Prevention of Iatrogenic Atrial Tachycardia After Ablation of Atrial Fibrillation

A Prospective Randomized Study Comparing Circumferential Pulmonary Vein Ablation With a Modified Approach

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Background—Circumferential pulmonary vein ablation (CPVA) is effective in curing atrial fibrillation (AF), but new-onset left atrial tachycardia (AT) is a potential complication. We evaluated whether a modified CPVA approach including additional ablation lines on posterior wall and the mitral isthmus would reduce the incidence of AT after PV ablation.

Methods and Results—A total of 560 patients (291 men, 52%; age, 56.5±7.3 years) entered the study; 280 were randomized to CPVA alone (group 1) and 280 to modified CPVA (group 2). The primary end point was freedom from AT after the procedure. In group 1, 28 patients (10%) experienced new-onset AT, and 41 (14.3%) experienced recurrent AF. In group 2, 11 patients (3.9%) experienced AT, and 36 (12.9%) had recurrent AF. Group 1 was more likely to experience AT than group 2 (P<0.005). Freedom from AF after ablation was similar in both groups (P=0.57). Among those in group 1, gap-related macroreentrant AT was documented in 23 of the 28 patients (82%), and focal AT was seen in 5 (18%). In group 2, gap-related macroreentrant AT was found in 8 of the 11 patients (73%), and focal AT was seen in 3 (27%). Two patients in group 1 and 1 patient in group 2 had both AT and AF. The strongest predictor of AT was the presence of gaps (P<0.001).

Conclusions—Modified CPVA is as effective as CPVA in preventing AF but is associated with a lower risk of developing incessant AT. (Circulation. 2004;110:3036-3042.)

Key Words: ablation ■ fibrillation, atrial ■ mapping ■ tachycardia, ectopic atrial

Circumferential pulmonary vein ablation (CPVA) is an effective strategy for curing atrial fibrillation (AF), but this procedure requires multiple lesions that, if nontransmural, may predispose to proarrhythmias such as left atrial macroreentrant tachycardias. Different line designs have recently been reported in a small series of patients to better prevent either recurrent AF or new-onset atrial tachycardia (AT), but there are no conclusive data. The purpose of this prospective randomized study was to compare the freedom from new-onset AT in patients with AF who were undergoing CPVA alone or a modified CPVA (CPVA-M) approach.

Study Sample
Patients with AF referred to the San Raffaele Hospital (Milan, Italy) for CPVA between January 2002 and January 2003 were assessed for inclusion. Follow-up ended at 12 months. Inclusion criteria included the following: age of 18 to 70 years, symptomatic AF, and NYHA functional class I or II. Exclusion criteria included left atrial size >55 mm, ejection fraction <30%, contraindication to anticoagulation, recent myocardial infarction, prior ablation for AF, presence of left atrial thrombus, and preexisting AT or flutter. No patient was receiving antiarrhythmic drugs or amiodarone before ablation, and ≥5 months had elapsed since amiodarone was stopped. Written informed consent was obtained from every patient participating in this study in accordance with a protocol approved by the institutional Human Research Committee. Randomization was performed according to a computer-generated randomization scheme in permuted blocks of 4. Assignments were concealed in opaque, sealed envelopes that were numbered consecutively.

Study Protocol
Patients were randomized to CPVA-M or CPVA alone. The CPVA-M approach included 2 additional ablation lines in the posterior left atrium connecting the contralateral superior and inferior PVs (Figure 1) and along the mitral isthmus between the inferior aspect of the left-sided encircling ablation line and the mitral annulus.

Received May 10, 2004; revision received August 5, 2004; accepted August 18, 2004.
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© 2004 American Heart Association, Inc.
Circulation is available at http://www.circulationaha.org DOI: 10.1161/01.CIR.0000147186.83715.95

