Atrial Structure and Function

Left Atrial Passive Emptying Function Determined by Cardiac Magnetic Resonance Predicts Atrial Fibrillation Recurrence After Pulmonary Vein Isolation

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Background—Although pulmonary vein isolation has become a mainstream therapy for selected patients with atrial fibrillation (AF), late recurrent AF is common and its risk factors remain poorly defined. The purpose of our study was to test the hypothesis that reduced left atrial passive emptying function (LAPEF) as determined by cardiac magnetic resonance imaging has a strong association with late recurrent AF after pulmonary vein isolation.

Methods and Results—Three hundred forty-six patients with AF referred for cardiac magnetic resonance pulmonary vein mapping before pulmonary vein isolation were included. Maximum LA volumes (VOL_max) and volumes before atrial contraction (VOL_bac) were measured; LAPEF was calculated as (VOL_max−VOL_bac)/VOL_max×100. Kaplan–Meier curves were constructed to determine late recurrent AF stratified by LAPEF quintile. Cox proportional hazards regression was used to adjust for known markers of recurrence. During a median follow-up of 27 months, 124 patients (35.8%) experienced late recurrent AF. Patients with recurrence were more likely to have nonparoxysmal AF (75.8% versus 51.4%; \( P < 0.01 \)), higher mean VOL_max (60.2 versus 52.8 mL/m²; \( P < 0.01 \)), and lower mean LAPEF (19.1% versus 26.0%; \( P < 0.01 \)). Patients in the lowest LAPEF quintile were at highest risk of developing recurrent AF (2-year recurrence for lowest versus highest: 60.5% versus 17.3%; \( P < 0.01 \)). After adjusting for known predictors of recurrence, patients with low LAPEF remained significantly more likely to recur (hazard ratio for lowest versus highest quintile, 3.92; 95% confidence interval, 2.01–7.65).

Conclusions—We found a strong association between LAPEF and recurrent AF after pulmonary vein isolation that persisted after multivariable adjustment. (Circ Cardiovasc Imaging. 2014;7:586-592.)

Key Words: atrial fibrillation  ■ catheter ablation  ■ magnetic resonance imaging
technique to quantify LAPEF. The purpose of our study was therefore to analyze the association of CMR-determined LAPEF with recurrent AF after PVI at a large tertiary referral center. We hypothesized that poor LAPEF would be independently associated with an increased rate of late recurrent AF after PVI.

Methods

Patients

For derivation of our study cohort, we initially included all patients who underwent CMR at Brigham and Women’s Hospital for definition of pulmonary vein anatomy before PVI from September 2005 through June 2011 (n=721). At our institution, CMR is the standard technique for imaging pulmonary veins before PVI in all patients without any absolute contraindications to CMR scanning (permanent pacemaker or defibrillator, severe claustrophobia, glomerular filtration rate <30 mL/min per 1.73 m²). We then further restricted our sample to patients in sinus rhythm at the time of CMR to separate LA passive function from active emptying function; 375 patients (52.0%) were in AF during CMR and were therefore excluded. The final study sample consisted of 346 patients. Patient demographics and comorbidities were ascertained by a physician at the time of CMR. Paroxysmal AF was defined as AF that terminated spontaneously <7 days after onset, whereas nonparoxysmal AF was defined as AF extending beyond 7 days. Research ethics committee of our institution approved the study for conducting patient follow-up.

CMR Protocol

CMR was performed with a 1.5- or 3.0-T CMR system (Signa CV/i HDxt platform, General Electric Healthcare, Waukesha, WI, and Tim Trio, Siemens, Erlangen, Germany, respectively). All images were ECG-gated and acquired with breath-holding, whenever possible, with the patient in a supine position. The CMR protocol consisted of standard techniques, including 2-dimensional (2D) cine steady-state free precession imaging in radial long axis and a stack of parallel short axis for cardiac function (temporal resolution, 45–55 ms; in-plane resolution, 2–3 mm), 3D magnetic resonance angiography during slow infusion of 0.2 mmol/kg of gadobenate dimeglumine (Multihance; Bracco Diagnostics, Inc) was used to determine pulmonary vein anatomy.

Late gadolinium enhancement imaging. Imaging for determination of pulmonary vein anatomy before PVI in all patients with the patient in a supine position. The CMR protocol consisted of standard techniques, including 2-dimensional (2D) cine steady-state free precession imaging in radial long axis and a stack of parallel short axis for cardiac function (temporal resolution, 45–55 ms; in-plane resolution, 2–3 mm), 3D magnetic resonance angiography during slow infusion of 0.2 mmol/kg of gadobenate dimeglumine (Multihance; Bracco Diagnostics, Inc) was used to determine pulmonary vein anatomy.

