Implantable loop recorder for augmenting detection of new-onset atrial fibrillation after typical atrial flutter ablation

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BACKGROUND Patients with typical atrial flutter (AFL) undergoing successful cavotricuspid isthmus ablation remain at risk for future development of new-onset atrial fibrillation (AF). Conventional monitoring (CM) techniques have shown AF incidence rates of 18%–50% in these patients.

OBJECTIVES To evaluate whether continuous monitoring using implantable loop recorders (ILRs) would enhance AF detection in this patient population.

METHODS Veteran patients undergoing AFL ablation between 2002 and 2019 who completed at least 6 months of follow-up after the ablation procedure were included. We compared new-onset AF detection between those who underwent CM and those who received ILRs immediately following AFL ablation.

RESULTS A total of 217 patients (age: 66 ± 9 years; all male) participated. CM was used in 172 (79%) and ILR in 45 (21%) patients. Median follow-up duration after ablation was 4.1 years. Seventy-nine patients (36%) developed new-onset AF, which was detected by CM in 51 and ILR in 28 (30% vs 62%, respectively, $P < .001$). AF detection occurred at 7.7 months (IQR: 4.7–17.5) after AFL ablation in the ILR group vs 41 months (IQR: 23–72) in the CM group ($P < .001$). Eleven patients (5%) experienced cerebrovascular events (all in the CM group) and only 4 of these patients (36%) were on long-term anticoagulation.

CONCLUSION Patients undergoing AFL ablation remain at an increased risk of developing new-onset AF, which is detected sooner and more frequently by ILR than by CM. Improving AF detection may allow optimization of rhythm management strategies and anticoagulation in this patient population.

KEYWORDS Arrhythmia detection and monitoring; CTI-dependent atrial flutter; Implantable loop recorder; New-onset atrial fibrillation; Typical atrial flutter

(Heart Rhythm O^2 2021;2:255–261)

Introduction

Typical atrial flutter (AFL) is a common cardiac arrhythmia for which catheter ablation is highly successful.[1,2] However, patients who have undergone successful AFL ablation remain at risk for the future development of atrial fibrillation (AF) and thromboembolic events. Previous studies using conventional monitoring (CM) techniques, including intermittent electrocardiograms (ECGs), Holter monitors, and transtelephonic monitors (TTM), have demonstrated the occurrence of new-onset AF in this population to range from 18% to 50%.[3–17] Such a wide range suggests the limitations of CM for identifying true occurrence of AF in these patients. Long-term continuous monitoring with implantable loop recorders (ILRs) has been shown to increase the rate of arrhythmia detection compared with CM.[18] Prior studies have also investigated the utility of ILR for detecting AF in patients undergoing AFL ablation.[19,20] However, it is unclear whether patients participating in these studies had been adequately screened to exclude prior occurrence of AF. In addition, the population included in these studies was rather heterogeneous. We therefore investigated the occurrence of new-onset AF in an exclusive population of male veteran patients

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2666-5018/

https://doi.org/10.1016/j.hroo.2021.04.003

KEY FINDINGS

- Patients who have undergone atrial flutter (AFL) ablation remain at elevated risk for development of atrial fibrillation (AF).
- AF after AFL ablation is detected sooner and more frequently by continuous monitoring using implantable loop recorders (ILRs) than conventional monitoring.
- Earlier detection of AF may be useful for optimizing anticoagulation in this patient population.

undergoing successful AFL ablation using continuous monitoring by ILR. We hypothesized that continuous monitoring using ILR should enhance AF detection beyond CM as well as improve anticoagulation and arrhythmia management in these patients.

