

ORIGINAL PAPER

The Role of Dobutamine Stress Echocardiography in Detecting Coronary Artery Disease Compared With Coronary Angiography

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Background: Ischemic heart disease (IHD) causes more deaths, disability and economic loss in developed and developing countries than any other disease. Our country belongs to the group of countries in transition, and it has seen a continuous growth in mortality and morbidity rates caused by cardiovascular diseases. An early, accurate and fast diagnosis of the myocardial ischemia is the main step toward reducing patient morbidity and mortality, and hospital costs. It also reduces prolonged diagnostic observation, defines the strategy of approach and etiological treatment in order to prevent serious complications. **Objectives:** The aim of this study is to examine the occurrence of segmental wall motion abnormalities during pharmacological stress and measurement of coronary flow reserve in order to establish the diagnostic value of Dobutamine stress echocardiography in detecting and assessing the degree of myocardial ischemia and coronary stenosis in patients with suspected coronary artery disease, and to justify its wider application as a non-invasive diagnostic method. **Methods:** The research study covered 86 adult subjects of both genders, referred to dobutamine stress echocardiography test and assessment of coronary flow reserve as part of their cardiological evaluation. **Results:** The study results obtained indicate a high degree of sensitivity (97%), specificity (83%) and accuracy (95%) of the dobutamine stress echocardiography as a non-invasive diagnostic method compared to invasive diagnostics i.e. coronary angiography. Measurement of coronary flow reserve represents a strong diagnostic and prognostic tool in evaluation patients with suspected CAD. **Conclusions:** The Dobutamine stress echocardiography (DES) has come a long way as a diagnostic tool, from detecting myocardial ischemia, viability, and prognostics to problems underlying the coronary artery diseases. The safety and cost-effectiveness of the Dobutamine stress echocardiography as a diagnostic procedure has been proved. In modern cardiology, the DSE occupies a significant place in the evaluation of patients with known or suspected coronary artery disease, which has contributed to its accessibility and availability in a great number of centers. **KEY WORDS:** DOBUTAMINE, STRESS ECHOCARDIOGRAPHY, CORONARY FLOW RESERVE, CORONARY ANGIOGRAPHY.

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1. INTRODUCTION

Industrial and technological revolution associated with the economic and social transformation has resulted in a dramatic change of the disease responsible for morbidity and death (1, 2, 3, 4, 5). While in the 19 century, infectious diseases and malnutrition were the biggest cause of death today, at the beginning of 21 century, cardiovascular disease (CVD) and neoplasms were found dominant health problems (6, 7, 8, 9).

Continuous development of economic opportunities, urbanization, radical changes in the nature of work-related activities and dramatic changes in lifestyle lead to a larger number of risk factors (stress, obesity, physical inactivity, elevated blood sugar and blood lipids, smoking and alcohol consumption) that directly affect the morbidity and mortality from cardiovascular diseases (10, 11, 12, 13, 14, 15).

Early diagnosis of ischemic myocardial disease is an essential step towards reducing morbidity and mortality related to ischemic heart disease. The timely detection and diagnosing heart disease before its severe manifestations such as sudden death, myocardial infarction and heart failure is a major goal of modern diagnostic cardiology.

2. RESEARCH OBJECTIVES

Ischemic heart disease (IHD) causes more deaths, disability and economic loss in developed and developing countries than any other disease. A serious problem in the whole world is ischemic

heart disease (IHD), which causes high mortality, morbidity and disability in people at most productive age. The fight against this disease is one of the foremost health priorities.

The epidemiology of the ischemic heart disease depends on fixed risk factors, such as sex, age and genetic predisposition, and on multiple risk factors that can be addressed, such as elevated lipid levels, arterial hypertension, diabetes mellitus, obesity, lifestyle (physical inactivity and stress), smoking, and alcohol consumption.

An early, accurate and fast diagnosis of the myocardial ischemia is the main step toward reducing patient morbidity and mortality, and hospital costs.

The aim of this Study is to examine the occurrence of segmental wall motion abnormalities and measurement of coronary flow reserve in order to establish the diagnostic value dobutamine during pharmacological stress test in order to evaluate the role of Dobutamine stress echocardiography in detecting and assessing the degree of myocardial ischemia and coronary stenosis in patients with suspected coronary artery disease, and to justify its wider application as a non-invasive diagnostic method.

