

How small could a detectable reentrant circuit be in a localized microreentrant tachycardia?



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Introduction

Microreentrant atrial tachycardias (AT) can be defined as atrial arrhythmias with a cycle length (CL) coverage greater than 85% in a small area (arbitrarily set as a circuit with a diameter <2–3 cm) and a centrifugal activation to the rest of the atrial chamber.¹ Although debate is still ongoing in the literature as to the precise definition of microreentry,² it is common practice to refer to the phenomenon in terms of the more general concept of localized reentry, since the size of the reentrant circuit is presumed to be in the order of centimeters.¹ This is the first description of a reentrant AT whose CL was entirely detected by a few bipolar pairs of a high-density mapping catheter whose recording field of view is in the order of a few millimeters.

Case report

A 72-year-old woman presented for radiofrequency ablation of an atypical atrial flutter after she had already undergone 2 previous pulmonary vein isolation procedures and 1 ablation procedure for the treatment of a perimitral atrial flutter. Some months after the previous ablation procedure, she had developed a different atypical atrial flutter. Owing to the distal-to-proximal activation of the coronary sinus catheter, this AT was mapped in the left atrium by means of the Rhythmia mapping system and the mini-basket Orion catheter (Boston Scientific, Marlborough, MA).

The activation map (Figure 1) showed a centrifugal pattern of activation starting from the anterior antrum of the left inferior pulmonary vein, where a crowding of isochronal lines was noted. The propagation map (Supplementary Video) showed a localized reentry at this location, from which an anterior and a posterior front spread centrifugally and collided septally.

Despite the apparent existence of a localized reentry whose critical size was in the order of centimeters, interrogation of

KEY TEACHING POINTS

- This is the first description of a reentrant atrial tachycardia whose cycle length was entirely detected by a few bipolar pairs of a high-density mapping catheter whose recording field of view is in the order of a few millimeters.
- Using the ultra-high-density Rhythmia mapping system (Boston Scientific, Marlborough, MA), we have been able to fully characterize the activation pattern and clearly identify through visual impression the targeted spot that matched the area of electrogram fractionation captured by the basket catheter.
- Electrograms in the microreentrant circuit can be completely filtered out by the larger field of view of the conventional ablation traces. Thus, without high-resolution catheters, microreentrant circuits may be completely missed and misdiagnosed as areas of scarring.

bipolar electrograms (EGMs) in that region showed that the electrical activity spanning the whole CL was detected by a few pairs of close bipoles of the Orion catheter, whose inter-electrode spacing is 2.5 mm (Figure 2).

Particularly, only 1 pair of bipoles showed a continuous highly fractionated potential spanning the entire CL of the tachycardia, indicating clearly that the microreentry was actually confined to a region whose size was in the order of millimeters (Figure 2, bipole F3–4). This finding was in line with our preliminary speculation by looking at the propagation maps that clearly showed a very small area of reentry at this spot (Supplementary Video). Over-drive pacing and entrainment maneuvers were attempted but no capture was obtained. When the ablation catheter (IntellaNAV Mifi OI [Boston Scientific, Marlborough, MA], equipped with 3 mini-electrodes at the tip) was positioned at the corresponding spot of bipolar pair F3–4 in

