CHADS\textsubscript{2} and CHA\textsubscript{2}DS\textsubscript{2}-VASc scores as predictors of left atrial ablation outcomes for paroxysmal atrial fibrillation

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Received 27 March 2013; accepted after revision 3 June 2013; online publish-ahead-of-print 28 June 2013

Aims
The selection of patients with atrial fibrillation (AF) that will benefit most by left atrial ablation remains suboptimal. CHADS\textsubscript{2} score has been shown to be associated with post-ablation AF recurrences. However, data regarding the CHA\textsubscript{2}DS\textsubscript{2}-VASc score are lacking. In addition, there is paucity of data regarding the exact predictive value, in terms of sensitivity and specificity, of each of these scores as to AF recurrence. This study aimed to evaluate the merit of the CHADS\textsubscript{2} and CHA\textsubscript{2}DS\textsubscript{2}-VASc scores in predicting arrhythmia recurrence after a single ablation procedure for paroxysmal AF.

Methods and results
One hundred and twenty-six patients (78 males, median age 61 years) with symptomatic paroxysmal AF underwent left atrial ablation. Over 16 months (interquartile range: 10.8–26.0), 89 patients were recurrence-free (70.6%). Larger left atrial volume (\(P = 0.039\)), diabetes (\(P = 0.001\)), dyslipidemia (\(P = 0.003\)), coronary artery disease (\(P = 0.003\)), class III antiarrhythmic drugs (\(P = 0.017\)), CHADS\textsubscript{2} (\(P = 0.006\)), and CHA\textsubscript{2}DS\textsubscript{2}-VASc (\(P = 0.016\)) scores were univariately associated with recurrence. In the multivariate analysis, both CHADS\textsubscript{2} (hazard ratio: 1.91, 95% confidence interval 1.09–3.36, \(P = 0.023\)) and CHA\textsubscript{2}DS\textsubscript{2}-VASc (hazard ratio: 1.97, 95% confidence interval 1.16–3.33, \(P = 0.012\)) were independently associated with AF recurrence. Cut-off analysis showed that a score \(\geq 2\) for both the CHADS\textsubscript{2} (sensitivity = 46% and specificity = 79%, area under the Receiver’s operating characteristic curve, AUC = 0.644) and CHA\textsubscript{2}DS\textsubscript{2}-VASc score (sensitivity = 57% and specificity = 65%, AUC = 0.627) showed the highest predictive value for AF recurrence.

Conclusions
CHA\textsubscript{2}DS\textsubscript{2}-VASc score is an independent predictor of left atrial ablation outcomes for paroxysmal AF, with a similar predictive value to CHADS\textsubscript{2}. However, the predictive accuracy of both is mediocre.

Keywords
Atrial fibrillation • Catheter ablation • CHADS\textsubscript{2} score • CHA\textsubscript{2}DS\textsubscript{2}-VASc score • Recurrence

Introduction
The identification of reliable predictors of atrial fibrillation (AF) recurrence following left atrial (LA) ablation may contribute to better patient selection and therefore, improvement of the overall success rate of the procedure. Several predictors of arrhythmia recurrence following LA ablation including LA size, LA fibrosis, non-paroxysmal AF, hypertension, and elevated levels of common inflammation markers have been proposed in previous studies.\textsuperscript{1–4} The majority of these studies included mixed populations of paroxysmal and persistent AF patients. Left atrial size appears to be the best pre-procedural predictor of AF recurrence following single ablation procedure in the patients with paroxysmal AF, even in patients with a relatively small LA.\textsuperscript{1}

A multiparametric score may be more accurate for prediction of arrhythmia recurrence following LA ablation. The CHADS\textsubscript{2} and the CHA\textsubscript{2}DS\textsubscript{2}-VASc scoring systems are validated risk stratification models used for prediction of ischemic strokes and vascular
What’s new?
- CHA2DS2-VASc score is independently associated with arrhythmia recurrence after a single LA ablation procedure for paroxysmal AF.
- CHA2DS2-VASc scores were predictors of adverse events including thromboembolic events or death after catheter ablation of AF.
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- However, there is paucity of data regarding the association of the CHA2DS2-VASc score to post-ablation recurrences, as compared with the predictive value of CHADS2. The objective of this study was to investigate whether CHADS2 and, especially, CHA2DS2-VASc are useful predictors of arrhythmia recurrence after a single LA ablation procedure for paroxysmal AF.

