

# Image Based Approaches for Atrial Fibrillation:

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CARMA Center, SCI Institute, CVRTI  
Bioengineering Department



# Disclosures

**Who would pay me, I am a PhD?**

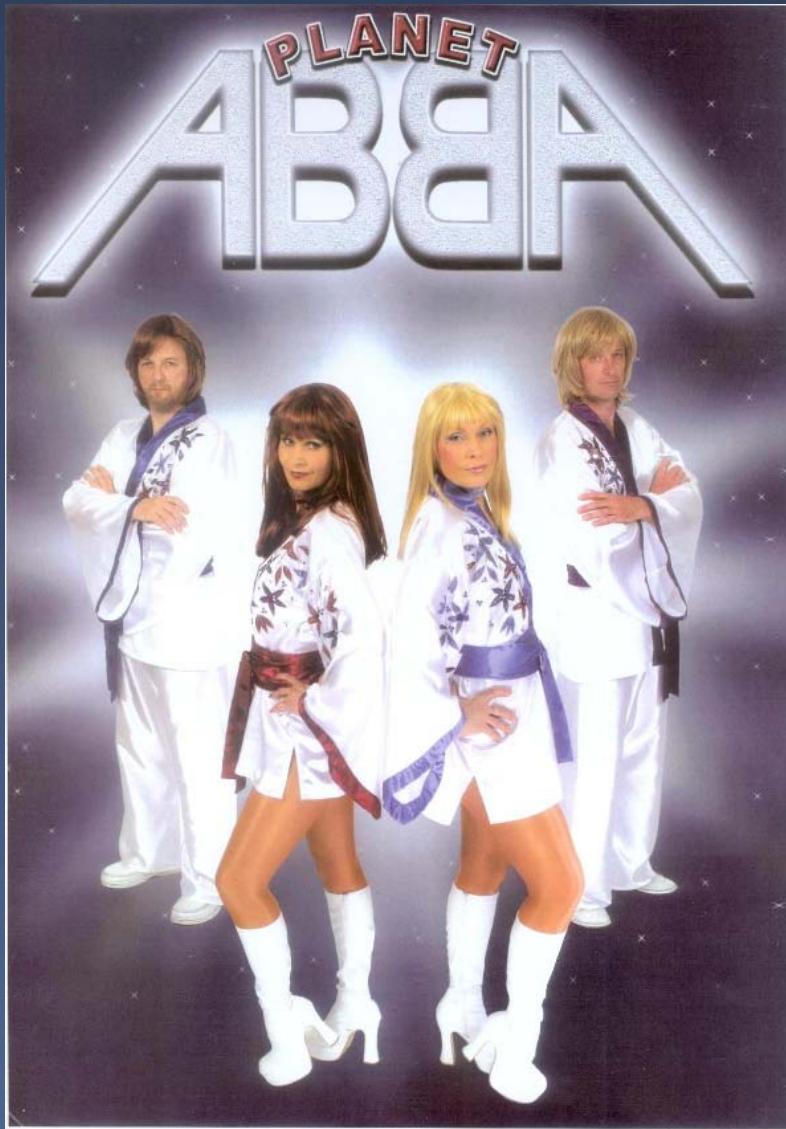
**Thank Goodness for the NIH!**



# Paradox



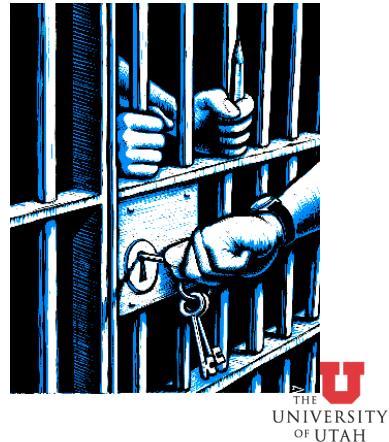
# Things We All Know about Sweden





# Kingston





# For Your Information (Ego)

## Most PhDs per capita

- 1 Kingston, Ont. 1.67%
- 2 Guelph, Ont. 1.4%
- 3 Victoria, B.C. 1.27%
- 4 Ottawa-Gatineau, Ont. 1.22%
- 5 Saskatoon, Sask. 1.05%



## Least PhDs per capita

- 1 Barrie, Ont. 0.15%
- 2 Oshawa, Ont. 0.20%
- 3 Brantford, Ont. 0.22%
- 4 Saint John, N.B. 0.24%
- 5 Abbotsford, B.C. 0.28%

Los Alamos,  
New Mexico

or

Madison,  
Wisconsin

THE  
UNIVERSITY  
OF UTAH

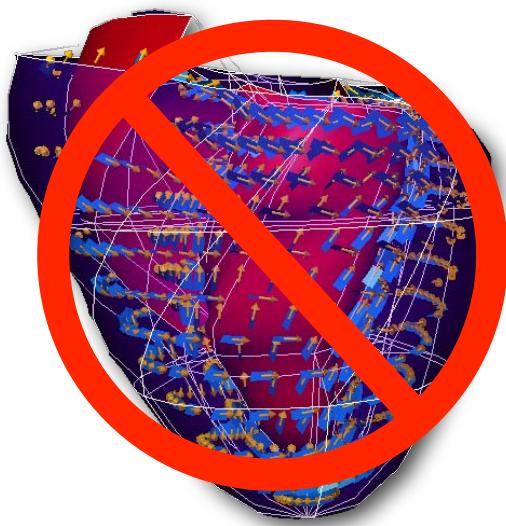
Ghana

or

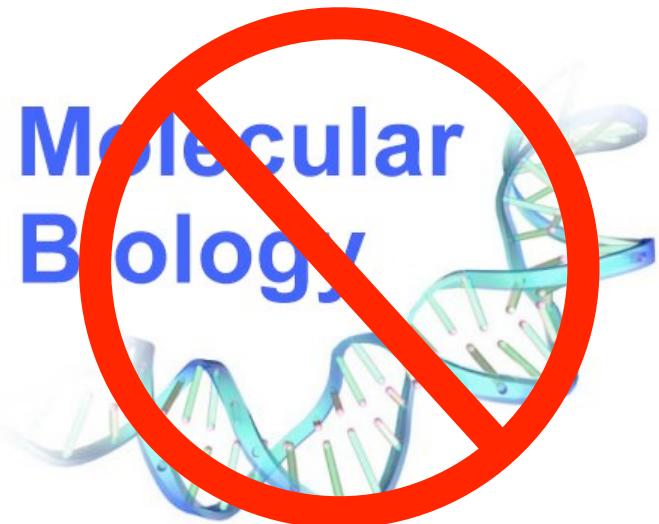
Israel

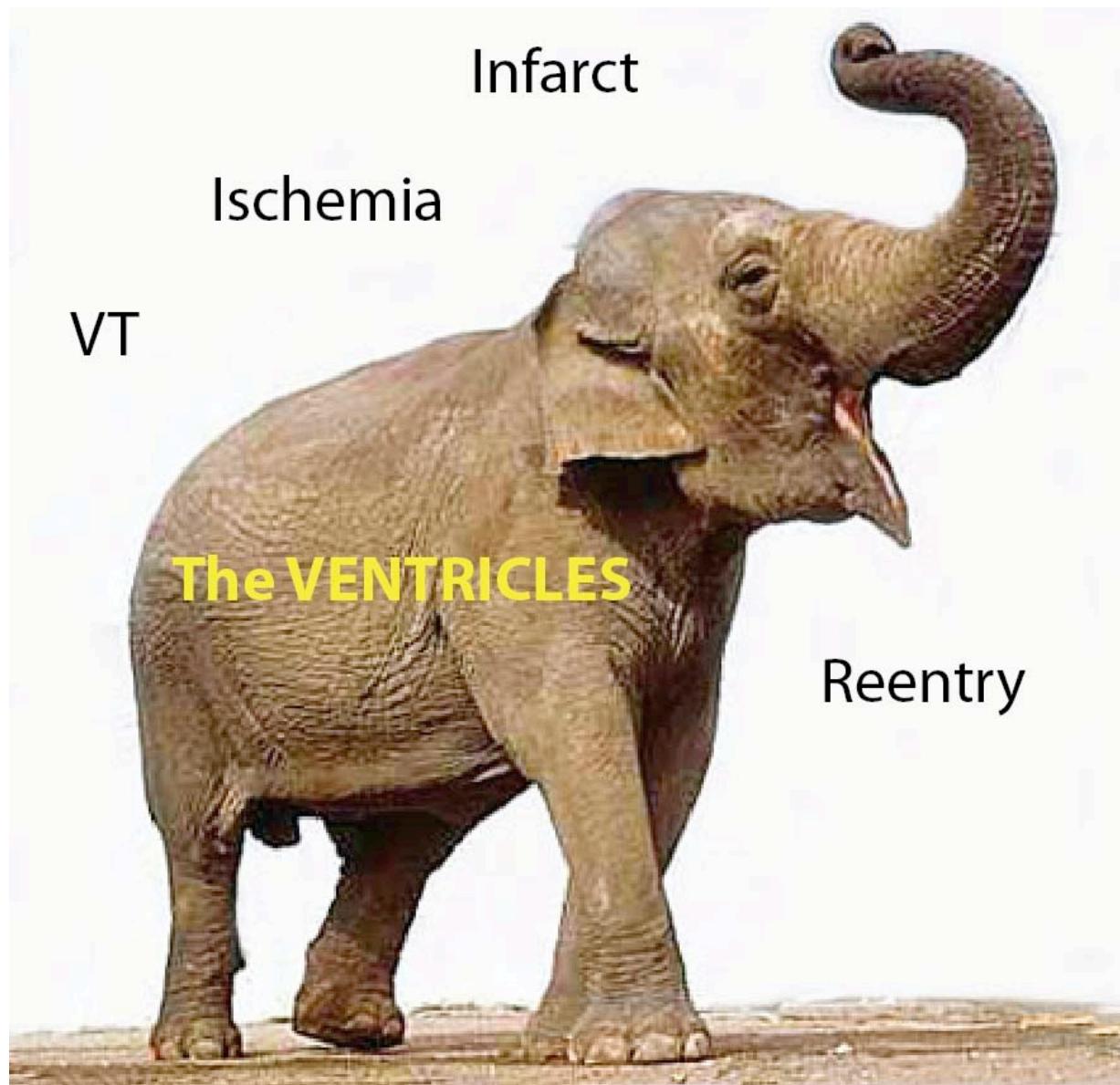


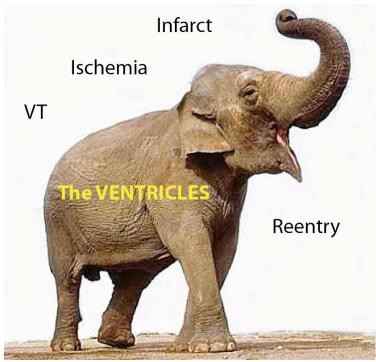
# Paradox



$$\bar{J}_e = g_{ix} \frac{\partial \Phi_e}{\partial x} + g_{iy} \frac{\partial \Phi_e}{\partial y} + g_{iz} \frac{\partial \Phi_e}{\partial z}$$
$$\bar{J}_i = g_{ix} \frac{\partial \Phi_i}{\partial x} + g_{iy} \frac{\partial \Phi_i}{\partial y} + g_{iz} \frac{\partial \Phi_i}{\partial z}$$







## The ATRIA

Fibrillation

Flutter



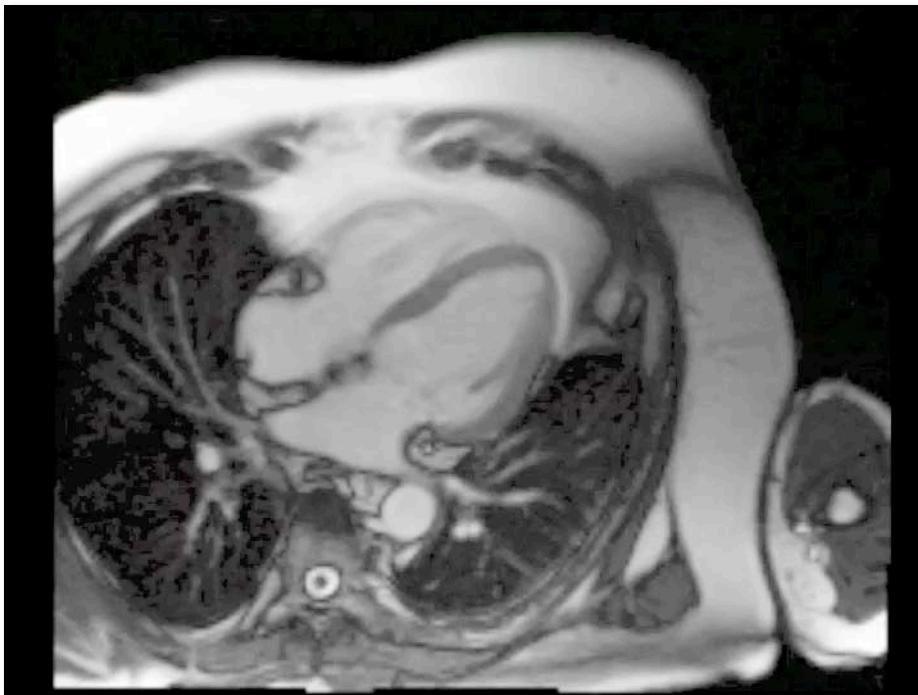
# CARMA



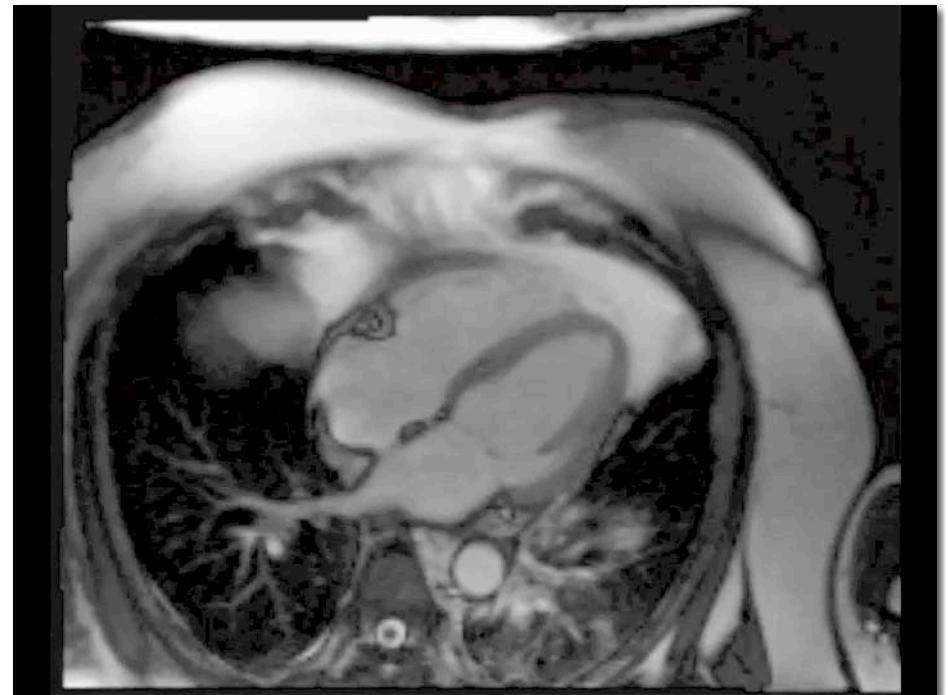
# What is Atrial Fibrillation? = Afib = AF



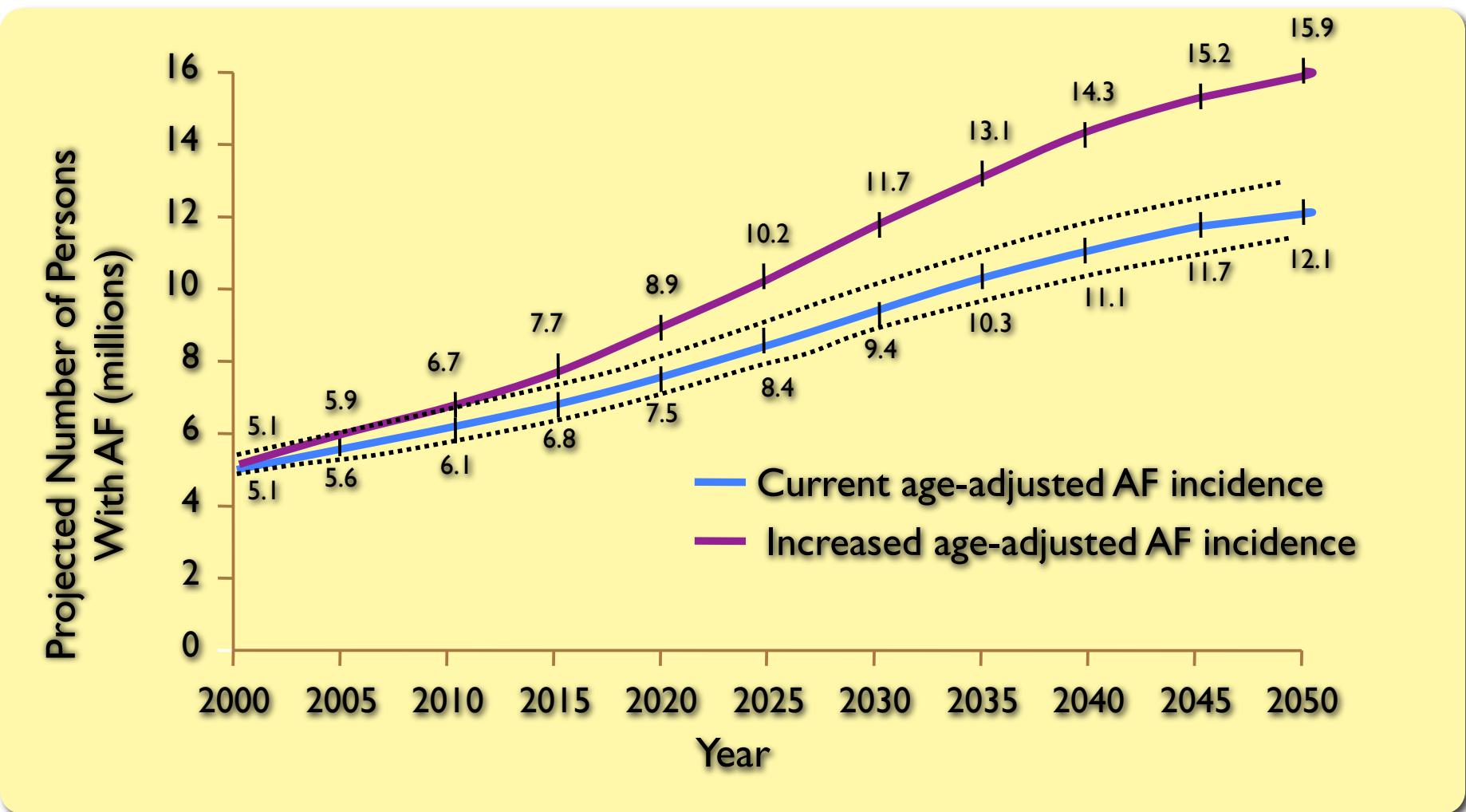
## Normal Contraction



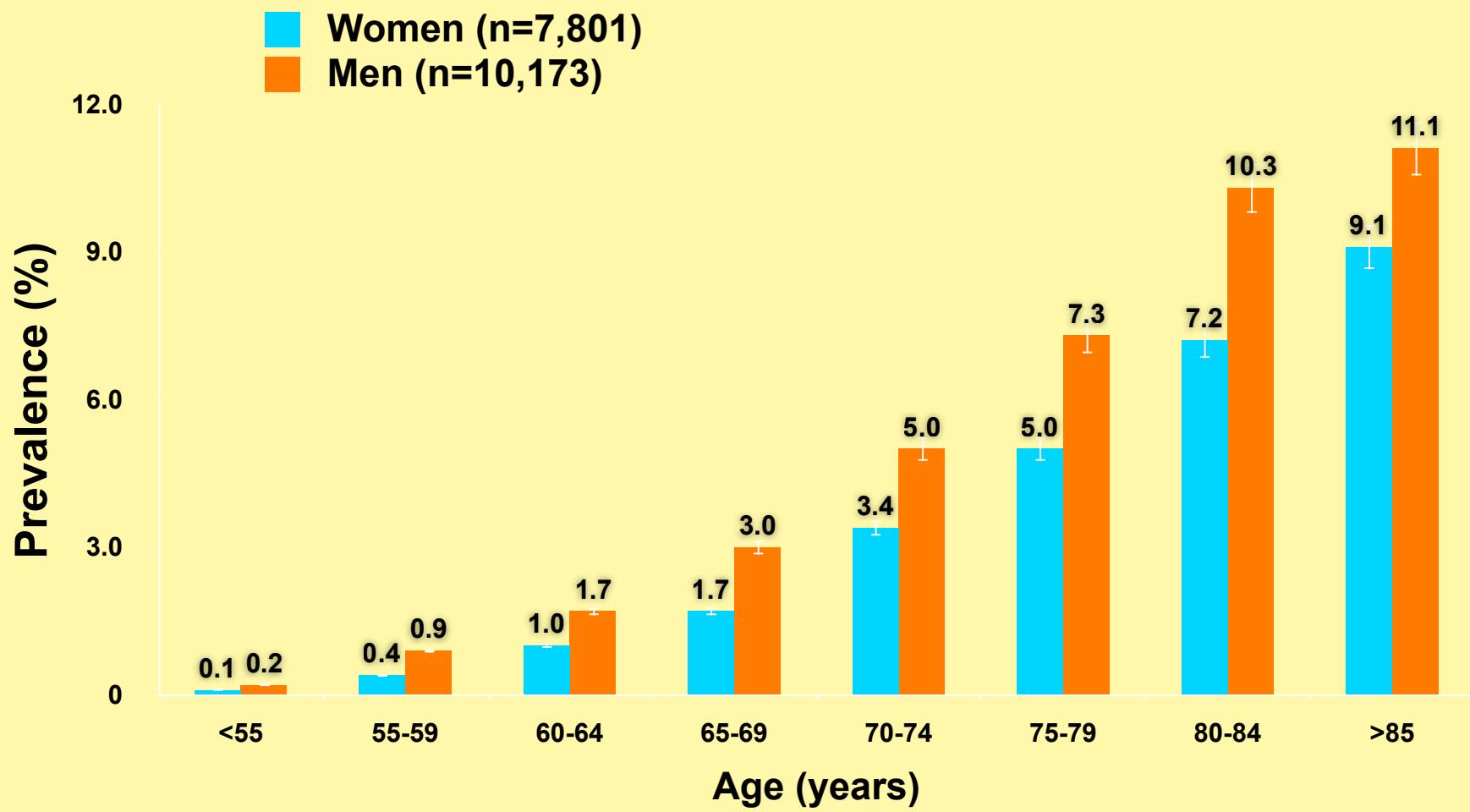
## Atrial Fibrillation



# AF Prevalence



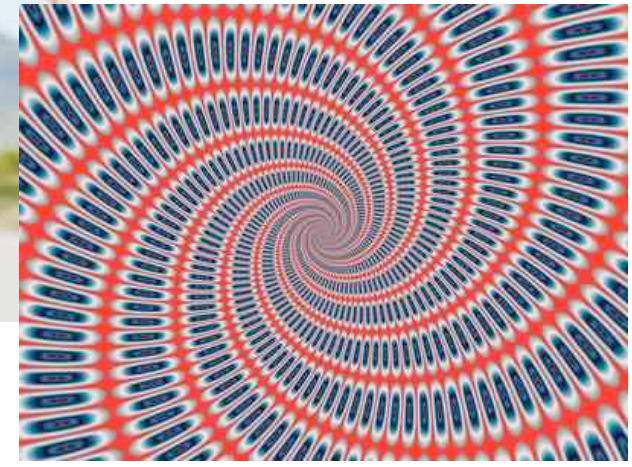
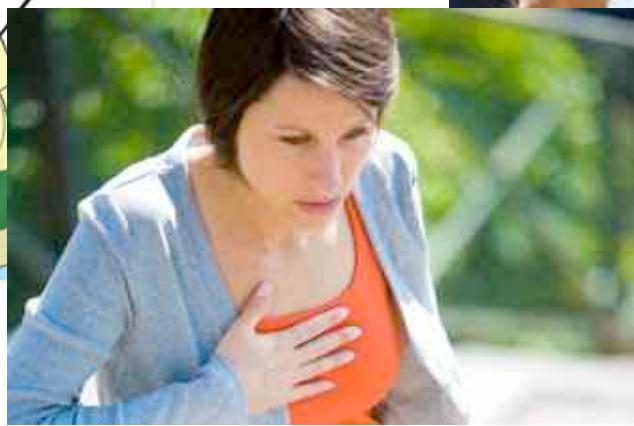
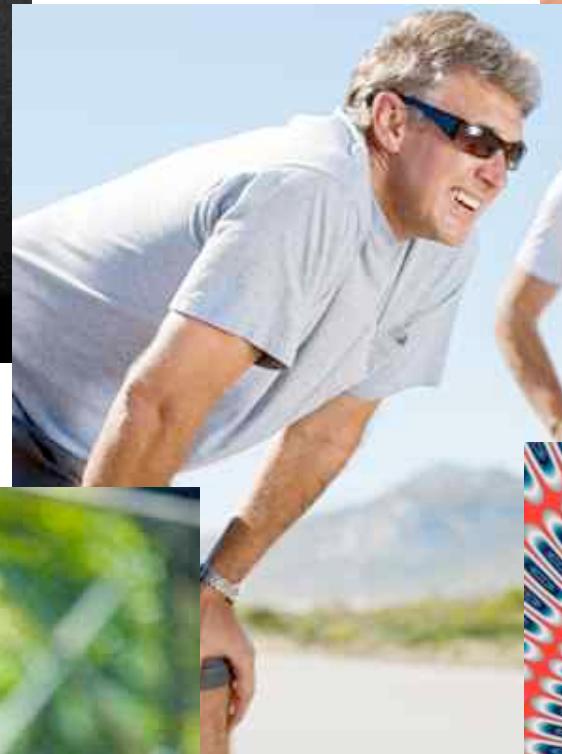
# We All Get Older



