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Research paper

Association between pulmonary vein orientation and ablation outcome in patients undergoing multi-electrode ablation for atrial fibrillation

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ABSTRACT

Background: Previous studies reported on the impact of pulmonary vein orientation on pulmonary vein isolation (PVI) outcome in atrial fibrillation patients undergoing laser balloon PVI and point-by-point radiofrequency ablation.
Objective: Demonstrate the association between pulmonary vein orientation and PVI outcome after multi-electrode radiofrequency ablation.
Methods: 120 patients undergoing PVI with a circular MER catheter were included. A left atrial ECG-triggered CT was performed in all patients prior to PVI. The orientation of all pulmonary veins at the insertion into the left atrium was measured in the axial and coronal planes. pulmonary veins were classified as having a ventral/dorsal and caudal/cranial orientation depending on the pulmonary vein trunk angle as compared to the median angle.
Results: Mean age was 56 years, arrhythmia-free survival after a median follow-up of 20 months was 54.2%. Left upper pulmonary vein orientation within the coronal plane was associated with arrhythmia-free survival, ranging from 58% with a cranial pulmonary vein orientation to 21% with a caudal orientation ($p = 0.003$). Similarly, arrhythmia-free survival was 50% in patients with a caudal orientation and 33% in patients with a cranial orientation of the left lower pulmonary vein in the coronal plane ($p = 0.036$). Pulmonary vein orientation in the axial plane and orientation of the right-sided pulmonary veins were not associated with arrhythmia-free survival. Multivariable analysis showed an independent association between both left upper (hazard ratio 2.8, $p = 0.001$) and left lower (hazard ratio 0.490, $p = 0.034$) pulmonary vein orientation and arrhythmia-free survival.
Conclusion: In MER ablation, orientation of the left upper and caudalpulmonary veins in the coronal plane were independently associated with arrhythmia-free survival after multi-electrode PVI.

1. Introduction

Pulmonary vein isolation (PVI) is an effective treatment for atrial fibrillation (AF),[1,2] although ablation success is varies between 60–80% after long-term follow-up.[3–5] Besides conventional radiofrequency (ablation, several other techniques have been developed to perform PVI, including endoscopically assisted laser balloon ablation[6,7] and multi-electrode radiofrequency (MER) ablation.[8–10] We recently reported that pulmonary vein orientation significantly influences ablation outcome in laser balloon ablation,[11] but not in contact force sensing ablation.[12] These results suggest that the efficacy of ablation catheters with a circular design may be impacted by pulmonary vein orientation. Therefore, we aimed to determine the association between pulmonary vein orientation and arrhythmia-free survival in patients with AF undergoing MER PVI.

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2. Methods

Data from 120 consecutive patients suffering from highly symptomatic, drug-refractory AF wi who underwent a first PVI using the MER ablation catheter (PVAC, Medtronic Inc.) and in whom CT imaging had been performed were entered in a prospective registry. Exclusion criteria were: a previous PVI attempt, left atrium diameter exceeding 50 mm in the parasternal long-axis view, severe valvular heart disease and contraindications to post-interventional oral anticoagulation. Directly prior to the ablation procedure, all patients underwent transesophageal echocardiography to rule out LA thrombus.

2.1. CT characteristics

All patients underwent CT imaging of the left atrium to guide the procedure. Cardiac multislice CT (MSCT) angiography was performed by a team of experienced CT technologists using a 64-slice scanner (Lightspeed VCT XT, GE Healthcare). A bolus of 70 ml of nonionic contrast medium of agent (Optiray 350, Mallinckrodt, The Netherlands) was infused through a large antecubital vein at a rate of 5 ml/s, followed by 50-ml saline solution flush. Automatic detection of the contrast bolus in the left atrium was used to initiate data acquisition. Delay times varied significantly because of flow rate differences in patients, but were generally in the range of 5–15 seconds. Craniocaudal scanning was performed during breath-hold and using retrospective ECG gating (to be able to determine volume changes of the left atrium, but not used in this study). Collimation was 64 × 0.5 mm, rotation time 400 ms, and the tube voltage was 120 kV with mA dose modulation variable between 80 − 200 mA. In accordance with local protocols, pulmonary vein analysis was performed at 40% of the RR interval, to ensure maximum contrast enhancement in the atrium. After acquisition, MSCT data were exported, post-processed, and analyzed on a dedicated workstation (GE Healthcare, Little Chalfont, UK). The images were reviewed by an independent investigator who was not involved in the ablation procedures and was not informed about the PVI outcome in these patients to prevent unconscious bias.

