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Original Research Article

Dobutamine-stress echocardiography speckle-tracking imaging in the assessment of hemodynamic significance of coronary artery stenosis in patients with moderate and high probability of coronary artery disease

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ABSTRACT

Background and objective: Myocardial deformation indices are considered as sensitive markers of ischemia and may be useful in the quantification of hemodynamic significance of coronary artery disease (CAD). We sought to determine the diagnostic value of speckle-tracking echocardiography derived myocardial deformation parameters at rest and during stress to determine hemodynamically significance coronary artery stenosis in patients with moderate and high probability of CAD.

Materials and methods: In 81 patients (mean age, 64 ± 8.6 years) with stable CAD inducible myocardial ischemia was evaluated by dobutamine stress echocardiography (DSE) and adenosine magnetic resonance imaging (AMRI). Based on AMRI patients were divided into two groups: nonpathologic ($n = 41$) and pathologic ($n = 40$). Strain and strain rate (SR) parameters and their changes from the rest (BASE) to low stress (MIN), peak stress (MAX), and recovery (REC) were analyzed using 2D speckle-tracking imaging (STI).

Results: In the nonpathologic group, systolic longitudinal and circumferential strain increased significantly from BASE to MIN, as well as systolic SR from BASE to MIN and from MIN to MAX in longitudinal plane. In contrast, in the pathologic group, insignificant longitudinal systolic SR increase and radial and circumferential systolic SR decrease from MIN to MAX was observed. Discriminant function analysis revealed that select STI derived

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parameters best classify patients into predefined AMRI groups (pathologic and nonpathologic) with the accuracy respectively 90.9% and 83.3%. According to ROC analysis these myocardial deformation parameters had the greatest predictive value of significant coronary artery stenoses: longitudinal strain at high dose (AUC 0.811, sensitivity 89.4%, specificity 64.7%), longitudinal strain rate at high dose (AUC 0.855, sensitivity 88.1%, specificity 71.0% at high doses). The sensitivity and specificity of inducible wall motion abnormalities were 74.0% and 85.0% (AUC 0.798) and was lower compared with the diagnostic value of longitudinal myocardial deformation parameters.

Conclusions: Left ventricular strain and strain rate analyses during DSE can be used in the assessment of hemodynamic significance of coronary artery stenosis in patients with moderate and high risk for CAD.

1. Introduction

Deaths from coronary artery disease (CAD) account for more than half of cardiovascular (CV) mortality; hence, early diagnosis and treatment are warranted [1]. The choice of treatment strategy should be primarily based on the hemodynamic significance of coronary artery stenosis [2]. Myocardial deformation indices are considered as sensitive markers of ischemia and may be useful in the quantification of hemodynamic significance of coronary artery stenosis [3–5]. Currently there are no published studies that analyzed the association of speckle-tracking echocardiography (STI) derived myocardial deformation parameters and myocardial perfusion evaluated by cardiac adenosine magnetic resonance imaging (AMRI) that has sensitivity and specificity noninferior to invasive fractional flow reserve testing [6].

The aim of this study was to determine the diagnostic value of STI-derived myocardial deformation parameters at rest and during dobutamine stress to determine the hemodynamic significance of coronary artery stenosis in patients with moderate and high probability of CAD.

2. Materials and methods

This was a cross-sectional prospective study that included patients without known CAD with moderate and high probability of CAD, determined by a Diamond–Forrester score [7].

2.1. Study population

Patients admitted to the Department of Cardiology, Hospital of Lithuanian University of Health Sciences, for investigation of suspected CAD during the period from April 2013 to April 2014 were enrolled into the study. A total of 81 patients with a moderate or high risk of CAD and a good LV systolic function defined as LV ejection fraction (EF) ≥55% with no wall motion abnormalities (WMA) at rest were included. Patients with any of the following criteria were excluded from the study: history of cardiovascular or valvular heart disease, left ventricular ejection fraction <55% on echocardiography, known hypersensitivity to contrast agents, mental diseases, pregnancy or breast-feeding, severe renal impairment (estimated glomerular filtration rate ≤30 mL/min/1.73 m^2), contraindications to cardiac AMRI.

All patients gave written informed consent before undergoing DSE.

The study was approved by the local ethics committee.

2.2. Evaluation of myocardial ischemia

In all patients myocardial ischemia was evaluated by two imaging techniques: echocardiography (at rest and during dobutamine stress echocardiography [DSE]), and cardiac magnetic resonance imaging (myocardial perfusion at rest and adenosine stress myocardial perfusion, AMRI). Beta-blockers and nitrates were discontinued 48 h before to the study. Intravenous dobutamine was initiated at 5 μg/kg/min and the dose was increased every 3 min to 10, 20, 30 and 40 μg/kg/min. Atropine up to 1 mg was added if necessary. The conventional echocardiography system (Vivid 7, GE Healthcare, Horten, Norway) with 1.5–4.6 MHz transducer was used. A 12-lead electrocardiogram, blood pressure, and standard two-dimensional echocardiograms were taken at baseline, low-dose, peak dobutamine levels and during recovery. The dobutamine infusion was terminated once 85% of the maximal predicted heart rate was achieved. Stress test was terminated prematurely and the patient was assigned to the pathologic group in the presence of severe chest pain or other intolerable symptoms, severe arrhythmia, >2 mm ST-segment elevation or depression, systolic blood pressure >230 mmHg, diastolic blood pressure >120 mmHg, or a drop in systolic blood pressure >20 mmHg.

Off-line speckle-tracking analysis (EchoPac, GE Healthcare) was performed using images obtained during DSE. Cardiac cycles associated with atrial or ventricular extrasystolic beats were excluded. The minimum frame rate used for analysis was 90 with an average being 101 ± 8.8. Conventional echocardiographic measurements were performed according to the American Association of Echocardiography recommendations [8]. LV ejection fraction was calculated using the modified Simpson's biplane method with manual tracing of the endocardial borders at end-diastole and end-systole in the apical 4- and 2-chamber views. All segmental analyses were based on the conventional American Society of Echocardiography 16-segment LV model [8]. Each segment was assigned a

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