



# DBP: Image Analysis for Atrial Arrhythmias

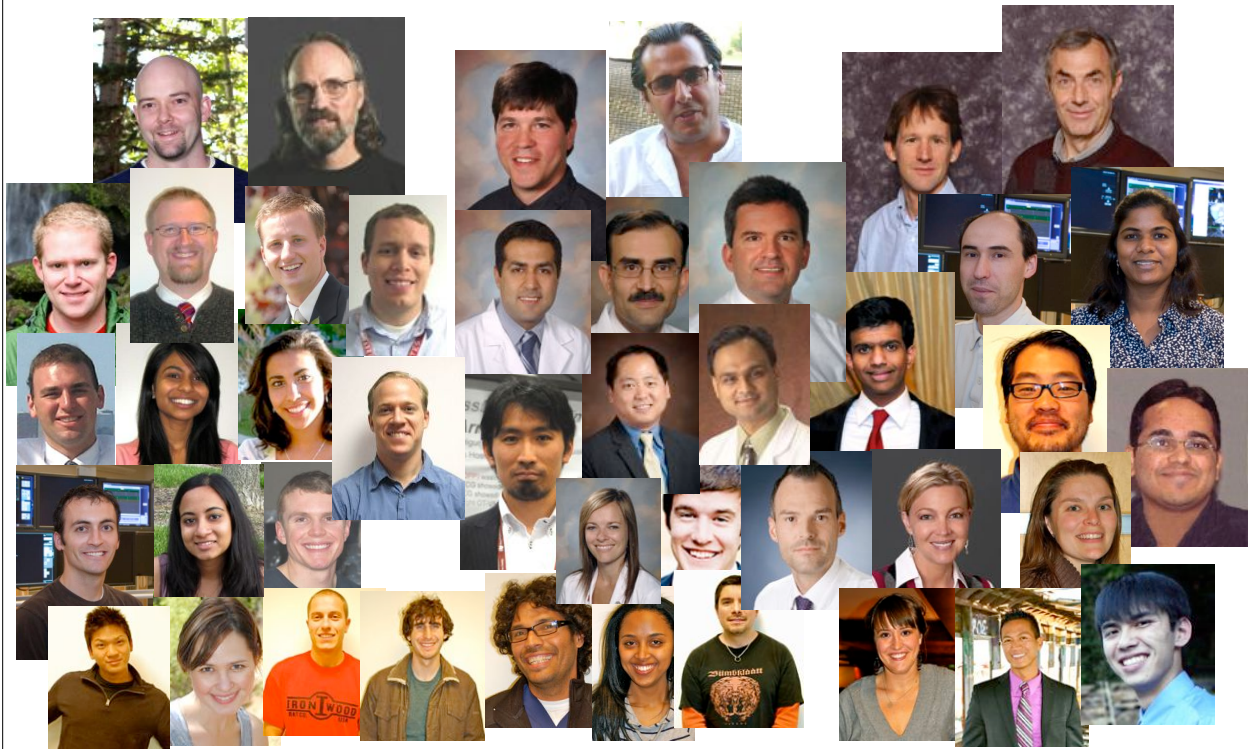
Rob MacLeod and Josh Cates  
SCI Institute, CARMA  
University of Utah



## Driven (Crazy?) by Doctors

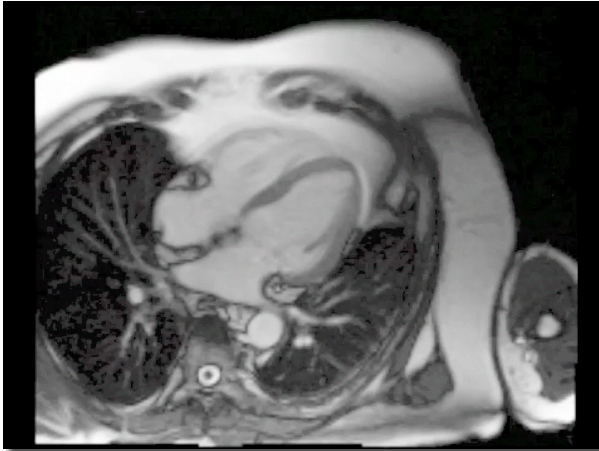


# The CARMA Team

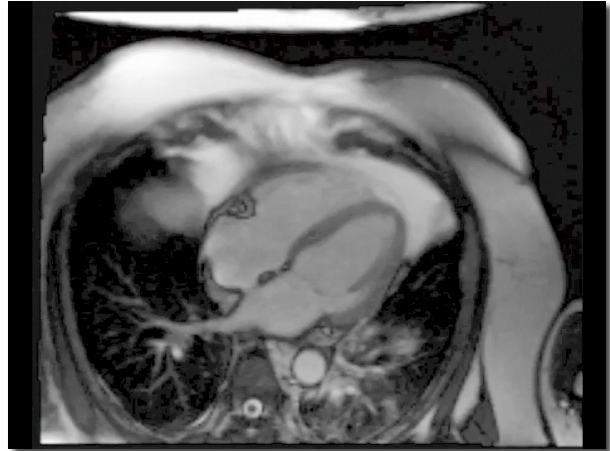


**CARMA = Comprehensive  
Arrhythmia Research and  
MAnagement**

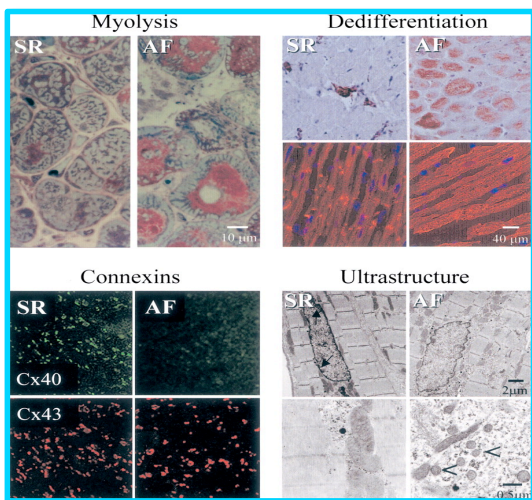
Normal Contraction



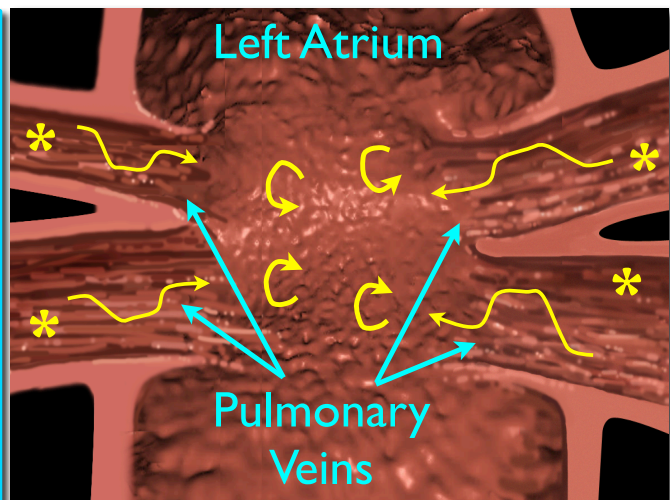
Atrial Fibrillation



# What We Know About AF



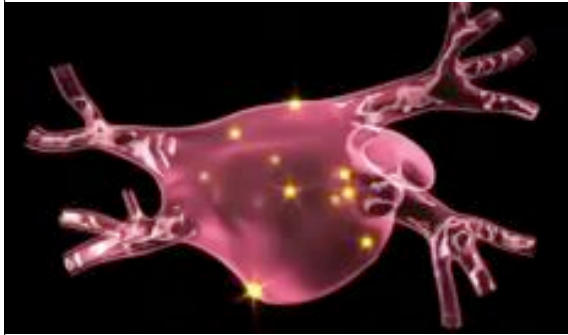
Substrate



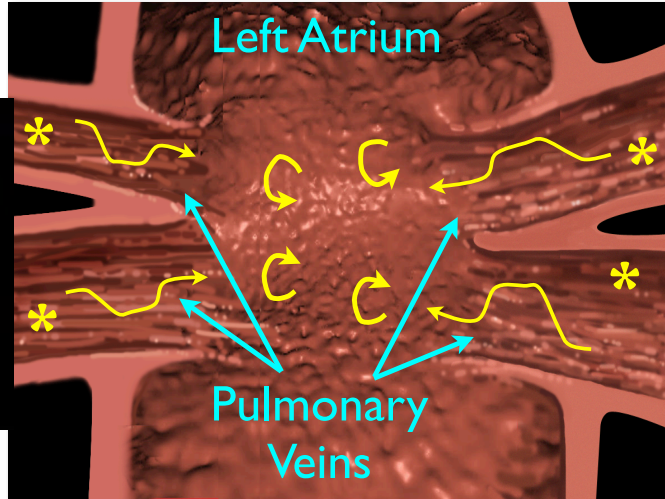
Triggers



# What We Know About AF

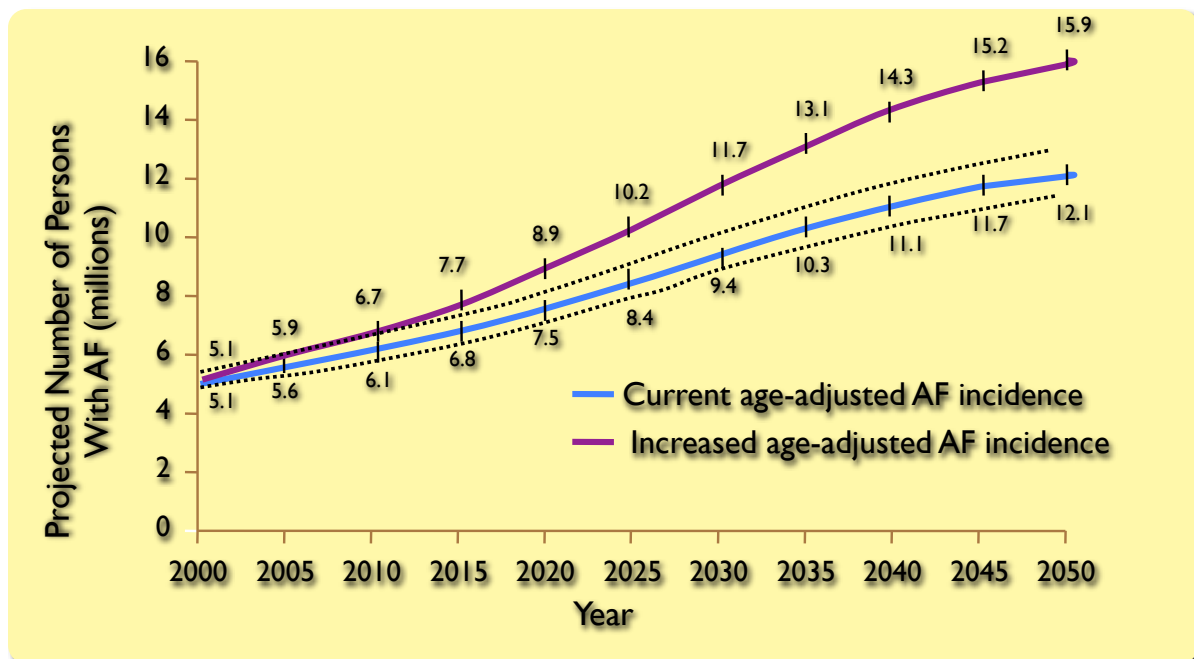


AF



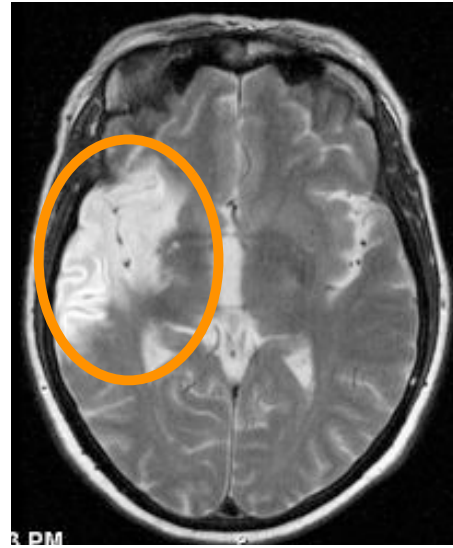
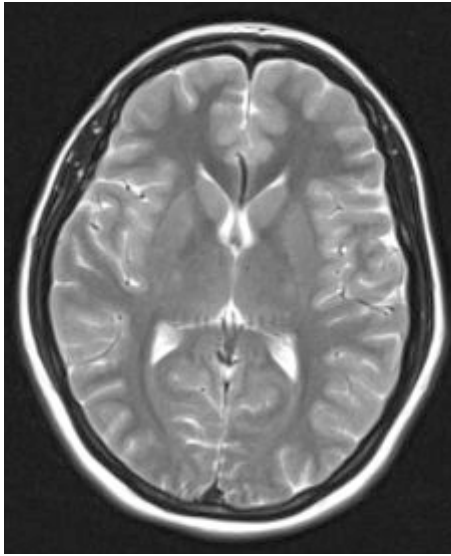
Triggers

## AF Prevalence



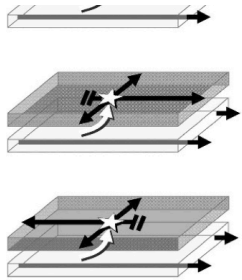


# 20% of Strokes

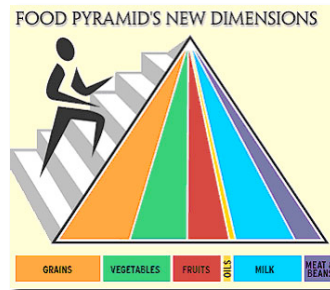


**\$20 billion/year**

# What We Do Not Know about AF: Everything Else



ft, A small portion of the atrial wall in cross section is shown. The site of activation from the breakthrough is represented as a single syncytium of cells.



