Predictive Value of Thromboembolic Risk Scores Before an Atrial Fibrillation Ablation Procedure

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Risk Scores for Atrial Fibrillation Ablation. ***Introduction:*** **It is not clear whether transesophageal echocardiography (TEE) should be performed prior to a planned atrial fibrillation (AF) ablation in all patients.**

Methods and Results: **The objectives of this study were to determine in 681 consecutive patients: (i) the relationship between the CHADS2 and CHA2DS2-VASc scores, the presence of a thrombogenic milieu and left atrial (LA) volume; (ii) the need for TEE in patients with low and intermediate thromboembolic risk assessed; and (iii) the predictive accuracy of the these 2 scores for the presence of thrombi in the LA/LAA (LA appendage) before a planned AF ablation. The prevalence of thrombi was 1%. All patients with thrombi had LA dilatation, a CHADS2 score ≥1 and a CHA2DS2-VASc score ≥2. CHADS2 or CHA2DS2-VASc scores <2 had an almost maximal negative predictive capability of excluding the presence of a thrombus (99.8% and 100%, respectively; 95% CI: 99–100). A CHADS2 score ≥2 had a sensitivity and specificity of 86% (95% CI: 42–100) and 82% (95% CI: 79–85), respectively, to predict the presence of a thrombus in the LA/LAA, while a CHA2DS2-VASc score ≥2 had a sensitivity and specificity of 100% (95% CI: 59–100) and 67% (95% CI: 63–70). The area under the curve for CHADS2 and CHA2DS2-VASc scores ≥2 was 0.928 (95% CI: 0.906–0.946) and 0.933 (95% CI: 0.912–0.951), respectively.**

Conclusion: **Not all patients undergoing planned endocardial pulmonary vein isolation need preprocedural TEE. Both scores <2 had an almost maximal negative predictive capability of excluding the presence of a thrombus in the LA/LAA.** *(J Cardiovasc Electrophysiol, Vol. 24, pp. 139-145, February 2013)*

anticoagulation, atrial fibrillation, catheter ablation, CHADS, CHADS$_2$-VASc, thromboembolic risk, transoesophageal echocardiography

Introduction

Catheter ablation is now an accepted procedure for the treatment of atrial fibrillation (AF). The presence of thrombi in the left atrium (LA) and/or left atrial appendage (LAA) is an established contraindication to catheter ablation of AF. According to the Heart Rhythm Society, European Heart Rhythm Association, and European Cardiac Arrhythmia Society Expert Consensus Statement performing preprocedural transoesophageal echocardiography (TEE) to screen for the presence of thrombi in all patients before AF ablation remains controversial.[1,2] Anticoagulation guidelines recommend adhering to AF cardioversion guidelines when dealing with patients in AF at the time of ablation.[3,4] According to these recommendations, a TEE should be performed before the ablation procedure in all patients in AF for more than 48 hours or for an unknown duration, if adequate systemic anticoagulation has not been maintained for at least 3 weeks prior to the ablation procedure.[3,4]

The most commonly used schemes for stratifying the risk of stroke and thromboembolism are the CHADS2 score (congestive heart failure [CHF] or left ventricular ejection fraction [LVEF] $\leq$ 40%, hypertension, age $\geq$ 75 years, diabetes mellitus, previous stroke and/or transient ischemic attack [TIA] [doubled risk weight]) and the CHA2DS2-VASc score (which includes the following additional clinical risk factors: history of vascular disease, age between 65 and 74 years, and gender; compared to the CHADS2, age $\geq$ 75 years and previous stroke carry a double risk weight).[3,4] However, no thromboembolic risk score has been validated in patients with AF undergoing TEE before pulmonary vein isolation (PVI).

The objectives of this study were (i) to determine the relationship between these scores, the presence of thrombi in the LA/LAA, the presence of a thrombogenic milieu defined as spontaneous echo contrast (SEC) accompanied by low LAA peak emptying flow velocity, and LA volume; (ii) to determine the need for TEE before PVI in patients with low and intermediate thromboembolic risk assessed by these 2 risk scores; and (iii) to determine the predictive accuracy of the 2 scores for the presence of thrombi in the LA and/or LAA before a planned PVI.

