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Original article

Quantitative validation of left atrial structure and function by two-dimensional and three-dimensional speckle tracking echocardiography: A comparative study with three-dimensional computed tomography

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ABSTRACT

Background: The aim of this study was to validate the accuracy of three-dimensional (3D) speckle tracking echocardiography (STE) and two-dimensional (2D)-STE for the assessment of left atrial (LA) volume and function by comparison with 3D-computed tomography (CT) performed on the same day as STE.
Methods: LA phasic volume and emptying function (EF) were measured in 28 patients with paroxysmal atrial fibrillation undergoing catheter ablation (62 ± 11 years old) using both 3D-STE and 2D-STE during sinus rhythm. LA phasic volume and function measured by 3D-STE and 2D-STE were validated using 3D-CT as a gold standard.
Results: The intraobserver correlation coefficient and variability in maximum LA volume assessed by 3D-STE were 0.99 and 1.4 ± 6.0%, respectively. The interobserver correlation coefficient and variability in maximum LA volume assessed by 3D-STE were 0.99 and 0.2 ± 4.5%, respectively. There were strong correlations between LA phasic volume measured by 3D-CT and those measured by 3D-STE ($r = 0.98$, $p < 0.001$). There were correlations between LA phasic function measured by 3D-CT and those measured by 3D-STE ($r = 0.85$–0.88, $p < 0.001$). There was a better agreement between 3D-CT and 3D-STE in the assessment of LA phasic volumes and function than between 3D-CT and 2D-STE in apical 2- and 4-chamber view.
Conclusions: 3D-STE allows more accurate measurement of LA volume and function than 2D-STE and has high reproducibility.

Introduction

Left atrial (LA) volume and function are thought to reflect left ventricular (LV) diastolic function and may serve as useful predictors of cardiovascular outcomes [1–3]. Thus, assessment of LA volume and function is important in the clinical setting. Recently, two-dimensional speckle tracking echocardiography (2D-STE) has been used to evaluate LA structure and function using Simpson's method with the assumption of uniform geometry [4–6]. However, since cardiac motion is three-dimensional, 2D-STE is limited by the geometrical assumptions required to use Simpson's method [5]. In contrast, three-dimensional speckle tracking echocardiography (3D-STE) has a major advantage in that there is improved accuracy in the evaluation of cardiac chamber volume without any geometrical assumptions [5–8]. For the left ventricle, 3D-STE was shown to be superior to 2D-STE for the measurement of LV volume and function [5–8]. However, there has been no study

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of LA structure and function using 3D-STE. A previous validation study using a phantom reported that LA volume obtained by 3D-computed tomography (CT) was significantly correlated with true LA volume ($r = 0.97$, $p < 0.05$) and LA volume measured by 3D-CT was an accurate and feasible method [9]. Therefore, the purpose of this study was to validate the accuracy of 3D-STE for the measurement of LV volume and function using 3D-CT as a gold standard.

Methods

Study population and study protocol

LA phasic volume (maximum, pre-atrial contraction, and minimum volume) and LA phasic emptying function (EF) (total, passive, and active EF) in 28 patients with paroxysmal atrial fibrillation undergoing catheter ablation (19 men, mean age 62 ± 11 years) were measured using both 3D-STE and 2D-STE during sinus rhythm. Exclusion criteria were severe mitral regurgitation or stenosis, previous mitral valve surgery, permanent cardiac pacemaker implantation, elevated creatinine (>1.5 mg/dl), and iodine allergy. In addition, 2 subjects were excluded from the study because of poor echocardiographic recordings due to severe obesity or emphysema. LA phasic volume and function measured by 3D-STE and 2D-STE in apical 2- and 4-chamber view were compared with the values measured by enhanced 3D-CT performed on the same day as a gold standard in a blind manner to validate the STE measurement.

