Letter to the Editor

Ablation of Cavotricuspid Isthmus-Dependent Flutter Using a Mini-Electrode–Equipped 8-mm Ablation Catheter: Case Series

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Catheter ablation is the treatment of choice for the prevention of recurrences and the long-term management of patients with cavotricuspid isthmus (CTI)-dependent atrial flutter. In current clinical practice, CTI ablation is performed with the use of large-tip or irrigated ablation catheters, since they have been shown to reduce the procedure duration and to increase the success rate as compared to the use of a standard 4-mm ablation catheter.[1]

A limitation of the large-tip ablation catheter is the impaired near-field electrogram resolution.[2] A novel catheter technology designed to address this issue includes the embedment of mini-electrodes (ME) in close proximity to the edge of large-tip ablation catheters. Electrical activity recorded from the MEs, in contrast to the conventional bipolar recording, may provide improved spatial resolution, detailed and more accurate localization of the catheter tip, as well as reliable guidance for the titration of the radiofrequency energy delivered.[3,4] Gupta et al have reported a case where this novel ablation catheter was used successfully for ablation of a gap in a previously deployed linear lesion across the CTI in a patient with recurrent atrial flutter.[5]

In the present study, we aimed to evaluate the efficacy and safety of this novel ablation catheter in a small series of consecutive patients with CTI-dependent atrial flutter.

Methods

The ablation catheter used in all ablation procedures (IntellaTip MiFi XP; Boston Scientific) is an 8-mm ablation catheter with three MEs (diameter 1.2 mm) equally spaced in a radial array (every 120°), embedded at a distance of ~2 mm from the catheter tip. The MEs are insulated from the 8 mm bipolar electrode by a surrounding sleeve, providing dielectric isolation. Distinct local electrograms can be recorded by the MEs in either a unipolar or a bipolar configuration.

Ablation was performed under therapeutic doses of oral anticoagulants, or following cessation of oral anticoagulant treatment and bridging with subcutaneous low molecular heparin. During the procedure, a deflectable decapolar diagnostic catheter was positioned in the coronary sinus and a quadripolar catheter was placed in the right ventricle. If the patient was in sustained atrial flutter, the CTI dependence of the underlying reentry circuit was validated using the standard electrophysiological criteria of entrainment during pacing from the CTI and the proximal bipole of the coronary sinus catheter. If the

patient was in sinus rhythm, ablation was performed under pacing from the proximal bipole of the coronary sinus catheter.

The ablation catheter was advanced into the right ventricle, close to the tricuspid valve annulus. An ablation line was deployed from the tricuspid valve annulus to the inferior vena cava along the central isthmus (6 o'clock in left anterior oblique projection). Radiofrequency energy was applied either intermittently or continuously during catheter dragging, depending on physician preference and anatomic peculiarities. Ablation was performed using a maximal power of 70W and maximal temperature of 65°C.

The ablation endpoint was achievement of bidirectional CTI block persisting during a 20-minute waiting period. The following electrophysiological criteria were used for documentation of bidirectional CTI block: differential pacing maneuvers;[6] presence of widely split double potentials along the ablation line;[7] and assessment of the atrial activation sequence and measurement of ablation-induced prolongation in transisthmus intervals, during pacing from the coronary sinus ostium and low lateral right atrium.[8]

Monitoring of arrhythmia recurrence was performed using 24-hour Holter monitoring three months post-ablation and/or by a 12-lead surface ECG in case of symptomatic arrhythmia.

Results

Our case series included seven consecutive patients (mean age 66.7 ± 11.4 years, 5 men) with CTI-dependent flutter and no evidence of structural heart disease, who underwent catheter ablation in our department. One case was a redo procedure performed 6 months following the initial ablation procedure. Monitoring of bipolar electrograms recorded by the MEs enhanced accurate localization of the catheter tip, primarily at the ventricular and the inferior vena caval edge of the ablation line, and facilitated validation of conduction block (Figures 1 & 2).

