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 ± 13 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 1. Results

<table>
<thead>
<tr>
<th>Catheter-endocardial contact</th>
<th>Mean impedance (ohms)</th>
<th>Maximum impedance (ohms)</th>
<th>Ventricular electrogram (mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>114 ± 16</td>
<td>117 ± 16</td>
<td>5 ± 5</td>
</tr>
<tr>
<td>Firm</td>
<td>141 ± 26*</td>
<td>150 ± 30*</td>
<td>12 ± 5*</td>
</tr>
<tr>
<td>Contact 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>112 ± 18</td>
<td>114 ± 17</td>
<td>4 ± 3</td>
</tr>
<tr>
<td>Firm</td>
<td>134 ± 21†</td>
<td>142 ± 25†</td>
<td>10 ± 4†</td>
</tr>
<tr>
<td>All poor contact applications</td>
<td>113 ± 16</td>
<td>116 ± 16</td>
<td>5 ± 4</td>
</tr>
<tr>
<td>All firm contact applications</td>
<td>139 ± 24†</td>
<td>147 ± 28†</td>
<td>14 ± 5†</td>
</tr>
</tbody>
</table>

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

correlation between catheter-endocardial contact pressure and lesion volume. 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 re-entrant 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.‡ 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.‡ 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 1). 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).
Impedance measurements. The impedance was 
25 ± 15 ohms (22% ± 13%) greater when the cath-
eter was firmly in contact with the right ventricle 
(130 ± 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) be-
tween the first and second applications of 2 W of ra-
diofrequency energy when the catheter was in either 
firm or poor contact with the endocardium.

DISCUSSION

Main findings. These are the first data to demon-
strate that firm catheter-tissue contact is an impor-
tant determinant of impedance in human beings 
when very low-power radiofrequency energy is ap-
plied to the right ventricular endocardium. The 
measured impedance is 22% greater when the abla-
tion catheter is in firm contact with the endocardial 
surface rather than poor contact.

Comparison with previous studies. Previous inves-
tigation 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 animals10 
and studies in human beings11 have shown an early 
decrease in impedance as heating occurs at the cath-
eter-endocardial interface. No previous study in an-
imals or human beings has demonstrated an associ-
ation between catheter-tissue contact pressure and 
measured impedance, although the present study indi-
cates 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 as-
sociated 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 appli-
cations 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. 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, 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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REFERENCES