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Comparison of cardiac computed tomography versus cardiac magnetic resonance for characterization of left atrium anatomy before radiofrequency catheter ablation of atrial fibrillation

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ABSTRACT

Background: The outcome of radiofrequency catheter ablation (RFCA) has been improved by the pivotal role of cardiovascular imaging such as cardiac computed tomography (CCT) or cardiac magnetic resonance (CMR) for the characterization of left atrium (LA) anatomy before RFCA. The aim of this study is to compare the procedural characteristics, overall radiation exposure and clinical outcomes between RFCA guided by image integration with CCT versus CMR.

Methods: Four-hundred patients with drug-refractory paroxysmal or persistent AF referred to RCFA were matched with the propensity score matching analysis to CCT (n: 200) or CMR (n: 200) for evaluation of LA before RFCA procedure. Left atrium diameter, left atrium volume, variant of pulmonary veins' anatomy, pulmonary veins' ostial dimensions, procedural characteristics, overall radiation exposure and rate of AF recurrence after RFCA were measured and compared between the two groups.

Results: The 2 groups were homogeneous with similar follow-up (557 ± 302 vs. 523 ± 265 days, respectively, p:0.24). The CCT group showed higher LA volume vs. CMR group (117 ± 46 vs. 101 ± 40 mL, $p < 0.001$). No differences were observed regarding procedural characteristics. AF recurrence at follow-up was similar (29% vs. 26%, p:0.5) despite a higher radiation exposure in the CCT group vs. CMR group (40.4 ± 23.7 mSv vs. 32.8 ± 23.5 mSv, $p < 0.005$). LA volume detected by CMR was the most robust independent predictor of AF recurrence at multivariate analysis [(HR: 1.08 (1.01–1.15), p: 0.02].

Conclusions: CCT and CMR provide similar information before RFCA. However, RFCA CMR-guided is associated with a lower overall cumulative radiation despite similar outcome in comparison with CCT-guided RFCA.

1. Introduction

Atrial fibrillation (AF) is the most common arrhythmia with an overall prevalence of 0.5–2% and 5–6% in the general population [1] and among the elderly, respectively [2]. It accounts for more than 400,000 hospitalizations each year [3] and it is the attributed cause for 15% of all strokes, totaling more than 100,000 per year [3]. Moreover, the prevalence of AF is expected to double by 2030 [4]. Several antiarrhythmic drugs are available for the treatment of AF, but the maintenance of sinus rhythm is often suboptimal [5]. The use of radiofrequency catheter ablation (RFCA) in order to perform complete circumferential linear lesions of pulmonary veins in a point-by-point fashion is the most established strategy for pulmonary vein (PV) isolation [6] and it has proved effective in drug-refractory AF disease [7,8]. The mean single-procedure success has been estimated up to 65% at up to year [9] with a major complication rate between 1% and 8% [10]. However, because of the complexity and variability of left atrium (LA) and PV anatomy, RFCA remains technically very challenging even for experienced electro-physiologists. Due to these limitations, the outcome of RFCA has been improved by the pivotal role of multimodality cardiovascular imaging such as cardiac computed tomography (CCT) or cardiac

Abbreviations: AF, atrial fibrillation; CCT, cardiac computed tomography; CEMRA, contrast enhanced magnetic resonance angiography; CMR, cardiac magnetic resonance; DAP, dose area product; DLP, dose length product; ED, effective dose; LA, left atrium; PV, pulmonary vein; RFCA, radiofrequency catheter ablation; SD, standard deviation.

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magnetic resonance (CMR) for the characterization LA anatomy before RFCA [11–19]. However, no comparative data between CCT and CMR have been described regarding the impact of different imaging modalities on procedural and clinical outcomes. The aim of this study is to compare the procedural characteristics, overall radiation exposure and clinical outcomes between RFCA guided by image integration with CCT versus CMR.