Methods

Patients
Consecutive patients with symptomatic, drug-refractory paroxysmal AF who underwent LA ablation were screened. Patients were classified as having paroxysmal AF according to the current guidelines. Exclusion criteria were left atrial volume (LAV) > 70 mL for women and > 80 mL for men, intracardiac thrombi documented by transesophageal echocardiography, systemic heart failure left ventricular ejection fraction (LVEF) < 45%, NYHA III-IV, previous ablation for AF, persistent AF, inadequate follow-up and/or inability to provide informed consent. Transthoracic and transesophageal echocardiograms were performed in all subjects. LVEF and LAV were recorded. The CHADS2 and CHA2DS2-VASc scores were calculated for each patient according to current guidelines. The institutional ethics committee approved of the study protocol, and written informed consent was obtained from all patients.

Catheter ablation procedure
Oral anticoagulation was stopped at least 3 days before the ablation procedure, and all subjects were anticoagulated with enoxaparin (1 mg/kg b.i.d.). Antiarrhythmic drug (AAD) treatment was suspended for the day of the ablation procedure and restarted the following day. The ablation procedure has been described in details elsewhere. Following a single transseptal puncture, the three-dimensional geometry of the left atrium was reconstructed using the CARTO 3 navigation system (Biosense Webster, Inc.). Wide circumferential lesions for isolation of large atrial areas around both ipsilateral pulmonary veins (PV antral isolation) were applied using a 3.5 mm tip ablation catheter (Thermo Cool Navi-Stop, Biosense Webster, Inc.). Circumferential ablation was performed on the posterior wall > 1 cm and on the anterior wall > 5 mm away from the defined PV ostia. The endpoint of ablation was the absence or dissociation of potentials in the isolated area as documented with the circular mapping catheter (Lasso, Biosense Webster, Inc.). When PV conduction was still present following wide circumferential lesions around both ipsilateral veins, both PVs were mapped sequentially by the circular mapping catheter to localize the earliest PV potentials. Based on the earliest PV potentials recorded by the circular mapping catheter, RF energy was reapplied to close the conduction gap. A waiting period of 30 min was allowed to confirm absence of re-conduction.

Postablation care and follow-up
After the procedure, warfarin was restarted. Warfarin was continued for at least 3 months. All subjects underwent ambulatory monitoring the first two postprocedural days. Recurrences during this blanking period were treated with AADs and/or cardioversion if needed. The patients were seen by the referring cardiologist for 24–48 h ambulatory monitoring at the first, third, sixth, and twelfth month after the index procedure. Patients were additionally advised to report any symptoms of arrhythmia between scheduled visits. A final re-evaluation of the symptoms and ambulatory recordings was performed 16 months [interquartile range (IQR); 10.8–26.0] following the index procedure. Documented symptomatic or asymptomatic AF episodes lasting more than 30 s or atrial tachycardias following a 3 month blanking period were considered as recurrence.

Statistical analysis
Continuous variables are presented as median values (IQR) and were compared using the Pearson’s χ² or Fisher’s exact test, if the produced 2 × 2 matrices contained cells with expected values < 5. Binary logistic regression analysis was used to test the independent association of CHADS2 and CHA2DS2-VASc scoring systems with LA ablation outcome. Receiver’s operating characteristic (ROC) curves were constructed to test the ability of CHADS2 and CHA2DS2-VASc scores to predict recurrence and identify optimal cut-off values. Comparisons of the areas under the ROC curves (AUCs) were performed using the Wilcoxon test. All analyses were performed with SPSS 17.0 software package (SPSS Inc.). Double-sided P values < 0.05 were considered as statistically significant.

Results
The final study population consisted of 126 patients (78 males, median age 61 years (IQR: 52–66)) with paroxysmal AF. The duration of history of AF episodes was 4 (IQR: 2–7) years. The frequency distribution of CHADS2 and CHA2DS2-VASc scores in the studied patients is illustrated in Figure 1. Median LVEF and LAV were 65% (IQR: 60–65) and 55 mL (IQR: 45–65), respectively. Hypertension, diabetes mellitus, dyslipidemia, and coronary artery disease were present in 44.4%, 11.9%, 39.7%, and 6.3% of patients, respectively. Of the 126 study patients, 49 (38.9%) patients were on an angiotensin converting enzyme inhibitor or angiotensin II receptor blocker and 41 (32.1%) patients were treated with a statin, while β-blockers were prescribed in 17 patients (13.5%).

During the 3 months blanking period, class I and class III AADs were prescribed in 19 (15.1%) and 48 (38.1%) of patients,
respectively. After the 3 months blanking period, AADs were continued in 22 patients (17.5%) who had an early recurrence (i.e. during the blanking period). Prescribed AADs after the blanking period were disopyramide in 1 patient, propafenone in 3 patients, sotalol in 10 patients, and amiodarone in 8 patients.

