



Validation of the MB-LATER score for prediction of late recurrence after catheter-ablation of atrial fibrillation☆



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ABSTRACT

Background: Reliable identification of atrial fibrillation (AF) patients more likely to be AF-free long-term post-single catheter ablation (CA) would facilitate appropriate risk communication to patients. We validated the recently proposed MB-LATER score for prediction of late recurrences of AF (LRAF) post-CA. **Methods:** Patients who underwent CA for symptomatic AF refractory to ≥ 1 antiarrhythmic drugs at the Johns Hopkins Hospital, Baltimore, between March 2003 and December 2015, for whom ≥ 1 -year post-CA follow-up data were available, were enrolled.

Results: Of 226 patients (median age 58.5 years [IQR: 52.0–65.0], 163 males [72.1%], 142 [62.8%] with paroxysmal AF), LRAF occurred in 133 patients (58.8%) during a median 2-year follow-up (IQR: 1.1–4.1). The mean MB-LATER score was significantly higher in patients with versus those without LRAF (2.4 ± 1.2 vs. 1.9 ± 1.3 , $p = 0.002$) and showed modest but significant predictive ability for LRAF (AUC: 0.62 [95% CI: 0.54–0.69], $p = 0.003$).

A score cut-off value of >2 showed the best predictive ability for LRAF (70.4% [61.5–77.9]), with modest sensitivity (42.9% [34.3–51.7]) and specificity (74.2% [64.1–82.7]). Kaplan-Meier survival free from AF was significantly better for patients with a MB-LATER score of ≤ 2 than for those with a score of >2 (log-rank $p = 0.005$).

Conclusion: In our study, the MB-LATER score showed a significant but modest predictive ability for LRAF post-AF ablation. Further prospective validation is needed to better define the potential role of the MB-LATER score in patient selection and treatment decision-making post-AF ablation.

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1. Introduction

Catheter ablation (CA) is increasingly used for treatment of atrial fibrillation (AF) [1,2]. However, only a limited proportion of eligible AF patients (4–19%) can be treated using CA, as shown in contemporary general AF registers [3,4], or nationwide cohorts [2]. Although CA is superior to antiarrhythmic drug (AAD) therapy for rhythm control in symptomatic AF, up to 50% of patients may require repeated CA,

depending on follow-up duration and patient characteristics [1,5], and AF may reoccur despite multiple repeated CA procedures.

The reliable identification of AF patients more likely to be AF-free long-term post-single CA or those who would benefit from re-do procedure post-index AF ablation would facilitate appropriate risk communication to patients and patient selection for CA. Several prediction tools have been developed to assess the risk of late AF recurrence post-CA, as summarized in a recent review [6]. The recently reported MB-LATER score for prediction of very late AF recurrences post-CA, which has been derived in a single-centre cohort of AF patients post-AF ablation, performed better than the APPLE, ALARMc, BASE-AF₂, CHADS₂, CHA₂DS₂VASc or HATCH score in the original cohort [7] but has not been externally validated as yet.

In the present study, we validated the predictive value of MB-LATER score for late AF recurrence in a cohort of consecutive AF patients who underwent AF ablation at the Johns Hopkins Hospital, Baltimore,

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between March 2003 and December 2015. We also compared the MB-LATER with CAAP-AF (coronary artery disease, left atrial [LA] diameter, age, non-paroxysmal AF, antiarrhythmic drugs [AADs] failed and female sex), CHADS₂ (congestive heart failure, hypertension, age ≥75 years, diabetes mellitus, prior stroke) and CHA₂DS₂-VASc (congestive heart failure or left ventricular systolic dysfunction, hypertension, age 65–74 years, diabetes mellitus, prior stroke, vascular disease, age ≥75 years, female sex) scores in predicting late AF recurrence post-CA.

2. Methods

2.1. Patient selection

All patients who underwent CA for recurrent symptomatic nonvalvular AF refractory to ≥1 class I or III antiarrhythmic drug (AAD) at the Johns Hopkins Hospital, Baltimore, between March 2003 and December 2015, for whom ≥1-year follow-up data after the procedure were available, were enrolled. The study was approved by the Johns Hopkins Hospital Institutional Review Board. All patients signed written informed consent for database participation.