Left Atrium Analysis

We used a commercial software package (CMR42: Circle Cardiovascular Imaging, Canada) to analyze LA emptying function. LA volumes were measured at (1) the beginning of LV diastole (defined as the frame immediately before opening of the mitral leaflets, \(V_{OL_{min}}\)), (2) the end of passive LV filling (defined as the frame immediately before LA contraction, \(V_{OL_{max}}\)), and (3) the end of LA contraction (\(V_{OL_{max}}\)). The inferior LA border was defined as the plane of the mitral annulus based on prior convention. To calculate LA volumes, we measured atrial length (from the midpoint of the mitral annulus plane) and border (excluding atrial appendage and pulmonary veins) in the 2- and 4-chamber views (Figure 1). We then applied the biplane area–length method: \(LA_{volume} = (4-chamber \text{ area})(2-chamber \text{ area})x0.85/\text{atrial length}\). LAPEF was calculated as \((V_{OL_{max}}-V_{OL_{min}})/V_{OL_{max}}\times100\). We also calculated LA active emptying function \((V_{OL_{max}}-V_{OL_{bac}})/V_{OL_{max}}\times100\) and LA total emptying function \((V_{OL_{min}}-V_{OL_{bac}})/V_{OL_{max}}\), consistent with a previous methodology.

PVI Protocol

For patients with paroxysmal AF, PVI consisted of point-by-point radiofrequency ablation to encircle the left and right pulmonary veins or by the use of a cryoballoon catheter (Arctic Front, Medtronic Inc, Minneapolis, MN). In all cases, PVI was confirmed by recording within the veins using a circular multipolar catheter to confirm entrance block into the veins. For patients with persistent AF, additional linear LA ablations were performed in addition to PVI. Often, this consisted of linear ablations to create conduction block across the LA roof and along the region between the lateral mitral annulus and left inferior pulmonary vein. Areas of complex fractionated electrograms during AF were also targeted for ablation. If sinus rhythm could not be restored with ablation alone, administration of ibutilide or external cardioversion was performed to restore sinus rhythm.

Outcomes

The primary outcome of interest was late recurrence of AF. Patients were interviewed during regular clinic visits as a part of post-PVI care or via telephone using standard checklists and a follow-up questionnaire. Late recurrent AF (termed recurrent AF) was defined as

Figure 1. Measurement of left atrial function by cardiac magnetic resonance. Left atrial passive emptying function (LAPEF) was determined as the difference between volumes at maximum LA size (LA volume \([LAV]_{max}\)) and LA size before atrial contraction \([LAV]_{min}\). LAVs were determined according to the area–length method. LAAEF indicates LA active emptying function; and LATEF, LA total emptying function.

\[ LAV = \frac{8}{3\pi} (2C Area)(4C Area) \]

\[ \text{Length}^* \]

\[ \text{Area} \]

\[ * \text{Shorter length between 4C and 2C} \]
AF occurring >3 months after PVI and confirmed by either ECG or cardiac monitoring. Patients underwent electrocardiography at all clinical visits; otherwise routine outpatient cardiac monitoring was performed only in patients based on symptoms. Patients were followed postprocedure at 3- to 6-month intervals via clinic visits. The duration of follow-up was determined from the CMR study date (time zero) to the occurrence of an end point. If no end point occurred, patients were censored at the date of the last clinical follow-up.

Statistical Analysis
We described continuous variables as means (±SD) and categorical variables as percentages. Bivariate comparisons of patients with and without the primary outcome (late recurrent AF) were performed using the t test (continuous variables) and the χ² test (categorical variables).

To further examine the association of LAPEF with late recurrent AF, we stratified LAPEF into quintiles and examined their relationship with the outcome by constructing Kaplan–Meier curves showing survival free from late recurrent AF. We then performed an adjusted time-to-event analysis using Cox proportional hazards regression, including age, sex, and covariates that were found to predict recurrent AF in prior studies that included hypertension,5 LA volume (VOLmax) adjusted for body surface area (BSA),5,15 nonparoxysmal AF,15 diabetes mellitus,6 left ventricular systolic function,16 and >1 ablation procedure.3 We also prespecified that covariates would be included in the model if they had a P value of <0.15 on bivariate analyses. The group of patients in the highest (best) quintile of LAPEF served as the reference group. The proportional hazards assumption was tested in each multivariable model and was found to be valid.

