Original Research

Left Atrial Volumetric and Strain Analysis by Three-Dimensional Speckle-Tracking Echocardiography in Noncompaction Cardiomyopathy: Results from the MAGYAR-Path Study

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Introduction: Noncompaction cardiomyopathy (NCCM) is a rare congenital cardiomyopathy characterised by a distinctive 2-layered appearance of the myocardium due to hypertrabecularisation and deep intertrabecular recesses. The present study was designed to assess left atrial (LA) volumes and volumetric and strain-based functional properties by three-dimensional speckle-tracking echocardiography (3DSTE) in NCCM.
Methods: The study included 12 consecutive NCCM patients. Their results were compared to 20 age- and sex-matched healthy controls. Complete two-dimensional Doppler echocardiography and 3DSTE were performed in all cases.
Results: Calculated LA maximum (76.5 ± 26.8 mL vs. 45.3 ± 15.1 mL, p=0.0002) and minimum (56.9 ± 27.3 mL vs. 25.3 ± 15.2 mL, p=0.0002) volumes and LA volume before atrial contraction (67.1 ± 28.2 mL vs. 35.7 ± 16.4 mL, p=0.0004) were significantly greater in NCCM patients. Total, active, and passive LA emptying fractions proved to be smaller in NCCM. Peak global radial (-9.3 ± 7.8% vs. -16.8 ± 10.2%, p=0.05), circumferential (12.8 ± 8.4% vs. 26.2 ± 9.2%, p=0.0003), longitudinal (12.8 ± 8.2% vs. 22.5 ± 8.5%, p=0.004), and area (26.7 ± 18.5% vs. 51.6 ± 20.3%, p=0.001) strains were significantly smaller in NCCM patients as compared to matched controls.
Conclusions: Significantly greater LA volumes and compromised LA functional properties could be demonstrated by 3DSTE in patients with NCCM.

Noncompaction of the left ventricular (LV) myocardium is a rare congenital cardiomyopathy characterised by a distinctive 2-layered appearance of the myocardium due to hypertrabecularisation and deep intertrabecular recesses.[1] It usually presents with ventricular dysfunction, thromboembolic events and arrhythmias. However, little is known about the behaviour of the left atrium (LA) in noncompaction cardiomyopathy (NCCM) at this time.[2] Several non-invasive clinical tools, including three-dimensional (3D) speckle-tracking echocardiography (STE), have been demonstrated to be useful for the assessment of LA function.[3] The present study was designed to assess LA volumes and volume- and strain-based functional properties by 3DSTE in NCCM.

Methods

Patient population

The present study included 12 patients

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with typical features of NCCM. The diagnosis of NCCM was confirmed in all patients according to Jenni's criteria.[1] Their results were compared to 20 age- and sex-matched healthy controls. Complete two-dimensional (2D) Doppler echocardiography and 3DSTE were performed in all NCCM cases and controls. Diabetes mellitus (DM) was defined in accordance with the criteria of the American Diabetes Association[4] and World Health Organisation.[5] Hypertension was defined as either a systolic or a diastolic elevation of the blood pressure (>140/90 mmHg), or ongoing antihypertensive therapy. Hypercholesterolemia was defined as a total cholesterol level >5.0 mmol/L or current treatment with lipid-lowering medications. All subjects were enrolled in the MAGYAR-Path Study (**M**otion **A**nalysis of the heart and **G**reat vessels b**Y** three-dimension**A**l speckle-t**R**acking echocardiography in **Path**ological cases). This was organised at the Cardiology Centre of the University of Szeged to evaluate the usefulness, diagnostic and prognostic value of 3DSTE-derived volumetric, strain, rotational, dyssynchrony, etc., parameters in pathological cases ("Magyar" means "Hungarian" in the Hungarian language). Informed consent was obtained from each patient and control subject and the study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki, as reflected in *a priori* approval by the institution's human research committee.

Two-dimensional echocardiography

Complete Doppler 2D echocardiographic examinations were performed in all cases. Standard 2D echocardiographic studies were carried out using commercially available Toshiba Artida™ echocardiography equipment (Toshiba Medical Systems, Tokyo, Japan) with a PST-30SBP (1-5 MHz) phased-array transducer. Left ventricular (LV) and LA dimensions, volumes and LV ejection fraction (EF) were calculated in accordance with the guidelines.[6] Colour Doppler echocardiography was used to visually quantify the degree of mitral regurgitation.

Three-dimensional speckle-tracking echocardiography

All patients underwent 3D echocardiographic acquisitions immediately after a 2D echocardiographic study, using the same Toshiba Artida™ echocardiography equipment and a commercially available PST-25SX matrix-array transducer with 3DSTE capability.[3,7] Within a single breath-hold and during a constant RR interval, 6 wedge-shaped subvolumes were acquired from an apical window to create full-volume 3D datasets. The sector width was decreased as much as possible to improve the temporal and spatial resolution of the image in order to obtain a 3D full-volume dataset of the LA with optimal border delineation. LA chamber quantification was performed offline using 3D Wall Motion Tracking software version 2.5 (Toshiba Medical Systems, Tokyo, Japan). Three-dimensional echocardiographic datasets were displayed in apical 4-chamber (AP4CH) and 2-chamber (AP2CH) views and 3 short-axis views in basal, mid-atrial, and superior LA regions (Figure 1). In the AP4CH and AP2CH views, the endocardial border was traced by the user, who set multiple reference points starting at the base of the LA at mitral valve level, progressing toward the LA apex, and excluding the LA appendage and pulmonary veins from the LA cavity. The epicardial border was adjusted manually or by setting a default thickness for the myocardium. After detection of the LA borders on the end-diastolic reference frame, 3D wall motion tracking, which is based on a 3D block-matching algorithm, was automatically performed by the software. The user could correct the shape of the LA if needed throughout the entire cardiac cycle.

3DSTE-derived volumetric measurements

The following volumetric calculations were performed:[3,7]

1. maximum LA volume (V_{max}) at end-systole, the time at which LA volume was largest just before mitral valve opening,
2. minimum LA volume (V_{min}) at end-diastole, the

Table 1. The way of calculating left atrial stroke volumes and emptying fractions in each phase of left atrial motion.

	Reservoir	Conduit function	Active contraction
Stroke volumes (mL)	Total SV = V_{max} - V_{min}	Passive SV = V_{max} - V_{preA}	Active SV = V_{preA} - V_{min}
Emptying fractions (%)	Total EF = Total SV/V_{max}	Passive EF = Passive SV/V_{max}	Active EF = Active SV/V_{preA}

EF – ejection fraction; LV – left ventricular; SV – stroke volume; V_{max} – maximum left atrial volume; V_{min} – minimum left atrial volume; V_{preA} – left atrial volume before left atrial contraction.

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