CTI bidirectional block was achieved in all patients following a mean number of 8.9 ± 5.4 lesions with a mean ablation time of 409 ± 227 s. Mean procedure duration was 59.5 ± 20.1 min and mean fluoroscopy dose was 45.8 ± 23.4 Gy.cm^2. During the post-ablation validation of CTI bidirectional block, the mean transisthmus intervals during pacing from the coronary sinus ostium and low lateral right atrium were 141 ± 28.9 ms and 141 ± 23.5 ms respectively.

In our case series, no procedural complications occurred and the in-hospital course of all patients was uneventful. During a mean follow-up period of 195 ± 27 days, one patient presented recurrence of CTI flutter documented by 12-lead ECG.

Discussion

In the present study we report the feasibility of radiofrequency catheter ablation of CTI-dependent flutter in a series of seven consecutive patients, with the use of a novel 8-mm non-irrigated catheter equipped with three radially distributed MEs, embedded near the catheter tip. To our knowledge this is the first case series of CTI ablation using this novel catheter technology. Ablation procedures were performed by three consultant electrophysiologists, without prior specific training in this novel catheter technology. In all cases, bidirectional CTI block was achieved without associated complications. The procedural characteristics in our case series were comparable to those of previous trials reporting data on the use of conventional 8-mm tip catheters in CTI flutter ablation (Table 1). It is worth noting that the total duration of radiofrequency applications in our case series was the lowest when compared to previous trials. However, this is a hypothesis-generating finding and needs to be validated by future, adequately powered studies with direct head-to-head comparison of different ablation catheters.

Previous experience in experimental models

This novel catheter has been reported to display enhanced spatial resolution in experimental models. In an experimental model of myocardial infarction in swine, the ME-equipped catheter facilitated the identification of late potentials in ischemic ventricular scar, which could not be detected by the standard 4 mm bipolar electrode.[9] It has also been shown to improve the resolution of mapping of complex fractionated atrial electrograms during atrial fibrillation.[10] In addition, lesion formation resulted in a significantly greater reduction in electrogram amplitude and maximum frequency in bipolar ME as compared to a conventional tip-to-ring configuration.[2] Thus, monitoring of electrogram amplitude and frequency has been proposed as a surrogate of effective lesion deployment.

