

Improving Thermal Effect On Biological Tissue Using Multiphysics Simulation and Shape Optimization



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Boston, MA

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Renal Denervation

Renal denervation

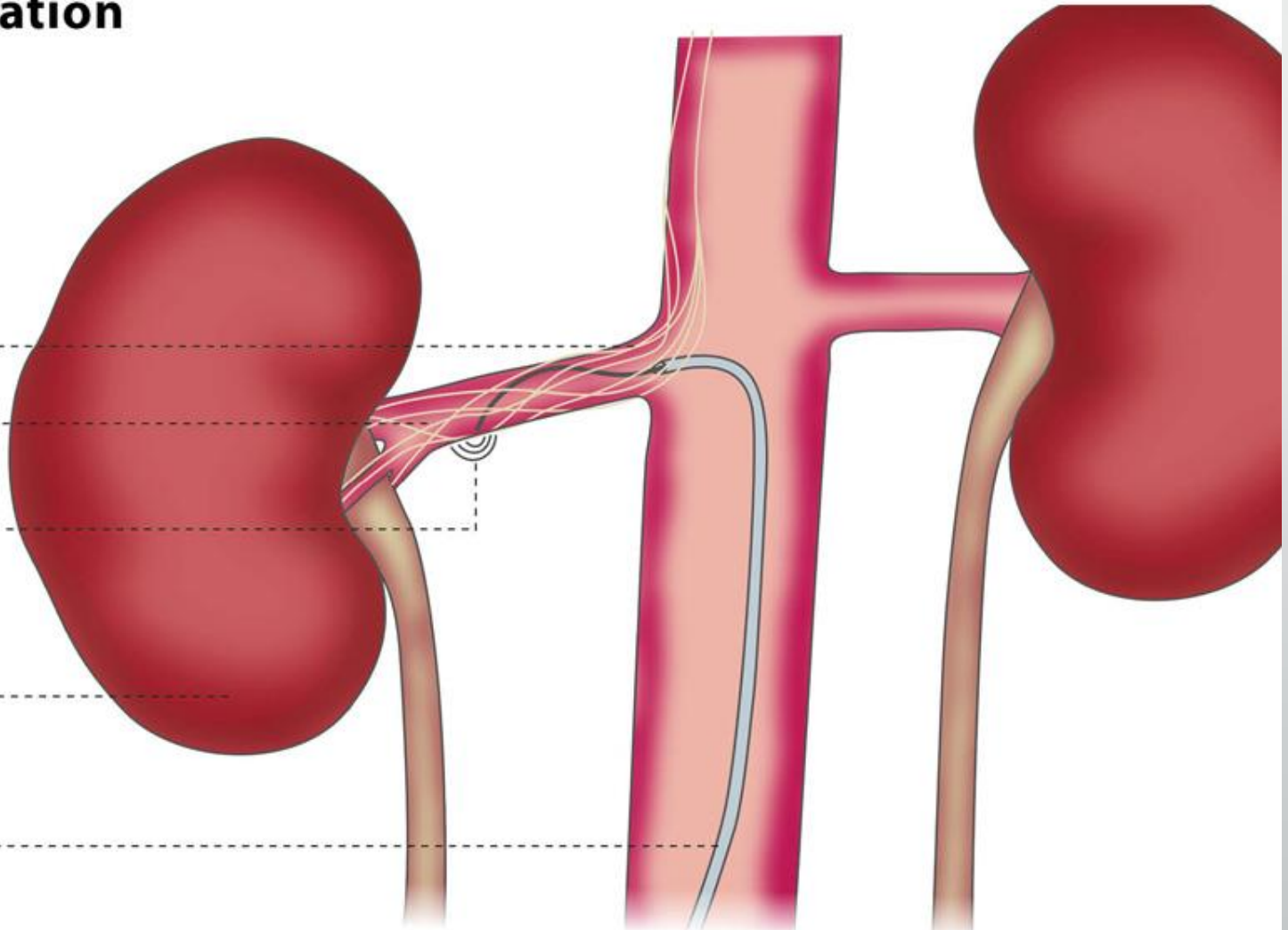
Renal nerves

Renal artery

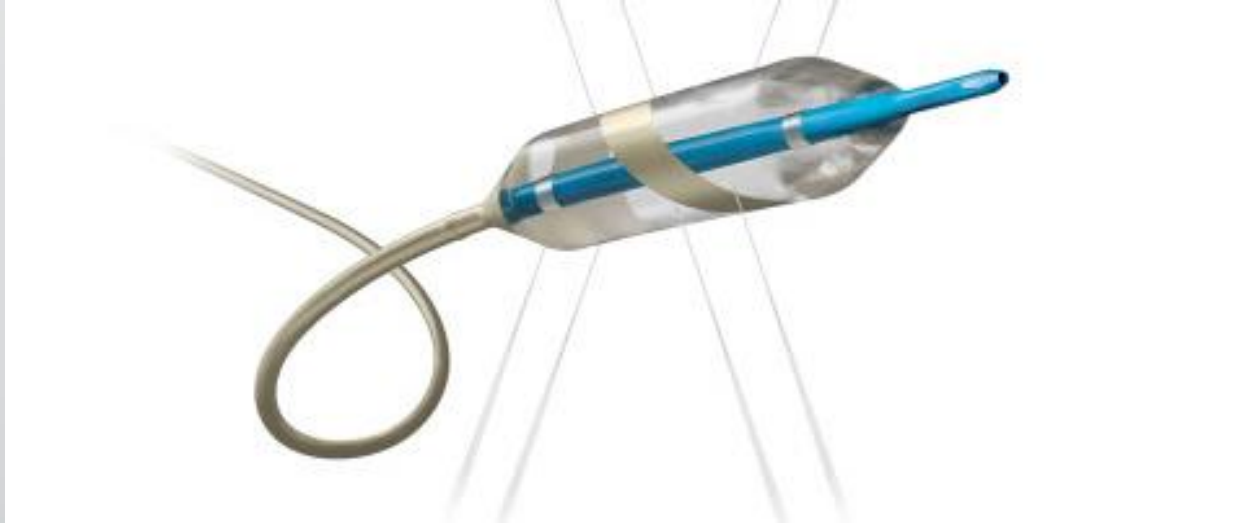
Radiofrequency energy

Kidney

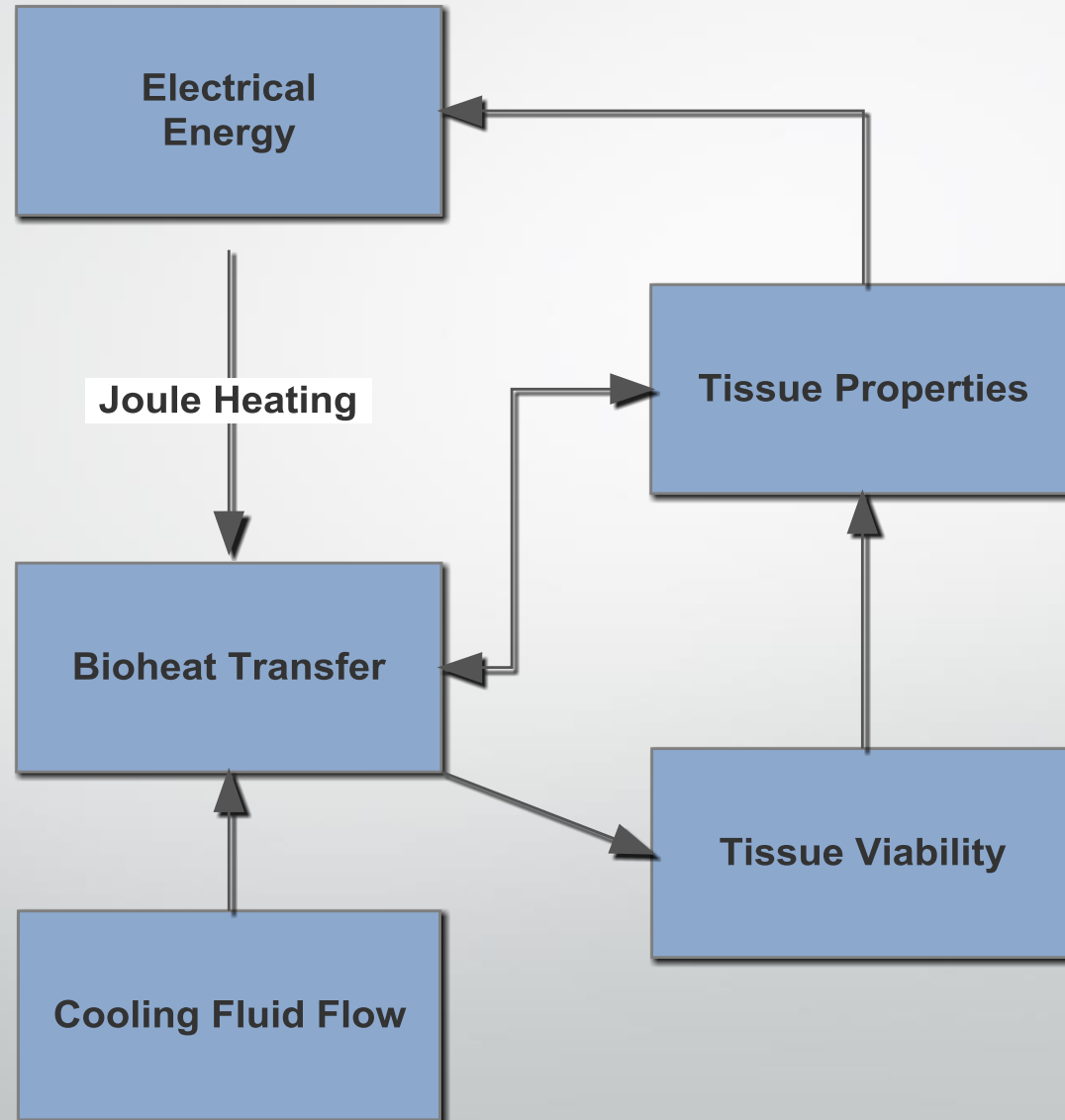
Catheter



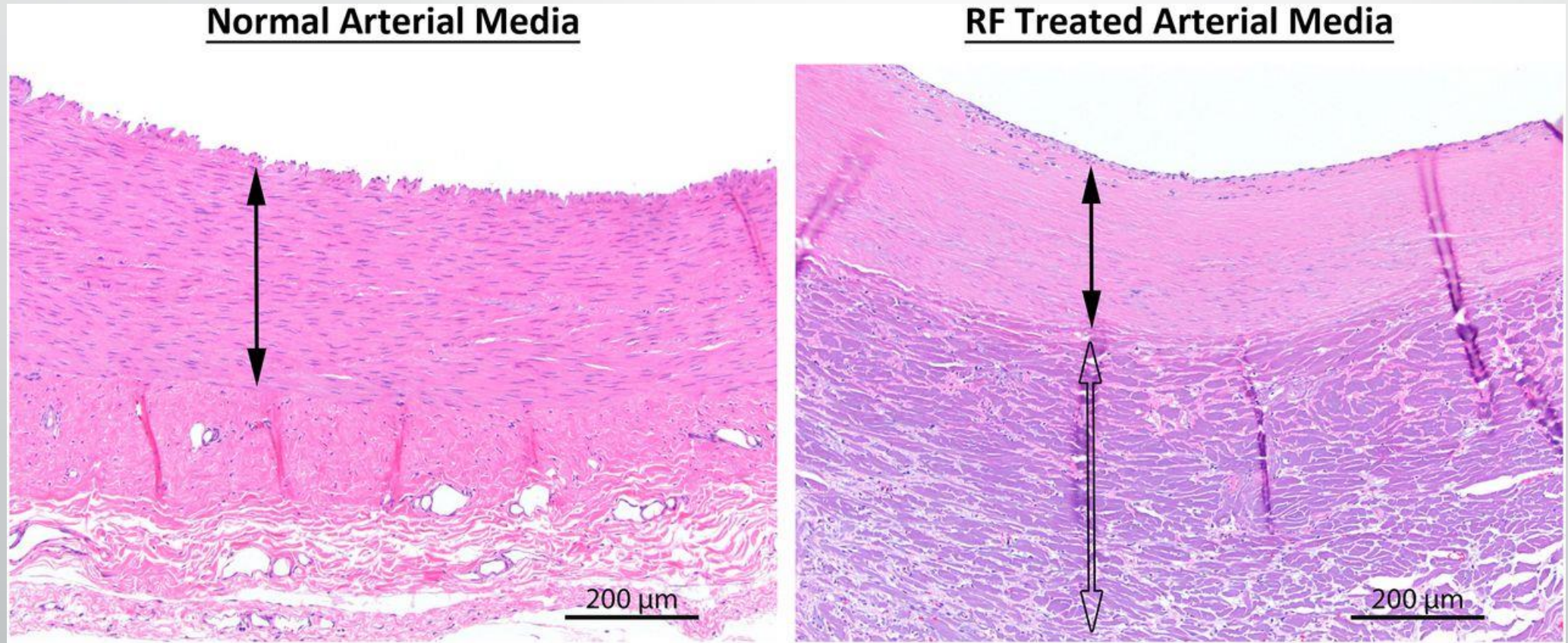
Balloon Catheter Design



