Twenty-Four–Hour Holter Monitor Follow-Up Does Not Provide Accurate Heart Rhythm Status After Surgical Atrial Fibrillation Ablation Therapy

Up to 12 Months Experience With a Novel Permanently Implantable Heart Rhythm Monitor Device

Thorsten Hanke, MD; Efstratios I. Charitos, MD; Ulrich Stierle, MD; Antje Karluss, MD; Ernst Kraatz, MD; Bernhard Graf, MD; Axel Hagemann, MD; Martin Misfeld, MD, PhD; Hans H. Sievers, MD

Background—Twenty-four–hour Holter monitoring (24HM) is commonly used to assess cardiac rhythm after surgical therapy of atrial fibrillation (AF). However, this “snapshot” documentation leaves a considerable diagnostic window and only stores short-time cardiac rhythm episodes. To improve accuracy of rhythm surveillance after surgical ablation therapy and to compare continuous heart rhythm surveillance versus 24HM follow-up intraindividually, we evaluated a novel implantable continuous cardiac rhythm monitoring (IMD) device (Reveal XT 9525).

Methods and Results—Forty-five cardiac surgical patients (male 37, mean age 69.7±9.2 years) with a mean preoperative AF duration of 38±45 m were treated with either left atrial epicardial high-intensity focus ultrasound ablation (n=33) or endocardial cryothermy (n=12) in case of concomitant mitral valve surgery. Rhythm control readings were derived simultaneously from 24HM and IMD at 3-month intervals with a total recording of 2021 hours for 24HM and 220 766 hours for IMD. Mean follow-up was 8.3±3.97 m (range 0 to 12 m). Mean postoperative AF burden (time period spent in AF) as indicated by IMD was 37±43%. Sinus rhythm was documented in 53 readings of 24HM, but in only 34 of these instances by the IMD in the time period before 24HM readings (64%, P<0.0001), reflecting a 24HM sensitivity of 0.60 and a negative predictive value of 0.64 for detecting AF recurrence.

Conclusion—For “real-life” cardiac rhythm documentation, continuous heart rhythm surveillance instead of any conventional 24HM follow-up strategy is necessary. This is particularly important for further judgment of ablation techniques, devices as well as anticoagulation and antiarrhythmic therapy.

Key Words: atrial fibrillation ■ surgical therapy ■ heart rhythm documentation ■ follow-up study

Because of its remarkable results, with a 90% success rate of restoring sinus rhythm and a risk reduction of stroke to more than 95%, the Cox Maze III procedure up to now is considered the gold standard for atrial fibrillation ablation therapy.1,2 However, these results have to be addressed with the confinement that procedural success had been evaluated by postoperative symptomatic atrial fibrillation episodes only.3

Numerous studies, however, have demonstrated that a majority of AF episodes are asymptomatic and even in patients with symptomatic atrial fibrillation a lack of correlation between symptoms and actual heart rhythm was reported.4 Furthermore, asymptomatic AF episodes even increase after atrial fibrillation ablation treatment.5–7

AF and Documentation
To document asymptomatic AF episodes more precisely, heart rhythm documentation is mostly achieved by short-time—“snapshot”—rhythm surveillance at often irregular time intervals with different short- or midterm cardiac rhythm monitor devices. The ability of these monitor techniques to accurately identify patients with AF has yet not been quantified. Furthermore, reporting the analysis of these device driven results incorporates different uncertainties: rhythm documentation “at last follow-up” overestimates success rate while using actuarial methods underestimates it.8,9 Therefore, in order to document postprocedural heart rhythm appropriately and thus enable a more “real-life” success report after ablation therapy, it has been proposed that an implantable...
Continuous cardiac rhythm monitoring device would be most appropriate.8,9

Continuous Heart Rhythm Surveillance
We report the first experience in surgical atrial fibrillation therapy with a permanently implantable direct cardiac rhythm monitor device (IMD), the Reveal XT 9525 (Medtronic, Inc). It was the aim of the present study to accurately evaluate heart rhythm development after surgical ablation therapy and to examine potential discrepancies in identifying postprocedural atrial fibrillation recurrence by intra-individually comparing 2 different types of follow-up strategies: conventional 24-hour Holter monitoring (24HM) at prescheduled time intervals and continuous cardiac rhythm surveillance.9,10

