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Research paper

Measurement of left atrial volume by 2D and 3D non-contrast computed tomography compared with cardiac magnetic resonance imaging

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A B S T R A C T

Background: Cardiac magnetic resonance imaging (MRI) is considered the gold standard for assessment of left atrial (LA) volume. We assessed the feasibility of evaluating LA volume using 3D non-contrast computed tomography (NCCT). Furthermore, since manual tracing of LA volume is time consuming, we evaluated the accuracy of the LA area using 2D NCCT imaging for LA volume assessment.

Methods: MRI and NCCT imaging were performed in 69 patients before and one year after aortic valve replacement. In 3D MRI and 3D NCCT, each slice was manually traced, excluding the pulmonary veins and atrial appendage, and multiplied by slice spacing, thus generating a measure of LA volume. The LA volume was indexed to body surface area. On 2D NCCT, the largest axial cross-section LA area was traced manually.

Results: The mean LA volume was 102 ± 28 ml in MRI compared with 103 ± 28 ml in 3D NCCT. 3D NCCT showed good agreement with MRI measurements (mean difference −0.7 ml/m^2; 95% confidence interval (CI) −2.2 to 0.9). By Bland-Altman, 3D NCCT also showed good agreement with MRI (limits of agreement: −18.7–17.4 ml/m^2). Furthermore, good correlation was found between 2D NCCT and 3D NCCT LA volume (r = 0.93).

Conclusion: 2D and 3D measurements of LA volume in non-contrast computed tomography are feasible and accurate.

1. Introduction

Albeit time consuming and less readily available than cardiac computed tomography (CT), cardiac magnetic resonance imaging (MRI) is considered the gold standard for quantification of the cardiac chambers. Quantification of the left atrial (LA) volume with contrast cardiac CT shows very good agreement with MRI[1,2].

We aimed to evaluate the agreement and correlation between LA measurements in non-contrast CT (NCCT) compared with MRI. Furthermore, since manual tracing of LA volume is time consuming and therefore inconvenient in clinical practice, we evaluated whether the largest cross-sectional LA area in 2D NCCT imaging is suitable for LA volume assessment.

2. Methods

Patients scheduled for aortic valve replacement were prospectively included. Both MRI and NCCT were performed before and one year after surgery. LA maximal volume was indexed for body surface area (*LA volume index = LA volume/body surface area*). All examinations were performed at the Department of Cardiology, Odense University Hospital, Denmark.

The study was approved by the Danish Data Protection Agency and the Regional Scientific Ethical Committees for Southern Denmark (S-20130064). All patients provided their written informed consent. The study was registered with https://clinicaltrials.gov/(NCT02316587).

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Abbreviations and acronyms

2D	Two-dimensional
3D	Three-dimensional
CI	Confidence interval
CT	Computed tomography
LA	Left atrial
MRI	Magnetic resonance imaging
NCCT	Non-contrast computed tomography

2.1. Cardiac magnetic resonance imaging

MRI was performed on a Phillips Ingenia 1.5 T scanner with the Omega HP gradient system (Philips Electronics, Amsterdam, The Netherlands). A 32-channel dStream Torso coil was used during image acquisition. We obtained 20–24 sequential short-axis 8-mm thick cine slices encompassing the entire heart during multiple breath-hold sequences.

Images were analysed blinded to CT data on a work station with a Philips software package (2.6.3.5 2013). With continuous short-axis slices, maximal volumes were traced manually. LA volume was measured in ventricular end-systole preceding mitral valve opening and excluding the pulmonary veins and the left atrial appendage.

2.2. Cardiac computed tomography

NCCT scans were performed on a Siemens Somatom Definition Flash 128-slice scanner (Siemens Healthcare Solutions, Forchheim, Germany). A sequential non-contrast enhanced prospective ECG-gated scan (R-R interval 60–79%; tube voltage 120 kV; tube current 50 mA) was acquired and reconstructed with 3 or 5 mm slice spacing. Patients with a heart rate > 70 bpm received a maximum of 15 mg intravenous Seloken® (AstraZeneca), except when β-blockers were contraindicated.

Images were transferred to a SyngoVia (Siemens Healthcare Solutions) workstation and analysed blinded to MRI data (M.H.F). The LA volume was calculated by multiplying each manually traced LA area by the slice spacing (Fig. 1)[3]. The pulmonary veins and the left appendage were carefully identified - when needed this was assisted by the sagittal and coronal images - and excluded. As a simple 2D-estimate of LA volume, the largest axial cross-section area was traced.

