A prospective, randomized comparison of temperature-controlled vs manually delivered radiofrequency catheter ablation in patients undergoing atrioventricular nodal modification or accessory pathway ablation

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Aims In a prospective, randomized study, the effect of temperature control on radiofrequency catheter ablation was compared in 69 patients undergoing atrioventricular nodal modification (n = 32) or ablation of an accessory pathway (n = 37).

Methods and results Thirty-five patients were randomized to temperature control, 34 to manually delivered radiofrequency ablation. The success rate was 92.5% for accessory pathway ablation and 100% for atrioventricular nodal modification. Mapping duration was significantly reduced only in patients undergoing atrioventricular nodal modification. The number of applications was higher for manually delivered ablation in patients undergoing atrioventricular nodal modification (5.6 ± 1.1 vs 1.9 ± 0.4, P=0.004) as was the cumulative energy delivered (5034 ± 1008 vs 2054 ± 517 W, P=0.013) whereas the mean power per application was higher with temperature control (41.4 ± 1.8 vs 34.1 ± 1.1 W, P=0.002). No significant differences in these parameters were found in patients undergoing accessory pathway ablation. Coagulum formation on the catheter tip was observed more often with manually delivered ablation (5.3% vs 0.9%, P=0.026). The success rate with the initially randomized application mode was higher for temperature control (94.3% vs 61.8%, P=0.003).

Conclusions Temperature control during radiofrequency current ablation significantly reduces mapping duration, necessary applications and cumulative energy in atrioventricular nodal modification, but not accessory pathway ablation. Coagulum formation on the catheter tip still occurs but is significantly reduced compared to manually delivered radiofrequency current.

Key Words: Radiofrequency ablation, supraventricular tachycardia, accessory pathway, temperature monitoring.

Introduction

Radiofrequency current catheter ablation has been shown to be an effective and safe therapy for patients with accessory atrioventricular pathways and atrioventricular nodal reentrant tachycardia (AVNRT). It exerts its effect by producing well-demarcated myocardial lesions caused by resistive as well as conductive tissue heating. However, the use of radiofrequency current in the manual mode leaves the operator unaware of the temperature at the electrode-tissue interface. This may cause potential complications such as coagulum formation caused by overheating of the catheter tip. Therefore, ablation catheters equipped with a thermistor at the catheter tip have been developed that regulate the power output to achieve a steady, operator-selected temperature at the catheter tip. Initial studies both in animal experiments and in patients undergoing atrioventricular junctional ablation or accessory pathway ablation have shown potential benefits of temperature control. The aim of the present study was to determine whether temperature control improves procedure performance both during accessory pathway ablation and atrioventricular nodal modification for AVNRT.

Methods

Patient characteristics

Seventy-eight consecutive patients who underwent an attempt at catheter ablation of AVNRT or an accessory pathway...
pathway were screened. Each patient enrolled gave written informed consent to take part in the study. There were 45 women and 33 men; the mean age was 46.6 ± 14.5 (± SD) years. The arrhythmogenic substrate was an accessory pathway in 45 and AVNRT in 33 patients. Patients were prospectively randomized to the initial use of either temperature control or manual radiofrequency current delivery. Nine patients screened were excluded from further analysis because of (1) a substrate requiring more complex diagnostic or mapping procedures, and therefore likely to require longer procedure duration and more radiofrequency current applications (one Mahaim syndrome, two patients with permanent junctional reciprocating tachycardia, one patient undergoing reablation of an accessory pathway), (2) more than one electrophysiological substrate (one ectopic atrial tachycardia in addition to AVNRT, one patient with two accessory pathways), (3) non-successful ablation procedures (two patients initially randomized to temperature control, one patient initially randomized to manual mode). The data of the remaining 69 patients were used for analysis. There were 37 patients with an accessory pathway and 32 patients with AVNRT. We compared temperature-controlled and manually delivered radiofrequency current ablation procedures with regards to (1) procedure duration, (2) mapping duration (measured from introduction of the mapping catheter into the heart until the successful application), (3) fluoroscopy time, (4) number of applications, (5) cumulative energy delivered (total sum of each application energy), (6) cumulative application duration (sum of each application duration), (7) mean duration of each application, (8) mean power, (9) number of impedance rises >150Ω and (10) number of coagulum formations. Data were compared using the unpaired t-test (values expressed as mean ± SEM). The number of necessary mode switches and the number of patients eventually successfully treated with one or other mode were compared using the chi-square test. Probability values <0.05 were considered to be statistically significant.