Mechanisms

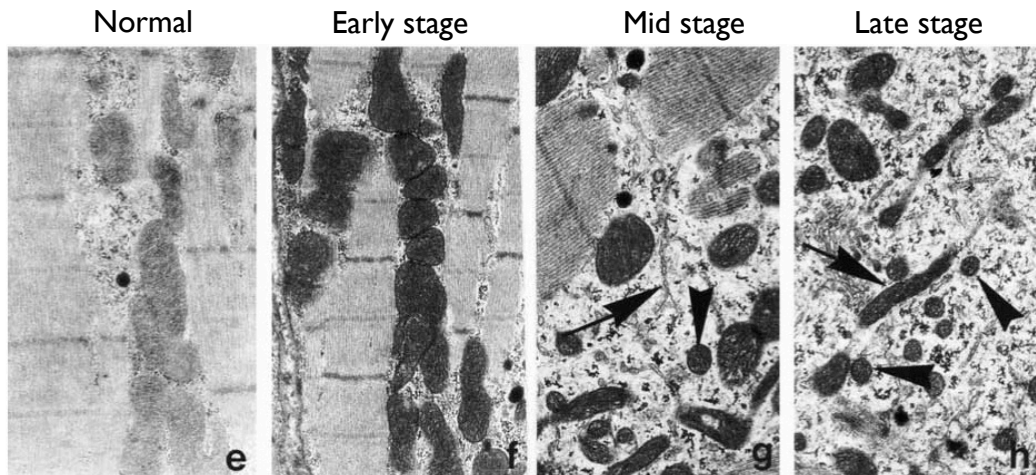
Time Course

Environmental  
Factors

Genetics

# The CARMA Mantra

“AF is a heart tissue disease”

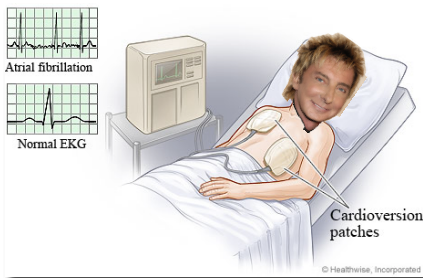
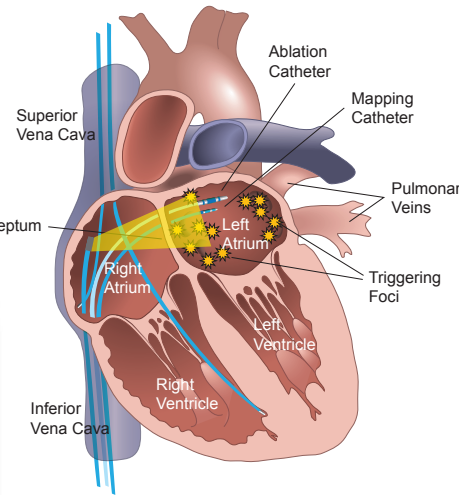
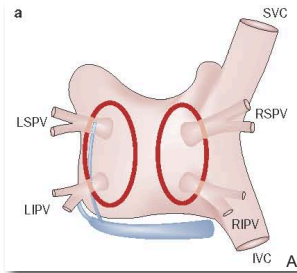


Ausma J, ....Allessie M ...J mol Cell Cardiol. 2001: 2083.

