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Original article

Pre-procedural evaluation of the left atrial anatomy in patients referred for catheter ablation of atrial fibrillation

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ABSTRACT

Background: Cardiac computed tomography (CT) provides accurate imaging of the pulmonary vein (PV) and left atrial (LA) anatomy. This study aimed to evaluate the prevalence and morphological characteristics of anatomical variants that could influence atrial fibrillation (AF) ablation procedures.
Methods and results: One thousand forty consecutive patients (62 ± 10 years, 243 female, 644 paroxysmal AF) undergoing pre-procedural imaging with a 320-row CT and their first AF ablation procedure were analyzed. A total of 194 (18.7%) patients had anatomical variants. Left, right, and inferior common PVs were observed in 118, 5, and 6 patients, respectively. Three right and left PVs were observed in 44 and 4 patients, respectively. Three patients had remnants of PVs after lobectomies, and significant PV stenosis was observed in one. Supernumerary PVs that drained into the LA and diverticula were observed in eight patients. One patient had a string-like structure connecting the LA septum and posterior LA, and the others had membranous structures incompletely compartmentalizing the LA. Three patients had persistent left superior vena cavae, two strong deviations of the LA and PVs, and one dexiocardia. All patients underwent successful PV isolation during the index procedure.
Conclusions: Patients referred for AF ablation often have anatomical variants, which could influence the procedure. This information might aid in planning procedural strategies, and reducing unexpected procedural complications in AF ablation.

Introduction

Atrial fibrillation (AF) is the most common cardiac arrhythmia, and catheter ablation is recognized as a reasonable therapeutic option for the treatment. Confirmed electrical disconnection of the left atrium (LA) from the pulmonary veins (PVs) is the cornerstone of the catheter ablation of paroxysmal AF, and is an important component of more extensive ablation procedures for persistent AF [1–3]. The integration of three-dimensional electroanatomical mapping systems with pre-acquired images of the cardiac anatomy is a recent major advancement in AF ablation. Prior studies have shown that cardiac computed tomography (CT) provides an accurate imaging of the PV and LA anatomy with excellent spatial resolution, supplying the necessary anatomic information for a successful ablation. The objective of this study was to evaluate the prevalence and morphological characteristics of clinically important anatomical variants that could influence the AF ablation procedure using pre-procedural cardiac CT in a large population referred for catheter ablation of AF.

Methods

Study population

This study consisted of 1040 consecutive patients who underwent cardiac multidetector CT (MDCT) prior to their first catheter ablation of AF at our institute between October 2010 and December 2014. All patients underwent a PV antrum isolation (PVAI) in the index procedure, and the ablation lines were placed around the ostia of the ipsilateral PVs. AF was classified according to the HRS/EHRA/ECAS 2012 Consensus Statement on Catheter and Surgical Ablation of AF [3]. All patients gave their written informed consent for participation in the study.

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CT scanning

Gated contrast-enhanced CT of the chest was performed with a 320-row MDCT scanner (Aquilion one, Toshiba, Otawara, Japan). A bolus of 70–100 ml of iodinated contrast media was injected intravenously at an injection rate of 3.0–4.5 ml/s using an automatic injector to regulate the iodine injection speed as 22.2 mgI/kg/s. Scanning was initiated with a 10-second delay after the signal density level reached a predefined threshold of 200 Hounsfield units in the LA. The following parameters were used for scanning: electrocardiogram-gated acquisitions, 120 kVp, 110–206 mAs, and 320 × 0.5-mm slice collimation. Scans were performed from the tracheal bifurcation to the diaphragm. Reconstructions were performed with a FC13 to generate 0.5-mm-thick slices with a reconstruction interval of 0.5 mm with a workstation (SYNAPSE VINCENT, Fujifilm, Tokyo, Japan). All images were acquired in the supine position and reviewed independently by an experienced radiologist and cardiologist.

Mapping and ablation protocol

The ablation was performed according to the strategy described previously [4–7]. In brief, after a single transseptal puncture, two long sheaths (SL0, St. Jude Medical, Minneapolis, MN, USA) were introduced into both superior PVs. Pulmonary venography during ventricular pacing and contrast esophagography were performed to obtain the relative locations of the PV ostia vis-a-vis the esophagus. Two circular mapping catheters (Lasso, Biosense Webster, Diamond Bar, CA, USA) were placed in the superior and inferior PVs, and the left-sided, then right-sided, ipsilateral PVs were circumferentially and extensively ablated guided by a 3-D mapping system (CARTO3, Biosense Webster). The endpoint was the achievement of bidirectional conduction block between the LA and PVs. Radiofrequency current was delivered point-by-point with a 3.5 mm externally irrigated-tip quadripolar ablation catheter (Thermocool, Biosense Webster) with a power of up to 35 W, target temperature of ≤38 °C, and irrigation rate of 30 ml/min. The power was limited to 20 W on the posterior wall close to the esophagus. In patients with non-paroxysmal AF, a substrate modification, when AF persisted after the PVAI, was performed sequentially to eliminate any complex fractionated atrial electrograms in both atria [5,6].

