Successful Irrigated-Tip Catheter Ablation of Atrial Flutter Resistant to Conventional Radiofrequency Ablation

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Methods and Results—Of 170 patients referred for ablation of common atrial flutter, conventional ablation of the cavotricuspid isthmus with >21 applications failed to create a bidirectional block in 13 (7.6%). An irrigated-tip catheter ablation was performed on identified gaps in the ablation line according to a protocol found to be safe in animals: a moderate flow rate of 17 mL/min and temperature-controlled (target, 50°C) RF delivery with a power limit of 50 W. Bidirectional isthmus block was achieved in 12 patients by use of a mean delivered power of 40±6 W with a single application in 6 patients and 2 to 6 applications in the other 6. No side effects occurred during or after the procedure.

Conclusions—Irrigated-tip catheter ablation is safe and effective for achieving cavotricuspid isthmus block when conventional RF energy has failed. (Circulation. 1998;98:835-838.)

Key Words: atrial flutter • catheter ablation

Right atrial flutter is a macroreentrant tachycardia propagating counterclockwise or, less commonly, clockwise in the right atrium (RA). Its circuit has now been extensively mapped.1-3 Catheter ablation using radiofrequency (RF) energy targeting the cavotricuspid isthmus is very effective.4-7 Bidirectional isthmus conduction block is the best end point to reduce as much as possible the recurrence rate after ablation.2,8,9 Nevertheless, it cannot be achieved with conventional RF technology in a small subset of patients.5 Experimental studies have shown that deeper and wider lesions can be performed safely in the atrial myocardium with irrigated-tip catheters.10 We investigated the safety and efficacy of irrigated-tip catheters in a consecutive series of patients referred for ablation of typical atrial flutter in whom isthmus block could not be achieved with conventional RF energy.

Methods
Between April 1997 and May 1998, 170 patients underwent typical flutter ablation at our institution. Patients with recurrent flutter or those who had had a failed ablation at other centers were excluded. Catheter ablation failed to create isthmus block in 13 patients: 1 woman and 12 men, 33 to 71 years old (mean, 56±10 years) who had been suffering from atrial flutter for 20±20 months. A mean number of 2.5±1 antiarrhythmic drugs, including amiodarone in 8, were tried unsuccessfully. Seven patients had structural heart disease: surgically closed atrial septal defect (n=1), dilated cardiomyopathy (n=1), ischemic heart disease (n=2), and hypertrophic cardiomyopathy (n=3) (Table).

Conventional RF Ablation
The method of RF ablation has been described elsewhere.5 RA mapping was performed to demonstrate activation around the tricuspid annulus and through the isthmus: lateromedial for counterclockwise flutter with isthmus electrograms centered on the flutter plateau or mediolateral for clockwise flutter. Electrograms were recorded with a PPG Midas polygraph using high-gain amplification (0.1 mV/cm) and a 30/500-Hz band pass. The linear lesion was made sequentially (with point-by-point ablation) from the tricuspid annulus to the inferior vena cava with a quadripolar 4-mm-tip electrode catheter with temperature control (Cordis-Webster, Medtronic Inc). RF energy (550-kHz unmodulated sine wave output up to 70 W) was delivered through a Cordis-Stockert generator with a temperature setting of 70°C for 60 to 90 seconds at each point without moving the catheter. The end point was interruption of flutter and bidirectional isthmus block demonstrated by activation mapping during pacing from the low lateral RA and proximal coronary sinus adjacent to the ablation line,2,5 in addition to a complete line of block defined by on-site recording of widely separated local double potentials (Figure 1). The first component (DP1) resulted from local activation produced by the upstream flank of the line, and the second potential (DP2) was the latest component of RA activation propagating around the tricuspid annulus to the opposite flank of the line.