Methods

Study population

The study population comprised veterans who underwent radiofrequency ablation of AFL at the Corporal Michael J. Crescenz Veterans Affairs Medical Center (CMCVAMC) in Philadelphia between November 2002 and May 2019. Participating subjects were required to have undergone at least 6 months of follow-up post ablation. Patients with a prior history of AF were excluded. Data for the study patients were collected by performing a query of all records available within the Veterans Affairs–based computerized patient record system. This query was accomplished by reviewing patients' problem lists, inpatient and outpatient physician notes, scanned ECGs, TTM reports, ILR reports, imaging, and any other investigational work-up available in the computerized patient record system. Patient charts were reviewed to determine comorbid medical conditions present prior to AFL ablation, including age, coronary artery disease, systolic heart failure, valvular disease, hypertension, diabetes, chronic obstructive pulmonary disease, sleep apnea, chronic kidney disease, alcohol use, preprocedure AF, and preprocedure cerebrovascular events (CVE). Preprocedure echocardiograms were reviewed for left ventricular ejection fraction, left atrial size, and valvular disease. All ILR reports and associated tracings were reviewed. The use of medications, including beta-blockers, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, antiarrhythmic drugs, and anticoagulant agents (warfarin and direct oral anticoagulants) was determined both before and after ablation. Patients were deemed to be on long-term anticoagulation if they remained anticoagulated $\geq$1 year after ablation. The time from the ablation procedure to the development of postablation AF or CVE was determined. Scanned ECGs, Holter monitors, event monitors, and ILR recordings were correlated with clinical notes to further verify postablation AF. When available, radiographic information including computed tomography and magnetic resonance imaging were correlated with clinical progress notes to further validate postablation CVE. The above study protocol was approved by the institutional review board of CMCVAMC and adhered to the guidelines set forth in the Declaration of Helsinki. It was determined by the institutional review board to be "exempt from patient consent" owing to the use of retrospective and de-identified data.

AFL ablation

All procedures followed institutional guidelines of CMCVAMC. Our approach for AFL ablation has previously been described.[3] Briefly, a decapolar catheter was deployed in the coronary sinus and a decapolar or duodecapolar catheter was positioned in the right atrium (RA) behind the tricuspid valve and anterior to the crista terminalis with its distal tip overlapping lower lateral RA and the lateral cavotricuspid isthmus (CTI) region. Under fluoroscopic guidance, the mapping catheter was advanced via a long sheath into the RA and onward to the CTI region. Intracardiac echocardiography was used to facilitate catheter positioning and monitoring during lesion creation as per operator preference. For patients who presented in AFL, entrainment was performed to confirm that this was CTI-dependent arrhythmia. For patients who presented in sinus rhythm (and had clinically documented AFL), ablation was performed while pacing from the proximal poles of the catheter in the coronary sinus. The ablation endpoint was rate-independent bidirectional CTI block persisting for at least 20 minutes and this was required to be achieved for all patients included in this study. Following this, sheaths and catheters were removed.

ILR implant

Beginning in 2014 when the use of the ILR platform was approved by our local Veterans Affairs administration, patients were offered ILR as the first-line monitoring strategy after AFL ablation. Those who declined ILR underwent CM. Prior to 2014, all patients underwent CM. The ILR device (Reveal or LINQ; Medtronic Inc, Minneapolis, MN) was implanted while the patient was still on the procedure table. This was accomplished by administering 5–10 cc of 1%–2% lidocaine in the skin and subcutaneous tissue of the left parasternal area along the third or fourth intercostal space. Next, a small stab incision was made, through which the ILR delivery system was advanced, and the device was positioned to record an adequate signal. The site of implant was then closed with topical tissue adhesive application with or without prior application of a suture to approximate the underlying subcutaneous tissue. In all cases the ILR settings were programmed for detection as follows: AT/AF detection – least sensitive, Episode duration $>$10 min, and Ectopy rejection – aggressive. We chose these settings so as to maximize the accuracy of AF detection by the ILR platform, based on our prior experience.[21]