2. Methods

2.1. Study population

Study population was extracted from a cohort of 700 consecutive patients with drug-refractory paroxysmal or persistent AF referred to our institution to undergo a first RFCA from January 2011 to December 2012 by propensity-score matching analysis [20]. Exclusion criteria were hypersensitivity to contrast agents, estimated glomerular filtration rate ≤60 ml/min, inability to sustain a breath hold, pregnancy, presence of pacemaker or implantable cardioverter device. According to the propensity score matching analysis and exclusion criteria, 400 patients were identified as evaluated by CCT (n: 200; mean age 61.6 ± 10.9 yo; male: 155) or CMR (n: 200; mean age 59.7 ± 10. yo; male: 166) for evaluation of LA before RFCA. Written informed consent was obtained from all patients and the study protocol was approved by the institutional ethical committee.

2.2. Transthoracic echocardiography (TTE) protocol

In all cases, TTE was obtained with patients in the left lateral decubitus position using a commercially available system (IE33 system, Philips Medical System, Andover, MA) in the parasternal (long-axis and short-axis) and apical (2- and 4-chamber) views at baseline. For each patient, LA diameter defined as antero-posterior diameter measured on the 3-chamber view, end-diastolic and end-systolic left ventricle volumes were measured. Left ventricle ejection fraction was calculated by echocardiography biplane Simpson's rule.

2.3. CCT scan protocol

The CCT was performed with Discovery CT 750 HD scanner (GE Healthcare, Milwaukee, WI) with the following parameters: slice configuration 64 × 0.625 mm. Gantry rotation time 350 ms, tube current and tube voltage adapted to body mass index as previously described [21]. The patients received a 90 ml bolus of contrast medium (Iomeron 400 mg/ml, Bracco, Milan, Italy) through an antecubital vein at an infusion rate of 5 ml/s, followed by 50 ml of saline solution. The scan was performed according to the bolus tracking technique. In patients with heart rate <65 bpm during breath hold test, a prospective ECG-triggering (SnapShot Pulse, GE Healthcare, Milwaukee, WI) was used [22]. On the contrary, in patients with heart rate ≥65 bpm during breath hold test, the CCT scan was based on retrospective ECG-triggering with modulation dose technique [23]. Finally, in patients in AF at moment of scan, no ECG-gated spiral scan was performed. A post-processing adaptive statistical iterative algorithm (ASIR, GE Healthcare, Milwaukee, WI) was used instead of the standard filtered back-projection algorithm for all patients [24].

2.4. CMR scan protocol

All patients were evaluated in a 1.5-T scanner with Discovery MR450 (GE Healthcare, Milwaukee WI) with 8-element phased-array coil. After acquisition of localizer images of the heart, steady-state free precession cine sequences were acquired during held expiration in multiple short axes of left ventricle and 3 additional long-axis views (two-chamber, three-chamber and four-chamber) using the following parameters: repetition time 3.2 ms, echo time 1.4 ms, flip angle 58°, matrix 256 × 256, field of view 380 × 380 mm, slice thickness 8 mm. Then, a contrast enhanced magnetic resonance angiography (CEMRA) was performed as previously described in order to image LA anatomy [25]. Specifically, a pre-contrast 3D-FSPGR sequence was performed in a single breath hold in order to provide an anatomical reference to have a full coverage of LA and pulmonary vein anatomy with the following parameters: TR/TE 3.9 ms/1.5 ms, flip angle 35°, thickness/spacing 3.0 mm/−1.5 mm, matrix 320 × 190, 0.5 signal averages, bandwidth 63 kHz, centric k-space filling, fat suppression. Then, 0.1 mmol/kg of Gadolinium-BOPTA (Multihence, Bracco, Milan Italy) was administered at a flow rate of 2 mL/s through a 20-gauge needle positioned in the left antecubital vein using a power injector (Spectris SolarisTM; Medrad Inc., Pittsburgh, PA), followed by 20 mL of saline flush at the same flow rate and a post-contrast 3D-FSPGR acquisition was performed. The scanning delay after the beginning of Gadolinium-BOPTA injection was established by 3D-Fluoro tracking system [26].

2.5. CCT and CMR post-processing

Datasets were transferred to a dedicated workstation (AW4.5, GE Healthcare, Milwaukee WI) and centrally analyzed by two radiologists (G.P. and D.A., both with ≥ 8 years of clinical experience in cardiac imaging performance and analysis) blinded by the clinical history of the patient. A third radiologist (A.I.G. with ≥8 years of clinical experience in cardiac imaging performance and analysis) adjudicated the measurements in case of disagreement. For each patient the following measurements were performed.

