Target Temperatures of 48°C versus 60°C During Slow Pathway Ablation: A Randomized Comparison

S. ADAM STRICKBERGER, M.D., TAKASHA TOKANO, M.D., HUNG FAT TSE, M.D., MICHAEL H. KIM, M.D., HAKAN ORAL, M.D., MATTHEW FLEMMING, M.D., FRANK PELOSI, M.D., GREGORY F. MICHAUD, M.D., BRADLEY P. KNIGHT, M.D., RAJIVA GOYAL, M.D., and FRED MORADY, M.D.

From the Division of Cardiology, University of Michigan Medical Center, Ann Arbor, Michigan

Slow Pathway Ablation. ***Introduction:*** **The relationship between temperature at the electrode-tissue interface and the loss of AV and ventriculoatrial (VA) conduction is not established, and the optimal target temperature for the slow pathway approach to radiofrequency ablation of AV nodal reentrant tachycardia (AVNRT) is unknown. Therefore, the purpose of this study was to compare target temperatures of 48°C and 60°C during the slow pathway approach to ablation of AVNRT.**

Methods and Results: **The study included 138 patients undergoing ablation for AVNRT. Patients undergoing slow pathway ablation using closed-loop temperature monitoring were randomly assigned to a target temperature of either 48°C or 60°C. The primary success rates were 76% in the patients assigned to 48°C and 100% in the patients assigned to 60°C ($P < 0.01$). The ablation procedure duration (33 ± 31 min vs 26 ± 28 min; $P = 0.2$), fluoroscopic time (25 ± 15 min vs 24 ± 16 min; $P = 0.5$), and mean number of applications (9.3 ± 6.5 vs 7.8 ± 8.1; $P = 0.3$) were similar in patients assigned to 48° and 60°C, respectively. The mean temperature (46.1° ± 24.8°C vs 48.7° ± 3.2°C; $P < 0.01$), the temperature associated with junctional ectopy (48.1° ± 2.0°C vs 53.5° ± 3.5°C, $P < 0.0001$), and the frequency of VA block during junctional ectopy (24.6% vs 37.2%; $P < 0.0001$) were less in the patients assigned to 48°C compared to 60°C. The frequency of transient or permanent AV block was similar in each group (2.8% vs 3.6%; $P = 0.2$). In the 60°C group, only 12% of applications achieved an electrode temperature of 60°C. During follow-up of 9.9 ± 4.2 months, there was one recurrence of AVNRT in the 48°C group and none in the 60°C group.**

Conclusions: **Compared to 48°C, a target temperature of 60°C during radiofrequency slow pathway ablation is associated with a higher primary success rate and a higher incidence of VA block during junctional ectopy induced by the radiofrequency energy. AV block is not more common with the higher target temperature, but only if VA conduction is aggressively monitored during applications of radiofrequency energy.** *(J Cardiovasc Electrophysiol, Vol. 10, pp. 799-803, June 1999)*

atrioventricular nodal reentrant tachycardia, paroxysmal supraventricular tachycardia, radiofrequency catheter ablation, temperature monitoring

Introduction

Successful ablation of AV nodal reentrant tachycardia (AVNRT) using the slow pathway approach is routinely achieved with an electrode-tissue interface temperature of 48°C to 50°C.[1] In contrast, permanent loss of accessory pathway and AV conduction during radiofrequency catheter ablation occurs with an electrode-tissue interface temperature of approximately 60°C.[2,3] The clinical utility and risk associated with a higher target temperature during radiofrequency slow pathway ablation have not been determined. The purpose of this study was to compare the

Address for correspondence: S. Adam Strickberger, M.D., Division of Cardiology, University of Michigan Medical Center, 1500 E. Medical Center Drive, Box 0022, Ann Arbor, MI 48109. Fax: 734-936-7026.

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clinical outcome of target temperatures of 48°C to 60°C in patients undergoing radiofrequency slow pathway ablation for AVNRT.