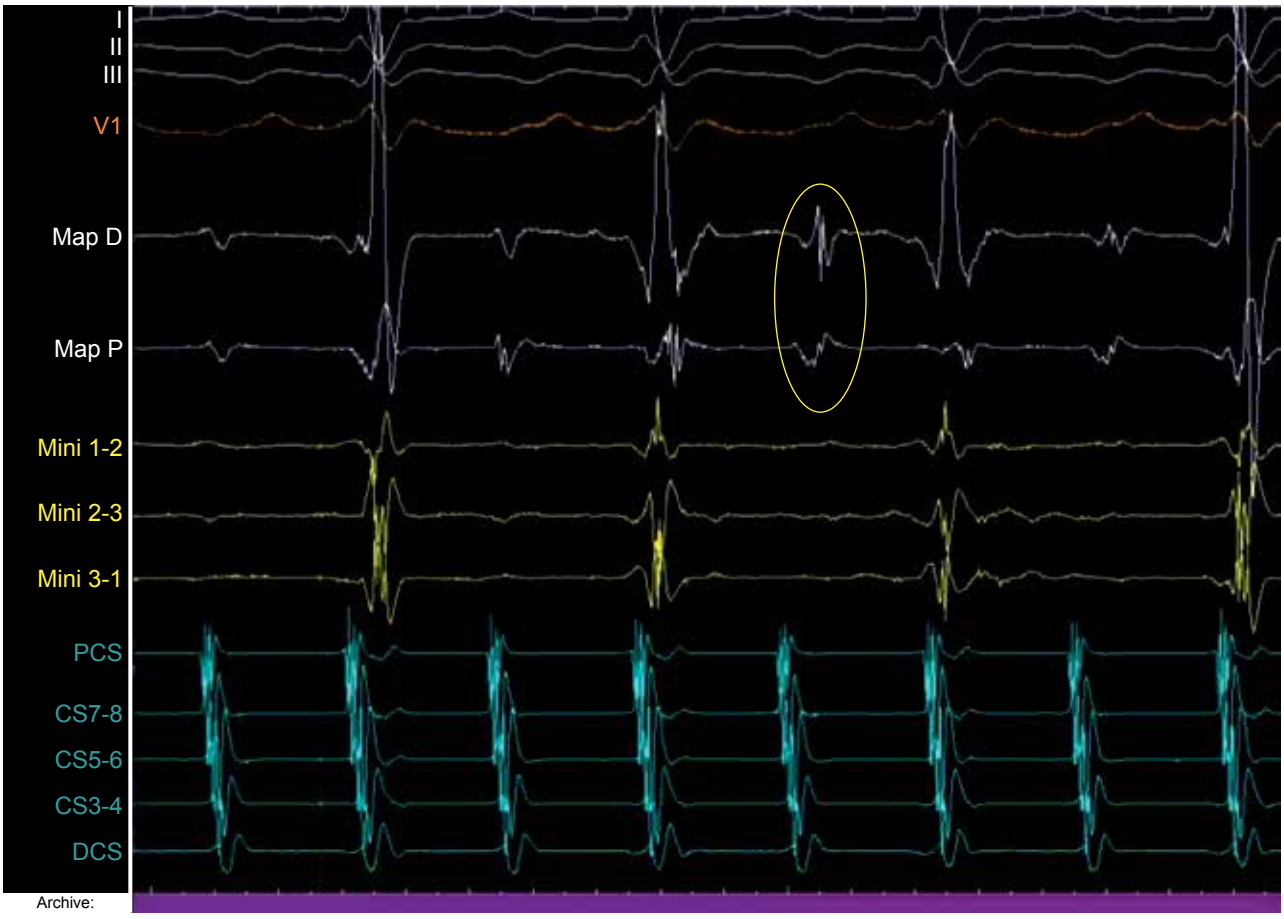

Figure 1. Discrepancy in the amplitude of atrial electrograms recorded by mini-electrode and conventional bipolar configurations in the ablation catheter during ablation at the ventricular edge of cavotricuspid isthmus. Surface electrocardiogram (ECG) and intracardiac recordings during ablation of typical cavotricuspid isthmus-dependent atrial flutter. From top to bottom, surface ECG leads (I, II, III, V1), distal and proximal conventional bipoles of the 8-mm ablation catheter (Map D and Map P), bipolar electrograms recorded by mini-electrodes (Mini 1-2, Mini 2-3 and Mini 3-1), and bipoles of a decapolar catheter placed in the coronary sinus. The conventional distal bipole of the ablation catheter records high-amplitude ventricular electrograms as well as low-amplitude atrial electrograms (yellow oval shape), suggesting an optimal site to initiate the deployment of the linear lesion. However, the mini-electrodes display only ventricular electrograms, suggesting that the tip of the ablation catheter is situated in the right ventricle and dragging of the catheter towards the atrium is needed to avoid unnecessary energy delivery within the right ventricle.
PCS – proximal coronary sinus bipole; DCS – distal coronary sinus bipole.

Potential advantages of the novel catheter in the setting of CTI ablation

The local electrograms recorded by the MEs improve the accuracy of the catheter tip localization. The antenna of the conventional bipole (8 mm tip to second ring) spans a distance of 11.5 mm and is situated medially to the ablation focus. Therefore, a spatial gap exists between the conventional bipole antenna providing intracardiac recordings and the catheter tip where radiofrequency energy is delivered. This discrepancy can be overcome by assessing the electrical activity recorded by the "narrow antenna" of the MEs situated at the tip of the ablation catheter (Figures 1 & 2). In our series, monitoring of ME local recordings facilitated the CTI ablation procedures in the following stages:

A. Accurate localization of the ventricular edge of the ablation line

When the conventional distal bipolar electrode records a local electrogram characteristic of the tricuspid valve annulus based on the ratio of the atrial and ventricular electrogram amplitudes, the tip of the catheter is actually located within the right ventricle, as evidenced by the absence of atrial electrograms on the ME recordings (Figure 1). In similar situations, the ablation cath-