To assess inter- and intra-observer variability, 20 patients were randomly selected. Two observers (M.H.F. and R.A.A.) independently repeated LA volume measurements to validate the reproducibility. Repeated measurements were performed 2–3 weeks after the initial measurements and blinded to previous CT and clinical data.

2.3. Statistics

Correlations between the modalities were assessed using Pearson's correlation coefficient, and regression analysis was used to assess associations between modalities. Agreement between different modalities was assessed using Bland-Altman plots adjusted for unequal numbers of repeated measurements[4,5]. These plots were supplemented by lines stemming from linear regressions of the differences on the averages, also called the Bradley-Blackwood procedure,[6] in order to support the visual assessment of trends across the measurement scale. To assess inter- and intra-observational differences, Bland-Altman limits of agreement were shown, supplemented with Pearson's correlation

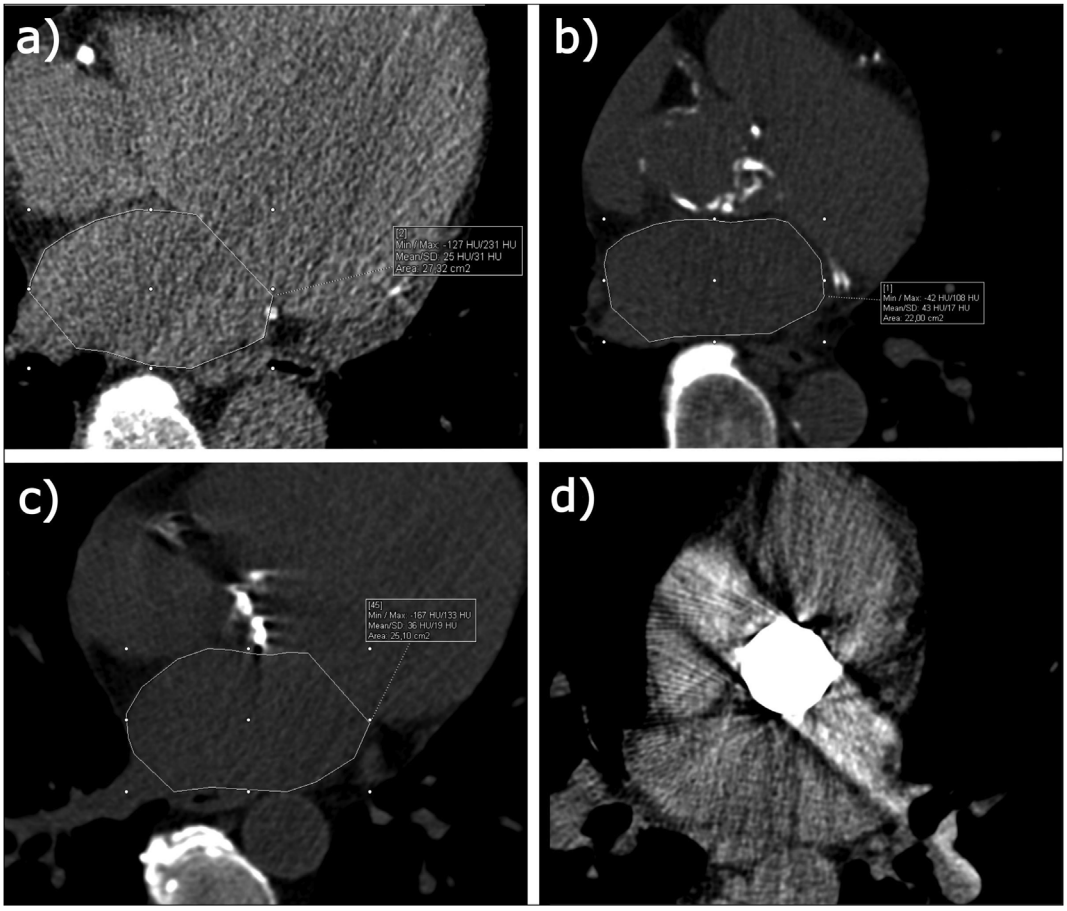

Fig. 1. LA imaging examples in NCCT (a) with no aortic valve calcification, (b, c) mild aortic valve calcification, and (d) after a mechanical aortic valve replacement.