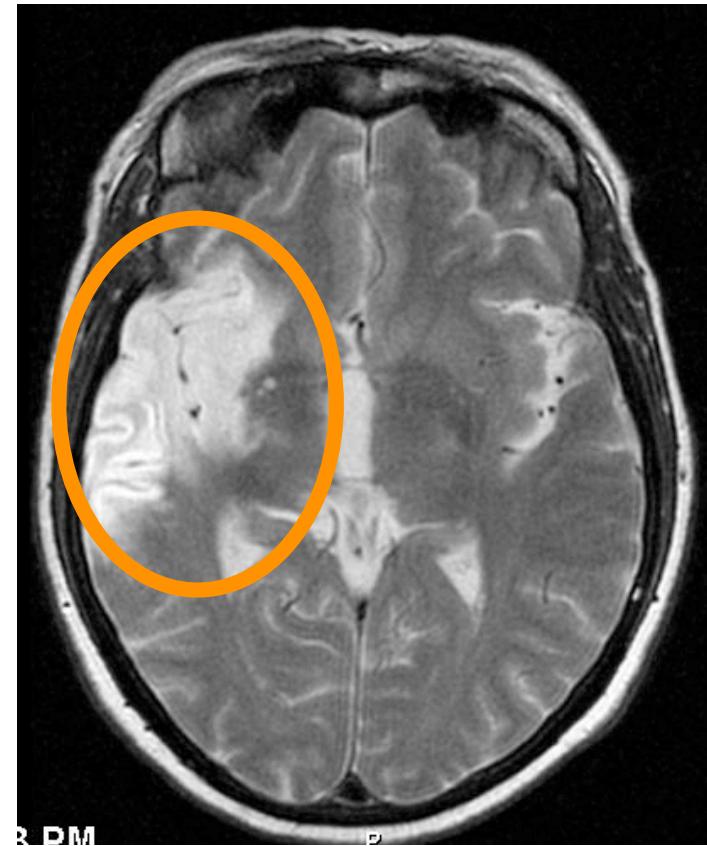
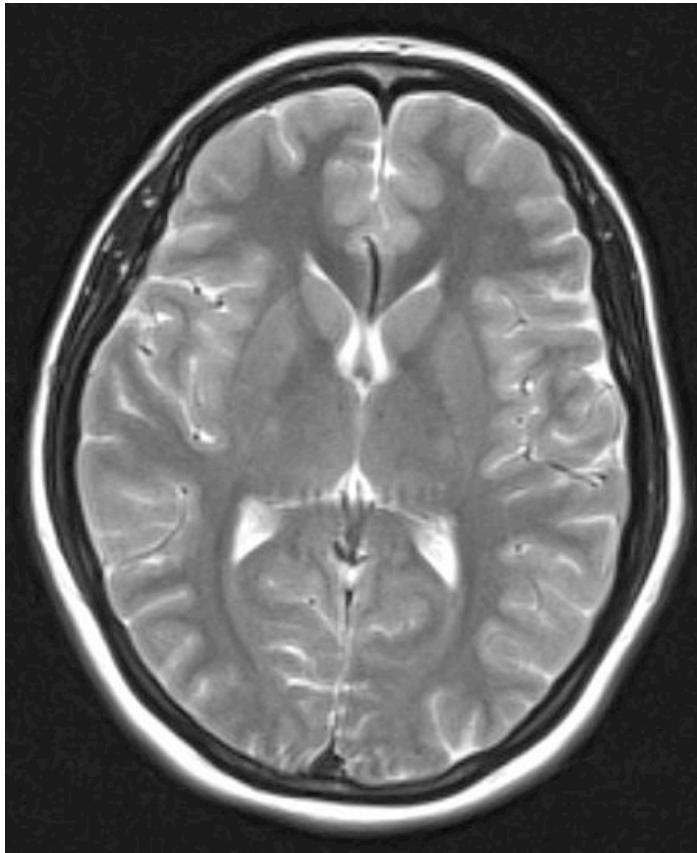
Go AS, et al. JAMA. 2001;285:2370-2375.



# So What?



# 20% of Strokes



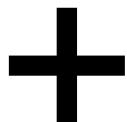
\$20 billion/year



# What Causes AFib?



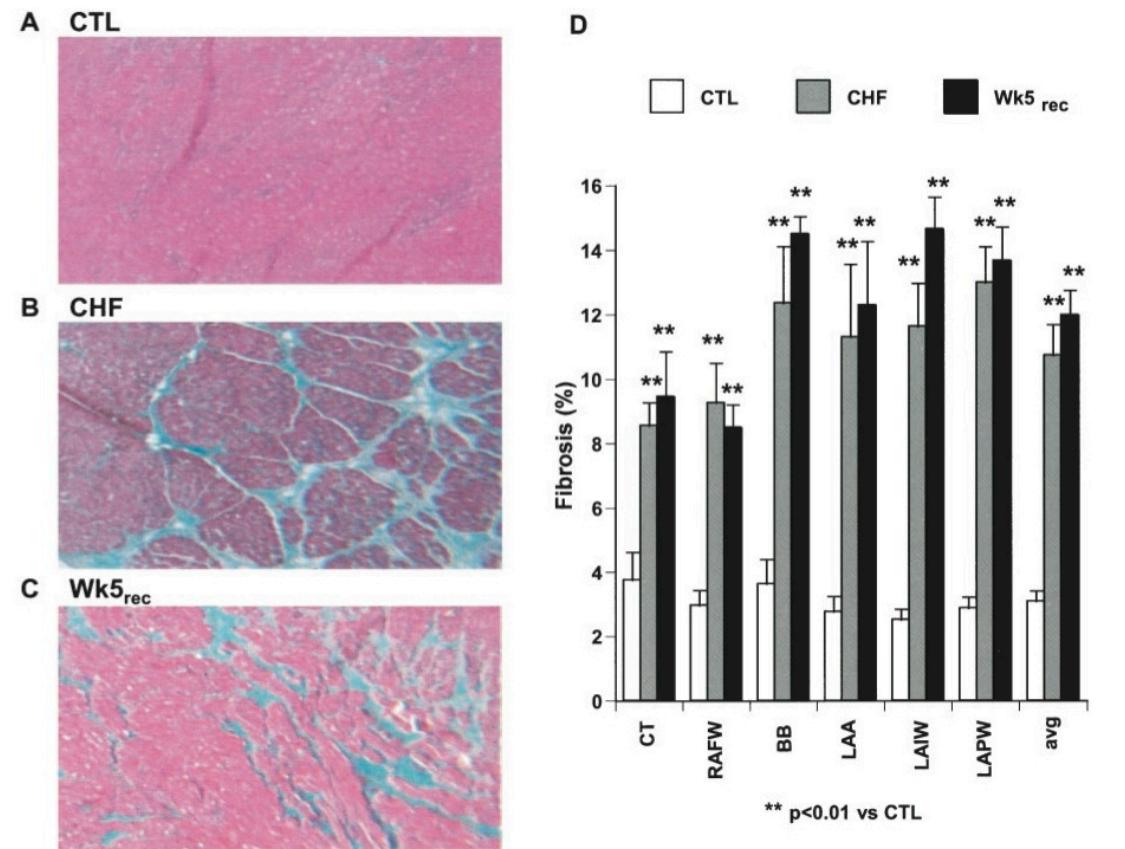
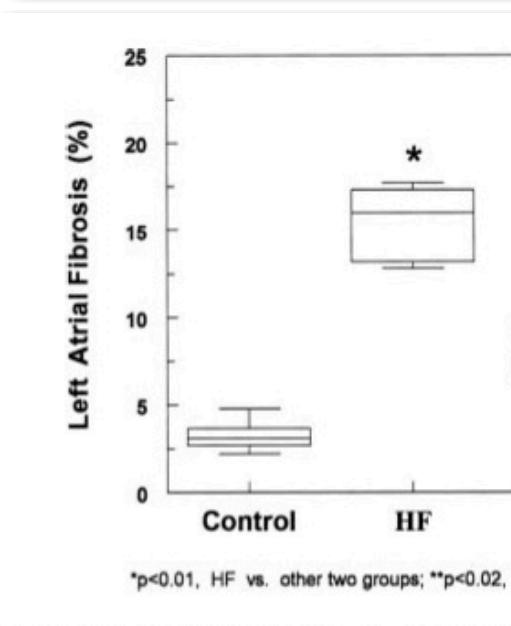
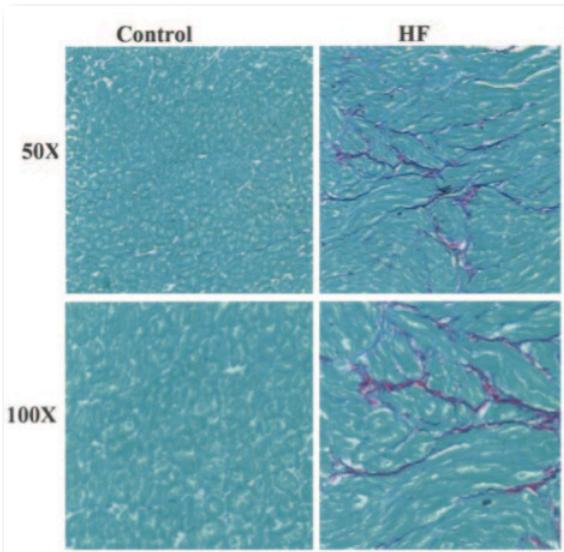
# Substrate



# Trigger



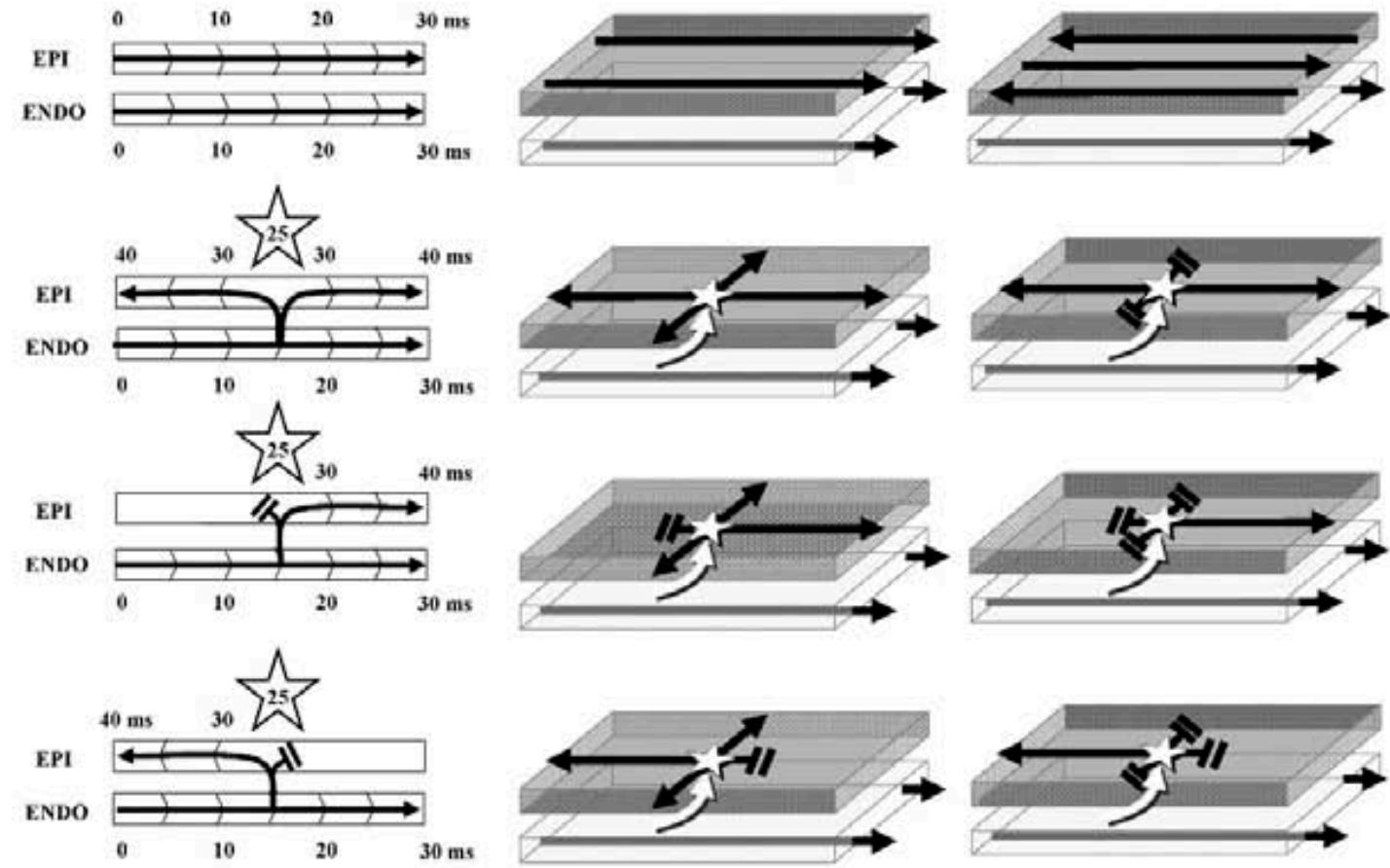
# Substrate:Fibrosis



Lee KW, et al. Circ. 2006: 1703-1712.

Shinagawa K, .... Nattel S. Circ. 2002: 2672-2678.

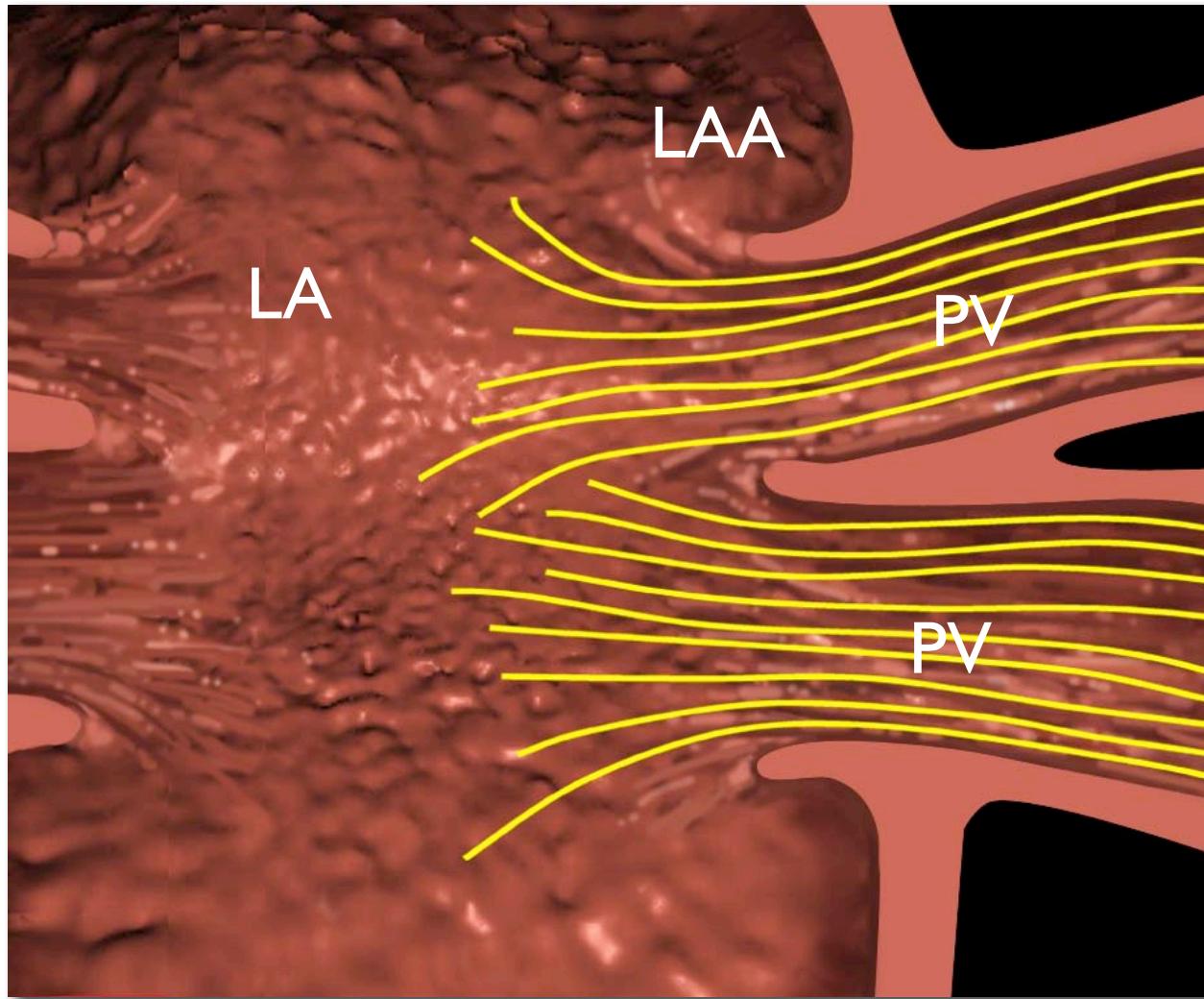
# Complex Propagation



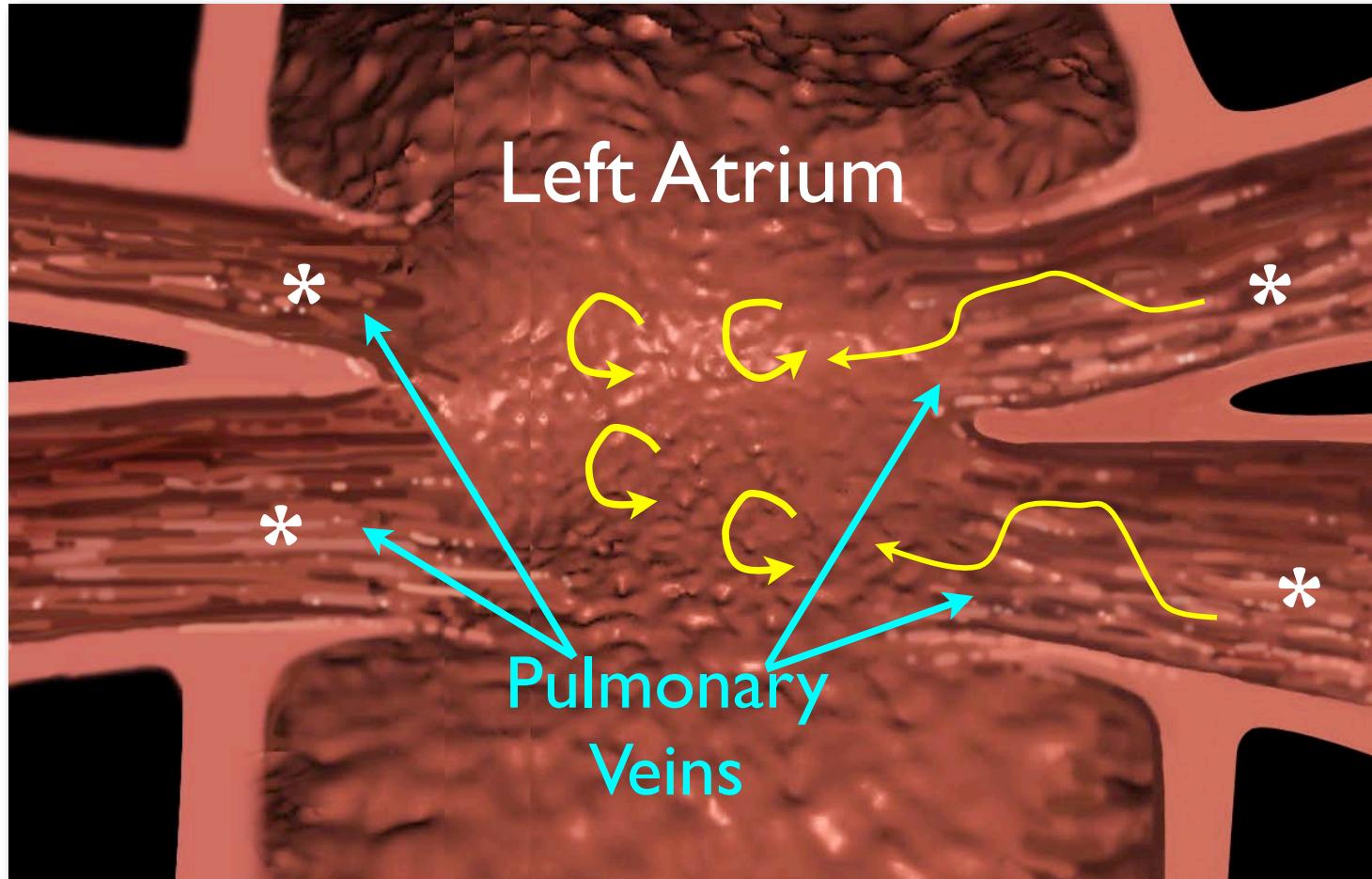
de Groot, .... Allessie MA. Circ. 2010: 1674-1682.