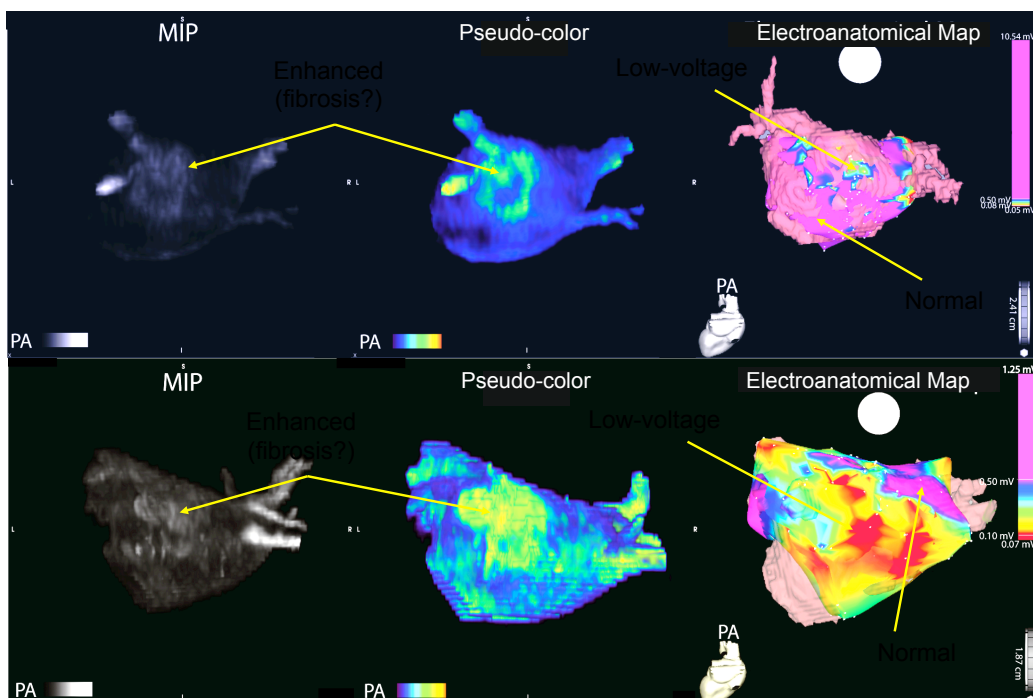
## Structure Matters



# Effective Treatment of AF Eventually Involves Intervention



## CARMA Started Here

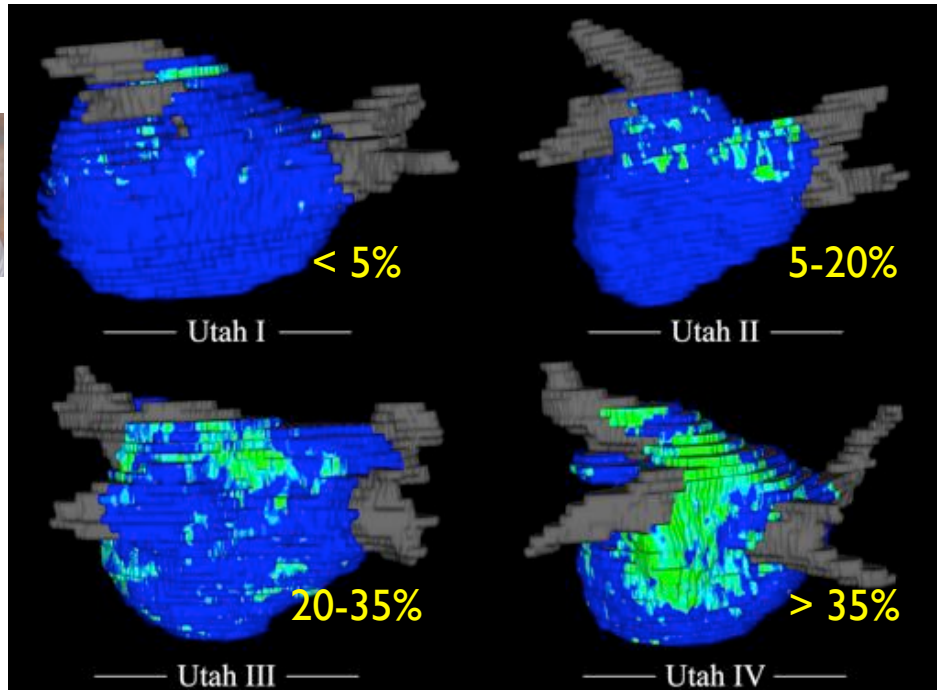




# Utah Scoring Scheme: 2011

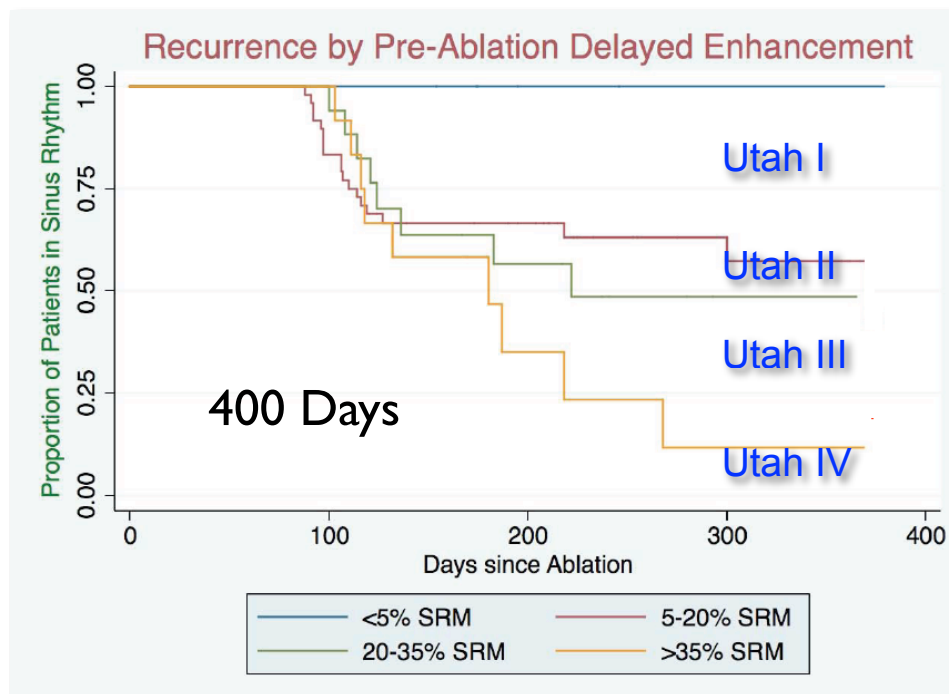


Nazem Akoum

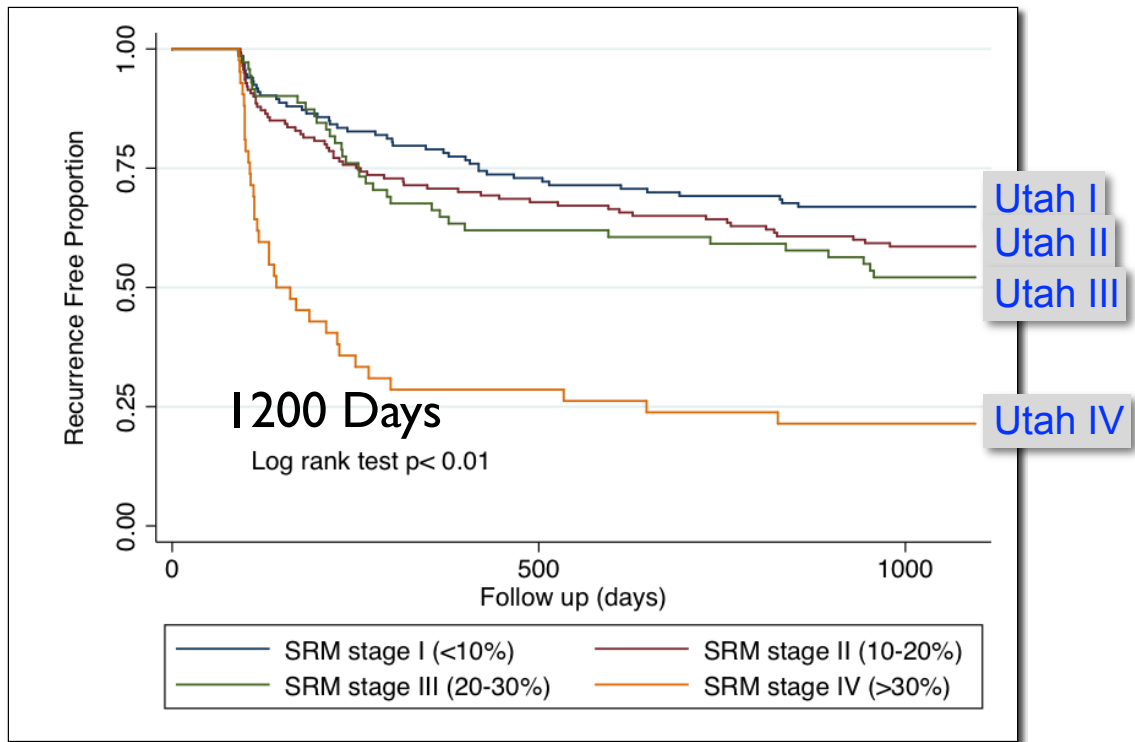


Akoum et al. J Cardiovasc Electrophysiol, 22:16-22, 2011

## Utah Score Predicts Outcome



# Utah Score Predicts Outcome



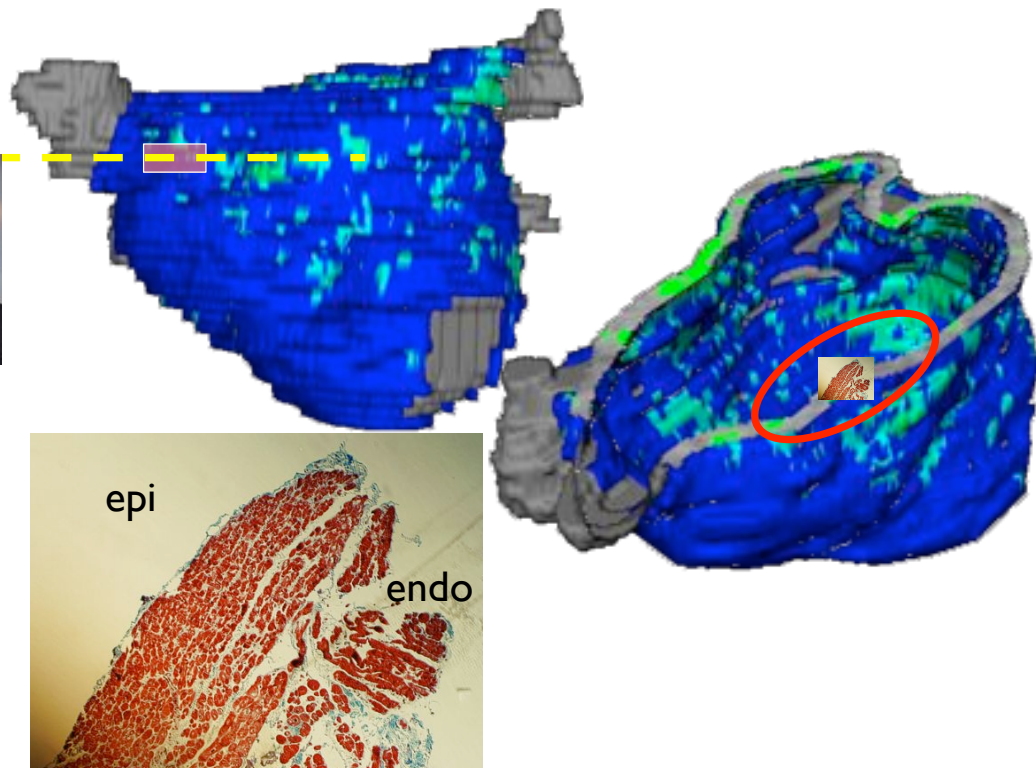
# MRI & Fibrosis: Blue is Normal



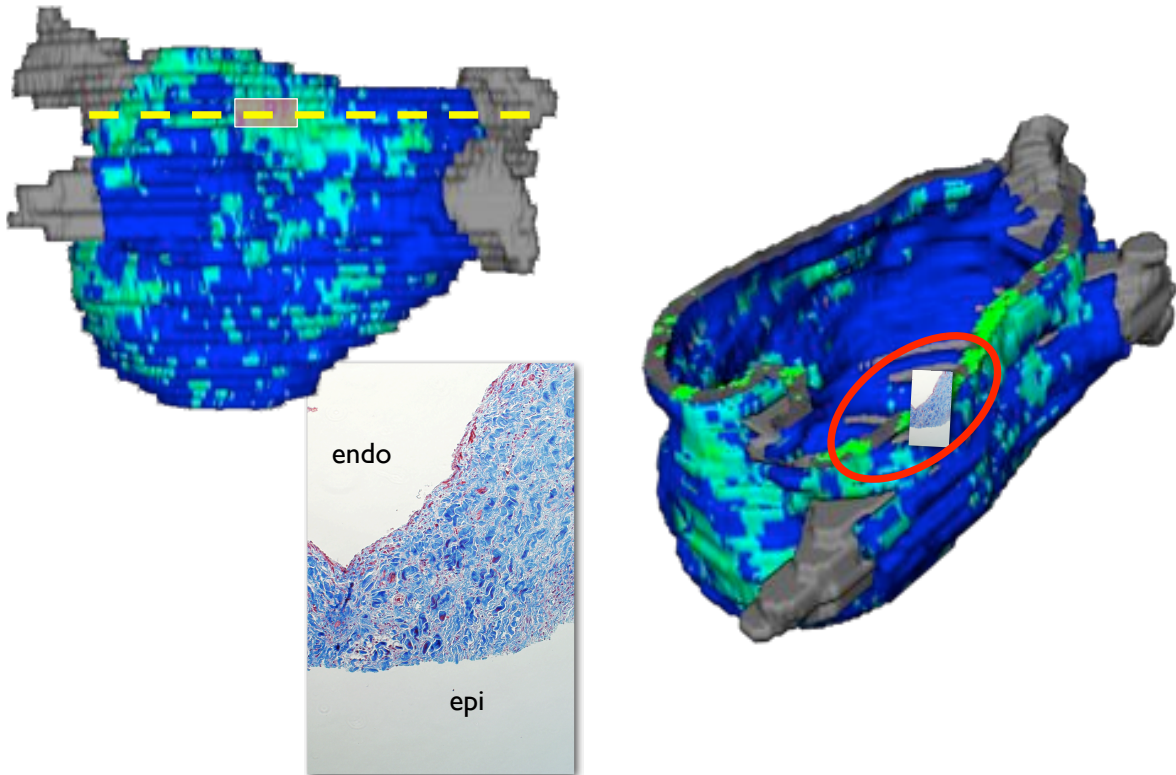
Chris McGann



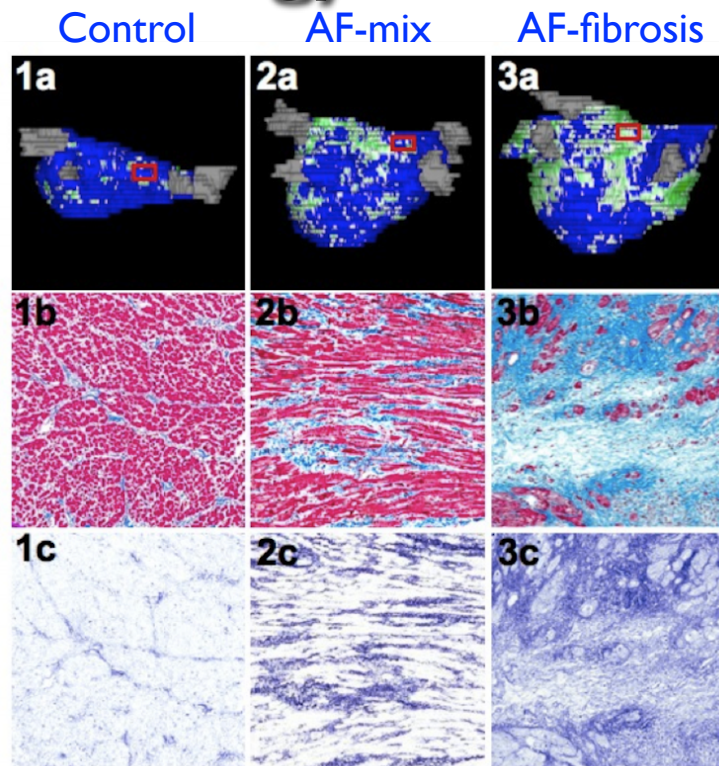
Amit Patel



# MRI & Fibrosis: Green is Fibrosis

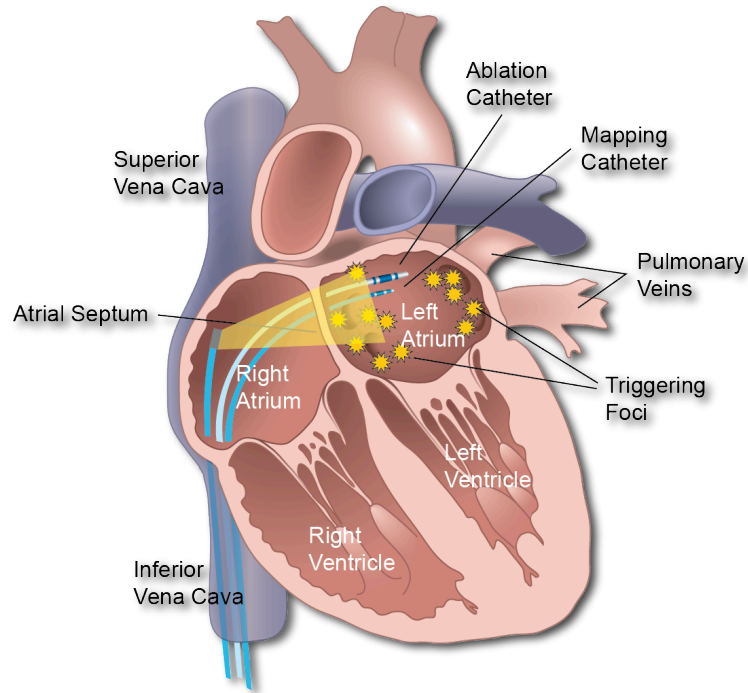


# Histology Summary

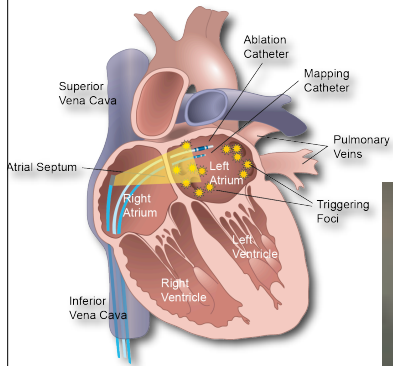