Methods

Patient Population

One hundred thirty-eight consecutive patients with AVNRT referred for catheter ablation were enrolled under a protocol approved by the Committee on Human Research at the University of Michigan. There were 40 men and 98 women (mean age 48 ± 15 years; ± SD). Seven patients had coronary artery disease, and the remainder were free of structural heart disease. The patients had symptoms attributable to AVNRT for 13.7 ± 13.5 years. There were no significant differences in clinical characteristics between the patients randomized to a target temperature of 48°C or 60°C.

Baseline Electrophysiologic Testing

Electrophysiologic tests were performed after treatment with antiarrhythmic medications had been discontinued for at least five half-lives. Three quadripolar catheters were inserted into a femoral vein and positioned in the high right atrium, across the tricuspid valve to record the His-bundle electrogram, and in the apex of the right ventricle. The intracardiac electrograms and leads V_1, I, II, and III were displayed on an oscilloscope and recorded using a Siemens-Elema Mingograph 7 recorder (Solna, Sweden) at paper speeds of 25 to 100 mm/sec. After the catheters were positioned, 3,000 U of heparin was administered intravenously. Pacing was performed with a programmable stimulator (Bloom Associates, Reading, PA, USA). The diagnostic portion of the procedure was directed at determining the inducibility of AVNRT and measuring the conduction properties and refractory periods of the AV node. If AVNRT was not inducible in the baseline state, isoproterenol was infused at a rate of 2 to 4 μg/min, and the pacing maneuvers were repeated. The diagnosis of AVNRT was established using previously published criteria.[4] Target sites for slow pathway ablation were selected during sinus rhythm using a combined anatomic and electrogram mapping approach.[5] Bipolar recordings from the distal pair of electrodes of the ablation catheter were made at each site at a bandpass of 50 to 500 Hz, a gain of 80 mm/mV, and with a recording speed of 100 mm/sec.

Thermistor Ablation Catheter

A 7-French bipolar electrode catheter (EP Technologies, Inc., Sunnyvale CA, USA) with a deflectable shaft and a 4-mm distal electrode with a thermistor embedded in the tip of the distal electrode was used for all patients. The thermistor bead was incorporated into the surface of the distal electrode and thermally insulated from the surrounding platinum electrode with a polyamide plastic sleeve. The catheters were individually calibrated and accurate to within ±2°C from 37°C to 100°C.

Ablation Protocol

Radiofrequency energy was delivered by a generator that delivered a continuous, unmodulated sine-wave output at 500 kHz and had a maximum power output of 50 W (EPT 1000, EP Technologies, Inc.). The radiofrequency generator automatically adjusted power to achieve the preprogrammed target temperature (see following). This device was interfaced with a personal computer that continuously measured and recorded power, impedance, and tip temperature during each radiofrequency application. Radiofrequency energy was delivered between the 4-mm distal electrode of the ablation catheter and a large adhesive electrode positioned over the left scapula. If junctional ectopy occurred, the energy application was continued for 60 seconds; otherwise, the application was continued only for 20 seconds. Because AV block during slow pathway ablation is almost always heralded by ventriculoatrial (VA) block during junctional ectopy,[6] the applications of radiofrequency energy were immediately discontinued in the event of VA block during junctional ectopy or if a change in AV conduction was noted. The inducibility of AVNRT was assessed after each application of radiofrequency energy.

Study Protocol

The patients were randomly assigned to a target temperature of 48°C or 60°C. If the tachycardia was still inducible after ten applications of radiofrequency energy, the operator had the option to choose the alternate target temperature.

