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On the Deformation and Interpolation of Phase Maps

David Vidmar, MSc and Wouter-Jan Rappel, PhD*

Department of Physics, University of California, San Diego

A recent article by Pathik et al.¹ analyzes electrograms from patients using a basket catheter and constructs 2D phase maps which were projected onto the 3D atrial surface. They report transient rotors in the 2D maps that were absent in the corresponding 3D maps. This discrepancy in observed activation patterns is surprising since rotational activity on a 2D grid will be preserved when that grid is projected onto a curved 3D surface unless the relative position of electrodes is changed. Specifically, if a 2x2 square sub-grid of electrodes in 2D activates consecutively in a rotational pattern, the mapping of this sub-grid into 3D amounts to a smooth deformation of the same underlying pattern to a curved surface. This smooth deformation should preserve the consecutive activation sequence and therefore the rotational pattern.

We believe that the authors' improper interpolation of phase in this paper may, in part, explain their counterintuitive observations. The authors state that phase at each electrode is projected onto a grid and interpolated to determine phase at all intermediate points. Phase, however, is a circular quantity representing the angle of a complex phase vector. The interpolation therefore must be conducted using the complex phase vectors themselves rather than the scalar phase (2). Because phase transitions discontinuously from $+\pi$ to $-\pi$ at activation events, scalar interpolation assigns a phase of zero to points located halfway between electrodes on either side of an activation front. Thus, scalar interpolation incorrectly marks such points as being far from activation (half a cycle) when, in reality, they are at activation. This also results in phase maps showing no clear activation fronts, as seen in Pathik et al.¹. Importantly, Roney et al. show that using this improper scalar interpolation obscures even simple rotational activation patterns (Fig 1B in Ref. (2)). Such mathematical concepts are critical to properly interpret clinical phase maps.

References

1. Pathik B, Kalman JM, Walters T, Kuklik P, Zhao J, Madry A, Sanders P, Kistler PM, Lee G. *Heart Rhythm*. Epub 2017, September 13.
2. Roney CH, Cantwell CD, Bayer JD, Qureshi NA, Lim PB, Tweedy JH, Kanagaratnam P, Peters NS, Vigmond EJ, Ng FS. *Circ Arrhythm Electrophysiol*. 2017; 10:e004899. [PubMed: 28500175]