3. PATIENTS AND METHODS

The retro-prospective study covered 86 adult subjects of both sexes, referred to dobutamine stress echocardiography test as part of their cardiological evaluation. The patients were examined using ATL HDI-3000 ultrasound machine, equipped with a 2,25MHz adult cardiac probe, broadband transducer (2-7Mhz) for assessing coronary flow reserve and MPT7-4 TEE multiplane transesophageal probe.

The state of arte protocol was performed during dobutamine stress test. The drug was infused through an antecubital vein starting from dose 5 µg/kg/min. to maximal dose 40 µg/kg/min. (mean peak dose 36.9 ± 4.3 µg/kg/min.). To achieve 85% age predicted heart rate atropine in mean dose of 1.2 ± 0.8 was added in 54% of studies at the top of maximal dobutamine dose. Echocardiographic evaluation of LV wall motion was performed before and each step of dobutamine infusion, with the

patients in the supine left lateral position. LV wall motion was evaluated in 17 segments. Positive stress echocardiography result was defined as the new or extended left ventricular wall motion abnormality. At the same time during test the measurement of coronary flow reserve with high frequency imaging of left anterior descending coronary artery (LAD) was performed.

The patients for whom invasive cardiac diagnostics was indicated following the Dobutamine stress echocardiography were subjected to heart catheterization- angiography. Coronary angiography was performed in all patients and coronary artery disease was defined as significant when diameter stenosis was more than 50%.

Indices of diagnostic methods were calculated as ratio of the following values: sensitivity, specificity, positive predictive value, negative predictive value and accuracy. The parameters obtained and results of each method applied were statistically processed.

4. RESULTS

Among all the patients referred for dobutamine stress echocardiography (DSE) 86 entered the study. Baseline characteristics of the population are depicted in Table 1. Hemodynamic behavior of our patients is shown in Table 2.

Demographics	
Men	56 (65%)
Women	30 (35%)
Age, yrs (SD)	57,1 ± 13
Cardiovascular history and cardiac risk factors	
Hypertension	64 (80%)
Smoking	47 (54%)
Dyslipidemia	64 (74%)
Diabetes Mellitus	29 (34%)
History of heart disease	55 (64%)
BMI ≥ 25kg/m ²	62 (72%)

TABLE 1. Study population and clinical characteristics

In our study, DSE total of 86 patients according to the perceived deterioration of regional abnormalities or development of new regional abnormalities of certain segments of the left ventricle and in accordance with the equivalent distribution of coronary artery flow for all 17 LV segments and es-

tablished the existence of single vessel coronary heart disease in 33 patients (38%), and multiple coronary disease in 41 patients (48%), while normal findings were found in 12 patients (14%).

LV Ejection fraction (EF%)	57.05
Left ventricle end-diastolic volume LVEDV (ml)	153.66
Left ventricle end-systolic volume LVESV (ml)	62.97
Left ventricle end-diastolic diameter LVEDD (mm)	4.74
Heart rate at rest (beats/min.)	68 ± 12
Heart rate at peak (beats/min.)	148 ± 14
Rest systolic blood pressure (mmHg)	131 ± 20
Peak systolic blood pressure (mmHg)	153 ± 31
Rest rate- pressure product	8,944 ± 1,983
Peak rate-pressure product	22,747 ± 2,542
Maximal dobutamine dose ((µg /kg /min.)	36.9 ± 4.3
Atropine use (mg)	1.2 ± 0.8
Resting wall motion score index (WMSI)	1.3 ± 0.7
Number of ischemic segments	3.1 ± 2.1
Normal DSE patients	12
Resting wall motion abnormalities, patients (%)	4 (5%)
New or worsening wall motion abnormalities	70 (81%)

TABLE 2. Echocardiographic and dobutamine stress (DES) data

The involvement of coronary arteries during DSE are shown in Figure 1 and 2. Coronary angiography confirmed normal finding in 12 patients (14%), single vessel disease in 34 patients (40%) and multiple vessel disease in 40 patients (47%). The results of coronary angiography are shown in Figure 3.

