Effects of Stepwise Ablation of Chronic Atrial Fibrillation on Atrial Electrical and Mechanical Properties

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Objectives
This study sought to evaluate the effects of stepwise catheter ablation of chronic atrial fibrillation (AF) on atrial electrical and mechanical properties.

Background
Although stepwise catheter ablation of chronic AF is associated with acute arrhythmia termination and a favorable clinical outcome, atrial tissue damage following the procedure has not been evaluated.

Methods
Forty patients who had previously undergone catheter ablation of chronic AF were studied. In the index procedure, termination of AF was achieved by catheter ablation alone in 36 of 40 patients (90%). Electroanatomical mapping was performed in sinus rhythm 1 month after the index procedure, during which the surface area of scar (bipolar voltage of $<0.05$ mV), low-voltage tissue ($<0.5$ mV), and atrial propagation were evaluated. Left atrial (LA) mechanical function was assessed by transthoracic echocardiography.

Results
Electroanatomical mapping showed areas of scar and low-voltage accounting for 31% ± 12% and 32% ± 17% of the total LA surface area respectively, with the ablated pulmonary vein region accounting for 20% ± 4% of the LA surface area. The area of scar outside the pulmonary vein region represented 14% ± 12% of the LA surface area using the initial randomized ablation strategy, and 6% ± 8% ($p = 0.02$) using a specific ablation strategy. Atrial conduction was diversely affected by ablation with a wide range of LA conduction times observed (range 100 to 360 ms). The LA contraction was shown in all patients by the presence of late diastolic mitral flow (37 ± 15 cm/s) and a mean LA active emptying fraction of 18 ± 11%. At 9 ± 5 months of follow-up, 39 patients (98%) were in sinus rhythm.

Conclusions
Stepwise ablation achieving sinus rhythm in patients with chronic AF has a significant impact on LA electrical activity but is associated with recovery of LA function. (J Am Coll Cardiol 2007;49:1306–14) © 2007 by the American College of Cardiology Foundation

Catheter ablation of atrial fibrillation (AF) can eliminate atrial arrhythmias leading to improvements in left atrial (LA) and left ventricular (LV) function and also quality of life (1–4). Various ablation techniques to modify atrial substrates in addition to pulmonary vein (PV) isolation have been proposed for treatment of long-lasting AF (5–7). A stepwise ablation approach combining multiple atrial and venous targets is capable of restoring sinus rhythm in chronic AF without pharmacological or electrical cardioversion and is associated with a favorable clinical outcome (8). However, this technique may damage extensive areas of the atrial myocardium, potentially resulting in loss of LA mechanical function and alteration of interatrial/intra-atrial conduction (7,8), in contrast to conventional ablation strategies deploying a stereotypic lesion set at specific anatomical structures (5,6,9–11).

The goal of the present study was to evaluate the impact of an extensive ablation strategy for chronic AF on the surface area of scar/low-voltage tissue, atrial propagation during sinus rhythm, and overall LA mechanical function.

Methods

Study population. The study was composed of 40 of 120 consecutive patients (33%) with symptomatic and drug-
re refractory chronic AF who had undergone previous catheter ablation. Electroanatomical mapping was performed during sinus rhythm ≥1 month after the index procedure (5 ± 3 months). In 29 patients, electroanatomical mapping was performed during a repeat ablation procedure for recurrent arrhythmias (paroxysmal AF/atrial tachycardia [AT] 8, persistent AF 0, persistent AT 21). The remaining 11 patients presented with symptomatic atrial ectopic beats and underwent an electrophysiological study. Baseline characteristics of the studied patients are presented in Table 1. All patients gave written informed consent to the study protocol, which was approved by our institutional review board. Catheter ablation. The index procedural end point was restoration of sinus rhythm without antiarrhythmic drugs or electrical cardioversion. If AF was converted into AT, mapping and catheter ablation of subsequent AT was performed. The AT was defined as an organized atrial rhythm with a monomorphic P-wave and consistent endocardial activation sequence in both atria.