**Electrophysiological study**

Electrophysiological study and ablation were done in a single session in all patients in the fasting, non-sedated state. The number and type of diagnostic catheters used were individualized to the patient’s underlying arrhythmogenic substrate.

**Accessory atrioventricular pathways**

Patients were randomized after localization of the accessory pathway, established during endocardial mapping by the currently accepted criteria[14–16]. This was done in order to exclude differences in mapping duration between both randomized groups caused by more ‘difficult’ accessory pathway locations in one group. In all patients with overt pre-excitation, a single catheter approach, as previously described, was attempted first[10]. If this approach failed or in concealed accessory pathways, additional catheters were placed in the high right atrium, right ventricular apex, His bundle position and, if necessary, in the coronary sinus. Mapping was done during sinus rhythm or atrial pacing (overt pre-excitation) or during circus movement tachycardia or ventricular pacing (concealed pathways). In patients with left-sided accessory pathways, a retrograde aortic approach, in patients with right-sided pathways a right atrial approach, always from the inferior vena cava, was used.

**AVNRT**

In patients with AVNRT, electrode catheters were placed in the high right atrium, right ventricular apex and His bundle position. Once the tachycardia mechanism was defined, catheter ablation was performed using standard techniques. In patients with AVNRT, a posterior approach was initially attempted. Mapping criteria included presence of a ‘slow pathway’ potential or fractionated atrial activity and an A/V ratio of ≤0.5 in the mapping catheter. If radiofrequency current applications failed at this site the catheter was moved further mid-septally until successful cure of the arrhythmia was achieved. Success was defined as non-inducibility of AVNRT regardless of the presence of dual atrioventricular nodal pathway physiology or presence of atrioventricular nodal echoes, before and after an isoproterenol infusion aimed to increase the basal heart rate to 120%.

**Ablation equipment**

The ablation system used (HAT 200 S, Dr Osypka GmbH, Grenzach-Wyhlen, Germany) generates 500 kHz unmodulated radiofrequency current and provides closed-loop feedback temperature control. In the temperature-control mode the power output is automatically regulated to keep the temperature at the catheter tip selected by the operator (adjustment of power every 0.5 s below the pre-selected temperature and every 0.125 s if the pre-selected temperature is exceeded). In the power control mode power output is kept constant. There is an automatic power shutdown at 100°C in the temperature control mode and at an impedance of 200Ω in both modes. The sampling rate of the system is 8/s for temperature and impedance. Pre-selected temperature was 70°C in all applications with temperature control. In all other applications the power output was initially set to 20 to 30 W. If desired, the output could be increased in 5 W increments.

The duration of each application was 20 to 60 s or until catheter dislodgement or automatic power shut-off occurred. After each application with automatic shut-off the catheter was withdrawn and inspected for visible coagulum formation. For ablation without temperature monitoring a standard 7 F quadripolar mapping and ablation catheter with a 4 mm tip electrode (Webster-Cordis, U.S.A.) was used. For temperature-controlled ablation we used a steerable, 7 F quadripolar...
The data of the reablation procedures are not included in the analysis. All patients were successfully reablated and in 3/32 patients (9.4%) after atrioventricular nodal modification. After 10 unsuccessful applications the operator was free to use any catheter or delivery mode as deemed necessary for ablation success. All ablation procedures were performed by the same operator.

