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Original Article

The combination of electroanatomic mapping and minielectrodes in a series of cases of redo procedures

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ABSTRACT

Background: In patients with supraventricular tachycardia, catheter ablation is an important treatment option. However, approximately one quarter of these patients remain symptomatic, so sustainable strategies for the treatment of those patients who do not benefit from the first catheter ablation are required.
Methods: In a series of redo procedures, we investigated the combined use of an electro-anatomic mapping system and an ablation catheter with mini-electrodes.
Results: Catheter ablation was successful in two patients with recurrent common type atrial flutter and one patient with recurrent ectopic atrial tachycardia. In a patient with recurrent perimitral flutter, the ablation procedure had to be stopped early, due to pericardial effusion.
Conclusion: The combination of electro-anatomic mapping and mini-electrodes might be useful, especially in the treatment of ectopic atrial tachycardias, but also in redo procedures of CTI ablations, that require not only the visualization of the tachycardia, but also the detection of a local focus or a local gap. For an optimal use of the ME ablation catheter, the generator settings should be evaluated in further studies.

1. Introduction

Electrophysiology studies and catheter ablation (CA) have become important treatment options for several types of cardiac arrhythmias. Especially for supraventricular tachycardia (SVT), CA is an established and safe procedure bringing symptomatic improvement and satisfaction to at least three quarters of patients after 1 year.[1]

However, one quarter remain symptomatic, therefore sustainable strategies to treat those patients who do not benefit from the first CA are required.

In recent years, technical developments have produced various new ablation catheters[2–4] and several electroanatomic mapping systems (EAMSs) that allow outstanding anatomical rendering and have gained increasing importance in complex ablation procedures like re-ablations.[5]

Nevertheless, it remains unclear which combination of ablation catheter and EAMS appears most promising to achieve good results in redo procedures.

We therefore initiated this study to test the combination of two modern techniques, minielectrodes (MEs) and electroanatomic mapping, in a series of cases of supraventricular redo procedures.

2. Material and methods

This study is a prospective single-center study of a consecutive series of patients presenting with recurrence of SVT despite previous CA.

Patients' baseline characteristics were collected from their medical history. In all patients, the right femoral vein was cannulated with one 6 French, one 7 French, and one 8 French sheath. The 10-pole Dynamic XT™ catheter (Boston Scientific®, MA, USA) and the 20-pole Blazer DX 20™ catheter (Boston Scientific®, MA, USA) were used as diagnostic catheters.

As ablation catheter, the IntellaTip MiFi OI™ (Boston Scientific®, MA, USA) was chosen with an open irrigated 4.5-mm tip electrode. This ablation catheter has three radially positioned, equally spaced

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MEs, 1.3 mm from the tip. The distance between these MEs is 2.4 mm. Bipolar recordings were made between these MEs: m1–2, m2–3, and m3–1 to generate more precise signal localization.

LABSYSTEM™ PRO (Boston Scientific®, MA, USA) was used as the EP Recording System with identical cut-offs for all electrodes including MEs (voltage range: 5 mV, low cut-off: 30.0 Hz, high cut-off: 250 Hz, notch filter: disable).

All procedures were performed by means of the EnSite™ NavX™ (Abbott®, IL, USA) as EAMS, which can be used to create geometric models of the patient's cardiac chambers and build activation mapping. The mapping system also enables signals from every catheter, lead, and guidewire to be visualized and recorded.

Ablation was done with the Ampere™ RF Ablation Generator (Abbott®, IL, USA) and a Cool Point™ Irrigation Pump (Abbott®, IL, USA) in a power control mode using a standard setting (energy: 40 Watt, temperature: 45 °C, impedance: 150 Ω, duration: 180 s, automatic irrigation flow adjustment: 2 ml/min at rest and 30 ml/min during radiofrequency ablation).

For each procedure, the fluoroscopy time and the total procedural duration time (from skin incision or vein puncture to skin suture) were recorded. Success rate and complications were also recorded.