Multiphysics Problem



Traditional Development



Optimization

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Designing New Structures with Shape Optimization

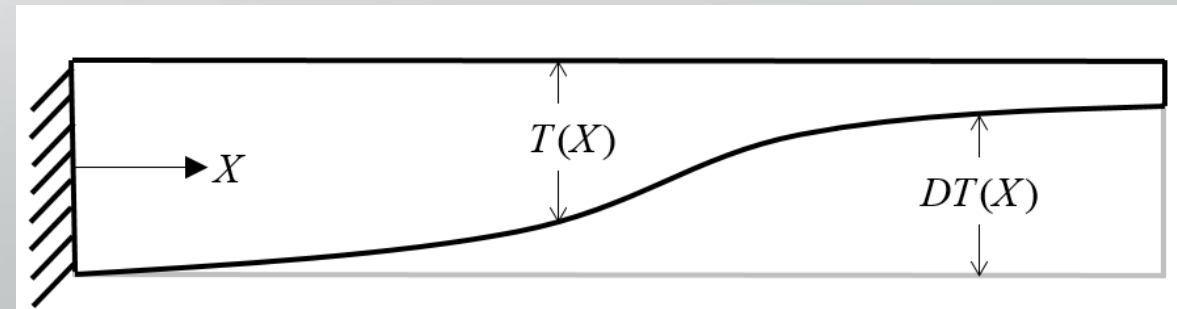
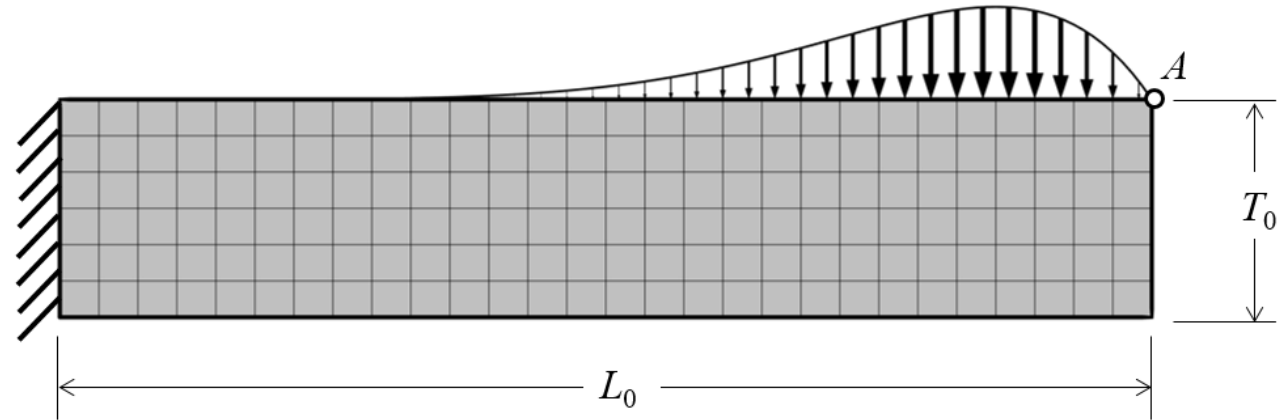


