other hand, treadmill exercise is recognized as the best physiologic stressor available. It is completely noninvasive, well-known to both patients and physicians, and offers additional valuable hemodynamic and ECG information while evaluating the patient's symptoms and functional capacity.[1] However, treadmill exercise echocardiography is technically demanding, requires a digital line loop system to counteract the effects of hyperventilation, cannot precisely determine the onset of ischemia, and may risk missing critical information if reversible mechanical dysfunction resolves too quickly during recovery before echocardiographic imaging can take place.[8]

Although studies have compared dobutamine stress with bicycle echocardiography there is no data directly comparing dobutamine with echocardiography immediately after treadmill exercise.[9,10] This study was therefore conducted to compare the effectiveness of dobutamine and treadmill exercise echocardiography for detecting coronary artery disease.

Materials and Methods

This prospective observational study was conducted in the Department of Cardiology, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh from January 2000 to December 2021. A total of 77 suspected coronary artery disease patients were enrolled using a purposive sampling technique.

Written consent was obtained from all participants before data collection. The entire intervention followed the principles of human research specified in the Helsinki Declaration and was conducted in compliance with current regulations and the General Data Protection Regulation (GDPR).[11,12]

According to the study's inclusion criteria, patients with heart failure, unstable angina, recent myocardial infarction, previous cardiac surgery or coronary angioplasty, congenital or valvular heart disease, uncontrolled hypertension, or documented serious arrhythmia were excluded. Significant coronary artery disease was defined as a reduction of more than 70% in the lumen diameter of any of the three coronary arteries or their primary branches, or more than 50% narrowing of the lumen diameter of the left main coronary artery.

Each patient underwent both dobutamine and exercise treadmill echocardiography on the same day, in random order. A symptom-limited maximal treadmill exercise stress test was conducted following the modified Bruce protocol. The test was stopped if any of the following end points were reached: a systolic blood pressure greater than 220 mm of Hg, a diastolic blood pressure greater than 120 mm of Hg, or the occurrence of serious arrhythmia, either alone or in combination. In comparing the procedures wall motion scores were measured.[13]

Demographic and clinical information for all participants was documented. Data were processed, analyzed, and disseminated using MS Office and SPSS version 23.0. In the statistical analysis, a P value of less than 0.05 was considered significant.

Results

In analyzing the demographic characteristics of our participants, we found that out of the 77 total participants, the majority (84.4%) were male, while 15.6% were female. The mean BMI was 27.1 ± 3.7(kg/m²). Clinically, effort angina and akinesia at rest were observed in 68.8% and 45.5% of the participants, respectively. Regarding vessel involvement, 44.2% of the participants had single vessel disease, 24.7% had double vessel disease, and 19.5% had triple vessel disease.

In this study, we compared the peak hemodynamic data of participants during dobutamine echocardiography and treadmill exercise electrocardiography, and found statistically significant differences with p-values below 0.05. Additionally, when examining peak stress characteristics between exercise immediately following peak dobutamine-atropine infusion and treadmill exercise, we noted no significant differences in positive test results or failed stress tests between the two procedures. However, when comparing the heart rate (HR, beats per minute), systolic blood pressure (SBP, mm Hg), diastolic blood pressure (DBP, mm Hg), mean blood pressure (mean BP, mm Hg), percentage of maximum heart rate (% max HR), and pressure-rate product (PRR, mmHg × HR/100), we found significant differences between the procedures. In

this current study, assessing both maximal and submaximal stress, we observed significant differences between the procedures (p<0.001).

Table-I

Demographic and clinical data (N=77)

Characteristics	n	(%)/Mean ±SD
Gender distribution		
Male	65	84.4%
Female	12	15.6%
BMI, effort angina and akinesia status		
BMI (kg/m^2)	77	27.1 ±3.7
Effort angina	53	68.8%
Akinesia at rest	35	45.5%
Vessel involvement		
Single vessel diseases	34	44.2%
Double vessel diseases	19	24.7%
Triple vessel diseases	15	19.5%
Undefined	9	11.7%

BMI-body mass index

Table-II

Peak hemodynamic data of participants in dobutamine and treadmill exercise echocardiography (N=77)

Characteristics	DE	TEE	p-value
HR (Beat/min)	137.2 ± 26.4	147.1 ± 21.7	0.012
SBP (mmHg)	159.6 ± 29.3	181.7 ± 23.8	<0.001
DBP (mmHg)	102.7 ± 9.8	110.3 ± 14.6	<0.001
PRR, (mmHg) × HR/100	220.6 ± 59.8	346.5 ± 65.4	<0.001

Table-III

Peak stress characteristics between exercise immediately after peak dobutamine atropine infusion and treadmill exercise (N=77)