Coronary flow reserve measurements

In our study, a total of 86 subjects successfully completed the measurement of coronary flow reserve in 79 patients, or in 92%. Coronary flow velocity reserve (CFR) (initial/peak diastolic velocity) was ≥ 2.5 in regular findings at a flow rate of pathological findings (CFR) was between 0.8 to 2.2 depending on the degree of stenosis of coronary arteries. Our results clearly indicate that the highly reduced coronary flow reserve CFR 0.8 to 1.5 indicates se-

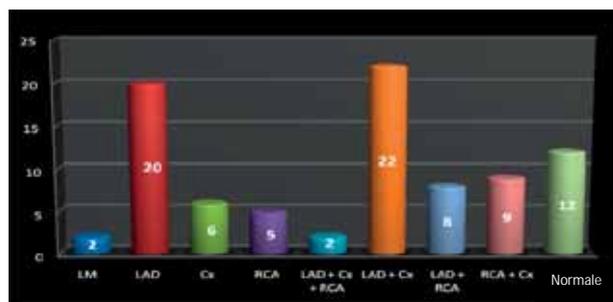


FIGURE 1. Involvement of coronary arteries obtained by dobutamine stress echocardiography (DSE) in all patients

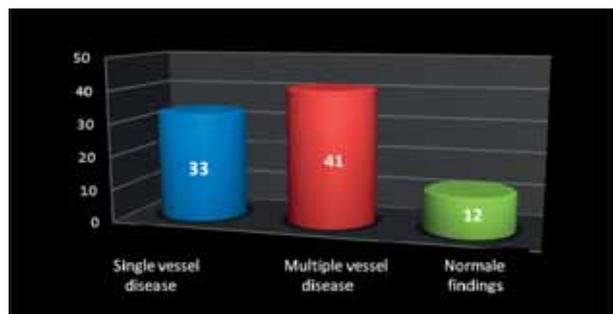


FIGURE 2. Interpretation of dobutamine stress test (DSE) results in all patients

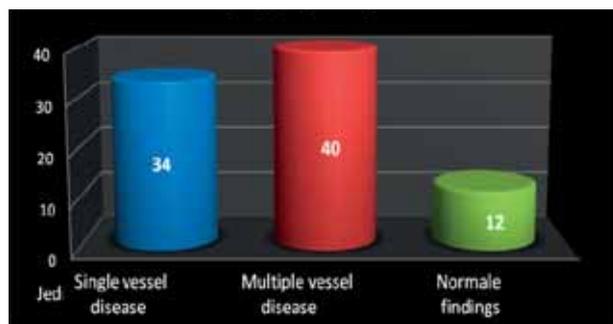


FIGURE 3. Interpretation of results obtained by coronary angiography in all patients

vere coronary artery stenosis \geq , which is found in 38 patients (44%), moderate reduction of coronary flow reserve from 1.5 to 2.2 CFR was found in 29 pa-

tients (34%), clearly indicates a moderate stenosis of the coronary arteries \geq 70%. In 12 patients (14%), coronary flow reserve was preserved CFR \geq 2.5 which is an indirect indication of the normal coronary status figure 5..

Side effects and complications had appears in 38 patients (44%) underwent dobutamine stress echocardiography, and also 38 patients (44%) underwent coronary angiography. The type of side effects and complications are shown in Table 4. In our sample of patients is registered 1 side effect, which can be considered life-threatening, in the form of ventricular tachycardia (VT), and 2 cases of relatively dangerous complications of cardiac arrhythmia in the form of paroxysmal supraventricular tachycardia (SVPT), while 8 patients registered harmless cardiac rhythm disturbances in the form of supraventricular and premature ventricular beats and atrial fibrillation. In our sample was not recorded occurrence of acute infarction, stroke, or death. Among other complications in 6 patients reported chest pain and dys-

pnea, hypotension in 3 patients, headache in 10, transient bradycardia in 2 patients, and 1 allergic reaction.