Walter Frei December 29, 2015

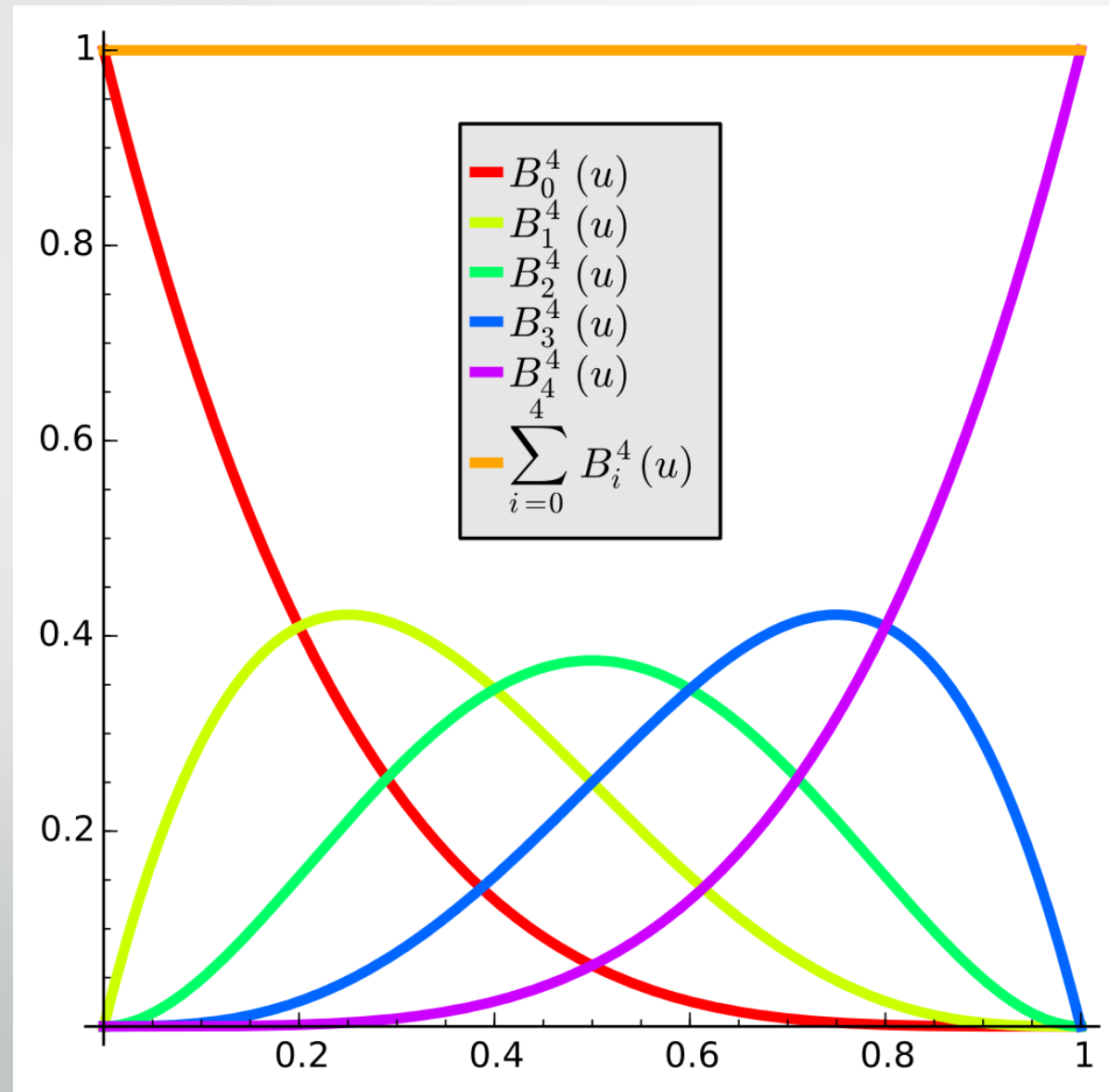
While designing a structure, have you ever been unsure of how to achieve what you want? Then you will want to add a useful technique called shape optimization to your Multiphysics modeling skill set. Today, we will discuss the concept of shape optimization and demonstrate its use through a classical problem.

