Does the number of simultaneously activated electrodes during phased RF multielectrode ablation of atrial fibrillation influence the incidence of silent cerebral microembolism?

Marcus Wieczorek, MD,[*] Reinhard Hoeltgen, MD,[†] Martin Brueck, MD, FESC[‡]

From the [*]Department of Electrophysiology, School of Medicine, Witten/Herdecke University, St. Agnes-Hospital Bocholt, Germany, [†]Department of Electrophysiology, St. Agnes-Hospital Bocholt, Germany, and [‡]Division of Cardiology, Klinikum Wetzlar, Germany.

BACKGROUND Asymptomatic cerebral embolus (ACE) detected by diffusion-weighted magnetic resonance imaging (DW-MRI) following atrial fibrillation (AF) ablation has been reported at varying rates with different ablation techniques.

OBJECTIVE To evaluate the incidence of ACE after phased radiofrequency ablation for AF with procedural modifications that potentially reduce the embolic load.

METHODS One hundred twenty consecutive patients with AF underwent MRI before ablation, 24 hours after ablation, and at 4–6 weeks. In all patients, simultaneous activation of pulmonary vein ablation catheter electrode pairs 1 and 5 was forbidden. While in 60 group 1 patients, a maximum of 4 electrode pairs could be activated at a time, and in 60 group 2 patients, ablation was limited to a maximum of 2 pairs. All patients were on uninterrupted phenprocoumon, with an attempted activated clotting time of >300 seconds during ablation.

RESULTS Both patient groups were comparable. A total of 28 DW-positive lesions were detected in 24 of 120 patients (20%). Seventeen group 1 patients (28.3%) were positive for new asymptomatic DW cerebral lesions compared with 7 group 2 patients (11.7%) ($P = .039$). During MRI follow-up, 3 patients (2.5%) were diagnosed with a small T2-positive asymptomatic glial scar. Procedure time was longer in group 2 patients than in group 1 patients (159 ± 39 vs 121 ± 15; $P < .001$).

CONCLUSIONS Limiting the number of simultaneously activated electrode pairs to 2 significantly reduces the rate of ACE in patients treated with a multielectrode duty-cycled phased radiofrequency catheter system for AF. This reduction corresponds with a significant prolongation of the total procedure time.

KEYWORDS Multielectrode phased ablation; Pulmonary vein isolation; Silent cerebral microembolism; Anticoagulation

ABBREVIATIONS **ACE** = asymptomatic cerebral embolism; **AF** = atrial fibrillation; **DW** = diffusion weighted; **FLAIR** = fluid-attenuated inversion recovery; **INR** = international normalized ratio; **MES** = microembolic cerebral signals; **MRI** = magnetic resonance imaging; **PV** = pulmonary vein; **PVAC** = pulmonary vein ablation catheter; **PVI** = pulmonary vein isolation; **RF** = radiofrequency; **TCD** = transcranial Doppler

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Introduction

There is now consensus that in the treatment of patients with paroxysmal atrial fibrillation (AF), the goal of catheter ablation is to achieve permanent pulmonary vein isolation (PVI).[1]

However, the safety of PVI is paramount, as ablation is an elective procedure for a not directly life-threatening condition.[2] Among adverse events associated with AF ablation, symptomatic thromboembolism in the form of stroke and transient ischemic attack has been observed after 0.23% and 0.71% of the procedures, respectively.[3] In addition, depending on the definition, asymptomatic cerebral emboli (ACEs) visible on postablation magnetic resonance imaging (MRI) have been reported in 7.4%–21.4% of the procedures by using open-irrigated radiofrequency (RF) catheters,[4,5] the most frequently used in AF ablation procedures.[6] Studies have also compared the incidence of ACE by using irrigated RF against PVI ablation catheters including cryoballoon and phased RF ablation,[5,7] and phased RF has been associated with an increased ACE incidence, with rates from 8.1% to 38.9%.[7,8] Gaseous emboli via transseptal sheaths and bipolar heating due to unintentional electrode interaction have been proposed as root causes for the ACE incidence with phased RF.[8,9]

In a recently published study, we observed the lower ACE incidence of 8.1% by applying uninterrupted oral anticoagulation and specific sheath/catheter management with phased RF.[8] Retrospective analysis further confirmed that

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Address reprint requests and correspondence: Dr Marcus Wieczorek, School of Medicine, Witten/Herdecke University, St. Agnes-Hospital Bocholt, Barloer Weg 125, GER-46397 Bocholt, Germany. E-mail address: drmwieczorek@t-online.de.

electrode interaction can contribute to ACE, thus confirming the preclinical work by Haines et al.[9] A transcranial Doppler (TCD) study demonstrated that point-by-point nonirrigated RF ablation within the left atrium produces significantly more microembolic cerebral signals (MES) per application than other technologies, which might also contribute to ACE.[2]

With up to 10 active nonirrigated 3-mm electrodes, the pulmonary vein ablation catheter (PVAC) might increase the embolic load per energy application, thus increasing the likelihood of asymptomatic ischemic cerebral lesions. The aim of this prospective and randomized study was to evaluate whether further ACE reduction after PVAC ablation can be achieved by limiting the number of active electrode pairs per energy application to 2.