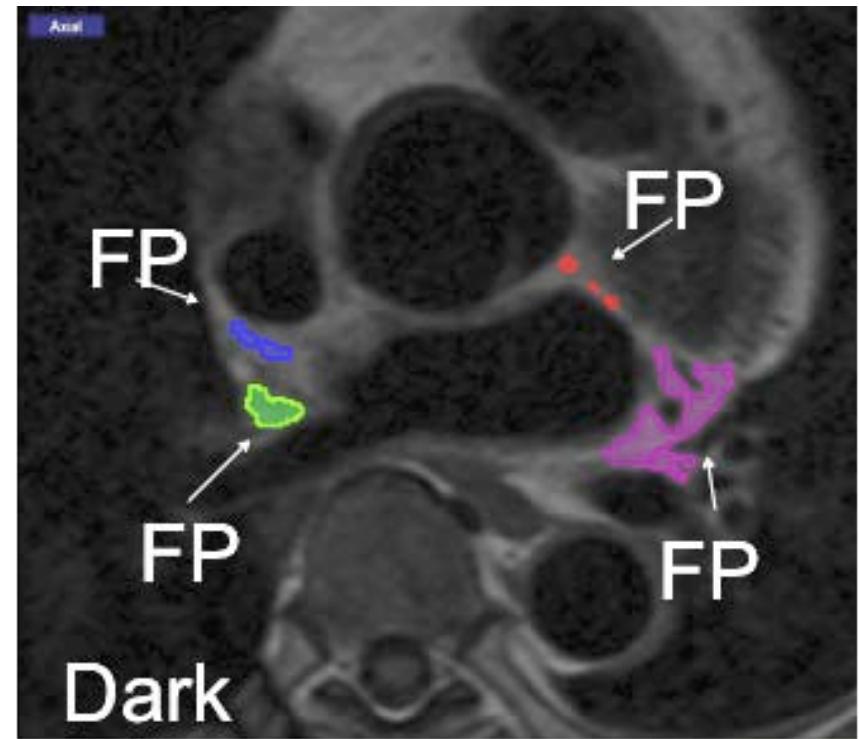
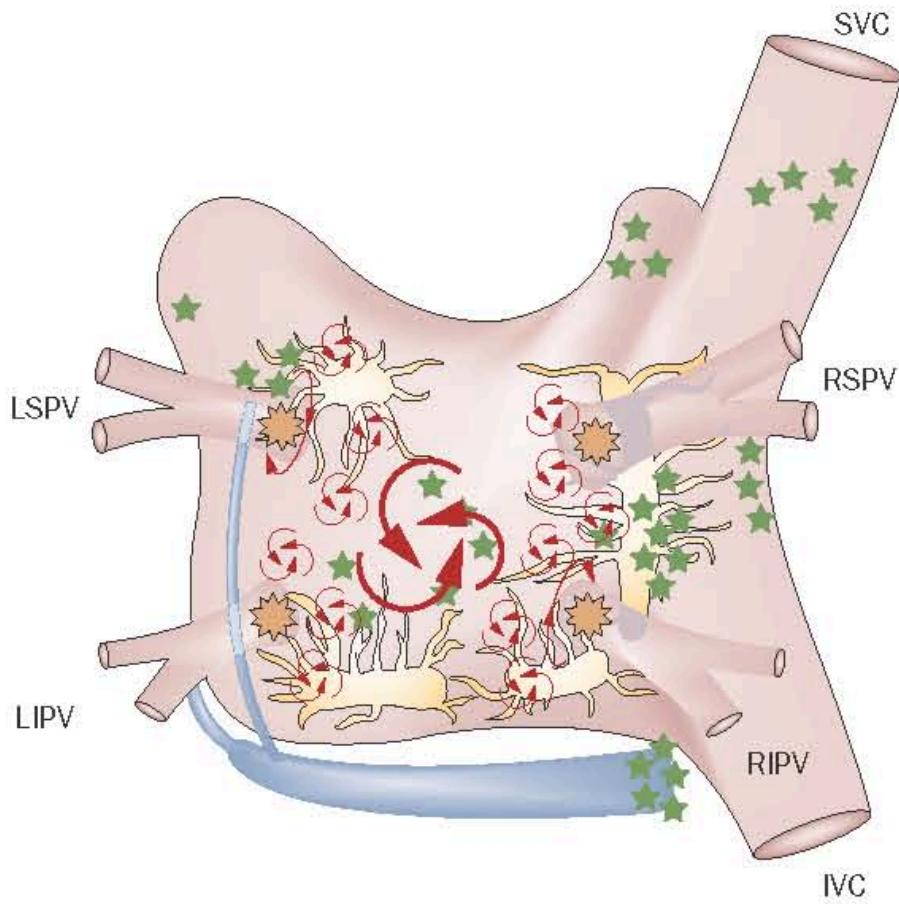
# Substrate: Extension of muscle sleeves



# Triggers

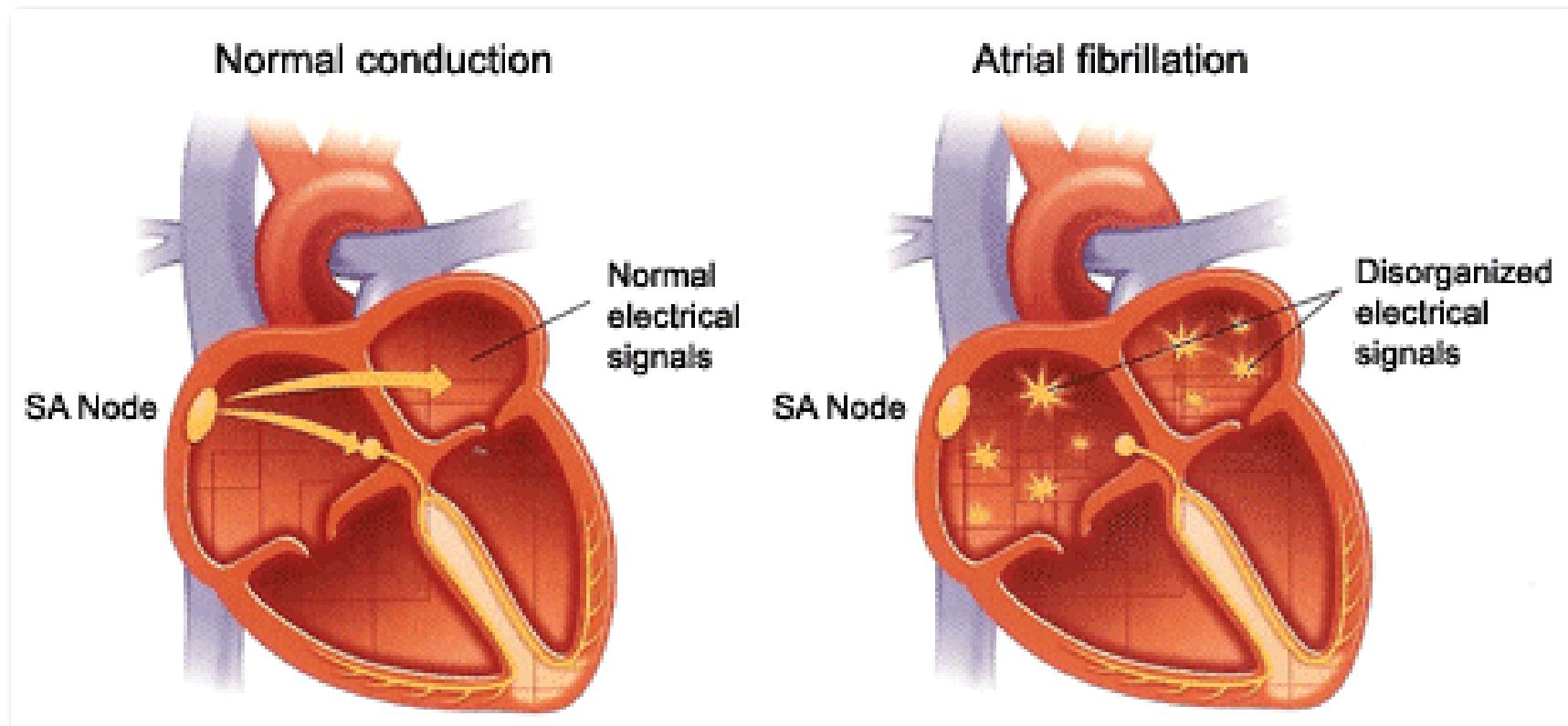


# Nervous System

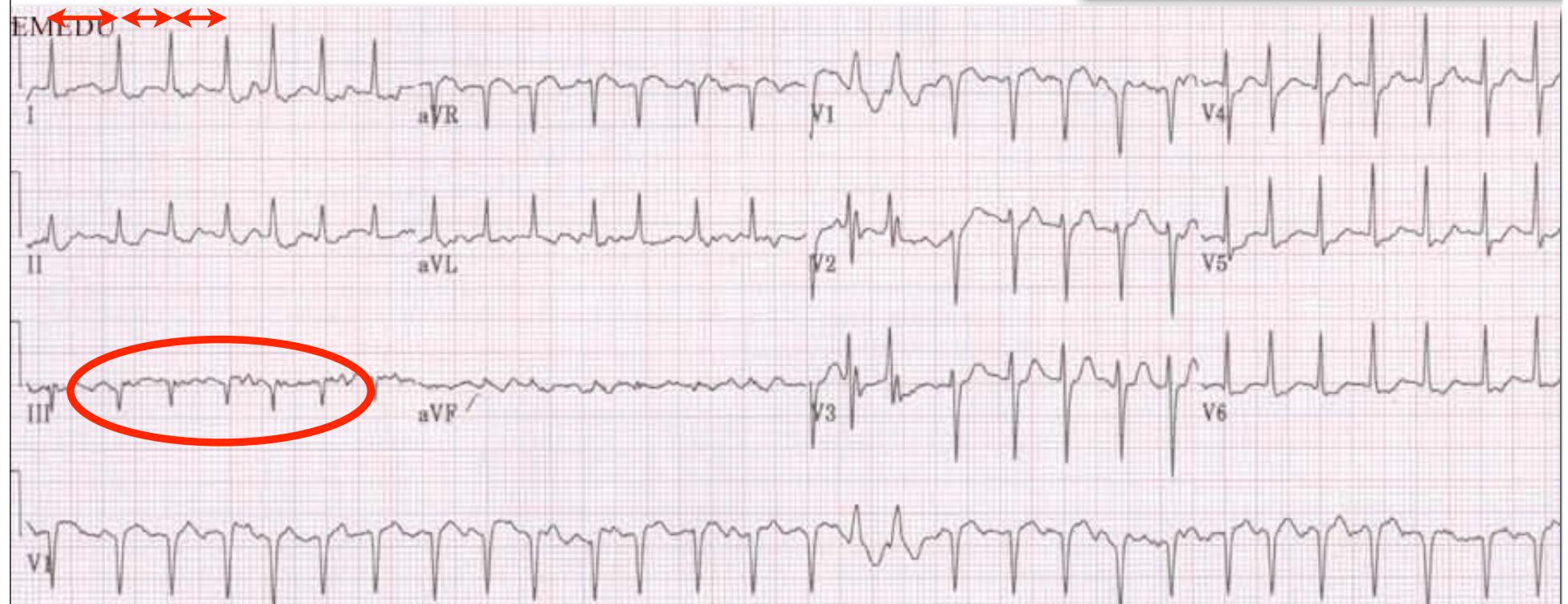
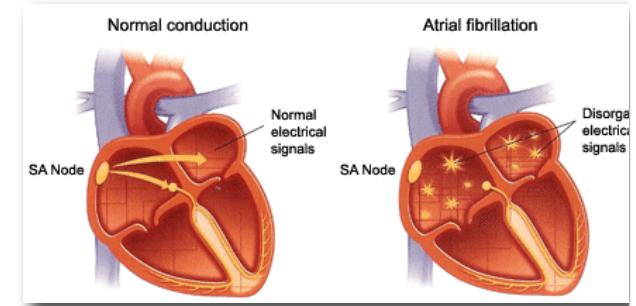


Dewire et. al. Nat. Rev. Cardiol., 2010: 129–138.

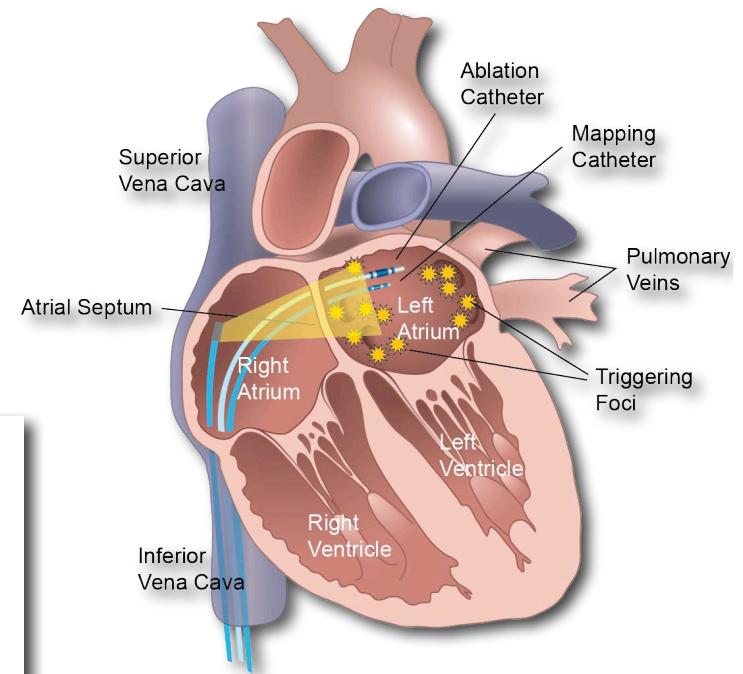
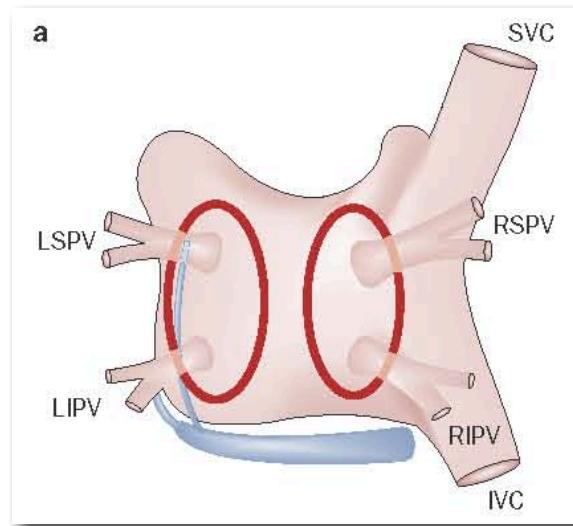
# Clinical Result



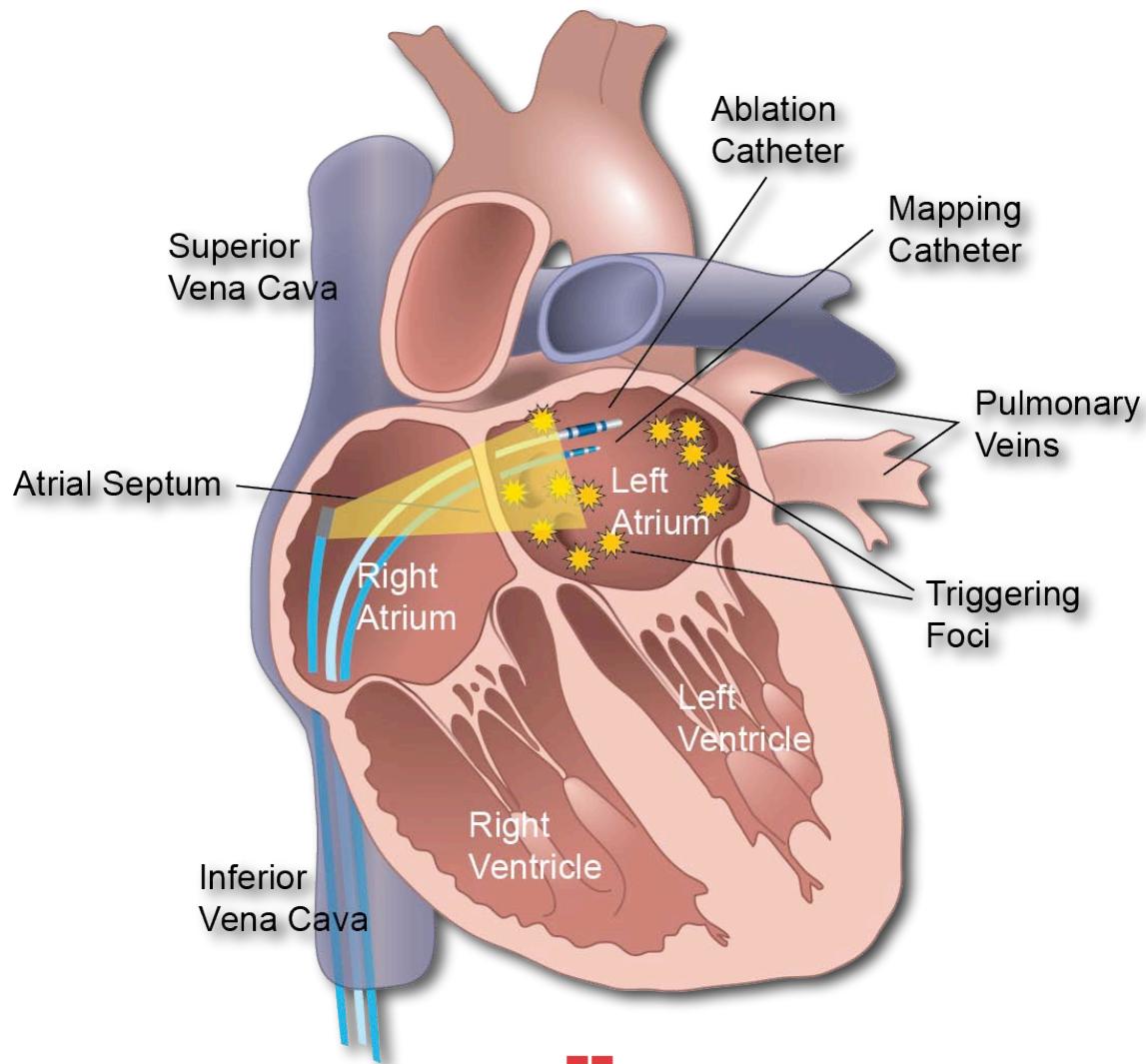
# Clinical Result



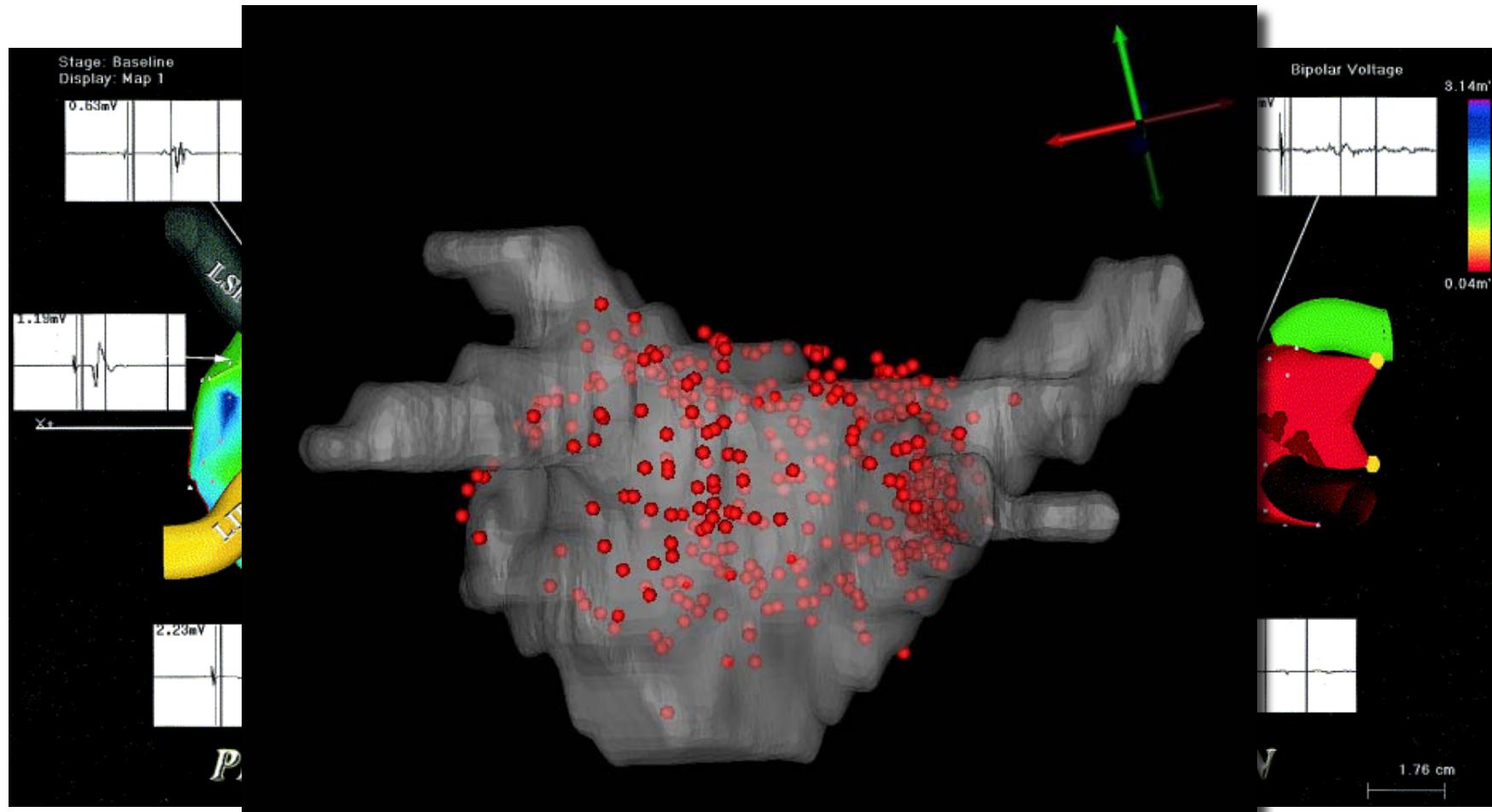
# Treatment?



# Catheter Ablation



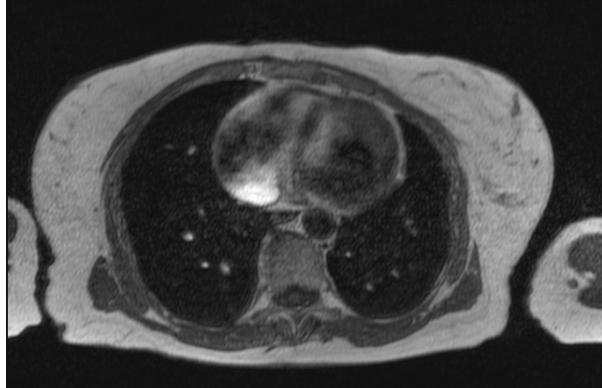
# Electroanatomical Mapping



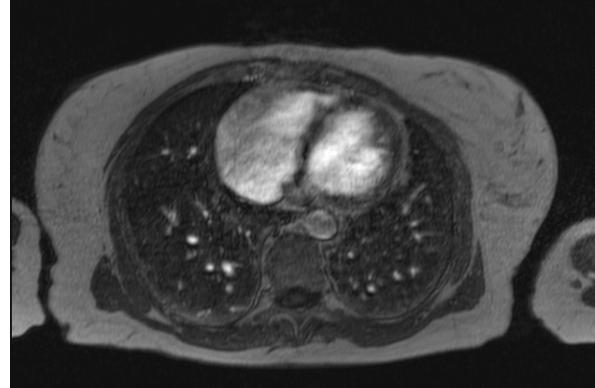
# Imaging?



