REVERSE LEFT ATRIAL REMODELING ASSESSMENT AFTER PAROXYSMAL ATRIAL FIBRILLATION ABLATION: OUR FIRST EXPERIENCE

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REVERSE LEFT ATRIAL REMODELING ASSESSMENT AFTER PAROXYSMAL ATRIAL FIBRILLATION ABLATION: OUR FIRST EXPERIENCE (Abstract) We aimed to assess reverse left atrial (LA) remodeling at 6 months after ablation of paroxysmal atrial fibrillation (AF), and to identify the most relevant parameter of reverse LA remodeling. Material and methods: Left atrial size was assessed by echocardiography: antero-posterior (AP) diameter, LA area in apical 4 and 2 chambers (A4c, A2c), LA volume by biplane formula (LAV1), and by computed-tomography (LAV2). Results: Seventy-eight consecutive patients with mean age of 57.41 ± 8.05 years were prospectively included; 60 (76.9%) were with paroxysmal AF less than 24 hours and 18 (23.1%) less than 7 days duration. All echocardiographic and computed-tomographic evaluations were made within 4 weeks before ablation and at 6 months after ablation procedure by the same operator. Circumferential or segmental pulmonary vein isolation was performed by radiofrequency in 58 (74.4%) patients, and by cryotherapy in 18 (23.1%) patients. At 6 months 53 (67.9%) patients were in stable sinus rhythm and 18 (23%) out of those on antiarrhythmic drugs. At 6 months after ablation all parameters of LA size decreased statistically significant. Conclusions: In our first experience, endocardial catheter ablation results in significant conversion in sinus rhythm and 18 (23%) out of those on antiarrhythmic drugs. At 6 months after ablation all parameters of LA size decreased statistically significant. Conclusions: In our first experience, endocardial catheter ablation results in significant conversion in sinus rhythm in patients with paroxysmal AF. The maintenance of stable sinus rhythm after ablation procedure determined a significant reverse LA remodeling, irrespective of parameter used for LA size assessment. The most relevant parameter for assessing reverse LA remodeling in patients with endocardial ablation of paroxysmal AF was LA volume by echocardiography. Keywords: ATRIAL FIBRILLATION, LEFT ATRIUM, VOLUME, REMODELING.

Discovering of the pulmonary vein role as triggers in atrial fibrillation (AF) initiation and maintenance was fundamental for its therapy (1). Pulmonary vein isolation by catheter ablation is nowadays a well-known curative technique in selected patients (2, 3). After AF onset, structural, electrical and mechanical remodeling of the left atrium (LA) facilitates its own perpetuation (“AF begets AF”) (4). LA size is an important marker of structural remodeling, recommended by current guidelines (5). LA size can be assessed by anterior-posterior diameter, area or volume; the current echocardi-
ogic recommendation being area or volume as parameters of LA remodeling assessment (6). It is well-known that echocardiography underestimates and computed-tomography (CT) overestimates LA volume (5).

It is well-known that stable sinus rhythm maintenance after AF ablation means reverse structural LA remodeling occurrence (decreasing LA size). It is associated with better outcomes in patients underwent AF ablation.

We aimed to assess reverse left atrial (LA) remodeling at 6 months after paroxysmal AF ablation and to identify the most relevant parameter of reverse LA remodeling.

**MATERIAL AND METHODS**

In this single center study, patients with paroxysmal or persistent AF were selected to undergo pulmonary vein isolation using first generation cryoballoon or by means of radiofrequency. Patients selection and inclusion in the study was made according with the current guidelines (2,3). The ablation procedure consisted of endocardial ostial isolation of each PV antrum by radiofrequency energy using a Lasso™ catheter (BiosenseWebster, CA, USA) and an irrigated tip Celsius™ Thermo Cool (Biosense Webster, CA, USA) or cryoablation (ICE® Cryoablation System, Medtronic, USA). Both procedures were done using local anesthesia by femoral access and deep sedation with Morphine fractionated i. v. during application of energy.

Left atrial size was assessed by echocardiography: antero-posterior diameter (AP), LA area in apical 4 and 2 chambers (A4c, A2c), LA volume by biplane formula (LAV1), and by computed-tomography (LAV2). All echocardiographic and CT measurements were made within 4 weeks before ablation and at 6 months after ablation procedure by the same operator.