Postablation follow-up

Patients were discharged home after monitoring overnight in the hospital. They were subsequently seen in follow-up 4–6 weeks after the ablation procedure and then again at 6 months

and 1 year post ablation. Beyond that, follow-up was recommended annually. For patients undergoing CM, at the first follow-up visit, patients were provided either 4 weeks of trans-telephonic monitor (TTM) or 14-day continuous monitoring using Zio patch (iRhythm Technologies, Inc, San Francisco, CA). Patients also underwent 12-lead ECG at each clinic visit and additional TTM or Zio patch monitoring was provided for symptoms suggestive of arrhythmia recurrence. For patients undergoing ILR monitoring, recordings were downloaded remotely (via CareLink; Medtronic Inc, Minneapolis, MN) by the device clinic personnel at the CMCVAMC every 2–3 months for the duration of the ILR (~3 years). Downloaded recordings were assessed for arrhythmia burden and the tracings were analyzed for accuracy of the diagnosed rhythm. In the event of discrepancy between the arrhythmia diagnosis and recorded rhythm, an electrophysiology provider was required to adjudicate. At the end of the ILR battery life, patients were given the option to have the device explanted with or without implantation of a replacement ILR.

Arrhythmia and anticoagulation management

In the event of arrhythmia detection (AF, AFL, significant bradyarrhythmia), patients were counseled for appropriate management including use of atrioventricular nodal blockers, antiarrhythmic drug (AAD) therapy, catheter ablation, and/or pacemaker implantation. Anticoagulation was continued for at least 4 weeks post AFL ablation. During the early study period (2002–2012), patients were offered the option of discontinuing anticoagulation if they did not have documented AF or AFL without AAD. However, after the guidelines were modified to include CHA_2DS_2-VASc score for decision-making regarding anticoagulation cessation in patients with AFL undergoing catheter ablation,[22] this option was offered only to patients with a CHA_2DS_2-VASc score of ≤ 1 who did not have any documented AF or AFL recurrence.

Study endpoints

The primary study endpoint was detection of AF lasting more than 30 seconds detected by CM or any AF detected by ILR. Similar assessment was made for occurrence of organized atrial tachyarrhythmia including AFL. Additionally, occurrence of CVE including transient ischemic attacks (TIA), ischemic strokes, and hemorrhagic strokes was also determined.

Statistical analysis

Continuous variables are expressed as mean ± standard deviation or as median with interquartile range (IQR), as needed. Categorical variables are expressed as numbers and percentages. Continuous variables were compared using the unpaired Student t test (parametric) or Mann-Whitney U test (nonparametric). Categorical variables were compared using the χ^2 test or Fisher exact test. Two-tailed $P < .05$ was considered statistically significant. The risk of AF after ablation was determined as a percentage and compared using univariate analysis. The duration until detection of AF was determined using the time interval between ablation and detection of first episode of AF. Time of detection was compared using Student t test. Kaplan-Meier curves were generated, and hazard ratios were determined using the log-rank test. All statistical analyses were performed using SPSS version 24 (IBM Corp, Armonk, NY).

Table 1 Baseline characteristics of the study cohort

	All veterans N = 217	ILR group N = 45	CM group N = 172	*P* value
Age	66 ± 9	66 ± 8	66 ± 10	.84
African-American	97 (45%)	20 (44%)	77 (45%)	.97
White	108 (50%)	23 (51%)	85 (50%)	.97
Body mass index	31.5 ± 7	32 ± 7	31 ± 7	.35
Hypertension	187 (86%)	35 (78%)	152 (88%)	.07
Diabetes mellitus	111 (51%)	20 (44%)	91 (53%)	.31
Coronary artery disease	97 (45%)	14 (31%)	83 (48%)	.04*
Congestive heart failure	96 (44%)	12 (27%)	84 (49%)	.01*
Prior CVE	16 (7%)	6 (13%)	10 (6%)	.09
Valvular disease	57 (26%)	4 (9%)	53 (31%)	.01*
COPD	66 (30%)	11 (24%)	55 (32%)	.33
Chronic kidney disease	53 (24%)	9 (20%)	44 (26%)	.44
Obstructive sleep apnea	64 (29%)	15 (33%)	49 (29%)	.53
Alcohol use	39 (18%)	7 (16%)	32 (19%)	.64
CHA_2DS_2VASc	3.1 ± 1.4	2.8 ± 1.7	3.2 ± 1.4	.13
LVEF (%)	46 ± 18	50 ± 16	45 ± 18	.07
LA diameter (cm)	4.3 ± 0.7	4.2 ± 0.7	4.3 ± 0.7	.61

CM = conventional monitoring; CVE = cerebrovascular event; COPD = chronic obstructive pulmonary disease; ILR = implantable loop recorder; LA = left atrium; LVEF = left ventricular ejection fraction.
*$P \leq .05$.