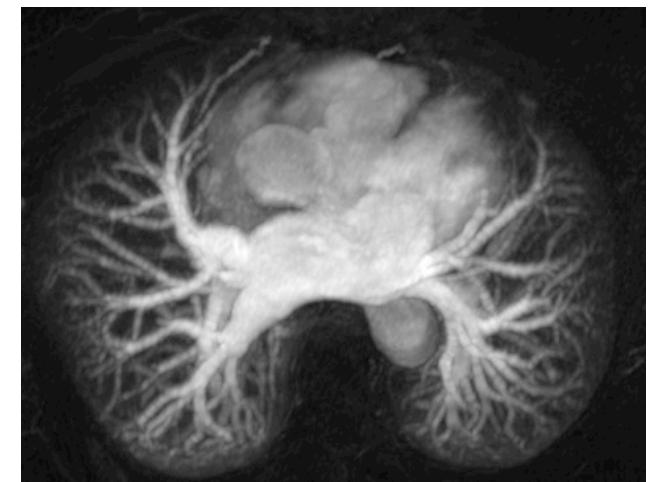
# MR Angiography



Pre

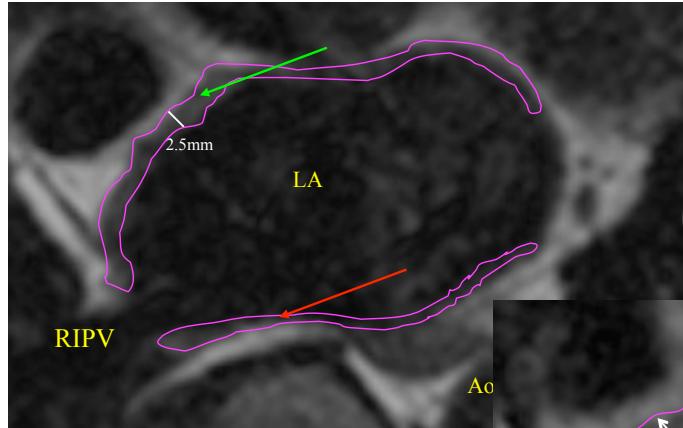


First Pass

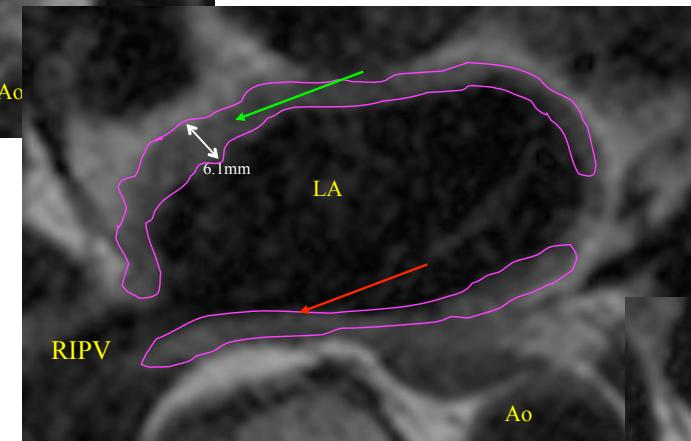


Subtraction

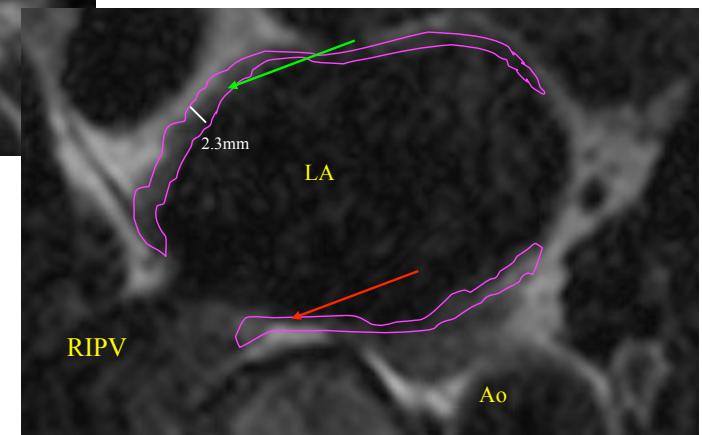
# Dark Blood MRI



Pre-treatment



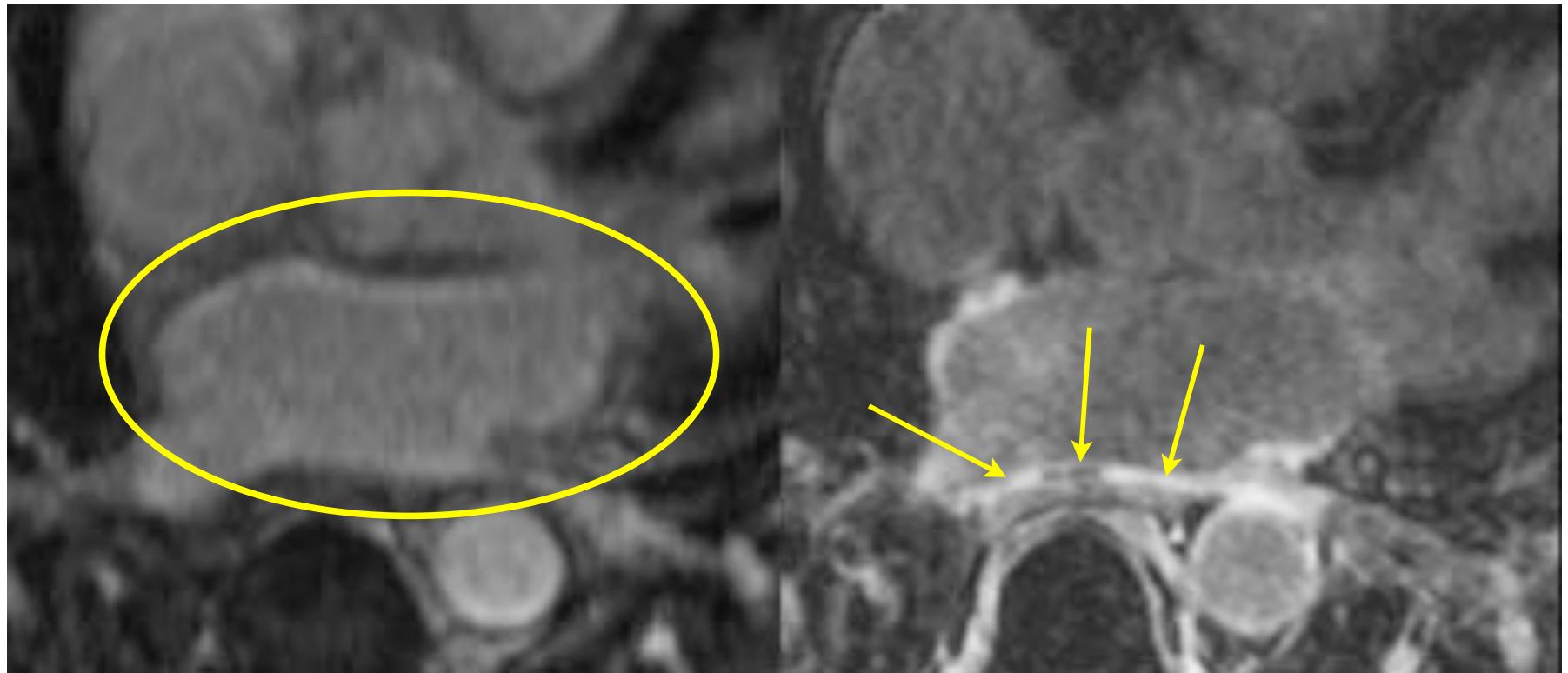
24 Hrs Post



3 Months Post



# Late Gadolinium Enhancement



Pre-treatment

3 month Post

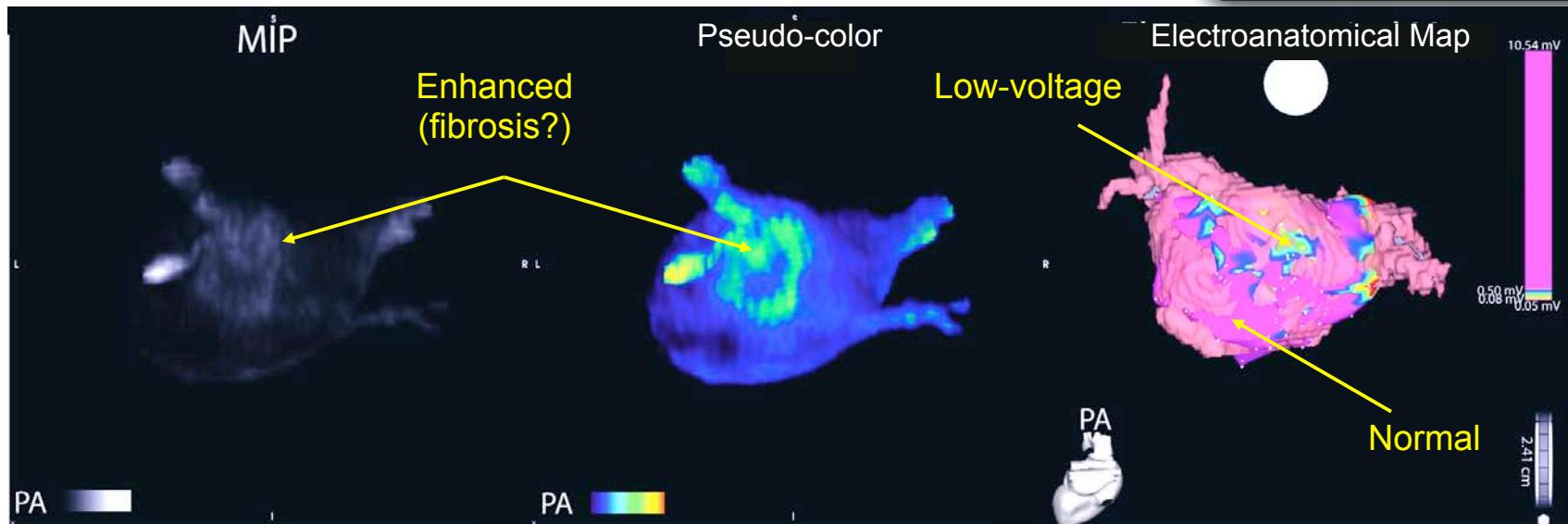
# Patient Workflow



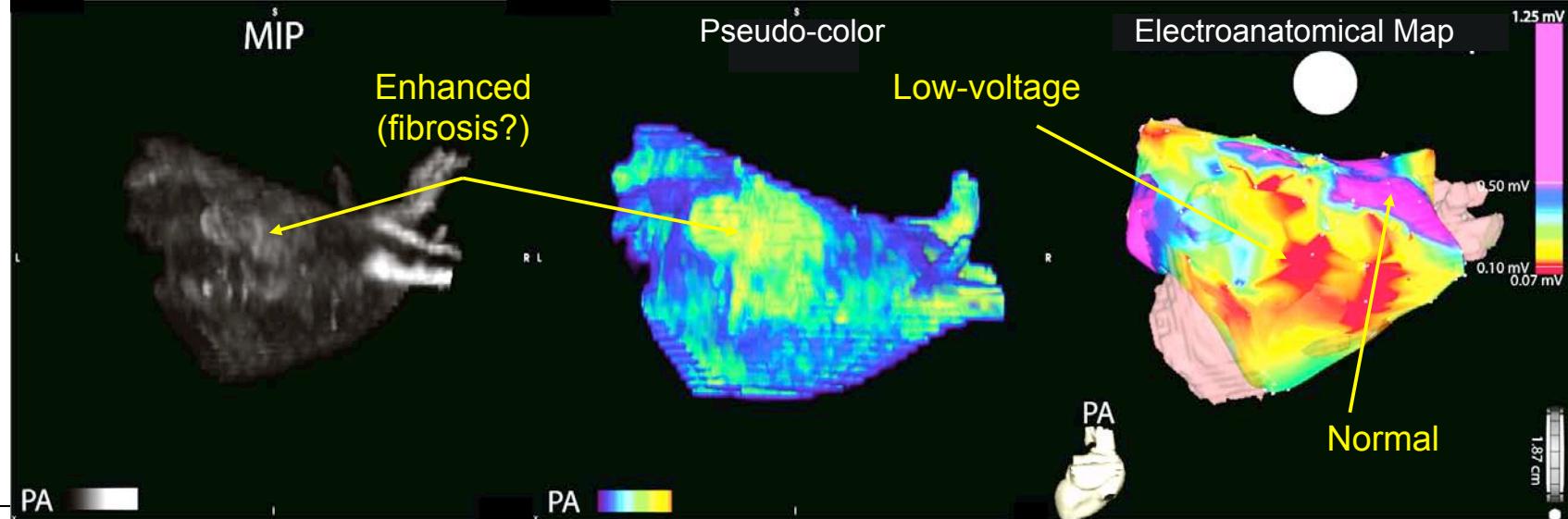
# Fibrosis and Outcome

Evaluation

Patient 1



Patient 2

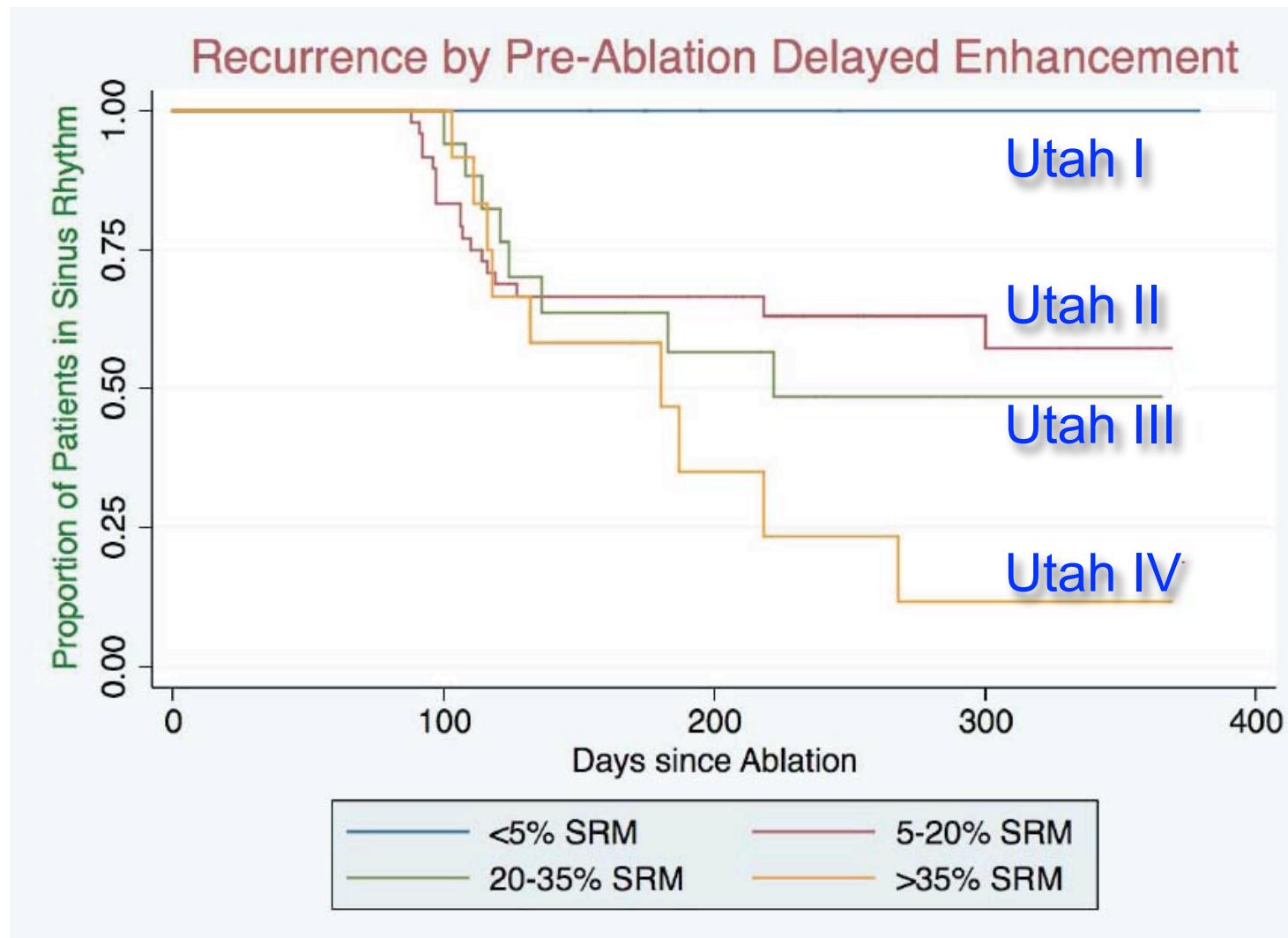


Success

Failure

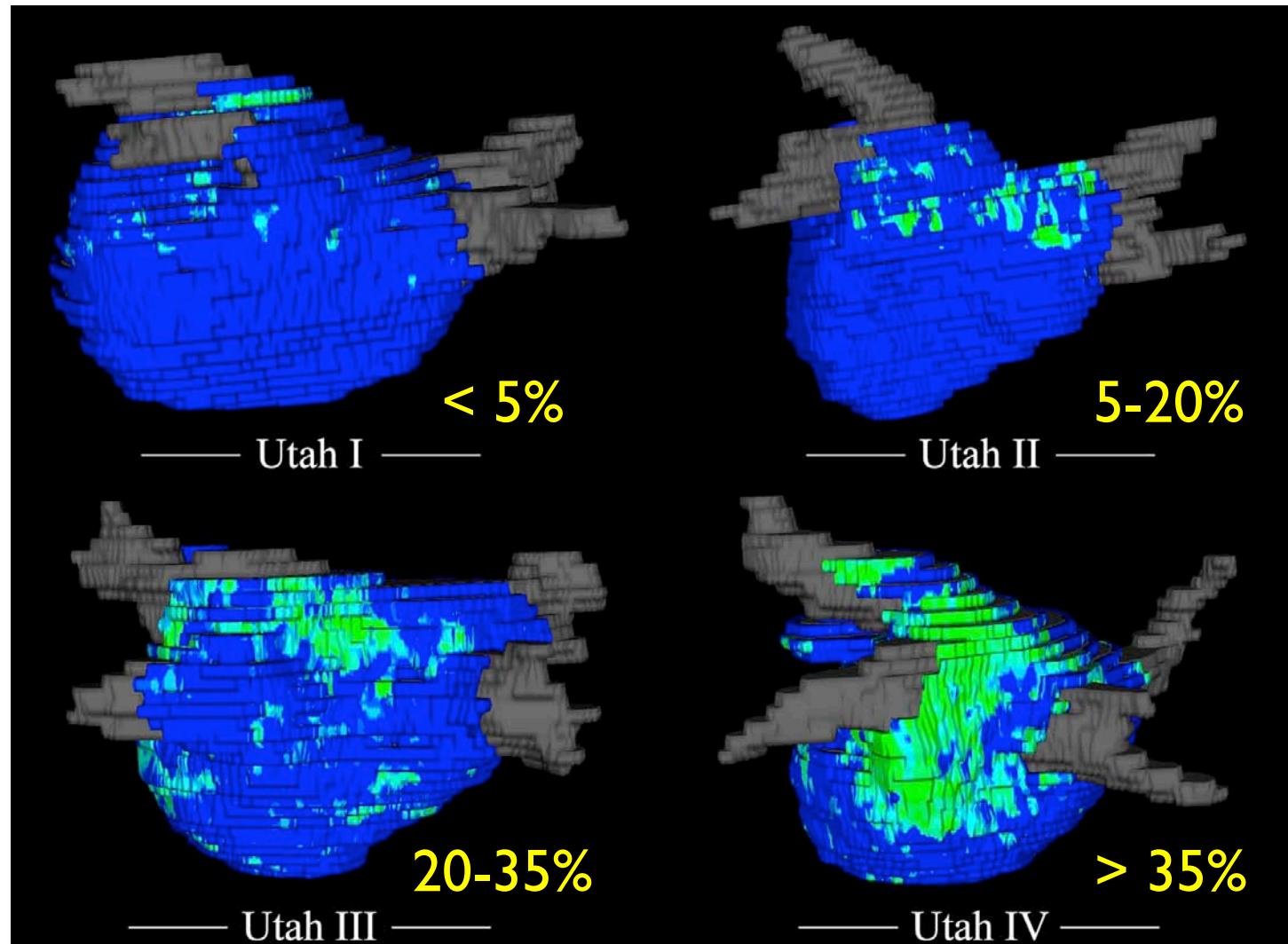
# Fibrosis Predicts Outcome

Evaluation



# Utah Scoring Scheme

Evaluation

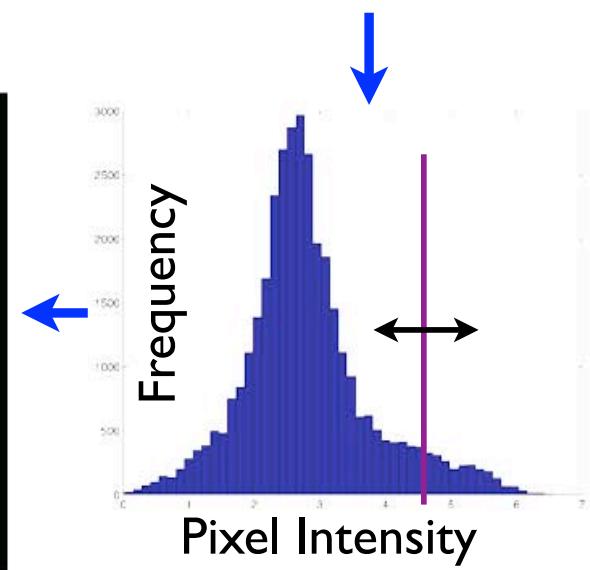
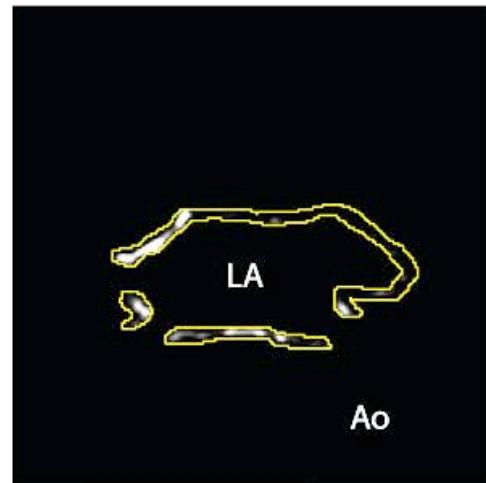
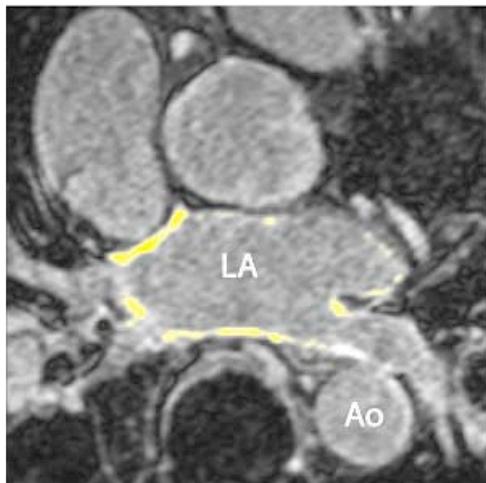
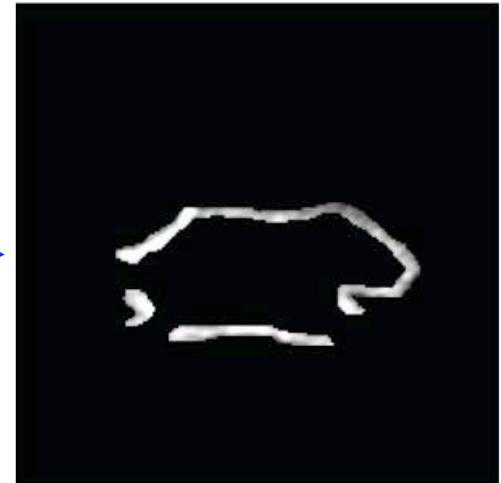
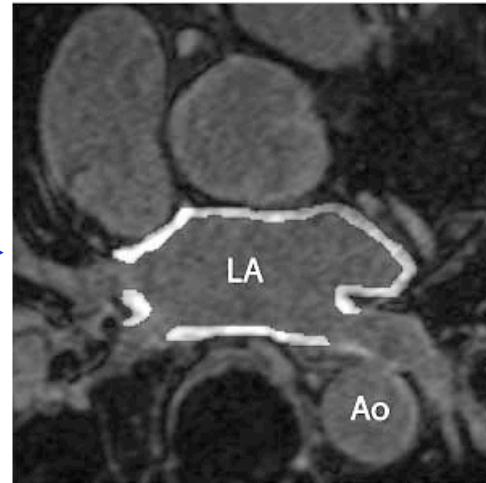
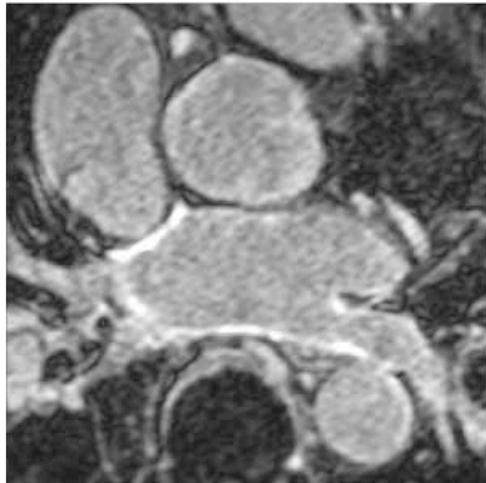


