The Utility of Transtelephonic Electrocardiograms for Detecting Arrhythmia Recurrences after Radiofrequency Catheter Ablation for Atrial Fibrillation

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Background: Extensive encircling pulmonary vein isolation (EEPVI) is effective for atrial fibrillation (AF). However, the definition of success following ablation is commonly based on the lack of symptoms. The purpose of this study was to determine the incidence of recurrences of AF by daily transtelephonic electrocardiogram (T-ECG), as compared with Holter ECG, after ablation of AF.

Methods: Twenty-two patients with AF underwent EEPVI. Holter ECG tests were performed at one, three, and six months, in addition to a daily T-ECG for the first 180 days after ablation.

Results: A total of 6012 T-ECGs were obtained. Of these, 18.9% (1136) showed AF. Patients with AF were asymptomatic for 41.4% (470) of the episodes. Additionally, in 64% (14 of 22) of the patients, AF recurrences were recorded by T-ECG, whereas Holter ECG tests did not detect AF recurrences in 50% of the patients (7 of 14).

Conclusions: T-ECG is better than Holter ECG in detecting AF relapses. The absence of symptoms should not be interpreted as absence of AF.

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Key words: Electrophysiology, Holter ECG, Radiofrequency

Introduction

Radiofrequency catheter ablation has become an effective treatment for drug-refractory atrial fibrillation (AF). The clinical efficacy for ablation procedures have been based in large part on patient symptoms suggestive of AF, routine electrocardiograms (ECGs), or 24-h Holter recordings. Although AF is often associated with typical symptoms such as palpitations, dizziness, and dyspnea, a significant proportion of patients remain asymptomatic, especially in the setting of the anti-arrhythmic drug administration, and the most important problem associated with asymptomatic AF is the need for oral anticoagulation after the ablation procedure. The results of a review of studies comparing Holter monitors and transtelephonic event monitors in the diagnosis of palpitations found that the diagnostic yield was 66 to 83 percent when transtelephonic event monitors were used for monitoring, compared
to 33 to 35 percent when Holter monitors were used.\textsuperscript{7} We compared the diagnostic yield of transtelephonic event monitors with those of Holter monitoring to determine whether transtelephonic event monitoring is a reliable and objective means to determine when to stop anticoagulation therapy in patients after catheter ablation for AF.

**Methods**

**Patient population**

Twenty-two of 133 consecutive patients who underwent catheter ablation for atrial fibrillation gave consent, and were thus enrolled in our study. AF is classified as paroxysmal if episodes terminate spontaneously in less than seven days, and persistent if episodes continue beyond seven days. Long-standing persistent AF was defined as AF lasting for more than 1 year. In our study, there were 9 patients with paroxysmal and 13 with persistent AF, including 7 with long-standing AF.

**Study protocol**

All patients gave informed, written consent to be enrolled in the study. A clinical examination, thyroid function test, electrocardiogram, chest radiography, transthoracic and transesophageal echocardiography, and three-dimensional computed tomography to reconstruct pulmonary vein (PV) and left atrium (LA) were routinely performed. All patients were treated with oral anticoagulants using warfarin potassium to achieve an international normalized ratio of 1.6 to 2.6 for more than two months before catheter ablation.

**Electrophysiological study**

After informed written consent was obtained, an electrophysiological study was performed in the postabsorptive state under light sedation.\textsuperscript{8} All anti-arrhythmic agents had been discontinued for >5 half-life periods. Oral anticoagulation was replaced by drip infusion of heparin >72 hours before ablation, and heparin ceased 3 hours before the procedure. After internal jugular and femoral vein punctures were performed, a heparin bolus (100 U/kg) was administered, and afterward, continuous infusion of heparin was provided, maintaining an activated clotting time value between 250 and 300 seconds. Surface ECG and bipolar endocardial electrograms were continuously monitored and stored on a computer-based digital amplifier/recorder system for offline analysis (Bard Electrophysiology). Intracardiac electrograms were filtered from 30 to 500 Hz and measured at a sweep speed of 100 mm/s.

**Catheter ablation**

The following catheters were introduced via the right femoral vein and right internal jugular vein for electrophysiological tests and ablation: (1) a 20-pole catheter (Woven\textsuperscript{TM} Diagnostic Electrode Catheter, Bard Electrophysiology) was positioned in the coronary sinus; (2) a circumferential 20-pole catheter (Lasso\textsuperscript{TM}, Biosense-Webster) was introduced into the PV after transseptal access with the use of a long sheath (Mullins\textsuperscript{TM} 8F transseptal Catheter Introducer Set, Medtronic, and Swartz\textsuperscript{TM} SR0, St. Jude Medical) and (3) a 4-mm tip ablation catheter (Navistar\textsuperscript{TM}, Biosense-Webster) was used for mapping and ablation. After LA reconstruction, each PV ostium was identified by selective venography and tagged on the electro-anatomical map. Radiofrequency energy was delivered with a target temperature of 55°C and a maximal power limit of 30 W. The end point of the PV isolation was defined by complete elimination or dissociation of PV potentials, as determined by the circumferential catheter.\textsuperscript{9} LA roof ablation was performed in 10 patients by the creation of a contiguous line of ablation lesions joining the superior PVs.\textsuperscript{10}

