Radiofrequency Ablation of Atrial Fibrillation

Is the Persistence of All Intraprocedural Targets Necessary for Long-Term Maintenance of Sinus Rhythm?

Claudio Pratola, MD; Elisa Baldo, MD; Pasquale Notarstefano, MD; Tiziano Toselli, MD; Roberto Ferrari, MD, PhD, FESC

Background—Several approaches have been developed for radiofrequency catheter ablation of atrial fibrillation, but the correct intraprocedural end point is still under debate, and few data exist about the destiny of ablation lesions over time. The aim of the present study was to evaluate the long-term maintenance of intraprocedural end points of ablation procedures.

Methods and Results—Inclusion criteria were (1) a previous ablation procedure of pulmonary vein (PV) encircling performed for drug-refractory persistent atrial fibrillation; (2) a “complete” intraprocedural end point, which consisted of voltage abatement inside the lesions, PV disconnection, and exit-block pacing from inside the lesions, attained in all PVs; and (3) stable sinus rhythm documented during a minimum follow-up of 2.5 years after the procedure. Twenty volunteers were selected (12 males, mean age 59±7 years) and underwent a repeat electrophysiological study. After a follow-up of 36.4±4.7 months, complete voltage abatement was maintained around 32 PVs (40.0%), PV disconnection persisted in 12 (37.5%) of the previously isolated PVs, and exit block was present in 39 PVs (48.7%). Ten patients who underwent a redo ablation procedure because of recurrences of atrial fibrillation were used as the control group. Differences in intraprocedural end-point maintenance between the 2 groups were not statistically significant.

Conclusions—Common intraprocedural end points such as voltage abatement, PV disconnection, and exit block persist only in a limited number of patients, even when the outcome is favorable during follow-up. Further investigation will be required to determine whether such data will have implications for ablation strategies. (Circulation. 2008;117:136-143.)

Key Words: atrial fibrillation ■ pulmonary veins ■ radiofrequency catheter ablation

Radiofrequency (RF) catheter ablation has recently emerged as an important therapeutic option in patients with drug-resistant atrial fibrillation (AF), with a success rate of ≈75% in experienced centers. Since 1994, different approaches have been tested in patients with similar characteristics, but the intraprocedural target is still not well standardized. Both pulmonary vein (PV) encircling with and without PV disconnection have been reported with analogous results by different authors. Moreover, several data exist about conduction recovery in patients treated with RF ablation who underwent a repeat ablation procedure. The aim of the present study was to verify the long-term result of an ablation procedure of PV encircling with PV disconnection performed for drug-resistant persistent AF in patients in stable sinus rhythm (SR) at a minimum follow-up of 2.5 years after the initial procedure.

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Methods

Inclusion Criteria
Patients were enrolled in the study if they met the following criteria: (1) previous ablation procedure that consisted of PV encircling plus PV disconnection performed for drug-refractory recurrent persistent AF; (2) intraprocedural end point of voltage abatement inside the lesions, PV disconnection, and exit-block pacing inside the lesions; and (3) stable SR without the use of antiarrhythmic drugs (AADs), documented on serial ECG-Holter recordings and transtelephonic monitoring during a minimum follow-up of 2.5 years after the ablation procedure. Patients in AF at the time of the initial procedure were excluded from the study.

Study Population
Among 200 AF ablation procedures performed between January 2001 and September 2003 at our center, 130 were for drug-refractory persistent AF. Persistent AF was defined as AF that lasted >7 days or required electrical cardioversion. The intraprocedural end point described above was reached in all PVs in 80 patients, and 60 of these patients were followed up regularly for a minimum of 2.5 years. Fifty of these patients maintained stable SR during follow-up. Of these, 20 agreed to a repeat electrophysiological study (EPS). There were no statistically significant differences in patient characteristics among the 20 volunteers who agreed to the repeat EPS and the 30 patients who refused it. Among the SR volunteers (group 1), there were 12 men and 8 women, with a mean age of 59.2±7.7 years. Mean AF duration was 6±2.5 years, and the mean number of previously used, ineffective AADs was 2.4±0.9. Mean anteroposterior left atrial diameter was 42.7±3.4 mm, and all patients had preserved left ventricular function. All patients had stopped antiar-
Table 1. Clinical Characteristics of the Study Populations by Groups