2.2. Score calculation

The MB-LATER score was calculated according to its original definition [7] by assigning 1 point each for male gender, bundle branch block (i.e., QRS complex duration of ≥120 ms), left atrial (LA) diameter ≥ 47 mm, persistent AF (Pe-AF) and early recurrence of AF (ERAF) during the 3-month post-ablation blanking period, and 2 points for pre-ablation history of long-standing persistent AF (LS-PeAF). The score ranges from 0 to 6.

The CAAP-AF score (ranging 0 to 13 points) was calculated assigning 1 point each for coronary artery disease and female sex, 2 points for non-paroxysmal AF (Pe-AF or LS-PeAF), 0 to 4 points for LA diameter (0, 1, 2, 3 or 4 points for LA diameter of <4.0 cm, 4.0–4.4 cm, 4.5–4.9 cm, 5.0–5.4 cm and ≥5.5 cm, respectively) and 0 to 2 points for the number of AADs failed before CA (i.e. 1 point for 1 or 2 AADs failed and 2 points for >2 AADs failed) [8].

The CHA₂DS₂-VASc score was determined by assigning 1 point each for the presence of congestive heart failure (HF) and/or left ventricular ejection fraction <40%, hypertension, age 65 to 74 years, diabetes, peripheral vascular disease and/or coronary disease as well as for female gender. The age of ≥75 years and history of stroke were assigned 2 points each [9–11].

The CHADS₂ score was computed by adding 1 point for congestive HF, hypertension, age of ≥75 years and diabetes mellitus, and 2 points for prior stroke [9–11].

2.3. Preprocedural data and ablation strategy

Baseline data on demographics, co-morbidities, echocardiographic parameters and AADs use prior to the CA were obtained retrospectively from the hospital records, medical chart reviews and electronic EP database. Clinical type of AF was defined according to the current AF guidelines: paroxysmal AF (PAF) as AF spontaneously terminating within 7 days, PeAF as AF requiring cardioversion and LS-PeAF as AF persisting for >12 months [1,12]. The LA diameter was measured in the M-mode parasternal echocardiographic short axis view.

All patients underwent wide antral circumferential pulmonary vein isolation (PVI) using radiofrequency (RF) point-by-point ablation guided by standard electro-anatomical mapping system or cryo-balloon ablation. In patients with non-paroxysmal AF, additional substrate modification was performed on top of PVI, including the LA linear ablation (ablation of the roof line and mitral isthmus line or posterior box isolation) or the LA defragmentation (elimination of all complex fragmented atrial electrograms). If Pe-AF was not terminated during ablation, sinus rhythm was restored by external electrical cardioversion. In patients with organized atrial tachycardia (AT) during the procedure, an activation mapping of tachycardia and ablation of its critical substrate was performed. The patients with documented typical atrial flutter (AFL) underwent linear ablation of cavotricuspid isthmus.

2.4. Follow-up and outcome after the CA

Follow-up information was collected from hospital records and regular telephone contact. After the 3-month blanking period, AADs were generally discontinued and the CA outcome was evaluated. In all patients, a 24-hour Holter-monitoring was performed at 3 months and at 1 year post-CA. Patients reporting symptoms suggestive of AF recurrence were instructed to obtain an ECG and/or underwent an additional Holter-monitoring.

Any symptomatic or asymptomatic electrocardiographically documented atrial tachyarrhythmia (AF, AT and/or AFL) lasting >30 s after the procedure was considered "the AF recurrence"; AF recurrences registered during the first 3 months post-procedure were categorized as an ERAF, while those occurring after the blanking period were classified as a late recurrence of AF (LRAF).

2.5. Statistical analysis

Continuous variables with normal or asymmetrical distribution are presented as mean (±1 Standard Deviation [SD]) or median (with 25th and 75th percentiles), respectively. Categorical variables are given as counts with percentages. The relation between the variables specified in Tables 1 and 2, and the LRAF post-CA was assessed by univariate Cox-proportional hazard regression. The predictive value of the validated scores was calculated as the area under the ROC (Receiver Operating Characteristics) curve and expressed as c-statistics with 95% confidence interval. The areas under the curves were compared by the DeLong test. Clinical usefulness and net benefit of the tested scores was further assessed using the DCA (Decision Curve Analysis). The survival curves of freedom from AF were constructed by the Kaplan-Meier estimates and were compared by the Log-Rank test. A two-sided *p* value of <0.05 was considered statistically significant. The SPSS software, version 18.0 (IBM Corporation, Armonk, NY, USA) and MedCalc, version 18.0 were used for the statistical analysis.