A Background on Shape Optimization

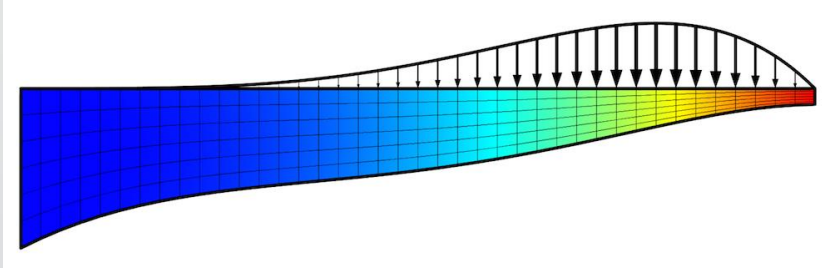
As engineers, researchers, and scientists, we are always striving to come up with improved designs. *Optimization* is the idea of altering model inputs, such as part dimensions and material



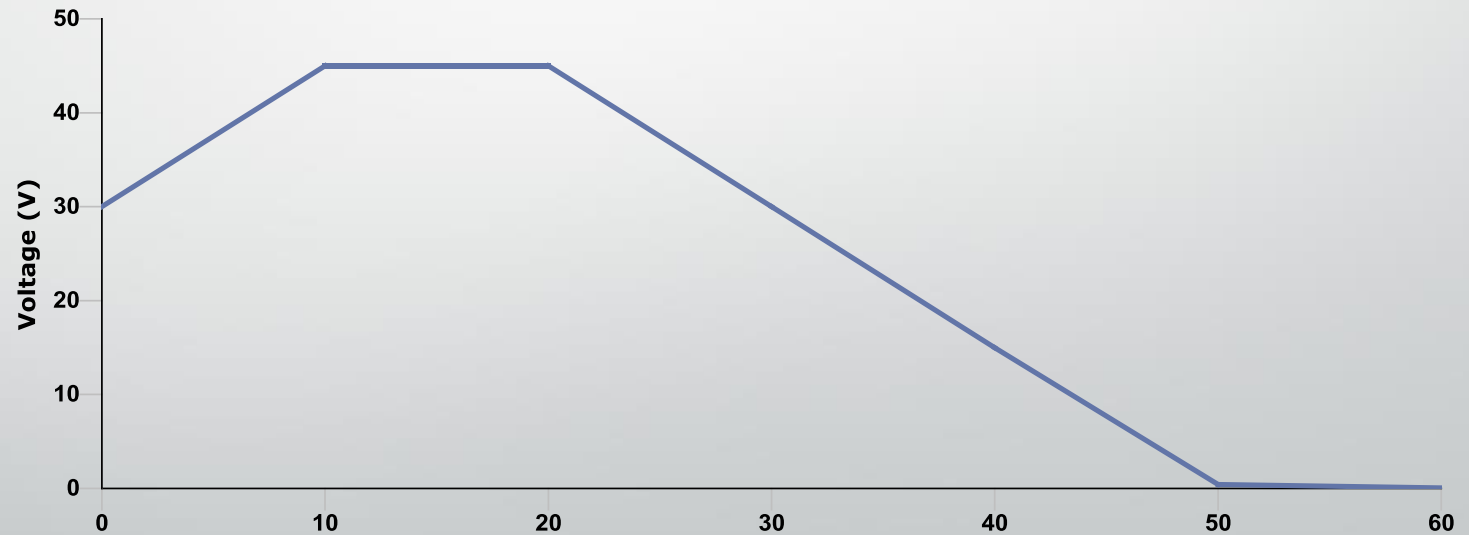
Bernstein Polynomials



Model



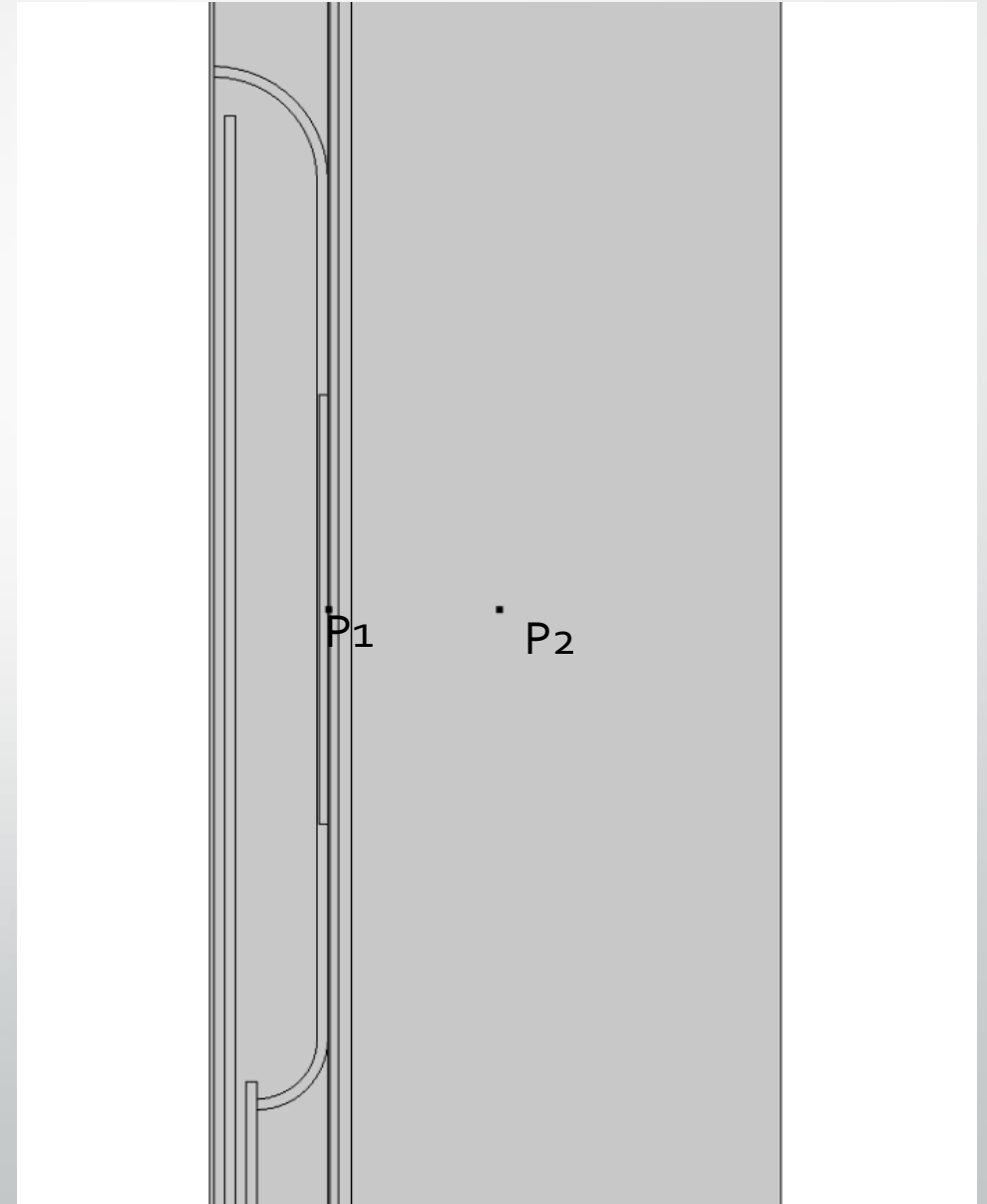
$$DT(\bar{X}) = T_0[C_0(1 - \bar{X})^4 + C_1\bar{X}(1 - \bar{X})^3 + C_2\bar{X}^2(1 - \bar{X})^2 + C_3\bar{X}^3(1 - \bar{X}) + C_4\bar{X}^4]$$



$$DV(\bar{t}) = T_0[C_0(1 - \bar{t})^4 + C_1\bar{t}(1 - \bar{t})^3 + C_2\bar{t}^2(1 - \bar{t})^2 + C_3\bar{t}^3(1 - \bar{t}) + C_4\bar{t}^4]$$