**Echocardiographic evaluation of left atrium size**

Transthoracic echocardiography is the recommended approach for assessing LA size. Left atrial AP diameter (fig. 1), LA area in 4 and 2 apical chamber view and LA volume by biplane area-length formula (fig. 2) measurements were done using two-dimensional (2D) transthoracic echocardiography with an IE33 machine (IE 33 Echocardiography System, Philips Healthcare, The Netherlands). All echocardiographic measurements were performed at end-ventricular systole, at maximal LA size (for maximal LA volume assessment).

As currently recommended, we optimized each view to avoid: an underestimation of LA volume by foreshortening of the major length of the LA, inaccurate assumption of the mitral annulus boundary, loss of lateral resolution of the LA wall in the apical view or dropout of the interatrial septum or anterior wall (5). All measurements by echocardiography were performed by the same operator, before and at 6 months after ostial endocardial AF ablation.
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Fig. 2. Left atrium area and volume measurement in 4 and 2 chambers view by bi-dimensional transthoracic echocardiography (A4C: apical four chamber views; A2C: apical two chamber views; L: length)

Computed tomographic evaluation of left atrium volume
All patients underwent cardiac contrast enhanced CT (Siemens Somatom Senzation 128-Slice Configuration, Siemens AG, Germany) for evaluation of the morphology of the left atrium, before AF ablation and at ± 6 months after this procedure. For maximal LA volume assessment, all CT images were ECG-gated. We applied the ellipsoid biplane area-length formula, after we obtained an optimal contour in transverse axis by tracing the endocardial border cavity (fig. 3). Each of the CT slices was performed at 1 mm so L dimension was equal with the totally number of the slices.

We performed the measurements avoiding an overestimation of LA volume on CT, by the following: the inclusion of part of LA appendage volume, the incorporation of the PV or overlap and the duplicate measurements of the multiple sequence scans. All measurements on CT were performed by the same operator, before and at 3 months after ostial endocardial AF ablation.

Statistical analysis
Data are presented as frequency distributions and simple percentages. Continuous variables are expressed as mean ± standard deviation. Statistical analysis was performed using SPSS 10 for Windows (SPSS Inc., Chicago, IL, USA). A p value <0.05 was considered significant.

RESULTS
Seventy-eight consecutive patients undergoing non-valvular AF catheter ablation were prospectively and consecutively included in this study; 60 (76.9%) out of these patients were with paroxysmal AF less than 24 hours and 18 (23.1%) with paroxysmal AF less than 7 days. Mean age
was 57.41 ± 8.05 years; 67% were men; 74% had have arterial hypertension, 33% coronary heart disease and 19% diabetes mellitus. Mean paroxysmal AF duration was 4.7±1.7 months.

Circumferential or segmental pulmonary vein isolation was performed by radiofrequency energy in 58 (74.4%) patients and by cryotherapy in 18 (23.1%) patients. Antral pulmonary vein isolation was obtained at 35W (by radiofrequency energy) and minus 40°C (by cryotherapy). In patients with paroxysmal AF longer than 24 hours we used exclusively radiofrequency energy and ablation procedure was completed by complex fractionated atrial electrogram and cavo-tricuspid istmus ablation (if common atrial flutter was confirmed before or during procedure).

At 6 months 53 (67.9%) patients were in stable sinus rhythm, 18 out of these patients being on antiarrhythmic drugs. A redo (a second procedure) procedure was made in 23 (29.5%) patients and 18 (78.3%) of these patients were converted in stable sinus rhythm until 6 months. At 6 months, all parameters for LA size decreased statistically significant (tab. I).

<table>
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<tr>
<th>PARAMETERS</th>
<th>BASELINE</th>
<th>AFTER 6 MONTHS</th>
<th>p</th>
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<tr>
<td>Anteroposterior diameter (AP); mm</td>
<td>42±7</td>
<td>40±8</td>
<td>0.050</td>
</tr>
<tr>
<td>Apical 4 chamber area (A4c); cm²/m²</td>
<td>26±7</td>
<td>23±6</td>
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<tr>
<td>Apical 2 chamber area (A2c); cm²/m²</td>
<td>26±8</td>
<td>24±6</td>
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<tr>
<td>Indexed left atrial volume by biplan formula (LAV1); ml/m²</td>
<td>44±16</td>
<td>37±10</td>
<td>0.010</td>
</tr>
<tr>
<td>Indexed left atrial volume by computed-tomography (LAV2); ml/m²</td>
<td>49±23</td>
<td>44±17</td>
<td>0.026</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Catheter ablation is now an accepted procedure for the treatment of AF (2, 3). In AF patients LA dilation is a marker of LA structural remodeling. This could result in a changed LA morphology and shape with a larger LA area and volume. LA volume and area and shape are the best parameters for LA size assessment as marker of LA structural remodeling.

