Atrial rhythm recurrences early after the procedure are not uncommon in patients undergoing atrial fibrillation (AF) ablation.1,2 These typically manifest as AF and/or organized atrial tachyarrhythmias (OATs) and can be encountered in as many as 45% of subjects for up to 3 months after the procedure.3 The mechanism underlying early recurrence of atrial arrhythmias (ERA) remain poorly understood but have been attributed to stimulatory effect of radiofrequency energy, imbalance in the autonomic supply of the heart, a generalized inflammatory state, and so forth, all of which are considered transient.3–5 Consistent with this hypothesis, up to 60% of patients manifesting ERA eventually become arrhythmia free without needing another ablation.1,2 Thus, at the present time it is common practice to treat ERA conservatively. This approach is also supported by the HRS/EHRA/ECAS consensus statement, which recommends against immediate reablation for such early arrhythmia occurrences.3 However, as our experience with AF ablation has grown, there is evidence supporting a strong and independent association between ERA and long-term recurrence of AF.1,2,7 These findings cast ERA in a new light and suggest that their occurrence may in fact reflect reestablishment of the original AF substrate. If this is true, then it would support a role for early repeat ablation in patients manifesting ERA. However, such an approach has not been widely adopted. This is probably because of reluctance on the part of physicians to perform early realablation because only half the patients manifesting ERA will have long-term AF recurrence. Thus, what is lacking currently is a better understanding of the corelationship between ERA events and future AF occurrences. This gap in our knowledge is largely due to our inability to continuously monitor patients after the AF ablation procedure. The monitoring modalities that are currently used include mobile cardiac outpatient telemetry (MCOT) or Holter units, which are typically worn for 1–4 weeks.3 The limitations of such an approach include a short recording duration and patient noncompliance. The implantable loop recorder (ILR) is an alternate modality that has been used for extended continuous monitoring in a variety of scenarios. ILRs, although requiring surgical implant, are small and unobtrusive and can overcome some of the limitations of MCOT and Holter units. Recently, Medtronic Inc (Minneapolis, MN) has developed an ILR, Reveal XT, which incorporates a unique ventricular signal-based algorithm for diagnosing atrial arrhythmias. Early experience with this device has shown promising results on its capability for accurately diagnosing AF.7 Because this device is able to make continuous recordings over extended periods (up to 3 years), it certainly has the capability of comprehensively assessing ERA in patients after ablation. Such enhanced recording also offers the possibility of furthering our understanding of the corelationship, if any, between subtypes of ERA and long-term AF recurrence. This in turn may allow us to develop a better approach for managing ERA.

Consistent with these aims, Pokushalov et al.8 in this issue of Circulation: Arrhythmia and Electrophysiology, report their observations on the use of ILR to detect ERA and select patients for early repeat catheter ablation after the initial AF ablation procedure. Their study population comprised 286 patients with paroxysmal AF. The investigators used wide-area pulmonary vein (PV) isolation and empirical linear ablations (left atrial roof and left inferior PV–to–mitral annular lines). Additionally in 28% of the patients, cavo-tricuspid isthmus ablation was also performed. Subjects were subsequently monitored by ILR (Reveal XT), and, based on whether ERA was observed (initial 3 months after ablation), these patients were randomly assigned to 3 treatment arms. Subjects who did not have ERA (group 1) were taken off antiarrhythmic drugs, (AADs), whereas those manifesting ERA (group 2) were further randomly assigned to treatment with AADs for 6 weeks (group 3) or repeat early ablation (group 4). In the latter group, early ablation was only offered to patients in whom ILR provided information on AF onset (atrial premature beats and/or OAT), whereas the remaining patients (manifesting AF onset without obvious trigger) received 6 weeks of AADs. All patients were followed for 1 year (from the time of ablation) by clinic visits and monthly ILR interrogations. The primary study end point was AF-free survival (defined as ILR-documented AF burden of <0.5% on any interrogation beyond 3 months). Patients not demonstrating this and/or requiring repeat ablation for arrhythmia recurrences beyond 3 months were considered to have failed the procedure. The investigators also compared outcomes between the various subgroups of patients, that is, those with

Role of Continuous Monitoring for Optimizing Management Strategies in Patients With Early Arrhythmia Recurrences After Atrial Fibrillation Ablation
Sanjay Dixit, MD, FAHA; Francis E. Marchlinski, MD, FAHA

© 2011 American Heart Association, Inc.