The techniques of catheter ablation performed in the index procedure have been presented elsewhere (8). In brief, ablation was performed using a 3.5-mm irrigated-tip ablation catheter (Biosense-Webster, Diamond Bar, California) at the following sites. (i) The PV isolation was performed with the end point of the abolition or dissociation of activities in all PVs. (ii) The superior vena cava (SVC) was isolated using the same technique and end point as used for PV isolation. If AF was terminated before targeting the SVC, the SVC was not ablated. (iii) The coronary sinus (CS) region was targeted first from the LA endocardium bordering the mitral annulus (inferior LA along the CS) and within the vessel if local rapid activities persisted. The end point was significant slowing of CS activity. (iv) Atrial ablation was performed at all sites showing any of the following electrogram features: continuous electrical activity, complex and fractionated electrograms, a gradient of activity, or prolongation of local cycle length activity, or shorter cycle length activity until similar to or greater than that recorded in the LAA. (v) Linear ablation was performed at the cavotricuspid isthmus, the LA roof, and the mitral isthmus. The end point of linear ablation during AF was significant reduction or abolition of local electrograms. After restoration of sinus rhythm, additional ablation was performed until completion of conduction block as described elsewhere (5,6). In patients with persistent AF after steps (i) to (v) inclusive, ablation was performed in the right atrium (RA) in the same manner as used in step (iv).

In the initial 70 consecutive patients, PV isolation, SVC disconnection, CS ablation, and atrial ablation in the LA were performed in a randomized sequence followed by linear ablation and atrial ablation in the RA until AF was terminated (randomized ablation strategy). Based on the results of a previous study (8), ablation was performed in a specific sequence in the last 50 consecutive patients as follows: PV isolation and roof line ablation were performed first, followed by CS and atrial ablation (specific ablation strategy). The SVC disconnection was performed optionally if the local cycle length was shorter than elsewhere in the RA.

Twenty-five and 15 patients underwent the randomized and specific ablation strategies, respectively. Termination of AF was defined as restoration of sinus rhythm or conversion into AT, and was achieved by catheter ablation alone in 36 of 40 patients (90%).

Electrophysiological study. All patients received antiarrhythmic drugs for 2 months after the index procedure, and discontinued these drugs ≥5 half-lives before the study. Amiodarone was being taken by 11 patients (28%) at the time of the study. The surface electrocardiogram and intracardiac electrograms were measured at a sweep speed of 100 mm/s using a digital amplifier/recording system (Bard Electrophysiology, Lowell, Massachusetts). A single bolus of 50 IU/kg of heparin was administered after the transseptal puncture. For endocardial mapping, a 6-F quadripolar catheter (Xtrem, ELA Medical, Montrouge, France) was positioned in the CS. Electroanatomical mapping of the LA and/or RA using the Carto system (Biosense-Webster) was performed during either sinus rhythm (LA 36, RA 24) or pacing at a cycle length of 600 ms from the CS, LAA, or RA appendage (LA 4, RA 2) when ectopic beats were present.

The earliest activation site in the sinus node region was distinguished as multicentric or unicentric pacemaker activity. Multicentric pacemaker activity was defined as the presence of earliest activation sites separated by ≥10 mm with an activa-

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**Table 1** Baseline Characteristics of Patients (n = 40)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value (Range)</th>
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<tbody>
<tr>
<td>Age (yrs)</td>
<td>54 ± 9</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>35/5</td>
</tr>
<tr>
<td>Structural heart disease (%)</td>
<td>17 (43)</td>
</tr>
<tr>
<td>Median duration of AF (months)</td>
<td>72 (range 7–360)</td>
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<tr>
<td>Median duration of persistent AF (months)</td>
<td>12 (range 1–168)</td>
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<tr>
<td>Echocardiographic data before the index procedure</td>
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<tr>
<td>LVEF before the index procedure (%)</td>
<td>58 ± 16</td>
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<tr>
<td>LA dimension before the index procedure (mm)</td>
<td>46 ± 8</td>
</tr>
<tr>
<td>Parasternal</td>
<td>46 ± 8</td>
</tr>
<tr>
<td>Longitudinal</td>
<td>59 ± 9</td>
</tr>
<tr>
<td>Transverse</td>
<td>46 ± 8</td>
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</tbody>
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AF = atrial fibrillation; LA = left atrium; LVEF = left ventricular ejection fraction.
tion time difference of $\leq 5$ ms (12). Unicentric pacemaker activity was defined as the presence of localized earliest activation site surrounded by sites with an activation time difference of $> 5$ ms.

Interatrial and intra-atrial conduction times were evaluated by duration from onset of P-wave to earliest and latest activation time in the LA.

