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Review Article

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Stress Echocardiography for Detection and Assessment of Coronary Heart Disease. The Early Years

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Abstract

Stress echocardiography has been evolved over the last few decades as an important diagnostic, prognostic and follow up investigation, in clinical practice. Its main indications include the diagnosis of myocardial ischaemia and the detection of myocardial viability. It may give useful information to the invasive cardiologist and the cardiac surgeon and guide the decision for possible revascularization. It is simple to perform, quite safe for the patient and has a high sensitivity and specificity for both detection of ischaemia and viability.

Keywords

Coronary artery disease, Stress echocardiography, Myocardial viability

Introduction

The first studies regarding the application of stress echocardiography for assessment of myocardial ischaemia, were published in the early 1970s with the use of M-mode echocardiography [1] and in the late 1970s with the use of 2D- echocardiography [2].

The indications for stress echocardiography are listed in Table 1. These include the detection of CAD, the assessment of the extent and the severity of ischaemia, the risk stratification after acute MI, the evaluation of the coronary patient preoperatively and the detection of myocardial viability.

Stress echocardiography can be performed with either bicycle ergometer or with pharmacologic stressors, such as the sympathomimetics dobutamine and arbutamine, or the coronary vasodilator agents, adenosine and dipyridamole.

Interpretation of Wall Motion

In normal subjects, exercise is associated with increased thickening of the endocardium and with a decrease in end-systolic volume. In other words, wall motion improves with exercise. In the presence of ischaemia, there is lack of improvement of segmental wall motion, compared to other hyperdynamic segments, worsening of pre-existing hypokinesis, or new wall motion abnormality. Regional wall motion is analysed by using a 16-segment left ventricular model and a 5-point scoring system, as recommended by the American Society of Echocardiography [3].

Normally contracting segments are given a value of 1, hypokinetic segments 2, akinetic segments 3, dyskinetic segments are given a value of 4, and aneurysmal segments are given a value of 5. By dividing the total sum of the scores with the number of segments, we can get an index, which reflects the extent and severity of wall-motion abnormalities.

Index of wall-motion abnormalities = total kinesis score/ number of segments

The sensitivity of exercise echocardiography in the detection of CHD ranges between 74% and 97% and the specificity between 64% and 96%. The sensitivity is lower in patients with single-vessel disease and higher in patients with multivessel disease [4].

It is more difficult to interpret wall motion in patients with left bundle branch block (LBBB), because of some paradoxic

Table 1: Indications for stress echocardiography.

Detection of myocardial ischaemia
Assessment of the extent of myocardial ischaemia
Post-MI risk stratification
Detection of myocardial viability
Preoperative evaluation of the coronary patient

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Table 2: Sensitivity of dipyridamole echocardiography for CAD detection.

Study	n	Sensitivity SVD (%)	Sensitivity MVD (%)	Dose (mg/kg)
Picano [7]	66	37	85	0.56
Picano [8]	93	50	85	0.84
Agati [9]	32	67	100	0.84
Mazeika [10]	55	10	77	1.00

Table 3: Occurrence of significant side effects during dipyridamole echocardiography of 10,451 patients: The echo-persantine international cooperative study group.

Side effect	n
Hypotension/Bradycardia	58
ST-segment Elevation	13
Myocardial Ischaemia	8
Ventricular Tachycardia	7
Atrial Fibrillation	7
A-V Block	6
Bronchospasm	5
Myocardial Infarction	3
Asystole	3
Acute Heart Failure	3
Death	1
Total	113

septal motion. In such a case myocardial thickening rather than endocardial motion is considered for detection of ischaemia.

Pharmacologic Stress Echocardiography

Approximately 30% of patients referred for stress echo are unable to achieve maximal exercise test [5], because of musculoskeletal abnormalities, chronic obstructive pulmonary disease or peripheral vascular disease. The sensitivity of the test may thus be influenced negatively. Pharmacologic stress testing has been introduced to overcome the difficulties. The commonest agents or stressors used are dipyridamole, adenosine, dobutamine and arbutamine.

Dipyridamole Stress Echocardiography

Dipyridamole is a potent coronary vasodilator. Its action is mediated through an increase in endogenous adenosine levels, by inhibiting adenosine reuptake into the endothelial and blood cells [6].

The use of dipyridamole echocardiography for the detection of CAD was first reported by Picano [7-10]. Using a dose of 0.56 mg/kg over 4 minutes, Picano found a sensitivity of 56% and a specificity of 100% in detecting CAD. By increasing the dose to 0.84 mg/kg over 10 minutes, the sensitivity of the study increased to 74%, without a change in specificity. Ischaemia was detected as a new or worsening wall-motion abnormality.

Sensitivity for single-vessel disease remains very low, usually less than 50%, whereas for multivessel disease ranges from 77% to 100% (Table 2).

The sensitivity of dipyridamole echocardiography can be increased when atropine is administered intravenously at a dose of 0.25 mg increasing it every minute up to 1 mg, in patients with a negative high-dose dipyridamole test [11].