Given the prior relationship described between LAPEF and left ventricular systolic function,12 we tested whether the association of LAPEF and late recurrent AF was dependent on left ventricular ejection fraction (LVEF) by adding an interaction term (LAPEF×LVEF) to our multivariable model. We then stratified subjects based on preserved (≥50%) versus reduced (<50%) EF and analyzed the association of LAPEF with late recurrent AF in these strata.

For purposes of clinical applicability, we then analyzed the rate of AF recurrence at 2 years and created a logistic regression model with the previously mentioned clinical characteristics (hypertension, BSA-adjusted VOLmax, nonparoxysmal AF, diabetes mellitus, left ventricular systolic function, ≥1 ablation procedure). We used this model to generate a receiver operating characteristic curve and C statistic to evaluate model discrimination for prediction of 2-year recurrence. We subsequently added LAPEF to the clinical model to assess whether

| Table 1. Characteristics of Patients With and Without Late Recurrent AF |
|---------------------------------|-----------------|-----------------|-----------------|
|                                 | Late Recurrent AF* | No (n=222) | P Value |
| Demographics                    |                  |                |             |
| Age, mean±SD                    | 56.2±11.3        | 55.9±10.6      | 0.79        |
| Male, n (%)                     | 96 (77.4)        | 164 (73.9)     | 0.46        |
| Medical history                 |                  |                |             |
| Hypertension, n (%)             | 71 (57.3)        | 109 (49.1)     | 0.15        |
| Diabetes mellitus, n (%)        | 24 (19.4)        | 39 (17.6)      | 0.68        |
| Hyperlipidemia, n (%)           | 50 (40.3)        | 82 (36.9)      | 0.53        |
| Coronary artery disease, n (%)  | 13 (10.5)        | 23 (10.4)      | 0.97        |
| Heart failure, n (%)            | 26 (21.0)        | 47 (21.2)      | 0.96        |
| Chronic kidney disease, n (%)† | 8 (6.5)          | 20 (9.0)       | 0.40        |
| Valvular heart disease, n (%)‡ | 9 (7.3)          | 21 (9.5)       | 0.49        |
| Prior AF ablation, n (%)        | 26 (21.0)        | 45 (20.3)      | 0.88        |
| Nonparoxysmal AF, n (%)         | 94 (75.8)        | 114 (51.4)     | <0.01       |
| β-blocker use, n (%)            | 77 (62.1)        | 148 (66.7)     | 0.39        |
| ACE inhibitor use, n (%)        | 51 (41.1)        | 76 (34.2)      | 0.20        |
| Statin use, n (%)               | 43 (34.7)        | 82 (36.9)      | 0.67        |
| Antiarrhythmic drug use, n (%)§ | 93 (75.0)        | 151 (68.0)     | 0.17        |
| Diagnostics                     |                  |                |             |
| Ejection fraction, mean±SD      | 57.9±9.3         | 58.2±9.9       | 0.81        |
| LA volume (BSA-adjusted), mean±SD║| 60.2±19.3        | 52.8±16.4      | <0.01       |
| LAPEF, mean±SD                  | 19.1±10.5%       | 26.0±11.4%     | <0.01       |
| LATEF, mean±SD                  | 37.3±15.8%       | 45.4±14.7%     | <0.01       |
| Body mass index, mean±SD        | 30.2±5.2         | 29.3±5.2       | 0.11        |
| Late gadolinium enhancement (any), n (%)  | 39 (17.6) | 16 (12.9) | 0.26        |

AF indicates atrial fibrillation; BSA, body surface area; LA, left atrial; LAPEF, LA passive emptying function; and LATEF, LA total emptying function.

*Recurrent AF >3 mo after ablation procedure.
†Chronic kidney disease=glomerular filtration rate (GFR) 30-59 ml/min per 1.72m²; patients with GFR <30 were excluded from scan.
‡Includes ≥moderate aortic stenosis, aortic regurgitation, mitral stenosis, or mitral regurgitation.
§Class I or class III antiarrhythmic drug, prescribed at hospital discharge.
║Volume in mL/m².
discrimination improved. In addition, we generated an receiver operating characteristic curve using the logistic model to evaluate the sensitivity and specificity of LAPEF alone, using LAPEF (continuous) as a predictor of late recurrent AF in the model. Based on this curve, we generated sensitivity and specificity values for 3 selected cutoffs (LAPEF <20%, LAPEF <25%, and LAPEF <30%).