Electrically silent areas (scar) were defined as those with absence of recordable activity or a bipolar voltage amplitude $< 0.05$ mV; low-voltage areas were defined as those with contiguous areas $< 0.5$ mV on bipolar voltage maps, as reported elsewhere (12,13). Mean bipolar voltage of the chamber was calculated from all acquired points including those displaying electrical silence. Higher-density mapping was performed to evaluate scar/low-voltage areas; the location of scar/low-voltage tissue was described and the percentage of LA surface area occupied by this tissue was determined. For the purpose of analysis, the LA was divided into 8 regions: the PV, LAA, anterior LA, LA roof, septal LA, posterior LA, inferior LA, and lateral LA. Atrial tissue 0.5 to 1.0 cm from the PV ostia was included within the PV region. The posterior LA approximated a square, the corners of which were defined by the 4 PV orifices. The LA roof was defined as a band of 1 to 2 cm between the superior PVs, which separated the posterior LA from the anterior LA. The anterior LA extended from the LA roof to the superior mitral annulus. The inferior LA extended from the lower aspect of the 2 inferior PV ostia to the inferior mitral annulus. The lateral LA was defined as atrial tissue between the posterolateral mitral annulus (4 o’clock) and the lower lip of the LAA.

**Follow-up and echocardiograms.** Patients were hospitalized for 1 day at 1, 3, 6, and 12 months after the procedure for clinical review and ambulatory monitoring. Antiarrhythmic drugs were administered for 2 months after the index procedure. If tachyarrhythmia was not observed during this period, these antiarrhythmic drugs were discontinued.

Transthoracic echocardiography was performed $\geq 1$ month after the electroanatomical mapping, by which time persistent recurrent arrhythmias were eliminated and stable sinus rhythm was restored. Pulsed Doppler gains were adjusted to provide a smooth velocity distribution without introducing noise at a 100-mm/s sweep speed. All measures were acquired in sinus rhythm and stored on magnetic optical disks for offline analysis with a customized software package (Echopac, GE Medical Systems, Horten, Norway). The LA volumes at P-wave onset and end-systolic volume were calculated using the electrocardiogram as a timing reference. The LA active emptying volume and LA active emptying fraction were then derived. Late diastolic peak velocity (peak A-wave velocity) was measured from the apical 4-chamber view in patients in whom sinus rhythm was maintained, with the sample volume placed at the tip of the mitral leaflets by averaging 3 consecutive cycles. The LA filling fraction was also calculated from time velocity integral of mitral flow (3). Reproducibility of the aforementioned measurements has been reported elsewhere (3).

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**Figure 1** Electroanatomical Mapping of the Right Atrium Displaying Activation Time and Bipolar Voltages

(A) Unicentric pacemaker activity is observed in the midposterior right atrium 28 mm from the junction of the superior vena cava. (B) Purple represents bipolar voltages of $\geq 0.5$ mV.
**Statistical analysis.** Continuous variables are expressed as mean ± SD. A comparison between the groups was performed with the Student $t$ test or the Wilcoxon rank-sum test, as appropriate. A paired comparison was performed using the Student $t$ test or the Wilcoxon signed rank test, as appropriate. All tests of significance were 2-tailed, and a $p$ value <0.05 was considered as statistically significant.

**Results**

**Electroanatomical mapping.** Electroanatomical maps of the LA and RA were created with 81 ± 15 and 73 ± 20 points, respectively. High-density mapping was performed at the borders between scar and low-voltage tissue, or low-voltage tissue and tissue with a voltage of ≥0.5 mV, thus 53% of points in the LA were acquired in low-voltage tissue. The volumes of the LA and RA geometries created by Carto were 89 ± 37 cm$^3$ and 95 ± 25 cm$^3$, respectively, and their surface areas were 115 ± 26 cm$^2$ and 129 ± 22 cm$^2$, respectively.

**Atrial propagation during sinus rhythm.** The median atrial cycle length was 930 ms (range 600 to 1,350 ms) during mapping in the RA. All but 1 patient showed the earliest activity in the posterior RA along the crista terminalis, and 1 patient showed the earliest activity in the high anterolateral RA. Unicentric pacemaker activity was observed in 12 patients (50%) (Fig. 1), and caudal shift of the earliest activation (≥20 mm from the junction of the RA and SVC) was observed in 6 patients (25%).

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**Figure 2** Propagation Map of the Left and Right Atrium During Sinus Rhythm

Earliest activation is the high anterior left atrium, corresponding to the Bachmann bundle insertion (A to D).
Earliest activation in the LA was observed 36 ± 18 ms after the onset of the P-wave at the high anterior LA in 24 patients (67%), corresponding to the insertion site of Bachmann bundle into the LA (Fig. 2). Three patients showed simultaneous activation in the Bachmann bundle insertion region and LA septum. In the remaining 12 patients, the site of earliest activation was the LA septum; in 11 of these 12 patients, the Bachmann bundle insertion region showed low-voltage or scar (Fig. 3).