Results

Study population

Between 2002 and 2019, a total of 217 male patients underwent successful AFL ablation at the CMCVAMC and were included in the study. The mean age of the population was 66 ± 9 years. At the time of the procedure 158 patients presented in AFL and 59 presented in sinus rhythm. Following successful ablation, 172 (79%) of these patients underwent CM and 45 (21%) underwent ILR monitoring. The median follow-up duration was 4.1 years (IQR: 1.3–6.9). The follow-up duration was longer in patients undergoing CM compared with ILR monitoring (5.4 years [IQR: 2.3–7.8] vs 1.3 years [IQR: 0.5–2.4], respectively; $P < .001$). Baseline characteristics of patients in the study are shown in Table 1. There was no difference in age or racial composition between the 2 groups. Patients in the CM group had a higher prevalence of coronary artery disease (48% vs 31%, $P = .04$), congestive heart failure (49% vs 27%, $P = .01$), and valvular disease (31% vs 9%, $P = .01$). There was no difference in the left ventricular ejection fraction or left atrial size between the 2 groups at time of ablation. There was also no difference in the CHA_2DS_2-VASc scores between the 2 groups (3.2 ± 1.4 for CM and 2.8 ± 1.7 for ILR; $P = .13$) at time of ablation.

Table 2 Major outcomes of the study

	All Veterans N=217	ILR group N=45	CM group N=172	*P* value
New AF	79 (36%)	28 (62%)	51 (30%)	<.001*
Time to new AF (IQR), months	24 (9–52)	7.7 (4.7–17.5)	41 (23–72)	<.001*
New CVE	11 (5.1%)	0	11 (6.4%)	.13
Long-term anticoagulation (>1 y)	93 (43%)	31 (69%)	62 (36%)	<.001*
Median follow-up (IQR), years	4.1 (1.3–6.9)	1.3 (0.5–2.4)	5.4 (2.3–7.8)	<.001*

AF = atrial fibrillation; CM = conventional monitoring; CVE = cerebrovascular event; ILR = implantable loop recorder.
*$P \leq .05$.

Detection of new-onset atrial fibrillation

Within the entire cohort (n = 217), new-onset AF was detected in 79 patients (36%; Table 2). AF detection rate was significantly higher in patients undergoing ILR vs CM (62% vs 30%, respectively; $P < .001$). Also, the time to AF detection was significantly shorter in the ILR vs CM groups (7.7 months [IQR: 4.7–17.5] vs 41 months [IQR: 23–72], respectively; $P < .001$). A Kaplan-Meier curve comparing the rate of detection of new-onset AF between the 2 groups over a 3-year period is shown in Figure 1. AF was detected in 47% of patients in the ILR group within 1 year after undergoing AFL ablation.

Long-term anticoagulant use and occurrence of new cerebrovascular events

More patients in the ILR group received long-term anticoagulation compared with the CM group (69% vs 36%, $P < .001$). Eleven (5.1%) patients experienced CVE after ablation and they were all in the CM group. CVE occurred at a median of 29 months (IQR: 18– 66) after ablation. CVE were categorized as ischemic stroke (4/11), hemorrhagic stroke (4/11), TIA (2/11), and unspecified (1/11). Among the 11 patients with CVE, 6 (55%) had AF or AFL detected after ablation. The median CHA_2DS_2-VASc score for these patients was 3. At the time of CVE, 7 patients were not receiving anticoagulation and 4 patients were on warfarin therapy. The reasons for patients not receiving anticoagulation included the following: no history of stroke or arrhythmia other than AFL in 2 patients, self-discontinuation in 2 patients, fall risk in 1 patient, and for unknown reasons in 2 patients. Of the 6 patients who developed ischemic stroke or TIA, 3 (50%) had AF or AFL detected after ablation either before or after CVE. Five of these patients (83%) were not on anticoagulation at the time of CVE. One patient had a mechanical mitral valve and experienced CVE despite being on warfarin therapy with an international normalized ratio of 3.2 at the time of the event.