Follow-up

In 35 patients, a repeat electrophysiological study was done to exclude recurrence of AVNRT or accessory pathway conduction. The remaining patients were seen in our hospital at 3 months, and 1 and 2 years after the procedure, when patients were questioned about recurrent symptoms, and a standard 12-lead ECG, a Holter and a treadmill test were done.

Results

Clinical results

Successful interruption of the accessory pathway was achieved in 37/40 patients (92.5%) and non-inducibility of AVNRT in all 32 patients (100%). All patients excluded from further analysis were also successfully ablated, except the patient with additional ectopic atrial tachycardia. In this patient, AVNRT was cured by radiofrequency current ablation and atrial tachycardia. In this patient, AVNRT was cured by radiofrequency current ablation and atrial tachycardia was medically controlled. Mean procedure duration, mapping duration, fluoroscopy time, ablation energy, duration and power per application for atrioventricular nodal modification and accessory pathway ablation are listed in Table 1. Clinical characteristics, accessory pathway location and mapping criteria of both randomized patient groups are listed in Table 2. After a follow-up of 23.1 ± 1.6 months arrhythmia recurrence occurred in 2/37 patients (5.4%) after accessory pathway ablation and in 3/32 patients (9.4%) after atrioventricular nodal modification. All patients were successfully reablated. The data of the reablation procedures are not included in the analysis.

Mode switch

Of the 69 patients analysed, 35 were randomized to temperature control and 34 to the manual mode. The success rate before mode switch (≤5 applications) did not differ in the accessory pathway group (73.7% with temperature-control vs 66.7% in the manual mode, P=ns) but did differ in the AVNRT group (93.8% with temperature control vs 56.3% in the manual mode, P<0.05). In the temperature-control group, six patients (17.1%) had to be switched to the manual mode. However, only two patients (5.7%) were eventually successfully ablated with manual radiofrequency current delivery. The remaining patients were not successfully ablated until temperature control was re-established. In contrast, of the 34 patients randomized to the manual mode, 13 patients (38.2%) were switched to temperature control. All were eventually successfully ablated in this mode. Therefore, 33/35 patients (94.3%) of the patients initially randomized to temperature control were finally ablated in this mode, whereas only 21/34 patients (61.8%) randomized to the manual mode were eventually successfully treated in this mode (P=0.003). In the accessory pathway group, there was no difference with regards to the necessity of a mode switch (26.3% of the patients randomized to temperature-control vs 33.3% of the patients randomized to the manual, P=ns). However, there was also a tendency for a higher final success rate with temperature-control (94.7%) as opposed to manually delivered radiofrequency current (66.7%, P=ns). In patients undergoing atrioventricular nodal modification, both the rate of mode switch (6.2% with temperature-control vs 43.8% with the manual mode, P=0.04) and the success rate with the initially randomized mode (93.8% with temperature-control vs 56.3% with manual delivery, P=0.04) were significantly different in favour of temperature-control (Table 3).

Table 1 Procedure parameters in accessory pathway ablation and atrioventricular nodal modification

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AP ablation</th>
<th>AV nodal modification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ablation success</td>
<td>37/40 (92.5%)</td>
<td>32/32 (100%)</td>
</tr>
<tr>
<td>nA</td>
<td>7 ± 1.4</td>
<td>3.8 ± 0.7</td>
</tr>
<tr>
<td>tM (min)</td>
<td>149.7 ± 15.5</td>
<td>110.5 ± 7.6</td>
</tr>
<tr>
<td>tX (min)</td>
<td>106.4 ± 14.9</td>
<td>451.7 ± 2.8</td>
</tr>
<tr>
<td>E (W)</td>
<td>5924 ± 1166</td>
<td>3544 ± 619</td>
</tr>
<tr>
<td>tApp (s)</td>
<td>168.7 ± 30.7</td>
<td>94.5 ± 16.1</td>
</tr>
<tr>
<td>Pm (W)</td>
<td>33.1 ± 3</td>
<td>37.7 ± 1.2</td>
</tr>
<tr>
<td>Recurrence</td>
<td>2/37 (5.4%)</td>
<td>3/32 (9.4%)</td>
</tr>
</tbody>
</table>

E = cumulative ablation energy; nA = number of applications; Pm = mean ablation power; tApp = cumulative application duration, tM = mapping duration, tX = procedure duration, tXM = fluoroscopy time.