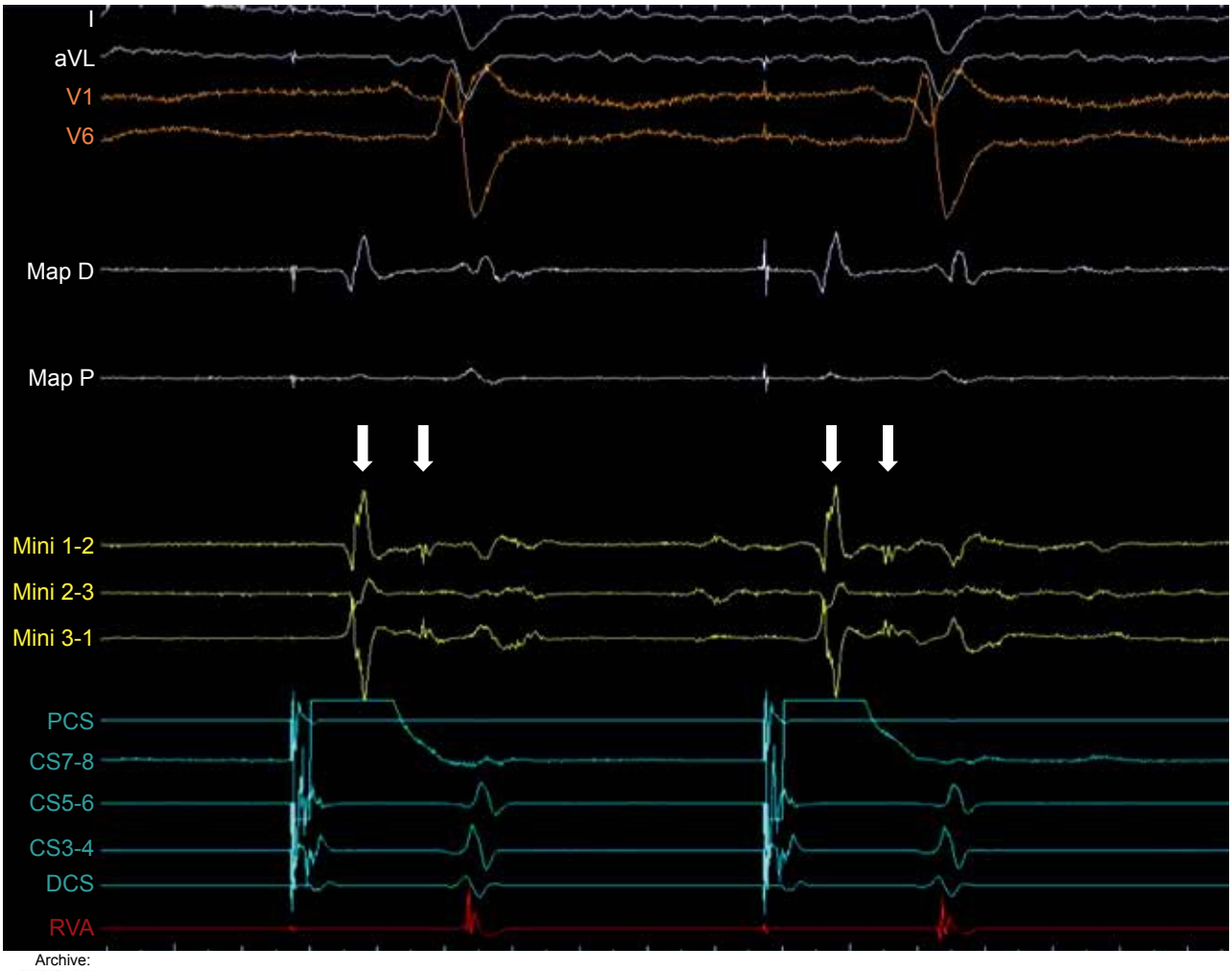

Figure 2. Verification of cavotricuspid isthmus block using electrical information derived from the mini-electrode bipolar recording. Verification of clockwise cavotricuspid isthmus block during coronary sinus pacing indicated by the recording of widely split double potentials from the bipolar mini-electrodes (white arrows), but not by the conventional distal bipole of the 8-mm ablation catheter (Map D). The presence of a double potential is recorded by two of the three pairs of mini-electrodes (Mini 1-2 and 3-1), while the absence of double potentials and the low amplitude of recording in the third bipole (Mini 2-3) is due to the lack of direct contact with the myocardium.