It has been reported that the sensitivity can be increased from 70% to 85%, with atropine, and in patients with single-vessel disease this can be increased from 55% to 76%.

The addition of dobutamine to high-dose dipyridamole echocardiography may also increase the sensitivity for CAD detection. In a study of 150 patients the sensitivity to detect CAD increased from 71% to 92% with dobutamine [12].

Side effects with dipyridamole echo occur in a small percentage of patients. In the Echo Persantine International Cooperative Study Group [13], of the 10,451 patients studied, side effects occurred in only 113 patients (1.2% of cases). These are listed in Table 3.

Dobutamine Echocardiography

Dobutamine is a synthetic catecholamine which acts on α_1, $_1$, and β_2 receptors. At lower doses it mainly increases myocardial contractility and at higher doses, contractility and heart rate [14]. The combined inotropic and chronotropic properties of dobutamine make it suitable for use in patients with CAD, for induction of ischaemia.

Berthe, et al. [15] were the first to report on the use of dobutamine echocardiography in post myocardial infarction patients, in 1986. Dobutamine was firstly used up to 20 mcg/kg/min, but more recently it is administered at a dose of 5 mcg/kg/min and increased every 3 minutes to 10, 20, 30 and 40 mcg/kg/min. The infusion end points are, > 85% of patient's predicted maximum heart rate, the occurrence of angina or malignant arrhythmias, significant ST-segment changes, significant deviations of blood pressure or development of large wall-motion abnormalities.

The haemodynamic effects of high-dose dobutamine infusion are an increase in heart rate, an increase in systolic blood pressure and a decrease in diastolic blood pressure. The predicted maximum heart rate is achieved in only the minority of patients undergoing dobutamine echocardiography, and the sensitivity is thus influenced negatively. In order to improve the sensitivity for ischaemia detection, the administration of atropine, at a dose of 0.25 mg iv every minute up to 1 mg, has been suggested in patients not achieving 85% of the target heart rate [16].

Any eventual serious ischaemic side effects of dobutamine can be reversed with the i.v. administration of esmolol at a

dose of 0.5 to 1 mg/kg, or with sublingual nitro-glycerine. Relative contraindications to dobutamine administration are uncontrolled atrial fibrillation, hypertension, hypertrophic cardiomyopathy, and significant ventricular or supraventricular arrhythmias.

Possible side effects of dobutamine infusion include, atrial and ventricular arrhythmias, which may occur up to 25% of individuals, tremors, dyspnoea, headache, chest pain and palpitations, whose incidence ranges from 6% to 12%. No sustained ventricular tachycardia and ventricular fibrillation may also occur in some patients, the latter may occur however in patients with depressed left ventricular function and severe ischaemic heart disease [17,18].

During dobutamine infusion myocardial contractility, thickness and motion are enhanced, in normal subjects. In case of ischaemia, the normal response of the myocardium is abolished and hypokinesis, akinesis or even paradoxical motion or dyskinesis, may occur. Lack of augmentation of contraction is a manifestation of milder forms of ischaemia. Sometimes, contraction is enhanced at low doses and deteriorates at high dobutamine doses. This is known as the biphasic response [19].

Several investigators have reported the sensitivity and specificity of dobutamine echocardiography in detecting CAD (Table 4). In nearly all studies reported the maximal dose used was 40 mcg/kg/min; atropine was used in only a small percentage of patients.

Significance of Coronary Lesions

The physiologic significance of the stenotic lesions remains an important issue for the practising clinician especially when the diameter reduction of the diseased vessel, is less than 70-80%. In such cases objective evidence of myocardial ischaemia in the territory of the diseased artery is needed for the interventionist to proceed to revascularization. In one study dobutamine stress echocardiography was used to identify candidates for revascularization. Patients with dobutamine-induced ischaemia had revascularization. After 7 months of follow-up 8 of the 12 patients who underwent PCI had a negative test for ischaemia, whereas 26 of 32 patients with initial negative test remained negative [20,28].

Concluding Remarks

Stress echocardiography has been established as an important modality in the diagnosis of inducible myocardial ischaemia and the detection of myocardial viability. It is safe for the patient, easy to perform and to interpret. In addition, it has no radiation exposure and it is reproducible. Its sensitivity and specificity remain high. These properties make stress echocardiography a first line diagnostic technique, which guides interventionists in decision-making for invasive management of patients with coronary artery disease.

Table 4: The detection of CAD with dobutamine echocardiography.

Study	n	Sensitivity	Specificity
Sawada, et al. [20]	103	89	85
Cohen, et al. [21]	70	86	95
Previtali, et al. [22]	35	68	100
Marcovitz, et al. [23]	141	96	66
Martin, et al. [24]	40	76	60
Mazeika, et al. [25]	50	78	93
Segar, et al. [26]	85	95	82
Marwick, et al. [27]	217	72	83

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