The median procedural and fluoroscopy time were 200 min (IQR: 200–220) and 16 min (IQR: 10–24), respectively. Procedural complications were uncommon. Groin haematomas were seen in three (2.4%) subjects. Transient cerebral ischemic attacks occurred in two patients (1.6%). Cardiac tamponade occurred in two patients (1.6%) and was effectively managed by pericardiocentesis without the need for surgical intervention.

Recurrence and CHADS2/CHA2DS2-VASc scores

After a median follow-up period of 16 months (IQR: 10.75–26), 89 patients were free from arrhythmia recurrence (70.6%). Atrial fibrillation recurrence rates progressively increased matching parallel increases in CHADS2 and CHA2DS2-VASc scores. For a CHADS2 score of 0, 1, and ≥2, the recurrence rates were 19.2%, 26.3%, and 47.2%, respectively (Figure 2). Cut-off point analysis showed that a CHADS2 score ≥2 displayed the highest predictive value for AF recurrence (sensitivity = 46% and specificity = 79%, AUC = 0.644) (Figure 3). The recurrence rate was significantly higher in patients with CHADS2 score ≥2 in relation to those with CHADS2 score <2 (47.2% vs. 22.2%, P = 0.005). Similarly, there was an ascending pattern of recurrence rate with higher CHA2DS2-VASc; for a CHA2DS2-VASc score of 0, 1, 2, and ≥3 the recurrence rates were 19.4%, 23.7%, 36.7%, and 45.5%, respectively (Figure 2). The optimal cut-off point for CHA2DS2-VASc score displaying the best predictive value was ≥2 (sensitivity = 57% and specificity = 65%, AUC = 0.627) (Figure 3). The recurrence rate was significantly higher in patients with CHA2DS2-VASc score ≥2 compared with those with <2 (40.4% vs. 21.6%, P = 0.023). In view of the ROC curves based on the CHADS2 and CHA2DS2-VASc scores in predicting events, the differences between the areas under the curves did not reach statistical significance (P > 0.05). Interestingly, patients with CHADS2 (55 vs. 65 mL, P = 0.001) and CHA2DS2-VASc (55 vs. 60 mL, P = 0.023) scores ≥2 displayed significantly higher LAV.

Univariate and multivariate recurrence correlates

The clinical, echocardiographic, and procedural data of study groups are depicted in Table 1. Patients with AF recurrence displayed an increased LAV (60 vs. 55 mL, P = 0.039). Moreover, diabetes mellitus (P = 0.001), dyslipidemia (P = 0.003), coronary artery disease (P = 0.003), class III AADs (P = 0.017), statin use (P < 0.001), and higher CHADS2 (P = 0.006) and CHA2DS2-VASc (P = 0.016) scores were univariate
predictors of arrhythmia recurrence (statin use was strongly correlated, as expected, with dyslipidemia, coronary disease, and diabetes; all these factors were associated to recurrence and, as a result, there was a secondary correlation of statins to AF recurrence, which became statistically non-significant after adjustment for the presence of diabetes, dyslipidemia, and coronary artery disease, $P = 0.128$).

The multivariate analysis showed that the CHADS2 score was independently associated with AF recurrence after adjustment for age, gender, LAV, and use of AADs ($P = 0.023$). The multivariate hazard ratio for each additional CHADS2 score point was $1.91$ (95% confidence interval 1.09–3.36). TheCHA2DS2-VASc score was also an independent predictor of AF recurrence after adjustment for the same potential confounders (hazard ratio: 1.97, 95% confidence interval 1.16–3.33, $P = 0.012$).

Discussion

The main findings of this study include the following: (i) CHADS2 and CHA2DS2-VASc scoring systems are independent predictors of AF recurrence following a single-catheter ablation procedure; (ii) CHA2DS2-VASc is equally predictive of recurrences to CHADS2, without any demonstrable advantage in that respect; (iii) for both scores, a cut-off point $\geq 2$ displayed the highest predictive value for AF recurrence; (iv) the predictive value of any of the two scores is modest.

