On the accuracy of CartoMerge for guiding posterior left atrial ablation in man

Hua Zhong, MS,* Joan M. Lacomis, MD,† David Schwartzman, MD‡

*From the *Department of Computer Science, Carnegie Mellon University, and †Department of Radiology and ‡Cardiovascular Institute, University of Pittsburgh, Pittsburgh, Pennsylvania.*

BACKGROUND Recent reports suggest that the CartoMerge system is useful for guiding human posterior left atrial (PLA) endocardial ablation.

OBJECTIVE To assess the accuracy of the CartoMerge system during PLA ablation.

METHODS Sixteen patients undergoing PLA catheter ablation were studied. In each patient, registration of preoperative computed tomographic (CT) and intraoperative electroanatomic left atrial images was performed to create CartoMerge images. Encircling of right and left pulmonary venous vestibules with ablation points was then performed guided solely by intracardiac echocardiography, with point locations saved on a CartoMerge image to which the operator was blinded. The accuracy of the CartoMerge image was then assessed by measuring the distance from the location of each ablation point on the image to its actual anatomic location. In five patients, accuracy of registration of each of three left atrial CT images (just prior to mitral valve opening, at end-diastasis, at end-atrial contraction) with the electroanatomic image was compared. In two patients, accuracy of registration using left atrial image data alone was compared with that which used both left atrial and thoracic aorta image data.

RESULTS In each patient, inaccuracy of the CartoMerge image was apparent, the magnitude of which was similar for right- and left-vestibule ablation points. Accuracy was significantly improved when the end-atrial contraction CT image was used for registration. The inclusion of thoracic aorta image data did not improve accuracy.

CONCLUSIONS The CartoMerge system is inaccurate. Inaccuracy may be reduced by using CT and electroanatomic images obtained at the same point in the atrial mechanical cycle.

KEYWORDS Atrial; Atrial fibrillation; Catheter ablation; Intracardiac echocardiography; Electroanatomic mapping

(Heart Rhythm 2007;4:595–602)

Introduction

The electrophysiologic significance of the posterior left atrium (PLA) is now established, and catheter ablation is increasingly performed in this region with intent to cure atrial fibrillation (AF). However, the PLA is geometrically complex and relatively difficult to access. Experience has taught us that conventional techniques for endocardial PLA navigation, based on fluoroscopy, electrographic information, or virtual imaging, are flawed. For several years, it has been apparent that multidetector computed tomography (CT) yields accurate, highly detailed images of the PLA.[1] These preoperative images improved conceptual clarity but beyond the mind's eye could not be used intraoperatively.[2] Recently, a commercial software system (CartoMerge, Biosense Webster, Diamond Bar, CA) was introduced that purports to accurately register a preoperative left atrial (LA) CT image with an intraoperative LA electroanatomic image, thus harnessing the CT information for navigation.[3] Several reports detailing evaluations of this technology in man have concluded that the system is accurate and thus useful for guiding PLA ablation.[4–7] However, in each of these reports, the accuracy assessment used indices derived by the CartoMerge system itself. In the present report, we detail the results of a study in which a system-independent assay of accuracy was performed.

Methods

Patients

All patients provided informed consent. The study cohort consisted of 16 patients, each referred for PLA catheter ablation intended to cure symptomatic paroxysmal (n = 5) or persistent (n = 11) AF. There were 12 men, and the cohort ranged in age from 46 to 68 years. No patient had undergone a prior ablation procedure. No patient had significant heart valve disease, and each had a normal left ventricular ejection fraction. Patients were taking a variety of medications, including beta-blockers (n = 6), calcium channel blockers (n = 3), renin-angiotensin inhibitors (n = 12), propafenone (n = 1), sotalol (n = 1), dofetilide (n = 1), and amiodarone (n = 2).

Drs. Schwartzman and Lacomis have in the past or are currently receiving funding in the form of research grants (unrelated to this study) and/or lecture/consulting fees from the following companies: General Electric Healthcare Systems, Medtronic, EP Medsystems, St. Jude Medical, Boston Scientific, and/or Biosense Webster. **Address reprint requests and correspondence:** David Schwartzman, M.D., UPMC Presbyterian, B535, Pittsburgh, PA 15213-2582. E-mail address: schwartzmand@upmc.edu. (Received December 19, 2006; accepted January 29, 2007.)

1547-5271/$ -see front matter © 2007 Heart Rhythm Society. All rights reserved. doi:10.1016/j.hrthm.2007.01.033

CT imaging

Imaging was performed within 24 hours of electroanatomic mapping using a 64-detector scanner (VCT, General Electric Healthcare, Milwaukee, WI) and dual-barrel contrast injector (Stellant D, Medrad, Pittsburgh, PA). Injection and scanning parameters were as follows: test bolus of 20 cc iodixanol 320 (General Electric Healthcare), 20 cc saline flush at 5 cc/s timed for the aortic root; scanning bolus of 50 cc iodixanol 320, 50 cc mix of 25 cc iodixanol/25 cc saline, 50 cc saline flush at 5 cc/s, killivolts peak (kVP) 120, mA 450–800 with dose modulation (peak dose 40%–80% of RR interval), 15–18 cm field of view (FOV), single breath hold at functional residual capacity, retrospective electrocardiogram (ECG)-gated (patients with paroxysmal AF, all five of whom were in sinus rhythm at the time of CT scanning) or nongated (patients with persistent AF, all 11 of whom were in AF at the time of CT scanning) helical acquisition with 0.625 mm slice thickness, 350 ms rotation time, and pitch adjusted to the heart rate.