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Methods

Patients

A total of 681 consecutive patients who underwent a systematic examination by TEE between January 2001 and December 2010 within 24 hours before a planned PVI for nonvalvular AF were included in the study. The Hospital Ethics Committee approved the protocol. Informed consent was obtained from each patient before the TEE was performed. The study complies with the Declaration of Helsinki. A retrospective review of medical records was independently performed by 2 study investigators blinded to previous echocardiographic findings and risk scores (M.F. and B.M.). The investigators verified the accuracy of the reported findings in all patients. Only the initial TEE findings were used for analysis when a patient underwent more than one TEE during the study period. Two-dimensional transthoracic echocardiography was also performed to determine the LVEF and LA volume. LA dilatation was defined as an LA volume index greater than 28 mL/m^2 (assessed with the ellipsoid formula). The clinical data were reviewed until up to 3 months before the planned AF ablation procedure. CHADS2 and CHA2DS2-VASc scores ranging from 0 to 6 and 0 to 9, respectively, were calculated at the time of the TEE.[3,4] Data from all patients were available for CHADS2 and CHA2DS2-VASc score calculation from the database. Low and intermediate thromboembolic risks were defined as a CHADS2 and CHA2DS2-VASc score of 0 and 1, respectively.[3,4] The type of AF was defined according to the guidelines from the European Society of Cardiology.[4] The classification of AF was reviewed, and in patients with AF episodes that fell into more than one category, the most frequent pattern of AF was used. All patients, regardless of the type of AF and thromboembolic risk score profile assessed by CHADS2, were kept under anticoagulation therapy with a therapeutic international normalized ratio (INR) between 2 and 3 for at least 1 month before the planned PVI. The general practitioner checked INR values every week for at least 1 month before the procedure. The INR values were then verified for all patients with thrombi in the LA/LAA. A great effort was made to ensure the accuracy of the scores and INR values by contacting the patients and/or their general practitioners. Antithrombotic therapy was discontinued 3 days before admission, and therapeutic doses of low-molecular weight heparin (LMWH) were administered instead. The endocardial PVI was performed according to the accepted standard methods and established guidelines.[1,2,5]

Transesophageal Echocardiography

TEE was performed in all patients within 24 hours before the planned AF ablation procedure using commercially available equipment with a multiplane phase array transducer. Standard esophageal intubation and TEE acquisition were performed according to established guidelines.[6-8] Thrombus was defined as a circumscribed and uniformly echodense intracavitary mass distinct from the underlying LA/LAA endocardium and the pectinate muscles, and present in more than one imaging plane.[8] SEC was defined as a dynamic "smoke-like" echo with the characteristic swirling motion using the optimal gain setting during the cardiac cycle, [9] and assessed visually as mild, moderate or severe. Sludge (moderate or severe SEC) was defined as a dynamic gelatinous, precipitous echodensity, without a discrete mass, present throughout the cardiac cycle. An LAA peak emptying velocity $\leq$ 20 cm/s was considered low. The decision of whether the PVI procedure should be cancelled after detection of sludge by TEE was made for each patient by the electrophysiologist. However, the ablation procedure was cancelled in all patients with a thrombus in the LA/LAA.

Statistical Analysis

Categorical data were presented as frequencies and percentages, and continuous variables are expressed as mean $\pm$ standard deviation. Categorical, ordinal, and numerical variables were compared between groups using the χ^2, Cochran and Wilcoxon rank sum tests, respectively. Spearman's rank coefficient was used to assess the significance of correlations between variables. The predictive performance of the 2 scores was assessed using sensitivity, specificity, and predictive values, and exact 95% confidence intervals (CI) derived from an F-distribution, and by graphing ROC curves. All statistical tests were 2-tailed and performed with SPSS 15.0 (SPSS Inc., Chicago, IL, USA) or MedCalc (Mariakerke, Belgium). Statistical significance was set at a P-value $<$0.05.

Results

All patients (n = 681) had nonvalvular AF and most had paroxysmal AF (69%). The mean age of the patients was 57 $\pm$ 11 years, 78% were men, and the mean body mass index (BMI) was 28 $\pm$ 3 kg/m^2.

LA Thrombi

The clinical and echocardiographic parameters of patients with and without thrombus in the LA/LAA are presented in Table 1.

The prevalence of thrombi in the LA/LAA before the AF ablation was 1% (7 patients). All thrombi were found in the LAA. All patients with a thrombus except one were efficiently protected by anticoagulation therapy for at least 1 month before the procedure, according to the INR values. The patient that was not efficiently protected was the only one with paroxysmal AF. He had a CHADS2 score of 3, a CHA2DS2-VASc score of 4, and his last INR value was 1.6 before switching to LMWH. All other patients had persistent AF. Consequently, the prevalence of LAA thrombi among patients with persistent AF was significantly higher than among patients with paroxysmal AF (3% vs 0.2%) (Table 2).

In 2 out of 7 patients, the LAA thrombi were well organized and laminated. In the other 5 patients, the LAA thrombi were less well organized. None of the patients with thrombi had a history of TIA and/or stroke. Six out of 7 (86%) had CHF. The mean CHADS2 and CHA2DS2-VASc scores were significantly greater in patients with a thrombus than in patients without thrombus Table 1. All patients with a thrombus had a CHADS2 score of at least 1, and a CHA2DS2-VASc score of at least 2. The percentage of LAA thrombi in high-risk patients (CHADS2 and CHA2DS2-VASc $\geq$2) was significantly greater than in intermediate or low-risk patients (4.9% and 3.1% vs 0.2% and 0%, respectively, P $<$ 0.001). LAA thrombi were significantly associated with persistent AF (P = 0.002), CHF (P $<$ 0.001), diabetes mellitus (P = 0.017), SEC (P $<$ 0.001), and low LAA peak emptying

TABLE 1

Clinical and Echocardiographic Parameters of Patients with or without Thrombus in the LA/LAA

