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Relation between impedance and endocardial contact during radiofrequency catheter ablation

Lesion size during radiofrequency catheter ablation in patients with paroxysmal supraventricular tachycardia (PSVT) is thought to be related to multiple factors, including contact pressure at the catheter-endocardial interface. Therefore a predictor of contact pressure at a potential target site for ablation might be useful. In this study 25 patients underwent duplicate 2 W applications of radiofrequency energy with the catheter in poor and firm contact with the right ventricular endocardium after successful ablation treatment for PSVT. The mean age of the patients was 44 ± 15 years. Fifteen patients underwent slow pathway ablation for atrioventricular nodal reentrant tachycardia, and 10 patients underwent ablation for an accessory pathway. The mean impedance for low-energy applications in firm contact (139 ± 24 ohms) was 22% ± 13% greater (*p* 0.0001) than in poor contact with the right ventricle (113 ± 16 ohms). The maximum impedance was 27% greater when the catheter was in firm (147 ± 28 ohms) rather than poor contact (116 ± 16 ohms), with the endocardium (*p* 0.0001). These results suggest that higher impedance measurements may be obtained with low-energy applications of 2 W when the ablation catheter is in firm contact with the endocardium. (Am Heart J 1994;128:226-9.)

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Catheter ablation of accessory pathways using radiofrequency energy is the therapy of choice for paroxysmal supraventricular tachycardia (PSVT).[1-4] The efficacy rates are high, but multiple applications are required and the procedure can be protracted. Experiments in animals have demonstrated a direct

Table I. Results

Catheter-endocardial contact	*Mean impedance (ohms)*	*Maximum impedance (ohms)*	*Ventricular electrogram (mV)*
Contact 1			
Poor	114 ± 16	117 ± 16	5 ± 5
Firm	141 ± 26*	150 ± 30*	12 ± 5*
Contact 2			
Poor	112 ± 18	114 ± 17	4 ± 3
Firm	134 ± 21†	142 ± 25†	10 ± 4†
All poor contact applications	113 ± 16	116 ± 16	5 ± 4
All firm contact applications	139 ± 24‡	147 ± 28‡	11 ± 5‡

*Significantly different from poor catheter-endocardial contact 1 (p 0.0001).
†Significantly different from poor catheter-endocardial contact 2 ($p < 0.001$).
‡Significantly different from all applications with poor catheter-endocardial contact (p 0.0001).

correlation between catheter-endocardial contact pressure and lesion volume.[5-6] Therefore some ineffective applications may be the result of poor endocardial contact. Predicting the adequacy of catheter-endocardial contact before attempted lesion formation would be useful. Measured impedance during delivery of very low-power radiofrequency energy may be such a marker of tissue contact. The purpose of this study was to prospectively determine the magnitude of impedance change during a very low power application of radiofrequency energy as a function of endocardial contact. The usefulness of this technique for assessing endocardial contact will be discussed.

METHODS

Patient population. Twenty-five consecutive patients undergoing radiofrequency catheter ablation for paroxysmal supraventricular tachycardia were included in the study. Slow pathway ablation was performed in 15 patients referred for treatment of typical atrioventricular nodal reentrant tachycardia (AVNRT). The remaining 10 patients had ablation of accessory atrioventricular pathways. The mean age was 44 ± 15 years, and 14 of the 25 patients were women. All patients were free of structural heart disease or chronic obstructive pulmonary disease.

Catheter ablation procedure. A 7F steerable electrode catheter with a distal electrode 4 mm in length (Mansfield Scientific, Mansfield, Mass.) was used in all 25 patients. Techniques for positioning the ablation catheter have been described previously.[1-3] The power source used in this study supplied a continuous, unmodulated output at 500 KHz (EP Technologies, Inc., Mountain View, Calif.). Current was applied between the distal electrode of the ablation catheter and a large-diameter skin electrode placed on the posterior chest. Through an interface with a microcomputer (T-1600, Toshiba Electronics, Tokyo, Japan), this device measures and stores applied power and impedance during each application of radiofrequency energy. After successful ablation of either the slow pathway in patients with AVNRT or the accessory pathway, patients underwent the investigational protocol.

Experimental protocol. Informed consent was obtained from all patients under a protocol approved by the Human Research Committee at the University of Michigan. In each patient the ablation catheter was introduced into the right ventricle. Under fluoroscopic guidance it was slowly withdrawn until it was no longer in consistent contact with the endocardium as manifested by sliding of the tip during the cardiac cycle. The absence of consistent contact was confirmed by the observation of a bipolar capture threshold > 3.0 V (2 msec pulse width). A bipolar electrogram was recorded with minimal filtering (0.05 to 1000 Hz). To measure impedance without producing a lesion, 2 W of radiofrequency power was applied for 30 seconds. Previous studies in animals have shown that applications at this output do not result in detectable injury.[7,8] The catheter was then repositioned in firm contact with the right ventricular endocardium, as defined by a capture threshold ≤ 1.0 V. As before, a bipolar electrogram was recorded. Two watts of radiofrequency power was again applied for 30 seconds, and impedance was measured. To assess the reproducibility of this measurement and to determine whether there was a time-dependent factor that could influence it, the protocol was repeated a second time in each patient.

Statistical analysis. Continuous variables are expressed as mean ± SD and were compared with Student's t test for paired or unpaired variables. Probability values < 0.05 were considered statistically significant.

RESULTS

Electrogram characteristics. The ventricular electrograms were 2.4 times larger when the catheter was in firm endocardial contact rather than in poor endocardial contact (p 0.0001; Table I). For applications in firm contact with the right ventricular endocardium, the mean ST-segment elevation was 3 ± 2 mV and the mean ventricular capture threshold was 0.6 ± 0.2 mV (Fig. 1).