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distance lines were created with contiguous radiofrequency (RF) lesions at a Webster) as previously described in detail.1–4 Briefly, encircling electroanatomic mapping was performed with the CARTO System (Biosense-Webster) as previously described in detail.1–4 Briefly, encircling lines were created with contiguous radiofrequency (RF) lesions at a distance of 15 mm from the PV ostia when possible with ipsilateral intravenous lines, provided that there were distinctly identifiable ostia. Energy was applied for up to 30 seconds with a limit of 100 W and a target temperature of 60°C with an 8-mm-tip deflectable ablation catheter (Navistar, Biosense-Webster). The end point of ablation was voltage abatement of the local atrial electrogram by 80% or <0.05 mV. Completion of the connecting lines was assessed in a systematic fashion by pacing maneuvers from the proximal and distal coronary sinus while recording double potentials along the ablation lines. Spacing of double potentials >150 ms along the line was used as the criterion defining a block. Gaps were defined as breakthroughs in an ablated area and identified by sites with single potentials and by early local activation. The electroanatomic activation map showed a sudden change from early to late activation along the ablation line and/or no potentials within the encircled area. Lines were defined as being complete or having single or multiple gaps. Gaps in a single PV were arbitrarily defined as single gap and as multiple gaps if >1 PV. If gaps were found in ablation lines, repeated RF application was performed to close the gap. Electrically silent areas, appearing as gray on the 3D maps, were defined as no recordable activity or amplitude <0.05 mV (the baseline noise in the Biosense system).

Follow-Up
Patients were discharged on warfarin and without antiarrhythmic drugs if sinus rhythm persisted and were instructed to contact our center in case of recurrent palpitations. Follow-up was scheduled at 1, 3, 6, and 12 months. Patients were instructed to send a transtelephonic ECG recording (Sorin Life Watch, Sorin) to the central monitoring center every working day or in the event of symptoms. Traces were reported by physicians blinded to treatment. Patients were monitored with Holter recordings before discharge; at 1 week; and 1, 3, 6, and 12 months after the procedure. Patients were contacted and uniformly interviewed via telephone at 3-month intervals. An independent blinded committee evaluated all events. There was a 6-week blanking period during which arrhythmia occurrence was regarded as a transient phenomenon. Arrhythmias developing or persisting beyond this period were included in the analysis, and repeated catheter ablation was recommended in highly symptomatic patients.

Repeated Ablation Procedure
During the repeated procedure, previous lesions lines were evaluated, and gaps were closed when possible with focal RF applications. In patients with AT, RF applications were directed at the critical isthmus in macroreentrant AT or at the sites of earliest activation in focal AT. Entrainment mapping also was performed to identify sites within the reentry circuit (postspacing interval within 20 ms of the tachycardia cycle length). RF energy was delivered with a limit of 80 W and a target temperature of 60°C at each site. Procedural success was defined as termination of AT by RF ablation and inability to reinduce AT before and during isoproterenol infusion (6 μg/min).

AT Definition
Macroreentrant AT was defined as follows: (1) continuous sequence of atrial activation, with earliest activation adjacent to latest activation; (2) range of activation times >90% of the tachycardia cycle length; and (3) demonstration of entrainment criteria by pacing at the sites within the presumed reentrant circuit to identify the reentrant circuit and its critical isthmus. AT was considered to be left atrial in origin if the distal coronary sinus atrial electrogram preceded the proximal coronary sinus atrial electrogram or in any case if left atrial electrograms were recorded throughout diastole with the ablation catheter. Focal AT was defined as follows: radial spreading in all directions from a single site of earliest activation and range of activation duration less than the AT cycle length.

Study End Points
The primary end point of the study was freedom from symptomatic incessant AT. The secondary end point was freedom from recurrent AF. The electrophysiological findings of the index and repeated procedures were also studied.
Statistical Analysis
The sample size for this study was determined from the anticipated frequency of postablation new-onset AT in the CPVA or CPVA-M group. From our own experience, we predicted a 10\% new-onset AT rate after CPVA during a 1-year observation period. We assumed that CPVA-M would result in a 4\% new-onset AT rate. From these assumptions, we predicted that 280 patients per group would be required to have an 80\% power to detect an absolute difference of 6\% with a 1-sided \( \alpha \) value of 0.05. No interim analysis was performed. We planned to meet the sample size after a 1-year observation period. Continuous variables were compared by use of the Mann-Whitney \( U \) test. For categorical variables, the \( \chi^2 \) test and the exact method were applied. AF and AT-free survival estimates were calculated by the Kaplan-Meier method, with the time of the outcome end point. Cox regression analysis was performed to assess the differences in outcome between the 2 randomized groups was assessed with the log-rank test. Data were censored if the patient died or was lost to follow-up. No significant differences were found between the 2 randomized groups (Table 1). The mean duration of the procedure and fluoroscopy was 92±14 and 110±16 minutes and 10±11 and 21±7 minutes in groups 1 and 2, respectively. Complete encircling of all PVs in both groups was comparable, 82\% and 80\% in groups 1 and 2, respectively. In group 1, 39 patients had single gaps, and 12 had multiple gaps. This was not significantly different from group 2, which had 49 and 7 patients with single and multiple gaps, respectively (Table 1). Multiple gaps were located particularly around the right superior and inferior PVs in both groups. In group 2, gaps were also localized along the posterior line in 1 patient and the mitral isthmus line in 1 patient. At the end of the first procedure, gaps persisted despite multiple targeted RF applications. Complications were comparable between the 2 randomized groups, with 2 cases of pericardial tamponade requiring aspiration and drainage in each group and 3 and 2 access-site hematomas in the CPVA and CPVA-M groups, respectively. There were no thromboembolic events or cases of PV stenosis in either group.