Patients and Methods

Surgical Ablation
From July 31, 2007 until July 27, 2008, 45 cardiac surgical patients with a history of atrial fibrillation from a single center prospectively received a novel implantable cardiac monitor device peroperatively. 43 patients were primarily scheduled for cardiac surgery; left atrial ablation therapy was performed concomitantly. In 2 patients, lone atrial fibrillation was the indication for left atrial ablation surgery. Preoperative patient demographics are displayed in the Table. Because of the small study group, comparison of different ablation lesion sets or different ablation devices with respect to sinus rhythm reestablishment was not intended; therefore, 2 different patient groups were included in the study. In 33 patients, concomitant left atrial ablation and in 2 patients left atrial ablation only was achieved by using high-intensity focused ultrasound epicardially (Epicor Cardiac Ablation System, St. Jude Medical). Isolation of the pulmonary veins was achieved by creating a “box lesion,” in patients with longstanding persistent atrial fibrillation an additional ablation line of the left atrial isthmus was applied. In 12 patients, concomitant endocardial left atrial ablation therapy was performed utilizing cryothermia (ATS CryoMaze Surgical Ablation System, ATS Medical, Inc) before mitral valve surgery. Ablation lines in these patients are described elsewhere.11 In all patients, the IMD was implanted subcutaneously in the left pectoral region promptly after chest closure.

Continuous Heart Rhythm Surveillance
The insertable cardiac rhythm monitor Reveal XT 9529 is a small leadless device that is implanted subcutaneously in the left pectoral area. It is programmed to automatically store ECG data on detection of arrhythmia events by analyzing the irregularity/regularity of R-R intervals; technical performance of the device has been described in detail elsewhere.12 By storing only irregular RR intervals (these intervals; technical performance of the device has been described in detail elsewhere.12 By storing only irregular RR intervals (these intervals), the device is able to calculate the duration of irregular heart rhythm (AF) with the overall observed regular heart rhythm (SR), thus creating the parameter “real atrial fibrillation burden.” As part of the presented study, the following information was stored by the device:

1. Relative AF burden: defined as the percentage of observational time being in atrial fibrillation.
2. Absolute AF burden, defined as the average hours of atrial fibrillation duration per day for the time being observed.
3. Total AF load, defined as the average hours of atrial fibrillation duration per day over the whole observational period.
4. AF episode duration, defined as the various durations of AF episodes were arbitrarily classified in the following groups: 2 to 10 minutes, 10 minutes to 1 hour, 1 hour to 24 hours, and >24 hours.

Follow-Up
Patient follow-up was scheduled at 3, 6, 9, and 12 months postoperatively and then biannually for another 2 years at our outpatient clinic visit or at the referring cardiologists’ office. During these visits, 24HM rhythm documentation, IMD telemetry and documentation of clinical data as well as complications were performed. To avoid device-related potential overestimation of atrial fibrillation recurrence attributable to the first experience with this new device,12 all documented ECG AF episodes were manually validated by 2 different examiners. All patients received oral anticoagulation for the time being studied. Anticoagulation was switched to Aspirin 325 mg/day only in case of CHADS2 score <2 after a period of 6 months after ablation (n=1).13 Amiodarone, in the absence of contraindications, was administered to all patients for the first 3 postoperative months.

Statistical Analysis
The statistical analysis of the demographic data has been performed using ANOVA and χ² test. Continuous variables are presented as mean±SD as appropriate. The McNemar χ² test was used to compare the ability of 24HM and IMD to identify atrial fibrillation (negative predictive value defined as the proportion of patients in sinus rhythm as confirmed by the IMD, who are correctly diagnosed by the 24HM). The Wilcoxon signed rank test was used to compare atrial fibrillation recurrence as obtained by intermittent versus continuous monitoring. The Student t test was used to compare change in symptomatology as described by the EHRA classification. ROC Curve analysis was performed to compare the 24HM ability to identify AF episodes confirmed by the IMD. Values of P<0.05 were considered significant; values between 0.05 and 0.1 were classified as a trend toward significance. All statistical analyses were performed with SPSS 11.0 for Windows (SPSS, Inc).