Data were examined by radiology personnel who were highly experienced with atria and aorta imaging and who confirmed that in each patient image quality was excellent. Coronal, sagittal, and oblique reformats of the volume-rendered whole heart, thoracic aorta, and isolated LA were performed. For electrocardiographically gated studies, images were produced at 10% increments of the RR interval; for nongated studies, a single image was produced. All postprocessing as well as subsequent measurements were done using commercial software (Advantage version 4.2, General Electric Healthcare) as described elsewhere.[1] LA volume was measured after removing pulmonary vein sleeves beyond 2 cm of each pulmonary venoatrial junction. Endocardial lengths were measured directly using the Advantage software.

Electroanatomic imaging

All patients were studied under general anesthesia. Colloidal volume was delivered as necessary to achieve a mean LA pressure of between 8 and 10 mmHg. A Navi-Star catheter (Biosense Webster) was placed into the LA via an atrial transseptal route; it was coupled to an electroanatomic imaging system (Carto XP, Biosense Webster). An intracardiac echocardiography (ICE) catheter (UltraICE, Boston Scientific, Natick, MA) was placed into the LA via a separate atrial transseptal route.[8] To mimic the setting of CT image acquisition, all electroanatomic data were acquired with the lungs at functional residual capacity and in the absence of positive airway pressure. Data acquisition was gated to the QRS complex. Guided by ICE, four landmark registration points were acquired, each at a discrete, echocardiographically distinct anatomical site in the PLA (Figure 1).[7,9,10] Additional LA and proximal pulmonary vein surface registration points, each one guided by ICE to ensure firm (but not distending), stable electrode-endocardial contact were then acquired to encompass the entirety of the chamber in a spatially uniform manner (complete opacification using a fill threshold of 15 mm). Because of inter-individual variation in LA volume, this yielded a variable number of points. LA volume was assessed with all registration points using the Carto XP software.

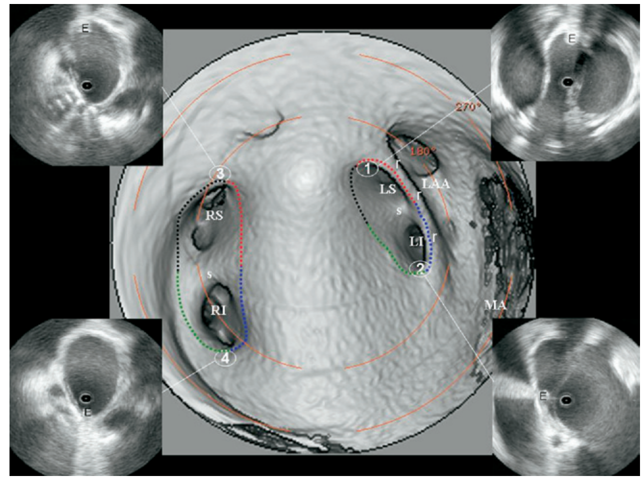

Figure 1 CT reconstruction of the PLA demonstrating an endocardial vantage. Each lesion path is schematized by a *dotted line*, with quadrant 1 shown in *red*, quadrant 2 in *blue*, quadrant 3 in *green*, and quadrant 4 in *black*. The left-vestibule lesion path traveled along the apex of the ridge-like tissue isthmus (r) separating the pulmonary vein and appendage vestibules (quadrants 1 and 2) and then continued on to the posterior wall (quadrants 3 and 4). For quadrants 1 and 2, the distance between the lesion path and the venoatrial junction, defined by the intervenous saddle (s), was variable and dictated by the vestibule anatomy.[9] For quadrants 3 and 4, the lesion path was at the venoatrial junction. The right-vestibule lesion path traveled along posterior (quadrants 1 and 2) and interatrial septal (quadrants 3 and 4) walls and was uniform at the venoatrial junction, which is defined by the intervenous saddle (s). The *encircled numbers 1, 2, 3, and 4* refer to the sites of each of the landmark registration points, an ICE snapshot of each of which is shown as an inset. In each snapshot is shown the position of the ablation electrode (E) at the landmark point. LAA = left atrial appendage vestibule; LI = left inferior pulmonary vein; LS = left superior pulmonary vein; MA = mitral annulus; RI = right inferior pulmonary vein; RS = right superior pulmonary vein.

In two patients, in addition to the LA points, fluoroscopically guided points (85 points in one patient, 116 points in the other) were acquired in a spatially uniform manner (complete opacification using fill threshold of 15 mm) along the endovascular surface of the ascending and descending thoracic aorta after retrograde access of the Navi-Star catheter.

Registration of CT and electroanatomic images

The Carto system incorporated an image segmentation and integration software module (CartoMerge, Biosense Webster). This module was used to perform one or more registrations of the electroanatomic image and the CT image(s) in each patient, using both landmark and surface registration points, as follows:

A. Persistent AF patients

1. In nine patients, all of whom were in AF during both CT and electroanatomic image acquisition, a single registration was performed: the LA CT image with the LA electroanatomic image.