Procedure/mapping duration and fluoroscopy time

There were no significant differences in procedure duration or fluoroscopy time with temperature control compared to the manual mode, although there was a
Table 2  Clinical and mapping characteristics

<table>
<thead>
<tr>
<th></th>
<th>TC-RFA (n=35)</th>
<th>mRFA (n=34)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (in years ± SD)</td>
<td>46-4 ± 13 1</td>
<td>46-9 ± 16</td>
<td>ns</td>
</tr>
<tr>
<td>Gender (female/male)</td>
<td>20/15</td>
<td>20/14</td>
<td></td>
</tr>
<tr>
<td>Underlying heart disease</td>
<td>2 CAD</td>
<td>1 CAD</td>
<td></td>
</tr>
</tbody>
</table>

**Accessory pathway**

<table>
<thead>
<tr>
<th></th>
<th>TC-RFA (n=35)</th>
<th>mRFA (n=34)</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Localization:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left free wall</td>
<td>9</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Left paraseptal</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Right free wall</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Right paraseptal</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Overt AP</td>
<td>14</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

**Overt**

<table>
<thead>
<tr>
<th></th>
<th>TC-RFA (n=35)</th>
<th>mRFA (n=34)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>V-QRS SR/atrial pacing (successful appl., ± SD)</td>
<td>-9 4 ± 8 5 ms*</td>
<td>-7 8 ± 8 3 ms**</td>
<td>ns</td>
</tr>
<tr>
<td>V-QRS SR/atrial pacing (non-successful appl., ± SD)</td>
<td>-2 ± 7 ms</td>
<td>-3 ± 7 2 ms</td>
<td>ns</td>
</tr>
</tbody>
</table>

**Concealed**

<table>
<thead>
<tr>
<th></th>
<th>TC-RFA (n=35)</th>
<th>mRFA (n=34)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of CEA during CMT (successful appl.)</td>
<td>4/5 (80%)</td>
<td>3/4 (75%)</td>
<td>ns</td>
</tr>
<tr>
<td>Presence of CEA during CMT (non-successful appl.)</td>
<td>4/26 (15%)</td>
<td>6/24 (25%)</td>
<td>ns</td>
</tr>
</tbody>
</table>

**AVNRT**

<table>
<thead>
<tr>
<th></th>
<th>TC-RFA (n=35)</th>
<th>mRFA (n=34)</th>
<th>P</th>
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</thead>
<tbody>
<tr>
<td>Inducibility before RFA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>13</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>After isoproterenol infusion</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Presence of SPP or FAA (%)</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>A/V ratio: successful appl. (± SD)</td>
<td>0.19 ± 0.1</td>
<td>0.18 ± 0.27</td>
<td>ns</td>
</tr>
<tr>
<td>non-successful appl. (± SD)</td>
<td>0.38-0.24</td>
<td>0.27-0.11</td>
<td>ns</td>
</tr>
</tbody>
</table>

*P<0.05; **P<0.01 as compared to non-successful appl.

**Table 3  Ablation success with respect to radiofrequency application mode**

<table>
<thead>
<tr>
<th></th>
<th>TC-RFA (n=35)</th>
<th>mRFA (n=34)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode switch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Success with initially randomized mode</td>
<td>6 (17.1%)</td>
<td>13 (38.2%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 (26.3%)</td>
<td>6 (33.3%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 (6.3%)</td>
<td>7 (43.8%)*</td>
<td></td>
</tr>
</tbody>
</table>

