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Reversal of left ventricular “rigid body rotation” during dipyridamole-induced stress in a patient with stable angina: a case from the three-dimensional speckle tracking echocardiographic MAGYAR-Stress Study

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Abstract

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The left ventricular (LV) twist is defined as the wringing motion of the heart around its long-axis in systole caused by oppositely directed counterclockwise apical and clockwise basal rotations resulted from the movement of two orthogonally oriented muscular bands. In some clinical circumstances, rotation at both basal and apical levels of the LV occurred in the same clockwise or counterclockwise direction during systole resulting the near absence of LV twist as called left ventricular “rigid body rotation” (LV-RBR). Hereby we present that LV-RBR normalization of LV rotational mechanics could be demonstrated at maximum hyperaemia during dipyridamole-induced stress by three-dimensional (3D) speckle tracking echocardiography in a patient with stable angina.

Keywords: Three-dimensional (3D), stress, speckle tracking, echocardiography, myocardial, mechanics, rigid body rotation

Introduction

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The left ventricular (LV) twist is defined as the wringing motion of the heart around its long-axis in systole caused by oppositely directed counterclockwise apical and clockwise basal rotations resulted from the movement of two orthogonally oriented muscular bands (1). In some clinical circumstances, rotation at both basal and apical levels of the LV occurred in the same clockwise or counterclockwise direction during systole resulting the near absence of LV twist as called left ventricular “rigid body rotation” (LV-RBR) (2-13). Three-dimensional (3D) speckle-tracking echocardiography (STE) is a new technique with potential for noninvasive assessment of LV myocardial movements (14,15). Hereby we present that LV-RBR normalization of LV rotational mechanics could be demonstrated at maximum hyperaemia during dipyridamole-induced stress by 3DSTE in a patient with stable angina.

Case presentation

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A 60-year-old man is presented, who was referred to our Cardiac Catheterization Laboratory due to stable angina. Only hypertension and hyperlipidemia were in his anamnesis. Coronary angiography showed left dominant coronary system with 30–40% lesions in the proximal left anterior descending (LAD) coronary artery, while left circumflex and right coronary (RC) arteries seemed to be intact. Fractional flow reserve measurements were performed showing 0.85 in LAD and 0.87 in RC suggesting haemodinamically non-significant lesions. The patient has been included in the MAGYAR-Stress Study (Motion Analysis of the heart and Great vessels bY three-dimensionAl speckle-tRacking echocardiography during Stress protocols), in which among others drug-induced stress-related pathophysiologic consequences were aimed to be examined (‘magyar’ means ‘Hungarian’ in Hungarian language). Informed consent was obtained from the patient and the study protocol was approved by the institution’s human research committee.

Following complete two-dimensional (2D) Doppler echocardiography 3DSTE was performed with the same Toshiba Artida^{TM} echocardiography equipment (Toshiba, Tokyo, Japan) using a 1–4 MHz matrix phased-array PST-25SX transducer (15). Six wedge-shaped subvolumes were acquired within a single breath-hold from the apical window to create full-volume 3D datasets at rest and at peak hyperaemia. Dipyridamole was used as a vasodilator stress agent using standard international protocols. During chamber quantifications 3D Wall Motion Tracking software version 2.7 was used. The apical two- (AP2CH) and four-chamber (AP4CH) views and three short-axis views at different LV levels from the LV base to apex were automatically selected from the 3D echocardiographic pyramidal dataset at end-diastole by the software. Two points of the LV endocardium at the edges of the mitral valve and one at the LV apex were marked manually on the AP2CH and AP4CH views. Then, the 3D endocardial surface was automatically reconstructed and tracked in 3D space throughout the cardiac cycle. Manual adjustments were also performed, if needed. Curves were generated by the software for quantification of global peak apical, midventricular and basal LV rotations at rest and at peak hyperaemia (*Figure 1*).