Results
Study Sample and Ablation Results After the Initial Procedure
Among 637 patients assessed for inclusion, 587 were suitable and 560 consented to inclusion in the study; 280 were assigned to CPVA (group 1) and 280 to CPVA-M (group 2). All patients received the assigned treatment, and no patient died or was lost to follow-up. No significant differences were found between the 2 randomized groups (Table 1). The mean duration of the procedure and fluoroscopy was 92±14 and 110±16 minutes and 10±11 and 21±7 minutes in groups 1 and 2, respectively. Complete encircling of all PVs in both groups was comparable, 82\% and 80\% in groups 1 and 2, respectively. In group 1, 39 patients had single gaps, and 12 had multiple gaps. This was not significantly different from group 2, which had 49 and 7 patients with single and multiple gaps, respectively (Table 1). Multiple gaps were located particularly around the right superior and inferior PVs in both groups. In group 2, gaps were also localized along the posterior line in 1 patient and the mitral isthmus line in 1 patient. At the end of the first procedure, gaps persisted despite multiple targeted RF applications. Complications were comparable between the 2 randomized groups, with 2 cases of pericardial tamponade requiring aspiration and drainage in each group and 3 and 2 access-site hematomas in the CPVA and CPVA-M groups, respectively. There were no thromboembolic events or cases of PV stenosis in either group.

Recurrences of Arrhythmias
During the 6-week blanking period, 54 (19\%) and 25 (9\%) patients in groups 1 and 2, respectively, had episodes of AT (\( P<0.001 \)). Beyond this blanking period, AT spontaneously resolved in 26 (48\%; \( P=0.002 \)) and 14 (56\%; \( P=0.016 \)) patients in groups 1 and 2, respectively. As a result, 28 of 280 (10\%) in group 1 and 11 of 280 (3.9\%; \( P=0.005 \), log rank) in group 2 continued to experience AT. Characteristics of the patients with AT are reported in Table 2. The mean time intervals between the initial procedure and the first occurrence of AT were 2.43±0.57 and 2.91±0.94 weeks in groups 1 and 2, respectively (\( P=0.14 \)). AT was incessant in all patients and in 8 resulted in syncope that required electrical cardioversion in 5 patients. Incident AF occurred in 14.3\% of group 1 and 12.9\% of group 2 (\( P=0.57 \); Table 1). The intervals between the initial procedure and the first episode of recurrent AF were 2.41±0.77 and 2.25±0.77 months in groups 1 and 2, respectively (\( P=0.35 \)). Among the 77 patients who experienced recurrent AF after ablation, 10 patients did not tolerate the arrhythmia despite antiarrhythmic drugs. Two patients (7\%) in group 1 and 1 patient (9\%) in group 2 had both AF and AT after PV ablation (Table 2; \( P=1.00 \)). Many patients had permanent AF, and <10\% had paroxysmal AF before the first procedure.

Repeated Procedure and Ablation Results
Among patients with recurrent AF, a repeated procedure was offered only to the 10 patients with drug-refractory symptomatic recurrent AF. However, only 3 wished to undergo a repeated procedure, which showed single gaps around the left superior PV in 2 and no gaps in the other. Patients with new-onset incessant AT all underwent a repeated procedure a mean of 4.5±0.8 months after the index procedure. Only multiple gaps were found in 82\% of group 1 and 73\% of group 2 patients (\( P=0.66 \)) at the second procedure, whereas at the end of the first procedure, single gaps were present in 46\% and 9\% and multiple gaps in 25\% and 64\%, respec-
TABLE 2. Characteristics of the 39 Patients Who Developed New-Onset AT After CPVA or CPVA-M

