The Influence of Heterogeneous Environments on Pulsed Electric Field Therapy Effects: Implications in Cardiac Ablation

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BACKGROUND

Pulsed electric field (PEF) therapy kills cells in targeted tissues via mechanisms dependent on local field effects, where different tissue layers will distort this distribution.

OBJECTIVE

Numerically evaluate the implications of the heterogeneous electrical conductivity tissues surrounding cardiac ablation sites on the spatial distribution of PEF ablation effects.

METHODS

A numerical model was created using human CT images and well-established tissue conductivity parameters to estimate the thoracic electric field and current distributions from a focal monopolar electrode delivering PEF to the endocardium.

RESULTS

Electrically heterogeneous environments surrounding cardiac ablation sites affects the spatial distribution of the electric field and current flow during PEF. Discontinuities of conductivity at tissue planes have a dispersive effect on the strength of the field with the most significant diminution of field strength occurring immediately adjacent to the myocardium at the high-impedance fibrous pericardium. These results indicate a protective effect from the heterogeneous tissue layers in the thoracic environment, reducing electric field exposures to extra-cardiac tissues. The pericardial fluid-sac system disperses and insulates the electric current from reaching critical structures in the extra-cardiac environment.

CONCLUSIONS

The electrically heterogeneous tissue layers surrounding the heart provide a protective effect to adjacent tissue during the application of PEF. These data support previously described preclinical and clinical findings of spared sensitive tissues, including esophagus, following PEF therapy.

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