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ORIGINAL ARTICLE

Assessment of diastolic reserve in hypertensive patients by dobutamine stress Doppler tissue imaging

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KEYWORDS

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Abstract *Background:* Many hypertensive patients are symptomatic mainly with exercise, because of the rise in filling pressures. Therefore, it is useful to evaluate left ventricular filling pressure with exercise. The study aims to determine the role of dobutamine stress echocardiography in assessment of diastolic reserve in hypertensive patients with normal ejection fraction.

Methods and results: 30 Hypertensive patients (53.8 ± 4.1 years) and 20 sex and age-matched healthy controls (51.9 ± 9.7 years) were recruited. Patients with coronary artery disease, significant valvular disease, hypertrophic cardiomyopathy, left ventricular systolic dysfunction (EF < 50%), atrial fibrillation and bad echogenic view were excluded. All groups underwent complete conventional echo and dobutamine stress echocardiography using pulsed wave Doppler tissue imaging at rest and during peak stress to measure early mitral inflow diastolic wave velocity (E), late mitral inflow diastolic wave velocity (A), E/A ratio, early diastolic myocardial wave velocity (E') and late diastolic myocardial wave velocity (A'). At rest; E' was significantly lower in patients than controls (9.3 ± 1.8 vs 14.9 ± 2.4 P value < 0.001) and E/E' (early mitral inflow diastolic wave velocity/early myocardial diastolic wave velocity) was significantly higher in patients (7.7 ± 1.3 vs 5.1 ± 1.0 P

Abbreviations: AF, atrial fibrillation; BP, blood pressure; CAD, coronary artery disease; DTI, Doppler tissue imaging; DSE, dobutamine stress echocardiography; LV, left ventricular; EF, ejection fraction; E, early mitral inflow diastolic wave velocity; A, late mitral inflow diastolic wave velocity; S', systolic wave velocity; E', early diastolic wave velocity; A', late diastolic wave velocity; ICT, isometric contraction time; IRT, isometric relaxation time; E/E' ratio, early mitral inflow diastolic wave velocity/early myocardial diastolic wave velocity; LVDP, left ventricular diastolic pressure.

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value <0.001). At peak stress; E/A ratio was significantly lower in patients ($P < 0.001$) while E/E' was significantly higher in patients than controls (8.4 ± 2.2 vs 4.8 ± 0.8 P value <0.001).
Conclusions: Dobutamine stress echocardiography using Doppler tissue imaging is useful in hypertensive patients with exertional dyspnea with normal resting filling pressure.

1. Introduction

Hypertension is the most common, readily, identifiable, and reversible risk factor for myocardial infarction, stroke, heart failure, atrial fibrillation, aortic dissection, and peripheral arterial disease.[2] Impaired left ventricular diastolic filling is also a common finding in hypertensive patients, especially in those with ventricular hypertrophy, even in the absence of evidence of decreased systolic performance.[3]

In many patients with essential hypertension in the absence of coronary artery disease, left ventricular systolic and diastolic function is normal at rest but may respond abnormally during exercise and develop exertional dyspnea even with good systolic function during exercise.[3] This phenomenon may reflect impaired left ventricular diastolic filling at stress and this is called lack of diastolic reserve[4]

Impaired diastolic reserve is defined as: (A) under baseline condition: no or mild degree of diastolic dysfunction and normal filling pressures. (B) Under stress or during exercise: overt diastolic dysfunction with elevated filling pressure and complaints of dyspnea.[4]

The E/E' ratio has been applied for that objective. In subjects with normal myocardial relaxation, E and E' velocities increase proportionally, and the E/E' ratio remains unchanged or is reduced.[5] However, in patients with impaired myocardial relaxation, the increase in E' with exercise is much less than that of mitral E velocity, such that the E/E' ratio increases.[6] In that regard, E/E' was shown to relate significantly to LV filling pressures during exercise, when Doppler echocardiography was acquired simultaneously with cardiac catheterization.[1]

Dobutamine stress echocardiography (DSE) is an accurate and noninvasive technique that is widely used for the detection of underlying coronary artery disease (CAD).[7] Using Doppler tissue imaging (DTI), a dobutamine-induced reduction in the peak annular velocities in systole and diastole has been demonstrated to identify CAD.[8]

It is most useful in hypertensive patients with unexplained exertional dyspnea who have mild diastolic dysfunction and normal filling pressures at rest. In those patients the E/E' ratio increases with exercise.[6]

2. Patients and methods

2.1. Patient selection

Thirty hypertensive patients (11) males and (19) females with mean age (53.8 ± 4.1) years were enrolled who were referred to the cardiology clinic in the Menoufyia University and (20) age and sex matched, apparent healthy, individuals as the control group. All participants provided informed consent and the study protocol was approved by the institutional ethics committee.

Hypertension was defined as a previous blood pressure recording on 2 separate occasions of >140 mmHg systolic or >90 mmHg diastolic or the ongoing prescription of antihypertensive medication.[9]

Patients with CAD, significant valvular disease, hypertrophic cardiomyopathy, left ventricular systolic dysfunction (EF <50%), AF and bad echogenic view were excluded.

Patients underwent detailed history, thorough clinical examination, 12 lead ECG, and complete echocardiogram.

2.2. Conventional echocardiography

Echocardiographic examination was done by using the commercially available (Vivid 9, General Electronic Healthcare, GE Vingmed, Norway) equipped with a 1.7–4 MHz phased-array transducer. Echocardiographic imaging was obtained in the parasternal long- and short-axis, and apical two, three and four-chamber views using standard transducer positions (LV end-diastolic and end-systolic diameters, septal and posterior wall thickness and ejection fraction) were measured in accordance with the recommendations of the American Society of Echocardiography.[10]

From the apical window, a 1- to 2-mm pulsed Doppler sample volume was placed at the mitral valve tip, and mitral flow velocities from 5 to 10 cardiac cycles were recorded. The mitral inflow velocities were traced and the following variables were obtained: peak velocity of early diastolic wave velocity (E), late diastolic wave velocity (A) and E/A ratio.[11] (Fig. 1).

Doppler tissue imaging of the mitral annulus was obtained from the apical 4-chamber view. A 1.5-mm sample volume was placed at the lateral annulus. Analysis was performed for the measurement of systolic wave velocity (S'), early diastolic wave velocity (E'), late diastolic wave velocity (A'), E'/A' ratio, isometric relaxation time (IRT) and isometric contraction time (ICT) at rest. E/E' ratio at rest was calculated.[12]

2.3. Dobutamine stress protocol[13]

Beta-adrenergic blocking agents were withdrawn for the preceding 48 h prior to the study. Dobutamine was infused at doses of 5, 10, 20, 30 and 40 μg/kg/min for 3 min each. A 12-lead electrocardiogram, blood pressure, and two-dimensional (2D) echocardiograms were taken at baseline, at low dose dobutamine, peak dobutamine, and at recovery (Fig. 2).

Transmitral flow was used to measure (early diastolic wave velocity (E), late diastolic wave velocity (A) and E/A ratio) at peak dose using DTI lateral mitral annular velocities; systolic wave velocity (S'), early diastolic wave velocity (E'), late diastolic wave velocity (A'), E'/A' ratio, isometric relaxation time (IRT) and isometric contraction time (ICT) were measured at peak dose (Fig. 3). E/E' ratio at peak stress was calculated.[12]

The stress test was terminated when 85% of the maximal predicted heart rate was reached, or earlier if the patient had