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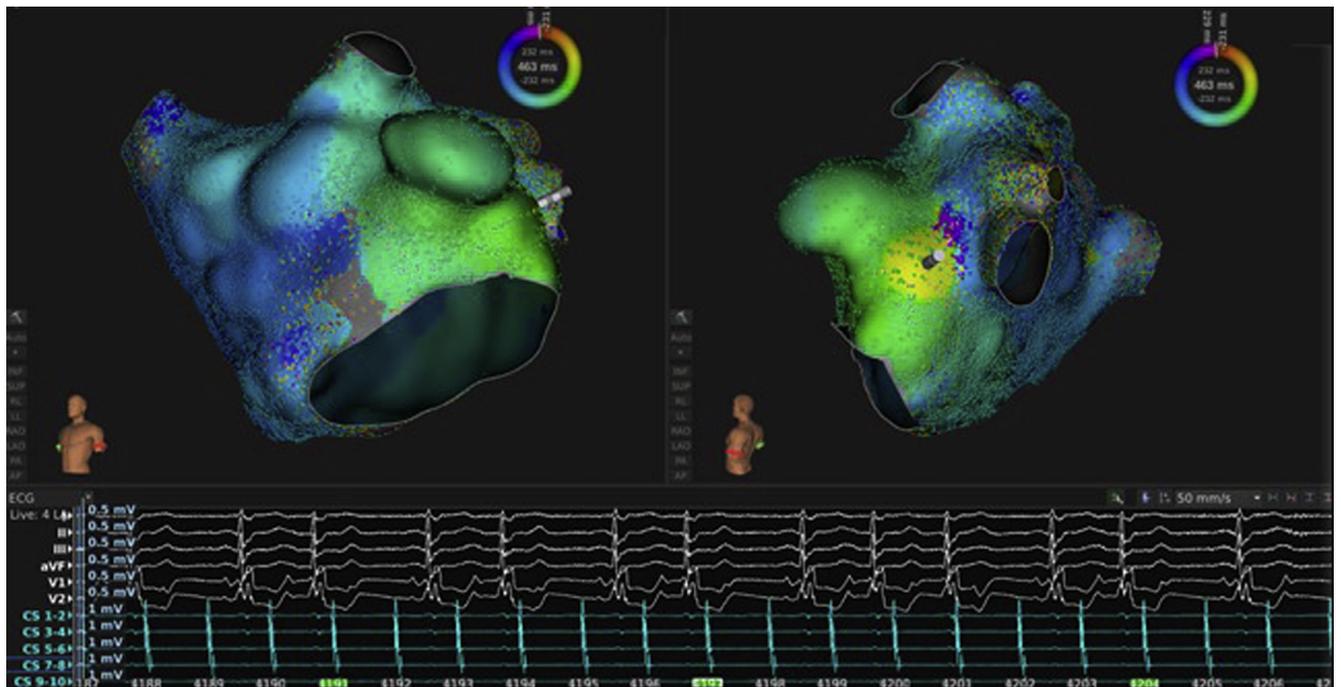


Figure 1 Activation map of the microreentrant atrial tachycardia. In the right panel, a posterior left lateral view shows some isochronal crowding just anterior to the left inferior pulmonary vein. From this spot, 2 centrifugal wavefronts (1 anterior and 1 posterior) spread to the septum, where they collide.

Figure 2, no EGM was detected by the conventional ablation traces (**Figure 3**). The mini-electrode pairs detected only a part of the very long fragmented EGM previously recorded by the Orion catheter. Since the field of view of the ablation mini-electrodes is similar to that of the Orion bipoles, we hypothesize that the difference in the signal displayed was due to the difference in electrode

technology and surface, and the catheter tip was very close (but not completely overlapped) to the precise ablation target point identified by the bipolar pair of the Orion catheter. After 7 seconds of radiofrequency ablation (35 W, 40°C) at this spot, the arrhythmia stopped (**Supplementary Figure**). After a follow-up of 8 months, no AT recurrence was reported by the patient.