An incomplete line was identified by the presence of gaps defined as isolated or fractionated potentials centered on the isoelectric interval of adjacent double potentials as previously described.11 In the present study group, failure of conventional RF ablation was defined as the inability to achieve isthmus block after >21 RF applications, which is the mean number ±2 SD of RF applications required for successful conventional RF ablation in our patients.
Irrigated-Tip Catheter Ablation

The irrigated-tip catheter (Cordin Webster, Medtronic Inc) was used for ablation during the same session by targeting previously identified resistant gap(s) (during flutter or low lateral RA pacing) (Figure 2). RF was delivered according to a protocol found to be safe in experimental studies. This consisted of temperature-controlled RF delivery (a power limit of 50 W with a target temperature of 50°C) for 30 to 60 seconds at each point. Normal saline (0.9%) was infused through the irrigated-tip catheter with a Gemini Imed pump (battery powered to avoid 50-Hz line noise) at a rate of 17 mL/min during RF delivery. Between applications, a flow rate of 3 mL/min was used to maintain patency. For each application, the achieved power and temperature as well as impedance were noted at 20 seconds. The 12-lead ECG was carefully scrutinized during and after each application as well as at the end of the procedure to monitor ST changes. Procedural success was defined as the achievement of stable bidirectional isthmus block. When the irrigated-tip catheter was withdrawn, the tip was carefully examined to note the presence of clot or char. No procedural anticoagulation was used.

Postablation Care

Subcutaneous low-molecular-weight heparin (2500 IU) was usually administered once or twice a day if left ventricular function was impaired. In case of a prior thromboembolic event and/or history of atrial fibrillation, subcutaneous heparin was preferred (partial thromboplastin time = twice the control value). Twenty-four-hour Holter recording was performed on day 1 to 3 after ablation combined with 5 days of in-hospital telemetry. Twelve-lead ECGs and physical examinations were performed every day to be sure that no side effects, including myocardial ischemia, occurred. Transthoracic echocardiography and an exercise stress test were performed 3 to 5 days after the procedure. Patients were discharged on day 5 without antiarrhythmic drugs. Follow-up examination was performed by the referring physician, and information regarding any cardiovascular events was obtained by telephone.

Clinical Details

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age, y</th>
<th>SHD</th>
<th>Ablation Parameters at the Resistant Site(s)</th>
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<td>Power, W</td>
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<tr>
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<td>59</td>
<td>ASD</td>
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<tr>
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<td>50</td>
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<tr>
<td>SD</td>
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</table>

SHD indicates structural heart disease; ASD, atrial septal defect; SHD, pacing stimulus to atrial activation at His level; Sti-CS, stimulus to proximal coronary sinus; Sti-DP2, stimulus to second component of the double potential; and DP1-DP2, interval between the two components of the double potentials recorded on the line. *Isthmus block could not be achieved.

Irrigated-Tip Catheter Ablation

Efficacy

At the end of the failed ablation procedure with conventional RF, 9 patients were in sinus rhythm and 4 (patients 2, 3, 11, and 12) in persistent flutter (counterclockwise, n = 3, and clockwise, n = 1). With the irrigated-tip catheter, the flutter was interrupted within 30 seconds during the first application in patients 2 and 11, the second application in patient 12, and the ninth application in patient 3. However, it was reinducible in patient 3. Bidirectional isthmus block was achieved in 12 patients (all except patient 3) with a median of 1 and a mean of 2.5 ± 1.9 RF applications. The mean delivered power was 40 ± 6 versus 14 ± 6 W with conventional RF energy. Six patients required a single application, and 6 required 2 to 6 RF applications (Table). In patients successfully ablated with a single RF application, the site of ablation was a previously identified gap exactly where multiple attempts failed (Figure 2). The resistant gaps were located in the ventricular third of the isthmus in 6 patients, in the middle of the isthmus in 5, and near the inferior vena cava edge in 2. The mean procedure duration and fluoroscopic time (conventional and irrigated ablation) were 185 ± 54 and 76 ± 38 minutes.

Bidirectional isthmus block was associated with conduction times from the low lateral RA pacing stimulus to the atrial electrogram at the His bundle of 113 ms, to the proximal coronary sinus of 140 ms, and to DP2 of 156 ms, as well as a craniocaudal low lateral RA activation sequence during coronary sinus pacing. A line of double potentials with
a mean DP1-DP2 interval of 123±25 ms was observed during low lateral RA pacing (Table).