Clinical and Echocardiographic Parameters	Patients With Thrombus (n = 7)	Patients Without Thrombus (n = 674)	P-Value
Clinical parameters			
Mean age (years)	63 ± 7	56 ± 11	NS
Men	5 (71%)	529 (78%)	NS
Mean BMI (kg/m^2)	31 ± 5	28 ± 5	NS
Persistent AF	6 (86%)	203 (30%)	0.002
Coronary heart disease	0 (0%)	70 (10%)	NS
Hypertension	4 (57%)	261 (39%)	NS
Heart failure	6 (86%)	56 (8%)	<0.001
Diabetes mellitus	2 (29%)	42 (6%)	0.017
Previous TIA/stroke	0 (0%)	5 (1%)	NS
Mean $CHADS_2$	3.1 ± 1.2	0.8 ± 0.9	<0.001
Mean CHA_2DS_2-VASc	3.9 ± 1.1	1.2 ± 1.2	<0.001
Echocardiographic parameters			
SEC (%) absent mild moderate or severe (sludge)	1 (14%) 3 (43%) 3 (43%)	642 (95%) 27 (4%) 5 (1%)	<0.001
Low LAA emptying velocity (cm/s)	6 (86%)	19 (3%)	<0.001
Mean LA volume index (mL/m^2)	31 ± 5	37 ± 8	NS
Mean LVEF (%) LVEF ≤ 40%	39 ± 13 2 (28%)	45 ± 9 27 (4%)	NS

AF = atrial fibrillation; BMI = body mass index; LAA = left atrial appendage; LA = left atrium; LVEF = left ventricular ejection fraction; SEC = spontaneous echo contrast; TIA = transient ischemic attack; NS = nonsignificant.

TABLE 2

Clinical and Echocardiographic Parameters of Patients Depending on the Type of Atrial Fibrillation

Clinical and Echocardiographic Parameters	Paroxysmal AF (n = 472 or 69%)	Persistent AF (n = 209 or 31%)	P-Value
Clinical parameters			
Mean age (years)	56 ± 11	58 ± 10	0.033
Men	357 (76%)	176 (85%)	0.004
Mean BMI (kg/m^2)	28 ± 5	29 ± 5	<0.001
Coronary heart disease	47 (10%)	23 (11%)	NS
Hypertension	169 (36%)	93 (45%)	0.022
Heart failure	21 (4%)	39 (19%)	<0.001
Diabetes mellitus	25 (5%)	19 (9%)	0.044
Previous TIA/stroke	1 (0.2%)	4 (2%)	NS
Mean $CHADS_2$	0.7 ± 0.9	1.0 ± 1.1	<0.001
Mean CHA_2DS_2-VASc	1.2 ± 1.2	1.4 ± 1.3	0.009
Echocardiographic parameters			
SEC (%)			
Absent	462 (98%)	179 (87%)	
Mild	10 (2%)	20 (10%)	<0.001
Moderate or severe (sludge)	0 (0%)	8 (3%)	
Low LAA emptying velocity (cm/s)	9 (2%)	16 (8%)	<0.001
Presence of thrombus	1 (0.2%)	6 (3%)	0.001
Mean LA volume index (mL/m^2)	34 ± 6	40 ± 9	<0.001
Mean LVEF (%)	46 ± 8	43 ± 10	NS
LVEF ≤ 40%	8 (1.7%)	21 (10%)	NS

AF = atrial fibrillation; BMI = body mass index; LAA = left atrial appendage; LA = left atrium; LVEF = left ventricular ejection fraction; SEC = spontaneous echo contrast; TIA = transient ischemic attack; NS = nonsignificant.

velocity ($P < 0.001$). LA volume index was not significantly different between patients with and without thrombi. In patients with LAA thrombi, the CHADS2 and CHA2DS2-VASc scores poorly but significantly correlated with BMI ($r = 0.187$, $P < 0.001$ and $r = 0.108$, $P = 0.007$, respectively) and LVEF ($r = –0.494$, $P < 0.001$ and $r = –0.384$, $P < 0.001$, respectively). Two of the patients experienced a TIA than 48 hours after the ablation. Relevant clinical data from these 2 patients are reported as follows (patient 1 and 2, respectively): 52 and 47 years; women and men; persistent and paroxysmal AF; CHADS2 score of 2 and 1; CHA2DS2-VASc score of 3 and 1. TIA was confirmed by MRI for the first patient only; indeed, for the second patient, the MRI results were negative. It is probable that the postprocedural TIAs were due to insufficient anticoagulation during the procedure, considering that none of these 2 patients a SEC or previous LA/LAA thrombus. No complication was observed in the whole group of patients during the TEE, apart from minor subjective discomfort associated with the procedure.