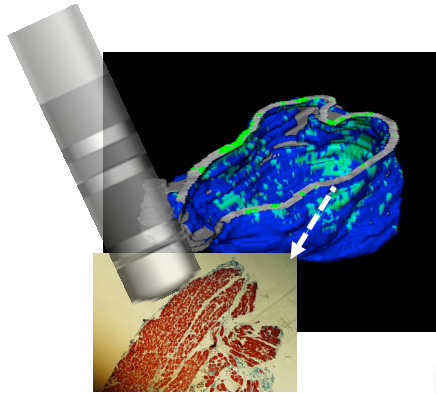
# Treatment Option: Ablation



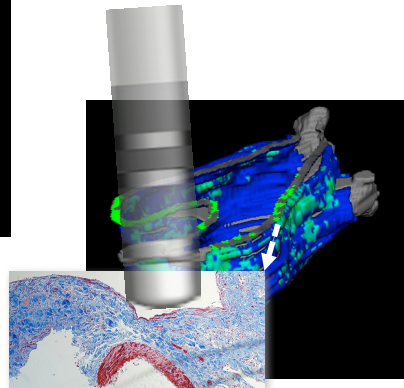
# Treatment Option: Ablation



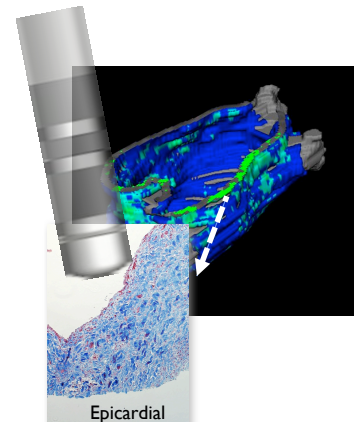
# Not All Lesions Can Be Effective



Likely Effective



Potentially Effective

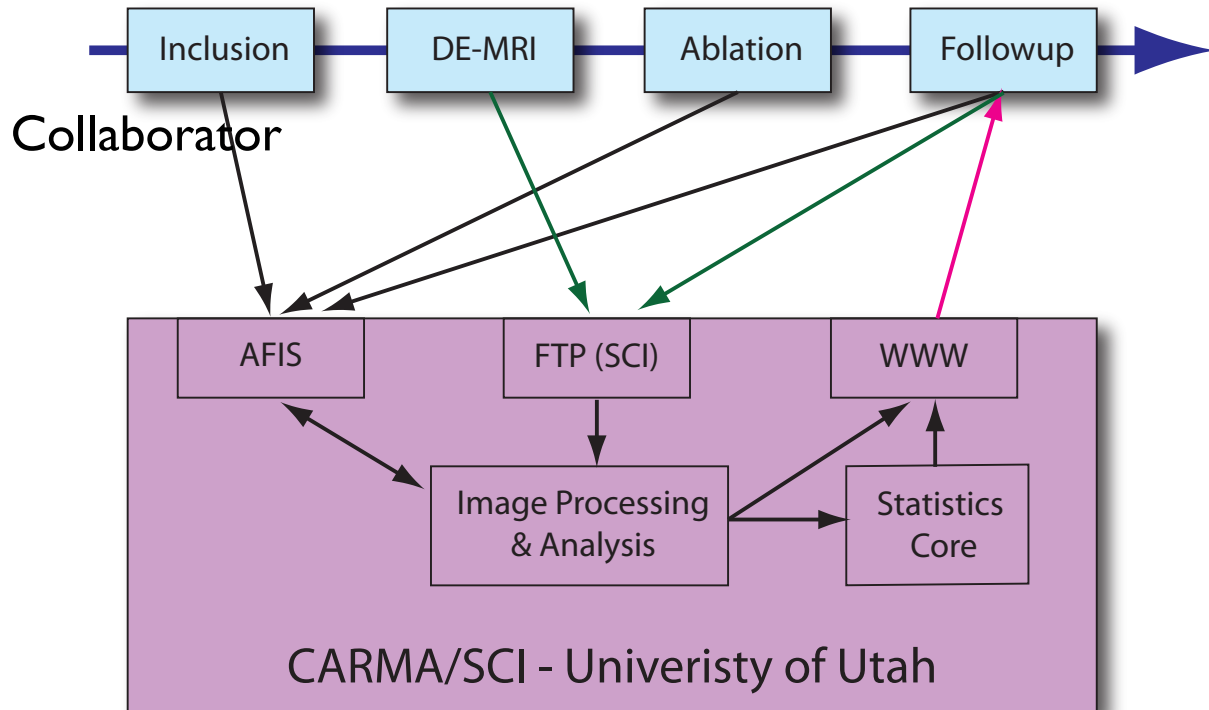


Not Effective

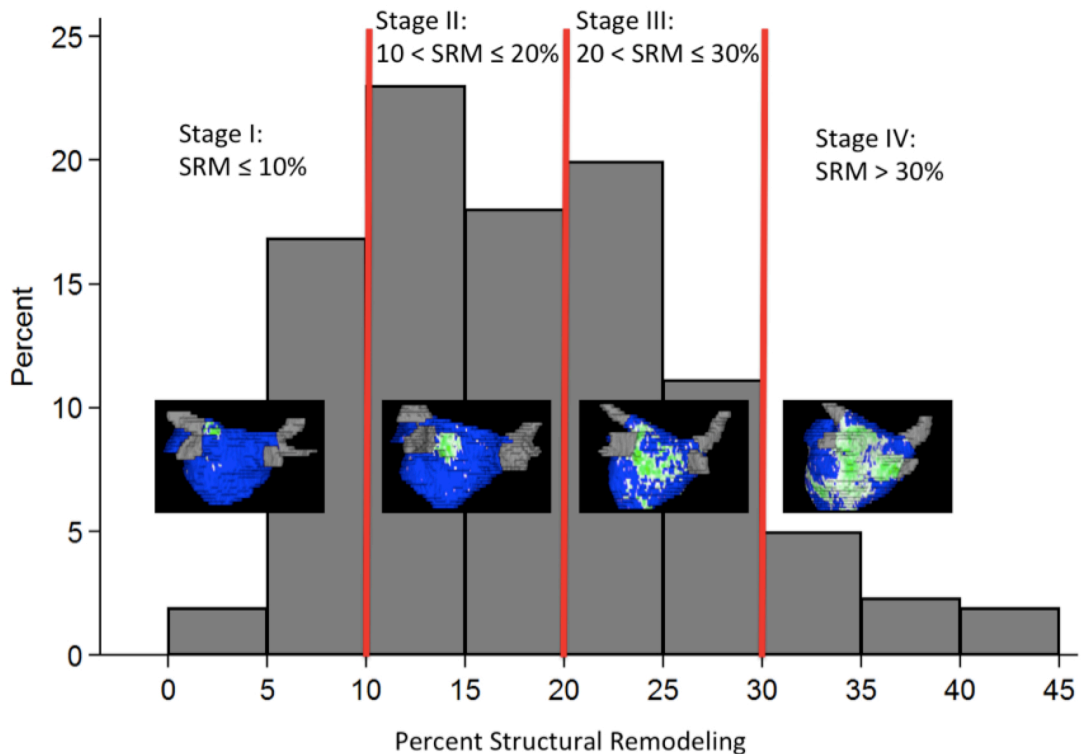


## DE-MRI Determinant of Successful Catheter Ablation of Atrial Fibrillation (DECAAF)

# DECAAF Organization



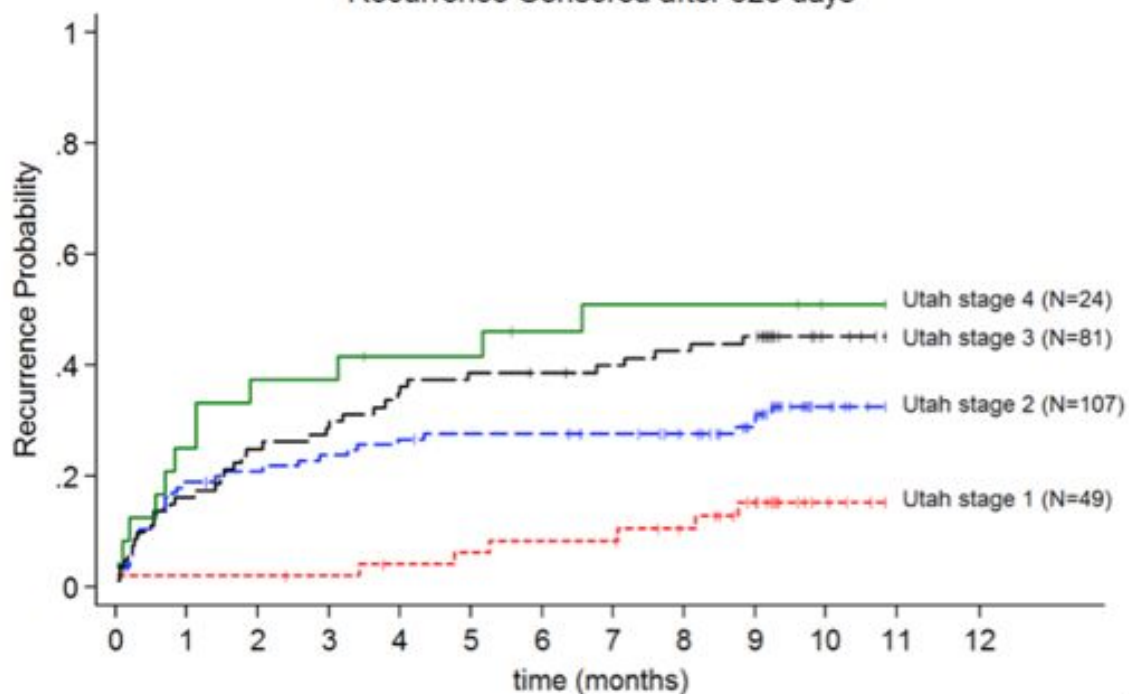
## Results Support Utah Reports



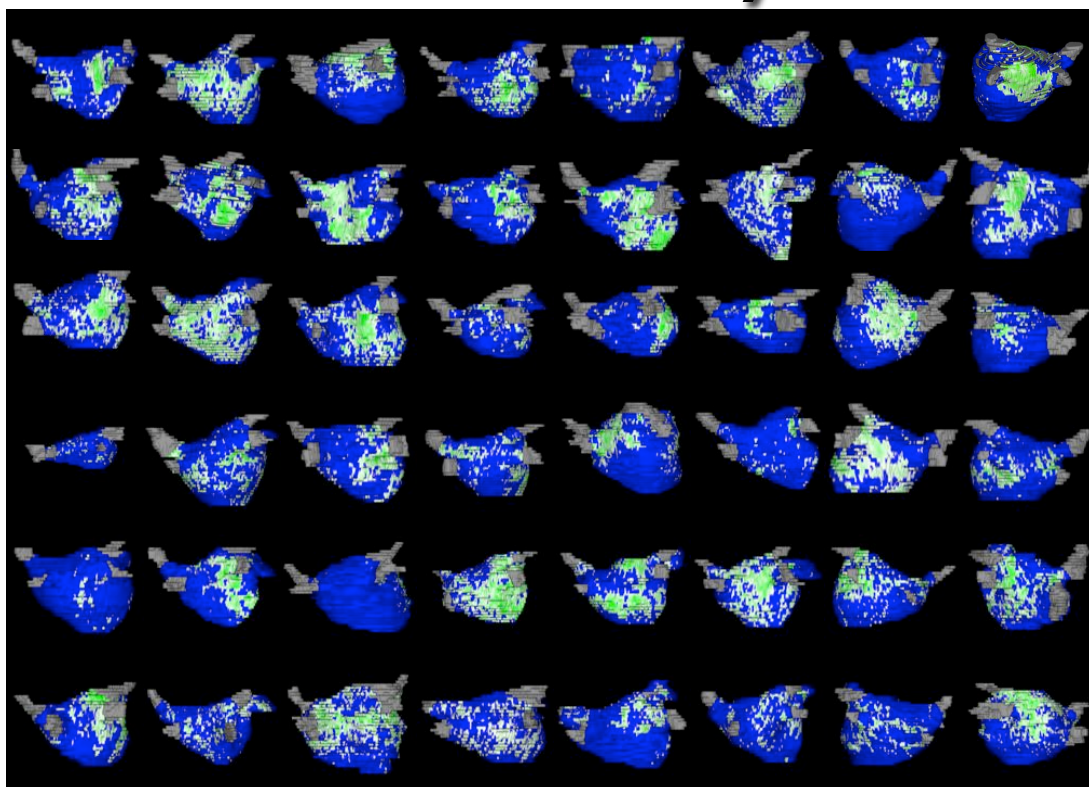


# Results Support Utah Reports

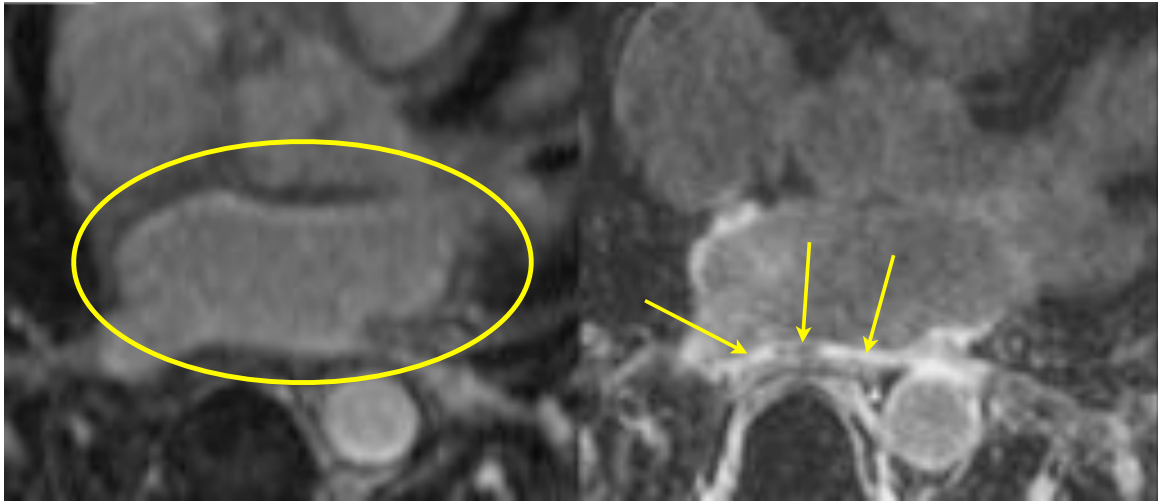
Cumulative Incidence of AFib Recurrence  
Recurrence Censored after 325 days