Occurrence of organized atrial tachyarrhythmias

Occurrence of organized atrial tachyarrhythmia and supraventricular tachycardia including AFL, atrioventricular nodal reentrant tachycardia, and atrial tachycardia are summarized in Table 3. Among the entire cohort, 37 patients (17%) developed either recurrent typical AFL (n = 13; 6%) or atypical AFL (n = 20; 9%). The rate of recurrence of typical AFL was similar between the CM and ILR group (5% vs 9% respectively, $P = .48$). There was a trend toward a higher rate of atypical AFL in the CM group vs ILR group (11% vs 2%, respectively, $P = .08$).

Antiarrhythmic drug use and catheter ablation during follow-up

Use of antiarrhythmic drugs and catheter ablation for AF, AFL or other supraventricular tachycardias after initial ablation are summarized in Table 4. Of note, 40 (18%) patients in the entire cohort received antiarrhythmic medications, including amiodarone in 9%, dofetilide in 4%, sotalol in 4%, flecainide in 3%, and propafenone in 0.5%. Ten patients (5%) underwent pulmonary vein isolation after CTI ablation, 3 of whom were in the ILR group. Seven patients (3%) underwent repeat CTI ablation, 1 of whom was in the ILR group.

Discussion

The salient findings of our study are that (1) new-onset AF can occur in 36% of patients after successful typical flutter ablation, (2) use of ILR can detect AF more frequently and earlier than CM in these patients, and (3) ILR monitoring was associated with an increased rate of long-term anticoagulation use. Of note, our study included only male veteran patients and so may not be generalizable to other populations.

The prevalence of AF remains high after successful AFL ablation, and previous studies have shown the utility of ILR

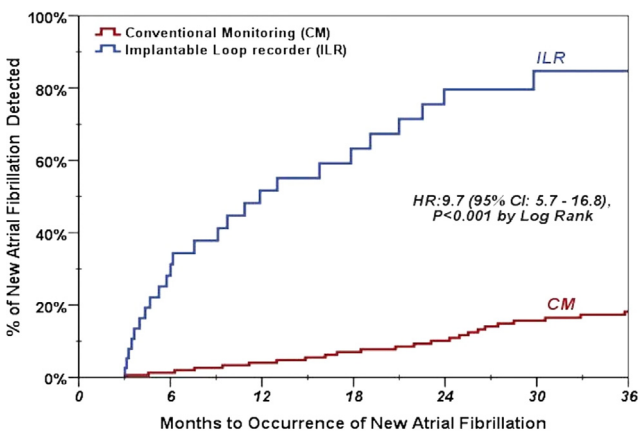

Figure 1 Kaplan-Meier curves showing time to atrial fibrillation detection by implantable loop recorders vs conventional monitoring.

Table 3 Prevalence of atrial and supraventricular tachycardia

	All veterans N = 217	ILR group N = 45	CM group N = 172	*P* value
AFL after ablation	37 (17%)	5 (11%)	32 (19%)	.27
Typical AFL	13 (6%)	4 (9%)	9 (5%)	.48
Atypical AFL	20 (9%)	1 (2%)	19 (11%)	.08
AFL, unspecified type	4 (2%)	0	4 (2%)	.58
Atrial tachycardia	5 (2%)	1 (2%)	4 (2%)	
MAT	1 (0.5%)	0	1 (0.6%)	
Accelerated junctional rhythm	1 (0.5%)	0	1 (0.6%)	
AVNRT	2 (0.9%)	0	2 (1%)	
SVT, otherwise unspecified	4 (2%)	3 (7%)	1 (0.6%)	