<table>
<thead>
<tr>
<th>Variable</th>
<th>CPVA (n=28)</th>
<th>CPVA-M (n=11)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age, y</td>
<td>59.6±5.8</td>
<td>59.6±5.2</td>
<td>1.00</td>
</tr>
<tr>
<td>Male, n (%)</td>
<td>16 (57)</td>
<td>7 (64)</td>
<td>0.77</td>
</tr>
<tr>
<td>Mean duration of AF, y</td>
<td>7.4±1.8</td>
<td>7.1±1.5</td>
<td>0.63</td>
</tr>
<tr>
<td>Mean left atrial diameter, mm</td>
<td>42.1±4.4</td>
<td>41.0±5.0</td>
<td>0.51</td>
</tr>
<tr>
<td>Mean left atrial ablated area, %</td>
<td>42.3±6.8</td>
<td>37.4±7.6</td>
<td>0.06</td>
</tr>
<tr>
<td>Cardiovascular diseases, n (%)</td>
<td>12 (43)</td>
<td>9 (82)</td>
<td>1.00</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>5 (18)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Dilated cardiomyopathy</td>
<td>10 (36)</td>
<td>2 (18)</td>
<td></td>
</tr>
<tr>
<td>Hypertrophic cardiomyopathy</td>
<td>1 (4)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>AF, n (%)</td>
<td>2 (7)</td>
<td>1 (9)</td>
<td></td>
</tr>
<tr>
<td>Paroxysmal</td>
<td>29 (93)</td>
<td>10 (91)</td>
<td>0.66</td>
</tr>
<tr>
<td>Chronic</td>
<td>23 (82)</td>
<td>8 (73)</td>
<td></td>
</tr>
<tr>
<td>Macroreentry</td>
<td>5 (18)</td>
<td>3 (27)</td>
<td></td>
</tr>
<tr>
<td>Focal</td>
<td>16 (57)</td>
<td>0 (0)</td>
<td>0.002</td>
</tr>
<tr>
<td>Single extrastimulus</td>
<td>4 (14)</td>
<td>5 (46)</td>
<td></td>
</tr>
<tr>
<td>Double extrastimuli</td>
<td>8 (29)</td>
<td>6 (54)</td>
<td></td>
</tr>
<tr>
<td>Inducibility, n (%)</td>
<td>18 (64)</td>
<td>7 (64)</td>
<td>1.00</td>
</tr>
<tr>
<td>Complete vagal denervation, n (%)</td>
<td>2 (7)</td>
<td>1 (9)</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Data are mean±SD when appropriate.

Follow-Up After Repeated Ablation of AT
Within the first week after repeated procedures, symptomatic AT occurred in 4 of the 28 patients (14%) in group 1, but all remained recurrence free during a mean follow-up of 6.3 months. In group 2, 2 of the 11 patients (18%) had transient recurrences of AT early after ablation without further recurrences over a mean follow-up of 8.2 months. Patients with focal AT and AF after the repeated procedure did not report any symptomatic arrhythmia during follow-up.

Discussion

Main Findings
Among patients with AF referred for PV ablation, CPVA-M, which included additional ablation lines in the posterior left atrium and mitral isthmus, was compared with CPVA alone to evaluate the prevalence, mechanisms, and clinical significance of AT after these 2 different approaches. Although freedom from recurrent AF was similar in the 2 groups, CPVA-M was associated with a lower risk of incessant AT. During short-term follow-up, incessant highly symptomatic AT was observed in 10% of patients after CPVA and 4% of patients after CPVA-M. The mitral isthmus and ipsilateral right PVs were common areas for macroreentry after CPVA and CPVA-M, respectively. The presence of multiple gaps and chronic AF before ablation were the strongest predictors of AT. Not infrequently, AT after PV ablation was focal (30%) and originated outside the ablation lines.