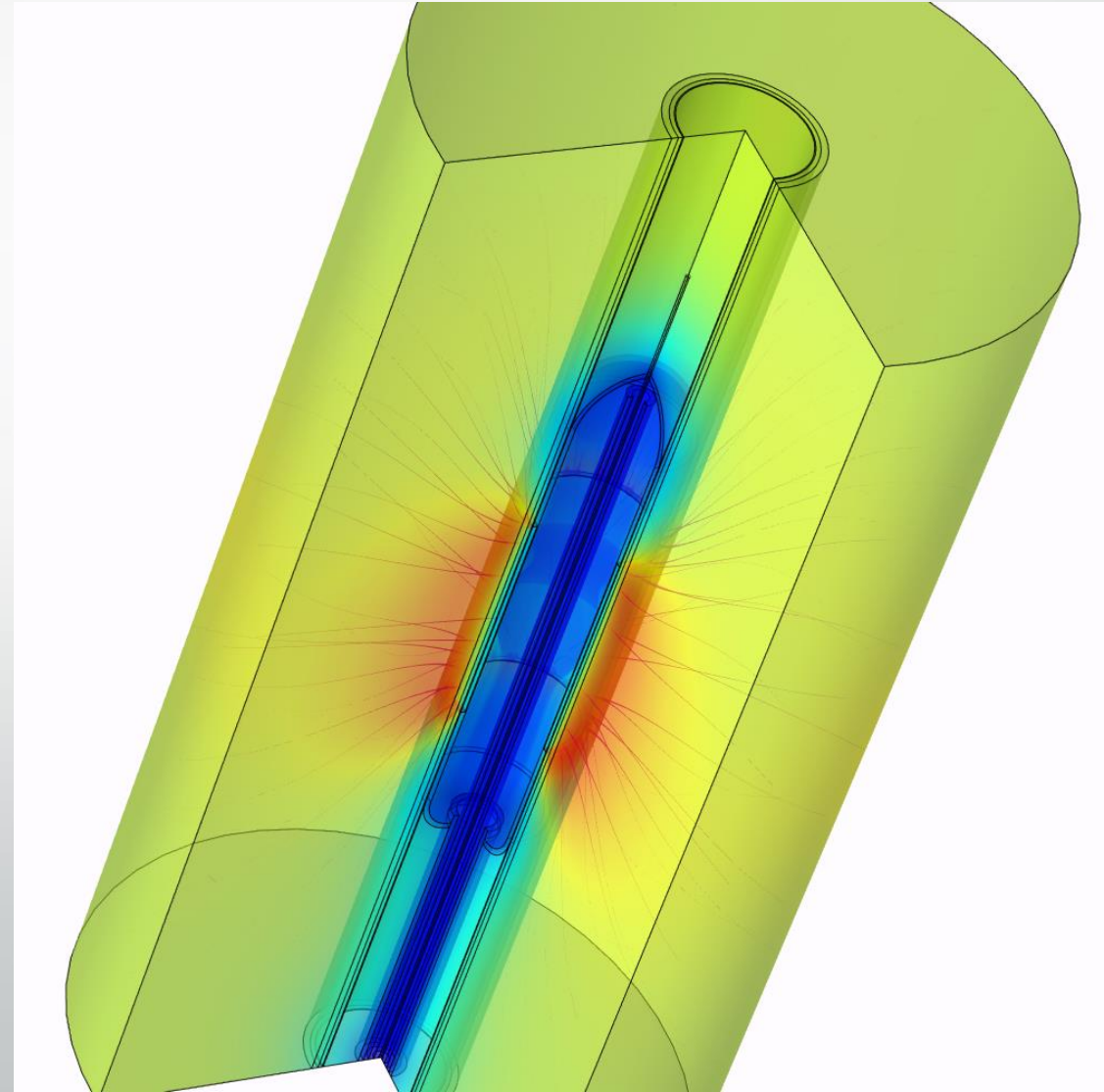
Optimization Criteria

- $P_1 < 50^{\circ}\text{C}$
(Constraint)