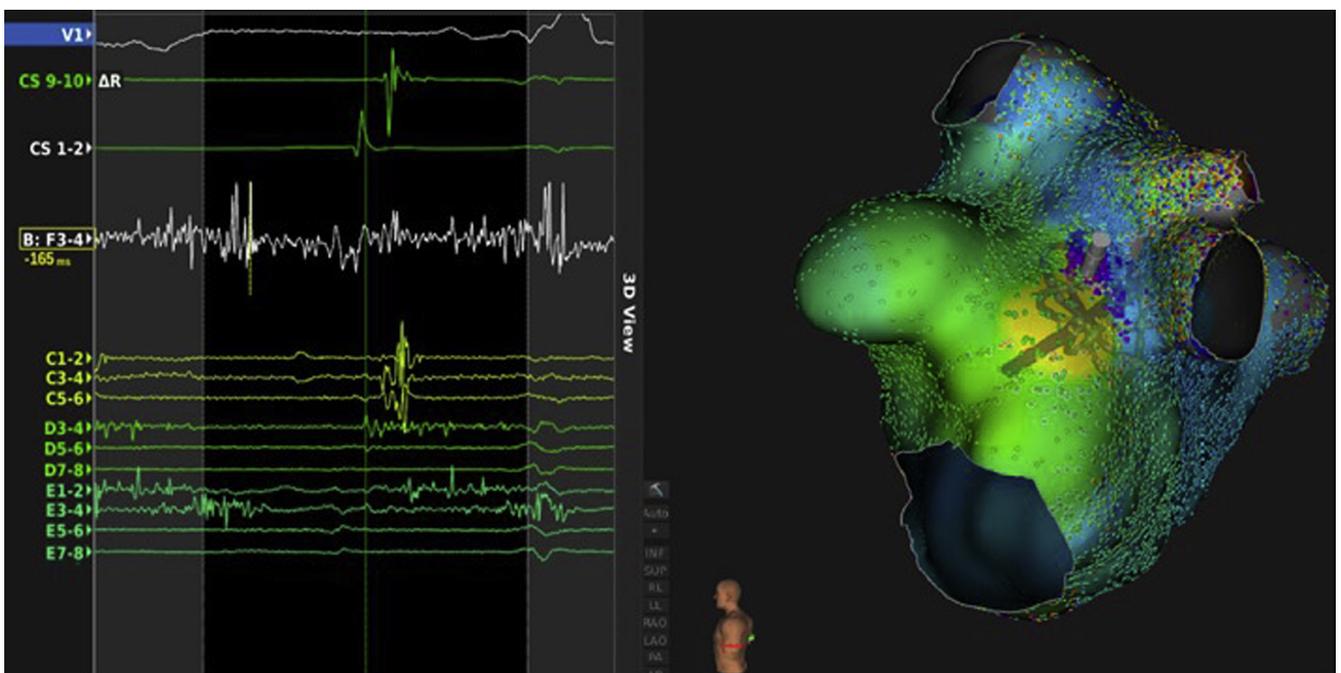


Figure 2 The Orion (Boston Scientific, Marlborough, MA) bipolar pair F3-4 (white in the picture) detects a continuous highly fragmented signal that spans the entire cycle length, showing that the microreentrant tachycardia is confined to a region size of the order of millimeters.