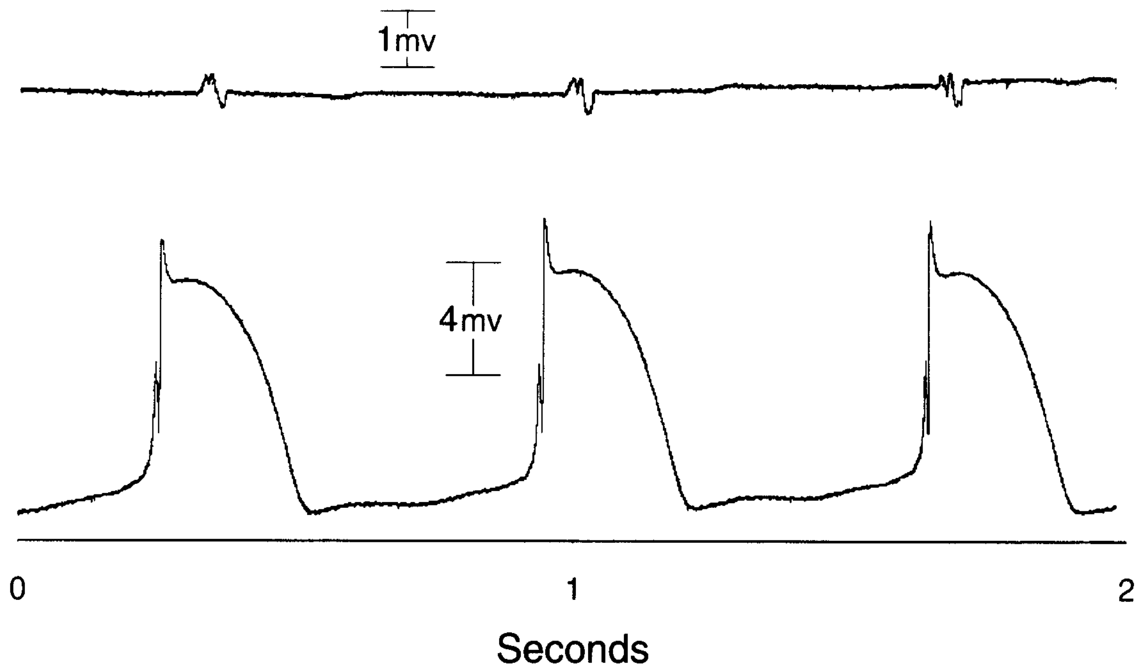

Fig. 1. Patient 7. *Top,* ventricular electrogram with catheter in poor contact with right ventricle. Note ventricular electrogram is 0.6 mV in amplitude and absence of ST-segment elevation. *Bottom,* ablation catheter in firm contact with endocardium of right ventricle. Ventricular electrogram is 9 mV in height with 7 mV of ST-segment elevation.

Impedance measurements. The impedance was 25 ± 15 ohms (22% ± 13%) greater when the catheter was firmly in contact with the right ventricle (139 ± 24 ohms) rather than in poor contact (113 ± 16 ohms, *p* 0.0001; Table I). Likewise, the maximum impedance for applications in firm contact with the right ventricle were 27% greater than for applications with poor catheter-endocardial contact (*p* 0.0001).

Reproducibility of electrogram and impedance data. There was no significant difference in the ventricular electrogram data or impedance data (Table I) between the first and second applications of 2 W of radiofrequency energy when the catheter was in either firm or poor contact with the endocardium.

DISCUSSION

Main findings. These are the first data to demonstrate that firm catheter-tissue contact is an important determinant of impedance in human beings when very low-power radiofrequency energy is applied to the right ventricular endocardium. The measured impedance is 22% greater when the ablation catheter is in firm contact with the endocardial surface rather than poor contact.

Comparison with previous studies. Previous investigation in human beings has demonstrated that body surface area and forced vital capacity are important determinants of impedance during applications of radiofrequency energy.[9] Experiments in animals[10] and studies in human beings[11] have shown an early decrease in impedance as heating occurs at the catheter-endocardial interface. No previous study in animals or human beings has demonstrated an association between catheter-tissue contact pressure and measured impedance, although the present study indicates that impedance when the catheter has poor endocardial contact may relate to the resistivity of blood versus muscle; the resistivity of blood being less than muscle.[12] Therefore the impedance of applications with poor endocardial contact would be more affected by the blood pool and, as was observed in the present study, would be expected to have a lower impedance.

Limitations. This study characterized the effects of firm versus poor tissue contact only. Catheter contact pressure obtained for ablation of PSVT is usually associated with the catheter in intermediate contact pressure with the endocardium. Additionally, these data were not obtained from potential target sites for ablation of PSVT; hence they may not predict the magnitude of change observed with low-power applications of radiofrequency energy in the ventricular cavity and at potential target sites for ablation of PSVT.

Clinical implications. Impedance monitoring has previously been shown to be an effective way to predict tissue heating during applications of radiofrequency energy for ablation of PSVT.[9] These data suggest that measured impedance is greater by about 20% when there is firm catheter-endocardial contact as opposed to poorer tissue contact. Contact pressure may be predicted by comparing the change in observed impedance where a 2 W application of radiofrequency energy is applied in the ventricular cavity and then to a potential target site. Because contact pressure is a predictor of lesion size,[6] impedance monitoring during low-energy applications at potential target sites may be able to predict sites with greater contact pressure and therefore decrease the applications of radiofrequency energy at sites with poor tissue contact. This could lead to a shorter procedure duration and fewer applications of radiofrequency energy. However, the relationship between tissue contact and impedance at target sites for ablation of PSVT requires further investigation.

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