Methods

Study population and protocol

One hundred twenty consecutive patients with a history of drug refractory paroxysmal and persistent AF underwent PVI with a PVAC (Ablation Frontiers, Inc, Carlsbad, CA). Exclusion criteria were as follows: age <20 and >80 years, an international normalized ratio (INR) <1.8 and >3.0 the day before PVI, severe valvular heart disease, acute coronary syndrome in the last 3 months, previous catheter ablation of AF, previous transient ischemic attack or stroke, previous pacemaker or implantable cardioverter-defibrillator implant, or any further contraindication to perform cerebral MRI. All patients gave written informed consent to the procedure including repetitive cerebral MRI before enrollment. On the day before PVI, all patients underwent a thorough cardiological assessment (including medical history, physical examination, electrocardiogram, transthoracic echocardiogram, and transesophageal echocardiogram) and a complete neurological evaluation by an experienced neurologist with a clinical reassessment the day after ablation. All patients received oral anticoagulation a minimum of 4 weeks before the procedure with a target INR of 2.0–3.0, which was not discontinued for PVI. INR was checked at least 1 day before the procedure. All patients were prospectively randomized to 2 different ablation strategies: 60 patients were ablated with activation of all electrode pairs showing local electrical activity at a time but without simultaneous activation of electrode pairs 1 and 5 to avoid uncontrolled tissue overheating when in proximity (group 1). This patient group served as the control group. It was compared with cerebral MRI findings in 60 patients treated with a maximum of 2 active pairs of electrodes at a time per RF application (group 2). As in group 1, simultaneous activation of pairs 1 and 5 was not allowed.

Cerebral MRI protocol

Cerebral MRI was performed the day before and the day after the procedure by using a 1.5-T scanner (1.5 Tesla MAGNETOM Avanto, Siemens, Erlangen, Germany). If new MRI findings were detected after PVI, a third MRI was performed after a minimum of 4 weeks. The detailed cerebral MRI protocol has been reported elsewhere.[10] Briefly, the MRI protocol included a sagittal T1-weighted spin-echo sequence to obtain a clear definition of the anterior and posterior cerebral commissures; an axial fluid-attenuated inversion recovery (FLAIR) sequence; and a diffusion-weighted (DW) sequence. The sequences were centered on the axis defined by a line passing between the anterior and posterior cerebral commissures. The definition of this line was important to ensure the reproducibility of the MRI sequences before and after the procedure. In the postablation MRI, acute embolic lesion was defined as a new focal hyperintense area detected by the DW sequence, which is confirmed by the apparent diffusion coefficient mapping to rule out a shine through T2 artifact. A corresponding positive FLAIR sequence was *not* necessary to meet the definition of ACE. The size and the location of the focal lesions were analyzed. Two certified radiologists blinded to the ablation technique independently analyzed all MRI scans.

Ablation protocol

Deep sedation was achieved by means of intravenous fentanyl, midazolam, and propofol or general anesthesia for patients diagnosed with sleep apnea. The ablation protocol was performed as reported earlier.[8,11] In brief, a steerable 10-F sheath (Bard Channel, Bard Electrophysiology Division, Lowell, MA) was introduced into the left atrium after transseptal puncture and hexapolar steerable 6-F catheters were placed in the left atrial appendage and coronary sinus for mapping and differential pacing. Left atrial contrast injection was performed for selective pulmonary vein (PV) angiograms. The PVAC and the multichannel duty-cycled RF generator (GENius, Ablation Frontiers, Medtronic, Carlsbad, CA) have been previously described.[11] The system can deliver temperature-controlled simultaneous applications of duty-cycled phased unipolar and bipolar RF energy over all 10 PVAC electrodes, where bipolar refers to adjacent electrodes (Figure 1). As a result of RF phasing, there is a variable current flow between activated electrode pairs, which depends on the chosen ablation mode. Bipolar current is generated between electrodes as long as they are "out of phase." There is only unipolar current of each selected electrode if they are "in phase." Different combinations of time intervals with electrodes being "in and out of phase" determine various ablation modes with fixed degrees of unipolar current: 20% with 4:1 mode, 33% with 2:1 mode, and 50% with 1:1 mode. There is a positive correlation between lesion depth and the percentage of unipolar current,[12] not observed with conventional RF energy. Bipolar current flow between the activated PVAC electrodes aims to create overlapping between the circumferential lesions. As there is no active irrigation of the PVAC electrodes, temperature control is managed by "duty cycling": power is switched on and off many times per second, while power control is achieved by the duration of current flow. The absence of active irrigation is considered one possible reason for the generation of microembolic events with PVAC