## Fibrosis Analysis



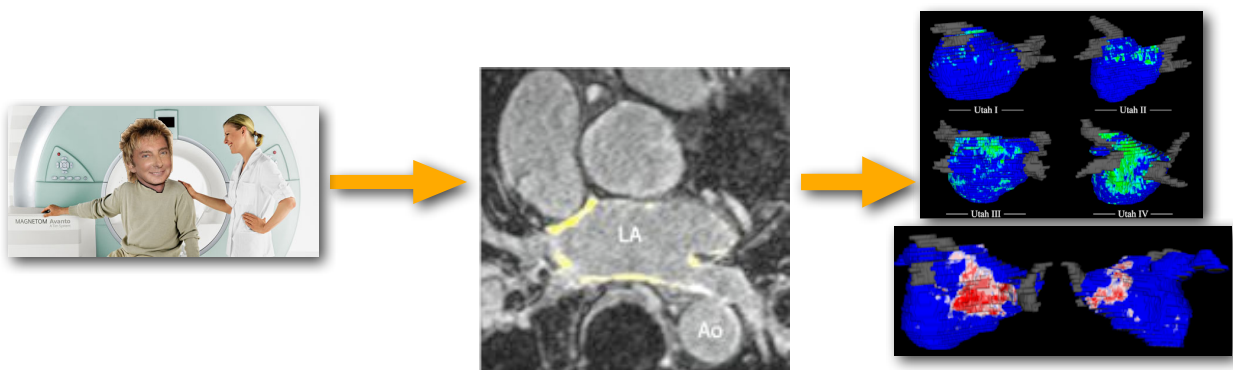
# Ablation Scar Analysis



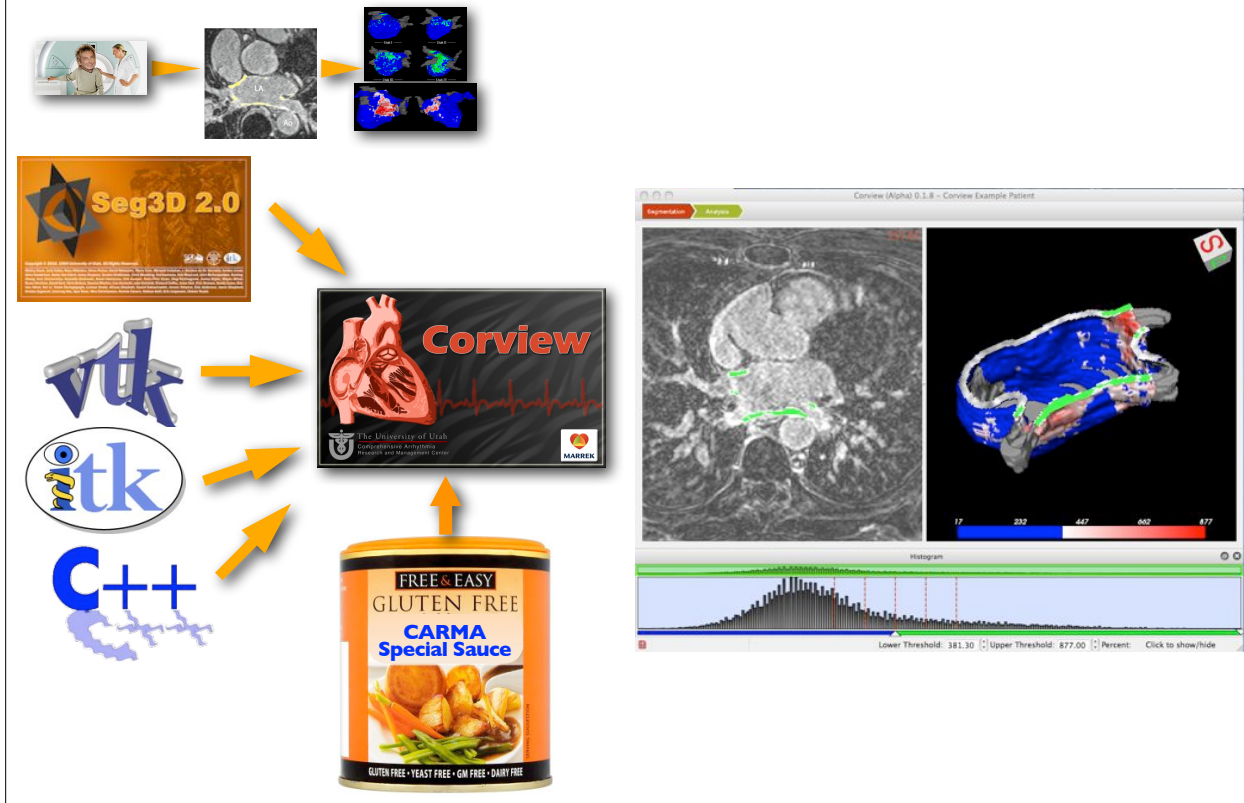
Pre-treatment

3 month Post

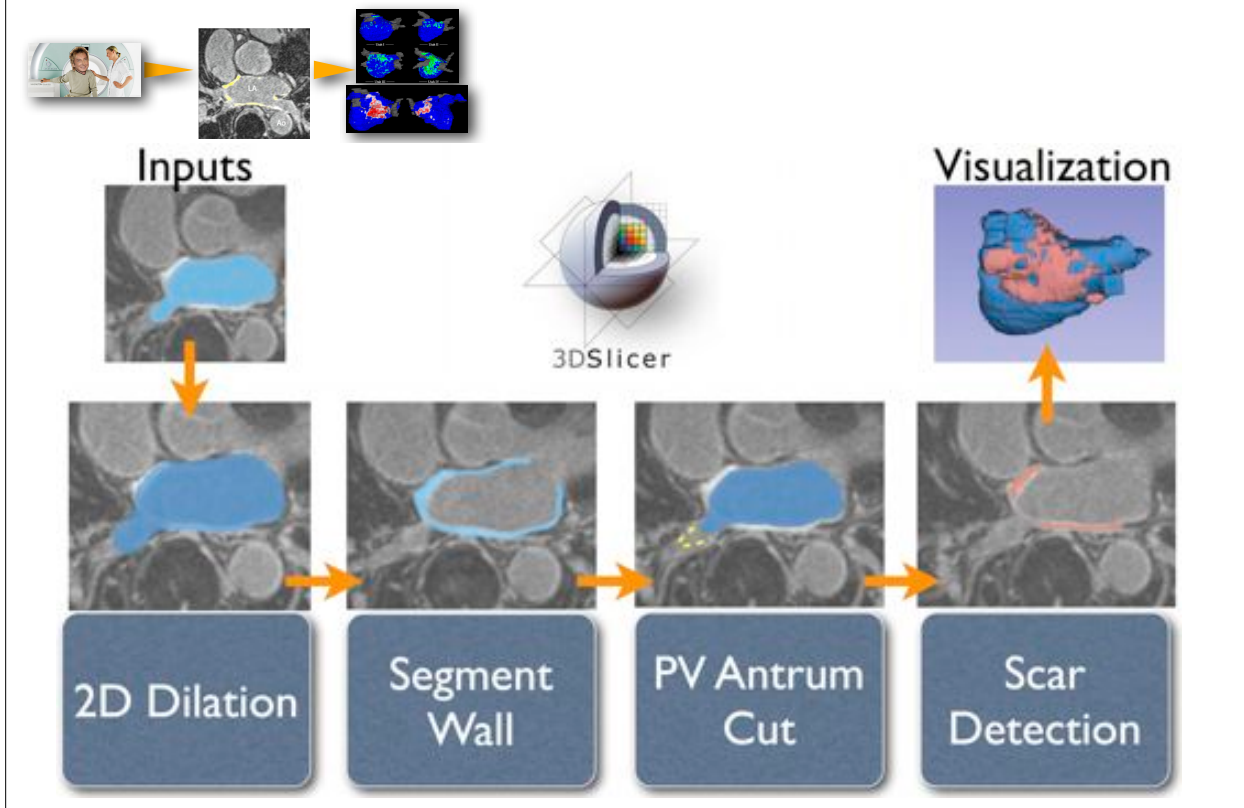
# The CARMA AF Workflow



# The Corview Workflow



# The Slicer Workflow





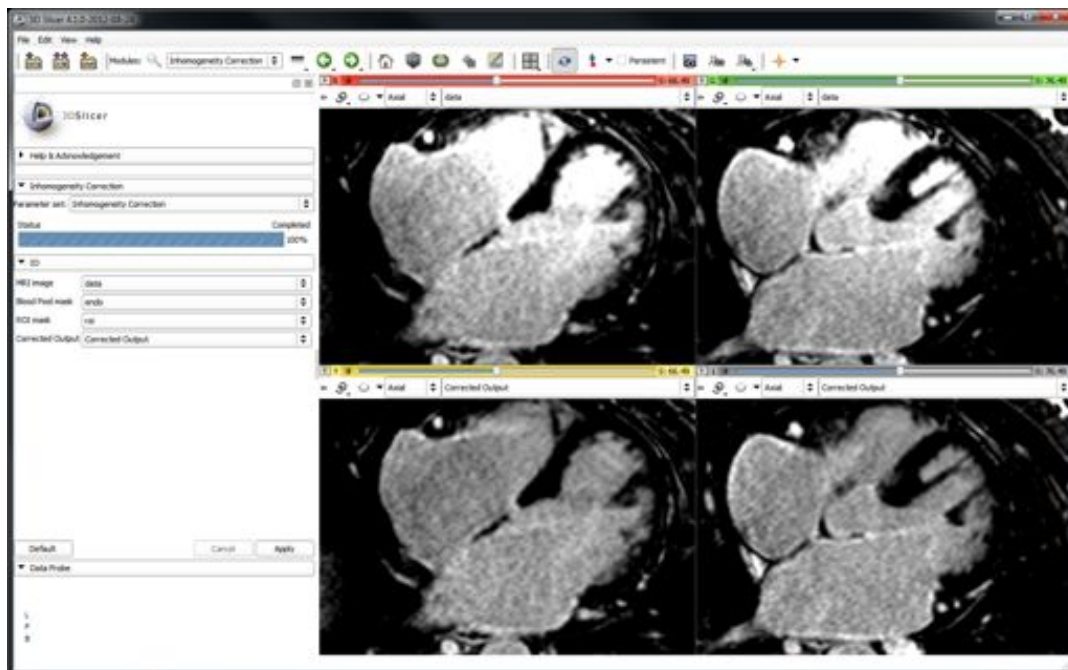
# CARMA Modules

## Activities

### Slicer Modules

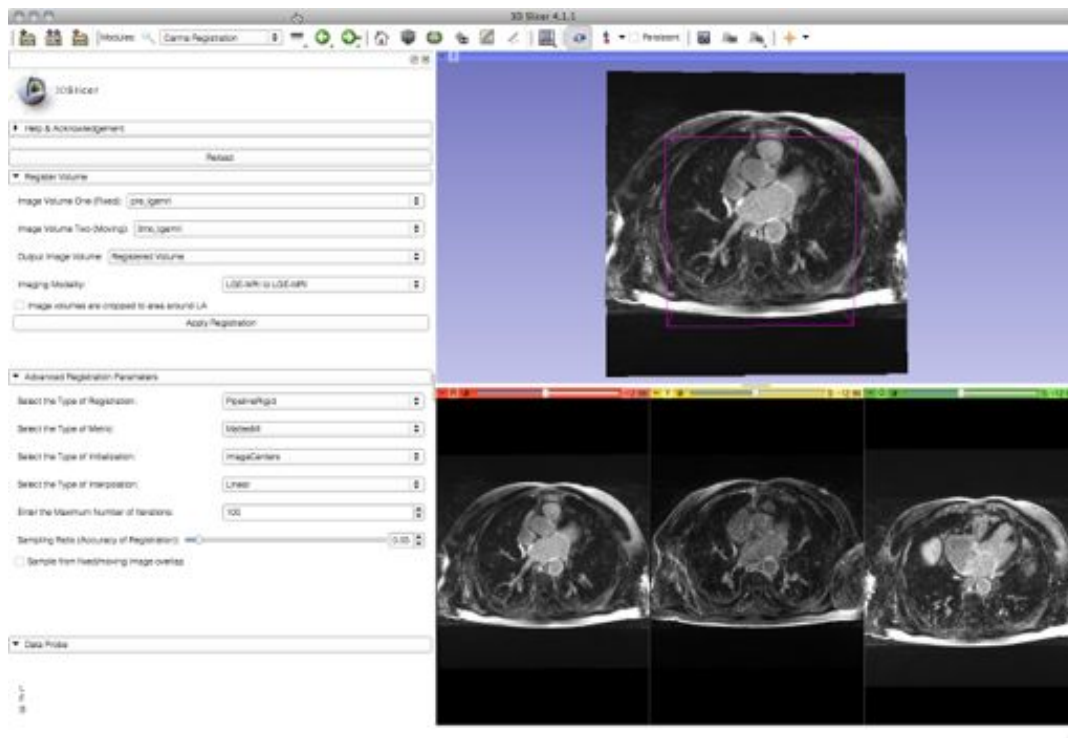
- CMR Toolkit Wizard
- Automatic Cardiac MRI Inhomogeneity Correction Filter
- Automatic Left Atrial (Post-ablation) Scar Detection
- Cardiac MRI Registration
- Cardiac MRI Registration Using BRAINSFit
- PV Antrum Cut Filter
- Axial Dilate Filter
- Boolean REMOVE Filter
- Threshold Model
- Isolated Connected Image Filter
- Connected Threshold Image Filter
- Automated Graph Cut LA Segmentation