- LA diameter: antero-posterior diameter measured on the 3-chamber view based on echocardiographic standard criteria with LA diastole defined as the last phase image before opening of the mitral valve.
- LA volume: angiographically derived volume assessed by segmentation process using mitral valve leaflets as landmarks to separate LA from left ventricle and excluding pulmonary veins and LA appendage.
- PVs ostia defined as the point of inflection between LA wall and pulmonary wall. The ostium was considered as common ostium when coalescence of the lower wall of the

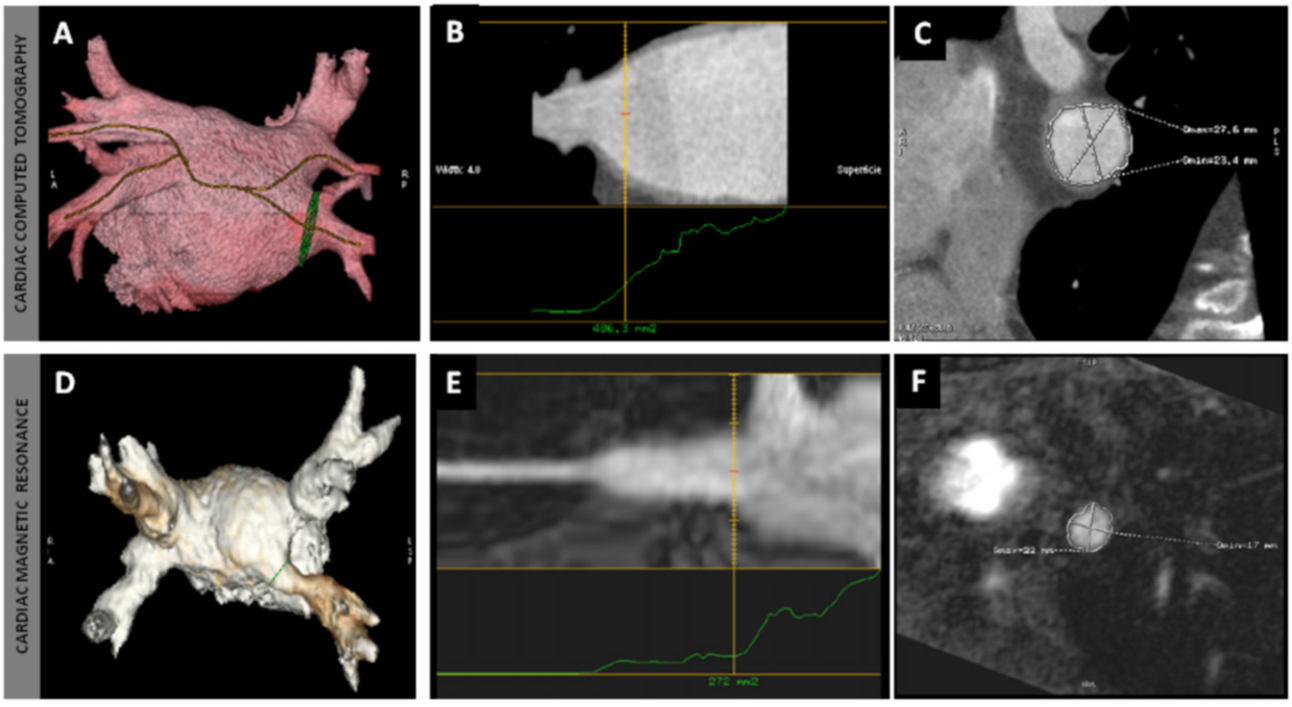

Fig. 1. Example for measurements of left atrium volume and pulmonary vein ostial area and diameters by cardiac computed tomography (upper panels) and cardiac magnetic resonance (lower panels). Volume rendering reconstruction (panels A and D) are displayed and the cutting planes at the junction of the pulmonary vein (green line) were oriented perpendicularly to the long axis of the pulmonary vein (panels B and E). The resulting reconstruction plane is used for the measurement of pulmonary vein ostial cross-sectional area and maximal and minimal diameters (panels C and F).