In patient 3, the procedure failed to interrupt the reinduced flutter despite 22 irrigated-tip catheter RF applications with a mean delivered power of 40±6 W, including repeating the ablation line 3 times. After ablation, a complete bidirectional isthmus block is achieved, as demonstrated by distal-to-proximal activation of Halo during LLRA pacing and proximal-to-distal during coronary sinus pacing. In both cases, widely separated double potentials are recorded on ablation line. First component results from local activation at upstream flank of line, and second component is latest component of RA activation propagating around tricuspid annulus to opposite flank of line. In both panels, second potential on line (DP2) is later than latest bipolar recorded on Halo catheter. Stimulus—DP2=170 ms during LLRA pacing (left) and 180 ms during coronary sinus pacing (right), while distal bipolar of Halo is activated 155 ms after pacing artifact. S indicates pacing stimulus; V, ventricular activation.

Safety
One audible pop was noted, but no impedance rise was observed. There were no significant side effects during or after the procedure as assessed by clinical evaluation and serial 12-lead ECG. After ablation, a stress test was obtained for all but 2 patients who were in cardiac failure. There was no clinical or electrical evidence of ischemia, although in patient 2, a 4-mm ST-segment depression was observed, related to hypertrophic cardiomyopathy. After a mean follow-up of 5±3 months, no recurrence of flutter was observed, including in patient 3. No patient developed clinical or ECG signs of ischemic disease.

Discussion
The present study indicates that bidirectional block can be successfully achieved with an irrigated-tip catheter in patients in whom conventional RF applications have failed.

Among 170 consecutive patients referred for cavotricuspid isthmus ablation, the incidence of resistant cases was 7.6%, comparable to that of other series. Because the long-term success of flutter ablation is clearly linked to the creation of bidirectional isthmus block, this has now become the usual end point for flutter ablation. The exact reason for resistance to conventional RF is unclear; it may be due to thicker than usual isthmus myocardium (as probably in patient 3) or to a site topography associated with an entrapped catheter preventing convective cooling by local blood flow and resulting in limited delivered power as low as 5 W (Table). Saline irrigation of the ablation electrode maintains a low electrode-tissue interface temperature and thus prevents impedance rise, allowing greater RF power delivery and thus producing larger and deeper lesions. This is certainly the mechanism of success particularly in patients cured with a
Irrigated-Tip Catheter Ablation

single application, because an identical site was targeted with both RF modalities.

Saline irrigation is a double-edged sword: by elimination of impedance rise, the autolimiting effect on delivered RF energy is lost, exposing the patients to a higher risk of tamponade or coronary injury due to very large lesions or popping. As demonstrated in animals, the risk is minimized by use of a relatively low power limit of 50 W, in the range of what is currently used in conventional RF ablation. Despite contradictory data in the literature, a temperature-controlled mode of RF delivery was used, in combination with a moderate flow rate, to preserve the relation between tip temperature and tissue temperature and therefore decrease the risk of popping; the mean achieved temperature was clearly under the upper limit chosen, which supports this hypothesis. Eight-millimeter-tip electrode catheters may also achieve similar results for resistant flutter.

Limitations

The small number of patients included in our series is an important limitation; however, they were selected from a large patient base. The repetition of lines at a more septal or lateral level might have been effective with conventional RF. This was not evaluated in this study but could be attempted before the use of an irrigated-tip catheter is envisaged. We did not systematically perform a coronary angiogram after the procedure as suggested in some studies using higher RF power, but we assessed coronary status by clinical and stress test evaluation and did not observe coronary side effects. However, the long-term follow-up of irrigated-tip lesions is unknown.

Conclusions

In a small subset of patients, complete cavotricuspid isthmus block cannot be achieved with conventional RF energy. Irrigated-tip catheters capable of delivering a higher amount of energy on sites resistant to conventional ablation RF allow this end point to be reached. The protocol used in this study with temperature control mode, low flow rates, and a power limit of 50 W appeared to be safe. Nevertheless, irrigated-tip catheters should be considered as backup therapy for resistant cases until a larger series with longer follow-up is available.

References

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