Thrombogenic Milieu

SEC was found in 38 patients (5.6%): mild SEC in 30 (4.4%) and moderate or severe SEC in 8 (1.2%). The prevalence of moderate/severe SEC was 2.4% for a CHADS2 score of 0, 4.2% for a score of 1, 3.8% for a score of 2, 76.9% for a score of ≥3 ($P < 0.001$). The prevalence of moderate/severe

TABLE 3

Distribution of Patients With and Without Thrombus in the LAA Depending on the Type of Atrial Fibrillation and Thromboembolic Risk ($CHADS_2$ and CHA_2DS_2-VASc Scores ≥ 2 Correspond to Patients at High Thromboembolic Risk; $CHADS_2$ and CHA_2DS_2-VASc Scores < 2 Correspond to Patients at Low or Intermediate Thromboembolic Risk)

	Paroxysmal AF		Persistent AF		Total	
	Without Thrombus	With Thrombus	Without Thrombus	With Thrombus	Without Thrombus	With Thrombus
$CHADS_2$ score						
0–1	400 (84.9%)	0	152 (74.9%)	1 (16.7%)	552 (81.9%)	1 (14.3%)
≥2	71 (15.1%)	1 (100%)	51 (25.1%)	5 (83.3%)	122 (18.1%)	6 (85.7%)
Overall	471 (100%)	1 (100%)	203 (100%)	6 (100%)	674 (100%)	7 (100%)
CHA_2DS_2-VASc score						
0–1	329 (69.9%)	0	122 (60.1%)	0	451 (66.9%)	0
≥2	142 (30.1%)	1 (100%)	81 (39.9%)	6 (100%)	223 (33.1%)	7 (100%)
Overall	471 (100%)	1 (100%)	203 (100%)	6 (100%)	674 (100%)	7 (100%)

AF = atrial fibrillation.

SEC was 0.9% for a CHA2DS2-VASc score of 0, 3.7% for a score of 1, 7.1% for a score of 2, 35.6% for a score of ≥3 ($P < 0.001$). In patients with a high-risk score (CHADS2 and CHA2DS2-VASc ≥2), the presence of sludge was significantly greater than in those with a low-risk score (CHADS2 and CHA2DS2-VASc < 2): 8.6% versus 3.1%, $P = 0.005$ and 7.8% versus 2.2%, $P < 0.001$, respectively. Overall, the combined prevalence of LA/LAA thrombus/sludge was 2.2%. The ablation procedure was cancelled in both patients with a thrombus in the LAA (n = 7) and patients with moderate or severe SEC (n = 8). Only 2% of patients with paroxysmal AF had SEC. No patient with paroxysmal AF had LAA sludge (0% vs 3.4% of patients with persistent AF, $P < 0.001$). All patients with persistent AF and a thrombus had a low LAA emptying velocity.

Risk Scores

A total of 552 patients (81.9%) had a CHADS2 score <2 and 451 (66.9%) had a CHA2DS2-VASc score <2, corresponding to a low or intermediate thromboembolic risk Table 3.

When both scores were lower than 2, a maximal negative predictive value was almost reached for the presence of LA/LAA thrombi: 99.8% for CHADS2 and 100% for CHA2DS2-VASc (95% CI: 99–100). Similarly, the positive predictive values for CHADS2 and CHA2DS2-VASc scores <2 were 5% (95% CI: 2–10) and 3% (95% CI: 1–6), respectively. A CHADS2 score ≥2 had a sensitivity and specificity of 86% (95% CI: 42–100) and 82% (95% CI: 79–85), respectively, to predict the presence of a thrombus in the LA/LAA. A CHA2DS2-VASc score ≥2 had a sensitivity and specificity of 100% (95% CI: 59–100) and 67% (95% CI: 63–70), respectively, to predict the presence of a thrombus in the LA/LAA. The area under the curve for CHADS2 and CHA2DS2-VASc scores ≥2 was 0.928 (95% CI: 0.906–0.946) and 0.933 (95% CI: 0.912–0.951), respectively (Fig. 1).

Patients with a thrombus in the LAA, compared to those without thrombus, had mean CHADS2 and CHA2DS2-VASc scores of 3.1 and 0.8, and of 3.9 and 1.2, respectively ($P < 0.001$). Patients with a low LAA emptying velocity, compared to those with an LAA emptying velocity >20 cm/s, had greater mean CHADS2 (1.6 and 0.8; $P = 0.001$) and CHA2DS2-VASc (2.3 and 1.2; $P < 0.001$) value. LA volume did not significantly correlates with CHADS2 ($r = 0.013$, $P = 0.85$) and CHA2DS2-VASc scores ($r = 0.034$, $P = 0.624$) in these patients.

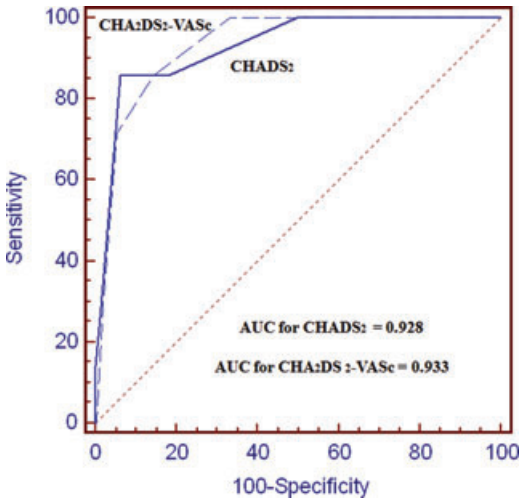

Figure 1. *ROC curves for CHADS2 (thick line) and CHA2DS2-VASc (thin line) scores ≥ 2 representing the sensibility and specificity of the 2 scores for the detection of a thrombus in the left atrium by transesophageal echocardiography.*