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<tr>
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<th>Group 1</th>
<th>Group 2</th>
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<tr>
<td>Patients, n</td>
<td>20</td>
<td>10</td>
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<tr>
<td>Age, y</td>
<td>59.2±7.7 (59.0)</td>
<td>59.3±6.7 (59.0)</td>
<td>0.93*</td>
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<tr>
<td>Male gender, n</td>
<td>12 (60.0%)</td>
<td>8 (80.0%)</td>
<td>0.42*</td>
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<tr>
<td>AF duration, y</td>
<td>6±2.5 (6.7)</td>
<td>5.1±2.8 (4.2)</td>
<td>0.41*</td>
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<td>Essential hypertension</td>
<td>16 (80.0%)</td>
<td>7 (70.0%)</td>
<td>0.66†</td>
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<tr>
<td>Type of cardiopathy</td>
<td></td>
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<tr>
<td>Hypertensive</td>
<td>6 (30.0%)</td>
<td>3 (30.0%)</td>
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<tr>
<td>CAD</td>
<td>2 (10.0%)</td>
<td>1 (10.0%)</td>
<td>1.00†</td>
</tr>
<tr>
<td>None</td>
<td>12 (60.0%)</td>
<td>6 (60.0%)</td>
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<tr>
<td>LA diameter, mm</td>
<td>42.7±3.4 (43.0)</td>
<td>43.6±3.9 (45.0)</td>
<td>0.45*</td>
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<td>No. of failed AADs</td>
<td>2.4±0.9 (2.5)</td>
<td>2.6±0.8 (3.0)</td>
<td>0.45*</td>
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<td>Initial procedure</td>
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<tr>
<td>Total duration, min</td>
<td>178±33 (175.0)</td>
<td>173±24 (173.5)</td>
<td>0.77*</td>
</tr>
<tr>
<td>RF time, min</td>
<td>42±8 (44.5)</td>
<td>43±7 (42.5)</td>
<td>0.78*</td>
</tr>
<tr>
<td>4-mm irrigated-tip catheter, n</td>
<td>3 (15.0%)</td>
<td>2 (20.0%)</td>
<td>1.00†</td>
</tr>
<tr>
<td>Redo procedure, mo</td>
<td>36.4±4.7 (36.2)</td>
<td>6.0±2.0 (6.0)</td>
<td>&lt;0.01*</td>
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<td>CAD indicates coronary artery disease; LA, left atrial.</td>
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<td>Data in parentheses are median for continuous variables and percentages for categorical variables.</td>
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<tr>
<td>*Mann–Whitney U test.</td>
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<td>†Fisher exact test.</td>
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rhythmic and oral anticoagulant therapy 3 and 6 months, respectively, after stable SR documented on serial ECG-Holter recordings. Ten patients in whom all of the previously described intraprocedural end points were reached in all PVS and who underwent a redo ablation procedure because of recurrences of AF were used as the control group (group 2). There were 8 men and 2 women in group 2, with a mean age of 59.3±6.7 years. Mean AF duration was 5.1±2.8 years, and the mean number of previously used, ineffective AADs was 2.6±0.8. Mean anteroposterior left atrial diameter was 43.6±3.9 mm, and all patients had preserved left ventricular function. They presented with a median of 2 AF episodes (range 1 to 6) documented by ECG or ECG-Holter recording after the blanking period (2 months) from the initial ablation procedure and underwent the second ablation a mean of 6±2 months after the first ablation. Patients’ clinical characteristics are detailed in Table 1.

The repeat EPS in patients in SR was approved by our institutional ethics committee. All patients provided written informed consent before the initial procedure and the repeat EPS or ablation.