3. Results

3.1. Study population

Of 226 patients undergoing AF ablation at a median age of 58.5 years (IQR: 52.0–65.0), 163 patients (72.1%) were male. Prior to CA, PAF, PeAF and LSPeAF was documented in 142 (62.8%), 64 (28.3%) and 20 patients (8.8%), respectively. The most prevalent comorbidities included hypertension (50.9%), obstructive sleep apnoea (18.6%), diabetes (9.7%) and congestive HF (9.7%). The median LA diameter was 4.1 (IQR: 4.0–5.2) cm. Baseline clinical characteristics of the study population are summarized in Table 1.

3.2. Procedure-related data

Most patients (*n* = 224) underwent RF AF ablation, while cryo-balloon AF ablation was performed in two patients. All patients underwent PVI procedure, and superior vena cava isolation was performed in 6 patients (2.6%). The LA substrate-based ablation on top of PVI consisted of the LA linear ablation (*n* = 153, 67.7%) or LA

Table 1
Baseline clinical characteristics of the study cohort.

	All patients (<i>n</i> = 226)	Patients with LRAF (<i>n</i> = 133)	Patients without LRAF (<i>n</i> = 93)	<i>p</i> -Value
Age (years)	58.5 (52.0–65.0)	58.0 (53.0–65.0)	59.0 (52.0–65.0)	0.918
Male sex	163 (72.1%)	91 (68.4%)	72 (77.4%)	0.138
BMI (kg/m ²)	29.3 (25.1–35.7)	30.5 (26.3–37.1)	27.8 (24.8–33.5)	0.008
Years since AF diagnosis	4.0 (1.7–8.0)	4.0 (2.0–8.0)	3.0 (1.0–7.0)	0.106
Paroxysmal AF	142 (62.8%)	83 (62.4%)	59 (63.4%)	0.874
Pe-AF	64 (28.3%)	39 (29.3%)	25 (26.9%)	0.689
Long-standing Pe-AF	20 (8.8%)	11 (8.3%)	9 (9.7%)	0.714
LV EF (%)	60.0 (55.0–60.0)	60.0 (55.0–60.0)	57.0 (55.0–60.0)	0.486
LA diameter (cm)	4.1 (4.0–5.2)	4.3 (4.0–5.3)	4.1 (4.0–4.7)	0.039
CHA ₂ DS ₂ -VASc score	1.0 (1.0–2.0)	1.0 (1.0–3.0)	1.0 (1.0–2.0)	0.176
Congestive HF	22 (9.7%)	13 (9.8%)	9 (9.7%)	0.966
Hypertension	115 (50.9%)	71 (53.4%)	44 (47.3%)	0.369
Diabetes mellitus	22 (9.7%)	14 (10.5%)	8 (8.6%)	0.765
Coronary disease	34 (15.0%)	24 (18.0%)	10 (10.7%)	0.120
OSA	42 (18.6%)	26 (19.5%)	16 (17.2%)	0.656
Prior stroke or TIA	19 (8.4%)	12 (9.0%)	7 (7.5%)	0.690
AADs number (<i>n</i>)	1.5 ± 0.9	1.6 ± 0.8	1.3 ± 0.8	0.038
I class AADs	54 (23.9%)	34 (25.6%)	20 (21.5%)	0.482
III class AADs	113 (50.0%)	70 (52.6%)	43 (46.2%)	0.344
Re-do ablation	27 (11.9%)	19 (14.3%)	8 (8.6%)	0.199
Early recurrence of AF	136 (60.2%)	107 (80.4%)	29 (32.2%)	<0.001

AF, atrial fibrillation; LRAF, late recurrence of AF; BMI, body mass index; LV, left ventricular; EF, ejection fraction; LA, left atrium; HF, heart failure; OSA, obstructive sleep apnea; TIA, transient ischemic attack.

Table 22a) The MB-LATER, 2b) Predictive value of the MB-LATER and CAAP-AF scores, 2c) CAAP-AF, CHADS₂ and CHA₂DS₂VASc score validation.

