Electroanatomic reconstruction of the left atrium, pulmonary veins, and esophagus compared with the "true anatomy" on multislice computed tomography in patients undergoing catheter ablation of atrial fibrillation

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BACKGROUND Current concepts of catheter ablation for atrial fibrillation (AF) commonly use three-dimensional (3D) reconstructions of the left atrium (LA) for orientation, catheter navigation, and ablation line placement.

OBJECTIVES The purpose of this study was to compare the 3D electroanatomic reconstruction (Carto) of the LA, pulmonary veins (PVs), and esophagus with the true anatomy displayed on multislice computed tomography (CT).

METHODS In this prospective study, 100 patients undergoing AF catheter ablation underwent contrast-enhanced spiral CT scan with barium swallow and subsequent multiplanar and 3D reconstructions. Using Carto, circumferential plus linear LA lesions were placed. The esophagus was tagged and integrated into the Carto map.

RESULTS Compared with the true anatomy on CT, the electroanatomic reconstruction accurately displayed the true distance between the lower PVs; the distances between left upper PV, left lower PV, right lower PV, and center of the esophagus; the longitudinal diameter of the encircling line around the funnel of the left PVs; and the length of the mitral isthmus line. Only the distances between the upper PVs, the distance between the right upper PV and esophagus, and the diameter of the right encircling line were significantly shorter on the electroanatomic reconstructions. Furthermore, electroanatomic tagging of the esophagus reliably visualized the true anatomic relationship to the LA. On multiple tagging and repeated CT scans, the LA and esophagus showed a stable anatomic relationship, without relevant sideward shifting of the esophagus.

CONCLUSION Electroanatomic reconstruction can display with high accuracy the true 3D anatomy of the LA and PVs in most of the regions of interest for AF catheter ablation. In addition, Carto was able to visualize the true anatomic relationship between the esophagus and LA. Both structures showed a stable anatomic relationship on Carto and CT without relevant sideward shifting of the esophagus.

KEYWORDS AF; Catheter; Ablation; Carto; CT; Esophagus; Anatomy

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Invasive therapy is increasingly used to treat patients with highly symptomatic atrial fibrillation (AF). Radiofrequency (RF) energy-induced lines encircling the pulmonary veins (PVs) outside the PV funnel at the level of the left atrium (LA) combined with linear lesion lines connecting the circles and the mitral annulus revealed promising results and are increasingly used.[1–5] The approach requires three-dimensional mapping systems to reconstruct the LA anatomy in order to facilitate three-dimensional orientation and catheter navigation.[1,2,4] In addition, because of the severe and potentially lethal risk for esophageal perforations during ablation, integration of an esophagus tag into the electroanatomic LA map

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visualizing the anatomic relationship has been studied and reported.[6,7]

The present study compared the electroanatomic reconstruction of the LA, PVs, and esophagus against the true anatomy displayed on contrast-enhanced multislice computed tomography (CT) scans.

Methods

Patient selection and characteristics

One hundred patients (75 men and 25 women, mean age 53 ± 10 years) with highly symptomatic AF were included in this prospective study. Inclusion criteria were a history of AF for more than 18 months, previously ineffective antiarrhythmic drug therapy (at least one antiarrhythmic drug), and at least three documented AF episodes together with corresponding symptoms. Eighty-five (85%) patients had paroxysmal AF and 15 (15%) had persistent AF. Persistent AF was defined as continuous arrhythmia throughout the 7-day Holter monitoring period prior to ablation. Organic heart disease was present in 22 (22%) patients (coronary artery disease in 9, valvular heart disease in 4, dilated cardiomyopathy in 9), 42 (42%) patients had a history of arterial hypertension, and 49 (49%) patients had so-called *lone AF*. Mean left ventricular ejection fraction was 61% ± 9%, and mean LA diameter was 42 ± 6 mm. The median history of AF was 5 years (range 1–10 years). AF ablation had been attempted previously in 32 (32%) patients, and isthmus ablation for common atrial flutter had been performed in 11 (11%) patients.

Mapping and ablation procedure

The ablation procedure was reported in detail previously.[8] In brief, the electroanatomic mapping system (Carto, Biosense Webster, Diamond Bar, CA, USA) was used for reconstruction of the LA and navigation of the mapping/ablation catheter (NaviStar, Biosense Webster). All PVs were visited with the catheter, and vessel tagging was performed. The vein–atrium transition was determined by combining information from the fluoroscopic cardiac silhouette, impedance changes, and PV–atrium electrogram characteristics, that is, fusion of the atrial electrogram component and the PV potential component. In addition, after reconstruction of the LA and before ablation, tagging of the esophagus was performed by advancing and withdrawing a Carto catheter covered by a conventional gastric tube in and out of the esophagus.

For ablation, circular lesions were deployed in the LA around the funnel of the PVs at the LA level. Additional linear lines were deployed between the circular lesions along the LA roof as well as between the left circular lesion and the mitral annulus. Individual adjustment of the lesion lines was performed as indicated from the esophageal course to prevent RF application in the direct vicinity of the esophagus.

CT imaging technique

The day before the ablation procedure, all patients underwent cardiac CT imaging using a multidetector four-row helical system (Somatom Volume Zoom, Siemens Medical Systems, Forchheim, Germany) as a standard imaging procedure. Patients swallowed 5 mL barium paste for contrast of the esophageal lumen. Data acquisition was performed in late diastole at a slice width of 2 mm and reconstruction increment of 1 mm. Coverage was completed within one breath-hold period (25–30 seconds). Imaging was initiated at the transaxial level of the aortic arch and carried caudally to cover the cardiac chambers. Nonionic iodinated contrast material (Imeron 300) was administered intravenously (80 mL at 2.5 mL/s).

Image data were reviewed using multiplanar reconstruction, maximum intensity projection, and three-dimensional volume rendering. Pathologic conditions influencing the esophageal course (e.g., esophageal tumors or hernias) were excluded on CT scans for all patients.

Measurements

Definitions

On CT, the PV ostium was defined as the reflection of the parietal pericardium at the point of intersection between the LA wall and the PV wall as seen on the two-dimensional source images.[9] On Carto, the PV ostium was determined by combining information from the fluoroscopic cardiac silhouette, impedance changes, and PV–atrium electrogram characteristics and marked by placement of anatomic mapping points.[8]

Comparison between CARTO and CT

Measurements on Carto and CT were performed independently by two different physicians blinded to each other's data. The following parameters were measured on Carto and CT (Figures 1 and 2): 1 = distance between the ostia of the left upper PV and right upper PV (RUPV), 2 = distance between the ostia of the left lower PV and the right lower PV, 3 = distance between the left upper PV ostium and the center of the esophagus, 4 = distance between the right upper PV ostium and the center of the esophagus, 5 = distance between the left lower PV ostium and the center of the esophagus, 6 = distance between the right lower PV ostium and the center of the esophagus. In addition, the length of contact between the LA and the esophagus and the length of the mitral isthmus line (distance between the inferior left lower PV ostium and the mitral annulus) were determined and compared. Furthermore, on CT the longitudinal outer distance between the ostia of the left upper PV and the left lower PV and the longitudinal outer distance between the ostia of the right upper PV and the right lower PV were measured and compared with the maximum longitudinal diameter of the respective circular lesion on Carto.