## Slicer: Intensity Correction

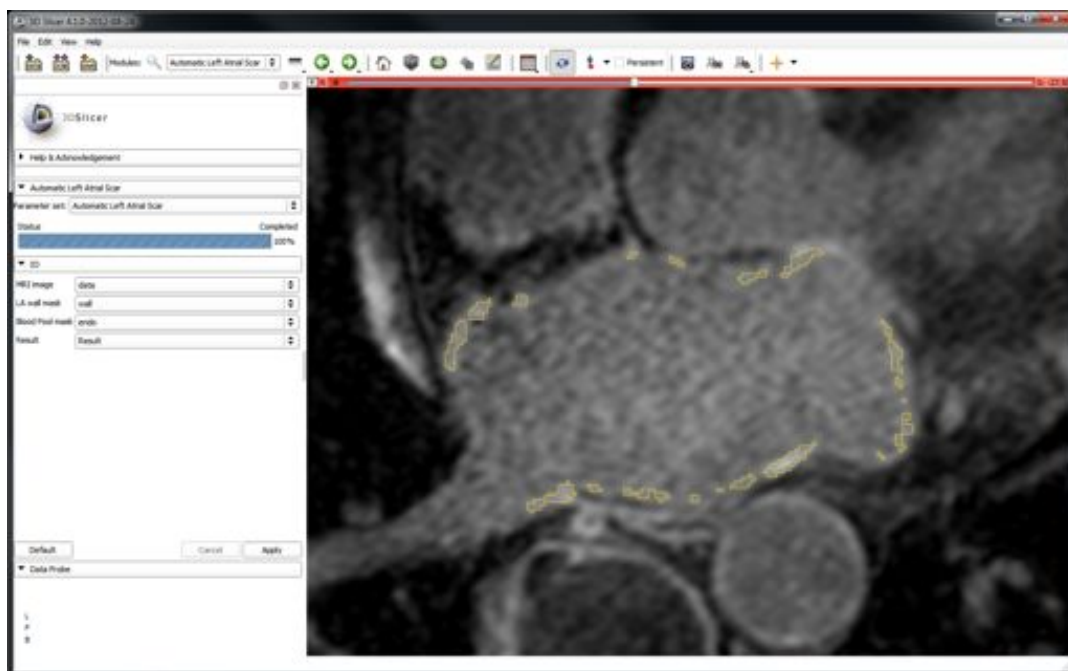




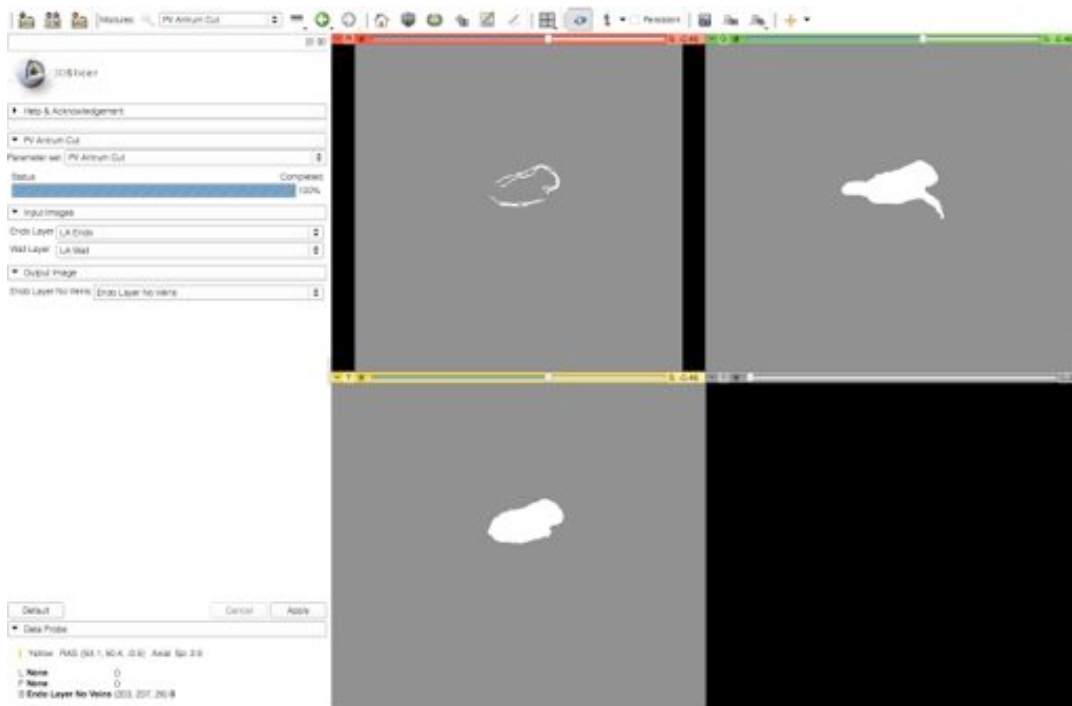
# Slicer: Registration



# Slicer: Scar Detection



# Slicer: Pulmonary Vein Removal



## Tutorials

### Tutorials

- [Automatic Cardiac MRI Inhomogeneity Correction Filter Tutorial](#)
- [Automatic Left Atrial Scar Tutorial](#)
- [Cardiac MRI Registration Tutorial](#)
- [Cardiac MRI Registration Using BRAINSFit Tutorial](#)
- [PV Antrum Cut Filter Tutorial](#)
- [Axial Dilate Filter Tutorial](#)
- [Boolean REMOVE Filter Tutorial](#)
- [Threshold Model Tutorial](#)
- [Isolated Connected Filter Tutorial](#)
- [Connected Threshold Filter Tutorial](#)
- [Slicer Workflow Tutorial](#)

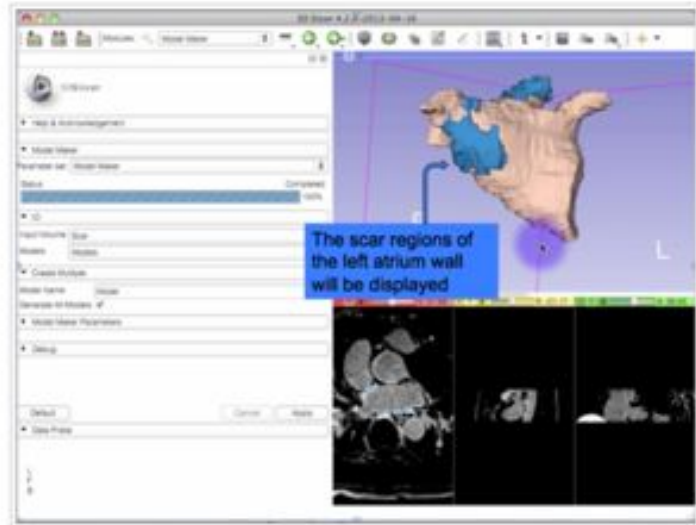
# Good Tutorials

## Events: TutorialContestJune2013

Congratulations to the winner of the Summer 2013 NAMIC Tutorial Contest !

- ▀ Tutorial: [Cardiac MRI Toolkit](#)
- ▀ Authors: Salma Bengali, Josh Cates, SCI, Utah

\$250 Prize sponsored by Steve Pieper, Ph.D., Isomics (many thanks!)



# 2013 Slicer Demo

## 2013 ISMRM CardiacStudyGroup CARMA

The logo for the ISMRM 21st Annual Meeting & Exhibition, featuring a blue oval with a mountain range and a stylized 'S' shape.

ISMRM  
21<sup>st</sup> Annual  
Meeting & Exhibition

Salt Lake City, Utah, USA  
20-26 April 2013  
"Discovery, Innovation & Application - Advancing MR for Improved Health"

A blue silhouette of a human head in profile, facing right, with a white caduceus symbol inside the head.The logo for CARMA, consisting of the word "CARMA" in white, bold, sans-serif capital letters on a dark gray rectangular background.The logo for The University of Utah, featuring a red 'U' above the text "THE UNIVERSITY OF UTAH" in black, sans-serif capital letters.

# Collaborative Projects

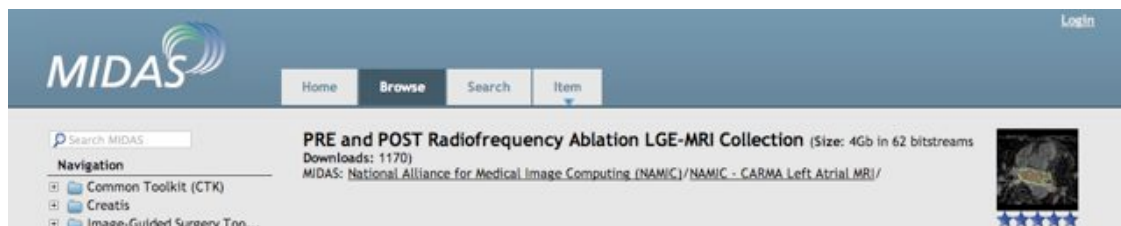
## Other Projects

- Image registration capabilities for longitudinal analysis: [Registration & Segmentation pipeline pilots & workflow development \(Dominik Meier, Alex Zaitsev\)](#)
- Evaluation of BRAINSFit and fiducial-based registration tools for LA wall alignment and longitudinal registration of PV: [BRAINSFit Registration of PVs](#)
- Collaboration with GA Tech -
  - Test and evaluate Behnood's wall segmentation - results and analysis are here: [Automatic Wall Segmentation](#)
  - Test and evaluate Yi Gao's atlas-based endocardial segmentation algorithm: [Automatic Endocardial Segmentation](#)
  - Test and evaluate Yi Gao's image and segmentation-driven registration algorithm: [Image and Segmentation-Driven Registration](#)

# Open Data

## Sample Data

- Sixty anonymized datasets containing LGE-MRI image data and segmentations of the left atrium from patients with atrial fibrillation: [Pre and Post Radiofrequency Ablation LGE-MRI Collection](#)
- Sixty segmentation datasets of the left atrium from patients with atrial fibrillation who have undergone radiofrequency catheter ablation for treatment: [CARMA Longitudinal Left Atrial Shape Data](#)
- Two subjects, two time points: [CardiacMRIs](#).



The screenshot shows the MIDAS website interface. At the top left is the MIDAS logo. A navigation bar contains links for Home, Browse, Search, and Item. Below the navigation bar is a search box labeled 'Search MIDAS'. On the left side, there is a 'Navigation' menu with links to 'Common Toolkit (CTK)', 'Creatis', and 'Image-Guided Surgery Too...'. The main content area displays the title 'PRE and POST Radiofrequency Ablation LGE-MRI Collection' with a size of 4Gb in 62 bitstreams and 1170 downloads. Below the title is the text 'MIDAS: National Alliance for Medical Image Computing (NAMIC) / NAMIC - CARMA Left Atrial MRI/' and a small thumbnail image of a brain scan with a star rating of five stars.