All patients gave informed consent to the conduct of the study (ClinicalTrials.gov.Id: NCT00806698), which was approved by the local ethics committee.

Statement of Responsibility
The authors had full access to the data and take responsibility for its integrity.

Results
Patients’ baseline demographics are displayed in the Table. All patients were followed postoperatively for a mean of 8.30±3.97 months (range 0 to 12 months). No procedure related complications occurred; 4 patients died of causes unrelated to the surgical ablation procedure.

There was 1 hospital death attributable to gastrointestinal bleeding and 3 late deaths (infective endocarditis n=1, respiratory failure attributable to pneumonia n=1, malignancy n=1). No embolic stroke events occurred during follow-up. Four patients during follow-up described AF symptoms after ablation therapy. In 2 of these patients, the 24HM diagnosed SR and at the time of 24HM assessment, patients did not sense any AF symptoms during 24HM with a high AF burden as documented by the IMD. The other 2 patients showed AF during 24HM with a high AF burden as documented by the IMD. These 4 patients were classified as “symptomatic.” All other patients, although being in AF as documented by the IMD were “asymptomatic.” Overall the mean EHRA classification score significantly decreased postoperatively to a mean of 1.05±0.23 at time of last follow-up (preop: 1.43±0.68, P=0.002). Furthermore, in patients with IMD-documented AF recurrence, a reduction in symptoms was also observed with a mean EHRA classification at latest follow-up of 1.06±0.24 (preop 1.38±0.65, P=0.009, paired
sampled t test, patients with documented postoperative sinus rhythm were excluded).

**Continuous Monitoring**
The overall time period spent in atrial fibrillation (relative AF burden) post ablation for the entire group was 37±43% (3 month follow-up data included). A histogram of the overall postoperative absolute AF burden (hours per day spent in AF) as assessed by the IMD is displayed in Figure 1 (3 month follow-up data included).

**Continuous Versus Intermittent Monitoring**
The overall observational heart rhythm surveillance with the IMD consisted of 220 766 hours, cumulative 24 hour Holter monitoring composed of 2021 hours. The IMD was able to identify significantly more episodes of atrial fibrillation recurrence than intermittent 24HM at regular time intervals. 85 instances of simultaneous 24HM and IMD readings were obtained. Among these, SR was indicated in 53 instances of 24HM readings. Simultaneous intraindividual telemetry of the IMD at the same prescheduled visits, however, revealed