Table 2a					
Score (points)	All patients (n = 226)	Patients with AF recurrence (n = 133)	Patients without AF recurrence (n = 93)	Univariate analysis	
				HR (95% CI)	p
MB-LATER score (0–6)	2.2 ± 1.3	2.4 ± 1.2	1.9 ± 1.3	1.23 (1.08–1.40)	0.002
Male gender (0–1)	163 (72.1%)	91 (68.4%)	72 (77.4%)	0.71 (0.49–1.02)	0.064
BBB (0–1)	14 (6.2%)	7 (5.3%)	7 (7.5%)	0.86 (0.40–1.83)	0.690
LA ≥47 mm (0–1)	80 (35.4%)	55 (41.3%)	25 (26.9%)	1.33 (0.94–1.88)	0.102
Type of AF (0–2) ^a , NPAF	84 (37.1%)	50 (37.6%)	34 (36.5%)	1.01 (0.78–1.32) ^a	0.913 ^a
ERAF (0–1)	136 (60.2%)	107 (80.4%)	29 (32.2%)	5.08 (3.29–7.83)	<0.001

Table 2b		
	MB-LATER score > 2 n (95% CI)	CAAP-AF score ≥ 6 n (95% CI)
Sensitivity (%)	42.9 (34.3–51.7)	57.9 (49.0–66.4)
Specificity (%)	74.2 (64.1–82.7)	57.0 (46.3–67.2)
Positive predictive value (%)	70.4 (61.5–77.9)	65.8 (59.4–71.7)
Negative predictive value (%)	47.6 (42.9–52.3)	48.6 (42.0–55.3)

Table 2c					
Score (points)	All patients (n = 226)	Patients with AF recurrence (n = 133)	Patients without AF recurrence (n = 93)	Univariate analysis	
				HR (95% CI)	p
CAAP-AF score (0–13)	5.7 ± 2.5	6.1 ± 2.6	5.3 ± 2.4	1.08 (1.01–1.16)	0.030
Coronary disease (0–1)	34 (15.0%)	24 (18.0%)	10 (10.7%)	1.41 (0.90–2.20)	0.128
LA diameter, cm (0–4) ^b	4.5 ± 0.9	4.7 ± 0.9	4.4 ± 0.8	1.13 (1.00–1.28) ^b	0.053 ^b
Age, years (0–3) ^c	57.8 ± 10.7	57.9 ± 10.1	57.6 ± 11.5	0.98 (0.82–1.17) ^c	0.811 ^c
PeAF or LS-PeAF (2)	84 (37.1%)	50 (37.6%)	34 (36.5%)	1.01 (0.85–1.21)	0.864
AADs failed (0–2) ^d	1.5 ± 0.9	1.6 ± 0.8	1.3 ± 0.8	1.21 (1.00–1.45) ^d	0.048 ^d
Female gender (1)	63 (27.9%)	42 (31.6%)	21 (22.6%)	1.41 (0.98–2.04)	0.064
CHADS ₂ score (0–6)	1.0 (0.0–1.0)	1.0 (0.0–1.0)	1.0 (0.0–1.0)	1.03 (0.86–1.22)	0.776
CHA ₂ DS ₂ VASc score (0–9)	1.0 (1.0–2.0)	1.0 (1.0–3.0)	1.0 (1.0–2.0)	1.09 (0.96–1.23)	0.164
CHF or LVEF<40%	32 (14.2%)	19 (14.3%)	13 (14.0%)	0.97 (0.59–1.57)	0.894
Hypertension	115 (50.9%)	71 (53.5%)	44 (47.3%)	1.10 (0.78–1.55)	0.572
Age ≥ 75 years	9 (4.0%)	5 (3.7%)	4 (4.3%)	1.01 (0.41–2.47)	0.982
Diabetes mellitus	21 (9.3%)	13 (9.8%)	8 (8.6%)	1.08 (0.61–1.92)	0.786
Stroke or TIA	19 (8.4%)	12 (9.0%)	7 (7.5%)	1.02 (0.56–1.84)	0.951
Vascular disease (PVD, CAD)	35 (15.5%)	25 (18.8%)	10 (10.7%)	1.46 (0.95–2.26)	0.087
Age 65–74 years	56 (24.8%)	34 (25.6%)	22 (23.6%)	1.05 (0.71–1.55)	0.799
Sex (female)	63 (27.9%)	42 (31.6%)	21 (22.6%)	1.41 (0.98–2.04)	0.064

AF, atrial fibrillation; BBB, bundle branch block; LA, left atrium; NPAF, non-paroxysmal AF; ERAF, early recurrence of AF; PeAF, persistent AF; LS-PeAF, longstanding persistent AF; AAD, antiarrhythmic drug; CHF, congestive heart failure; LVEF, left ventricular ejection fraction; TIA, transient ischemic attack; PVD, peripheral vascular disease; CAD, coronary artery disease; CI, confidence interval.