A 2-sided P < 0.05 was considered statistically significant for all tests. Analyses were performed with the use of SAS software, version 9.2 (SAS Institute).

Results

Patient Characteristics

The mean age of the study population was 56 years, and 75.1% were men. The most common comorbidities were hypertension (52.0%), sleep apnea (27.5%), and heart failure (21.1%). Approximately 1 of 5 patients (20.5%) had undergone prior PVI. The mean LAPEF among the study sample was 23.5 ± 11.6%, and the mean BSA-adjusted LA volume was 55.5 ± 17.8 mL/m².

During a median follow-up period of 27 months, 124 patients (35.8%) experienced late recurrent AF (>3 months after ablation). The mortality rate during the follow-up period was 11.3% and did not differ significantly between patients with and without recurrent AF (12.9% versus 10.4%; P = 0.47).

Univariable Association of LAPEF With Late Recurrent AF

Characteristics of patients with and without late recurrent AF are shown in Table 1. On average, patients with AF recurrence were more likely to have a history of nonparoxysmal AF (75.8% versus 51.4%; P < 0.01) and larger BSA-adjusted LA volumes (mean VOLmax 60.2 versus 52.8 mL/m²; P < 0.01; Table 1). Mean LAPEF was lower in patients with recurrent AF than in patients without recurrent AF (19.1% versus 26.0%; P < 0.01). There were no significant differences in age, sex, or other comorbidities between the 2 groups.

As shown in Table 2, the number of late recurrent AF cases increased in lower quintiles of LAPEF during the entire study period. After 2 years of follow-up, the AF recurrence rate for patients in the lowest LAPEF quintile (worst function) was 60.5%, whereas for patients in the highest LAPEF quintile (best function) it was 17.3%. The relationship between LAPEF and recurrent AF by quintile is shown in Figure 2; the trend was roughly linear, with lower LAPEF associated with a significantly higher rate of late recurrent AF (P < 0.001 for linear trend across quintiles). Figure 3 shows the Kaplan–Meier curves for the 5 LAPEF quintiles (log-rank P < 0.0001).

Table 2. Description of Late Recurrent AF Stratified by LAPEF Quintile

<table>
<thead>
<tr>
<th>LAPEF Quintile</th>
<th>Mean LAPEF, %</th>
<th>No. of Recurrences Within Quintile</th>
<th>Recurrence Rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 (Best function)</td>
<td>40.4</td>
<td>12/69</td>
<td>17.4</td>
</tr>
<tr>
<td>4</td>
<td>29.7</td>
<td>20/69</td>
<td>29.0</td>
</tr>
<tr>
<td>3</td>
<td>23.4</td>
<td>21/70</td>
<td>30.0</td>
</tr>
<tr>
<td>2</td>
<td>16.0</td>
<td>29/69</td>
<td>42.0</td>
</tr>
<tr>
<td>1 (Worst function)</td>
<td>8.2</td>
<td>42/69</td>
<td>60.9</td>
</tr>
</tbody>
</table>

AF indicates atrial fibrillation; and LAPEF, LA passive emptying function.

Multivariable Association With Recurrent AF

Results of the adjusted model are shown in Table 3. After adjusting for age, sex, and known clinical characteristics associated with AF recurrence (history of hypertension, history of diabetes mellitus, BSA-adjusted VOLmax, nonparoxysmal AF, LVEF, history of prior LA ablation), LAPEF maintained a strong association with AF recurrence. Compared with patients in the highest LAPEF quintile (best function), patients in the lowest LAPEF quintile (worst function) were ≈4× more likely to experience recurrent AF (hazard ratio for lowest versus highest quintile, 3.92; 95% confidence interval, 2.01–7.65; P < 0.0001). The presence of late gadolinium enhancement in the left ventricular myocardium did not modify the robust association of LAPEF with AF recurrence in the multivariable model (hazard ratio for lowest versus highest quintile, 3.88; P < 0.0001).

We then evaluated whether the association of LAPEF with late recurrent AF was dependent on LVEF by including an interaction term (LAPEFxLVEF) in our multivariable model. We found that a significant interaction was present (Wald χ² = 12.84; P = 0.012), which suggested that the association of LAPEF on late recurrent AF varied depending on LVEF. We subsequently stratified patients into categories of preserved LVEF (≥50%) versus reduced (LVEF <50%) systolic function and ran adjusted multivariable models for the 2 categories. For patients with LVEF ≥50%, there was a strong association between LAPEF and late recurrent AF (unadjusted hazard ratio for lowest versus highest quintile, 7.93; 95% confidence interval, 3.54–17.76; P < 0.0001), whereas for patients with LVEF <50% the association was not significant (unadjusted hazard ratio for lowest versus highest quintile, 0.98; 95% confidence interval, 0.23–4.15; P = 0.976). Full results of these models are presented in Tables I and II in the Data Supplement.