AF = atrial fibrillation; AFL = atrial flutter; AVNRT = atrioventricular nodal reentrant tachycardia; CM = conventional monitoring; ILR = implantable loop recorder; MAT = multifocal atrial tachycardia; SVT = supraventricular tachycardia.

for facilitating AF detection in this population.[20] The findings of our study are consistent with those observations. However, our cohort was bigger and comprised exclusively male veteran patients. Also, in our study we used prespecified arrhythmia detection settings, which have been previously shown to enhance the accuracy of the Medtronic ILR platform for AF detection.[21] Our study is also the first to compare the detection of new-onset AF in this patient population using ILR vs CM. As expected, AF detection was more frequent and occurred sooner after AFL ablation in the ILR vs CM group. Our data suggest that CM may miss at least half of patients with new-onset AF after undergoing AFL ablation. This may also be a reflection of longer monitoring time inherent to the use of ILR, which was a median duration of 1.3 years longer than CM. We acknowledge, however, that our study population may have had asymptomatic paroxysmal AF predating the AFL ablation that may have been overlooked before they received ILR. Nevertheless, failure to detect AF by CM has implications for the overall outcome of these patients, especially in light of the recently published EAST-AFNET4 trial, which showed that early rhythm control with AAD and catheter ablation for AF was associated with better long-term outcomes over an extended follow-up period.[23]

Table 4 Antiarrhythmic use following CTI ablation

	All veterans N = 217	ILR group N = 45	CM group N = 172	*P* value
Antiarrhythmic use after ablation	40 (18%)	3 (7%)	37 (22%)	<.001*
Amiodarone	19 (9%)	1 (2%)	18 (10%)	
Dofetilide	9 (4%)	1 (2%)	8 (5%)	
Sotalol	8 (4%)	0	8 (5%)	
Flecainide	6 (3%)	1 (2%)	5 (3%)	
Propafenone	1 (0.5%)	0	1 (0.6%)	
AF ablation	10 (5%)	3 (7%)	7 (4%)	.44
Re-do CTI ablation	7 (3%)	1 (2%)	6 (3%)	1
AVJ ablation	1 (0.5%)	0	1 (0.6%)	1
Slow pathway modification	1 (0.5%)	0	1 (0.6%)	1

AF = atrial fibrillation; AVJ = atrioventricular junction; CM = conventional monitoring; CTI = cavotricuspid isthmus; ILR = implantable loop recorder.
*$P \leq .05$.

Failure to detect asymptomatic paroxysmal AF also has implications for increased risk of CVE.[24] In our series, all CVEs after CTI ablation occurred exclusively in the CM group. While the CM group did have higher comorbidities (coronary artery disease, congestive heart failure, valvular disease, etc), they experienced less AF yet more CVEs. The former observation likely reflects lower AF detection rates with CM vs ILR monitoring; and although patients manifesting greater comorbidities are more prone to CVEs, we cannot discount undetected AF as a potential contributor. In addition, the majority of patients who experienced CVEs after ablation were not taking anticoagulation at the time of event. This may be reflective of the prevailing practice in that time period (before 2012) when patients with AFL were usually taken off anticoagulation 4–6 weeks after undergoing successful CTI ablation.[3] In our study, almost twice as many patients in the ILR group received long-term anticoagulation compared with the CM group. This may be because earlier and more frequent detection of AF by ILR can facilitate shared decision-making between physician and patient and increase the likelihood of patients staying on anticoagulation. However, we acknowledge that higher anticoagulation use in the ILR group may also reflect change in practice owing to guideline modifications that now recommend the use of CHA_2DS_2-VASc score for decision-making regarding anticoagulation cessation in patients with typical AFL undergoing catheter ablation.[22] We also want to point out that since this was a retrospective observational study, medical management decisions including criteria for continuing anticoagulation were left to patients' health care providers. Hence we cannot account for additional factors that may have influenced the rate of anticoagulation in the 2 patient groups. Furthermore, we acknowledge that contemporary guidelines recommend that long-term anticoagulation use in these patients should be based on the CHA_2DS_2-VASc scores. Thus, as per these recommendations, all of the patients who developed CVE in our study in the CM group should have remained on anticoagulation. Thus, the findings of our study may not change the current guideline practice. Nonetheless, medical providers often face the clinical reality of patient hesitancy to continue anticoagulation long term. Perhaps the objective documentation of arrhythmia occurrence on ILR may convince some of these patients to remain on long-term anticoagulation when it is indicated. This may be particularly useful in patient groups that are considered to be at a relatively lower risk—ie, men and women with CHA_2DS_2-VASc scores of ≥ 1 and ≥ 2, respectively. This may be worthwhile studying prospectively.