The atrium dilation has different consequences over the LA anatomic segments (5). The mitral annulus, the mitral-aortic junction and the interatrial septum are less susceptible to dilatation because they are relatively fixed. Because of lack of the fibrous component, the pulmonary vein antrum could modify their thickness and geometry in structural remodeled atria (7,8). Progressive LA dilation is associated with asymmetrical structural remodeling and shape changes (5,8). Recently it was shown that a remodeled LA during dilatation evolved from ellipsoidal shape through a spheroidal one. This spheroidal shape could be an independent predictor of recurrence after AF ablation and may be useful in selecting the best candidates for AF ablation (9).

The most widely used parameter for LA size assessment, AP linear dimension, should not be used as the sole measure of LA size (5). If is still used, 2D echocardiog-
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graphy in parasternal long-axis view is preferred over M-mode echocardiography (5).

When assessing the LA size and remodeling, the measurement of LA volume is recommended, because it considers alterations in LA chamber size in all directions. Two-dimensional echocardiographic LA volumes are typically smaller than those reported from CT or magnetic resonance imaging (5). Different methods exist for measuring LA volumes. Although the three linear measurements have been used to calculate LA volume using an ellipsoid model, the relative inaccuracy of these linear measurements limits this method. LA volume should be measured using the disk summation algorithm.

The LA endocardial borders should be traced in both the apical four- and two-chamber views. A single-plane approach can also be used, but this method is based on the geometric assumption that the LA is circular in the short-axis cut plane, which may not be always accurate. Although not recommended for routine use, this approach could be used in cases when planimetry in both views is difficult. Single-plane apical four-chamber indexed LA volumes are typically 1 to 2 mL/m² smaller than apical two-chamber volumes (5). Alternatively, a biplane calculation could also be performed using the LA areas and lengths measured from both the apical four- and two-chamber views. Although the area-length method still assumes an ellipsoidal LA shape, it has the advantage of reducing linear dimensions to only two measurements of atrial length, of which the shorter one is selected.

All parameters used to assess LA size decreased statistically significant after 6 months; it means that LA suffered a reverse remodeling after catheter ablation of AF. The most significant reducing was unregis-
tered of LAV1 (16%) comparing with 12% for A4C, 11% for LAV2, 10% for AP diameter and 8% for A2C. Therefore, we consider LAV1 or LA volume by echocardiography (bi-plane area-length formula) the most relevant parameter for assessing reverse LA remodeling in patients with endocardial ablation of paroxysmal AF.

Mean LA volume by echocardiography was smaller than by CT; it confirms that echocardiography might underestimate and CT might overestimate LA volume.

Echocardiography with the ellipsoid bi-plane dimension-length formula, is one of the recommended methods by both echocardiographic recommendations (5,6) although implying a certain degree of volume underestimation. Usually all patients selected for AF catheter ablation underwent a CT exam because of pre-procedural and intra-procedural utility.

However, echocardiography comparing with CT is cost efficient avoids irradiation exposure and is easier to use in daily practice.

Lower LA appendage contraction velocity could be a non-invasive pre-procedural predictor of persistent AF recurrences after ablation, indicating the possibility of reduced reverse remodeling of the LA (10).

Reverse structural remodeling takes longer and is still present 2 to 4 months after restoration of sinus rhythm (11). Pre-procedural delayed enhancement magnetic resonance imaging is also able to determine the degree of atrial fibrosis and is another tool to predict the reverse remodeling after ablation.

Study limits

This study was mainly designed to assess LA reverse structural remodeling in patients with non-valvular underwent AF
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catheter ablation. In this study, we did not
use any software for CT volume measure-
ments. By performing single operator eval-
uations, we avoided inter- but not in-
traoperative variability. Left atrial volume,
as marker of structural remodeling, was
assessed before and 3 months after AF
ablation. It is difficult to discuss the influ-
ence of the type of ablation energy during
AF ablation technique on LA volume, be-
cause the reduced number of patients; in
addition, the follow-up was only 6 months.

CONCLUSIONS
Endocardial catheter ablation results in
significant conversion on sinus rhythm in
patients with paroxysmal AF. The mainte-
nance of stable sinus rhythm after ablation
procedure determined a significant reverse
LA remodeling, irrespective of parameter
used for LA size assessment. The most
relevant parameter for assessing reverse
LA remodeling in patients with endocardial
ablation of paroxysmal AF was LA volume
by echocardiography.

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