The outcome, procedure duration, fluoroscopy time, and number of radiofrequency applications were recorded for each patient. The occurrence of junctional ectopy and the associated rate, temperature, and presence or absence of VA block were noted. Similarly, if AV block or a change in AV conduction occurred, the associated temperature, site of the block, and duration of the block were recorded. Because the radiofrequency energy was immediately discontinued if VA block was observed, a difference in the frequency of applications of energy associated with a change in AV conduction between groups was not expected. The risk of permanent complete AV block was prospectively defined as correlating to the frequency of VA block during junctional ectopy. A successful procedure was prospectively defined as the inability to induce AVNRT, with or without isoproterenol infusion, at the conclusion of the procedure. Successful ablation with no more than ten applications of radiofrequency energy was identified prospectively as a study endpoint. The ablation procedure duration was defined as the time required to perform the procedure after the diagnosis was established until the final application of radiofrequency energy. When patients randomized to 48°C crossed over to 60°C, the success rate was analyzed according to the primary technique.

Follow-Up

After the procedure, patients were told to call one of the investigators if complaints consistent with paroxysmal supraventricular tachycardia developed. Additionally, the patients were evaluated in person by one of the investigators 3 to 4 months after the procedure.

Statistical Analysis

Continuous variables are expressed as mean ± 1 SD. Continuous variables were compared using an unpaired *t*-test. The data from individual radiofrequency energy applications were used to evaluate the relationship among temperature, junctional ectopy, and AV and VA block. Discrete variables were compared by Chi-square analysis, and a regression analysis was used to assess the relationship between continuous variables. $P < 0.05$ was considered significant.

Results

The primary success rate of slow pathway ablation was 76% in patients assigned to a target temperature of 48°C and 100% in patients assigned to a target temperature of 60°C ($P < 0.0001$). There were 29 (42%) patients in the 48°C group and 15 (22%) patients in the 60°C group who required > 10 applications of radiofrequency energy to achieve a successful outcome ($P = 0.01$). Seventeen patients (25%) in the 48°C group crossed over to the 60°C target temperature group. No patient crossed over to the 48°C group from the 60°C group. The slow pathway was successfully ablated using a target temperature of 60°C in each of these patients.

The mean procedure duration (33 ± 31 vs 26 ± 28 min; $P = 0.2$), fluoroscopy time (25 ± 15 vs 24 ± 16 min; $P = 0.5$), and mean number of radiofrequency applications (9.3 ± 6.5 vs 7.9 ± 8.1 min; $P = 0.3$) were not significantly greater in patients randomized to a target temperature of 48°C as compared with 60°C, respectively.

The mean temperature obtained at the electrode-tissue interface during successful applications of radiofrequency energy in the 48°C group was 45.1° ± 2.8°C compared with 50.5° ± 3.0°C in the 60°C group ($P < 0.0001$). Likewise, the mean electrode-tissue interface temperature associated with unsuccessful applications of energy in patients randomized to the 48°C group (46.2° ± 26.0°C) was significantly less than in patients randomized to the 60°C group (48.4° ± 3.2°C; $P = 0.03$). An electrode-tissue interface temperature of 60°C was achieved during 12.0% of 352 energy applications when 60°C was the target temperature. The mean power during applications of energy in the 48°C group (24.3 ± 9.2 W) was significantly less than during applications of energy in the 60°C group (39.6 ± 8.4 W; $P < 0.0001$).

Junctional Ectopy, VA Block, and AV Block

All successful applications of radiofrequency energy were associated with junctional ectopy. Junctional ectopy occurred in association with 57.8% of the applications in the 48°C group and in 55.4% of applications in the 60°C group ($P = 0.4$). The mean electrode-tissue interface temperature recorded during applications that resulted in junctional ectopy was significantly less in the 48°C group (48.1° ± 2.0°C) than in the 60°C

