Counterclockwise and clockwise typical flutter and the transverse conduction barrier—Mirror-image circuits?

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Introduction

Counterclockwise (CCW) and clockwise (CW) forms of typical atrial flutter are regarded as mirror-image reentrant circuits,[1] although they rarely are observed in the same patient. Transverse conduction block in the right atrium is considered the conduction barrier necessary for circuit stability for both circuits, but its basis and location have been controversial.[2] This barrier has not been high-density mapped in humans.

Case report

A male patient (hypertension, left atrial enlargement [67 mL/m^2]) on no antiarrhythmic therapy presenting for atrial flutter ablation exhibited 2 different atrial flutters during the procedure. A duodecapolar electrode catheter marked coronary sinus activation and anteriorly placed right atrial (RA) poles mapped the tricuspid annulus (Supplemental Figure 1). These indicated CW (260 ms cycle length) and CCW (230 ms cycle length) circumannular rotation (movie: Supplemental video). Entrainment confirmed both to be cavotricuspid isthmus (CTI) dependent. High-density grid mapping was undertaken and lateral RA activation was contrasted in both circuits.

During CCW rotation, high lateral atrial wall recordings (Figure 1A, top; high right atrium, green) showed relatively simultaneous activation (gray arrows) corresponding with even transverse conduction evident on activation mapping. Electrograms across the crista showed continuous multicomponent morphology indicative of slow conduction (duration 50 ms; bull's-eye). In contrast, during CW rotation (Figure 1A, bottom), the same position showed widely spaced (125 ms) double potentials consistent with a transverse conduction barrier, and evident on activation mapping (dashed blue lines). The high-density grid uses orthogonal electrode pairs to mitigate false low-amplitude bipolar recordings of wavefronts traveling with a perpendicular component, yielding more accurate electrograms in regions of conduction block. This resulted in a clear depiction of different posterior RA conduction barriers in these opposing tachycardia circuits. The different activation patterns are evident in the propagation maps (Figure 1B and Supplemental video online). In CCW flutter, wavefronts (arrows) converge and sweep evenly (but slowly) across the lateral wall toward the CTI. In contrast, during CW rotation, the wavefront emerging from the lateral CTI ascends anteriorly, encountering conduction block (→I) posteriorly.

KEY TEACHING POINTS

- Typical and reverse typical atrial flutter was mapped in a single patient. Although both were cavotricuspid isthmus dependent, the circuits followed different paths with different conduction barriers (ie, were not mirror-image circuits).
- Transverse conduction block in the right atrium is considered the conduction barrier necessary for circuit stability for both circuits, but its basis and location have been controversial. In this case using high-density mapping indicated different characteristics during counterclockwise and clockwise rotation, indicating functional characteristics.
- Conduction barriers are necessary for the formation of and maintaining of reentry. Dynamic functional barriers may be present in circuits traditionally regarded as "anatomically determined."

Discussion

Conduction barriers are essential to reentry. Transverse conduction block in the posterior RA is considered important to maintaining the macroreentrant circuit of CTI-dependent atrial flutter, but its basis and extent have been controversial.[2] The conduction barrier may be anatomical (ie, crista