^a Type of AF: (0) paroxysmal AF, (1) persistent AF and (2) longstanding persistent AF.

^b LA diameter: (0) <4.0 cm, (1) 4.0–4.4 cm, (2) 4.5–4.9 cm, (3) 5.0–5.4 cm and (4) ≥5.0 cm.

^c Age: (0) <50 years, (1) 50–59 years, (2) 60–69 years and ≥70 years.

^d AADs failed: (0) none, (1) 1 or 2 AADs failed and (2) >2 AADs failed.

defragmentation ($n = 10$, 4.4%). Typical AFL was an additional ablation target in 8 patients (3.5%). Overall, 199 patients (88.1%) underwent a single AF ablation procedure, while AF CA was repeated in 27 patients (11.9%).

3.3. Recurrence of AF after ablation

During the median follow-up of 2.0 years (IQR: 1.1–4.1) after the last ablation procedure, LRAF was clinically detected in 133 patients (58.8%) after the 3-month blanking period. The median time from AF ablation to LRAF was 3.8 months (IQR: 3.2–6.6). The cumulative freedom from AF of 58.0% (95% CI: 51.5–64.5%) at 6 months decreased to 42.0% (95% CI: 35.5–48.5%) at 1 year and 40.3% (95% CI: 33.6–47.0%) at 3 years post-ablation.

Patients with LRAF had significantly higher median body mass index (30.5 kg/m² [IQR: 26.3–37.1] vs. 27.8 kg/m² [IQR: 24.8–33.5], $p = 0.008$) and the mean number of failed AADs before ablation (1.6 ± 0.8 vs. 1.3 ± 0.8, $p = 0.038$), a larger median LA diameter (4.3 mm [IQR: 4.0–5.3] vs. 4.1 mm [IQR: 4.0–4.7], $p = 0.039$) and higher ERAF rate during the 3-month blanking period post-ablation (80.4% vs. 32.2%, $p < 0.001$), compared to those without LRAF.

3.4. Validation of MB-LATER score for the LRAF prediction

The components of the MB-LATER score are presented in Table 2a. The mean MB-LATER score (2.4 ± 1.2 vs. 1.9 ± 1.3, $p = 0.002$) was significantly higher in patients with LRAF in comparison to those without LRAF after ablation. The MB-LATER score showed significant predictive ability for LRAF after ablation (AUC: 0.62 [95% CI: 0.54–0.69], $p = 0.003$), Fig. 1A. An MB-LATER score cut-off value of >2 showed the best predictive ability for the occurrence of LRAF post-ablation, but with only modest sensitivity and specificity (Table 2b). Kaplan-Meier survival rates regarding the freedom from AF for patients with a MB-LATER score of ≤2 were significantly better than for those with a score of >2 (log-rank $p = 0.005$, Fig. 1B, upper panel).

3.5. Comparison with other scores

The association between various components of the CAAP-AF, CHADS₂ and CHA₂DS₂VASc scores with LRAF occurrence after ablation is given in Table 2c. Regarding the CAAP-AF score, the number of failed AADs before the procedure was significantly related to LRAF ($p =$