Type of Atrial Fibrillation

The clinical and echocardiographic parameters of patients with paroxysmal versus persistent AF are presented in Table 2. Among the echocardiographic parameters, SEC, low LAA emptying velocity, and LA dilatation were more predominant in persistent AF than paroxysmal AF. A greater number of patients with persistent AF than paroxysmal AF had a thrombus in the LAA thrombus (3% vs 0.2%, respectively, $P < 0.05$) in this cohort of patients under therapeutic anticoagulation therapy. Similarly, a greater number of patients with persistent AF than paroxysmal AF had sludge ($P < 0.001$). Finally, the mean CHADS2 and CHA2DS2-VASc scores were significantly higher in patients with persistent AF than paroxysmal AF.

Discussion

The number of LA/LAA thrombi identified by TEE in AF patients with at least 1 month of therapeutic anticoagulation

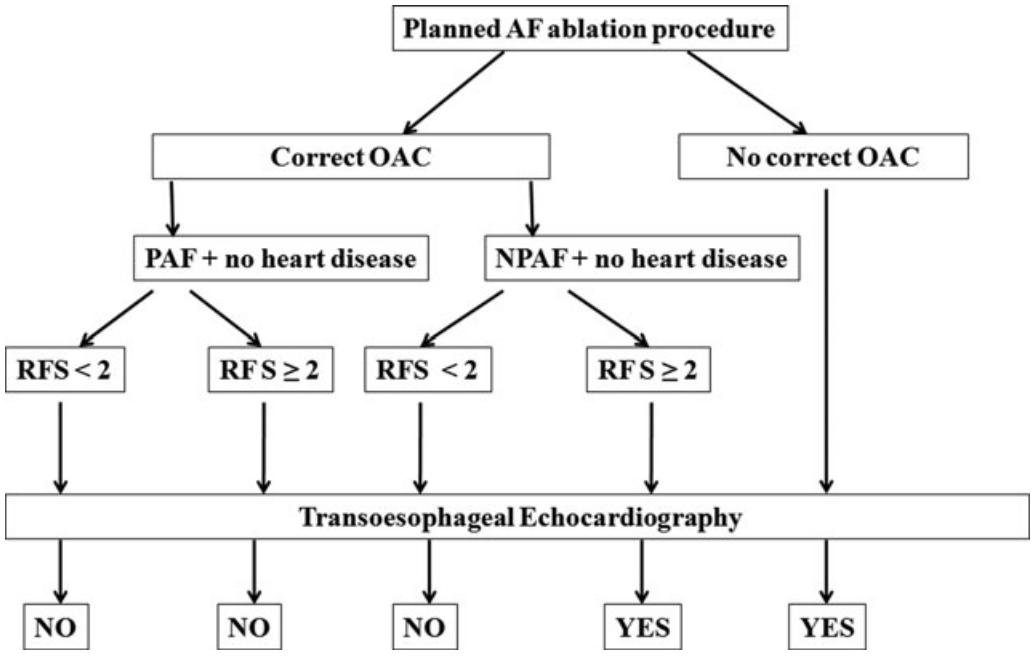

Figure 2. *Proposed algorithm for determining the need for transesophageal echocardiography before an atrial fibrillation ablation procedure. AF = atrial fibrillation; NPAF = nonparoxysmal atrial fibrillation; OAC = oral anticoagulation therapy for 4 weeks; PAF = paroxysmal atrial fibrillation; RFS = risk factor score; TEE = transesophageal echocardiography.*

treatment prior to planned PVI was low in the overall group of patients, and significantly higher in patients with persistent AF. This low prevalence, as well as the low prevalence of combined LA/LAA thrombus/sludge, is in agreement with previous studies.[10-12] This could be related to the fact that almost half of the patients were considered to have a low risk if assessed only with the CHADS2 score. However, with the CHA2DS2-VASc score the percentage of patients with low, intermediate, and high thromboembolic risk was similar; this is in accord to the better discrimination of the CHA2DS2-VASc score comparing to the CHADS2 score.

Relationship Between Risk Scores and LA/LAA Thrombi, Thrombogenic Milieu, and LA Volume

It has already been shown that the prevalence of LA/LAA thrombi gradually increases with the number of clinical risk factors[13-16] and CHADS2 score.[17] Our study confirms this finding (Table 2). All patients detected with LAA thrombi had persistent AF except one, who had paroxysmal AF, high thromboembolic risk assessed by the both scores and insufficient anticoagulation (last INR value <2). This underlines the importance of adequate anticoagulation in patients with AF and high thromboembolic risk, regardless of the type of AF. No LA/LAA thrombus was identified by TEE in any of the patients with a score of 0 for both assessments. However, a median score of 3 and 4 for the CHADS2 and CHA2DS2-VASc, respectively, was associated with the presence of a thrombus in the LAA, as previously reported.[11] LA volume was significantly different between patients with persistent and paroxysmal AF, but not between patients with or without LA thrombi, although this might be due to the low number of patients with LAA thrombi. However, all patients with thrombi had LA dilatation, and all thrombi were located in the LAA. In addition, LA volume did not significantly correlate with the 2 risk scores. Therefore, it seems that LA size has less influence on thromboembolic risk. In fact, LA parameters are not considered in current stroke risk prediction models. It is also known that LAA parameters, such as emptying velocity, correlate poorly with global LA parameters.[18] Conversely, LA and LAA functional parameters seem to be more important than LA size in predicting thrombotic tendency in this particular group of patients.