<http://www.insight-journal.org/midas>

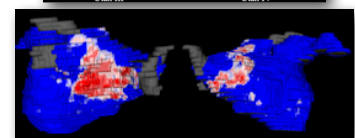
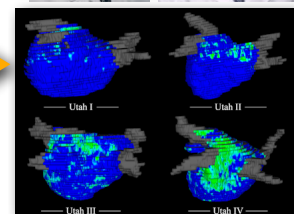
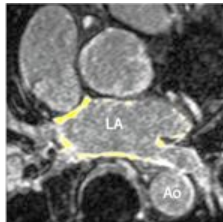
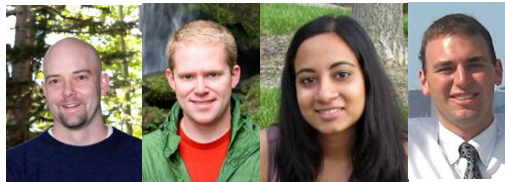




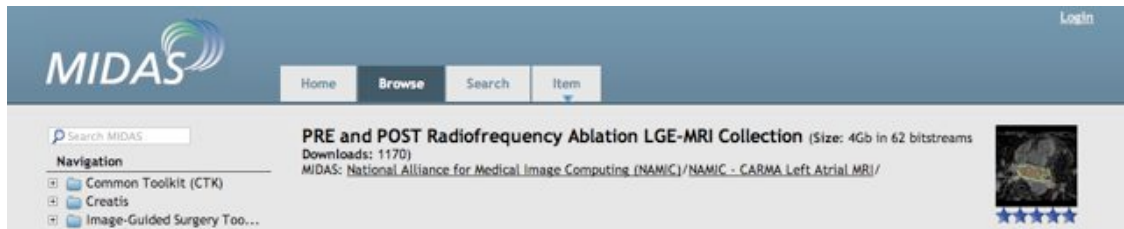
# What Has CARMA Brought to NA-MIC?



## Access to Image Based Medicine



# Access to Data



MIDAS Login

Home Browse Search Item

Search MIDAS

Navigation

- Common Toolkit (CTK)
- Creatis
- Image-Guided Surgery Too...

**PRE and POST Radiofrequency Ablation LGE-MRI Collection** (Size: 4Gb in 62 bitstreams  
Downloads: 1170)  
MIDAS: National Alliance for Medical Image Computing (NAMIC)/NAMIC - CARMA Left Atrial MRI/

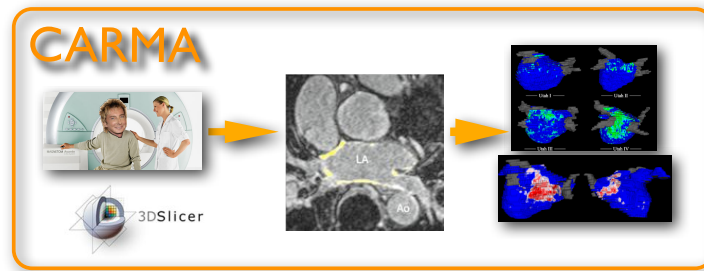
★★★★★



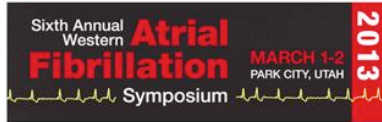
# Real World Testing



# Dissemination



Sixth Annual Western Atrial Fibrillation Symposium



7TH INTERNATIONAL CONFERENCE ON FUNCTIONAL IMAGING AND MODELING OF THE HEART



LONDON, JUNE 20-22



Heart Rhythm Society<sup>SM</sup>

EMBC 2014 - 2014 36th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)