group (53.5° ± 3.5°C; $P < 0.0001$). The frequency of VA block during junctional ectopy was less common in the 48°C group (24.6 %) than in the 60°C group (37.2%; $P < 0.001$). The temperature associated with VA block during junctional ectopy was 48.1° ± 1.9°C in the 48°C group compared with 53.1° ± 3.4°C in the 60°C group ($P < 0.0001$). The frequency of AV block was similar in each group (2.8% vs 3.6%; $P = 0.5$), although the temperature associated with AV block was less in the 48°C group (46.0° ± 3.4°C), than in the 60°C group (53.6° ± 3.5°C; $P < 0.0001$). Only one patient required a permanent pacemaker. This patient had been randomized to 48°C, but permanent 2:1 AV block developed after cross-over to a target temperature of 60°C. In both the 48°C and 60°C groups, the temperatures associated with VA or AV block were not significantly different than during applications of energy that resulted in junctional ectopy without changes in VA or AV conduction.

Long-Term Follow-Up

The mean follow-up duration was 9.9 ± 4.2 months for the entire cohort of 138 patients. During this time, one patient randomized to the 48°C group (1.4%), and no patient randomized to the 60°C group (0%; $P = 0.3$), had recurrence of AVNRT.

Discussion

Major Findings

The results of this study demonstrate improved efficacy for slow pathway ablation using a target temperature of 60°C compared with 48°C. Higher electrode-tissue interface temperatures and a higher risk of VA block during junctional ectopy were observed when the target temperature was 60°C. However, the incidence of AV block was similar with both the 60°C and 48°C target temperatures, probably because of close monitoring of VA conduction.

Temperature, Junctional Ectopy, VA Block, and AV Block

These results suggest that an electrode-tissue interface temperature of approximately 50°C is adequate for successful slow pathway ablation. Lower temperatures recorded from the electrode-tissue interface would be expected to be associated with smaller lesions than when a higher temperature is achieved. Because of the potential for complete AV block during this procedure, the low electrode-tissue interface temperatures achieved in both the 48°C and the 60°C groups may be one of the reasons why the incidence of this complication is low.[5-14]

Successful applications of radiofrequency energy during slow pathway ablation are associated with junctional ectopy, whereas complete AV block during slow pathway ablation is heralded by VA block during junctional ectopy.[5,6,10,12,15] In the present study, a higher incidence of VA block during junctional ectopy with applications of radiofrequency energy targeted to 60°C was anticipated. However, it also was anticipated that aggressive monitoring of VA conduction could prevent an increased incidence of AV block. In the present study, higher temperatures were associated with an elevated incidence of VA block, but not AV block, probably for this reason. However, it is reasonable to assume that the risk of AV block will be greater with a target temperature of 60°C than with a target temperature of 48°C if VA conduction is not monitored vigilantly.

Previous Studies

Ablation of AVNRT using catheters with temperature monitoring capabilities has been reported.[3,14,16] As in the present study, these previous reports indicated that successful slow pathway ablation typically occurs with temperatures of approximately 50°C. These studies focused on the success rates and temperatures associated with successful slow pathway ablation, but they did not address the issue of the temperature associated with VA block during junctional ectopy or how the incidence of VA block during junctional ectopy changes as a function of temperature. The data contained herein demonstrate that the incidence of junctional ectopy does not change with the higher temperatures achieved with targeting 60°C, although the risk of VA block does.

Limitations

Applications of energy were discontinued after 20 seconds if junctional ectopy did not result. The possibility that there was partial slow path-

way damage cannot be excluded. However, this seems unlikely, as AVNRT was inducible after each unsuccessful application of radiofrequency energy.

Clinical Implications

The incidence of junctional ectopy and the risk of VA block during junctional ectopy are substantial during radiofrequency ablation of AVNRT using the slow pathway approach, irrespective of whether an electrode-tissue interface temperature of 48°C or 60°C is targeted. The positive predictive value for AV block when VA block occurs during junctional ectopy is approximately 20%.[6] This implies there is a significant potential for AV block during radiofrequency ablation of the slow pathway. A larger lesion and greater success is attained with a target temperature 60°C; however, an even greater alertness to VA block is required.

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