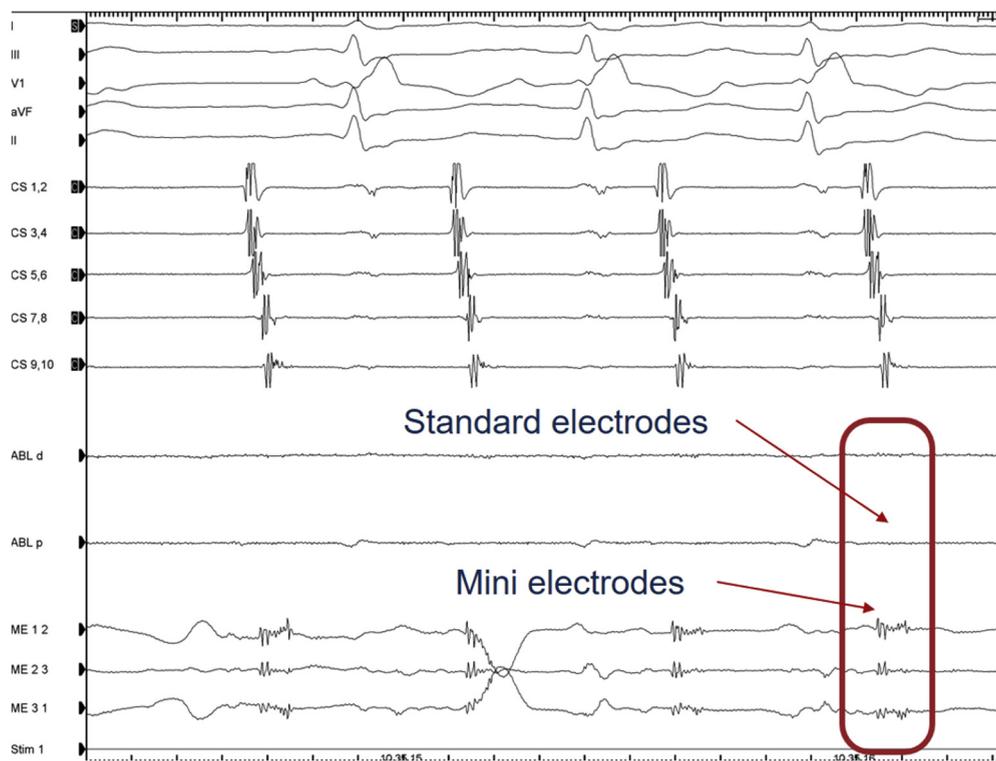


Figure 3 Conventional ablation traces completely filter out the low-amplitude continuous fragmented signal activity of the microreentrant circuit. The mini-electrode tracings detected only a part of it.

Discussion

Microreentrant tachycardias are well defined and are thought to be responsible for a small percentage of the AT usually seen after atrial fibrillation ablation or in the presence of spontaneous atrial scarring.³ Effective ablation of microreentrant ATs is usually achieved at sites with highly fractionated, low-amplitude EGMs. These EGM characteristics are highly sensitive, but not specific to microreentrant circuits.⁴ Indeed, low-amplitude and long-duration EGMs could be present at bystander sites that do not actively participate in the circuit.⁴ Mapping local activation within these regions of slow conduction has been limited by the resolution of EGM signals recorded by conventional mapping catheters. Furthermore, limited point density on previous mapping systems resulted in large areas of activation interpolation, and localized reentrant circuits often appeared as focal.^{5,6}

By using a 224-site grid array with an interelectrode distance of 2 mm, in an *in vitro* superfused preparation of infarcted canine left ventricular epicardium, Zuanetti and colleagues⁷ detected a small reentrant circuit at recording sites more than 1–2 cm from the center of the reentrant circuit; in this way, the reentrant loops were no longer hidden, but could be detected by a mapping resolution of 2–4 mm.⁷ Although this spacing is feasible in basic experimental studies, it may not always be so during the clinical mapping of arrhythmias. The wide adoption of high-resolution mapping systems provides improved EGM and spatial resolution

and could potentially shed additional light on the nature of arrhythmias of this kind. Using the Orion basket catheter with narrow interelectrode spacing, Luther and colleagues⁶ were able to fully characterize the activation pattern of most localized reentry circuits, in their experience, as small rotatory activations around scars ~ 1 cm in diameter.

The case described here is the first report of a reentrant circuit of a localized circuit confined to a region size of a couple of millimeters, ie, >5 -fold smaller than that reported in the literature on clinical mapping^{1,2,6} and comparable with the results from experimental mapping with electrical or optical sensors.^{7,8} The small surface of the electronically printed Orion electrodes (0.4 mm^2) and the reduced center-to-center interelectrode spacing (2.5 mm) allowed a very small reentrant circuit to be fully detected by just a few bipolar pairs, where a continuous activity spanning the entire CL could be identified. Using this system, we have been able to fully characterize the activation pattern and clearly identify through visual impression the targeted spot that matched the area of EGM fractionation captured by the Orion catheter. Another important point to emerge from this case is the evidence that EGMs in the microreentrant circuit can be completely filtered out by the larger field of view of the conventional ablation traces. This is due to the lower spatial resolution achievable with larger electrodes and spacing. Thus, without high-resolution catheters, microreentrant circuits may be completely missed and misdiagnosed as areas of scarring.

Conclusion

Microreentrant atrial activity may be localized in very small areas, in the order of millimeters, and its electrical activity may be filtered out by conventional catheters with larger electrodes and spacing.

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Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.hrcr.2020.01.003>.

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