Need for TEE Before Pulmonary Vein Isolation in Patients with Low and Intermediate Thromboembolic Risk

In patients with a low thromboembolic risk who underwent at least 1 month of therapeutic anticoagulation, no LA/LAA thrombus was identified. In patients with intermediate risk, only one LAA thrombus was detected, in a patient with persistent AF. These patients represent 81.9% and 66.9% of the overall group, according to the CHADS2 and CHA2DS2-VASc scores, respectively. Our data are in agreement with the results of a previous study.[19] Wallace *et al*. found, in a relatively small group of patients, a higher number of LA thrombi, including 3 patients with paroxysmal AF who however had congestive heart failure.[20]

Predictive Accuracy of the 2 Risk Scores for LA/LAA Thrombi before Planned Pulmonary Vein Isolation

CHADS2 and CHA2DS2-VASc values lower than 2 had the capability to exclude the presence of LA/LAA thrombi in patients planned for AF ablation and who underwent at least 1 month of oral anticoagulation in the therapeutic range.

Clinical Implications

The possible clinical implication of this study is that TEE is not needed to exclude the presence of LA/LAA thrombi in patients with both thromboembolic scores <2, regardless of the type of AF, when anticoagulation therapy has been correctly maintained for at least 1 month before a planned PVI procedure. However, TEE seems to be mandatory in patients with nonparoxysmal AF (but not in paroxysmal AF)

and high thromboembolic risk, as assessed by both scores, despite receiving correctly anticoagulation therapy. Therefore, we propose an algorithm to determine the need for TEE in these patients (Fig. 2).

According to this algorithm in patients with paroxysmal AF and proof of correct anticoagulation therapy for at least 1 month before the procedure, there is no need for TEE before a planned AF ablation in patients with paroxysmal AF, regardless of the values obtained for both scores. There is also no need for TEE in patients with nonparoxysmal AF and a score of <2. Nevertheless, we believe that a preprocedural TEE could be of interest in patients with heart disease, albeit we did not encounter any case of thrombus in any of the patients studied. Conversely, TEE is necessary in patients with nonparoxysmal AF and a risk score of at least 2 points (regardless of the anticoagulation status). TEE is also mandatory in patients with no correct or no proof of correct anticoagulation regardless of the type of AF or risk score. TEE is a low-risk procedure, but patients are often reluctant to undergo this type of examination, especially if repeated. In daily clinical practice, it seems that avoiding unnecessary TEE procedures while identifying and screening high-risk patients better would be useful to improve efficiency.

Study Limitations

Although 2 independent investigators verified the accuracy of the reported echocardiographic findings in all patients, this study is a retrospective analysis. Great effort was made to ensure the accuracy of the thromboembolic risk scores and INR values by contacting the general practitioner and/or cardiologist in charge of the patient. In addition, the number of LAA thrombi detected was low, perhaps because the study population was under adequate anticoagulation therapy for at least 1 month. The discontinuation of antithrombotic treatment, replaced by LMWH treatment 2–3 days before the procedure, could have had different effects on the thrombogenic milieu. In recent years, some centers have begun to perform AF ablation procedures under full oral anticoagulation.[21] However, our study was carried out before this trend started, from 2000 to 2010. The grading of SEC as mild, moderate or severe remains relatively subjective, but presently, no other quantification method that is more accurate is available.

Conclusion

The results of this study indicate that not all patients undergoing planned endocardial PVI need preprocedural TEE. CHADS2 or CHA2DS2-VASc scores <2 had an almost maximal negative predictive capability of excluding the presence of a thrombus in the LA/LAA. Therefore vein isolation could be performed safely without TEE in patients with CHADS2 and CHA2DS2-VASc scores of 0 and 1, respectively (corresponding to low and intermediate risk patients), regardless of the type of AF, if they have been on anticoagulation therapy for at least 1 month in a therapeutic range prior to the procedure. Larger, prospective studies using a similar methodology are necessary to confirm these results.