Initial Procedure

EPS and Mapping Procedure

The study was performed after confirmation of the absence of intracardiac thrombi by transesophageal echocardiography. All AADs except amiodarone (which was discontinued 4 to 5 months before the study) were discontinued at least 5 half-lives before the ablation procedure. Two standard 6F catheters were positioned via femoral veins: a quadripolar catheter (CRD-2; St Jude Medical, St Paul, Minn) at the His bundle region and a decapolar deflectable-tip catheter (Curve D, Biosense Webster, Diamond Bar, Calif) in the coronary sinus. A double transseptal puncture was performed with the standard electrophysiological approach, with the coronary sinus and the His catheters used for anatomic guidance. After transseptal puncture, intravenous heparin was administered to maintain an activated clotting time >250 seconds. Real-time 3D left atrial maps were reconstructed with a nonfluoroscopic navigation system (CARTO, Biosense Webster; NavX, Endocardial Solutions, St Paul, Minn),9 with a minimum of 60 anatomic points acquired with the CARTO system and with the mapping catheter roving inside the left atrium with the Ensite NavX system. Mapping was performed with an 8-mm-tip ablation catheter (Navistar, Biosense Webster) or with a 4-mm irrigated-tip catheter (Navistar Thermocool or Celsius Thermocool, Biosense Webster) when it became available. Maps were acquired during SR. The left atrial–PV junction was angiographically defined by hand injection of 5 to 10 mL of contrast medium in the anteroposterior view. At least 3 of the following anatomic and electrophysiological characteristics were needed to define the ostium: (1) the fluoroscopic position of the catheter tip corresponding to the angiographically defined ostium; (2) the point where the catheter tip suddenly dropped into the chamber during pullback; (3) the appearance of an atrial potential in the case of a silent PV segment; and (4) an impedance decrease. At least 4 locations were recorded to tag the ostium orifice of each PV on the electroanatomical map.10 After anatomic reconstruction, the area surrounding the PVS was further defined by recording the electrical signal of a mean of 8±2 points around each PV, and these points were tagged on the map (Figure 1).

Ablation Procedure

In all patients, RF ablation was performed to create circumferential lines around each PV, in accordance with an anatomic approach similar to that suggested by other authors.11 In the event of a common ostium or very close PV ostia, a single circumferential lesion was created for 2 or 3 contiguous veins.10 All patients underwent AF ablation in SR. RF pulses were delivered with a temperature setting up to 55°C and RF energy up to 50 W for the 8-mm-tip ablation catheter and 43°C and 35 W for the irrigated-tip catheter, until local electrogram amplitude was reduced ≥80% or decreased below 0.1 mV for up to 120 seconds. The ablation lines consisted of a contiguous local lesion deployed at a distance ≥5 mm from the ostia of the PVS, which created a circumferential line around each PV or around ipsilateral PVSs according to the anatomy (Figure 2). However, in case of a relatively narrow border between the anterior aspect of the left superior PV (LSPV) and the left atrial appendage, ablation was performed within 5 mm of the ostium of that vein.4,12–15 RF ablation sites were tagged on the reconstructed 3D map. Voltage abatement was confirmed by means of a remap of the same points around each PV tagged at the end of the anatomic reconstruction (Figure 2).11 After anatomic PV encircling with voltage abatement confirmation, electrophysiological PV mapping was performed by means of a multipolar, steerable, circular catheter (Lasso, Biosense Webster; Spiral, St Jude). The mapping catheter was inserted in each PV and positioned orthogonal to the PV axis as proximal as possible to the ostium to record the presence of a PV potential (PVP). Left PVSs were mapped during distal coronary sinus pacing and right PVSs during spontaneous rhythm. If PVPs persisted, the ablation procedure was performed by means of a fluoroscopic and electrophysiological approach similar to that proposed by other authors.16,17 Segments of the PV perimeter were targeted on the basis of which bipolar from the circular catheter showed the earliest activation. The power limit was set at 30 W when the site was at or inside the ostium and the irrigated-tip catheter was used. To further evaluate the left atrium–PV connection, electrical stimulation at an amplitude of 10 mA and a duration of 2 ms was performed inside the circumferential line of ablation.4 At the end of the procedure, an adjunctive RF ablation line was created in the right atrium along the cavoatrial isthmus with electrophysiological assessment of transthoracic block after 20 minutes.18 A “complete” intraprocedural end point was defined as attainment of all of the following: (1) complete voltage abatement, ie, the recording of low peak-to-peak bipolar potential (reduction of the atrial potential ≥80% or decrease below 0.1 mV) inside the lesion, as determined by local electrogram analysis and voltage remap; (2) PV disconnection, ie, either elimination or dissociation of distal PV spikes documented with the circular catheter within the PV at least 30 minutes after isolation; and (3) exit block, ie, inability to capture the atrium, as recorded in the coronary sinus, with an electrical stimulation inside the veins that was able to depolarize the local fibers.4
Postablation Management
All patients were discharged and given oral anticoagulant medication and continued low doses of class IC AADs. Twenty-four-hour Holter monitoring and clinical examinations were performed after 1, 3, 6, 9, and 12 months, and then every 6 months. In the event of stable SR, antiarrhythmic therapy was discontinued after 3 months, and oral anticoagulants were discontinued after 6 months. All patients without documented AF recurrences 2 years after ablation received a transtelephonic monitoring device (Telbios, Milan, Italy) for 1 year to document symptomatic arrhythmias or to transfer an ECG once per week if asymptomatic. The duration of each ECG was 30 seconds.