During sinus rhythm, the site of latest activation in the LA occurred at 181 ± 65 ms (range 100 to 360 ms) after the onset of the P-wave: at the LAA (16 patients, 44%), posterior LA (10 patients, 28%), or lateral LA (10 patients, 28%). In 4 patients (11%), the latest activity in the LA occurred after the QRS complex (LAA 3 and posterior LA 1) (Fig. 3). In 78%, 11%, and 11% of patients, atrial activation was complete before QRS, during QRS, and after QRS, respectively.

In the LA, the earliest and latest activations occurred at similar times after the onset of the P-wave irrespective of amiodarone use (p = 0.79, p = 0.38, respectively).

Voltage map. Mean bipolar voltages in the LA and RA were 0.60 ± 0.33 mV and 1.60 ± 0.69 mV (p < 0.0001), respectively (Fig. 4). Voltages in the LA and RA were similar between patients who were taking and not taking amiodarone at the time of the study (p = 0.5, p = 0.35, respectively). All electroanatomical maps showed bipolar electrograms with voltages of >0.5 mV in the LAA (Figs. 3 to 6).

The percentages of surface area accounted for by scar in the LA and RA were 31 ± 12% and 0 ± 1% (p < 0.0001), respectively, and the percentages of surface area of low-voltage tissue in the LA and RA were 32 ± 17% and 7 ± 10% (p < 0.0001), respectively. In all patients, the ablated PV region was accounted for by scar, representing 20 ± 4% of the total surface area of the LA (i.e., two-thirds of the total LA scar). Scar area outside the PV was 11 ± 11% (range 0% to 45%) of the LA surface area. The distribution of scar and low-voltage tissue in each region of the LA is shown in Figure 6.

Voltages in the Bachmann bundle region and atrial conduction. Twenty-one patients (58%) had low-voltage electrograms or scar in the anterior LA, that is, the Bachmann bundle insertion region. Although these patients had similar early onset of LA activation as the others (from P-wave onset: 37 ± 19 ms [range 14 to 83 ms] vs. 35 ± 17 ms [range 14 to 70 ms], p = 0.83), the time to completion of activation in the LA was significantly prolonged (from P-wave onset: 203 ± 64 ms [range 126 to 360 ms] vs. 152 ± 57 ms [range 100 to 330 ms], p < 0.003) (Fig. 3).

Surface area of scar/low-voltage tissue and ablation strategy. The percentages of surface area of scar and low-voltage tissue in the LA were compared between patients who underwent the randomized ablation strategy and specific ablation strategy (Figs. 3 to 5, Table 2). The percentages of surface area of low-voltage tissue were similar for both strategies (32 ± 17% vs. 31 ± 19%, p = 0.87), whereas that of scar was lower (26 ± 9% vs. 34 ± 13%, p =
0.066) in patients undergoing the specific ablation strategy. This difference was related to scar areas outside the PV region (6 ± 8% [range 0% to 28%] vs. 14 ± 12% [range 0% to 45%], p = 0.02) as a consequence of significantly shorter radiofrequency durations in the specific ablation strategy group (81 ± 22 min vs. 99 ± 22 min, p = 0.01).

Follow-up. Six patients (15%) underwent a repeat procedure for clinically recurrent arrhythmias at a median of 7 months (range 2 to 10 months) after the electroanatomical mapping. Mapping showed conduction recovery in 4 patients (right inferior PV 1, roof line 2, and mitral isthmus line 1) and a focal source in 2 patients (CS and RA). At 9 ± 5 months of follow-up from the index procedure, 39 patients (98%) were in sinus rhythm (35 patients [88%] were without antiarrhythmic drugs), of whom 1 patient had paroxysmal atrial arrhythmia. A single patient had persistent AT, and is awaiting a repeat procedure (Fig. 7).