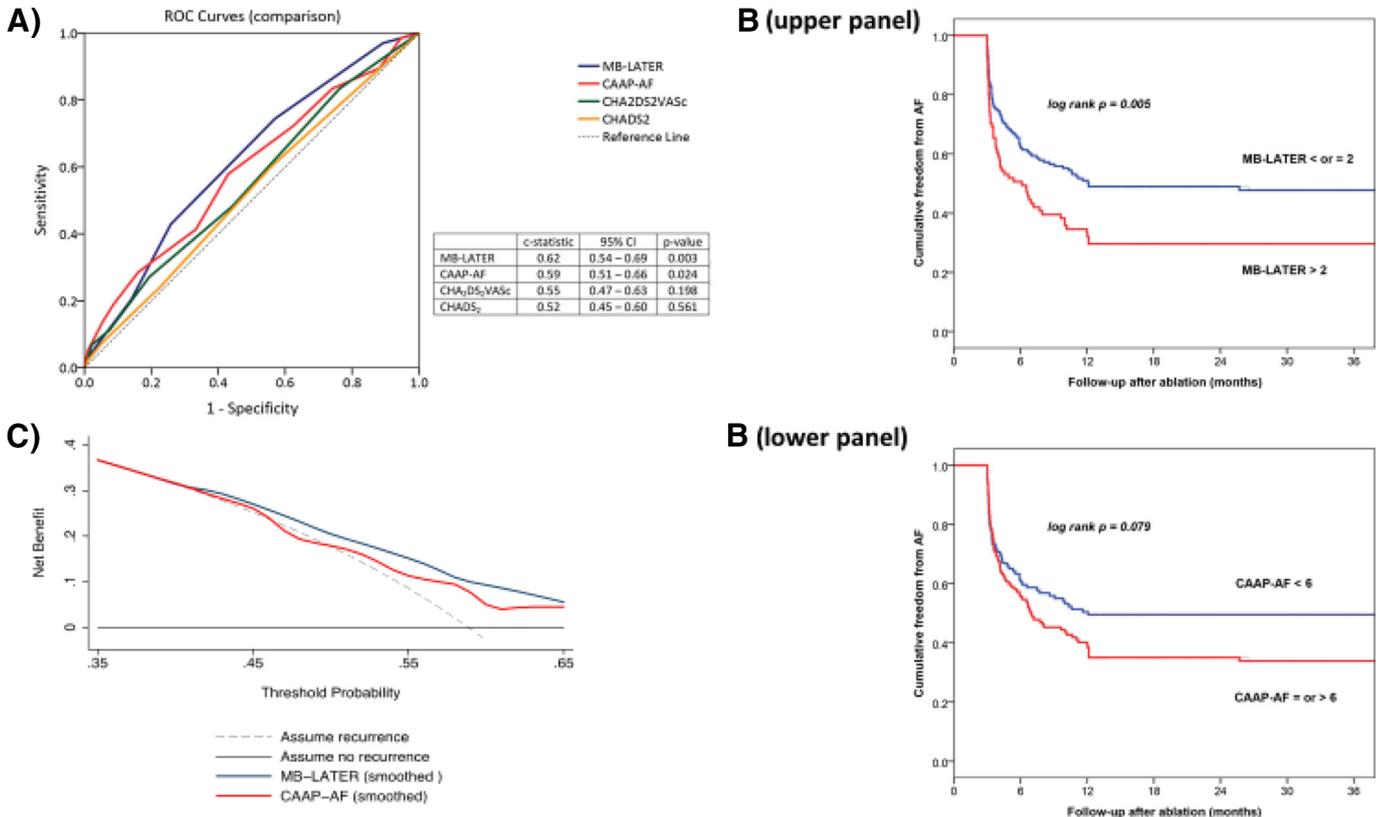


Fig. 1. A) Receiver Operating Characteristic (ROC) curve analysis of tested scores for prediction of late atrial fibrillation recurrence after ablation; B) Kaplan-Meier curve of AF-free survival after ablation according to cut-off value of MB-LATER score (≤ 2 or > 2), Upper panel, and CAAP-AF score (< 6 or ≥ 6), Lower panel; C) Decision curve analysis (DCA) for prediction of late atrial fibrillation recurrence after ablation. AF, atrial fibrillation.

0.048) while the LA enlargement category from 1 to 4 ($p = 0.053$) and female gender ($p = 0.064$) showed only a non-significant trend toward an increased LRAF rate. The CAAP-AF score showed a significant predictive value for the LRAF (AUC 0.59 [95% CI: 0.51–0.66], $p = 0.024$) with a score cut-off value of ≥ 6 having the best sensitivity and specificity of 57.9% and 57.0%, respectively (Table 2b), but probability of freedom from LRAF post-ablation was not significantly different between the patients grouped by the CAAP-AF score of ≥ 6 versus those with a score of < 6 (log-rank $p = 0.079$), Fig. 1B (lower panel).

The CHADS₂ and CHA₂DS₂VASc scores were not significantly related to LRAF occurrence (both $p > 0.05$), as shown in Table 2c, and the CHADS₂ (AUC 0.52 [95% CI: 0.45–0.60], $p = 0.561$) and CHA₂DS₂-VASc scores (AUC 0.55 [95% CI: 0.47–0.63], $p = 0.198$) had no significant predictive value for LRAF post-ablation, Fig. 1A.

There was no statistically significant differences between the c-indexes for the MB-LATER and CAAP-AF scores (0.03 [95% CI: -0.05 to 0.10], $p = 0.446$), MB-LATER and CHA₂DS₂VASc scores (0.07 [95% CI: -0.04 to 0.18], $p = 0.228$), or MB-LATER and CHADS₂ scores (0.09 [95% CI: 0.00 to 0.20], $p = 0.063$), as tested by the DeLong test.