### Table 1 Clinical, echocardiographic, and procedural data between patients with and without atrial fibrillation recurrence following left atrial ablation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Free from AF recurrence ($n = 89$)</th>
<th>AF recurrence ($n = 37$)</th>
<th>$P$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>59 (52–64)</td>
<td>63 (52–67)</td>
<td>0.144</td>
</tr>
<tr>
<td>Gender (males) (%);</td>
<td>55 (61.8)</td>
<td>23 (62.3)</td>
<td>0.969</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>27.1 (25.4–29.3)</td>
<td>27.7 (25.3–29.6)</td>
<td>0.624</td>
</tr>
<tr>
<td>Hypertension (%)</td>
<td>35 (39.3)</td>
<td>21 (56.8)</td>
<td>0.073</td>
</tr>
<tr>
<td>Diabetes mellitus (%)</td>
<td>5 (5.6)</td>
<td>10 (27)</td>
<td>0.001</td>
</tr>
<tr>
<td>Dyslipidemia (%)</td>
<td>28 (31.5)</td>
<td>22 (59.5)</td>
<td>0.003</td>
</tr>
<tr>
<td>Coronary artery disease (%)</td>
<td>2 (2.2)</td>
<td>6 (16.2)</td>
<td>0.003</td>
</tr>
<tr>
<td>Duration of history of AF episodes (years)</td>
<td>4 (2–7)</td>
<td>4 (2–5)</td>
<td>0.497</td>
</tr>
<tr>
<td>ACEI/ARBs after AF ablation (%)</td>
<td>31 (34.8)</td>
<td>18 (48.6)</td>
<td>0.147</td>
</tr>
<tr>
<td>Statins after AF ablation (%)</td>
<td>19 (21.3)</td>
<td>22 (59.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>$\beta$-blockers after AF ablation (%)</td>
<td>4 (10.8)</td>
<td>13 (14.8)</td>
<td>0.555</td>
</tr>
<tr>
<td>LAV (mL)</td>
<td>28 (35.1)</td>
<td>20 (54.1)</td>
<td>0.017</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>55 (45–65)</td>
<td>60 (48–75)</td>
<td>0.039</td>
</tr>
<tr>
<td>Procedure time (min)</td>
<td>60 (60–65)</td>
<td>60 (60–65)</td>
<td>0.070</td>
</tr>
<tr>
<td>Fluoroscopy time (min)</td>
<td>200 (200–220)</td>
<td>200 (200–220)</td>
<td>0.724</td>
</tr>
<tr>
<td>CHADS2 score</td>
<td>1 (0–1)</td>
<td>1 (0–2)</td>
<td>0.006</td>
</tr>
<tr>
<td>CHA2DS2-VASc score</td>
<td>1 (0–2)</td>
<td>1 (0–2)</td>
<td>0.016</td>
</tr>
</tbody>
</table>

Age, gender, left atrial volume, and use of AADs, along with the two scores (CHADS2 and CHA2DS2-VASc) were entered in the multivariate analysis (see text). AF, atrial fibrillation; AADs, antiarrhythmic drugs; ACEI, angiotensin converting enzyme inhibitor; ARB, angiotensin II receptor blocker; LAV, left atrial volume; LVEF, left ventricular ejection fraction.
suggesting that none of them could be used as a stand-alone risk stratification score for post-ablation AF recurrences. The findings regarding CHA2DS2-VASc score are novel and complement the already known association of CHADS2 to post-ablation AF recurrences.

The CHADS2 score is widely used for prediction of ischemic strokes and vascular events in patients with AF.6,7 The new multiparametric CHA2DS2-VASc score has been reported to display better discriminative power than CHADS2 for predicting thromboembolic risk in subjects with non-valvular AF.6,7 In previous studies, the components of the CHADS2 scoring system, including heart failure, hypertension, advanced age, and diabetes mellitus, have been associated with a poor outcome after catheter ablation of AF.1–3 This study demonstrated that CHADS2 and CHA2DS2-VASc scores, which combine these clinical parameters, are reliable predictive tools for AF recurrence following LA ablation. However, although the CHA2DS2-VASc score has better discriminative power for thromboembolic risk prediction, especially for low-risk (according to the CHADS2 score) patients, it does not appear in this study to perform better that the latter in predicting AF recurrences.

As anticipated, AF recurrence rates increased in parallel with increases in CHADS2 and CHA2DS2-VASc scores. Patients with low CHADS2 and CHA2DS2-VASc scores (0–1) displayed very high success rates (78.8% and 79.4%, respectively). Chao et al.7 have reported that the CHADS2 scoring system is a predictor of LA ablation outcomes for paroxysmal AF. The same group of investigators have shown that different patterns of recurrences occur in patients with different CHADS2 scores.11 We additionally showed that CHA2DS2-VASc displays similar accuracy to the classic CHADS2 score. However, demonstration of an association between a given parameter and a clinical outcome does not necessarily mean that the said parameter is of clinical value. It should also be shown that the studied parameter possess adequate predictive and discriminative power. In that respect, another novel piece of information offered by this study is the fact that the predictive value of both CHADS2 and CHA2DS2-VASc is moderate at best. With an AUC of around 0.64 and 0.627, respectively, in the ROC analysis for the two scores, it is obvious that they cannot be utilized as stand-alone prognosticators in this context. However, the fact that their predictive value remained significant after adjustment for such powerful predictors of recurrence as LA size indicates that they do possess independent predictive value and that they should probably be taken into account alongside other known correlates of recurrence.