---

Table. Patient Demographics and Atrial Fibrillation Data

<table>
<thead>
<tr>
<th>Patient Demographics</th>
<th>Total (n=45)</th>
<th>PAF (n=14)</th>
<th>PersAF (n=6)</th>
<th>LS PersAF (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean±SD), y</td>
<td>69.7±9.2</td>
<td>73±8.7</td>
<td>72±9.8</td>
<td>67.6±9.8</td>
</tr>
<tr>
<td>Male</td>
<td>37 (82.2%)</td>
<td>13 (93%)</td>
<td>4 (67%)</td>
<td>19 (76%)</td>
</tr>
<tr>
<td>AF duration (mean±SD), months</td>
<td>38±45</td>
<td>30±36</td>
<td>23±20</td>
<td>50±30</td>
</tr>
<tr>
<td>LA size (mean±SD), mm</td>
<td>47±11</td>
<td>47±7</td>
<td>43±9</td>
<td>51±8</td>
</tr>
<tr>
<td>Medical history</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Art. hypertension</td>
<td>42 (93%)</td>
<td>13 (93%)</td>
<td>6 (100%)</td>
<td>23 (92%)</td>
</tr>
<tr>
<td>Renal insufficiency</td>
<td>6 (13%)</td>
<td>1 (7%)</td>
<td>1 (17%)</td>
<td>4 (16%)</td>
</tr>
<tr>
<td>COPD</td>
<td>9 (20%)</td>
<td>1 (7%)</td>
<td>3 (50%)</td>
<td>5 (20%)*</td>
</tr>
<tr>
<td>Cardiovascular History</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valvular heart disease</td>
<td>23 (51%)</td>
<td>5 (36%)</td>
<td>3 (50%)</td>
<td>15 (60%)</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>21 (47%)</td>
<td>9 (64%)</td>
<td>3 (50%)</td>
<td>9 (36%)</td>
</tr>
<tr>
<td>New York Heart Association Class</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>11 (24%)</td>
<td>5 (35.5%)</td>
<td>3 (50%)</td>
<td>3 (12%)‡</td>
</tr>
<tr>
<td>II</td>
<td>14 (31%)</td>
<td>4 (29%)</td>
<td>2 (33%)</td>
<td>8 (32%)</td>
</tr>
<tr>
<td>III</td>
<td>20 (45%)</td>
<td>5 (35.5%)</td>
<td>1 (17%)</td>
<td>14 (56%)</td>
</tr>
<tr>
<td>IV</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>European Heart Rhythm Assoc. Class</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>30 (67%)</td>
<td>8 (57%)</td>
<td>3 (50%)</td>
<td>19 (76%)</td>
</tr>
<tr>
<td>II</td>
<td>10 (22%)</td>
<td>2 (14%)</td>
<td>3 (50%)</td>
<td>5 (20%)</td>
</tr>
<tr>
<td>III</td>
<td>5 (11%)</td>
<td>4 (29%)</td>
<td>...</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>IV</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>LV function Class</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>normal (&gt;60%)</td>
<td>21 (47%)</td>
<td>10 (71%)</td>
<td>2 (33.3%)</td>
<td>9 (36%)</td>
</tr>
<tr>
<td>reduced (40–59%)</td>
<td>15 (33%)</td>
<td>4 (29%)</td>
<td>2 (33.3%)</td>
<td>9 (36%)</td>
</tr>
<tr>
<td>severely reduced (&lt;40%)</td>
<td>9 (20%)</td>
<td>...</td>
<td>2 (33.3%)</td>
<td>7 (28%)</td>
</tr>
<tr>
<td>Pre-op anticoagulation status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin K antagonist</td>
<td>17 (38%)</td>
<td>4 (29%)</td>
<td>1 (17%)</td>
<td>12 (48%)</td>
</tr>
<tr>
<td>Aspirin</td>
<td>16 (36%)</td>
<td>7 (50%)</td>
<td>4 (67%)</td>
<td>5 (20%)</td>
</tr>
<tr>
<td>GPIIb/IIIa antagonist</td>
<td>2 (4%)</td>
<td>2 (14%)</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Others</td>
<td>7 (16%)</td>
<td>...</td>
<td>...</td>
<td>7 (28%)</td>
</tr>
<tr>
<td>None</td>
<td>3 (7%)</td>
<td>1 (7%)</td>
<td>1 (17%)</td>
<td>1 (4%)</td>
</tr>
<tr>
<td>Pre-op rhythm conversion treatment (2 options possible)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical</td>
<td>12 (27%)</td>
<td>2 (14%)</td>
<td>2 (33%)</td>
<td>8 (32%)</td>
</tr>
<tr>
<td>Pharmacological</td>
<td>6 (13%)</td>
<td>0 (0%)</td>
<td>2 (33%)</td>
<td>4 (16%)</td>
</tr>
<tr>
<td>None</td>
<td>28 (62%)</td>
<td>12 (86%)</td>
<td>2 (33%)</td>
<td>14 (56%)</td>
</tr>
</tbody>
</table>

SD indicates standard deviation; PAF, paroxysmal atrial fibrillation; PersAF, persistent atrial fibrillation; LS PersAF, longstanding persistent atrial fibrillation; COPD, chronic obstructive pulmonary disease; EHRA, European Heart Rhythm Association; EHRA I, no symptoms; EHRA II, mild symptoms with normal daily activity not affected; EHRA III, severe symptoms with normal daily activity affected. EHRA IV, disabling symptoms with normal daily activity discontinued. *P=0.09, †P=0.07, for all other comparisons P>0.2.
atrial fibrillation recurrence before the 24HM readings in 19 of these 53 instances, thus indicating an overall 34% failure for the 24HM to identify atrial fibrillation recurrence when applied at prescheduled follow-up visits (P<0.0001). This reflects a sensitivity of intermittent quarterly 24HM of 0.60 with a negative predictive value of 0.64. When applying the strategy, the overall mean relative burden for the 12-month follow-up period was lower than 71% or more than 17 hours/day respectively (Figure 2).