Repeat EPS
The repeat EPS was performed with the same technique both in the 20 volunteers and in the control group. All patients underwent a transesophageal echocardiography before the repeat procedure to exclude intracardiac clots and to verify the presence of an interatrial shunt after the first procedure. The transseptal puncture was performed with the same electrophysiological technique described previously, and intravenous heparin was administered as for the ablation procedure. The electroanatomic map of the left atrium was reconstructed with the same mapping system used for the ablation procedure and acquired at least the same number of points. All patients were in SR during the repeat EPS and had discontinued AADs for at least 5 half-lives. PV position was assessed as described previously. Voltage mapping of the area surrounding the PVs was performed in all patients, with a mean of 8 ± 2 points acquired at a distance ≤ 5 mm from each PV ostium to detect voltage recovery. Voltage recovery was defined as the presence of an atrial potential ≥ 0.1 mV or voltage recovery > 50% compared with the voltage map performed after ablation. To evaluate the left atrium–PV connection, electrical stimulation as described previously was performed at a distance ≤ 5 mm from each PV ostium. PV disconnection maintenance was checked by mapping the perimeter of each PV ostium with a multipolar ring catheter (Lasso, Biosense Webster; Spiral, St Jude) placed at the ostium of the PV, as described previously. Electrical disconnection of the PV was considered if no PVP was present at the perimeter of the ostium or inside the vein itself.

Statistical Analysis
Descriptive statistics are summarized as the mean ± SD and median for continuous variables and as frequency and percentages for categorical variables. Nonparametric tests, such as the Mann-Whitney U test for continuous variables and Fisher exact test for categorical variables, were used for comparisons between characteristics of patients in groups 1 and 2. With the assumption of multiple PVs within the same patient as independent entities, χ² test with Yates correction was used to analyze maintenance of end points in the PVs between groups during the repeat EPS. A probability value < 0.05 was considered significant. Statistical analysis was performed with SPSS version 13.0 software (SPSS, Inc, Chicago, Ill).

The authors had full access to the data and take full responsibility for its integrity. All authors have read and agree to the manuscript as written.

Results

Patient Characteristics
Baseline patient characteristics in each group are summarized in Table 1. There were no significant differences in patient characteristics between the 2 groups. Importantly, the total amount of RF delivery time during the initial procedure was...
not different between the 2 groups. The 4-mm irrigated-tip catheter was used in 3 patients in the volunteer group and 2 patients in the control group.

**Patients in SR After Initial Ablation Procedure (Group 1)**

During remap of the region surrounding the PVs, complete voltage abatement was found around 32 (40%) of 80 PVs, whereas voltage recovery was found at a variable amount around the remaining PVs (Figure 3). Specifically, complete voltage abatement was found around 10 LSPVs, 8 left inferior PVs (LIPVs), 8 right superior PVs (RSPVs), and 6 right inferior PVs (RIPVs). During the previous procedure, 32 (40%) of all PVs had a PV potential detected after anatomic encircling with RF lesions. At the repeat EPS, PV disconnection was maintained in 12 (37.5%) of the veins that had a PVP during the ablation procedure (6 LSPVs, 2 LIPVs, 2 RSPVs, and 2 RIPVs). Exit-block pacing at a distance \( \leq 5 \) mm from each PV ostium, as described previously, was found in 39 (48.7%) of the PVs (11 LSPVs, 12 LIPVs, 8 RSPVs, and 8 RIPVs). In PVs with no PVP, exit block was demonstrated around all of the PVs surrounded by complete voltage abatement and in only 46.1% of the veins surrounded by incomplete voltage abatement. When voltage recovery was found at a variable amount around a PV with a recovered PVP, exit block was never present. A complete intraprocedural end point, as described for the ablation procedure, was maintained in all of the PVs in only 1 patient. The complete end point was maintained in 3 PVs in 1 patient, 2 PVs in 4 patients, 1 PV in 13 patients, and 0 PVs in 1 patient. Bidirectional right isthmus block was maintained in all patients. Results are detailed in Table 2.