From the Cardiovascular Division, Department of Medicine, Hospital of the University of Pennsylvania, Philadelphia, PA.
Correspondence to Sanjay Dixit, MD, Cardiovascular Division, Department of Medicine, Hospital of the University of Pennsylvania, 9 Founders, 3400 Spruce St, Philadelphia, PA 19104. E-mail Sanjay.dixit@uphs.upenn.edu

(Circ Arrhythm Electrophysiol. 2011;4:791-793.)
© 2011 American Heart Association, Inc.
Circ Arrhythm Electrophysiol is available at http://circcep.ahajournals.org
DOI: 10.1161/CIRCEP.111.968073
and those without manifest triggers of AF randomly assigned to ablation versus AADs. Using this rather complicated study design and unconventional monitoring strategy, these investigators report single-procedure success of 42% at the end of 3 months. They also report long-term success rates of 89% in patients undergoing early repeat ablation targeting specific AF triggers and arrhythmia control rates of 63% in subjects having AF without obvious triggers that were managed on AADs. In comparison, subjects manifesting AF triggers who were randomly assigned to AADs did much worse (only 4% had long-term freedom from AF). On the basis of these observations, the investigators indicate that in patients having ERA after AF ablation, the strategy of deciding subsequent therapy guided by diagnostic data provided by continuous monitoring increases the probability of maintaining sinus rhythm. As stated, this certainly seems to be a more erudite approach in managing ERA than the current prevalent practice of not intervening during the initial blanking period. However, do the results of this study justify the authors’ claims?

To answer this, several aspects of the study deserve careful analysis. The premise of this study is the monitoring strategy that enabled these investigators to document AF recurrences and identify underlying triggers. The obvious question is whether Reveal XT can provide such detailed information. The Reveal XT platform has a dedicated AF detection algorithm that uses irregularity of the R-R intervals over a 2-minute window to calculate differences between consecutive R-R segments (similar to a Lorenz plot). AF is diagnosed on the basis of a certain pattern of “R to R” irregularity. However, P waves and/or atrial activity are not a part of this diagnostic algorithm. The device is capable of storing up to 22.5 minutes of patient-activated events. The device also has an episode log that can catalog 30 automatically detected AF episodes and up to 10 patient-activated episodes that are stored in the “role-over” memory (latest episode overwrites the oldest stored episode). In the clinical setting, Reveal XT has shown promising results, with an overall accuracy of 98.5%, sensitivity of 96.1%, specificity of 85.4%, and positive/negative predictive values of 79.3% and 97.4%, respectively, for detecting AF. However, it is important to note that the population of the current study (after AF ablation) is somewhat different from the subjects included in the original clinical trial in which the diagnostic performance of this device was assessed. Also, compared with the present study, in the previous trials the overall monitoring period for device was assessed. Also, compared with the present study, in the previous trials the overall monitoring period for device was assessed.