Model Discrimination for Recurrent AF at 2 Years

For purposes of clinical applicability, we evaluated the incremental ability of LAPEF to predict late recurrent AF 2 years after PVI. The overall 2-year rate of late recurrent AF was 33.4%. Model discrimination was relatively weak for the clinical model alone (C statistic = 0.674). With the addition of
LAPEF, model discrimination improved significantly (C statistic=0.724; \(P<0.0001\) compared with clinical model alone). The receiver operating characteristic curves corresponding to these models are shown in Figure 4.

**Sensitivity and Specificity of LAPEF Cutoff Values**

We generated a receiver operating characteristic curve representing the model with the outcome of late recurrent AF with LAPEF (continuous) as the lone predictor (Figure 5). Sensitivity and specificity for 3 selected LAPEF cut points are displayed. With lower LAPEF, sensitivity for predicting recurrence decreased while specificity increased (LAPEF <20%: sensitivity=0.58, specificity=0.68; LAPEF <25%: sensitivity=0.70, specificity=0.54; LAPEF<30%: sensitivity=0.83, specificity=0.36). The C statistic for the logistic model with LAPEF alone was 0.676.

**Discussion**

We found a strong association between CMR-determined LAPEF and late recurrent AF in patients undergoing PVI. This association was robust even after adjusting for other factors previously shown to be associated with recurrence, indicating that LAPEF represents an important predictor of outcomes in these individuals.

It has been recognized that impaired LA function independently contributes to adverse cardiac outcomes, including new-onset heart failure, heart failure hospitalization, and AF after cardiac surgery. LA passive function occurs in early diastole and represents the conduit phase of LA function because blood is transferred from the pulmonary veins into the left ventricle. In patients with impaired left ventricular relaxation, filling pressures increase and LA passive function declines. It has been hypothesized that this leads to the sequelae of LA stretch and pulmonary vein dilatation, which places patients at increased risk for AF. LAPEF can be precisely measured by CMR, which allowed us to investigate the
dicting late recurrent AF decreased while specificity increased. With lower LAPEF values, sensitivity for pre-passive emptying function (LAPEF) alone. Sensitivity and specificity of late recurrent atrial fibrillation (AF) in model using left atrial volume (LA) and clinical model alone (C statistics=0.724 and 0.674 respectively, \( P<0.0001 \)).

We chose to focus our study on patients undergoing PVI for AF because late recurrence of AF is a common clinical problem with an incidence of 25% at 1 year and 40% at 5 years, even with repeated PVI procedures. Prior studies have demonstrated several predictors of late recurrent AF after ablation, including nonparoxysmal AF, LA volume, and hypertension, although the associations have been generally weak and not universally observed. Currently, there is no accepted way of individualizing risk stratification for recurrence, and patients are generally provided with an expected success rate of 60% to 80% after 1 or possibly 2 procedures.

Our cohort showed a marked difference in the rate of late recurrent AF between quintiles; patients in the lowest quintile of LAPEF (worst LA passive function) had a recurrence rate of 60.5% at 2 years; conversely, those in the highest quintile of LAPEF (best LA passive function) had a recurrence rate of 17.3% during the same time period. Our findings support a mechanistic link between elevated filling pressures (as reflected by LAPEF) and late recurrent AF. Given the cost and potential complications associated with PVI, we think that LAPEF may represent a physiological marker that can assist physicians and patients in having more individualized discussions about the potential benefits of the procedure. Although there is no universally accepted cutoff for rate of recurrence that would prohibit consideration for PVI, as multiple factors such as symptom burden and quality of life enter into the decision-making process, over half of patients with LAPEF <10% in our sample experienced late recurrent AF, and these individuals should be considered at high risk for recurrence. This is in stark contrast to patients with LAPEF >40%, where <1 in 5 experienced recurrence. Because CMR is routinely performed in many centers before PVI, the assessment of LAPEF can be done with little added cost.