We calculated LA phasic function from time–LA volume curves during sinus rhythm. The time–LA volume curves were constructed in the apical 2- and 4-chamber views using 2D-STE and in the apical view using 3D-STE. These echocardiographic parameters measured by 3D-STE were compared with those obtained by 2D-STE from the apical 2- and 4-chamber views. LA total EF (reservoir function) was defined as (maximum LA volume – minimum LA volume)/maximum LA volume × 100%. LA passive EF (conduit function) was defined as (maximum LA volume – pre-atrial contraction LA volume)/maximum LA volume × 100%. LA active EF (booster pump function) was defined as (pre-atrial contraction LA volume – minimum LA volume)/pre-atrial contraction LA volume × 100%. Furthermore, LV ejection fraction, LV mass, and E/e' were measured. Measurements were made using criteria recommended by the American Society of Echocardiography [10]. LV mass and LA volumes were indexed to body surface area. LV ejection fraction was calculated using Teichholz formula by M-mode echocardiography. LV mass was calculated at end diastole using the following formula: LV mass = $0.8 \times 1.04 \times [(\text{LV dimension} + \text{LV posterior wall thickness} + \text{LV septal wall thickness})^3 - \text{LV dimension}^3] + 0.6$. Tissue Doppler measurement of mitral e' wave velocity was made at the septal annulus. The present study was approved by the ethics committee of our institution and informed consent was obtained from all patients before enrollment.

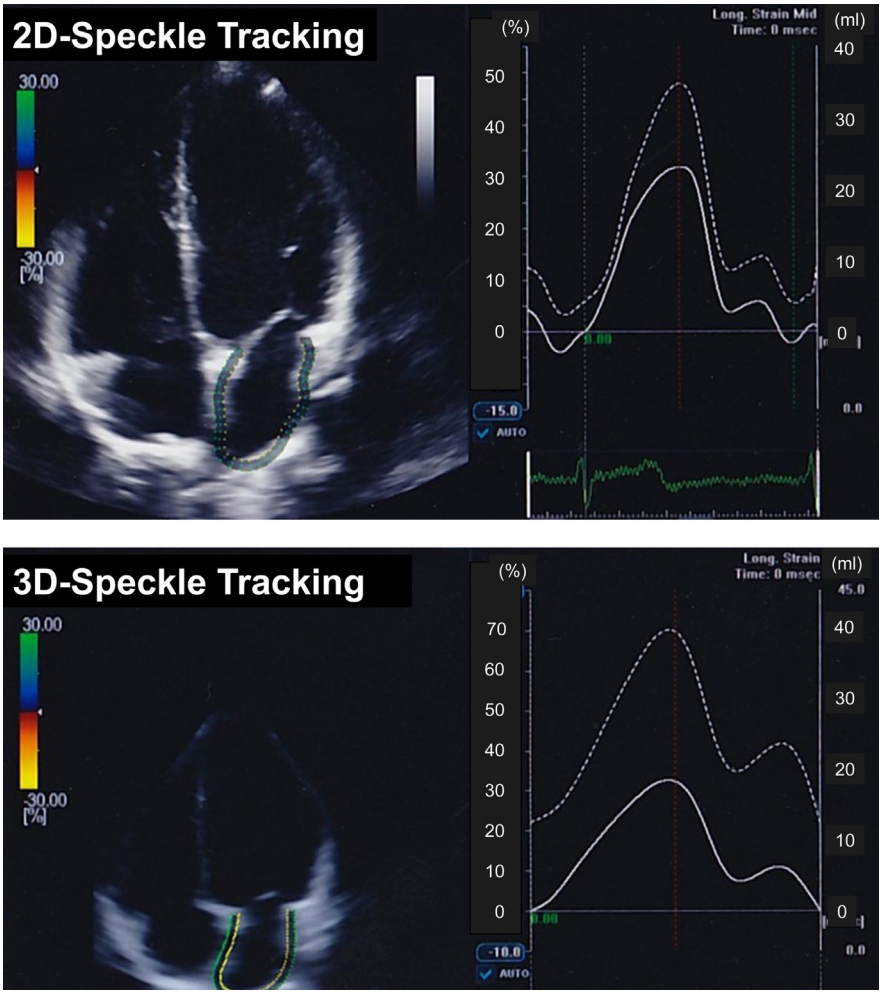

Fig. 1. Representative image of two-dimensional speckle tracking echocardiography and three-dimensional speckle tracking echocardiography. Solid line: time–left atrial strain curve (%); broken line: time–left atrial volume curve (ml).