To examine the ability of the quarterly performed 24HM as the widely regarded rhythm surveillance gold standard for the detection of AF recurrence, we evaluated all episodes of IMD-verified AF recurrence. The quarterly 24HM follow-up strategy correctly identified the recurrence of AF only when the overall mean relative burden for the entire follow-up period was over 71% or more than 17 hours/day respectively (Figure 3).

Data from the ROC analysis suggests that a low daily AF burden incorporates a high risk of success misinterpretation by the 24HM, even when performed at 3-month intervals. For example, in case of an AF burden of 10% during the whole observational period, the percentage of sinus rhythm interpretation failure by quarterly performed 24HM is still up to 50%, whereas with higher AF burden occurrence (>75%) this risk decreases to almost 0% (Figure 4). When the duration and frequency of the AF episodes were also taken into consideration, the quarterly 24HM follow-up strategy did not accurately and consistently predict AF recurrence in case of short AF episode duration (2 to 10 minutes, 10 minutes to 1 hour with a prevalence of <100 episodes over a 3-month period), although clinical significance of these short episodes is still unknown. But even in the setting of a low number of 1 hour to 24 hours AF recurrence episodes, there was a fairly high risk of not identifying AF recurrence for the 24HM follow-up strategy; for example in case of ten 1 hour to 24 hour AF recurrence episodes, the risk of AF detection failure was more than 40% (Figure 5).

**Discussion**

This study shows that continuous heart rhythm surveillance most accurately identifies AF recurrence after ablation therapy. In addition, the study provides strong evidence that commonly used intermittent follow-up strategy is significantly inferior to full disclosure heart rhythm observation with respect to AF recurrence detection.
AF and Symptoms
As shown in the presented series, patients being scheduled for surgical AF ablation therapy present with a low level of symptoms with respect to atrial fibrillation. In accordance with others, we showed that the patients’ overall low ability to sense AF typical symptoms not only decreases significantly postoperatively for the entire patient group but interestingly also among those patients with postprocedural documented AF recurrence. Therefore, measuring AF recurrence by judging patient’s symptoms leaves a high amount of uncertainty about the success of surgical AF ablation therapy.

Continuous Heart Rhythm Surveillance
Long-term continuous heart rhythm surveillance as assessed by a novel implantable monitor is able to detect recurrence atrial fibrillation after surgical left atrial ablation therapy (Figure 1). Furthermore, the IMD enables a closer and more “real-life” insight into the patients’ heart rhythm character by providing information about long-term real AF burden, long-term mean heart rate, and patient daily activity during the whole follow-up period (Figure 6).

Only few reports are available about continuous full disclosure heart rhythm observation in AF patients treated with an ablation procedure. The Puerefellner group reported 14 patients with atrial fibrillation (12 paroxysmal, 2 persistent) who received a dual chamber pacemaker device before left atrial radio frequency catheter based ablation. In their series, postprocedural daily atrial tachyarrhythmia burden in patients with nonstructural heart disease and normal LV function decreased from a median of 15% to 1.25%. The authors also concluded that only continuous heart rhythm surveillance accurately describes true AF burden. In contrast, in case of conventional 24HM rhythm documentation, this marker can only be extrapolated thus creating a “virtual” actual AF burden.

Continuous Versus Intermittent Heart Rhythm Surveillance
The primary findings of the present study are that in comparison to conventional follow-up strategies after surgical ablation therapy (ie, mainly symptom based evaluation or intermittent heart rhythm documentation with 24HM), con-
Continuous heart rhythm monitoring as achieved with an implantable event recorder documents significantly more episodes of recurrent AF (Figure 2). Furthermore, the accuracy of 24HM monitor strategy with respect to ablation success interpretation is dependent on follow-up frequency. When performing an annual 24HM follow-up strategy (this most possibly also accounts for rhythm interpretation “at last follow-up” as frequently reported in the literature) the risk of success misinterpretation almost reaches the level of “coin-flipping,” with an interpretation correctness of 50%. But even when performed quarterly, the level of correct interpretation by the 24HM in comparison to continuous heart rhythm surveillance is still unsatisfying with a sensitivity level of only 0.60 (Figure 2).