**Follow-up**

Patients with paroxysmal AF received no anti-arrhythmic drugs after ablation, and patients with persistent AF received an anti-arrhythmic drug within three months after ablation. At 1, 3, and 6 months after ablation, patients underwent clinical review, and a Holter ECG was performed to identify asymptomatic arrhythmias.

**Transtelephonic ECG recorder**

A transtelephonic ECG (T-ECG) is an ECG that is recorded outside the hospital and then sent to the hospital over the telephone. Patients were supplied with a T-ECG recorder (EV-50, Clinical Supply Co., Kagamihara, Japan) and instructed on its use. Up to three single-lead ECGs with a fixed length of 30 seconds could be stored on the card. Patients were asked to record at least two T-ECGs per day, regardless of symptoms, and also at the onset of any symptoms. T-ECG follow-up continued for 6 months post ablation and was stored in a database. Patients’ comments on the T-ECGs were recorded and submitted to the physicians at the outpatient clinic. Comments were stratified into three categories: asymptomatic, symptomatic, or not specified. Symptoms included palpitations (short lived), tachycardia (long lasting), and chest discomfort. T-ECGs were analyzed by two independent cardiologists and diagnosed as sinus rhythm (SR), AF, atrial tachy-
cardia (including atrial flutter) of 30-second duration, and premature atrial or ventricular contraction.

Anticoagulation therapy
Patients were reloaded with warfarin on the day after the ablation procedure, until their international normalized ratio was therapeutic. Warfarin treatment was stopped six months after ablation if AF was not detected by both Holter ECG and T-ECG recorded between 3 and 6 months after ablation, without the use of anti-arrhythmic drugs.

Statistical analysis
All values are expressed as mean ± SD. Comparison between groups was performed with a two-tailed Student t test. Qualitative parameters were compared by chi-square analysis or Fisher’s exact test. Statistical significance was established at P < 0.05.

Results

Clinical characteristics (Table)
Among the 22 patients enrolled, 19 were male, with a mean age of 64 ± 14 years (range 21 to 74 years). Their arrhythmic history lasted a median of seven years (range 1 to 35 years), and they had tried anti-arrhythmic drugs for a mean of 3 ± 1 (range 1 to 6). Baseline disease was present in 15 patients (69%): hypertension in 14 patients, ischemic heart disease in 3 patients, history of stroke in 5 patients, and diabetes mellitus in 2 patients. The mean left atrial diameter was 40 ± 7 mm (range 31 to 58 mm), and the mean left ventricular ejection fraction was 61 ± 7% (range 46% to 72%).

Catheter ablation
All target veins were successfully isolated requiring 75 ± 10 min (range 58 to 74 min) of radiofrequency application. The mean procedure duration was 213 ± 29 min (range 165 to 240 min) and the mean fluoroscopic exposure was 32 ± 5 min (range 25 to 36 min). No complications were observed in any of the patients. A second session was not performed in any of the patients with recurrence of AF in this study.

Follow up
We obtained 66 Holter recordings (3 Holter recordings per patient). By means of standard ECG and Holter recorded, 7 patients (31.8%) had an AF recurrence documented, and all of the 22 patients had at least more than one premature atrial contraction in their Holter recordings.

Table  Baseline clinical characteristics of the patients

<table>
<thead>
<tr>
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<th>n = 22</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>64 ± 14</td>
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<tr>
<td>Male, n (%)</td>
<td>19 (86)</td>
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<tr>
<td>Duration of AF (months)</td>
<td>84 ± 100</td>
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<tr>
<td>Number of Antiarrhythmic drug</td>
<td>3.3 ± 1.4</td>
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<tr>
<td>LA diameter (mm)</td>
<td>40 ± 7</td>
</tr>
<tr>
<td>LV ejection fraction (%)</td>
<td>61 ± 7</td>
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<tr>
<td>Paroxysmal AF/Persistent AF</td>
<td>9/13</td>
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<tr>
<td>Hypertension (%)</td>
<td>14 (64)</td>
</tr>
<tr>
<td>Ischemic Heart Disease (%)</td>
<td>3 (14)</td>
</tr>
<tr>
<td>Valvular Disease (%)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Cerebral infarction (%)</td>
<td>5 (23)</td>
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<tr>
<td>Diabetes Mellitus (%)</td>
<td>2 (9)</td>
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</table>

