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Real-Time Integration of MDCT-Derived Coronary Anatomy and Epicardial Fat

Impact on Epicardial Electroanatomic Mapping and Ablation for Ventricular Arrhythmias

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OBJECTIVES This study aimed to evaluate the feasibility and accuracy of real-time integration of multidetector computed tomography (MDCT) derived coronary anatomy and epicardial fat distribution and its impact on electroanatomical mapping and ablation.

BACKGROUND Epicardial catheter ablation for ventricular arrhythmias (VA) is an important therapeutic option in patients after endocardial ablation failure. However, epicardial mapping and ablation are limited by the presence of coronary arteries and epicardial fat.

METHODS Twenty-eight patients (21 male, age 59 ± 16 years) underwent combined endo-epicardial electroanatomical mapping. Prior to the procedure, MDCT derived coronary anatomy and epicardial fat meshes were loaded into the mapping system (CARTO XP, Biosense Webster Inc, Diamond Bar, California). Real-time registration of MDCT data was performed after endocardial mapping. The distance between epicardial ablation sites and coronary arteries was assessed by registered MDCT and angiography. After the procedure, mapping and ablation points were superimposed on the MDCT using a reversed registration matrix for head-to-head comparison of mapping data and corresponding fat thickness.

RESULTS Image registration was successful and accurate in all patients (position error 2.8 ± 1.3 mm). At sites without evidence for scar, epicardial bipolar voltage decreased significantly ($p < 0.001$) with increasing fat thickness. Forty-six VA were targeted; 25 (54%) were abolished by catheter ablation, in 21 (46%) ablation failed. In 5 VA no target site was identified and in 3 VA adhesions prevented mapping. In 2 VA ablation was withheld due to His-bundle vicinity and in 7 VA due to proximity of coronary arteries. In 4 VA catheter ablation was ineffective. At ineffective ablation sites epicardial fat was significantly thicker compared to successful sites (16.9 ± 6.8 mm [range 7.3 to 22.2 mm] and 1.5 ± 2.1 mm [range 0.0 to 6.1 mm], $p = 0.002$).

CONCLUSIONS Real-time image integration of pre-acquired MDCT information is feasible and accurate. Epicardial fat >7 mm and the presence of coronary arteries are important reasons for epicardial ablation failure. Visualization of fat thickness during the procedure may facilitate interpretation of bipolar electrograms and identification of ineffective ablation sites. (J Am Coll Cardiol Img 2013;6:42–52) © 2013 by the American College of Cardiology Foundation

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Epicardial electroanatomic mapping (EAM) followed by radiofrequency catheter ablation is an important therapeutic option in patients after endocardial ablation failure. However, despite the presence of a subepicardial substrate, epicardial EAM and ablation may have important limitations. Bipolar voltage mapping might not be accurate to delineate subepicardial scar and can overestimate its extent, as even thin layers of epicardial fat attenuate bipolar voltage (1–3).

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Once a potential ablation target site (TS) has been identified, ablation needs to be withheld in the vicinity of coronary arteries, usually visualized by repeated coronary injections, or it may not be effective due to thick epicardial fat, the presence of which can only be assumed when irrigated-tip ablation is ineffective (3,4). Cardiac multidetector computed tomography (MDCT) can reliably visualize coronary arteries and epicardial fat (5,6). Accurate real-time integration of MDCT-derived coronary anatomy and fat distribution during the ablation procedure is therefore desirable.

The purpose of this study was: 1) to evaluate epicardial fat distribution in patients undergoing combined endo-epicardial mapping and ablation; 2) to assess the feasibility and accuracy of real-time integration of MDCT-derived coronary anatomy and fat distribution with EAM; 3) to determine the influence of fat thickness on epicardial bipolar and unipolar voltage and ablation outcome; and 4) to evaluate the potential use of integrated MDCT to identify inappropriate ablation sites.

METHODS

Patients and baseline evaluation. The study population consisted of 28 consecutive patients (21 male, 59 ± 16 years of age) scheduled for combined endo-epicardial EAM and ablation (7–9). Ethics committee approval was not necessary because all performed procedures were part of routine clinical protocol. Informed consent was obtained from all patients. Before the procedure, patients underwent transthoracic echocardiography. When considered necessary, magnetic resonance imaging and/or nuclear imaging were performed to determine the presence of structural heart disease.

Pre-procedural MDCT acquisition and processing. Patients underwent cardiac MDCT before EAM using either a 64-detector row helical scanner (Aquillion 64; Toshiba multi-detector, Toshiba Medical Systems, Otawara, Japan) or a 320-detector row volumetric scanner (Aquillion ONE, Toshiba Medical Systems). The patients' heart rate and blood pressure were monitored before the scan. In case of a heart rate ≥65 beats/min and in the absence of contraindications, a beta-blocker was administered (metoprolol 50 to 100 mg orally or 5 to 10 mg intravenously). Scan parameters depended on body posture. For the 64-row contrast-enhanced scan, collimation was 64 × 0.5 mm, the tube voltage was 100 to 135 kV, and the tube current was 250 to 350 mA. For the 32-row contrast-enhanced scan, the heart was imaged in a single heartbeat using prospective triggering with the exposure interval depending on the heart rate. Scan parameters were as follows: 350-ms gantry rotation time, 100 to 135-kV tube voltage, and a tube current of 400 to 580 mA. For both scans, contrast material (Lomeron 400, Bracco, Milan, Italy) was administered, 80 to 110 or 60 to 90 ml, respectively, followed by saline solution flush (5).

The MDCT data were analyzed using MASS software (V2009-EXP LKEB, Leiden, the Netherlands). The aortic, endocardial, pericardial, and epicardial contours and the left main artery (LM) were traced (Fig. 1A). The distance between the epicardial and pericardial contours was computed to assess epicardial fat thickness. A bull's eye reconstruction of the epicardial surface was created and divided into 3 equal long-axis segments (basal, mid, and apical) and 8 equal short-axis segments A through H (6). For each segment, the mean epicardial fat thickness was calculated. The contours were converted into 3-dimensional meshes that could be imported into the EAM system (CARTO XP, Biosense Webster Inc, Diamond Bar, California). The vertices of the epicardial surface mesh were color-coded for fat thickness (Fig. 1B). In addition, the original cardiac MDCT data were loaded into the CARTO system, and cardiac structures were segmented. Before mapping, all meshes and the segmented images were merged to a final fusion image (FFI) using CARTO-Merge (IPE) software, enabling the registration and fusion of multiple datasets (Fig. 1C). After the procedure, all mapping and ablation points and registration matrix were exported from the CARTO system and superimposed on the corresponding short-axis MDCT slice using reversed registration (Fig. 1D).

ABBREVIATIONS AND ACRONYMS

EAM = electroanatomic mapping
FFI = final fusion image
LM = left main artery
LV = left ventricle
MDCT = multidetector computed tomography
RV = right ventricle
TS = target site
VA = ventricular arrhythmia