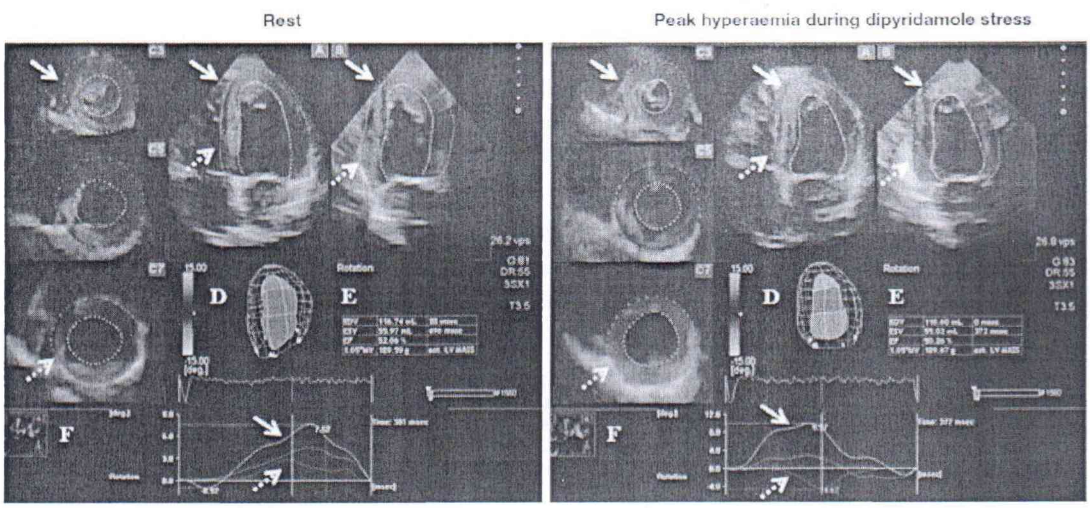

Figure 1

Left ventricular (LV) rotational characteristics of the patient are demonstrated at rest and at peak stress. Apical 4-chamber [A] and 2-chamber [B] views and short-axis views [C3, C5, C7] extracted from the three-dimensional (3D) echocardiographic dataset are presented. A 3D cast of the LV [D] and calculated volumetric and functional LV parameters are also demonstrated [E]. Counterclockwise rotation of the LV apex and LV base are shown demonstrating left ventricular “rigid body rotation” (LV-RBR) at rest, which become normally oriented with counterclockwise rotation of the LV apex and clockwise rotation of the LV base [F]. White arrow represents LV apex, while dashed arrow represents LV base.

No wall motion abnormalities could be detected both in resting conditions and at peak hyperaemia by visual assessment suggesting a negative stress test result. Interestingly, apical and basal LV rotations were in the same counterclockwise direction suggesting LV-RBR at rest. At peak hyperaemia basal LV rotation become clockwise-directed, while apical rotation remained counterclockwise oriented (*Figure 1*). Following stress at recovery phase, all these changes in rotational mechanics returned back to LV-RBR.

Discussion

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The evaluation of LV function by visual assessment is restricted by its known subjective nature. STE allows quantitative analysis of myocardial global and segmental deformations by assessing strain and rotational characteristics (15). Although 2DSTE has emerged due to its angle independency, this methodology does not allow to see the heart as a 3D organ. 3DSTE overcomes this limitation from a single 3D data acquisition from which all strain and rotational parameters could be calculated at the same time (15).

In healthy subjects, LV systole is associated with a counterclockwise rotation of the LV apex and a clockwise rotation of the LV base resulting in a towel-wringing motion as called LV twist (net difference between LV apex and LV base) (1). LV twist is the result of the movement of two orthogonally oriented mascular bands of a helical myocardial structure and responsible for up to 40% of LV stroke volume in physiologic studies (16). In the presented case, both LV apical and basal rotations were in the same counterclockwise direction at rest confirming near absence of LV twist (LV-RBR). Recently, LV-RBR could be demonstrated in different cardiomyopathies [noncompaction (2-7); dilated (8) and hypertensive (9) with reduced systolic funtion], congenital heart diseases [hypoplastic right heart syndrome (10), univentricular heart (11), Ebstein anomaly (12)] and amyloidosis (13). Interestingly, in a woman with postpartum cardiomyopathy with noncompaction phenotype and LV-RBR, 6-month heart failure treatment was associated with reversal of LV-RBR proceeding normally directed LV rotations (7). No structural or functional cardiac alterations, as well as LV wall depositions could be confirmed in our case. Although our knowledge is limited regarding the real prevalence of LV-RBR, the effect of classic risk factors (for instance hypertension) or a subclinical disease (focal oedema, inlammation, etc.) could explain its presence. Moreover, there is no literature, which could support the fact that a non-significant coronary artery disease and related haemodynamic changes are associated with LV-RBR, but obviously could not be excluded.

To the best of authors’ knowledge this is the first time to demonstrate normalization of LV rotational mechanics during dipyridamole-induced stress. In normal situation subepicardial myocardial fibers run in a left-handed direction leading to a clockwise rotation of the LV base and a counterclockwise rotation of the LV apex. Myocardial fibers on the subendocardial side run in a right-handed direction, and contraction of these fibers will cause the LV base to rotate in a counterclockwise direction and the LV apex to rotate in a clockwise direction. Due to greater radius of rotation of the subepicardium it consequently provides greater torque than the subendocardium resulting in a significantly expressed rotation of the subepicardium (16). In the presented case counterclockwise rotation of the LV base could be detected at rest which turned to normally directed clockwise basal LV rotation theoretically due to dipyridamole-induced vasodilation via altered blood supply at maximum hyperaemia. This case could highlight our attention on the importance on the assessment of changes in myocardial deformation during stress imaging.

Acknowledgements

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None.

Notes

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Informed Consent: Written informed consent was obtained from the patient for publication of this case report.

Footnotes

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Conflicts of Interest: The authors have no conflicts of interest to declare.

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