eter should be withdrawn slightly until a small atrial electrogram emerges in the ME recordings, denoting that the catheter tip is actually located on the tricuspid annulus. In this way, inadvertent delivery of ablation lesions within the right ventricle is averted. Although this small case series was not powered to provide evidence of a reduced complication rate, this technology has the potential to improve the safety of similar ablation procedures. Large scale, specifically designed studies are needed to evaluate this hypothesis.

B. Accurate localization of the inferior vena caval (IVC) edge of the ablation line

The enhanced spatial localization of the catheter tip by integrating information derived by the MEs can also prove useful when ablating at the IVC edge of the ablation line. When the conventional distal ablation bipole records no atrial electrogram, the MEs may still record low amplitude atrial electrograms, provided that the tip of the catheter is situated at a very posterior part of the CTI. Therefore, when the operator relies solely on the conventional bipolar electrogram, energy application may be terminated before the tip of the catheter has reached the IVC, potentially leaving posterior gaps that may enable persistent conduction through the CTI.

C. Identification of conduction gaps along the ablation line

The use of the ME technology facilitates the identifi-

Table 1. Procedural parameters of ablation in trials using 8-mm tip catheters for ablation of typical cavotricuspid isthmus flutter (reported in chronological order; trials using 8-mm split-tip catheters are not included in the list). The last row presents the relevant average data in our series (the redo case has not been included).

Study	Patients	RF applications	RF duration (s)	Fluoroscopy time (min)	Fluoroscopy dose (Gy.cm^2)	Procedure time (min)
Schreieck et al.[11]	50	12.9 ± 8.6	829 ± 605	15.7 ± 10.7		38.6 ± 27.3
Tsai CF et al.[12]	50	2 ± 1		14 ± 10		24 ± 15
Melo SL et al.[13]	26	8.2 ± 4.2	486 ± 251	15.4 ± 4.6		78.1 ± 2.5
Scavée C et al.[14*]	20	9 ± 5	690 ± 432	9.9 ± 6.8		37 ± 16
Marrouche et al.[15]	25	15 ± 10	660 ± 450	36 ± 23		90 ± 15
Feld et al.[16]	76	14 ± 8	1092 ± 584[†]	28.4 ± 19.5[‡]		122 ± 67[‡]
Kasai et al.[17]	24	4.7 ± 2.5		26 ± 12		126 ± 34
Da Costa et al.[18§]	32	18 ± 17	768 ± 780	21 ± 18		81 ± 30
Da Costa et al.[18‖]	123	10 ± 11		12 ± 11		65 ± 20
Iori et al.[19]	30	10 ± 5	556 ± 244	14 ± 6		78 ± 23
Thornton et al.[20]	30	26 ± 17	1459 ± 950	29 ± 15		144 ± 48
Gosavi et al.[21]	20	6.8 ± 2.9	690 ± 300			66 ± 30
Hillock et al.[22¶]	50	11		22	17	120
MiFi case series	6	9.8	463		50.1	64

*Only data pertaining to single-sensor 8-mm tip and not double sensor 8-mm tip reported.
[†]Rough estimation based on number of RF applications multiplied by reported mean duration of each RF application.
[‡]Data pertaining to total patient population subjected to ablation with large-tip ablation catheter (8-mm or 10-mm).
[§]Patient subgroup with long cavotricuspid isthmuses (>35 mm).
[‖]Patient subgroup with short cavotricuspid isthmuses (≤35 mm).
[¶]Median values reported.

cation of conduction gaps along a linear ablation lesion. This advantage is attributable to a more accurate spatial localization of the catheter tip, but also to improved discrimination of viable versus ablated tissue based on electrophysiological criteria.[4]

Conclusion

Based on a small series of consecutive patients, the use of an ME-equipped 8-mm ablation catheter is safe and efficacious for CTI ablation. Although our initial experience is promising, our data need to be verified by future larger scale studies.

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