References

1. Calkins H, Brugada J, Packer DL, Cappato R, Chen SA, Crijns HJ, Damiano RJ Jr, Davies DW, Haines DE, Haissaguerre M, Iesaka Y, Jackman W, Jais P, Kottkamp H, Kuck KH, Lindsay BD, Marchlinski FE, McCarthy PM, Mont JL, Morady F, Nademanee K, Natale A, Pappone C, Prystowsky E, Raviele A, Ruskin JN, Shemin RJ: HRS/EHRA/ECAS expert consensus statement on catheter and surgical ablation of atrial fibrillation: Recommendations for personnel, policy, procedures and follow-up. A report of the Heart Rhythm Society (HRS) Task Force on catheter and surgical ablation of atrial fibrillation. Heart Rhythm 2007;4:816-861.
2. Calkins H, Kuck KH, Cappato R, Brugada J, Camm AJ, Chen SA, Crijns HJ, Damiano RJ Jr, Davies DW, Dimarco J, Edgerton J, Ellenbogen K, Ezekowitz MD, Haines DE, Haissaguerre M, Hindricks G, Iesaka Y, Jackman W, Jalife J, Jais P, Kalman J, Keane D, Kim YH, Kirchhof P, Klein G, Kottkamp F, Kumagai K, Lindsay BD, Mansour M, Marchlinski FE, McCarthy PM, Mont JL, Morady F, Nademanee K, Nakagawa H, Natale A, Nattel S, Packer DL, Pappone C, Prystowsky E, Raviele A, Reddy V, Ruskin JN, Shemin RJ, Tsao HM, Wilber Wedge D; TASK FORCE MEMBERS; Chairs: Calkins H, Kuck KH, Cappato R; Section Chairs: Atrial Fibrillation: Definitions, Mechanisms, and Rationale for Ablation—, Chen SA, Prystowsky EN, Kuck KH, Natale A, Haines DE, Marchlinski FE, Calkins H, Davies DW, Lindsay BD, Damiano R Jr, Packer DL, Brugada J, Camm AJ, Crijns HJ, Dimarco J, Edgerton J, Ellenbogen K, Ezekowitz MD, Haissaguerre M, Hindricks G, Iesaka Y, Jackman WM, Jais P, Jalife J, Kalman J, Keane D, Kim YH, Kirchhof P, Klein G, Kottkamp H, Kumagai K, Mansour M, Marchlinski F, McCarthy P, Mont JL, Morady F, Nademanee K, Nakagawa H, Nattel S, Pappone C, Raviele A, Reddy V, Ruskin JN, Shemin RJ, Tsao HM, Wilber D; Document reviewers: Ad N, Cummings J, Gillinov AM, Heidbuchel H, January C, Lip G, Markowitz S, Nair M, Ovsyshcher IE, Pak HN, Tsuchiya T, Shah D, Siong TW, Vardas PE: HRS/EHRA/ECAS Expert Consensus Statement on Catheter and Surgical Ablation of Atrial Fibrillation: Recommendations for patient selection, procedural techniques, patient management and follow-up, definitions, endpoints, and research trial design. A report of the Heart Rhythm Society (HRS) Task Force on Catheter and Surgical Ablation of Atrial Fibrillation. Europace 2012;14:528-606.
3. Fuster V, Rydén LE, Cannom DS, Crijns HJ, Curtis AB, Ellenbogen KA, Halperin JL, Le Heuzey JY, Kay GN, Lowe JE, Olsson SB, Prystowsky EN, Tamargo JL, Wann S, Smith SC Jr, Jacobs AK, Adams CD, Anderson JL, Antman EM, Halperin JL, Hunt SA, Nishimura R, Ornato JP, Page RL, Riegel B, Priori SG, Blanc JJ, Budaj A, Camm AJ, Dean V, Deckers JW, Despres C, Dickstein K, Lekakis J, McGregor K, Metra M, Morais J, Osterspey A, Tamargo JL, Zamorano JL: American College of Cardiology; American Heart Association Task Force; European Society of Cardiology Committee for Practice Guidelines; European Heart Rhythm Association; Heart Rhythm Society. ACC/AHA/ESC 2006 guidelines for the management of patients with atrial fibrillation. Full text: A report of the American College of Cardiology/American Heart Association Task Force on practice guidelines and the European Society of Cardiology Committee for Practice Guidelines (Writing Committee to Revise the 2001 guidelines for the management of patients with atrial fibrillation) developed in collaboration with the European Heart Rhythm Association and the Heart Rhythm Society. Europace 2006;8:651-745.
4. Camm AJ, Kirchhof P, Lip GY, Schotten U, Savelieva I, Ernst S, Van Gelder IC, Al-Attar N, Hindricks G, Prendergast B, Heidbuchel H, Alfieri O, Angelini A, Atar D, Colonna P, De Caterina R, De Sutter J, Goette A, Gorenek B, Heldal M, Hohloser SH, Kolh P, Le Heuzey JY, Ponikowski P, Rutten FH: Guidelines for the management of atrial fibrillation: The Task Force for the Management of Atrial Fibrillation of the European Society of Cardiology (ESC). Eur Heart J 2010;31:2369-2429.
5. Natale A, Raviele A, Arentz T, Calkins H, Chen SA, Haïssaguerre M, Hindricks G, Ho Y, Kuck KH, Marchlinski F, Napolitano C, Packer D, Pappone C, Prystowsky EN, Schilling R, Shah D, Themistoclakis S, Verma A: Venice Chart international consensus document on atrial fibrillation ablation. J Cardiovasc Electrophysiol 2007;18:560-580.
6. Flachskampf FA, Decoodt P, Fraser AG, Daniel WG, Roelandt JRTC; for the Subgroup on Transesophageal Echocardiography, Valvular Heart Disease, on behalf of the Working Group on Echocardiography of the European Society of Cardiology: Recommendations for performing transesophageal echocardiography. Eur J Echocardiogr 2001;2:8-21.
7. Flachskampf FA, Badano L, Daniel WG, Feneck RO, Fox KF, Fraser AG, Pasquet A, Pepi M, Perez de Isla L, Zamorano JL: European Association of Echocardiography; Echo Committee of the European Association of Cardiothoracic Anaesthesiologists, Roelandt JR, Piérard L: Recommendations for transoesophageal echocardiography: Update 2010. Eur J Echocardiogr 2010;11:557-576.