**Figure 5.** Percentage of patients in whom the 24 HM follow-up strategy failed to identify AF recurrence plotted against the number of AF episodes of different duration. An example is indicated in dotted lines: in case of low number of long (>24 hour) AF burden episodes, the percentage of patients being misinterpreted by 24HM follow-up strategy is 0%; in case of high volume short AF burden episodes, this misinterpretation ratio increases to approximately 85%. ROC curve analysis: 2 minutes to 10 minutes: AUC 0.315, \( P = 0.52 \); 10 minutes to 1 hour: AUC 0.427, \( P = 0.442 \); 1 hour to 24 hours: AUC 0.611, \( P = 0.246 \); >24 hours: AUC 0.841, \( P < 0.001 \) (x axis in logarithmic scale; AUC indicates area under ROC curve).

**Figure 6.** Total AF load defined as absolute AF burden (hours/d) for the whole device observational period as stored by the implantable monitor device (IMD) in a patient postsurgical AF ablation. Late recurrence of elevated AF burden \( \) was associated with hemodynamically significant gastrointestinal bleeding. (Note: AF burden decreased during the first 3 months postablation).
AF Burden and Surgical Therapy

It has been suggested that pacemaker-derived continuous cardiac rhythm surveillance in comparison to intermittent rhythm documentation is more capable of detecting atrial fibrillation recurrence, whereby those series intermittent monitoring was achieved by calculating pacemaker data from randomly selected days within a prescribed monitoring window. We were able to reveal the inadequacy of commonly used intermittent 24HM (“snapshot”) heart rhythm documentation after surgical left atrial ablation in a larger and inhomogeneous patient cohort with a high prevalence of comorbidity and structural heart disease. For the first time in surgical atrial ablation fibrillation therapy we could demonstrate the importance of atrial fibrillation burden survey when judging 24HM result accuracy and reliability.

AF Burden Character and Ablation Success Interpretation

The risk for success misinterpretation by conventional 24HM follow-up strategies substantially rises in case of a low atrial fibrillation burden (Figure 4). This misinterpretation risk also accounts for the postprocedural incidence of different duration of atrial fibrillation recurrence episodes (Figure 5). Although infrequent short-time episodes are unlikely to be clinically significant, documentation of these episodes is important, as stated in the corresponding guidelines, recurrence of AT/AF episodes with 30 seconds or longer is classified as “procedural failure.” However, the clinical significance of very frequent short duration AF episodes (for example 1000 episodes within 3 months, each of 10-minute duration as shown in our results, Figure 5) still remains unknown. For patients with a low rate of long AF duration episodes (>24 hours) the ROC curve analysis showed a significant result, but sensitivity was only 0.60, indicating that also in this subset of patients, implantation of a small continuous cardiac rhythm monitoring device provides a high potential to increase certainty about ablation procedure success. This primarily accounts for evaluation of new ablation devices, new ablation lesion sets, and risk stratification of anticoagulation therapy irrespective of the chosen ablation approach (surgical versus catheter based) and also for scientific evaluation, where the most proper follow-up strategy must be used.

AF Burden: a Parameter to Alter Medical Therapies?

Forty-four patients in the reported study received anticoagulation therapy for the time period being studied (1 patient was treated with aspirin 325 mg/day), and no embolic stroke events occurred. Data from the Stroke Prevention in Atrial Fibrillation trial (SPAF) suggest that the risk for ischemic stroke is similar in patients with paroxysmal or longstanding persistent atrial fibrillation. This is especially important for the recurrence of postprocedural paroxysmal atrial fibrillation because these patients are the most difficult to identify with conventional heart rhythm documentation. It has been postulated that “AF burden” might serve as a refined additional marker for risk stratification of ischemic stroke. Data from a large pacemaker study were able to show an elevated risk of embolic stroke events in patients who present with an AF burden of more than 24 hours, and the authors propose that this parameter in the future might be useful to “guide anticoagulation therapy” but further data on this issue is still scarce and large trials are missing. Because of the lack of continuous full observational long-time cardiac rhythm surveillance in surgically ablated patients, these data are missing up to now. Whether anticoagulation regimen should be altered depending on the availability of AF burden data in our study cannot be answered because of the low number of the observed study population and the short mean follow-up time. This important issue can only be confirmed in larger prospective ablation therapy trials in the future.