**Table 4  Comparison of procedure duration and fluoroscopy time**

<table>
<thead>
<tr>
<th></th>
<th>TC-RFA (n=35)</th>
<th>mRFA (n=34)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>130 ± 12</td>
<td>133 ± 14 4</td>
<td></td>
</tr>
<tr>
<td>TX</td>
<td>20 6 ± 3 3</td>
<td>24 7 ± 4 9</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>TC-RFA (n=19)</th>
<th>mRFA (n=18)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>155 ± 20</td>
<td>144 2 ± 24 3</td>
<td></td>
</tr>
<tr>
<td>TX</td>
<td>29 7 ± 4 9</td>
<td>33 7 ± 8 2</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>TC-RFA (n=16)</th>
<th>mRFA (n=16)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP</td>
<td>100 3 ± 5 7</td>
<td>120 6 ± 13 9</td>
<td></td>
</tr>
<tr>
<td>TX</td>
<td>9 8 ± 2 3</td>
<td>14 5 ± 3 7</td>
<td></td>
</tr>
</tbody>
</table>

Tendency towards reduction in both parameters in patients undergoing atrioventricular nodal modification with temperature control (Table 4). However, mapping duration was significantly shorter with the use of temperature control in the AVNRT group (27-8 ± 3-1 vs 62 5 ± 14-5 min, P=0.026) but not in the accessory pathway group (112 ± 18 8 vs 100 ± 23-8 min, P=ns, Fig. 1).
All patients AVNRT

Figure 1 There was no significant reduction in mapping duration with temperature control compared to manually delivered radiofrequency ablation in the total patient population (left two columns) or the patients with accessory pathways (middle two columns). In patients undergoing atrioventricular nodal modification, however, mapping duration was significantly reduced (right two columns). AP = accessory pathway; AVNRT = atrioventricular nodal reentrant tachycardia; \( \square \) = manually delivered radiofrequency ablation; \( \mathbf{T} \) = temperature-controlled radiofrequency ablation.

Number of applications, cumulative energy, application duration and mean power per application

The number of necessary applications was not altered by temperature control in patients undergoing accessory pathway ablation (8.3 ± 1.8 vs 7.1 ± 2.2 for manually delivered ablation, \( P = \text{ns} \)) whereas in patients undergoing atrioventricular nodal modification a higher number of applications was needed with the manual mode (5.6 ± 1.1 vs 1.9 ± 0.4 for temperature-control, \( P = 0.004 \), Fig. 2 (a)). Accordingly, cumulative energy was not significantly different between temperature control and manual delivery in the accessory pathway group (7211 ± 1834 vs 4637 ± 1426 W, \( P = \text{ns} \)) whereas in the AVNRT group it was significantly higher in patients treated with the manual mode (5034 ± 1009 vs 2054 ± 517 W, \( P = 0.013 \), Fig. 2 (b)). The same was true for cumulative application duration (see Fig. 2 (c)). The mean duration of each individual application was not significantly different in either the accessory pathway group (23.6 ± 5.8 s for temperature control vs 20.0 ± 4.4 s for the manual mode, \( P = \text{ns} \)) or the AVNRT group (25.7 ± 2.2 s for temperature-control vs 25.0 ± 2.5 s for the manual mode, \( P = \text{ns} \)). Finally, there was no difference in mean power per application in the accessory pathway group (34.4 ± 2.4 W with temperature-control vs 31.8 ± 1.2 W with the manual mode, \( P = \text{ns} \)) whereas mean power was significantly higher for temperature-control ablation in the AVNRT group (41.4 ± 1.8 W vs 34.1 ± 1.1 W, \( P = 0.002 \), Fig. 2 (d)).