The MB-LATER score showed largest net benefit in comparison to other scores on DCA. The greater clinical usefulness of the MB-LATER score relative to the CAAP-AF score in the identification of patients at increased risk for LRAF post-AF ablation is demonstrated in Fig. 1C.

4. Discussion

The present study is the first external validation of the recently proposed MB-LATER score for prediction of LRAF post-AF ablation. Our study shows that the MB-LATER score was significantly associated with the occurrence of LRAF, with a modest predictive ability for LRAF (c-statistic of 0.62), and a MB-LATER score of > 2 had higher specificity

and positive predictive value for LRAF compared with the CAAP-AF score.

Reliable prediction of recurrent AF after CA could improve the patient selection and rationalize their recruitment for the procedure [13], which is invasive and associated with certain risk of serious complications [1,12]. In addition, a proportion of patients will require repeated CA due to recurrent AF, and appropriate risk communication could facilitate shared decision-making about the index CA for AF [5]. In addition, a reliable prediction of the risk for recurrent AF post-CA could inform the decision on re-ablation and discontinuation of AADs and oral anticoagulant drugs after the procedure in low-risk patients [6,13].

Numerous clinical, procedural and biochemical factors were reported to be related to the AF recurrence after CA [1,12,13]. Some of these risk factors were combined into several scoring systems for prediction of post-ablation AF recurrence as listed in Table 3 [6–11,14–20]. Of these, some scores were originally developed for the assessment of thromboembolic risk (CHADS₂ and CH₂DS₂VASc) or the risk of arrhythmia progression (HATCH) in AF patients [9–11]. However, their predictive value for LRAF, stroke and mortality after AF ablation has also been studied, with conflicting results [10,13,14]. This is unsurprising, since these scores are based on the presence of conventional cardiovascular risk factors, such as aging, hypertension, diabetes and heart failure [9]. Since CA is commonly performed in selected “younger” AF patients with no or minimal structural heart disease [1], such “general” scores can be expected to perform less well in predicting LRAF during short-to-mid-term follow-up after the procedure [14,15], as shown in our study.

Several other scores were formulated specifically for the assessment of risk for AF recurrence post-ablation [6–8,14–20]. Unlike the “general” scores, these specific scores mostly include risk factors that are more pertinent to CA outcomes, such as the clinical type of AF, total AF duration history, the LA size, early recurrence of AF within the post-ablation

Table 3
Scoring systems for the prediction of late recurrence of atrial fibrillation after catheter-ablation [7–11,14–20].

Risk factors	General scores			Specific scores							
	CHA ₂ DS ₂ -VASc	HATCH	(B)-R ₂ CHADS ₂	ALARMEc	APPLE	ATLAS	BASE-AF ₂	CAAP-AF	MB-LATER	PLAAF	
Age	✓	✓	✓		✓	✓		✓			
Gender	✓					✓		✓	✓	✓	
BMI or metabolic sy.				✓			✓				
AF type				✓	✓	✓	✓	✓	✓	✓	
Duration of AF history							✓			✓	
ERAF post-ablation							✓		✓		
LA size				✓	✓	✓	✓	✓	✓	✓	
Number of AADs failed								✓			
Smoking						✓	✓				
CHF, reduced LVEF or BBB	✓	✓	✓	✓	✓				✓		
Hypertension	✓	✓	✓								
Coronary or vascular disease	✓							✓			
Diabetes	✓		✓								
Stroke or TIA	✓	✓	✓								
COPD		✓									
Renal insufficiency			✓	✓	✓						
BNP			(✓)								
PV anatomy										✓	

BMI, body mass index; AF, atrial fibrillation; ERAF, early recurrence of atrial fibrillation; LA, left atrium; AAD, anti-arrhythmic drug; CHF, congestive heart failure; LVEF, left ventricular ejection fraction; BBB, bundle branch block; TIA, transient ischemic attack; COPD, chronic obstructive pulmonary disease; BNP, brain natriuretic peptide; PVs, pulmonary veins.

blanking period, number of AADs that failed prior to CA, etc. Indeed, as presented in Table 3, the variables included in most of these scores were patient age, non-paroxysmal type of AF, LA enlargement and heart failure [6–8,14–20]. While all CA-specific scores were retrospectively derived in the respective original cohort of selected AF patients who had already undergone CA-AF, so far only the APPLE and CAAP-AF scores have been externally validated [16,19].