Results

In total, 1040 patients (62 ± 10 years, 243 female, 644 paroxysmal AF) underwent cardiac MDCT prior to the first AF ablation procedure. The mean LA diameter was 41.6 ± 6.2 mm, and the left ventricular ejection fraction was 64.1 ± 8.8%. Among the 1040 patients, 846 (81.3%) patients had a normal LA and PV anatomy, whereas the remaining 194 (18.7%) patients had some anatomical variant, which could influence the AF ablation procedure.

The most common anatomical variant was a common PV. Left (Fig. 1A, B), right (Fig. 1C, D), and inferior common PVs (Fig. 2) were observed in 118 (11.3%), 5 (0.48%), and 6 (0.58%) patients, respectively. Three left PVs (Fig. 3A, B) and three right PVs (Fig. 3C, D) were observed in 4 (0.38%) and 44 (4.2%) patients. Three (0.29%) patients had remnants of PVs (Fig. 4A–C) after a lobectomy for lung cancer. In one (0.1%) patient, significant PV stenosis was observed in the LIPV despite no history of any previous procedure (Fig. 4D). In all cases except in the cases with inferior common PVs, an ipsilateral PV isolation was successfully achieved. In the patients with inferior common PVs, the PV was isolated segmentally.

Supernumerary PVs that drained into the LA and diverticula were observed in eight (0.77%) patients (Fig. 5). One patient had a string-like structure connecting the LA septum and posterior LA (Fig. 6). One patient had a membranous structure extending from the interatrial septum to the lateral LA like cor triatriatum sinister (Fig. 7). That membranous structure incompletely compartmentalized the LA. In both cases, transseptal LA catheterization into the posterior part of those structures enabled the achievement of a successful PVAI.

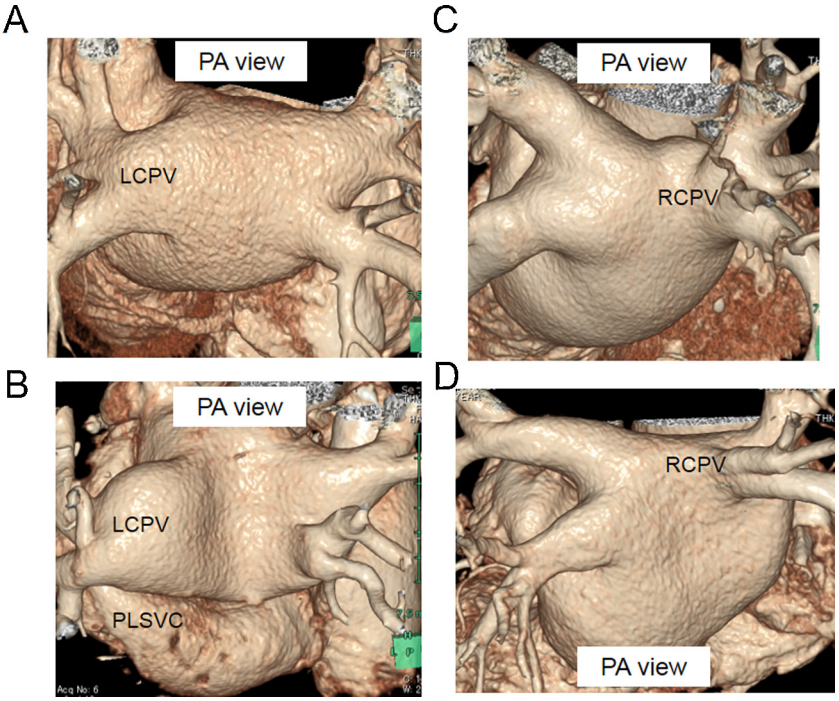

Fig. 1. Left common pulmonary vein (A, B), right common pulmonary vein (C, D), and a PLSVC (B). LCPV, left common pulmonary vein; RCPV, right common pulmonary vein; PLSVC, persistent left superior vena cava; PA, posteroanterior.