Variables	DE	TEE	p-value
Positive test results	48 (62.3%)	47 (61.0%)	0.868
Failed stress tests	4 (5.2%)	5 (6.5%)	0.732
HR (beats/min)	143.5 ± 21.2	152.6 ± 16.4	<0.001
SBP (mm Hg)	172.1 ± 24.8	126.7 ± 23.2	<0.001
DBP (mm Hg)	90.2 ± 10.1	69.9 ± 14.8	<0.001
Mean BP (mm Hg)	117.5 ± 14.1	87.7 ± 15.9	<0.001
% max HR	86.8 ± 13.1	93.8 ± 13.2	<0.001
PRR (mmHg) × HR/100	245.8 ± 57.7	193.9 ± 38.3	<0.001

Table-IV

Comparison of total number of positive stress test results obtained with exercise and dobutamine stress echocardiography during maximal and submaximal stress (N=77)

Variables	DE	TEE	p-value
	Mean ±SD		
Maximal stress	77.2 ±6.7	69.5 ±6.1	<0.001
Submaximal stress	62.5 ±5.2	39.5 ±4.9	<0.001

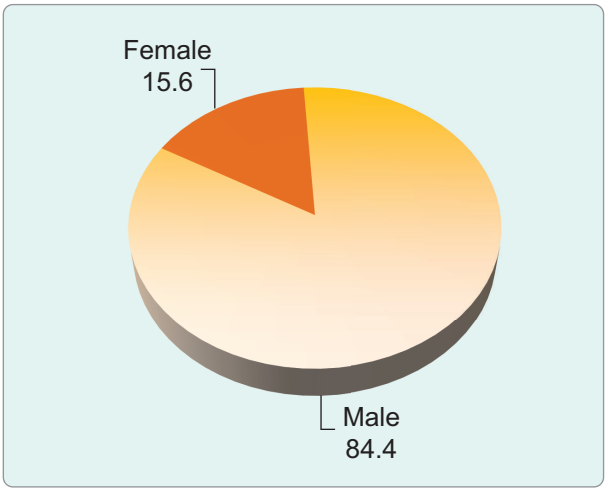

Figure 1: *Pie chart showed gender wise participant (N=77)*

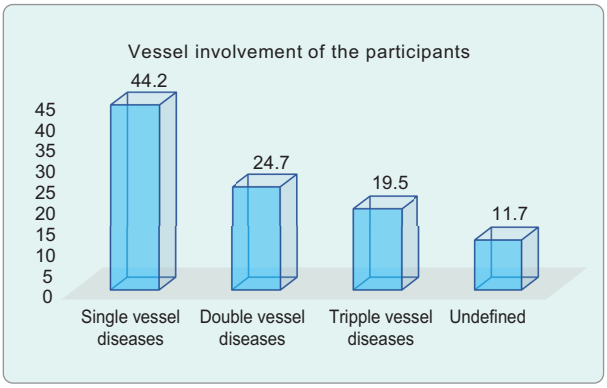

Figure 2: *Column chart showed vessel involvement wise participant (N=77)*

Discussion

The objective of this study was to compare the effectiveness of dobutamine and treadmill exercise echocardiography for detecting coronary artery disease.

In this study, the majority of participants were male, with a mean BMI (kg/m²) of 27.1 ± 3.7. Effort angina was present in 68.8% of the participants, and akinesia at rest was observed in 45.5%. Rallidis et al reported similar demographic characteristics.[13] Significant differences in peak hemodynamic data during dobutamine echocardiography and treadmill exercise electrocardiography were found. These findings are consistent with results from other studies.[13,14]

In this study, when analyzing peak stress characteristics between exercise immediately following peak dobutamine-atropine infusion and treadmill exercise, we observed no significant differences in positive test results or failed stress tests between the procedures. However, when comparing heart rate (HR, beats/min), systolic blood pressure (SBP, mm Hg), diastolic blood pressure (DBP, mm of Hg), mean blood pressure (mean BP, mm of Hg), percentage of maximum heart rate (% max HR), and pressure-rate product (PRR, mm of Hg × HR/100), we found significant differences between the procedures. Assessing both maximal and submaximal stress revealed significant differences between the procedures. Similar findings were noted in other studies.[13,15]

During treadmill exercise, the increase in heart rate is primarily attributed to sympathetic stimulation and, to a lesser extent, parasympathetic withdrawal. Systemic vascular resistance slightly decreases, while stroke volume increases due to the Frank-Starling effect, predominantly driven by increased venous return facilitated by sympathetic vasoconstriction of the large-capacitance veins and the pumping action of muscle contractions.[16] Despite the reduction in peripheral resistance, the significantly greater increase in cardiac output leads to an elevation in systolic blood pressure.[13]

Limitation of the study

This single-centered study had a small sample size and was conducted over a short period. Therefore, the findings may not accurately reflect the overall situation in the entire country.

Conclusion & Recommendation

Echocardiography performed immediately after treadmill exercise induces a greater ischemic burden compared to dobutamine–atropine infusion. This suggests that, in a clinical setting, exercise echocardiography should be preferred over dobutamine echocardiography for diagnosing ischemia, when feasible. The enhanced ischemic response during exercise echocardiography may lead to more accurate and reliable detection of ischemic conditions, ultimately improving diagnostic outcomes and patient care. Therefore, incorporating exercise echocardiography into routine practice can provide significant benefits in the assessment of ischemia.

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