- $P_2 > 60^{\circ}\text{C}$
(Criteria)

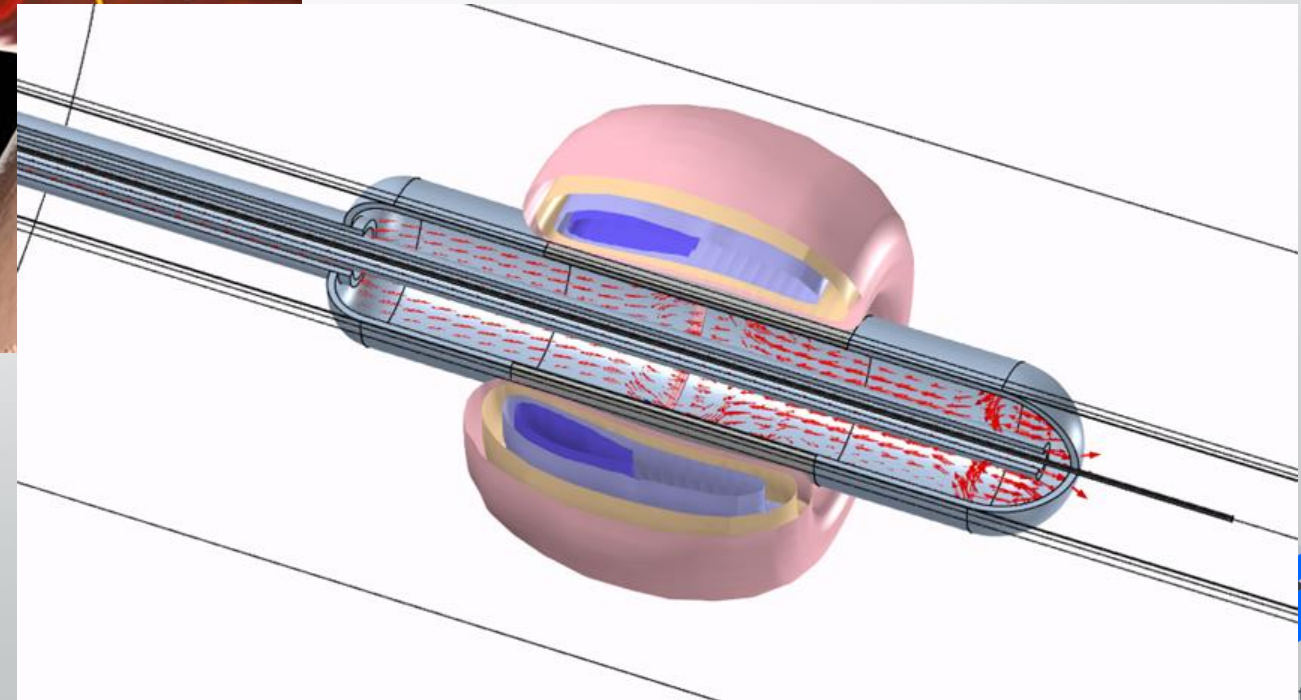
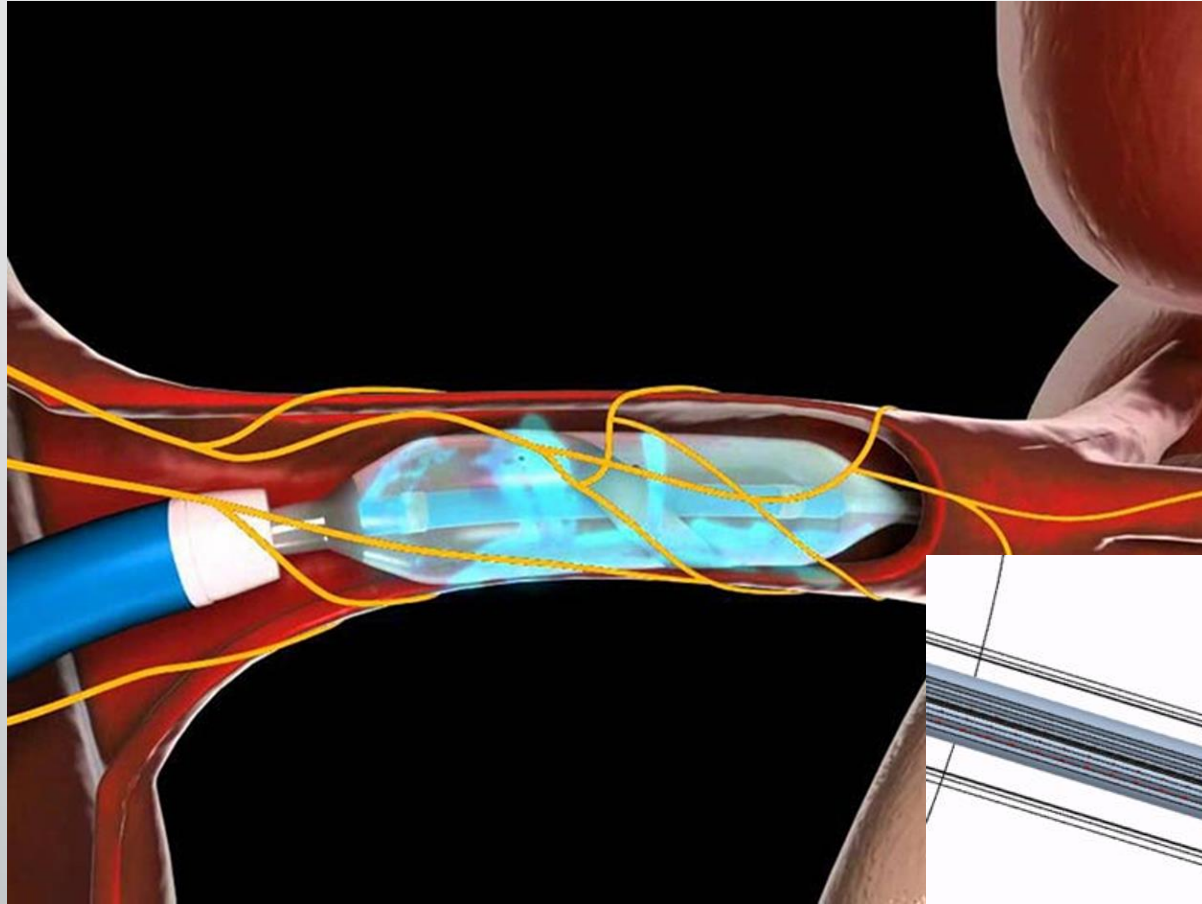


