

# Topology-guided ablation of atrial tachycardia

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**Introduction:** In the clinical world, it is widely known that atrial tachycardias (ATs) are predominantly driven by anatomical reentrant circuits, taking over the natural rhythm. However, following ablation, there is a possibility for the mechanism to change to a different circuit with a slower cycle length instead of terminating. To investigate this phenomenon, we combined AT with principles from topology (deformation and the index theorem).

**Methods:** The index theorem states that the sum of all topological charges (TC) should be 0, meaning that every clockwise rotation ( $TC = -1$ ) is accompanied by a counter-clockwise rotation ( $TC = +1$ ). However, in literature many clinical ATs are labeled as single loop, contradicting the index theorem. This observation led to the hypothesis concerning the existence of another rotational pattern exhibiting a non-zero TC. We referred to this pattern as the near-complete rotation.

$$TC = \oint \nabla LAT dl = \frac{T_{CCW} - T_{CW}}{TCL} \quad (1)$$

572 unique simulations were created on a spherical surface with 2D circular boundaries. For each boundary, the TC was calculated by integrating the LAT-gradient around the boundary. Subsequently, each simulation was virtually ablated by interconnecting boundaries to determine the terminating ablation line. Additionally, 24 well-recorded clinical ATs were retrospectively analyzed with our TC-calculation algorithm, searching for the rotation and near-complete rotation.

**Results:** In 100% of simulations the index theorem was satisfied. In case only one reentry circuit was seen, a near-complete rotation was detected around a different boundary. Additionally, virtual ablation terminated the tachycardia only when interconnecting boundaries with opposite TC. Connecting boundaries exhibiting reentry to a boundary with  $TC=0$ , resulted in the emergence of a tachycardia with slower cycle length. All 24 clinical cases confirmed the results observed in the simulations.

**Conclusion:** Reentrant atrial tachycardias are maintained by pairs of counter-rotating patterns. Tachycardias are only terminated by interconnecting boundaries with opposite TC.