**Patients With Recurrences After Initial Ablation Procedure (Group 2)**

During remap of the region surrounding the PVs, complete voltage abatement was found around 15 (37.5%) of 40 PVs, whereas voltage recovery was found at a variable amount around the remaining PVs. Specifically, complete voltage abatement was found around 5 LSPVs, 3 LIPVs, 4 RSPVs, and 3 RIPVs. During the previous procedure, 19 PVs (47.5%) had a PVP detected after anatomic encircling with RF lesions. At the repeat EPS, PV disconnection was maintained in 6 (31.6%) of the veins that had a PVP during the ablation procedure (3 LSPVs, 1 LIPV, 2 RSPVs, and 0 RIPVs). Exit-block pacing at a distance \( \leq 5 \) mm from each PV ostium, as described previously, was found in 16 (40.0%) of the PVs (3 LSPVs, 4 LIPVs, 4 RSPVs, and 5 RIPVs). In PVs with no PVP, exit block was demonstrated around all of the PVs surrounded by complete voltage abatement and in only 26.6%
of the veins surrounded by incomplete voltage abatement. When voltage recovery was found at a variable amount around a PV with a recovered PVP, exit block was never present. None of the patients had a complete intraprocedural end point, as described for the ablation procedure, maintained in all PVs. The complete end point was maintained in 2 PVs in 5 patients, 1 PV in 3 patients, and 0 PVs in 2 patients. Bidirectional right isthmus block was maintained in all patients. Results are detailed in Table 2. Differences in long-term maintenance of intraprocedural end points between the 2 groups were not statistically significant.

Procedural and Fluoroscopy Times
The mean procedure time for the repeat EPS in both groups was 91.8 ± 21 minutes (range 60 to 125 minutes), with a mean fluoroscopic time of 9.9 ± 1.8 minutes (range 8 to 13 minutes). A minimum of 85 ± 20 points were acquired for CARTO and Ensite NavX maps, respectively. No patient had complications due to the repeat EPS.

Discussion
The aim of the present study was to evaluate the long-term maintenance of intraprocedural end points of an ablation procedure of PV encircling with PV disconnection. The patient population was a small and selected subgroup of patients with persistent drug-resistant, recurrent AF with preserved left ventricular function and little atrial dilation in whom the complete intraprocedural end point of the ablation procedure was reached in all PVs. We decided to perform a repeat EPS in patients who had a successful AF ablation procedure. These data were compared with those obtained from patients who underwent a redo ablation because of AF recurrences.

Intraprocedural End Points in Previous Studies
Since the discovery of 1 or multiple PV foci that initiated human AF, different techniques have been proposed to target the source of arrhythmia, including segmental ostial ablation to isolate the PVs, electrophysiologically guided by PV spikes, and continuous circular lesions around PVs, anatomically guided by 3D electroanatomic mapping. A recent study has shown that continuous circular lesions are more effective than segmental ostial ablation in patients with paroxysmal AF. However the intraprocedural target is still under debate, and the same ablation approach has been performed in different centers looking for different intraprocedural end points. For example, with regard to PV encircling, some authors support the hypothesis that PV disconnection is critical for successful ablation, whereas others have concluded that PV isolation is not crucial in determining clinical success. An integrated approach with an adjunctive electrophysiological PV disconnection after anatomic PV disconnection.
encircling has been demonstrated to increase the success rate after an AF ablation procedure from 60% to 80%. The validation of 1 technique compared with another can only be made by means of a repeat EPS in asymptomatic patients after an effective ablation procedure. In the present study, we decided to consider all intraprocedural end points described previously to verify their maintenance at long-term follow-up in patients in apparently stable SR after the ablation procedure.