Study Limitations

As mentioned above, IMD readings were considered as gold standard to which results from the 24HM were compared. But one cannot be sure that all recurrent AF episodes had been captured by the device. But even if so, underestimation of AF recurrence would have had no negative influence on the comparative results. Because arrhythmia interpretation with IMD relies on R-R irregularity, one cannot rule out IMD misinterpretation of atrial tachycardia arrhythmia in case of atrial flutter. Because all patients did receive 24HM, this entity should have been captured by the examiners.

We could not always provide a simultaneous 24HM for every time point of our study. This, in our opinion, mirrors the real-life of patient compliance in accepting 24HM routine follow-up. Compliance is even decreasing by an increasing number of follow-up visits. By implanting a small leadless heart rhythm monitor device with the need for only a 10-minute duration device interrogation, the aspect of patient follow-up compliance is likely to be improved. Two different surgical ablation techniques have been applied in a small-sized patient cohort with even smaller AF classification subgroups. Thus comparison of ablation techniques or success rates of reasonable statistical significance is not feasible and was not the scope of the present study.

Conclusion

Postoperative evaluation of surgical AF ablation therapy on a symptom-based follow-up strategy overestimates therapy success because of the high amount of asymptomatic episodes in these patients. Continuous full disclosure long-term

Events Over Time: AF Burden Late Onset Development

Not only short-term follow-up cardiac rhythm surveillance but also long-term continuous assessment of cardiac rhythm is important. This is supported by our findings, as a small number of patients in our series developed an increased late onset of AF recurrence (Figure 6). Truncating long-term patient heart rhythm observation therefore might result in an incorrect ablation therapy interpretation or inadequate anticoagulation regimen. However, by implanting a continuous heart rhythm monitoring device after surgical AF ablation therapy we could show that postprocedural atrial fibrillation is a dynamic process with changing frequencies in the long run.
heart rhythm monitoring assessed with an implantable small heart rhythm monitor device after surgical atrial fibrillation ablation therapy provides a high density of information about postprocedural cardiac rhythm development as indicated by daily AF burden. This parameter in the future might serve as an indicator which implies the potential to meticulously evaluate the risk of embolic stroke events in the subset of patients after AF ablation therapy. Furthermore, IMD data assessment is achieving a higher certainty about ablation procedure success than conventional 24HM intermittent follow-up, even when accounted for intensified 24HM follow-up intervals. This is particularly important for further judgment of any AF ablation technique or AF ablation devices as well as anticoagulation and antiarrhythmic therapy. Studies with the intention to examine the success rate of any AF intervention should be assessed using continuous heart rhythm surveillance technology.

Acknowledgments

We thank Katrin Meyer for her excellent data management and secretarial support in the Clinic for Cardiac and Thoracic Aortic Surgery, University Hospital Schleswig-Holstein, Campus Lübeck, Germany, and we gratefully acknowledge the assistance of Ilka Neumann.

Disclosures

T.H. has received modest lecture honoraria from Medtronic, Inc.

References

Twenty-Four–Hour Holter Monitor Follow-Up Does Not Provide Accurate Heart Rhythm Status After Surgical Atrial Fibrillation Ablation Therapy: Up to 12 Months Experience With a Novel Permanently Implantable Heart Rhythm Monitor Device
Thorsten Hanke, Efstratios I. Charitos, Ulrich Stierle, Antje Karluss, Ernst Kraatz, Bernhard Graf, Axel Hagemann, Martin Misfeld and Hans H. Sievers

Circulation. 2009;120:S177-S184
doi: 10.1161/CIRCULATIONAHA.108.838474

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/120/11_suppl_1/S177

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation 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 is online at:
http://circ.ahajournals.org//subscriptions/