All procedures performed in studies involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

3. Case series presentation

3.1. Case 1

This 52-year-old man following a mitral valve annuloplasty and coronary artery bypass presented with atrial flutter. He had two prior electrophysiological examinations with cavotricuspid isthmus (CTI) ablation, and the current electroanatomic mapping showed that the right atrium did not cover the whole cycle length of the tachycardia. The subsequent mapping of the left atrium confirmed a perimitral circuit. The visualization of the ME catheter in EnSite showed an ablation catheter with a knob on the catheter tip which represented the ME (Fig. 1).

Attempting to ablate the mitral isthmus and the anterior line could not terminate the tachycardia during this ablation procedure, which was terminated early after 140 min examination time as echocardiography showed the start of pericardial effusion.

3.2. Case 2

This 77-year-old man had one previous CTI ablation, and the current electroanatomic mapping confirmed the recurrence of common type atrial flutter. Scanning the preexisting ablation line showed conduction gaps close to the cava and complementary ablation terminated the tachycardia and resulted in a complete bidirectional isthmus conduction block.

3.3. Case 3

In this 68-year-old woman with one prior ablation of a right-sided ectopic atrial tachycardia, electroanatomic mapping showed a relapse of an ectopic atrial tachycardia. Electroanatomic mapping with either the 20-pole diagnostic catheter or the MEs of the MiFi ablation catheter showed an origin of the tachycardia in the high right atrium. In a further detailed mapping of this region, the MEs visualized fractionated signals that were not recorded with the conventional bipolar electrodes (Fig. 2). Ablation at this point terminated the tachycardia and further electrophysiological stimulation maneuvers to restart the tachycardia failed.

3.4. Case 4

In this case, a 66-year-old man with one prior CTI ablation, the current electroanatomic mapping showed a recurrence of common type atrial flutter. The tachycardia terminated during diagnostic and the CTI was scanned for gaps in sinus rhythm.

Despite identical filter settings in the EP recording system, the MEs showed clearly higher signal amplitudes than the conventional electrodes on the preexisting ablation line. Ablation of these residual signals led to a complete bidirectional isthmus conduction block.

All cases are summarized in Table 1.

Fig. 1. Visualization of the 20-pole (orange) and 10-pole (yellow) diagnostic catheters and the MiFi ablation catheter (blue) in Ensite. The green knob on the catheter tip illustrates the minielectrodes.