Results

- 86 Iterations
- ~12.5 minutes each
- Initial pulse and then baseline voltage
- Other optimization criteria may be better



Conclusions



ASME V&V 40 and FDA Guidelines

Reporting of Computational Modeling Studies in Medical Device Submissions

Guidance for Industry and Food and Drug Administration Staff

Document issued on: September 21, 2016.

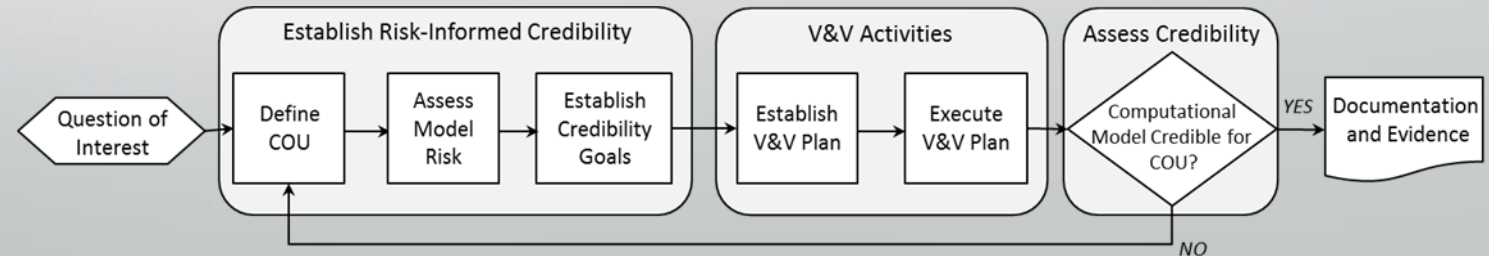
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Food and Drug Administration
Center for Devices and Radiological Health
Office of Device Evaluation
Office of Science and Engineering Laboratories

Activities		Credibility Factors
Verification	Code	Software Quality Assurance
		Numerical Code Verification
	Calculation	Discretization Error
		Numerical Solver Error
Validation	Computational Model	Use Error
		Model Form
	Comparator	Model Input
		Test Samples
	Assessment	Test Conditions
		Equivalency of Input Parameters
Applicability		Output Comparison
		Relevance of the Quantities of Interest
		Relevance of the Validation Activities to the COU



Thank You

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