Echocardiograms. Transthoracic echocardiograms were performed during stable sinus rhythm at a mean of 4 ± 3 months after the electroanatomical mapping. Compared with echocardiography performed before the index procedure (baseline), LV end-diastolic and end-systolic diameters decreased and LV ejection fraction increased without reaching statistical significance (55 ± 8 mm vs. 53 ± 5 mm, p = 0.11; 37 ± 11 mm vs. 34 ± 6 mm, p = 0.2; 58 ± 16% vs. 62 ± 10%, p = 0.2). The LA diameters decreased significantly (parasternal: 46 ± 8 mm vs. 41 ± 8 mm, p = 0.002; longitudinal: 59 ± 9 mm vs. 54 ± 10 mm, p = 0.001; transverse: 46 ± 8 mm vs. 41 ± 8 mm, p = 0.03). In 11 patients (28%) with a baseline LV ejection fraction ≤45%, LV ejection fraction significantly increased from baseline (median 43% [range 15% to 45%] vs. median 62% [range 38% to 68%), p = 0.02). The LV and LA dimensions after electroanatomical mapping were similar in patients irrespective of ablation strategy (LV end-diastolic diameter p = 0.8, LV end-systolic diameter p = 1.0, LA parasternal diameter p = 0.9, LA longitudinal diameter p = 0.8, LA transverse diameter p = 0.6).

All patients showed the presence of active late diastolic mitral flow with a mean peak velocity of 37 ± 15 cm/s (Fig. 8). The LA active emptying volume and the LA active emptying and filling fraction was available in 22 patients and were 8.3 ± 10.3 ml/m², 18 ± 11%, and 15 ± 9%, respectively. These variables were similar for both ablation strategies (Table 2).

Discussion

The present study describes the electrical and mechanical consequences of stepwise ablation of chronic AF. First, it quantifies the extent of scar or low-voltage areas after the procedure. Second, it shows the recovery of LA contractile function in the 98% of patients in whom sinus rhythm was maintained.
Evaluation of scar and low-voltage areas. Pulmonary vein isolation accounted for two-thirds of the total LA scar burden after ablation. Ablation in all other atrial regions aiming to achieve local organization and slowing of fibrillation cycle length was associated with a relative preservation of atrial voltages and propagation.

Although the presence of spontaneous scar in patients with AF is known (13), the extent of pre-existing scar or low-voltage areas was not investigated in the present study. Atrial bipolar voltage mapping after an ablation procedure estimates the viability of atrial tissue (14,15), but cannot distinguish between spontaneous and iatrogenic scar/low-voltage tissue. The extent of tissue damaged by ablation therefore may be smaller than that measured as scar or low-voltage tissue in the present study. From a clinical perspective, the distinction between spontaneous and iatrogenic scar is unlikely to be relevant, however, because both are likely to have similar electrical and mechanical consequences for atrial function.

Currently, many investigators target the posterior LA in addition to the PV and mitral isthmus linear lesion in surgical or ablative procedures for AF (2,16,17). The ablated areas using this approach account for 30% to 40% of the LA surface area (11). In the present study, the surface area of scar is comparable, but the distribution of lesions outside the PV is different. In one-third of patients undergoing stepwise ablation, an absence of scar or low-voltage tissue was shown in the posterior LA (Fig. 6). Instead, reduction of bipolar voltages was observed in the other regions such as the anterior LA or inferior LA, which are important regions in perpetuation of AF and thus may be targeted provided that AF termination is the desired procedural end point (7,8).

LA contraction. Recovery of atrial mechanical function is a major goal in the treatment of AF. Extensive catheter ablation of atrial tissue replaces myocardium with scar and prolongs intra-atrial conduction, thereby potentially compromising atrial mechanical performance. This is supported by the loss of LA contraction in 13% to 39% of patients who underwent the maze procedure despite remaining in sinus rhythm (18–21). This is in marked contrast to the present study, in which all patients in whom sinus rhythm was maintained after ablation showed recovery of LA contraction.
In the surgical treatment of AF, preservation of the LAA improves atrial contraction compared with the maze procedure in which the LAA is removed (22). Isobe et al. (20) showed that all patients had the presence of LA contraction after the surgical procedure in which both atrial appendages were preserved, whereas 27.5% of patients showed loss of LA contraction after the maze III procedure in which both appendages are removed. The ablation strategy in the present study avoids electrical disconnection of the LAA, and the resultant preserved bipolar voltages within the LAA may contribute to the restoration of LA contraction after ablation in a fashion analogous to LAA preservation during surgery.

A prior report has shown that preoperative LV ejection fraction and LA diameter are predictors of the presence of atrial contraction after the maze procedure (19), suggesting that an underlying atrial pathology is one factor associated with LA contraction. Although patients with a low ejection fraction or LA dilatation were included in the present study, recovery of LA contraction was observed in all patients in sinus rhythm.