Previous Studies
In a recent randomized study, among 40 patients undergoing CPVA with additional lines in the posterior left atrium and mitral isthmus, 1 patient (2.5%) developed new-onset left atrial flutter. Although there are no large studies on the prevalence, mechanisms, and clinical significance of AT as a complication of PV ablation, left AT has been reported in isolated reports after PV ablation, with an incidence ranging from 2.5% to 20%.7,9,11

Freedom From New-Onset AT and Recurrent AF After PV Ablation
The results of the present study demonstrated that <4% of patients who underwent CPVA-M experienced new-onset AT after ablation compared with 10% of patients who underwent CPVA alone, although there was no additional benefit in terms of freedom from AF. Therefore, additional lines of block in the posterior left atrium and mitral isthmus can reduce the risk of postablation AT without improving freedom from recurrent AF. Consequently, in patients with AF who undergo segmental PV isolation, additional lesion lines are unlikely to improve freedom from AF, because these lines appear to prevent primarily macroreentrant mitral isthmus–dependent AT, which is frequently observed after CPVA, as in our study. The success of CPVA-M in preventing macroreentrant AT is critically dependent on the completeness of the line of block between the mitral valve and the left inferior pulmonary encircling line. However, complete block in the mitral isthmus region may be difficult to achieve despite its small dimension. In the present study, we obtained complete block of the mitral isthmus in almost all patients without
tively, suggesting that recovery of conduction was an important factor in the occurrence of AT. Gaps were also detected on additional lines in 2 patients. Among patients with macroreentrant AT, the critical isthmus was localized to the area between the mitral annulus and left inferior PV in 16 patients after CPVA and in 2 after CPVA-M, between the right PVs (8 patients, 5 after CPVA), or between the left PVs (5 patients, 2 after CPVA) with the circuit passing between the 2 ipsilateral veins at the site where previous intervenous lines were performed (Figure 2). In fewer than one third of patients, AT was focal (Table 2). Focal AT originated from an area outside the lesion lines, from the left atrial appendage, around the transseptal puncture, or at the right atrium and occurred in patients without gaps. Right AT origins were the crista terminalis or anterior portion of the right atrium–inferior vena cava junction. RF ablation was successful in eliminating AT in all patients with up to 5 RF applications delivered on the earliest site for focal AT and on the critical isthmus for macroreentrant AT.

Predictors of New-Onset AT
Kaplan-Meier survival curves showed that patients who underwent CPVA alone were more likely to experience AT than those who underwent CPVA-M, but freedom from recurrent AF was similar (Figures 3 and 4). Among the clinical and procedural variables, the strongest predictors of AT were multiple gaps and chronic AF (Table 3).
additional ablation within the coronary sinus, which increases the risk of both perforation and tamponade. Previous reports on the creation of lines of block at the mitral isthmus required ablation within the coronary sinus in some subjects, although they used an irrigated-tip catheter with lower power and temperature settings. It should also be mentioned that, after completion of this study, 1 patient developed an atrioesophageal fistula that we believe was due to the excessive application of RF energy at the junction between the circumferential and posterior lines. As a result, we now use reduced generator settings of 55° and 50W on the posterior wall. In addition, we recommend that the posterior line be placed near the roof of the left atrium where the esophagus is less likely to be in direct contact with the LA. On the other hand, if additional lines are incomplete, it is likely that more rather than fewer proarrhythmias will occur, as recently reported. In keeping with our results, it has recently been shown that the most common type of macroreentrant left AT
after left atrial ablation for AF was mitral isthmus dependent, again underlining the importance of complete and permanent block at this site.\textsuperscript{11}

Mechanisms of New-Onset AT After PV Ablation
Because patients with a history of AT and/or atrial flutter were excluded from the study, AT was, in all probability, a manifestation of proarrhythmia resulting from gaps along left linear lesions.

Gap-Related Reentry
The results of the present study demonstrate that, among patients with postablation incessant AT, gap-related macro-reentry was the most important mechanism of AT after either CPVA or CPVA-M. The long circumferential lesions required to prevent AF create new fixed obstacles to propagation, and eventual discontinuities represent an ideal substrate for large gap-related reentrant circuits. Of the 80\% of patients in whom complete encircling was achieved at the time of the first procedure, 0 developed AT. This finding suggests that completeness of lesions is indeed crucial for preventing macroreentry and that conversely incompleteness promotes the occurrence of macroreentrant AT. Spontaneous resolution of AT occurring early after a repeated procedure suggests that it may be appropriate to defer a repeated ablation in patients with procedure-related proarrhythmias.

Distribution of Gaps After PV Ablation
Among patients who had a repeated procedure, we documented multiple gaps in several areas, particularly around the right superior PV and between the left superior PV and appendage, where only single gaps had been found at the initial procedure, suggesting that these are points at which recovery of conduction can easily occur. These data suggest an important role for the ablation lines between the ipsilateral veins not only for preventing recurrent AF but also for preventing macroreentrant AT. The aforementioned caveat of completeness of lines remains, and the width of tissue between the veins is often reduced to a narrow ridge, making complete ablation extremely difficult.