Akoum et al. J Cardiovasc Electrophysiol, 22:16-22, 2011



# Fibrosis Imaging

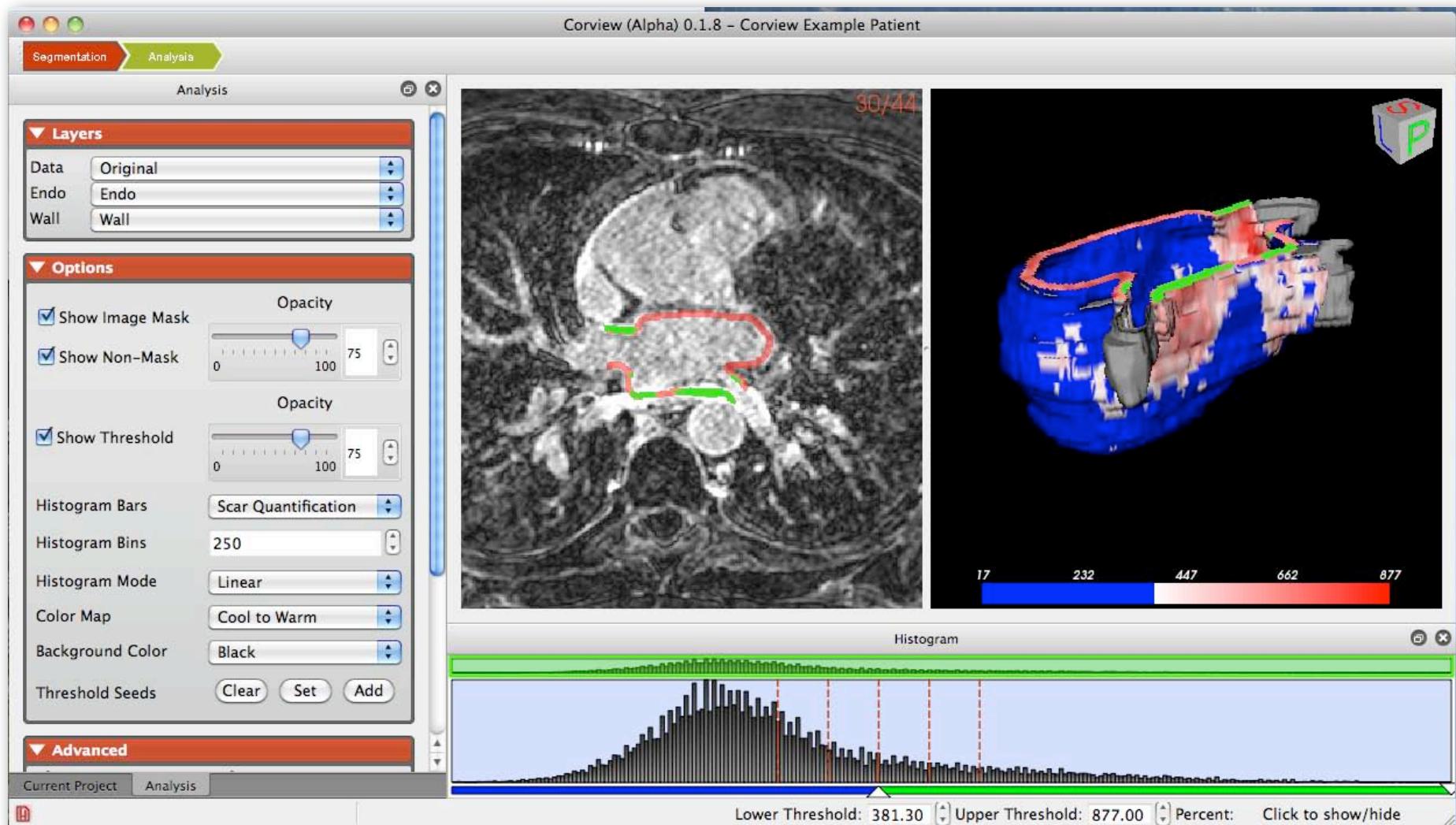
Evaluation





# Corview

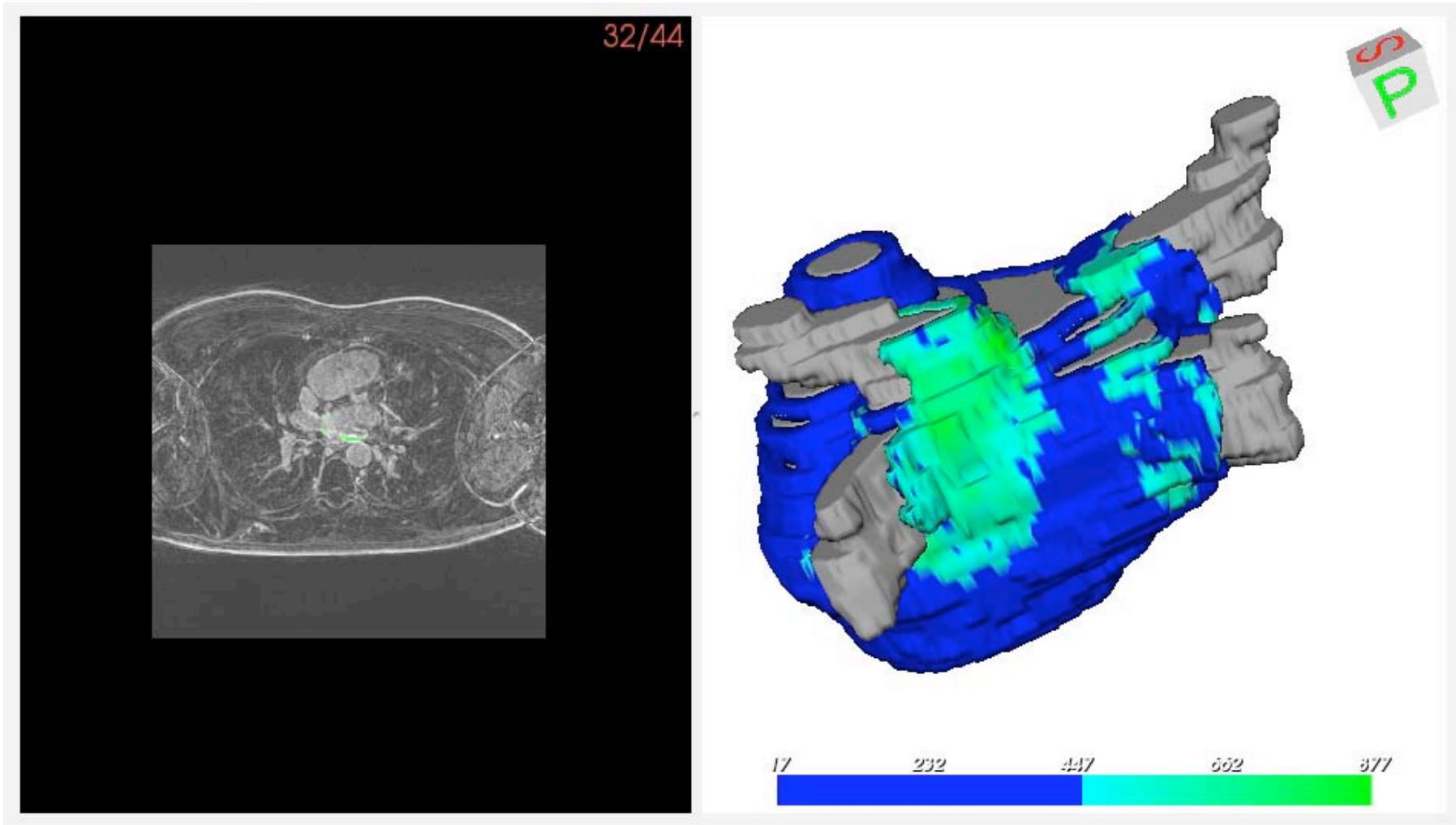
Evaluation





# Corview

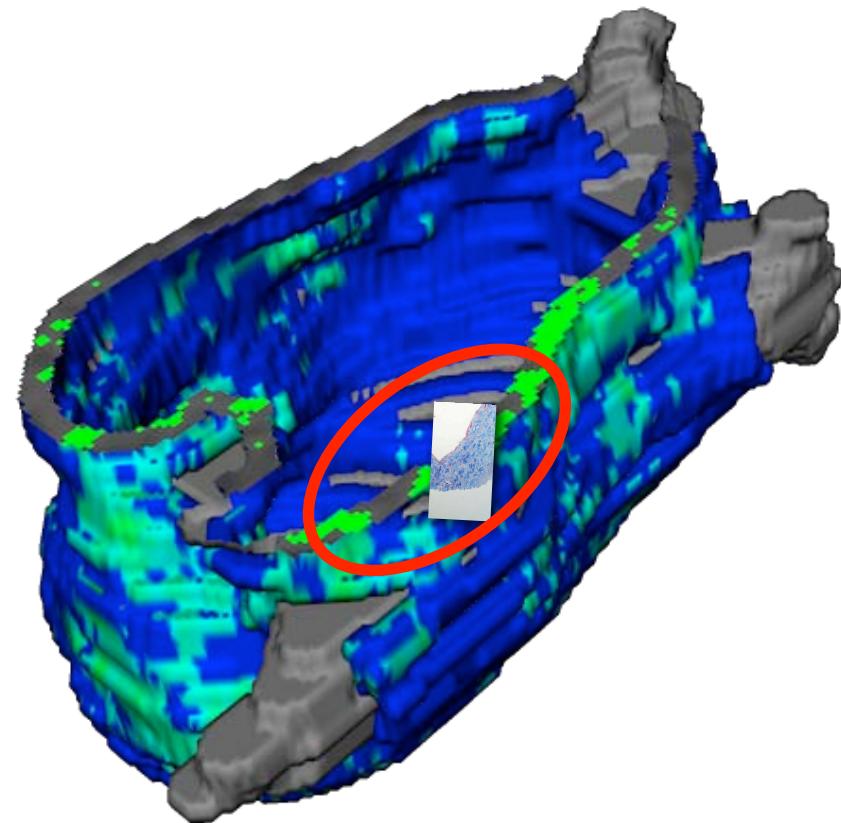
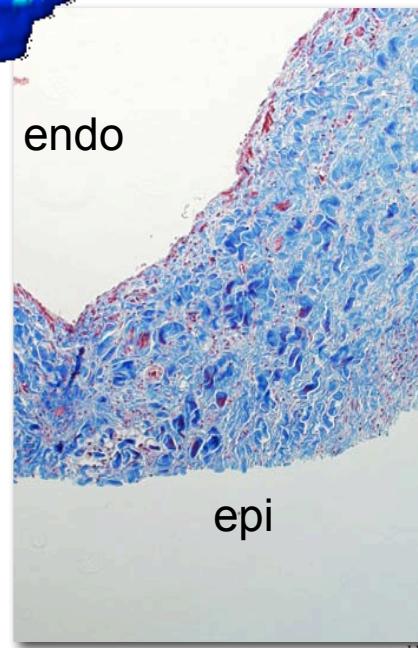
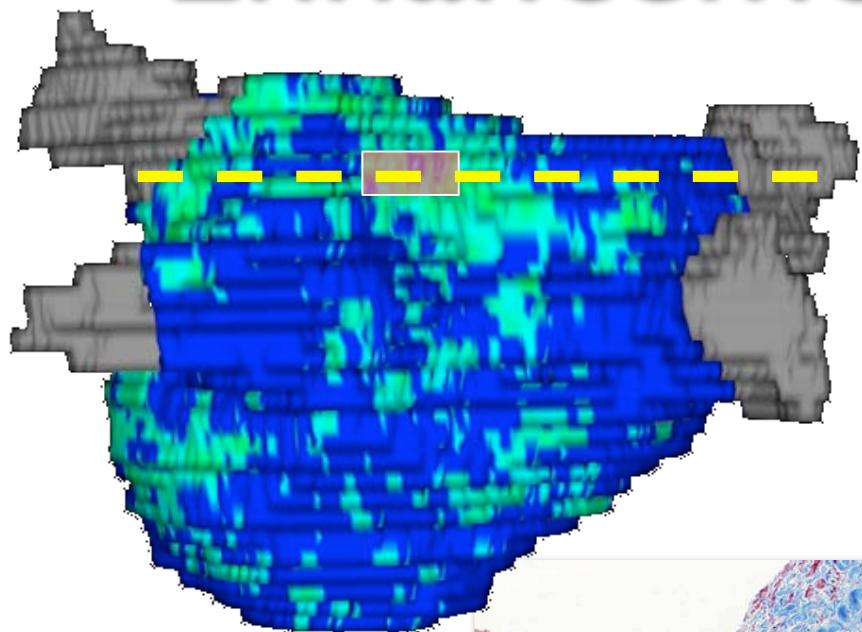
Evaluation



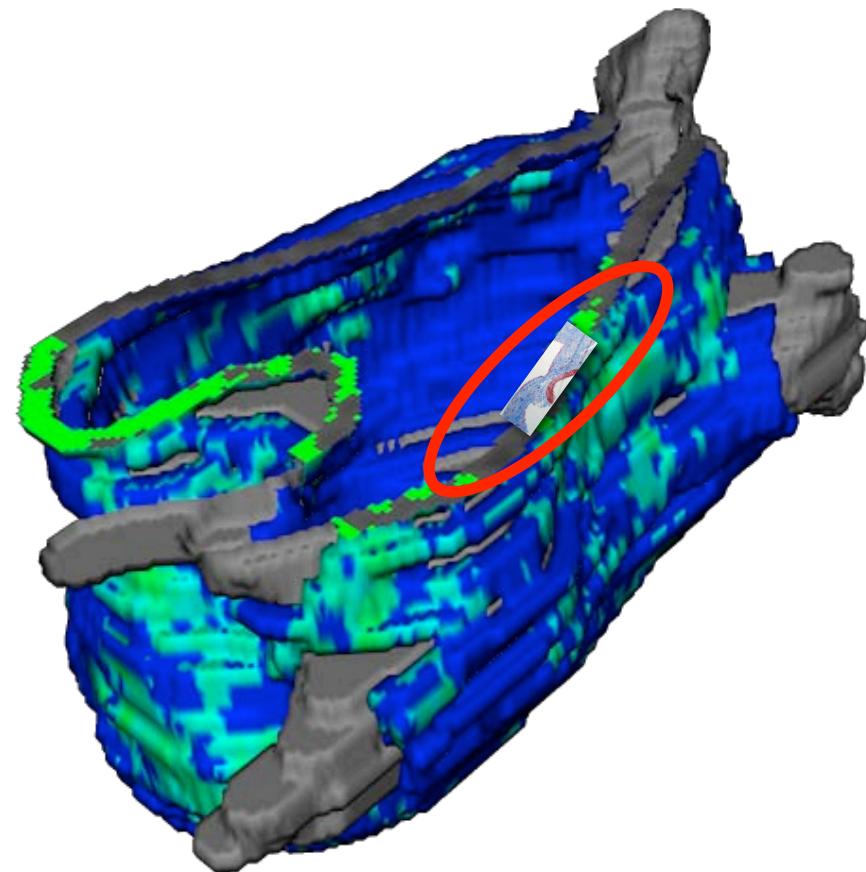
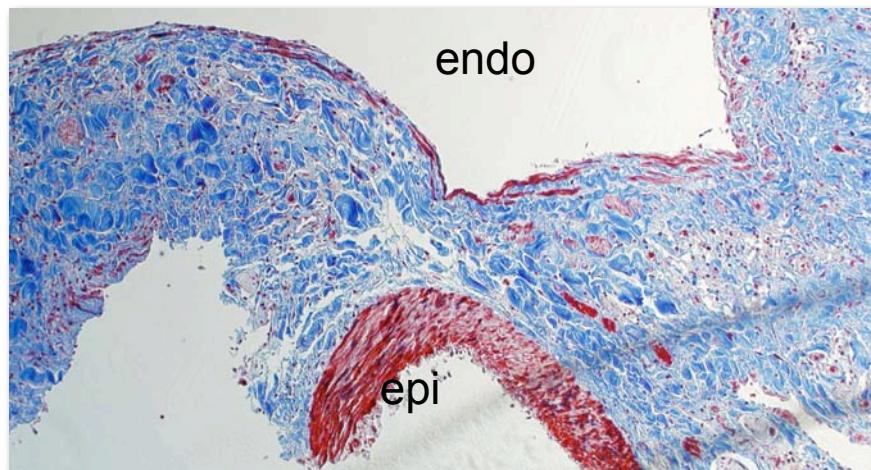
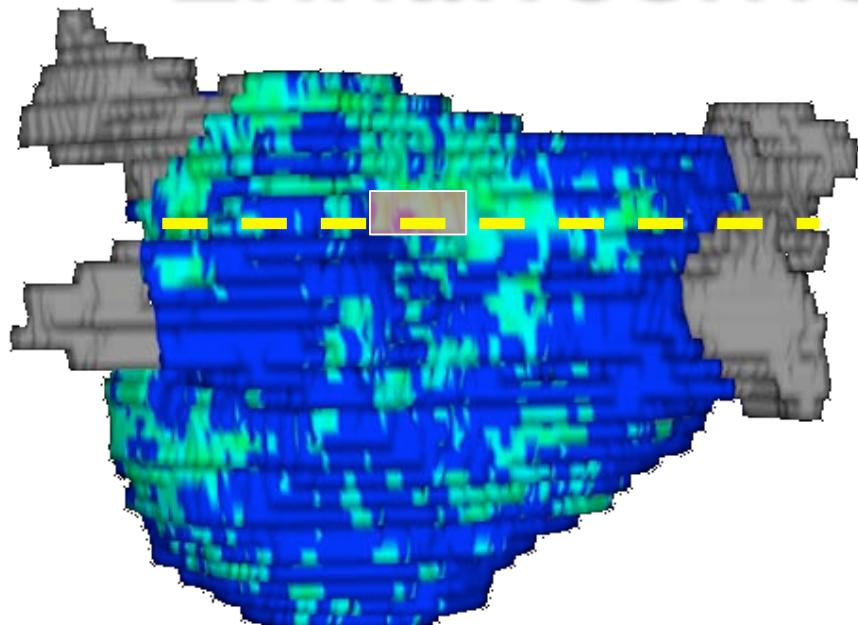
# Something Really New!