The MB-LATER (“May-Be-LATER”) score was originally formulated for the risk assessment of very late AF recurrence occurring beyond the first year in patients who were AF-free at 12 months after CA [7]. In the derivation study, the risk of very late arrhythmia recurrence progressively increased with the presence of Male gender, Bundle branch block, the LA diameter of ≥ 47 mm, non-paroxysmal Type of AF and Early Recurrence of AF within the 3-month blanking period after CA [7].

In the present study of an independent AF ablation cohort, the MB-LATER score showed a modest but significant predictive value for LRAF within 12 months post-ablation, thus supporting the score’s potentially broader clinical utility. This finding is of importance since the ablation strategy and intensity of rhythm monitoring for the detection of post-ablation AF recurrence considerably vary among EP centres [1,12,13]. In line with the MB-LATER derivation study [7], the present study confirms that the patients with MB-LATER score of >2 are at “high-risk” for AF recurrence after CA. In contrast to other scoring systems that require additional complex calculations [14,15,17] or pre-procedural imaging [17,20] (for example, in the ATLAS score the LA size is presented as LA volume assessed by cardiac CT and indexed to body surface area with 1 point increment in total score per each 10 ml/m² of LA volume), the MB-LATER score is a simple clinically based score consisting of readily available clinical parameters [7] and is very practical in a busy outpatient clinic. While in the original derivation study [7] male sex was associated with higher risk of delayed AF recurrence occurring >1 year post-ablation, our results suggest that female gender may be a significant risk factor for the “earlier” recurrence occurring within the first year after CA. Some [8,9,17,20] but not all [14,15,18] of the scores shown in Table 3 confirmed this finding.

We believe that the MB-LATER score is additionally strengthened by including data on the presence of ERAF during the blanking post-ablation period. The occurrence of ERAF within the blanking period, albeit a post-event information, is a very specific finding in patients undergoing CA of AF and one of the strongest independent predictors of definite ablation failure and late PV reconnection at follow-up EP

procedure [1,13]. Data on ERAF are generally available to the clinicians since most patients are regularly monitored during the first few months after CA [1]. In addition, clinical type of AF is gradually and logically weighted in the scoring process, according to the expected long-term AF recurrence rate after ablation of PAF, PeAF and LSPeAF [1,7,13].

The predictive ability for LRAF of the CAAP-AF score [8], which includes Coronary disease, the LA diameter, Age, Persistent or long-standing persistent AF, the number of AADs failed prior to CA and Female sex, has been recently shown in an external validation cohort of PAF patients who underwent cryo-balloon PVI procedure [19]. In our study, the CAAP-AF showed a modest predictive value for AF recurrence post-ablation. However, we were unable to determine the best cut-off value of the CAAP-AF score for the risk stratification for LRAF. Furthermore, we feel that the importance of the number of AADs that have been used prior to CA has been overestimated in the original CAAP-AF scoring study. This finding was derived from a “historical” AF ablation cohort, thus making its clinical utility questionable in the contemporary setting, when an “early” invasive treatment is more commonly offered to patients who failed a single AAD or even as a first-line treatment [1,12,13].

Similar to other clinical risk factor-based scores, the MB-LATER score showed a modest predictive ability, likely as a result of overall biological and clinical complexity of the respective diseases. Importantly, whereas reasonably well-performing risk scores could aid to clinical decision making, they should not be used as a substitute for comprehensive clinical assessment.

Our study is limited by its retrospective observational design. Follow-up after CA was based on intermittent rhythm monitoring, and therefore the AF recurrence rate post-CA could have been underestimated due to missed asymptomatic or short-lasting AF episodes. Nevertheless, clinical follow-up strategy in the present study was in line with the current guidelines and the real-world clinical practice [1,12,13]. Among several published specific scores we validated only the MB-LATER and CAAP-AF score. Other specific scores were not tested because the variables required for those scores calculation were not available due to the retrospective study design.

5. Conclusion

In the present study, the simple and readily available MB-LATER score showed a significant, but modest predictive ability for recurrent AF occurring within the first 12 months post-AF ablation. Further prospective validation in multiple independent AF ablation cohorts is

needed to better define potential role of the MB-LATER score in the risk communication to patients, shared decision-making about AF ablation, and treatment decisions post-AF ablation.

Conflict of interest

None declared.

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