Our findings must be interpreted in the context of our study design. Patients who were unable to undergo CMR before PVI were excluded, and certain comorbidities were therefore not available in our multivariable model (most notably, advanced renal insufficiency). As we were interested in the physiology of early (passive) diastolic filling, we also excluded patients who were in AF at the time of scan, because determination of LAPEF was not possible in these individuals. The use of LAPEF as a risk factor for late recurrent AF is therefore only applicable to patients in sinus rhythm at the time of CMR. In addition, because all patients did not undergo routine ambulatory ECG monitoring after PVI, some individuals may have experienced asymptomatic recurrent AF that was not counted in the primary outcome; this may have led to an underestimate of the risk of recurrence. However, our methods reflect the care of post-PVI patients (and determination of recurrence) in routine clinical practice during the study period. In addition, our results represent a single-institution experience, although our reported recurrence rate is similar to those published from other experienced centers. Finally, our study sample was predominantly men, although this reflects PVI practice patterns described elsewhere.

In conclusion, we found a strong association between CMR-determined LAPEF and recurrent AF after PVI that persisted after multivariable adjustment. We think that LAPEF may be used as a potential marker for risk stratification and to inform patients about the potential success rate of PVI in a more individualized manner.

Sources of Funding

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Loan Repayment award from the National Heart, Lung, and Blood Institute. Dr Neilan is supported by an American Heart Association Fellow to Faculty Grant (12FT12060588).

Disclosures

None.

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CLINICAL PERSPECTIVE

Although catheter-based pulmonary vein isolation can provide maintenance of sinus rhythm and relief of symptoms in patients with atrial fibrillation (AF), late recurrent postprocedural AF (>3 months) is a common clinical problem. It is currently difficult to predict which patients will experience late recurrent AF after pulmonary vein isolation. We sought to identify whether a physiological marker representing early left ventricular filling (left atrial passive emptying function [LAPEF]), determined by cardiac magnetic resonance, predicted late recurrent AF. Using a sample of 346 patients with AF undergoing pulmonary vein isolation at our institution with a median follow-up of 27 months, we found that LAPEF was strongly predictive of recurrence; patients in the lowest LAPEF quintile (worst function) were 4× as likely to recur compared with the highest LAPEF quintile, even after adjusting for other characteristics including left atrial volume. We think that LAPEF may be used to risk stratify patients undergoing pulmonary vein isolation for recurrence and therefore help clinicians and patients make more individualized choices.
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### Electronic Table 1. Hazard ratios for late recurrent AF, LVEF ≥50%

<table>
<thead>
<tr>
<th>LAPEF Quintile</th>
<th>Unadjusted model</th>
<th>Fully Adjusted model*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 (best function)</td>
<td>1.00 (Ref)</td>
<td>1.00 (Ref)</td>
</tr>
<tr>
<td>4</td>
<td>2.90 (1.22-6.90)</td>
<td>2.52 (1.05-6.04)</td>
</tr>
<tr>
<td>3</td>
<td>2.54 (1.05-6.18)</td>
<td>2.09 (0.85-5.16)</td>
</tr>
<tr>
<td>2</td>
<td>4.86 (2.11-11.20)</td>
<td>3.85 (1.65-9.00)</td>
</tr>
<tr>
<td>1 (worst function)</td>
<td>7.93 (3.54-17.76)</td>
<td>6.20 (2.71-14.20)</td>
</tr>
</tbody>
</table>

Wald Chi-square (unadjusted model) = 36.7
Wald Chi-square (fully adjusted model) = 54.8
*Fully adjusted model: includes age, sex, hypertension, BSA-adjusted left atrial volume, non-paroxysmal AF, diabetes, >1 prior ablation procedure

### Electronic Table 2. Hazard ratios for late recurrent AF, LVEF <50%

<table>
<thead>
<tr>
<th>LAPEF Quintile</th>
<th>Unadjusted model</th>
<th>Fully Adjusted model*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 (best function)</td>
<td>1.00 (Ref)</td>
<td>--</td>
</tr>
<tr>
<td>4</td>
<td>0.17 (0.02-1.42)</td>
<td>--</td>
</tr>
<tr>
<td>3</td>
<td>0.55 (0.16-1.89)</td>
<td>--</td>
</tr>
<tr>
<td>2</td>
<td>0.34 (0.08-1.45)</td>
<td>--</td>
</tr>
<tr>
<td>1 (worst function)</td>
<td>0.98 (0.23-4.15)</td>
<td>--</td>
</tr>
</tbody>
</table>

Wald Chi-square (unadjusted model) = 4.6
*Fully adjusted model was not performed given limited number of subjects (N=49) and outcome events (N=17)