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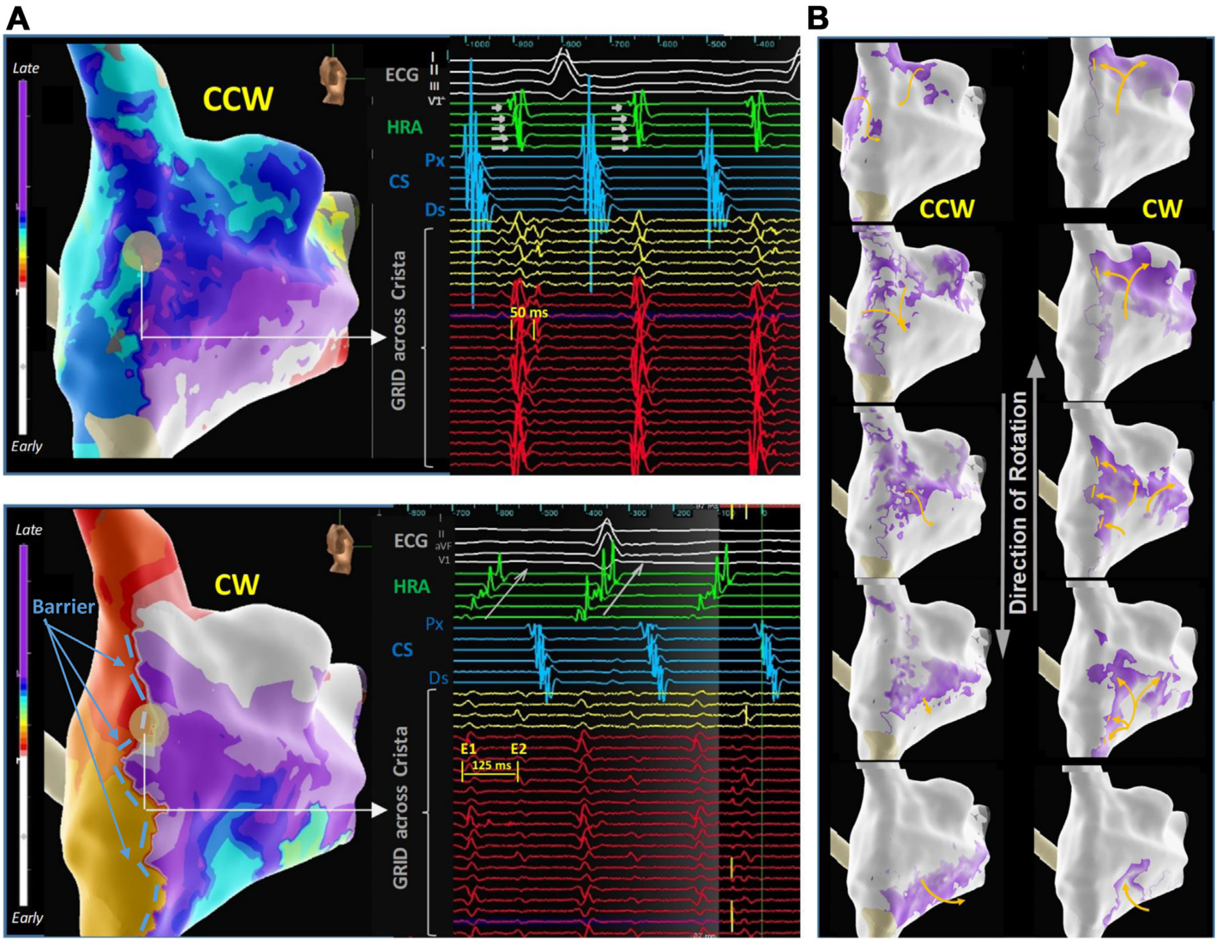

Figure 1 Activation and propagation maps, and right atrial intracadiac electrograms, contrasted between clockwise and counterclockwise right atrial flutter.

terminalis) and rate dependent,[3] or functional. Whether intercaval block needs to be complete has been disputed by studies in normal sinus rhythm indicating discontinuity with short gaps ("cristal breaks") permitting conduction.[4,5] None have examined the influence of *direction* of activation on transverse block.

This instance of CW and CCW in the same patient permits unique insights. CW was not a mirror-image circuit of CCW flutter and displayed different conduction barriers, which likely accounted for their slightly different cycle lengths. Intercaval block was observed during CW but not CCW rotation, indicating dependence on directionality. Thus typical flutter may occur without transverse conduction block, and conduction in this region can demonstrate anisotropic conduction properties. This aligns with recent observations indicating that conduction barriers in ventricular tachycardia circuits are affected by direction of wavefront propagation and rate of stimulation. The discovery of such dynamic functional barriers is unexpected in circuits traditionally regarded as "anatomically determined" (eg, scar-related ventricular tachycardia or typical atrial flutter). Characterization of fixed and functional conduction barriers improves understanding of location and stability of reentrant circuits and responses to perturbations, and ultimately guides ablation strategy of complex circuits.

Both flutters were abolished by CTI ablation.

Appendix

Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi:10.1016/j.hrcr.2022.09.005

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