Focal AT
This study shows that focal AT may be another mechanism of new-onset AT after PV ablation, but gap-related macroreentrant AT is more common. The presence of gaps seems not to be crucial in initiating focal AT, because neither single nor multiple gaps were found in patients with focal AT. This arrhythmia originated from within the body of the left or right atrium or around the transseptal puncture outside the ablation lines. In the present study, 3 patients with focal AT also experienced recurrent AF, and elimination of focal AT prevented recurrent AF. In keeping with another recent study,\textsuperscript{14} these findings suggest that non-PV foci can trigger AF. CPVA may be unmasking preexisting AT foci that were drivers for AF, but after substrate modification, conduction does not degenerate into AF.\textsuperscript{11}

Predictors of New-Onset AT After PV Ablation
Multivariate analysis indicated that multiple gaps and chronic AF are strong predictors of AT after ablation, but CPVA alone also predicts AT. Taken together, these findings suggest that CPVA-M is less proarrhythmic than CPVA alone and that every effort should be made to avoid gaps between ipsilateral PVs, especially in patients with chronic AF.

Catheter Ablation Results in Patients With Postablation AT
The high success rate of ablation in patients with postablation incessant macroreentrant AT is similar to that reported for common atrial flutter.\textsuperscript{15} The most common target site for ablation of macroreentrant AT after CPVA was the mitral isthmus and the area between the right PVs after CPVA-M. Successful ablation of macroreentrant AT with few RF applications in most patients indicates that the gaps responsible for AT were small and the critical isthmus was narrow, as recently reported.\textsuperscript{16}

Applications of RF energy on the earliest activation site also eliminated focal AT in most patients without complication.

Clinical Implications
Incessant AT occurring after CPVA is a relatively common complication, and its persistence often can result in syncope.
TABLE 3. Final Model of Cox Regression in the 560 Patients Who Underwent CPVA or CPVA-M

<table>
<thead>
<tr>
<th>Covariates</th>
<th>Regression Coefficient</th>
<th>P</th>
<th>Adjusted HR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Procedure (0/1 = CPVA-M/CPVA)</td>
<td>1.34</td>
<td>&lt;0.001</td>
<td>3.84</td>
<td>1.86–7.89</td>
</tr>
<tr>
<td>Gaps in &gt;1 PV (absent/multiple=0/1)</td>
<td>3.25</td>
<td>&lt;0.001</td>
<td>25.19</td>
<td>11.01–57.30</td>
</tr>
<tr>
<td>Gaps in 1 PV (absent/single=0/1)</td>
<td>2.43</td>
<td>&lt;0.001</td>
<td>11.33</td>
<td>5.02–25.55</td>
</tr>
<tr>
<td>AF (paroxysmal/chronic=0/1)</td>
<td>3.10</td>
<td>&lt;0.001</td>
<td>22.28</td>
<td>6.72–73.87</td>
</tr>
</tbody>
</table>

HR indicates hazard ratio.

Incessant AT can be a candidate for a relatively straightforward repeated procedure, as shown in this study. However, postablation AT may be a transient phenomenon and may resolve spontaneously over time. It is an important diagnosis, because the symptoms may be mistaken for AF and could lead to unnecessary treatment.

Study Limitations
The natural history of iatrogenic AT after PV ablation is largely unknown. The mean time interval between the index ablation and the repeated procedure in our study was 4.5 months. Therefore, we cannot exclude the possibility that some cases of AT might have resolved spontaneously over a longer time period.

Conclusions
CPVA is as effective as CPVA-M in curing AF, but additional lesion lines are associated with less postablation incessant AT, which frequently results in hemodynamic compromise and syncope. CPVA-M rather than CPVA alone should therefore be the recommended strategy, especially in patients with chronic AF. The most common target sites for ablation of AT were the mitral isthmus and the area between the right PVs. Multiple gaps are the strongest predictor for AT and create the substrate for macroreentrant AT. Documenting the cause of symptoms after PV ablation is crucial in guiding appropriate therapy.

References
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_Circulation_. 2004;110:3036-3042; originally published online November 1, 2004;
doi: 10.1161/01.CIR.0000147186.83715.95

_Circulation_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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