Arrhythmias	No (%)
Premature ventricular beats Supraventricular and Ventricular	7 (8%)
Atrial fibrillation	1 (1%)
Ventricular tachycardia	1 (1%)
Supraventricular paroxysmal tachycardia (SVPT)	2 (2%)

TABLE 5. Cardiac Arrhythmias caused by dobutamine stress echocardiography test

5. DISCUSSION

Our population showed similar baseline characteristics and hemodynamic response to dobutamine infusion to that reported on previous studies with DSE (16, 17, 18, 19, 20, 21, 22, 23).

The study results obtained indicate a high degree of sensitivity (97%), specificity (83%) and accuracy (95%) of the dobutamine stress echocardiography as a non-invasive diagnostic method compared to invasive diagnostics i.e. coronary angiography, which is the gold standard for the detection and evaluation of coronary artery diseases, identifying possible stenosis, anatomical location and quantifying their percentages. Our results are similar to that reported on previous published studies with DSE shown in Table 6 (16, 17, 19, 20, 21, 22).

In terms of safety stress echocardiography, Sicari R. et al. (2009) (2) authors point out that a minor, but limiting, side effects preclude the achievement of maximal pharmacological stress for <10% of patients with Dobutamine and <5% patients with dipyridamole stress test. The most common, minor and major complications during echo stress. The data highlight some obvious, though sometimes neglected, point: first, pharmacological stress testing should always be performed in the presence of a doctor. Second, every test carries a certain, generally lower risk. Third, all stress tests do not carry the same risk of major side effects. Dobutamine stress testing may be more dangerous than other forms of pharmacologic stress tests. These conclusions come mainly from the multicenter testing, meta-analysis of published papers

Type of side effect and complication	Dobutamine Stress Echocardiography	Coronary angiography	p
Chest pain and Dyspnea	6	9	0.589
Hypotension	3	6	0.493
Transitional bradycardia	2	5	0.440
Arrhythmia	11	9	0.812
Acute myocardial infarction	0	1	-
Cerebrovascular insult CVI	0	0	-
Allergic reaction	1	2	-
Hypertensive response	5	2	0.440
Headache	10	0	0.003
Vagal reaction	0	4	0.129

TABLE 4. Type of side effects and complications in all patients registered in the both methods: dobutamine stress test and coronary angiography

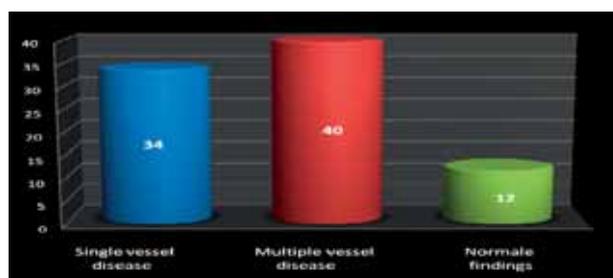


FIGURE 4. Interpretation of results obtained by coronarography in all patients

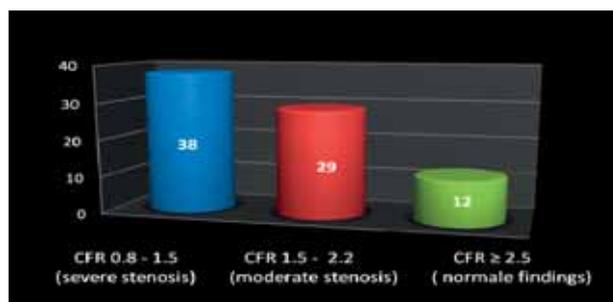


FIGURE 5. The results of measurement of coronary flow reserve in 79 patients

and registers of complications based on prospective data collection (German register), and retrospective data.

In the study, "Safety of Stress Echocardiography (from the International Stress Echo Complication Registry)" Varga A. et al. (2006) (13), authors evaluated the safety of different modalities of stress echocardiography in „real world“. The study comprised 300 centers with 71 researchers and the data were collected for 85 997 patients. From a total of 85 997 patients for dangerous life events were reported in 86 patients: during exercise stress testing in 4, during Dobutamine infusion in 63, and during dipyridamole in 19 patients. From a total of 86 patients with complications 5 died during Dobutamine stress test (ventricular fibrillation in 2, and cardiac rupture in 3 patients), and one patient after dipyridamole test died due to cardiogenic shock. Based on the performed analysis of the study authors conclude that a rate of one life threatening event every 1000 examinations. The authors conclude that stress echocardiography in the "real world" is a safe method but it can occur and possible serious complications.