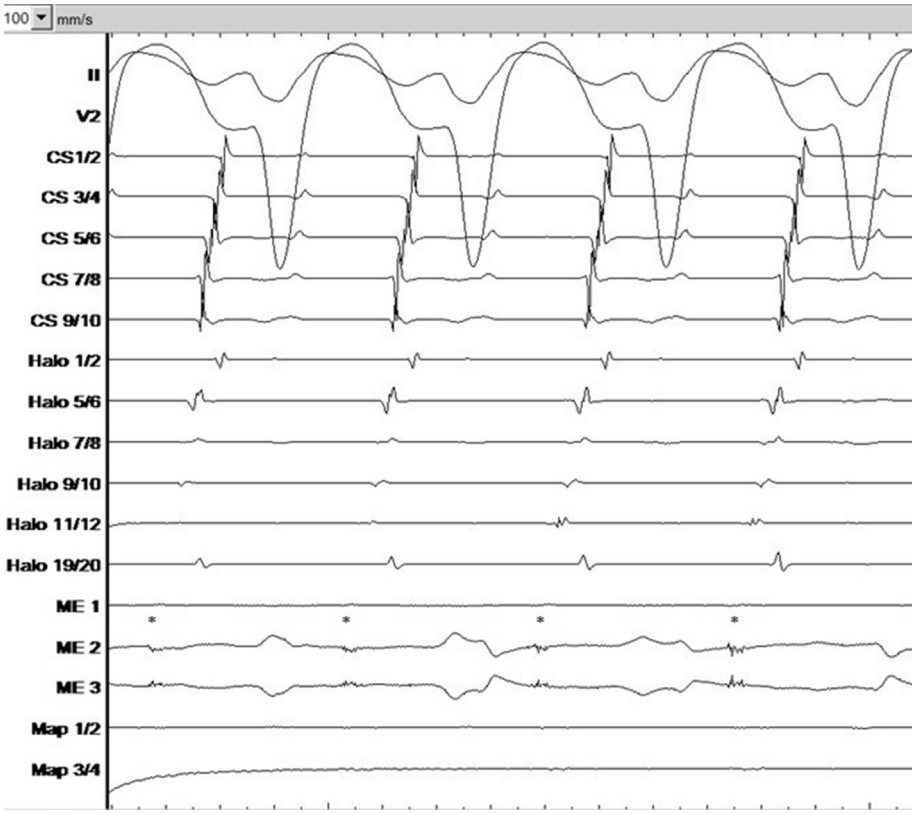

Fig. 2. In this patient with ectopic atrial tachycardia, the tightly coupled minielectrodes ME 2 and ME 3 detected early fractionated signals (*) in the high right atrium that could not be seen in the conventional ablation electrodes MAP 1/2 and MAP 3/4 although all electrodes recorded their signals at the same time. Ablation at this point terminated the tachycardia.

Table 1
Characteristics of all patients included in this series of cases of supraventricular re-ablation procedures.

	Case 1	Case 2	Case 3	Case 4
Gender	Male	Male	Female	Male
Age (years)	52	77	68	66
Number of previous procedures	2	1	1	1
Supraventricular tachycardia	Perimitral flutter	Common type atrial flutter	Ectopic atrial tachycardia	Common type atrial flutter
Radiation dose exposure (Gy^*cm^2)	8614	3963	1428	10358
Fluoroscopy time (minutes)	53.11	4.12	6.08	7.55
Procedural duration time (minutes)	140	30	125	112
Complications	Pericardial effusion 12 mm	–	–	–
Success	No	Yes	Yes	Yes

4. Discussion

4.1. Electroanatomic mapping and signal quality

To the best of our knowledge, this is the first visualization of ME catheters in EnSite NavX (Fig. 1).

However, the creation of a complete electroanatomic map with MEs solely appears rather impracticable in daily routine, but in addition to an initial map of the complete heart cavum with a multipole catheter, it might be helpful to amend additionally close-meshed points of a specific region in this way. Such usage of MEs for regional electroanatomic mapping might be all the more interesting as the detection of fractionated signals with low amplitude obviously works better with MEs when compared with conventional bipolar electrode records (Fig. 2).

This observation is supported by the findings of previous investigators who described higher signal amplitudes in the MEs than in the conventional ablation electrodes in general.[6,7]

The visualization of fractionated signals with MEs that were not seen with conventional bipolar electrodes was probably one of the most important findings in this series of redo procedures and even more surprising as previous studies described higher signal amplitudes recorded from the conventional bipolar electrodes than that recorded by the MEs.[8] Those differences between the two types of electrodes are explained not only by different surface diameters with accordingly different resistances but also by different recording spans between tip and ring electrode, when compared with MEs (Figs. 3 and 4).

The finding of fractionated signals on the MEs solely, as observed in this series of cases, therefore reflects the different electrical characteristics of tip-ring electrodes when compared with MEs. Avitall et al discussed in this context that electrical activity recorded from the MEs represents not only superficial endocardial tissues but also intramural tissues as deep as 9.3 mm away from the electrodes.[8]