Continuous values are shown as mean ± SD. AF: atrial fibrillation, LA: left atrial, LV: left ventricular, n: number

Transtelephonic ECG recordings
We obtained a total of 6012 T-ECG recordings (mean 273 T-ECGs per patient). Due to low signal quality, 418 (7.0%) recordings were excluded. Sinus rhythm, AF, atrial tachycardia, and premature atrial contraction (PAC) were diagnosed for 3817 (63.5%), 1136 (18.9%), 253 (4.2%), and 379 (6.3%) T-ECGs, respectively. Of the 1136 T-ECGs recorded during AF, 666 (59%) episodes were correctly recognized, but 470 (41%) recordings were not associated with symptoms. About half of the 379 T-ECGs with PAC were recorded with symptoms and 83% of the 253 T-ECGs with AT were recorded without symptoms.

A total of 965 T-ECGs recorded simultaneously with symptoms were: AF in 666 (69.0%), premature atrial contraction in 205 (21.2%), sinus rhythm in 47 (4.9%), atrial tachycardia in 42 (4.4%), and premature ventricular contraction in 5 (0.5%). A total of 4629 T-ECGs recorded without symptoms revealed sinus rhythm in 3770 (81.4%), AF in 470 (10.2%), atrial tachycardia in 211 (4.6%), premature atrial contraction in 174 (3.8%), and premature ventricular contraction in 4 (0.1%) (Figure).

Comparison between T-ECG and Holter ECG for the detection of arrhythmia after catheter ablation
During T-ECG recordings 14 (8 symptomatic and 6 asymptomatic) of the 22 patients (63.6%) had AF recurrences, whereas Holter ECG could document AF recurrences in only 7 of these 14 patients (P < 0.05). In other words, T-ECG could document AF in 7 patients (5 symptomatic and 2 asymptomatic) in whom Holter recordings or routine ECGs could not detect AF. Holter recording could detect premature atrial contractions in all of the 22 patients,
while T-ECG detected premature atrial contractions in 17 of 22 patients ($P < 0.05$).

**Anticoagulation therapy**

At 6 months after ablation, 11 of 22 patients stopped taking warfarin, while the remaining continued. Nine patients took anti-arrhythmic drugs; bepridil in four, cibenzoline in one, pilsicainide in one, propafenone in one, beta-blockade in one, bepridil and pilsicainide in one, and three of them had symptomatic and one of them had asymptomatic AF attacks. None of the 22 patients developed stroke or systemic embolism for a mean of 23 months during the follow up period.

**Discussion**

This study demonstrated that the detection rate for AF after catheter ablation of AF was higher using T-ECG compared with that of Holter ECG. Among 14 patients with AF recurrence, 41.4% were asymptomatic according to their T-ECG recordings. Furthermore, 10.2% of a total of 4629 recorded T-ECGs without symptoms were shown to exhibit AF. Arya et al.\textsuperscript{11} reviewed various studies addressing asymptomatic AF episodes. They concluded that the high prevalence of asymptomatic AF together with the poor correlation between symptoms and AF should caution physicians against relying on symptoms to make clinical decisions. Although the best device that can detect the recurrence of AF is an implanted device such as a pacemaker\textsuperscript{12} or an implantable loop recorder,\textsuperscript{13} it is difficult to implant these devices in every patient. Comparable results are also recently reported during T-ECG\textsuperscript{3} and 7-day Holter monitoring.\textsuperscript{14} In this study, we carefully stopped the anticoagulation therapy when there was an absence of AF monitored by the T-ECG and Holter ECG. Thus, no patients developed stroke or systemic embolism during the follow up period.

**Clinical implications**

The most important problem underlying asymptomatic AF is the need for oral anticoagulation after the ablation procedure. Therefore, withdrawal of oral anticoagulation after ablation should be considered carefully, and be based not on patient symptoms, but on reliable and objective measures such as a daily T-ECG combined with long-term Holter records.

**Study limitations**

The study has two major limitations: 1) The T-ECG lasted only 30 seconds, so some asymptomatic AF episodes may not have been recorded. 2) No comparisons among the T-ECGs with continuous monitoring employing automatic AF detecting devices were done to accurately estimate the number.
of T-ECG recordings per day required during the complete follow up. However, all patients recorded T-ECGs twice a day, and we could observe a higher incidence of persistent AF recurrences that lasted more than 48 hours. This time is important because the potential risk for forming LA thrombus is greater when the AF lasts over 48 hours, even in asymptomatic patients.

Conclusions
T-ECG is better than Holter ECG in evaluating AF recurrence after catheter ablation. The absence of symptoms should not be interpreted as absence of AF. Anticoagulation therapy could be stopped after successful ablation when using T-ECG to evaluate the potential for AF recurrence.

References
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