In addition to testing the regional LV wall motion abnormalities our study included the testing of coronary

flow reserve (CFR) during stress echocardiography, because it offered more information about the state of the coronary arteries about the presence of coronary artery disease. Thus, two information flow and function complement each other with respect to the wall motion abnormality highly specific and normal coronary flow reserve is highly sensitive for coronary disease.

A large number of papers, of which we will mention only significant: Rigo F. (2005), P. Voci et al. (2002), F. Rigo et al. (2006), Meimoun P et al. (2008), Sicari R et al. (2008), R. Sicari et al. (2009) (12, 13, 14, 15) indicating the good results obtained with the assessment of coronary flow reserve during transthoracic or transoesophageal echocardiography for noninvasive

diagnosis of coronary artery disease.

Assessment of coronary flow reserve increases sensitivity in detection of disease of the left anterior descending coronary artery, with a modest loss in specificity (12, 13, 14, 15). However, the use of coronary flow reserve as an independent diagnostic criteria „suffers“ from many practical problems.

6. RESULTS

Dobutamine stress echocardiography (DSE) is an adjustable, comfortable non-invasive tool that provides information on the presence, position and degree of ischemia based on the reaction of regional wall motion to stress, and on the basis of such information, it provides diagnostic and prognostic information on various states of the disease. The DSE enables the evaluation of the severity, affected area and anatomical location of coronary lesion. Lately, the evaluation of coronary flow reserve has been ever more applied, whereby the old dream of combining wall motion with concurrent evaluation of the coronary flow reserve in an echocardiography laboratory has turned into

Author	Stenosis (%) (CAD)	No. of patients	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Accuracy (%)
Sawada et al.	≥50%	103	89	85	91	81	83
Previtali et al.	≥50%	35	68	100	100	44	83
Cohen et al.	≥70%	70	86	95	98	72	89
Mazeika et al.	≥50%	50	78	93	97	62	82
Marcovitz and Armstrong	≥50%	141	96	66	77	91	89
Marwick et al.	≥50%	97	85	82	88	78	84
Forster et al.	≥70%	21	75	89	90	73	81
Segar et al.	≥50%	85	95	82	94	73	92
Marwick et al.	≥50%	217	72	83	89	61	76
Hoffmann et al.	≥70%	64	79	81	93	57	80
Cohen et al.	≥70%	52	86	87	94	72	87
Ostojic et al.	≥50%	150	75	79	96	31	75
Ho et al.	≥50%	54	93	73	93	73	89
Daoud et al.	≥50%	76	92	73	95	62	89
Dagianti et al.	≥50%	60	72	97	95	83	87
Pingitore et al.	≥50%	110	84	89	97	52	85
Schroder et al.	≥50%	46	76	88	97	44	78
Anthopoulos et al.	≥50%	120	87	84	94	68	86
Ling et al.	≥50%	183	93	62	95	54	90
Takeuchi et al.	≥50%	70	75	92	79	90	87
Dionisopoulos et al.	≥50%	288	87	89	95	71	87
Elhendy et al.	≥50%	306	74	85	94	50	76
Ho et al.	≥50%	51	93	82	87	90	88

TABLE 6. Sensitivity and specificity of DSE for detection of coronary artery disease

reality. The Dobutamine stress echocardiography indicate a high degree of sensitivity, specificity and accuracy as a non-invasive diagnostic method compared to invasive diagnostics i.e. coronary angiography,

The Dobutamine stress echocardiography (DES) has come a long way as a diagnostic tool, from detecting myocardial ischemia, viability, and prognostics to problems underlying the coronary artery diseases. The safety and cost-effectiveness of the Dobutamine stress echocardiography as a diagnostic procedure has been proved. In modern cardiology, the DSE occupies a significant place in the evaluation of patients with known or suspected coronary artery disease, which has contributed to its accessibility and availability in a great number of centers.

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