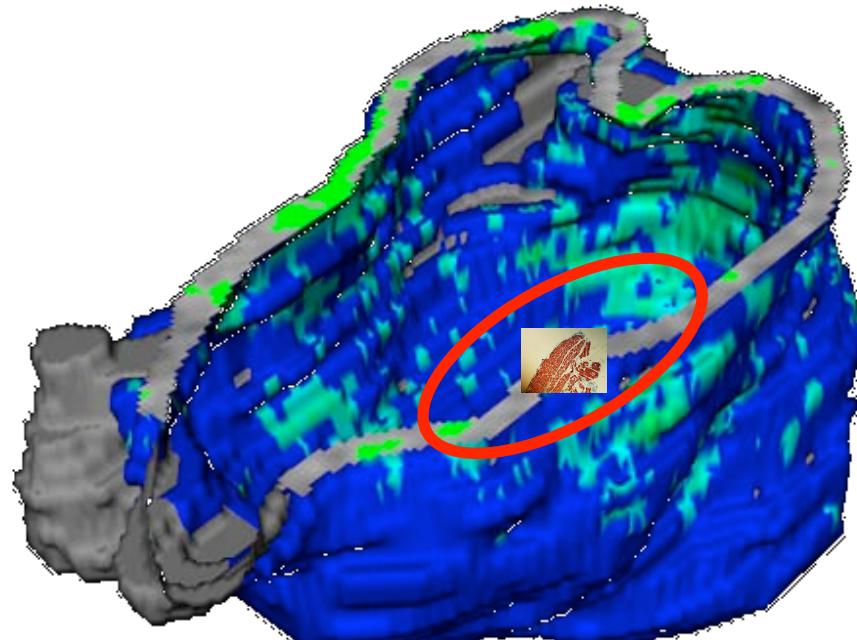
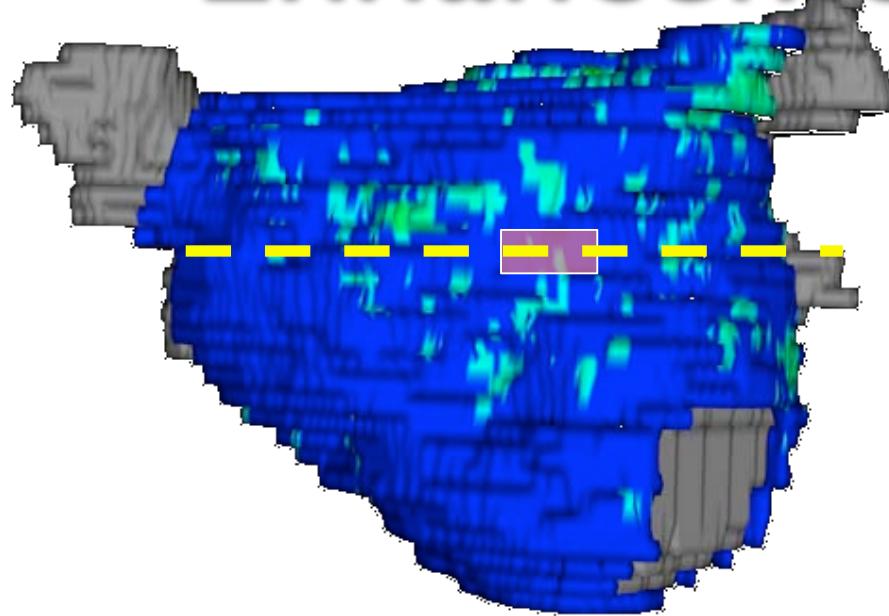
# Enhancement is Fibrosis



# Enhancement is Fibrosis



# Enhancement is Fibrosis

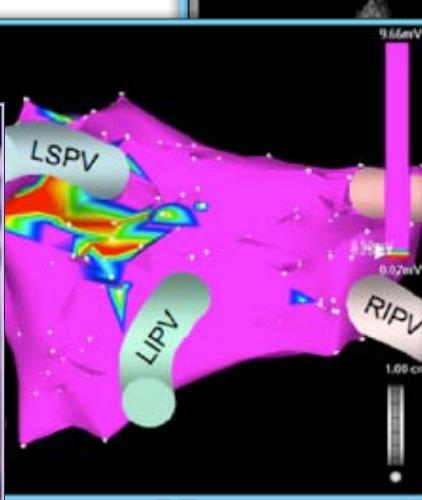
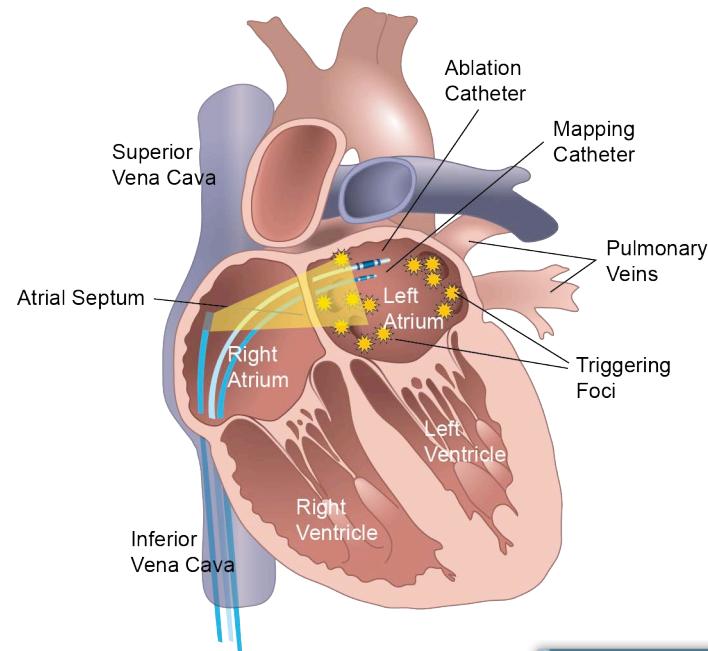


# Patient Workflow

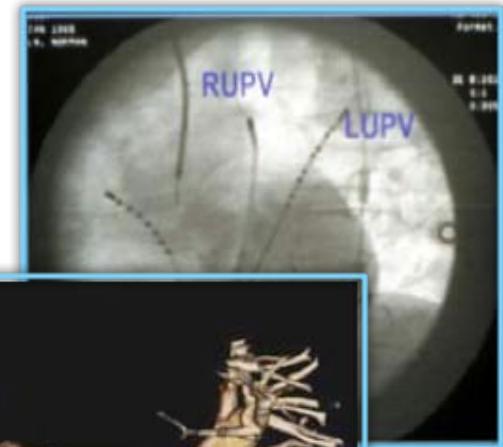


# Ablation Guidance

Treatment

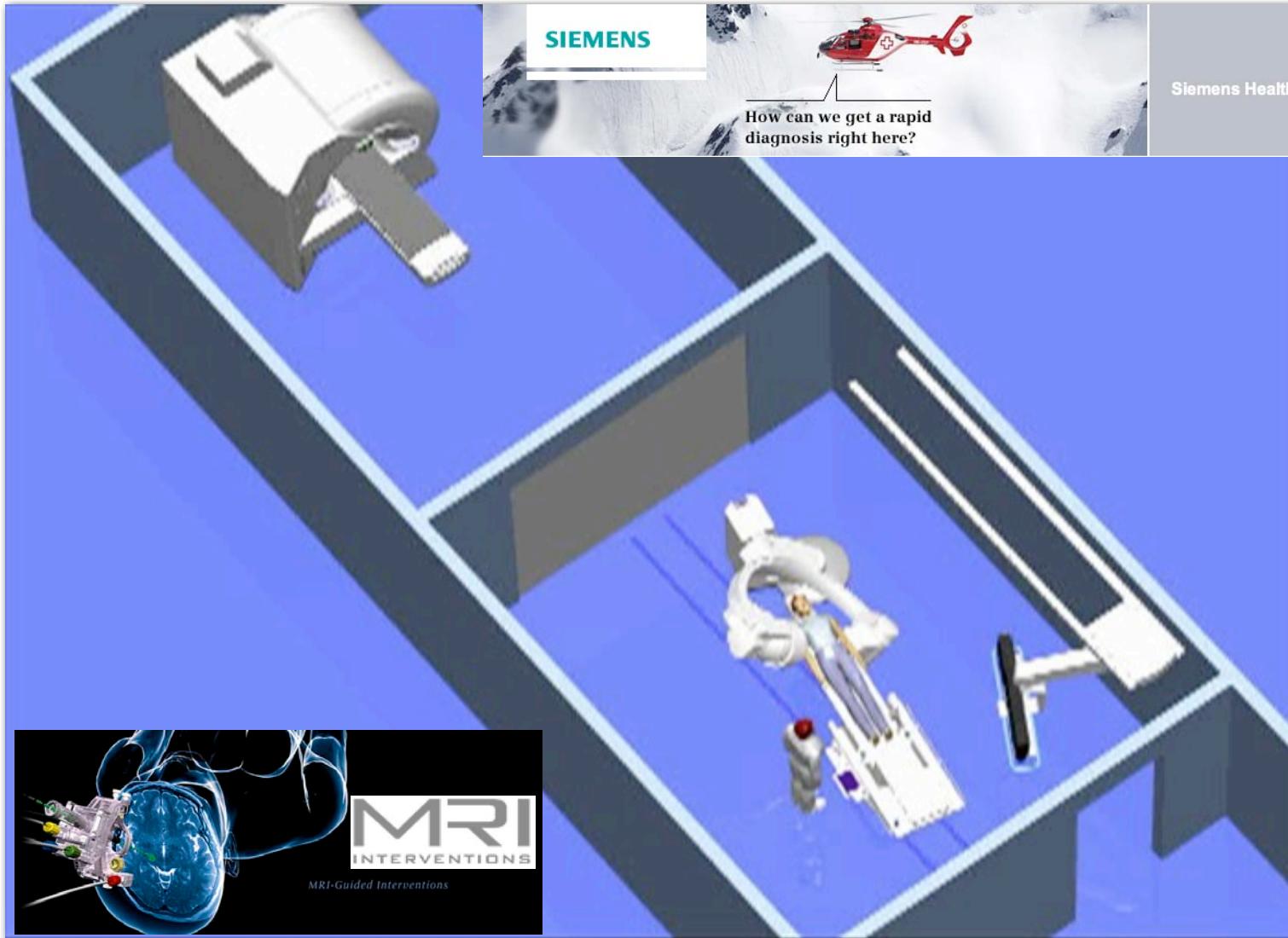


THE  
UNIVERSITY  
OF UTAH



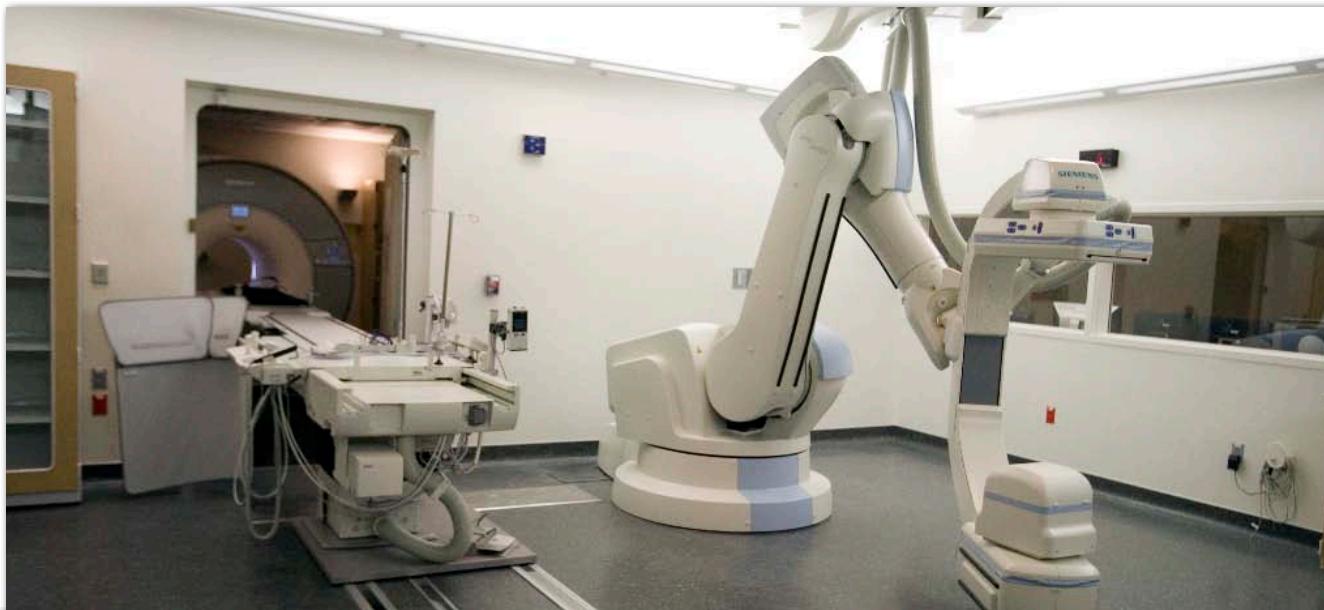
Treatment

# Real Time MRI



Treatment

# Real Time MRI



# Experiments!

Treatment



# MRI Misconceptions



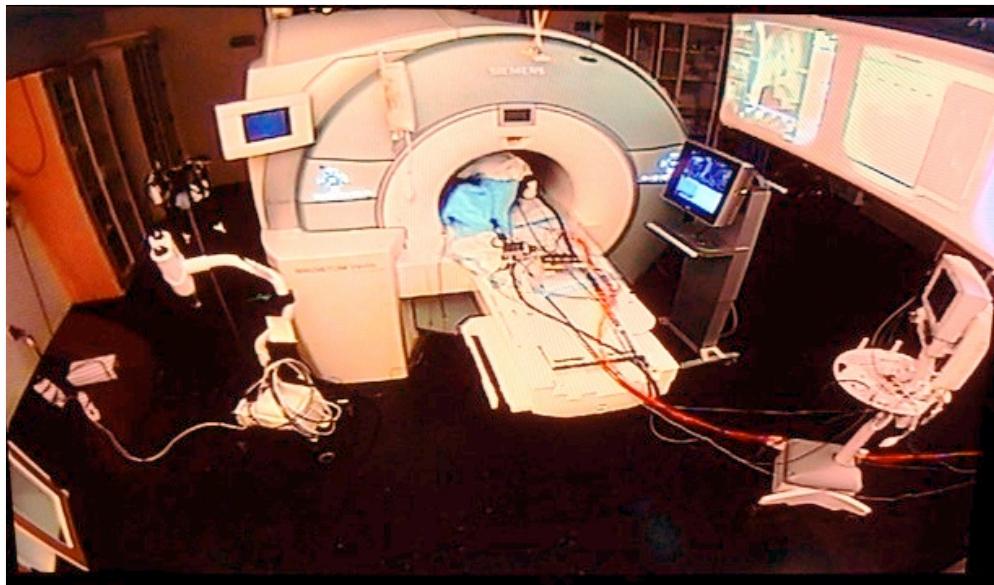
# Don't Try This At Home

The following clips will provide an impression, what forces are exerted on ferromagnetic objects and what dangers they can pose.

University of Utah 2005

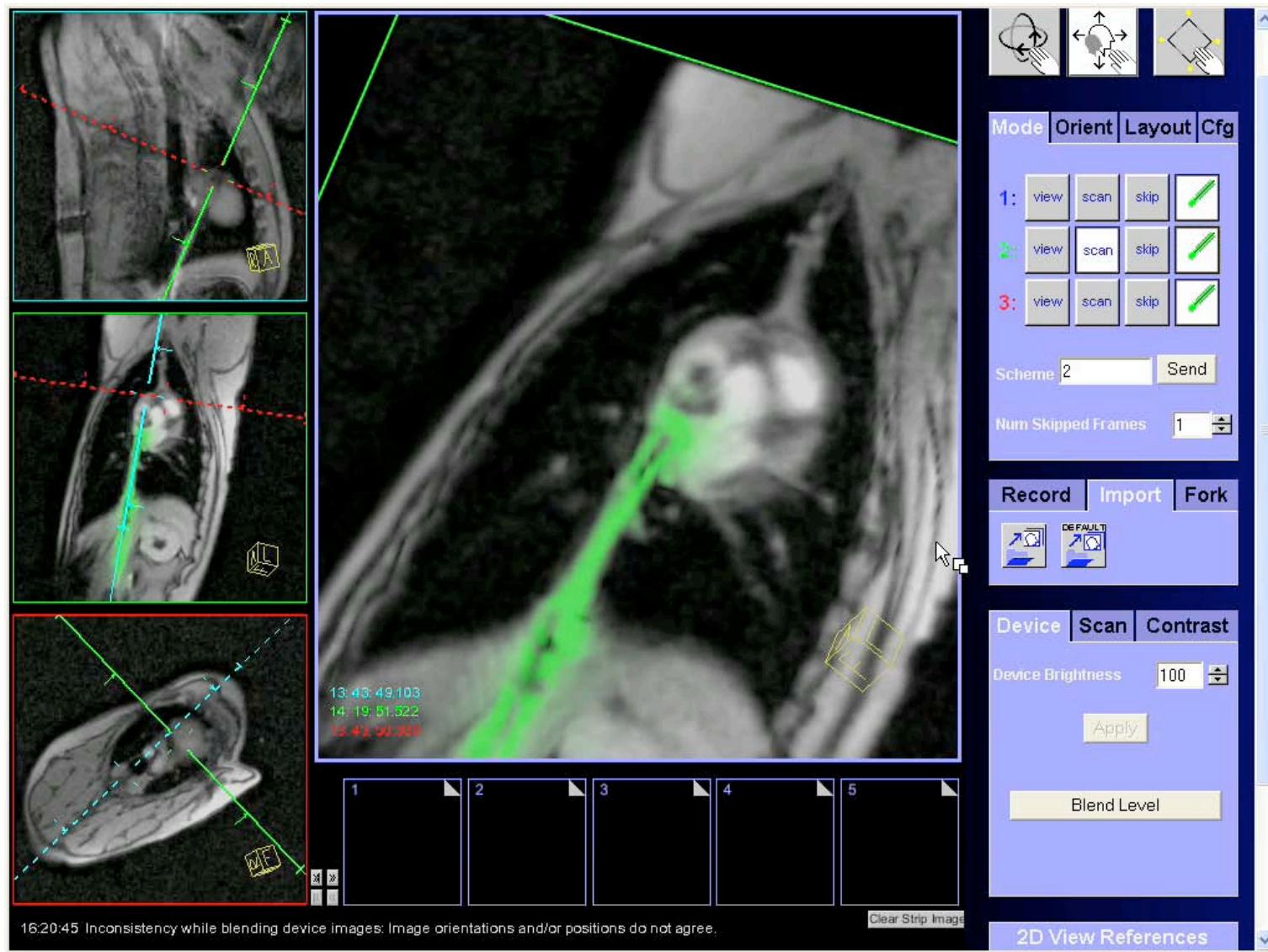


# Experiments!



# Treatment

# Real Time MRI



Treatment

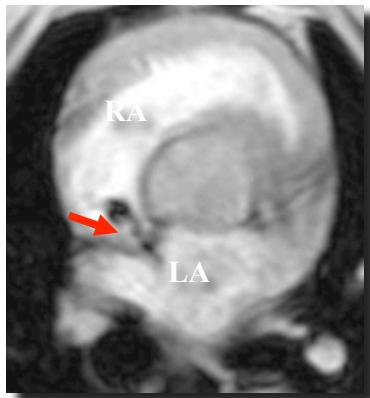
# Real Time MRI



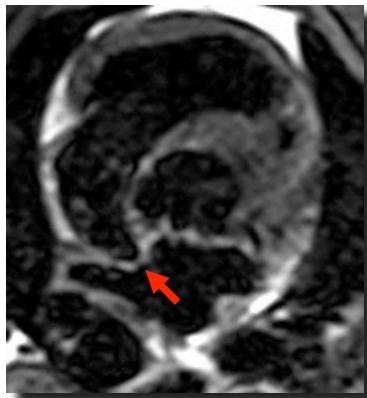
# Lesion Imaging

Treatment

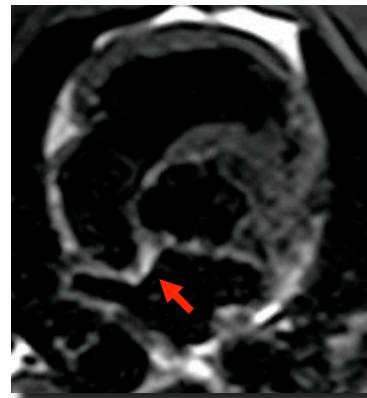
catheter



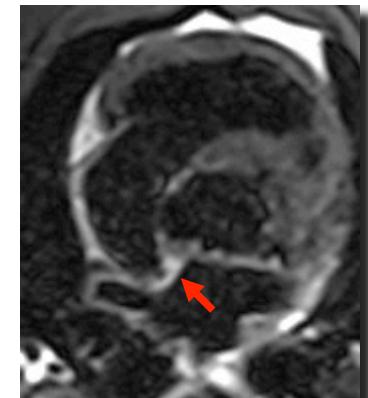
pre



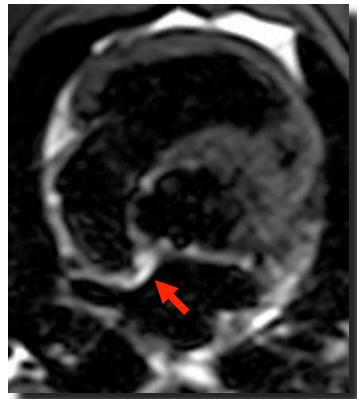
post 20 sec



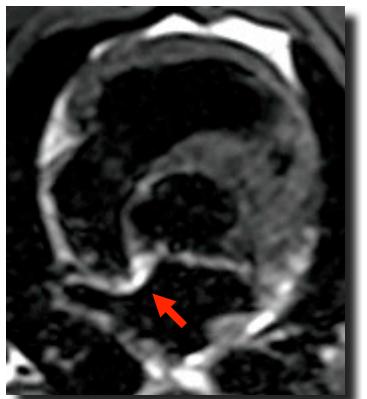
50 sec



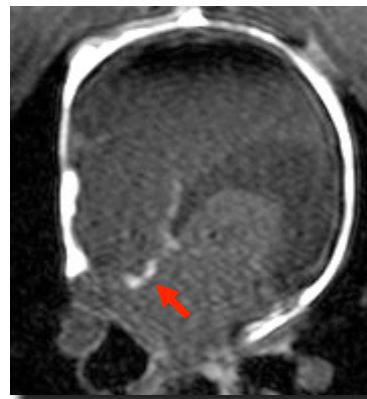
post 2:30 min



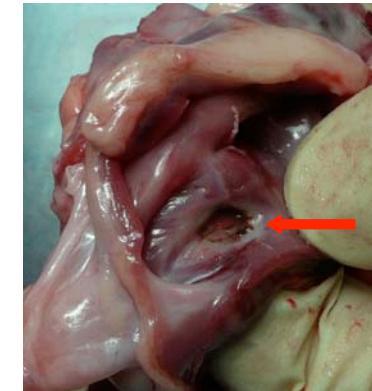
6 min



postmortem



excised LA



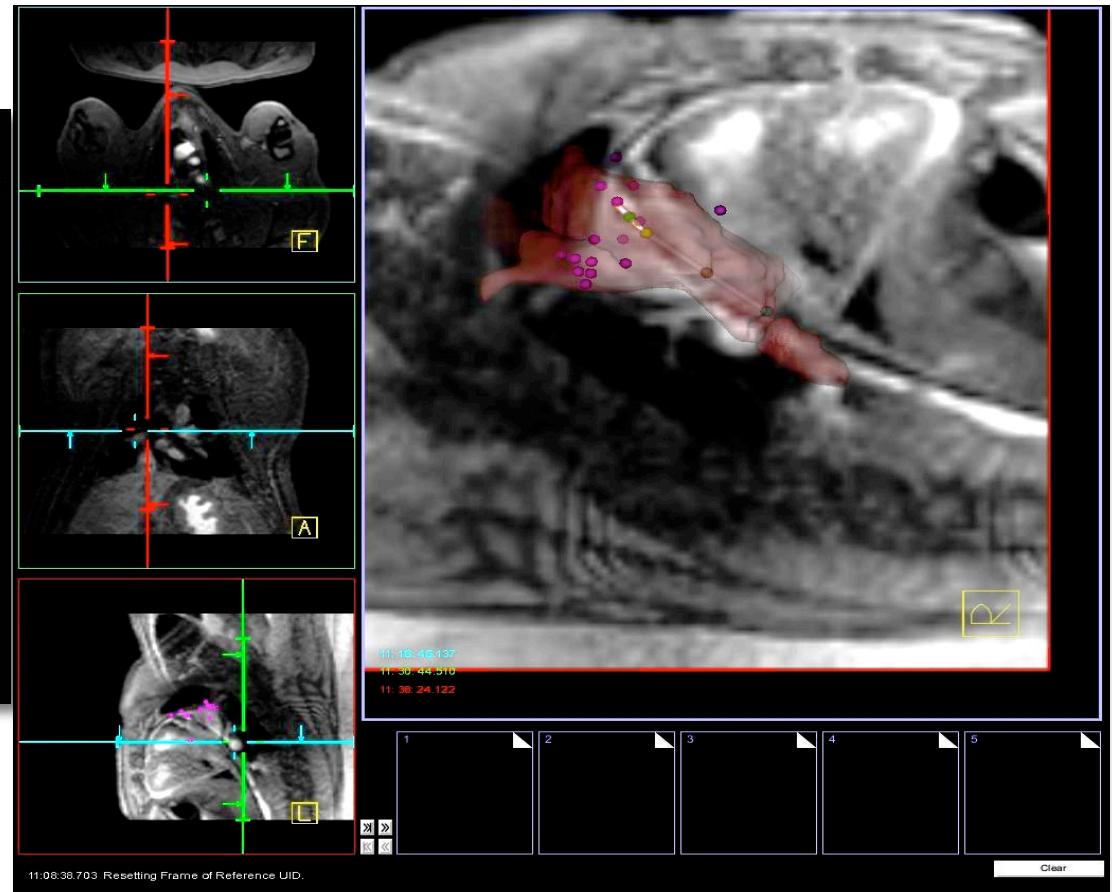
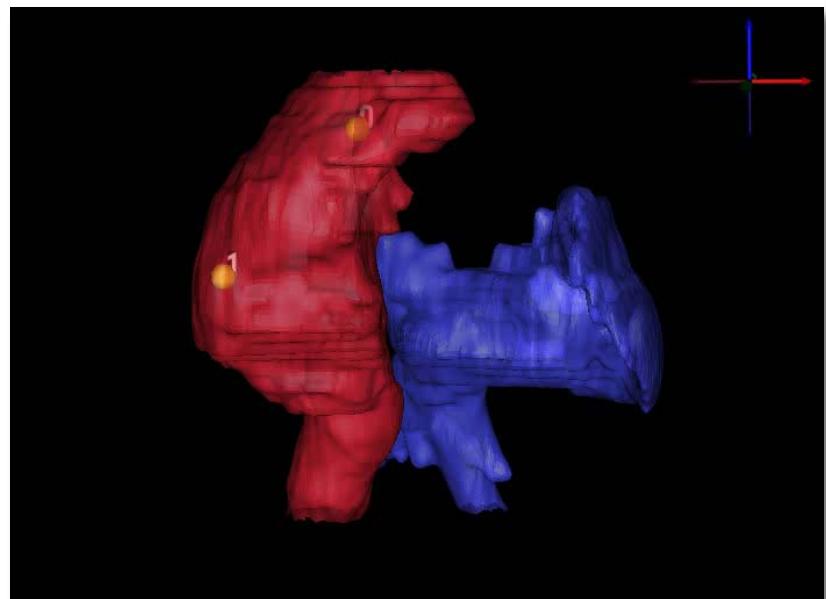
Ablation: 30 Watts, 30 sec