8. Aschenberg W, Schluter M, Kremer P, Schroder E, Siglow V, Bleifeld W: Transesophageal two-dimensional echocardiography for the detection of left atrial appendage thrombus. J Am Coll Cardiol 1986;7:163-166.
9. Fatkin D, Kelly RP, Feneley MP: Relations between left atrial appendage blood flow velocity, spontaneous echocardiographic contrast and thromboembolic risk in vivo. J Am Coll Cardiol 1994;23:961-969.
10. Puwanant S, Varr BC, Shrestha K, Hussain SK, Tang WH, Gabriel RS, Wazni OM, Bhargava M, Saliba WI, Thomas JD, Lindsay BD, Klein AL: Role of the CHADS2 score in the evaluation of thromboembolic risk in patients with atrial fibrillation undergoing transesophageal echocardiography before pulmonary vein isolation. J Am Coll Cardiol 2009;54:2032-2039.
11. Dorekamp M, Sohns C, Vollmann D, Luthje L, Seegers J, Wachter R, Puls M, Wieland Staab, Lotz J, Zabel M: Detection of left atrial thrombus during routine diagnostic work-up prior to pulmonary vein isolation for atrial fibrillation: Role of transoesophageal echocardiography and multidetector computed tomography. Int J Cardiol 2011. http://dx.doi.org/10.1016/j.ijcard.2011.06.124.
12. Khan MN, Usmani A, Noor S, Elayi S, Ching CK, Di Biase L, Patel D, Burkhardt JD, Cummings J, Schweikert R, Saliba W, Natale A: Low incidence of left atrial or left atrial appendage thrombus in patients with paroxysmal atrial fibrillation and normal EF who present for pulmonary vein antrum isolation procedure. J Cardiovasc Electrophysiol 2008;19:356-358.
13. Zabalgoitia M, Halperin JL, Pearce LA, Blackshear JL, Asinger RW, Hart RG: Transesophageal echocardiographic correlates of clinical risk of thromboembolism in nonvalvular atrial fibrillation. Stroke Prevention in Atrial Fibrillation III Investigators. J Am Coll Cardiol 1998;31:1622-1626.
14. The Stroke Prevention in Atrial Fibrillation Investigators: Predictors of thromboembolism in atrial fibrillation: II. Echocardiographic features of patients at risk. Ann Intern Med 1992;116:6-12.
15. The Stroke Prevention in Atrial Fibrillation Investigators: Predictors of thromboembolism in atrial fibrillation: I. Clinical features of patients at risk. Ann Intern Med 1992;116:1-5.
16. Wazni OM, Tsao HM, Chen SA, Chuang HH, Saliba W, Natale A, Klein AL: Cardiovascular imaging in the management of atrial fibrillation. J Am Coll Cardiol 2006;48:2077-2084.
17. Rader VJ, Khumri TM, Idupulapati M, Stoner CN, Magalski A, Main ML: Clinical predictors of left atrial thrombus and spontaneous echocardiographic contrast in patients with atrial fibrillation. J Am Soc Echocardiogr 2007;20:1181-1185.
18. Agmon Y, Khandheria BK, Meissner I, Petterson TM, O'Fallon WM, Wiebers DO, Seward JB: Are left atrial appendage flow velocities adequate surrogates of global left atrial function? A population-based transthoracic and transesophageal echocardiographic study. J Am Soc Echocardiogr 2002;15:433-440.
19. McCready JW, Nunn L, Lambiase PD, Ahsan SY, Segal OR, Rowland E, Lowe MD, Chow AW: Incidence of left atrial thrombus prior to atrial fibrillation: Is pre-procedural transoesophageal echocardiography mandatory? Europace 2010;12:927-932.
20. Wallace TW, Atwater BD, Daubert JP, Voora D, Crowley AL, Bahnson TD, Hranitzky PM. Prevalence and clinical characteristics associated with left atrial appendage thrombus in fully anticoagulated patients undergoing catheter-directed atrial fibrillation ablation. J Cardiovasc Electrophysiol 2010;21:849-852.
21. Gopinath D, Lewis WR, Di Biase L, Natale A. Pulmonary vein antrum isolation for atrial fibrillation on therapeutic coumadin: Special considerations. J Cardiovasc Electrophysiol 2011;22:236-239.