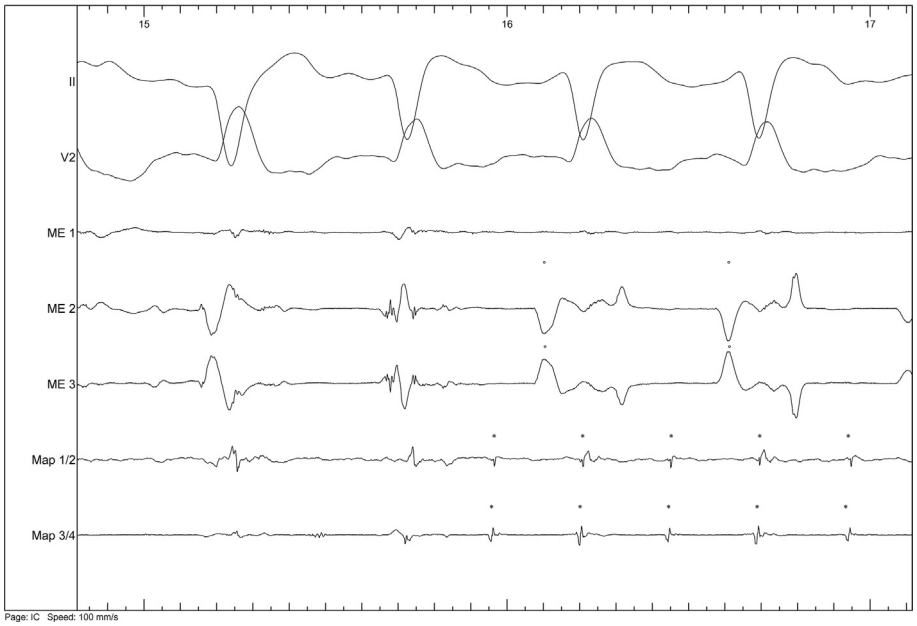

Fig. 3. Pulling the ablation catheter out of the right ventricular into the right atrium in order to find the best site to initiate the deployment of a linear lesion in a patient with ongoing flutter. While the conventional ablation electrodes with the wider "antennae" already show signals of atrial flutter (*) suggesting an atrial position of the ablation catheter tip, the minielectrodes still show ventricular signals (°), verifying the placement of the catheter tip in the right ventricle.

