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# A THERMODYNAMICS-BASED THERMOELASTIC CONSTITUTIVE MODEL OF CARDIAC RADIOFREQUENCY ABLATION

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Constitutive modeling of cardiac radiofrequency catheter ablation (RFCA) lacks reliable three-dimensional microstructural representations of the myocardium and the complex phenomena arising during tissue heating [1]. We propose a generalized constitutive framework of the myocardium consisting of a fully-coupled transversely isotropic thermo-hyperelastic model accounting for local anisotropies and multiscale cellular dynamics. We advance [2]: i) a biophysical rationale formulating a continuum damage approach based on a dynamical cell death model, ii) a fully coupled thermo-mechanical formulation stemming from the multiplicative decomposition of the deformation gradient and the additive decomposition of the strain energy density, and iii) anisotropic thermo-electrical conduction mechanisms based on three-dimensional myocardial fiber distribution. We additionally complement phenomenological constitutive dependences on the temperature. The numerical implementation of the overall multiphysics and multiscale model was conducted via a finite element scheme under the additional constraint of constant power control. We show the reliability of our generalized RFCA framework, obtaining a better matching of ablating volumes compared to the state-of-the-art. Elliptically-shaped thermal lesions, owing to the anisotropic thermo-electric conduction, and residual strains appear within the medium upon completion of the treatment and load removal. Stiffening and damage accumulation finally results in concurring towards a possible clinical translation.

## REFERENCES

[1] A. Petras, M. Leoni, J. M. Guerra, J. Jansson, L. Gerardo-Giorda, A computational model of open-irrigated radiofrequency catheter ablation accounting for mechanical properties of the cardiac tissue. *Int J Num Methods Biomed Eng*, **35**:e3232, 2019.

[2] L. Molinari, L. Gerardo-Giorda, A. Gizzi. A transversely isotropic thermo-hyperelastic constitutive model of myocardial tissue with a three-state cell death dynamics for cardiac radiofrequency ablation. *In Press*