Vergara et al. HRS 2011 vol. 8 (2) pp. 295-303



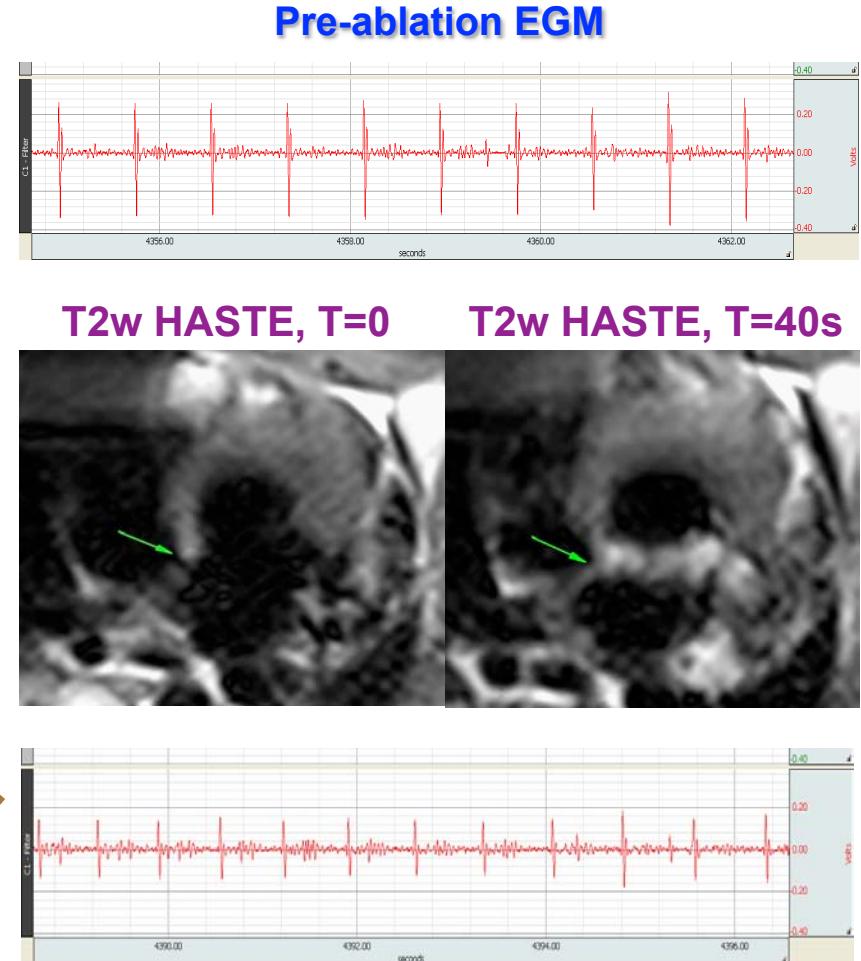
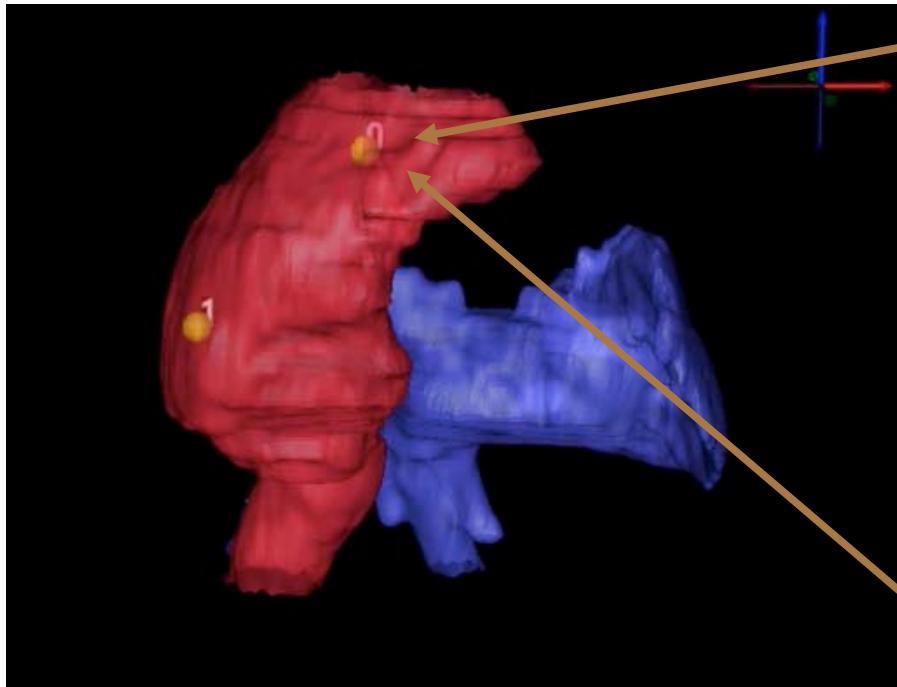
# Segmentation for Guidance

Treatment



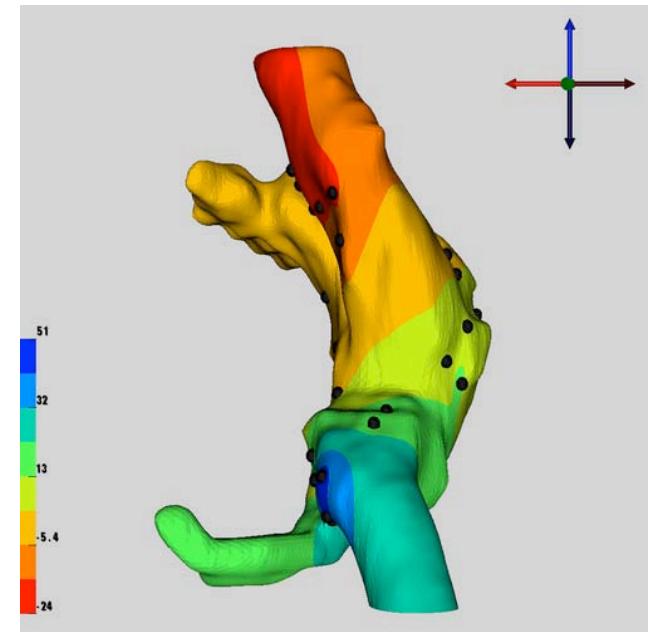
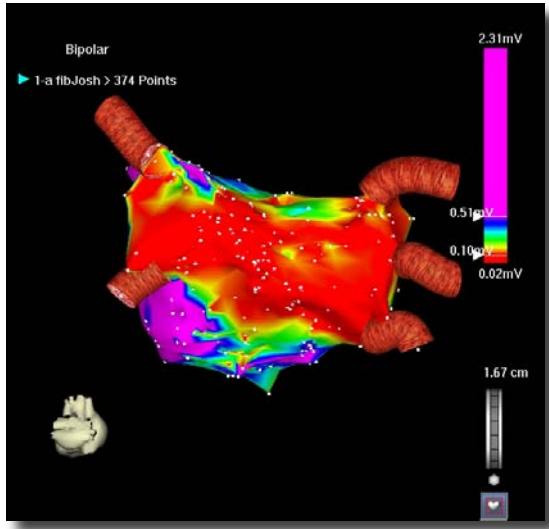
# Electrogram Recording

Treatment

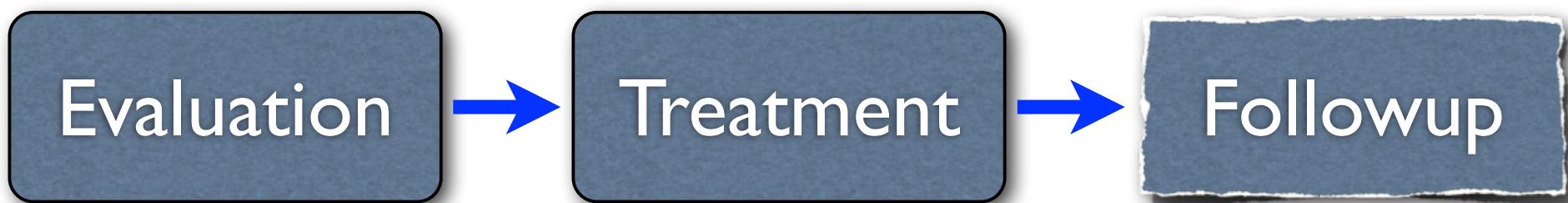


# Electroanatomical Mapping

Treatment

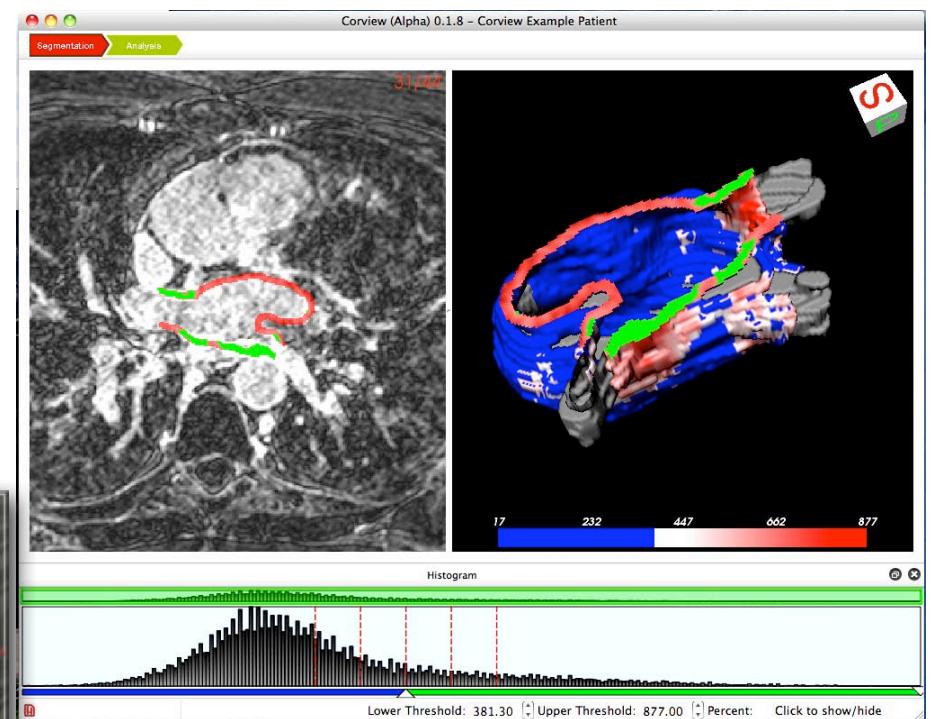
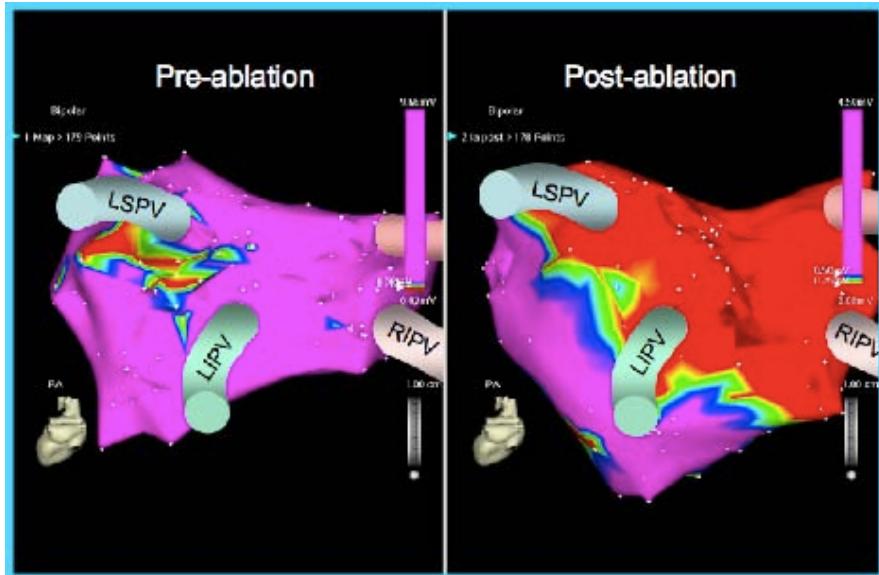


# Patient Workflow

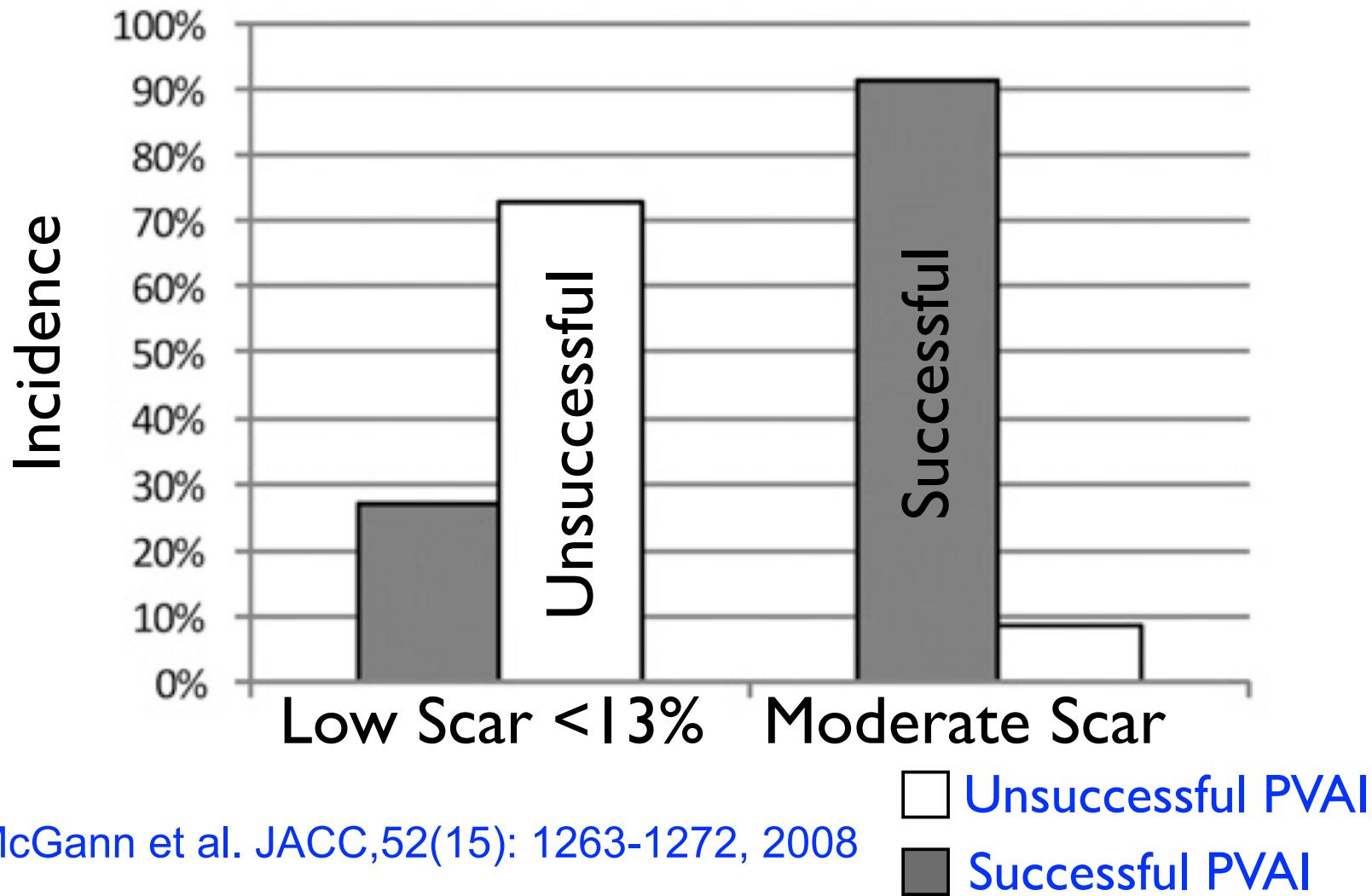


# EAM vs. MRI

Followup



# Scar Predicts Outcome



McGann et al. JACC, 52(15): 1263-1272, 2008



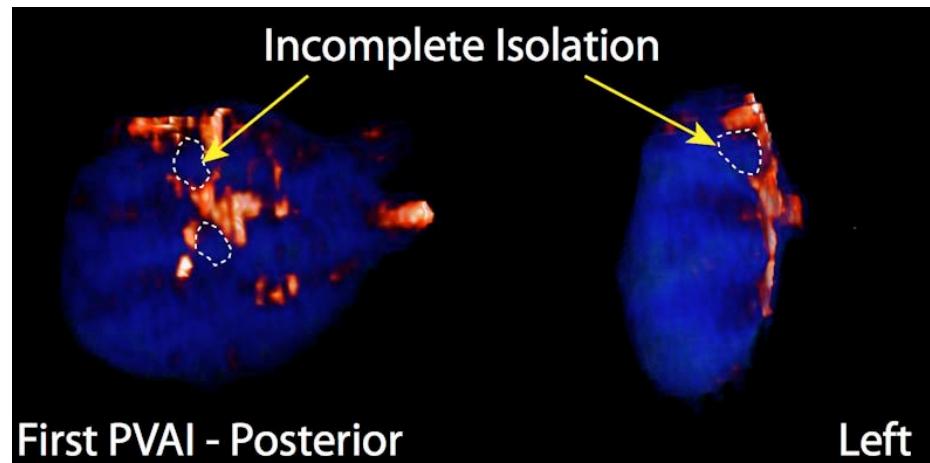
□ Unsuccessful PVAI  
■ Successful PVAI



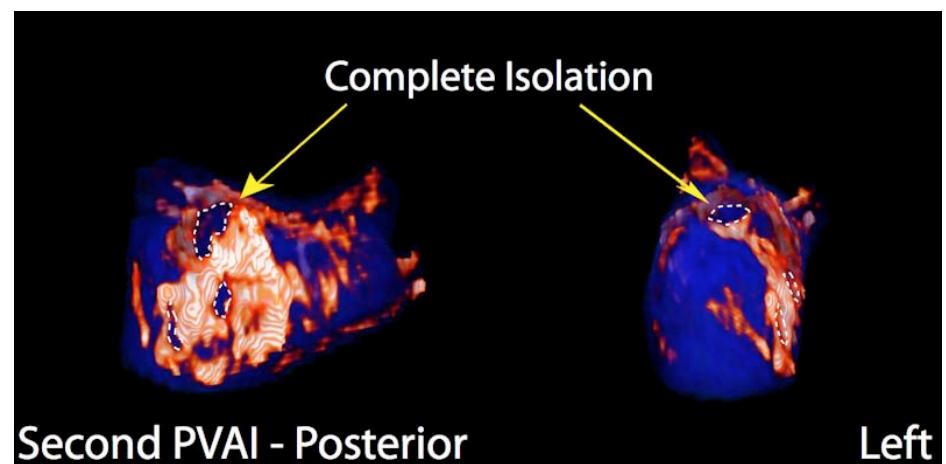
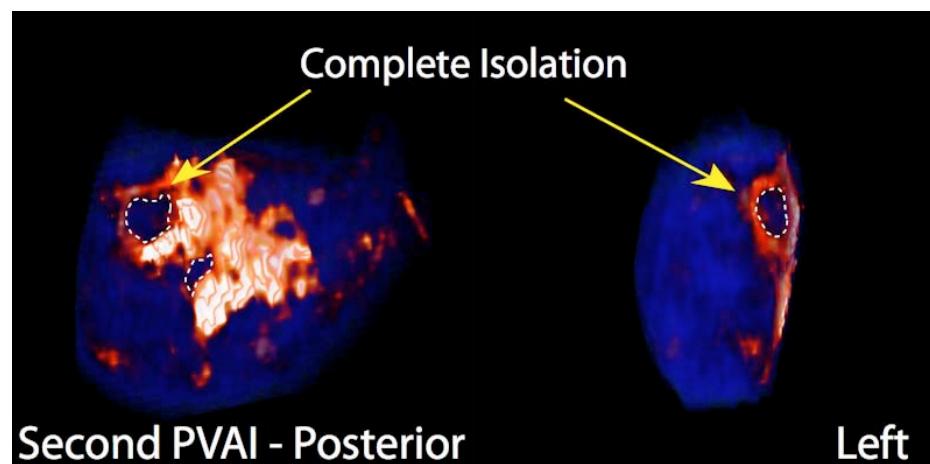
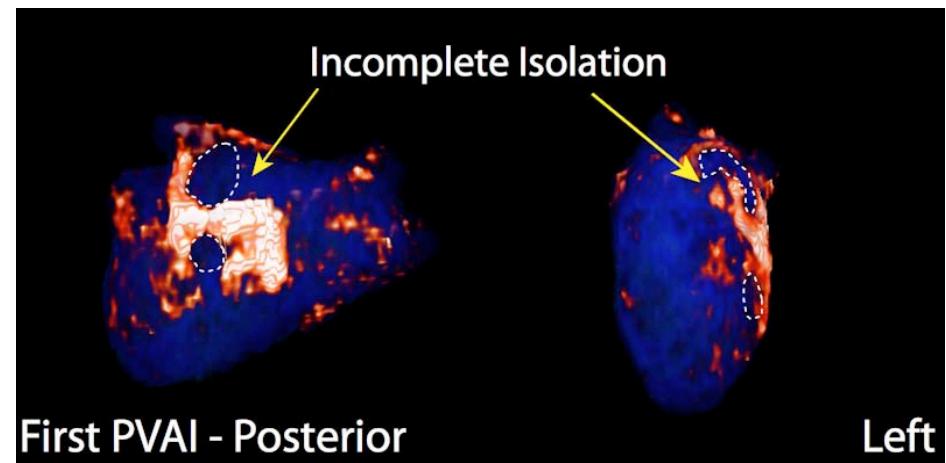
# Repeat Ablation