2.2. Pulmonary vein orientation measurement

The pulmonary vein trunk orientation measurement has been described in previously published reports.[11,13,14] The orientation of the pulmonary vein trunk at the site of insertion into the LA was assessed for all pulmonary vein s in both the axial and coronal (coronal) plane. A line was drawn in the direction of each pulmonary vein trunk in both the axial and coronal plane. Thereafter, the angle between the pulmonary vein trunk direction and the intersection line of the sagittal plane was measured in the axial and coronal plane (Fig. 1). Median pulmonary vein trunk angles were calculated in the axial and coronal plane for all four pulmonary vein trunks. pulmonary vein s were classified as having a ventral or dorsal orientation and caudal or cranial orientation, respectively depending on the individual angle as compared to the median angle in the axial and coronal plane. Common pulmonary vein s[15] were excluded from analysis.

2.3. Ablation protocol

All ablation procedures were performed under general anesthesia supervised by a cardiovascular anesthesiologist. After placement of a 6F quadripolar catheter in the coronary sinus, a single transseptal puncture was performed using a Brockenbrough needle under fluoroscopic and pressure guidance. Immediately after the transseptal puncture, 10,000 IU of unfractionated heparin was administered. An 8.5 F sheath (SL-1, St. Jude Medical, Minnetonka, MN, USA) was used for pulmonary vein angiography. All sheaths were continuously flushed with saline containing 2500 IU heparin per 500 mL saline. An activated clotting time between 300 and 350 seconds was targeted. Additional heparin was administered when needed. The activated clotting time was checked during the procedure at regular intervals of 30 minutes.

2.4. Multi-electrode catheter ablation

The MER catheter (PVAC™, Medtronic, Minneapolis, MN, USA) is a mapping and ablation catheter with a 25 mm diameter circular electrode array. This catheter has a bidirectional steering mechanism and an over-the-wire design. The details of this device have been described previously[8]. Using a 0.032″ in. guidewire placed in the pulmonary vein, the catheter was positioned at the antrum of each pulmonary vein to record local electrical activity at the veno-atrial junction prior to radiofrequency energy application, creating Ppulmonary vein templates. Radiofrequency energy was applied with a target temperature setting of 60 °C, energy setting of 4:1 or 2:1 ratio between bipolar and unipolar energy, and 60 s duration (Medtronic GENius, Minneapolis, MN, USA). Multiple circular ablation sets of radiofrequency energy were delivered using the available energy settings until isolation of each pulmonary vein was achieved. After ablations were performed at all veno-atrial junctions, the MER was used to remap all pulmonary vein ostia. If pulmonary vein s appeared to be incompletely isolated, additional radiofrequency energy applications were delivered using the MER until full isolation was achieved. No adenosine testing was performed.

2.5. Post-ablation management

Patients were hospitalized for at least 24 h and monitored telemetrically. Oral anticoagulants were resumed immediately after the procedure, with a target INR of 2.5–3.5, in accordance with local guidelines. Low molecular weight heparin was administered in a patient-weight dependent dose until INR was adequate.

2.6. Follow-up

A blanking period of 3 months was defined after PVI. Patients had outpatient visits at 3, 6 and 12 months after PVI, including 24–72 hour Holter ECG. Follow-up after the 12 month outpatient clinic visit was performed by the referring physician. Patients were immediately referred to the emergency room in case of symptoms. If no arrhythmia could be detected, patients underwent Holter ECG monitoring to exclude arrhythmia recurrence. Furthermore, patients were contacted telephonically at the end of the study period when they were discharged from follow-up and were inquired about any arrhythmia symptoms and use of anti-arrhythmic drugs (AADs).

2.7. Study endpoints

The primary endpoint of our study was arrhythmia-free survival, defined as patients without AF/atrial flutter/atrial tachycardia recurrence after a blanking period of 3 months. Arrhythmia recurrence was defined as an ECG showing the characteristics of AF/atrial flutter/atrial tachycardia, or on a 30 second telemetry strip, in accordance with the European consensus statement on AF ablation.[2] Patients who were still using antiarrhythmic drugs at the end of the study period were considered arrhythmia recurrences, in accordance with the European consensus statement.[2]