Few data are available about echocardiographic evaluation of LA mechanical function after catheter ablation of chronic AF. A previous report in which PV isolation and linear lesions (roof line and mitral isthmus line) were

| Variables of Patients Who Underwent Randomized Ablation Strategy and Specific Ablation Strategy |
|---------------------------------|---------------------------------|-------------------|
| Age (yrs)                        | 54 ± 9                          | 54 ± 9            |
| Duration of AF (months)          | 69 (7–240)                      | 72 (24–360)       |
| Duration of persistent AF (months)| 12 (1–168)                     | 12 (1–30)         |
| LVEF before the index procedure (%)| 59 ± 18                         | 56 ± 13           |
| LA dimension before the index procedure (mm) | | |
| Parasternal                      | 46 ± 6                          | 47 ± 11           |
| Longitudinal                     | 59 ± 10                         | 60 ± 7            |
| Transverse                       | 45 ± 8                          | 47 ± 6            |
| Total RF duration (min)          | 99 ± 22                         | 81 ± 22           |
| Heart rate (beats/min)           | 71 ± 18                         | 68 ± 15           |
| LA bipolar voltage (mV)          | 0.56 ± 0.27                     | 0.66 ± 0.43       |
| LA scar areas (%)                | 34 ± 13                         | 26 ± 9            |
| PV region scar areas (%)         | 20 ± 4                          | 20 ± 4            |
| Outside the PV scar areas (%)    | 14 ± 12 (0–45)                  | 6 ± 8 (0–28)      |
| LA low-voltage areas (%)         | 32 ± 17                         | 31 ± 19           |
| Latest activation time in the LA from P-wave (ms) | 189 ± 70                        | 170 ± 57          |
| Late diastolic mitral velocity (cm/s) | 34 ± 14                        | 41 ± 17           |
| LA emptying volume (ml/m²)       | 5.0 (0.0–16.0)                  | 7.0 (3.0–11.0)    |
| LA emptying fraction (%)         | 18 ± 13                         | 18 ± 8            |
| LA filling fraction (%)          | 13 ± 9                          | 17 ± 8            |

The duration of AF and persistent AF and the LA emptying volume are expressed as median, minimum and maximum.

RV = pulmonary vein; RF = radiofrequency; other abbreviations as in Table 1.

Figure 7: Clinical Outcome of the Studied Patients

<Post 2nd session>
Randomized ablation strategy
- No arrhythmias: 19 pts
- Recurrent arrhythmias: 6 pts
- Paroxysmal AF: 1 pt
- Persistent AF: 2 pts
Specific ablation strategy
- No arrhythmias: 1 pt
- Recurrent arrhythmias: 1 pt
- Persistent AF: 1 pt

<Post 3rd session>
Randomized ablation strategy
- No arrhythmias: 5 pts
- Recurrent arrhythmias: 1 pt
Specific ablation strategy
- No arrhythmias: 14 pts
- Recurrent arrhythmias: 1 pt
- Persistent AF: 1 pt

AF = atrial fibrillation; AT = atrial tachycardia; pt = patient.

Figure 8: Doppler Tracing at the Mitral Valve Inflow

Late diastolic mitral flow is shown.
performed showed that LA active emptying volume and emptying fraction (4.7 ± 2.14 ml/m², 21.8 ± 11%, respectively) were comparable with those in the present study (3), despite the fact that less atrial tissue was targeted.

Although recovery of LA contraction was shown in all patients in whom sinus rhythm was maintained after step-wise ablation, extensive atrial scar may be associated with suboptimal LA mechanical function, and the long-term effects on LA contraction and endothelial function are unknown. It is likely that the smaller the surface area occupied by scar tissue, the greater the likely benefit for atrial contractile function.

The presence of scar/low-voltage tissue in the LA, especially in the Bachmann bundle insertion, was associated with prolongation of LA conduction times. Intra-LA conduction disturbance results in asynchronous contraction of the LA, possibly attenuating atrial contractile performances. Furthermore, in patients in whom the latest activity in the LA occurred after the QRS, LA contribution to LV filling is smaller because of closure of the mitral valve before completion of LA contraction. Further refinement of techniques to identify sites crucial for maintenance of AF or subsequent AT on an individual basis is therefore necessary to minimize the extent of LA injury and to maximize the mechanical benefit of catheter ablation therapy for AF.

Conclusions. Stepwise ablation of chronic AF is associated with maintenance of sinus rhythm and recovery of LA function despite significant scarring in the LA.

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REFERENCES