

Computational modeling for predicting performance of engineering designs in service is now routine in many industries ...



And is increasingly used for implanted cardiovascular devices ...



But we need to analyze the device interacting with heart tissues in vivo and it's effect on cardiac physiology ...



And we need ways to include the effects of individual variation and human diversity ...



http://futurelightdna.com

We need ...

Predictive, mechanistic, integrative, *patient-specific* computational models of cardiac electrical, mechanical, hemodynamic and metabolic function





Heart Failure

- Condition in which the heart is unable to pump enough blood to meet the metabolic demands of the body
- Chambers enlarge, excess fluid backs up into the lungs and systemic circulation leading to edema, shortness of breath, cough, exercise intolerance ...
- 5 million Americans with heart failure
- 5-year mortality is 50%
- Highly heterogeneous syndrome
- There are multiple etiologies and comorbidities, including arrhythmia

Cardiac Resynchronization Therapy (CRT) for Dyssynchronous Heart Failure (DHF)

- Up to 40% of HF patients have conduction defects such as left bundle branch block (LBBB) resulting in ventricular mechanical dyssynchrony
- CRT using biventricular pacemakers can improve synchrony between LV and RV contraction
 - improves quality of life*
 - ▶ reduces mortality*
 - 30-40% of patients do not respond to CRT, especially those with myocardial infarcts
 - No accepted clinical predictor of CRT outcomes



RawBeeCG (2012) https://www.youtube.com/ watch?v=EM4Y5tCRvbc



*Cleland, 2005







The Decrease in LVESV at 6 Months Did Not Correlate with Baseline Electrical, Functional, Hemodynamic or Anatomic Measurements











How does CRT Affect Ventricular Mechanical Efficiency?



Computed Reduction in Septal Myocardium Performing "Negative" Work May Predict CRT Response





Non-invasive Model-Based Assessment

Model Predictions



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Clinical Validation



From Individual Patients to Populations 3D Models from Cardiac MR Imaging



Ventricular Shape Atlases (MESA Study)



Top 4 Left Ventricular Shape Modes

Top 3 Bientricular Shape Modes

Average

Shape

95th Percentile

Summary

- Patient specific computational models have potential to improve the diagnosis, device therapy and medical management of heart failure and ventricular fibrillation
- Population based models may identify new biomarkers of disease progression in acquired and congenital heart diseases

