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ORIGINAL ARTICLE

Assessment of left atrial deformation properties by speckle tracking in patients with systolic heart failure

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KEYWORDS

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Abstract *Objectives:* To evaluate left atrial (LA) function using speckle tracking based strain (SPTS) in systolic heart failure (SHF) patients.
Background: LA changes occur in patients with SHF and LA enlargement is commonly found by echocardiography. New speckle tracking based strain can be used to detect left atrial changes in SHF.
Materials and methods: Forty patients with clinical (SHF), EF < 40%, NYHA class II-IV and normal sinus rhythm were compared with twenty-five age and sex matched healthy controls. Conventional echo was done where the LV dimensions, volumes, EF, wall thickness & LA diameter were measured. LA total emptying, passive and active volumes & fractions were calculated in both apical 4 & 2 chamber views. Peak atrial longitudinal strain (PALS), Peak atrial contraction strain (PACS), LA strain at the end of LA contraction (Post-A strain) and LA contraction systolic index (LA CSI) were calculated from each LA wall. LV global strain (LVGS) was measured in apical 4, 2 and 3 chamber views and was averaged.
Results: SHF patients had significantly higher LA diameter volumes but lower LA fractions, Also, there were significantly lower LA PALS, PACS, Post-A and higher LA CSI, however, the LA strain parameters were negatively correlated with the NYHA class and positively correlated with LV global strain.
Conclusion: In patients with SHF, LA function is significantly reduced. Moreover, LA reservoir & booster pump function correlate negatively with heart failure symptoms and positively with LV global strain.

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1. Introduction

Heart failure (CHF) is a disease condition that is increasing in prevalence and is associated with significant morbidity and mortality. The prevalence of systolic and diastolic heart failure increases with advancing age between 5% and 10% in all subjects beyond the age of 60 years.[1]

Atrial function in a close interdependence with left ventricular (LV) function plays a key role in maintaining an optimal cardiac performance.

Left atrium (LA) modulates LV filling through its reservoir, conduit and booster pump function, whereas LV functions influence LA function throughout the cardiac cycle. The LA can act to increase LA pressure (in significant atrial disease) and can react to increased LV filling pressure (in significant ventricular diseases). LA remodeling is related to LV remodeling and LA function has a central role in maintaining optimal cardiac output despite impaired LV relaxation and reduced LV compliance.[2]

Strain is a measure of deformation and strain rate is a rate of such deformation. Strain echocardiography has been the most widely used tool to evaluate the ventricular myocardial mechanics in the field of echocardiography during the last decade.[3,4] Since the normal longitudinal, LA strain values were first described in 2006, recent studies have suggested that LA strain or strain rate can be measured either by a Tissue Doppler image or 2 dimensional (2D) speckle tracking image based echocardiography and these measurements are useful tools to evaluate the global or regional LA function.[4]

Speckle-tracking echocardiography (STE) is a new noninvasive ultrasound imaging technique that allows an objective and quantitative evaluation of global and regional myocardial function independently from the angle of insonation and from cardiac translational movements.[5]

Although STE technique was introduced for the exclusive analysis of LV function, several studies have recently extended its applicability to other cardiac chambers, such as the LA.[6] The atrial longitudinal strain, deriving from the application of the analysis of myocardial deformation using STE, atrial chambers is considered the first parameter useful for functional analysis of the LA and they present considerable feasibility and reproducibility.[7]

The objective of this study was to assess the LA mechanical changes in systolic heart failure patients by using the speckle tracking based strain imaging.

2. Patients and methods

The study included forty patients with clinical manifestation of SHF and 25 apparently healthy individuals with age and sex matched to the patient group (control group). All participants provided an informed consent and the study protocol was approved by the institutional ethics committee.

Inclusion criteria: Patients with clinical manifestation of systolic heart failure NYHA (II–IV), EF < 40 and with maintained sinus rhythm.

Exclusion criteria: Patients with recent acute coronary syndrome in the least 6 months, any rhythm other than sinus rhythm, patients with significant valvular lesions, congenital heart diseases and those with poor echocardiographic windows were excluded.

2.1. Conventional Echocardiography

Echocardiographic examination was done using the commercially available Vivid 9, (General Electric Healthcare, Vingmed, Norway) equipped with a 1.7–4 MHz phased-array transducer. Echocardiographic imaging was obtained in the parasternal long, short-axis, and apical two, three and four-chamber views using standard transducer positions. LV dimension, wall thickness, ejection fraction (EF%) by Simpson method, and LA Antero- posterior diameter by M. Mode in a long Para-sternal view were measured in accordance with the recommendations of the American Society of Echocardiography.[8]

LA volumes were measured using the area–length method from apical four and two-chamber views, according to the guidelines of the American Society of Echocardiography. LA volume at end systole (Max AV), end diastole (Min AV), and preceding atrial contraction (V Pre-A) in both apical four and apical two chamber views. Volumetric assessment of LA function was calculated by the following formulae in apical four-and two chamber views.[9]

- LA total emptying volume (LAEV): Max AV-Min AV.
- LA total emptying fraction (LAEF): Max AV-Min AV/Max AV.
- LA passive emptying volume (LAPEV): Max AV–VPRE A.
- LA passive emptying fraction (LAPEF): (Max AV–VPRE A)/Max AV.
- LA active emptying volume (LAAEV): VPRE A–Min AV.
- LA active emptying fraction (LAAEF): (VPRE A–Min AV)/VPRE A.[9]

3. Speckle tracking echocardiography

3.1. Image acquisition for longitudinal strain & strain rate

Apical four, two and three chamber views were obtained using conventional 2-D gray scale echocardiography. During breath hold with a stable ECG recording and 2-D sector width was adjusted to include LV and LA. Three consecutive cardiac cycles were recorded and were averaged and the frame rate was set between 60 and 80 frames per second.

3.2. Left atrium strain by speckle tracking echocardiography

The endocardial surface of each LA wall; septal, lateral walls, (A4C view), anterior and inferior walls (A2C view) were manually traced by a point-and-click approach and the epicardial surface tracing was then automatically generated by the system. After manual tracing, the software automatically divides each wall into 3 segments (apical, mid and basal).

During the reservoir phase, the LA fills up, stretches itself, and for this reason the atrial strain increases, reaches a positive peak at the end of atrial filling, before the opening of the mitral valve (peak atrial longitudinal strain PALS). After the opening of the mitral valve, LA empties quickly and shortens, The strain decreases up to a plateau corresponding to the phase of diastasis, followed by a second positive peak, but less than the first, which corresponds to the period preceding the atrial