Followup

Patient 1



Patient 2



McGann et al. JACC, 52(15): 1263-1272, 2008



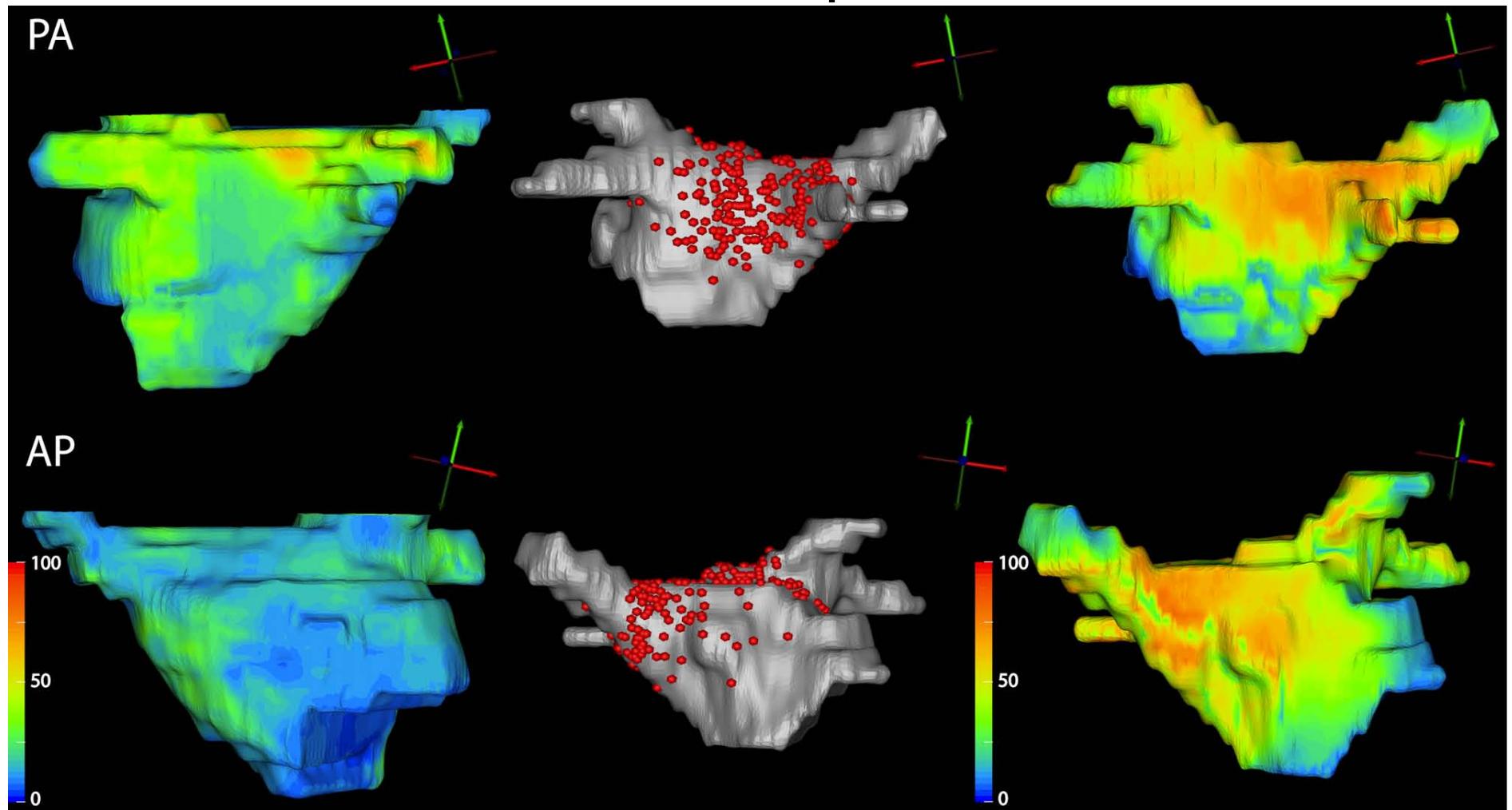
# Immediate Response

Followup

Pre-Ablation

Lesion Map

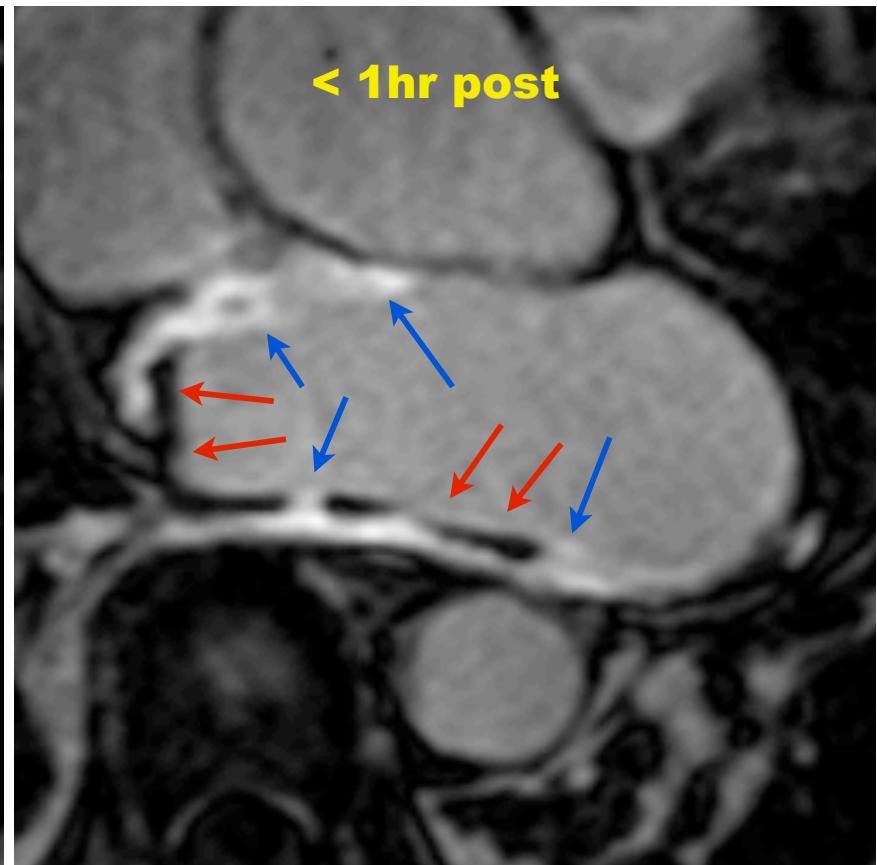
30 min Post Ablation



Followup

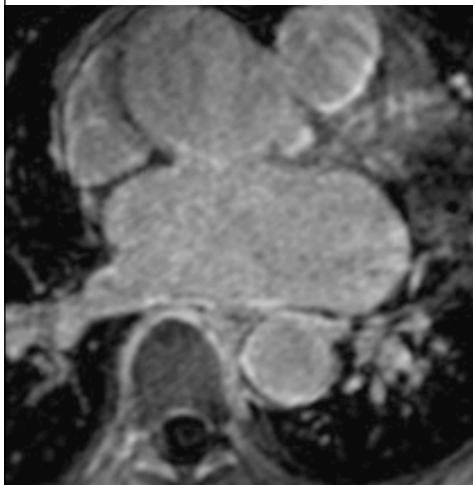
# “No Reflow”

LGE

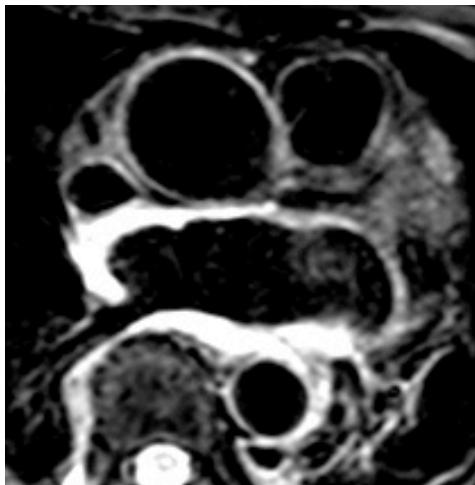


# Predicting Success

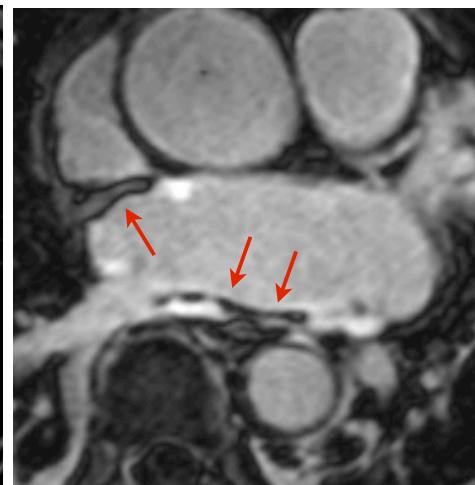
Followup



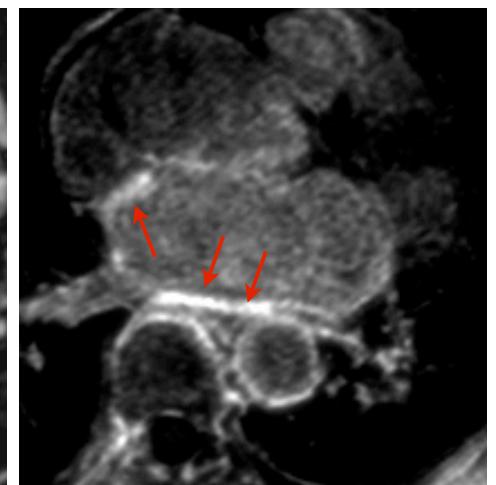
**LGE (pre)**



**T2w (<1hr)**

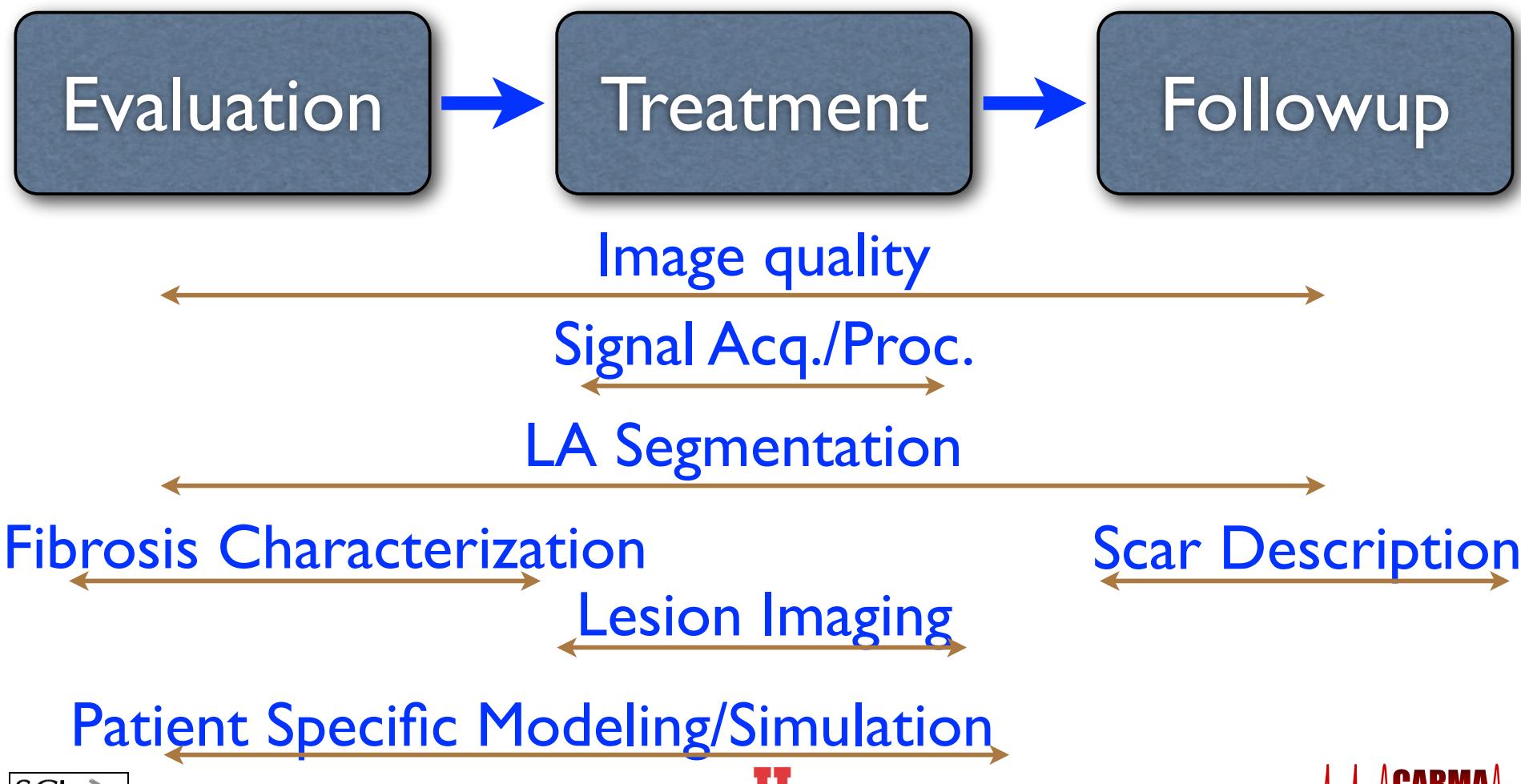


**LGE (<1 hr)**



**LGE (3 mo)**

# Open Challenges



# Animal Models of AFib



# Utah Cooperative Arrhythmia Program

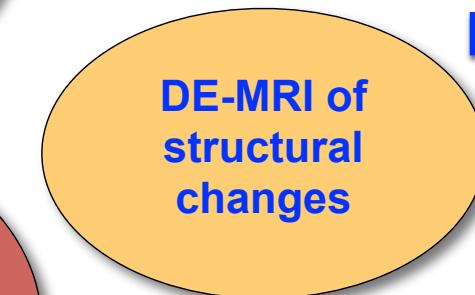
Hematology

Development  
of chronic AF  
animal model

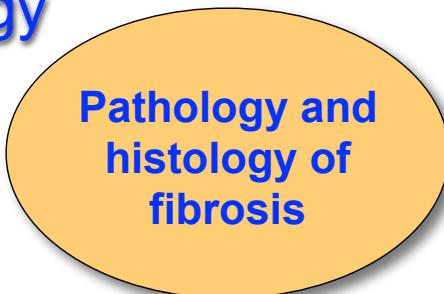
Utah State University



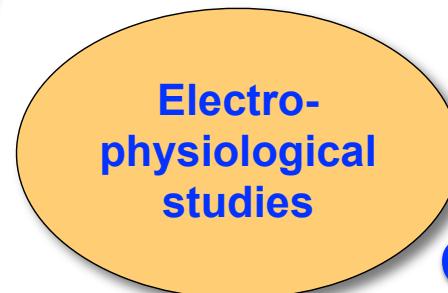
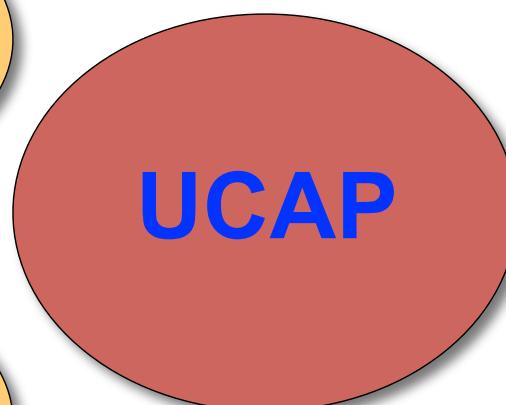
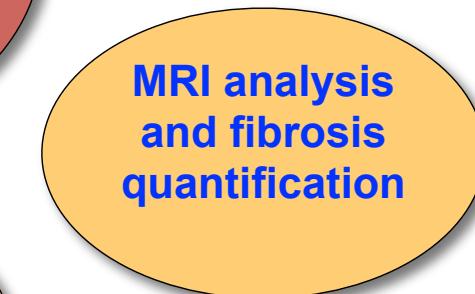
UCAIR,  
Radiology



Pathology



SCI

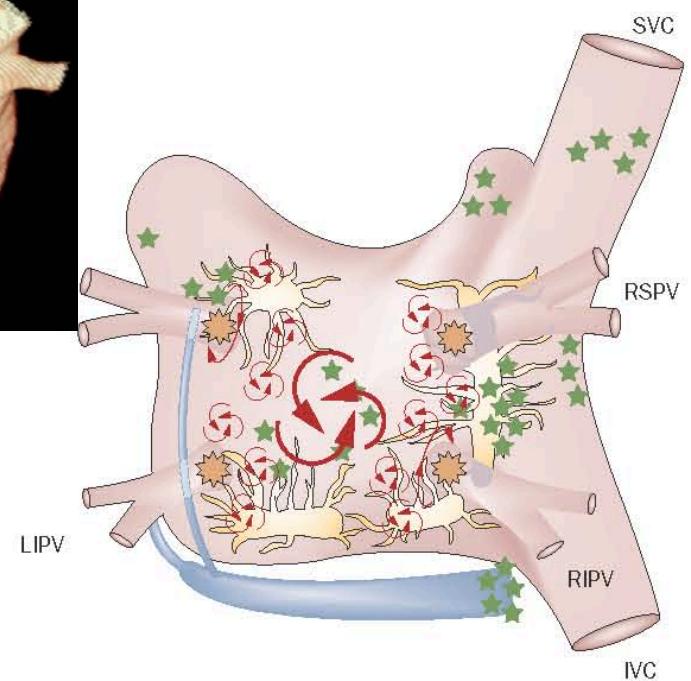
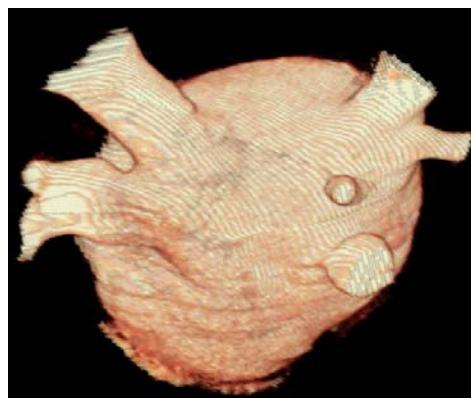
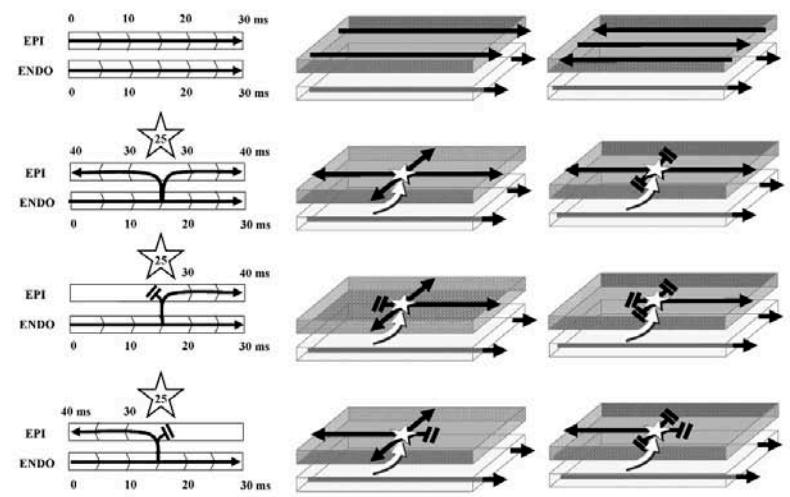
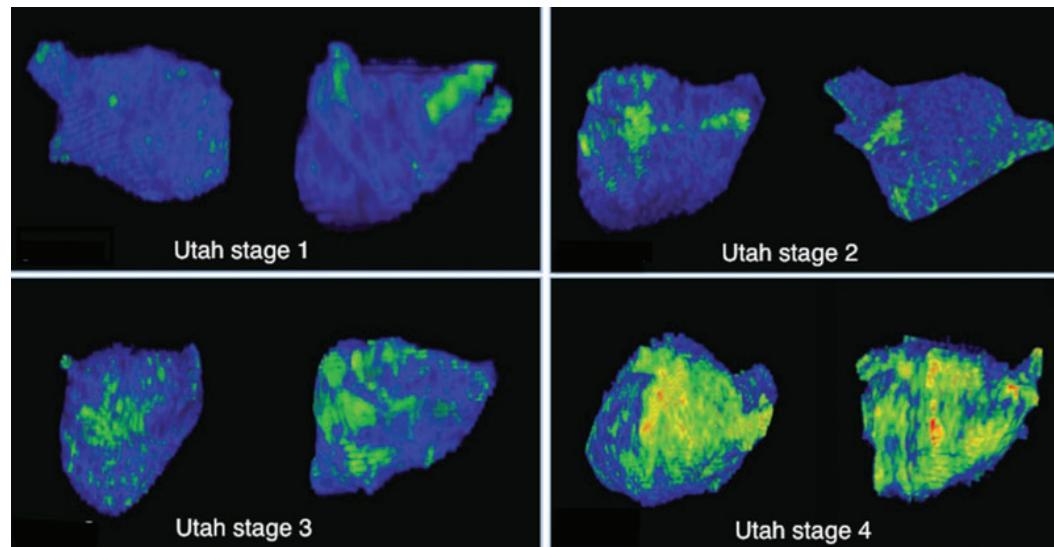
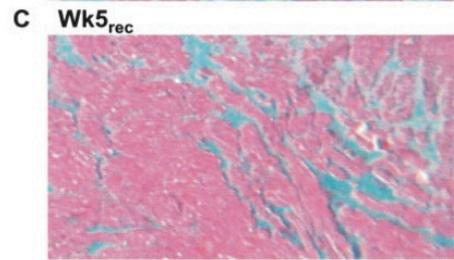
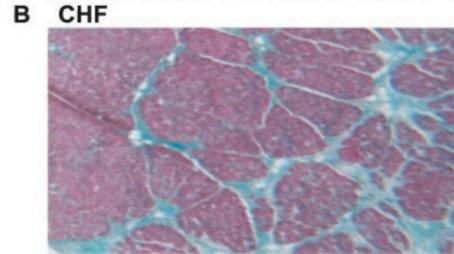
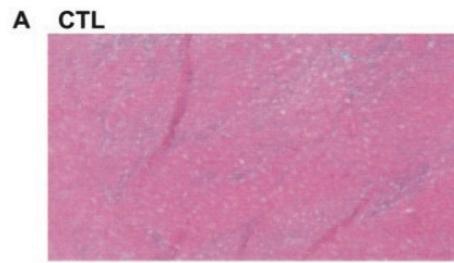


Clinical EP, Cardiology



# Where Are We?



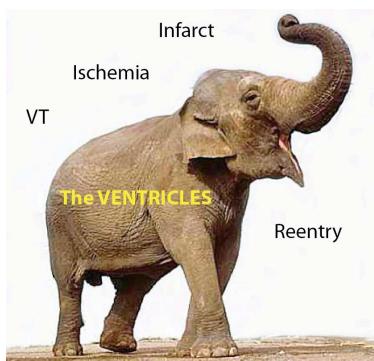


# Paradox

The ATRIA

Fibrillation

Flutter



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