It is interesting to note that despite higher detection of AF by ILR, more patients in the CM group received antiarrhythmic drug therapy. A possible explanation for this discrepancy is that patients with AF in the CM group were more likely to be symptomatic. It is also possible that patients

in the CM group had higher AF burden. Also, patients in the CM group showed a trend toward higher occurrence of atypical AFL, which can sometimes be more challenging to rate control than AF. Thus, these patients may have been more willing to receive and accept rhythm control.

Limitations

Our study represents a single-center experience consisting of an all-male veteran population with high incidence of comorbidities, and female subjects were not studied. Thus, our observations may not be generalizable. In addition, the sample size for patients who received ILR (n = 45) was small. We cannot exclude the possibility that patients included in the study may have had subclinical AF prior to ablation. Data for estimating AF burden were also not consistently available. Although we identified a trend toward higher rates of CVE in the CM group, our study does not prove that AF was the direct cause of the observed CVEs. Similarly, although the majority of patients experiencing thromboembolic CVEs were not anticoagulated, we cannot ascribe these as being exclusively AF related, given the high rates of other comorbid conditions present in our study population. Our study spanned 17 years, during which the approaches to arrhythmia monitoring and anticoagulation use have evolved. There may have been other unidentified differences in patient characteristics and arrhythmia management over this extended time period. Since our study was a retrospective one that extended over a long period, not all of the records pertaining to ILR and Zio-patch recordings were available for us to review and consistently validate. We are therefore unable to accurately assess the sensitivity and specificity of these platforms in our patient population. In a previous study, the reported sensitivity and specificity of the Medtronic Reveal XT platform were 96.1% and 85.4%, respectively.[25] We have also previously shown that extending the AF detection duration to 10 minutes enhances the accuracy of AF detection by the Reveal XT platform, with an overall sensitivity of 92.4%.[21,26]

Conclusion

Patients undergoing typical AFL ablation remain at an increased risk of developing new-onset AF, which is detected sooner and more frequently by continuous monitoring using ILR than using CM. Earlier detection of AF may be useful for optimizing anticoagulation and rhythm control in this patient population. However, since our study included only male veteran patients, these findings may not be generalizable to other populations.

Funding Sources

This study was supported by The Richard T. & Angela Clark Innovation Fund in Cardiovascular Medicine.

Disclosures

Gary Peng: None; Aung N. Lin: None; Edmond Obeng-Gyimah: None; Samantha N. Hall: None; Ya-wen Yang: None; Shiquan Chen: None; Michael Riley: None; Rajat Deo: None; Aasima Ali: None; Jeffery Arkles: None; Andrew E. Epstein: has received speaking honorarium from Medtronic, Inc; Sanjay Dixit: has received speaking honorarium and grant funding from Medtronic, Inc.

Authorship

All authors attest they meet the current ICMJE criteria for authorship.

Patient Consent

This study was determined by the institutional review board to be "exempt from patient consent" owing to the use of retrospective and de-identified data.

Ethics Statement

The study protocol was approved by the institutional review board of CMCVAMC and adhered to the guidelines set forth in the Declaration of Helsinki.

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