Main Findings

The present data about the incidence of conduction recovery and lesion healing during a repeat EPS in patients undergoing a redo ablation procedure because of AF recurrences are in accordance with those already reported by several authors. Interestingly, in the present study, such data were similar to those found in patients with documented stable SR 2.5 years after the procedure. In these patients, voltage recovery was found around 60% of the PVs, a recovered PVP was found in 62.5% of the veins that presented with a previous PVP, and exit block was not present around 51.3% of the PVs. These findings are in accordance with a recent study that demonstrated that even with surgical cryoablation, a complete linear lesion or complete PV isolation is obtained in only ≈65% of patients. The complete intraprocedural end point was reached in all PVs during the previous procedure in only 1 patient in group 1; however, all patients have always been asymptomatic during follow-up, and no asymptomatic arrhythmia has been documented on 24-hour Holter recordings or transtelephonic monitoring. These data support the hypothesis that maintenance of complete voltage abatement and/or PV disconnection is not necessary for SR maintenance.

Lesion Healing and Conduction Recovery in Previous Studies

Several data exist about conduction recovery after an ablation procedure. Recent reports have shown that recurrent AF after selective PV isolation is overwhelmingly associated with PV electrical reconnection and that repeat PV isolation without linear ablation provides effective treatment for recurrent AF. However, few data are available regarding asymptomatic patients undergoing a repeat EPS. In a prospective multistep approach with segmental ostial PV ablation, Cappato et al found late conduction recurrence across disconnected RF lesions in ≈80% of the targeted PVs 4 months after ablation. In the same study, however, clinical success after the first procedure was observed in 32% of patients despite the presence of late conduction recurrence, which suggests that the clinical efficacy of AF ablation with PV disconnection can also be achieved, at least for some time, despite conduction recurrence. In a recent work, the vast majority of patients who were AF-free without the use of AADs after PV disconnection showed no PVs that had recovered conduction, although a substantial atrial-PV delay was sometimes sufficient to maintain SR with the use of AADs. Other authors demonstrated noninvasively that trigger activity late after specific linear left atrial ablation remains relatively frequent but short and does not induce AF episodes in most patients, which implies that the modified substrate cannot sustain AF in the majority of patients.

Hypothesis for Different Procedural Success

We did not find statistically significant differences in voltage abatement, PV disconnection, and persistence of exit block in patients with and without recurrences after an AF ablation procedure (Table 2). Because the 4-mm irrigated-tip catheter had been used in a minority of patients, and both in patients with and without recurrences, different procedural outcomes, in our opinion, cannot be explained by a different type of ablation catheter. It is not easy to explain why the same degree of voltage abatement and PV disconnection was sufficient to ensure stable SR maintenance in some patients, whereas it was insufficient in others. Indeed, an explanation can be proposed that considers the interaction between the trigger and the substrate. First, the real importance of a possible AF trigger found during an EPS is not well defined, and conduction and/or voltage recovery in PVs that do not act, at that moment, as AF triggers may not influence the success of a procedure. Second, to the best of our knowledge, no data exist about a direct relation between clinical characteristics (eg, age, AF duration, left atrial diameter, or presence of cardiopathy) and the degree of atrial remodeling, which is the substrate for AF maintenance. It is possible that patients who remained in stable SR after the procedure had a less-remodeled atrium than those with recurrences, such that the same procedure with the same degree of intraprocedural end-point long-term maintenance was sufficient to maintain SR. These findings, in our opinion, are consistent with the above-mentioned report that suggested the importance of a substantial atrial-PV delay for SR maintenance after PV disconnection, even in the case of conduction recovery. It is well known that AF originates from the interaction of a trigger and a substrate. Although the trigger plays the major role in paroxysmal AF, as cardiopathy develops, atrial substrate becomes more important. The present study population consisted of patients with persistent AF with little atrial dilation. In these patients, the relative importance of trigger and substrate has not yet been defined clearly. The present data support the idea that in patients with persistent AF, atrial remodeling, ie, substrate modification, plays the major role, and the presence of voltage and/or PV conduction recovery does not necessarily mean that AF will recur.