Reveal XT accurately categorized AF in 96% of the patients having atrial arrhythmias after the ablation procedure. However, in 20% of patients, sinus rhythm with frequent premature atrial/ventricular complexes was misclassified as AF. Also in 25% of the subjects, signal undersensing resulted in rhythm misclassification as asystole or bradycardia. Thus, our own experience with Reveal XT in patients undergoing AF ablation shows it to be sensitive for detecting AF recurrences, but there was a high rate of false-positive categorizations. We therefore remain skeptical of the ability of Reveal XT as reported in the current study to consistently detect triggers initiating AF. Moreover, these investigators used only 10 beats before AF onset for trigger identification. In our opinion, 10 beats is too short a window to adequately and consistently define AF triggers because AF onset is not uncommonly preceded by several minutes of atrial instability. We also want to point out that because atrial activity is not always consistently visualized on the Reveal-generated, single ECG lead recording, this inadequacy may further limit accurate determination/categorization of AF triggers. These limitations may also be the reason why in approximately 35% of the subjects in this study, AF triggers were not seen. These AF occurrences were labeled “sudden onset” (without a triggering mechanism) by the authors, and they found better response of this form of AF to AADs. However, it is inconceivable for AF to initiate without a trigger (atrial premature complex or OATs), and so there is no good mechanistic explanation for the differential response of AF recurrences to AADs as observed in this study. It also remains unclear as to why these investigators chose to administer AADs for 6 weeks only in patients randomly assigned to conservative treatment. Probably the most interesting aspect of this study pertains to the authors’ claim that continuous monitoring guided their repeat ablation strategy, which translated into long-term procedural success. As per the study methodology, in subjects demonstrating atrial premature complexes preceding AF, PV reconnection was assessed, whereas in those showing OATs as AF triggers, the linear lines were tested for conduction. In the 54 patients undergoing early repeat ablation, at least 1 vein had reconnected in 80% of the subjects and conduction across the linear lines had recovered in 31% of the patients (11% across the cavo-tricuspid isthmus). However, as reported, it remains unclear whether the early repeat ablation approach was indeed tailored to the nature of the triggers because the authors have not specifically described PV reconnection rates and recurrence of conduction across linear lines vis-à-vis subjects manifesting atrial premature complexes and OATs as AF triggers, respectively. Furthermore, the unusually high recurrence of conduction across linear lines coupled with OATs that were observed after ablation in this series would suggest that creating empirical linear lines is indeed proarrhythmic in patients with paroxysmal AF and therefore ill-advised.

So, what are we to take from this study? First and foremost, these investigators are to be commended for their efforts in approaching the important issue of ERAs after AF ablation, using an innovative management approach guided by a continuous monitoring strategy. The study results offer some interesting observations on the differential response of ERA...
subtypes to early repeat catheter ablation versus AAD therapy. Although some of these observations are not adequately explained mechanistically, at the very least, they are hypothesis-generating and deserving of further exploration. More than anything else, the results of this study provide favorable evidence for extended monitoring in patients undergoing AF ablation using ILR and/or other similar recording devices. However, for the current generation of ILR devices to be universally acceptable for monitoring patients in this scenario, they must be capable of diagnosing atrial arrhythmias more accurately. This will require improvements in their diagnostic abilities, including finding a way to incorporate atrial activity as a part of the diagnostic algorithm. Given the rapid growth in the field of cardiac monitoring, it is quite conceivable that a future generation of ILR devices will be smaller with extended storage memory and better diagnostics. Such devices may indeed enable us to understand better the nature of early arrhythmia recurrences in patients undergoing AF ablation, and that knowledge may be helpful in facilitating better resource utilization for these patients.

**Sources of Funding**

This work was supported in part by the Harlan Batrus and Murray Bloom Research Funds at the University of Pennsylvania.

**Disclosures**

Drs Dixit and Marchlinski receive speaking honorarium from Medtronic and are co-investigators on a study grant funded by Medtronic.

**References**


**Key Words:** Editorsials ■ atrial fibrillation ■ ablation ■ monitoring
Role of Continuous Monitoring for Optimizing Management Strategies in Patients With Early Arrhythmia Recurrences After Atrial Fibrillation Ablation
Sanjay Dixit and Francis E Marchlinski

Circ Arrhythm Electrophysiol. 2011;4:791-793
doi: 10.1161/CIRCEP.111.968073
Circulation: Arrhythmia and Electrophysiology is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2011 American Heart Association, Inc. All rights reserved.
Print ISSN: 1941-3149. Online ISSN: 1941-3084

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circep.ahajournals.org/content/4/6/791

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation: Arrhythmia and Electrophysiology can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation: Arrhythmia and Electrophysiology is online at:
http://circep.ahajournals.org/subscriptions/