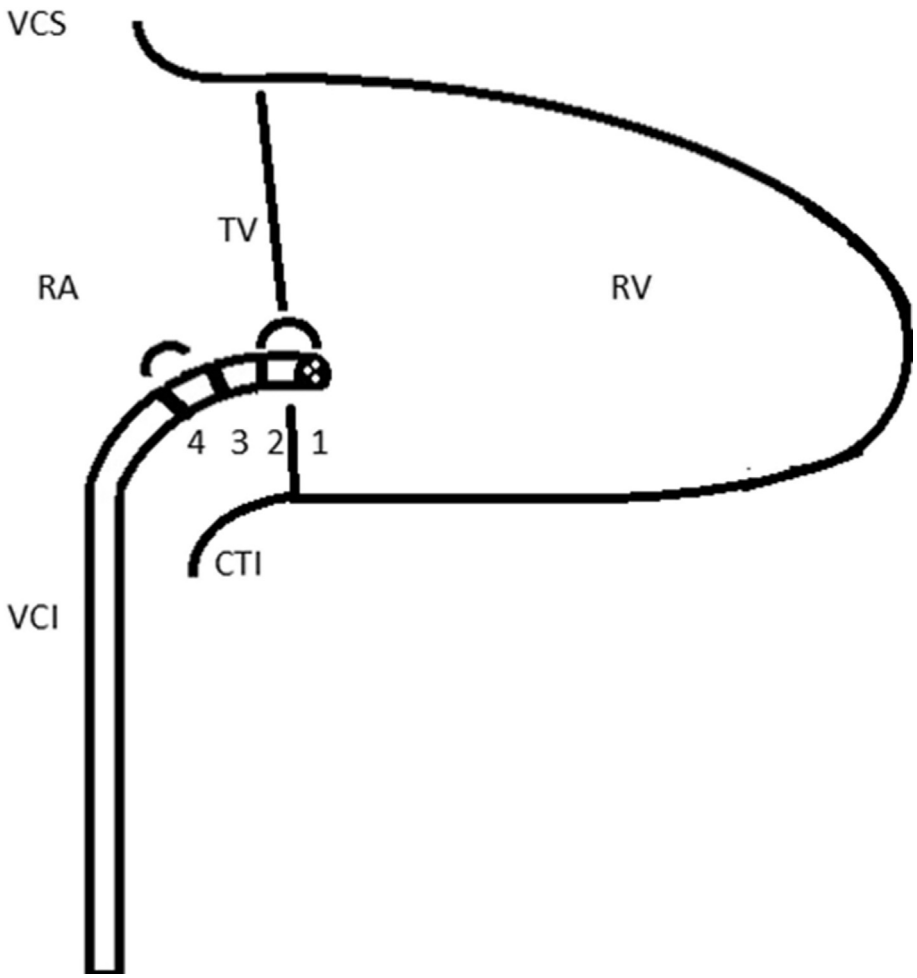

Fig. 4. This schematic illustrates why the conventional ablation electrodes show signals of atrial flutter whereas the minielectrodes show ventricular signals. VCI: vena cava inferior; RA: right atrium; VCS: vena cava superior; TV: tricuspidal valve; RV: right ventricular; 1, 2, 3, 4: conventional ablation electrodes; CTI: cavotricuspid isthmus.

In summary, our data support previous findings that an enhanced spatial localization of the catheter tip by integrating information derived by the MEs allows for the identification of small conduction gaps in linear lesions and precise ablation targeting,[9] but discrepant findings between conventional bipolar electrodes and MEs necessitates some experiences in the interpretation of these data also in the context of electroanatomic mapping.

4.2. Catheter ablation

Some studies report CTI ablation success rates up to 100%,[10] but recurrent atrial flutter in a long-term follow-up is common and might affect around 9% of all patients with an initial successful CTI ablation.[11] One possible explanation for unsuccessful CA is the high incidence of low catheter–tissue contact force at the CTI during CA of atrial flutter.[12] However, corresponding studies reported a recurrence of atrial flutter in 10% after CTI ablation irrespective of whether periprocedural contact force measurements were taken or not.[13]

Usage of MEs that record signals directly at the tip of the ablation catheter might be an alternative approach to ensure sufficient catheter–tissue contact during CTI ablation, but a previous study evaluating ME catheters during CTI ablation showed disappointing results of more than 50% crossover to another ablation catheter.[14] In the authors' opinion, the usage of ME ablation catheters with a 8 mm tip might be less effective to achieve complete conduction blocks in CTI ablation due to a limited power delivery under the temperature control mode presumably associated with the tip design.[14]

However, recently, the same study group reported the successful achievement of complete CTI blocks in 93.8% of all patients treated with ME catheters with a 10 mm tip,[9] and it remains uncertain whether these differences in the ablation success within the same study group were really just the result of different tip sizes or whether other reasons including better knowledge about optimal handling of ME catheters might play an important role in the explanation of these discrepancies.

Aware of these previous study results, we used a power control mode in this series of cases and achieved successful CTI ablations in both redo procedures of common type atrial flutter. However, the redo procedure of perimitral flutter in this series of cases remained unsuccessful and maybe the chosen setting with a power control mode instead of temperature control mode contributed the development of a pericardial effusion that necessitated an early termination of the ablation procedure.

Therefore, we came to the conclusion that the optimal generator setting for an optimal utilization of ME catheters should be evaluated in further studies.

4.3. Limitations

Although this case series was not sufficiently powered to provide evidence for a general recommendation to combine electroanatomic mapping and MEs, our data show the feasibility of a combination of these two modern techniques.

However, further studies dealing with the electrophysiological treatment of SVT and especially redo procedures should try to obtain data from a long-time follow-up to achieve better comparability with other data.

5. Conclusion

The combination of electroanatomic mapping and MEs might be useful, especially in the treatment of ectopic atrial tachycardias and also in redo procedures of CTI ablations, which require not only visualization of the tachycardia but also the detection of a local focus or local gap. For optimal use of the ME ablation catheter, the generator settings should be evaluated in further studies.

Conflict of interest

All authors have none to declare.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ihj.2018.07.008

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