Clinical Implications

The present study does not enable us to draw conclusions about the relationship between the failure of maintenance of

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<th>Table 2. End-Point Maintenance in PVs During Repeat EPS</th>
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<td></td>
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<tr>
<td>No. of PVs (%)</td>
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<td>Group 1</td>
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<tr>
<td>Voltage abatement</td>
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<tr>
<td>Disconnected PVs/PVs with PVP during ablation procedure</td>
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<td>Exit block</td>
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<td>“Complete” intraprocedural point</td>
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*χ² Test with Yates correction.
intraprocedural end points and clinical outcome. It suggests, however, that (1) common intraprocedural end points of AF ablation procedure often do not persist over time, both in patients with and in those without AF recurrences, and (2) SR can be maintained, at least for some time, despite areas of voltage and/or conduction recovery. Further studies are needed to confirm these data in larger populations, with comparisons at long-term follow-up of the results of different AF ablation intraprocedural targets.

Study Limitations
The present study has the following limitations: (1) The patient population is small. The present data do not prove that all asymptomatic patients have recovered PV conduction and/or voltage recovery after PV encircling with PV disconnection. (2) The study population was a well-selected group of patients with persistent AF and little atria dilation; thus, the present results refer only to this subgroup of AF patients. (3) Although asymptomatic, short episodes of paroxysmal AF were not documented on 24-hour ECG-Holter recording or by transtelephonic monitoring with an ECG transferred weekly to the same patient as independent entities could be a limitation of our statistical analysis.

Conclusions
After an ablation procedure of PV encircling with PV disconnection performed for persistent AF, common intraprocedural end points such as voltage abatement, PV disconnection, and exit block persist only in a limited number of patients, even when the outcome is favorable during follow-up. Further investigation will be required to determine whether such data will have implications for ablation strategies.

Disclosures
None.

References
5. Cappato R, Negroni S, Pecora D, Bentivegna S, Lupo PP, Carolei A, Esposito C, Furlanello F, De Ambroggi L. Prospective assessment of late voltage and/or conduction recovery. Further studies are needed to confirm these data in larger populations, with comparisons at long-term follow-up of the results of different AF ablation intraprocedural targets.

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Conclusions
After an ablation procedure of PV encircling with PV disconnection performed for persistent AF, common intraprocedural end points such as voltage abatement, PV disconnection, and exit block persist only in a limited number of patients, even when the outcome is favorable during follow-up. Further investigation will be required to determine whether such data will have implications for ablation strategies.

Disclosures
None.

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5. Cappato R, Negroni S, Pecora D, Bentivegna S, Lupo PP, Carolei A, Esposito C, Furlanello F, De Ambroggi L. Prospective assessment of late voltage and/or conduction recovery. Further studies are needed to confirm these data in larger populations, with comparisons at long-term follow-up of the results of different AF ablation intraprocedural targets.


**CLINICAL PERSPECTIVE**

Radiofrequency catheter ablation has emerged as an important therapeutic option in patients with drug-resistant atrial fibrillation. Different approaches have been tested, but specific intraprocedural targets and end points remain controversial. Demonstration that a particular procedural end point, such as conduction block into a pulmonary vein (PV), is critical requires the demonstration of persistence of that end point during follow-up. Recovery of ablation lesions is well reported, so the demonstration of persistence and relation of this to prevention of atrial fibrillation requires repeat electrophysiological study in asymptomatic patients after an effective ablation procedure. The aim of the present study was to verify the long-term result of encircling PV ablation with the end point of atrial potential abatement plus PV disconnection confirmed with a multipolar catheter. Repeat electrophysiology study was performed 2.5 years after successful ablation in a series of patients in stable sinus rhythm after previously persistent atrial fibrillation. These data were compared with those obtained from redo ablation procedures because of atrial fibrillation recurrences. In patients in stable sinus rhythm after ablation, only 37.5% of the PVs remained disconnected, and 60% of the PVs had recovered electrogram voltage within the ablation region. No statistically significant differences were noted between patients with and without recurrences after the initial ablation procedure. This study suggests that common intraprocedural end points such as voltage abatement and PV disconnection persist only in a limited number of patients, even when the outcome is favorable during follow-up. Further studies will be required to confirm these data in larger populations and to determine their implications for ablation strategies.
Radiofrequency Ablation of Atrial Fibrillation: Is the Persistence of All Intraprocedural Targets Necessary for Long-Term Maintenance of Sinus Rhythm?
Claudio Pratola, Elisa Baldo, Pasquale Notarstefano, Tiziano Toselli and Roberto Ferrari

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