Figure 2 Same configuration as in Fig. 1. Note that there was a significant reduction both in the number of applications (a), total cumulative energy required (b) and cumulative application duration (c) with temperature-control only in patients undergoing atrioventricular nodal modification. Mean power was significantly increased in this group as well as in the total patient population (d). \( E_c = \text{total cumulative energy; } n_A = \text{number of applications; } P_m = \text{mean power; } T_{\text{appl}} = \text{cumulative application duration.} \)
ent operator skills may have influenced the data, as larger number of patients included in that study, differ-
cacy of temperature control in radiofrequency current patients undergoing accessory pathway ablation' 23'.
catheter tip' 14'. A multicentre trial has proven the effi-
cient on accessory pathway location' 24'25'. Despite the

electrode interface rather than to the peak power or
myocardial temperature'21'. Clinical experience has
at the catheter tip does not represent changes of intra-
voltage110', although these results have been challenged
by other authors who found no strong correlation
between peak temperature and lesion size' 20'. This may
be explained by the fact that the temperature measured
at the catheter tip does not represent changes of intra-
myocardial temperature[21]. Clinical experience has
shown that temperature-controlled radiofrequency current
ablation may reduce coagulum formation at the

catheter tip[14]. A multicentre trial has proven the efi-
cacy of temperature control in radiofrequency current
ablation procedures[22]. In a recent, randomized study by
Strickberger et al. no effect of temperature monitoring, as opposed to our study with only one operator. Finally,
no patients with AVNRT were evaluated.

The results of our study suggest that substantial
improvement by temperature control may only be
achieved in this patient group. The fact that the number
of applications, cumulative energy and application
duration were lower with temperature control in the
AVNRT group, whereas the mean power was higher,
points to the operator's reluctance to apply sufficient
energy to the atrioventricular nodal region in the
manual mode for fear of inducing complete atrio-
ventricular block. This may result in an increased
number of inefficient applications because of insufficient
tissue heating, which may, in turn, be responsible for the
increased mapping duration. Sudden changes of imped-
ance during radiofrequency current ablation are indica-
tive of an increased risk of coagulum formation at the
catheter tip[23]. Therefore, impedance monitoring may
also be used to control the ablation power necessary for ablation[23,26,27], but whether this offers any advantage
over temperature control is yet unclear. Despite a sign-
ificant reduction in coagulum formation on the cath-
eter tip with temperature monitoring, impedance rises
and even charring may still occur. There are some
possible explanations for this observation: (1) The posi-
tion of the catheter tip may be in a parallel rather than
perpendicular orientation towards the endocardium,
resulting in a lower temperature recorded at the site of
the thermistor as compared to the lateral tip electrode
contacting the endocardium. An under-estimation of
tissue peak temperature of up to almost 8°C caused by
this mechanism has been demonstrated in animal
studies[28,29]. (2) The automatic shut-off algorithm of the
closed-loop system may be reacting too slowly so that
overheating of the catheter tip occurs before automatic
power shut-off. These problems may be overcome in the
future by catheters with multiple thermistors mounted
on the catheter tip[28] and improvements of the shut-off
system of temperature-controlled ablation generators.

**Limitations of the study**

The design of the study included a mode switch. This
may have reduced actual differences between both
modes. However, the authors felt that a mode switch
had to be included to ensure a maximal chance of
ablation success and exclude the tendency of the opera-
tor to switch preferably to one mode. Secondly, the
study included ablation data of only one operator.
Therefore, the number of patients was small. It is
conceivable that with larger patient numbers there may
have been an advantage of temperature control in
patients with accessory pathways, although this is not
supported by others[23] and our data do not show a
trend towards improved performance with temperature
control. Third, patients not successfully ablated were
excluded because non-successful studies inherently
have longer procedure durations than successful ones.
However, there were only two non-successful ablation

![Figure 3](https://example.com/fig3.png)

**Figure 3** With the use of temperature-control there was
a reduced incidence of impedance rises (left two columns)
and catheter tip coagulations (right two columns). However,
only the reduction in coagulum formation was statisti-
cally significant. Abbreviations as in Figs 1 and 2.
attempts in the temperature-control group and one in the group randomized to the manual mode. Therefore, it is unlikely that inclusion of non-successful ablation attempts would have changed the data significantly. Finally, the type of catheter used — apart from the implementation of a thermistor — may have influenced the ease of intraoperative mapping. At the time the study was performed only the thermistor-equipped catheter used was available for temperature-controlled radiofrequency current ablation with the HAT 200 S ablation system.

References