As to how CHADS2 and CHA2DS2-VASc can be associated to post-ablation AF recurrences, there are several plausible explanations. We observed that patients with high CHADS2 and CHA2DS2-VASc scores had significantly larger LA which is indicative of LA structural remodelling. High CHADS2 and CHA2DS2-VASc scores have been associated with advanced LA remodelling, including structural (enlarged LA size) and electrophysiological (low LA voltage and prolonged activation time) changes, which have been associated with recurrence following AF ablation.7,12 In addition, the CHADS2 score has been recently associated with LA fibrosis and inflammation.13,14

Atrial fibrillation patients with higher risk factor profiles for stroke (CHADS2 ≥2) had a significantly larger amount of LA fibrosis when compared with those patients who had either a moderate or low risk profile.13 Using delayed enhancement magnetic resonance imaging to stratify AF patients based on pre-ablation fibrosis, Daccarett et al.15 have demonstrated a higher recurrence rate in patients with mild (28%), moderate (35%), and extensive (56%) LA fibrosis. No recurrences were noted in patients with minimal fibrosis. Furthermore, an activated inflammatory status has been significantly associated with AF recurrence following LA ablation,16 and it has been shown that effective anti-inflammatory treatment can reduce the recurrence rate, at least in the short term.16 Given that several of the constituents of the two scores, including diabetes,16 vascular disease,17 heart failure,18 and hypertension,19 as well as CHADS2, as a whole, have been shown to be strongly associated with pro-inflammatory activation, inflammation may be an additional middle step between the CHADS2/CHA2DS2-VASc score and AF recurrence.

**Study limitations**

Asymptomatic episodes of AF may not have been recognized because AF recurrence was based on clinical symptoms and ambulatory monitoring for a short period. Although this approach has been adopted in many clinical studies, it is possible that the success rate has been overestimated due to asymptomatic episodes of paroxysmal AF. Another potential limitation is that a small number of patients with high CHADS2 and CHA2DS2-VASc scores were included in this study, and therefore our findings need validation in a larger cohort. In addition, the relatively small number of patients belonging to certain patient subsets (e.g. patients with coronary artery disease) did not allow for an adequate fitting of the multivariate regression model for these factors.

**Conclusions**

CHA2DS2-VASc score is independently associated with post-ablation AF recurrences at a statistical level similar to the CHADS2 score, without any observable advantage to the latter. Our results demonstrate a moderate predictive value of both these scores, suggesting that, rather than stand-alone predictors of recurrence, they can be used as complementary tools in the evaluation of the likelihood of future recurrences after an ablation procedure.

**Conflict of interest:** none declared.

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CHADS2 and CHA2DS2-VASc scores and left atrial ablation

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EP CASE EXPRESS

Ventricular tachycardia ablation in a patient with a parachute device: a decent word of warning

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A male patient with a history of an anterior wall myocardial infarction (2001) and a large aneurysm received an implantable cardioverter defibrillator in 2003 for recurrent ventricular tachycardia (VT) and a parachute device in 2011 for a deteriorated left ventricular function. Thereafter, he developed clusters of monomorphic VTs. A VT ablation with a primarily epicardial approach was performed. The substrate could well be depicted. Panel A shows the epicardial map. The exit site of the VT was apically inferior. During VT no diastolic potentials could be found epicardially. Therefore, an endocardial map was performed (Panel B). Here, diastolic potentials could be found during VT with perfect entrainment at the septal border of the parachute. However, the VT could only be slowed down and never be terminated despite extensive ablation. On amiodarone, the patient has had no spontaneous VTs for 6 months, probably because of extensive substrate modification.

The diastolic pathway of the VT was probably endocardially behind the parachute. So the target area of successful ablation was covered by the device. Patients with spontaneous or inducible VT, who are planned for a parachute device, should be evaluated for VT ablation before device implantation because the diastolic pathways may not be reached epi- or endocardially.

The full-length version of this report can be viewed at: http://www.escardio.org/communities/EHRA/publications/ep-case-reports/Documents/Ventricular-tachycardia.pdf.