## What Next?



# Improved Segmentation



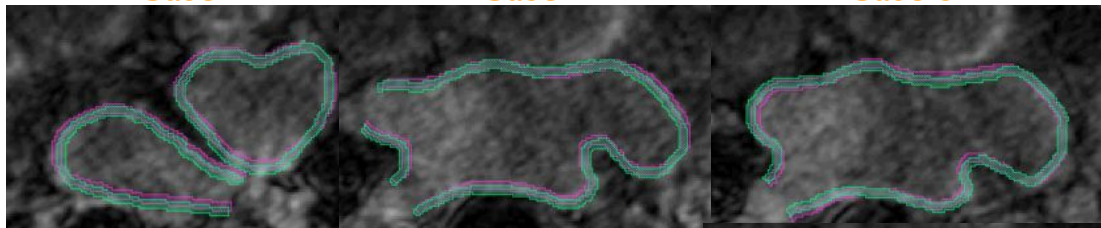
## Segmentation Performance

Case 1

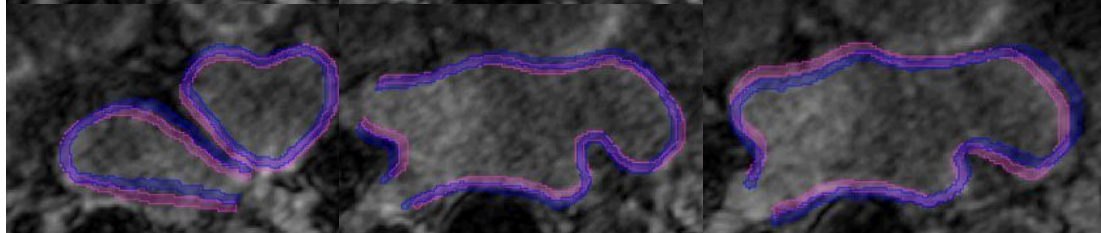
Case 2

Case 3

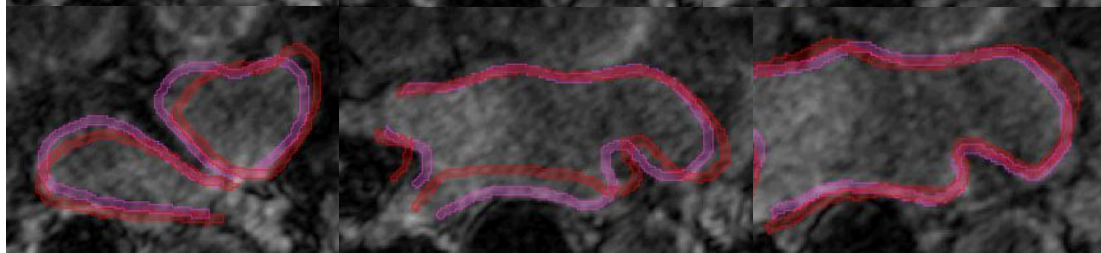
2 mm



4 mm

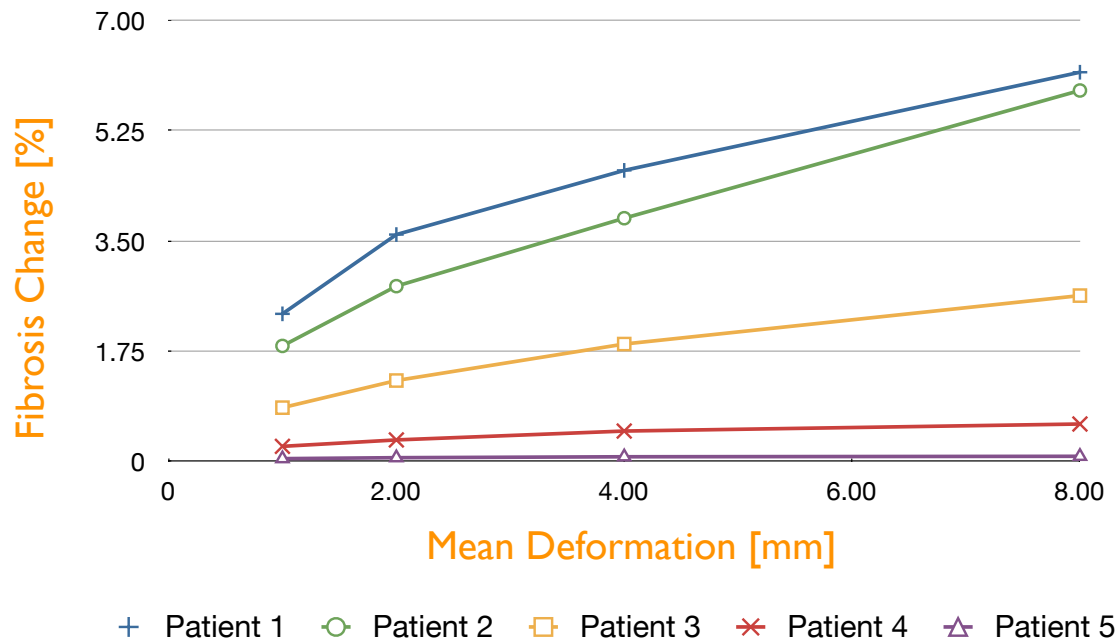


8 mm



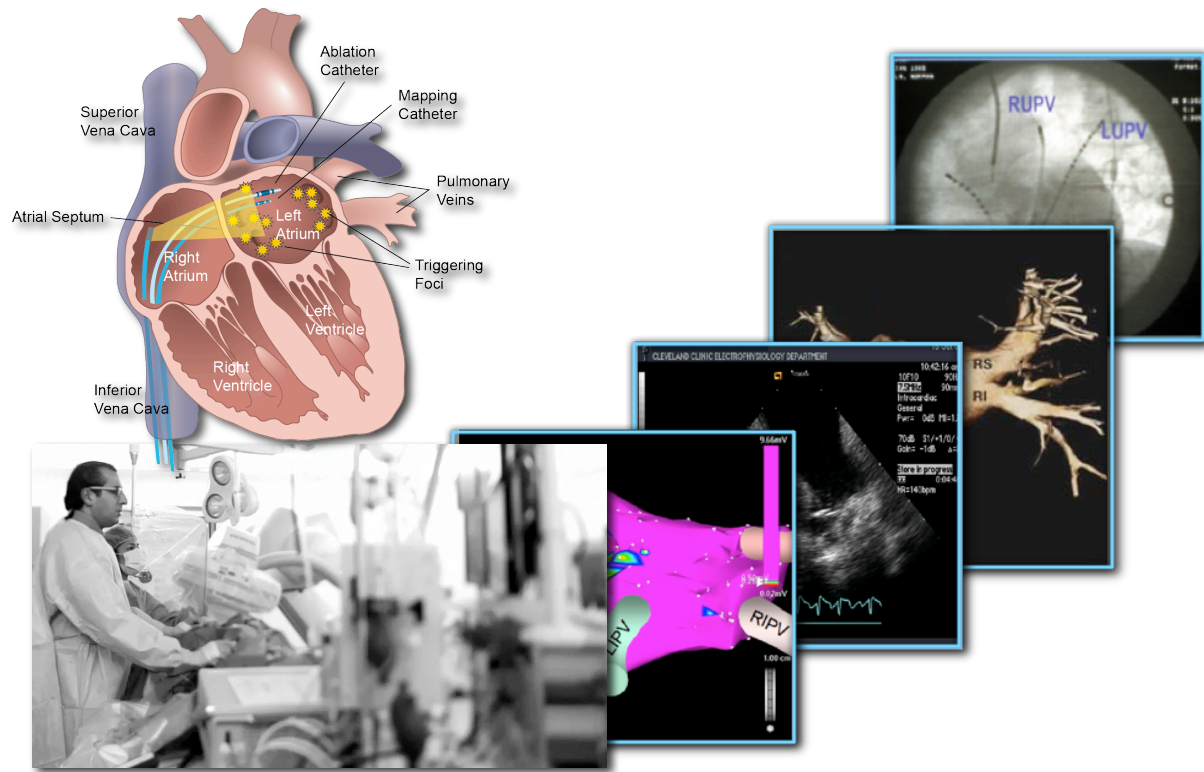


# Segmentation Performance

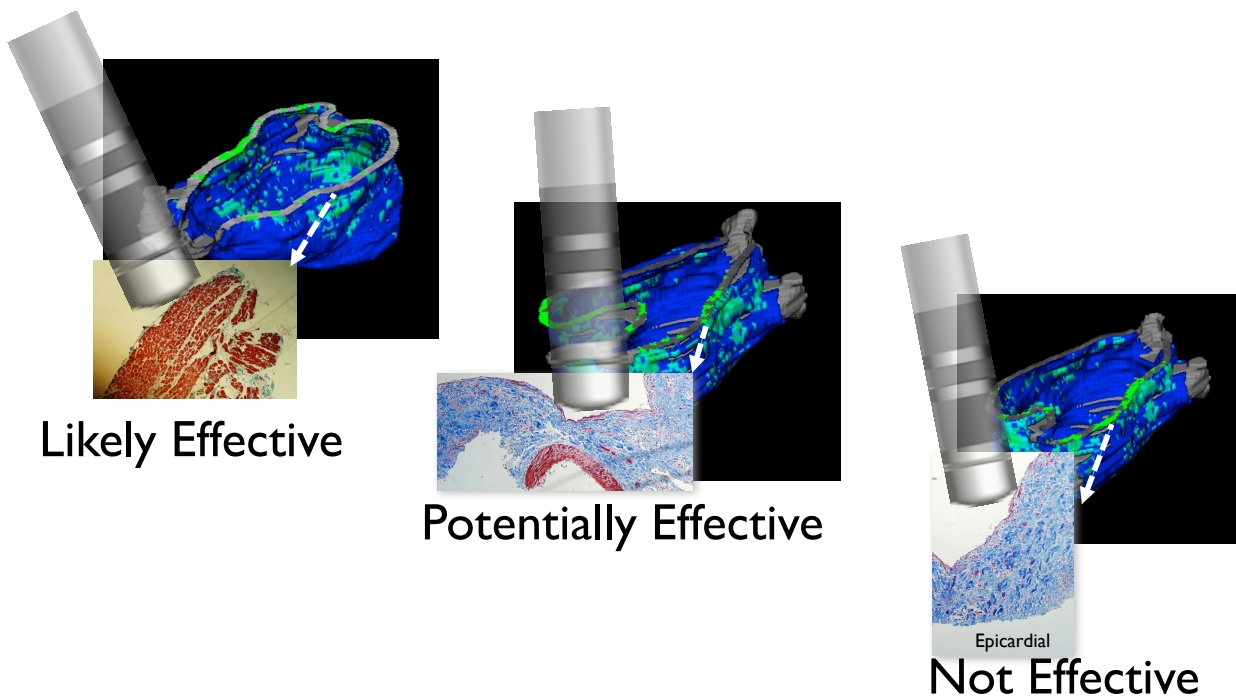


# Image Guided Ablation

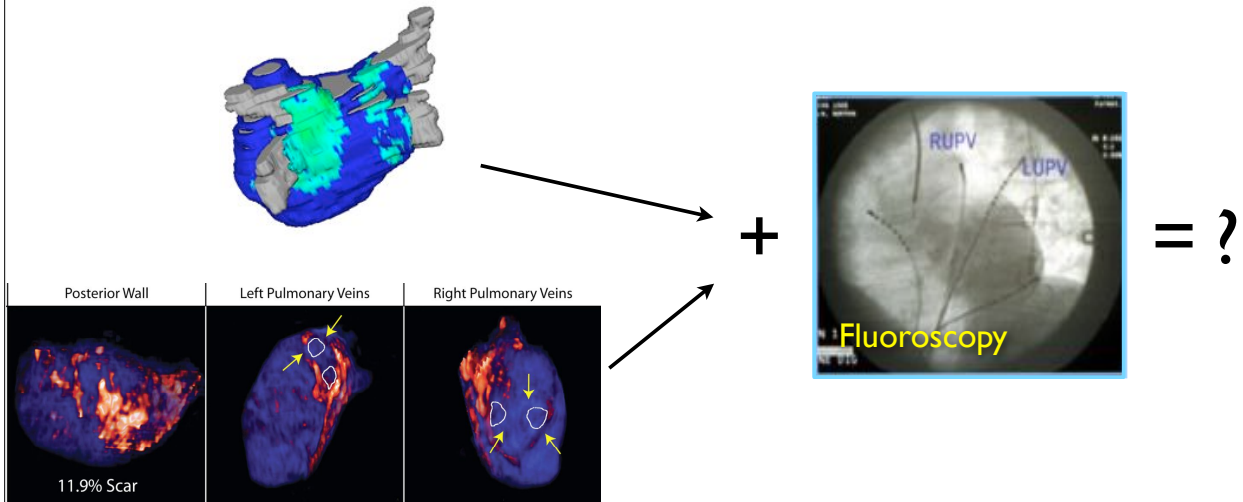
# RF Ablation



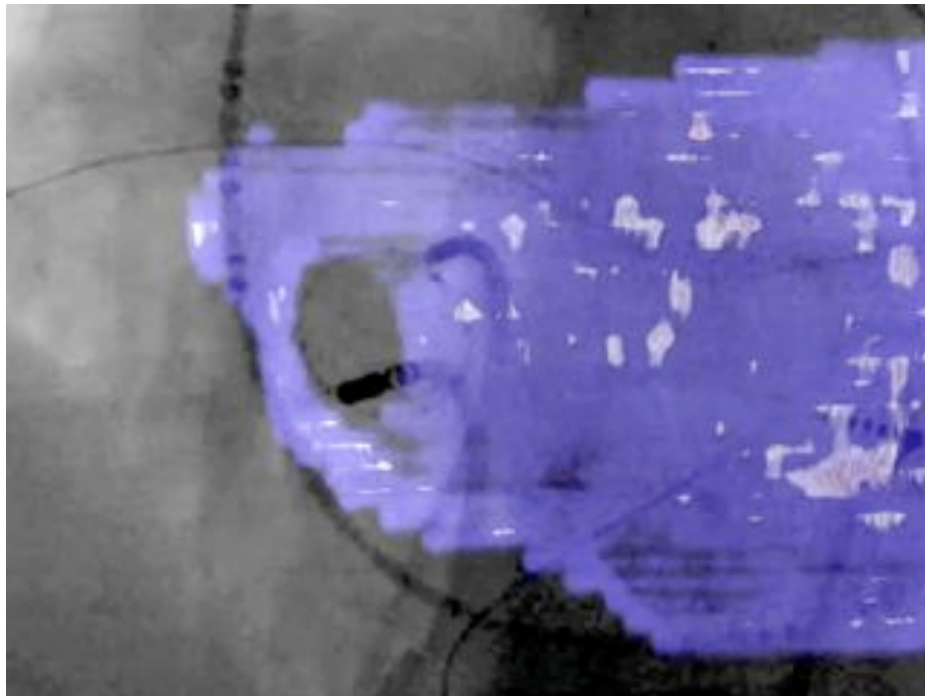
## Not All Lesions Can Be Effective



# Image Merging



# Fluoroscopy Results



# EAM (Carto) Results



## Shape



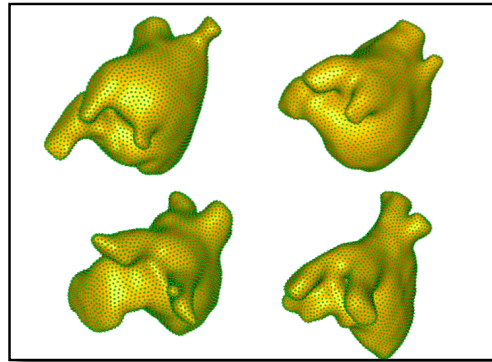
# Shape Analysis



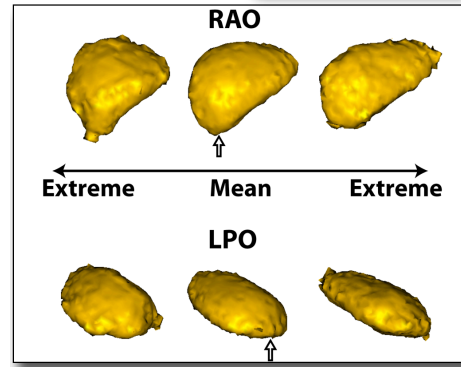
Greg Gardner



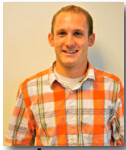
Josh Cates



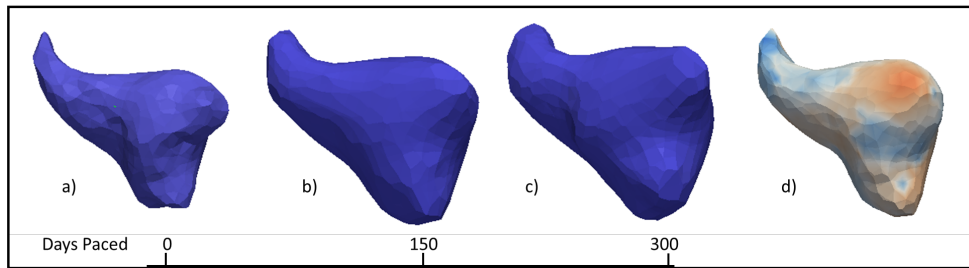
LA Shape



LAA Shape

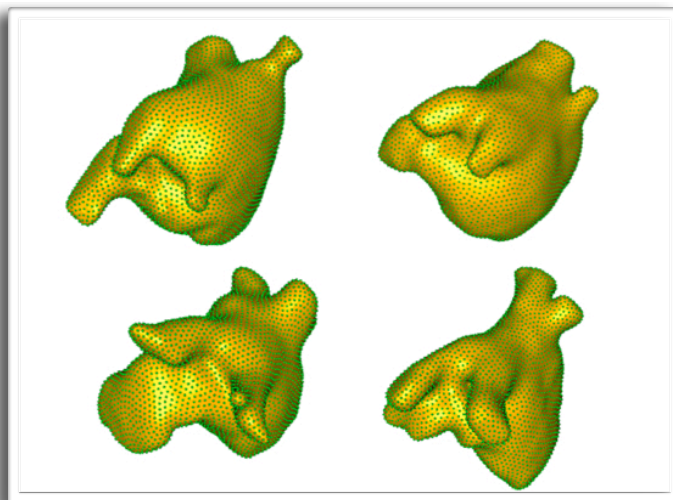


Jason Jenson



LA Shape Change over Time

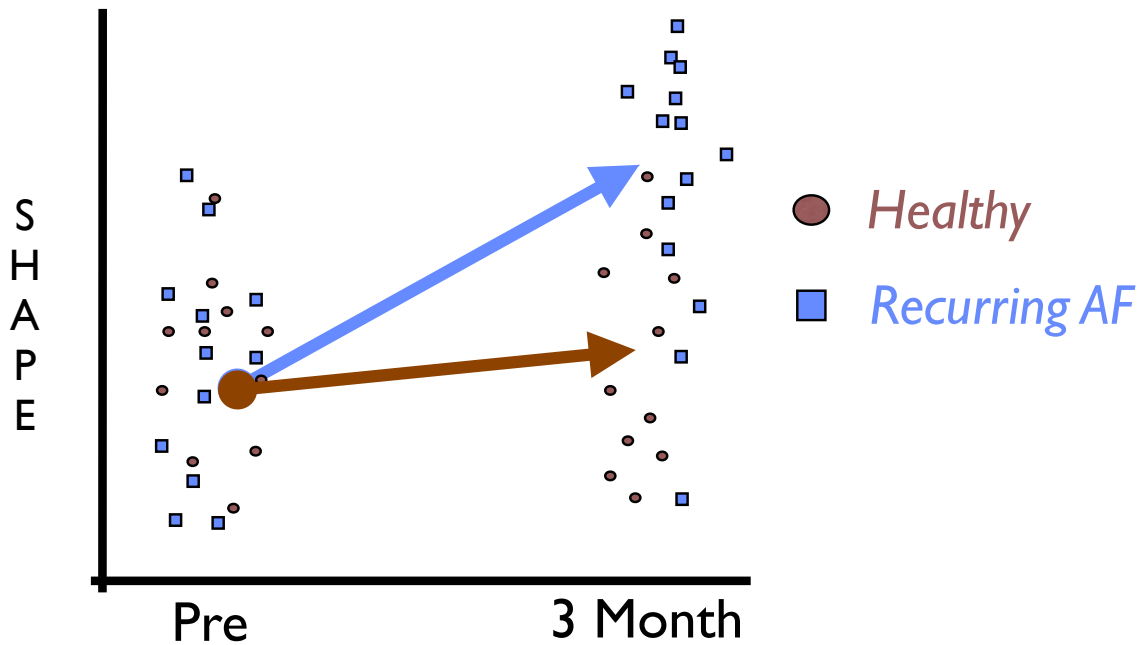
## LA Shape and Outcome



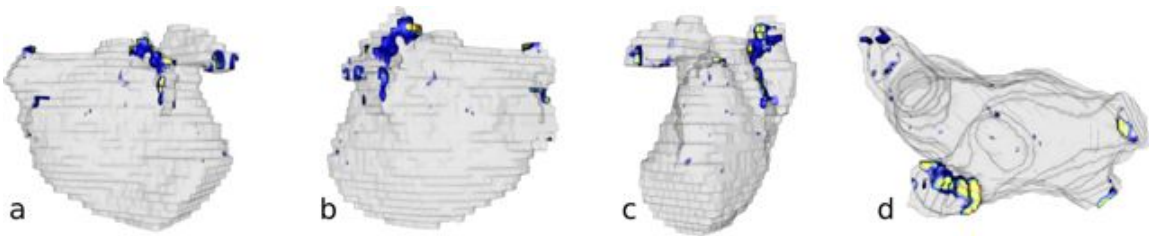
152 AF Patients

6 Shape Parameters

# LA Shape and Outcome



# Joint Shape and Image Prediction of Outcome

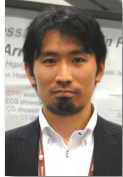


Gray: no-statistical difference. Color region: statistically different regions.

# Shape Based Registration



Greg Gardner



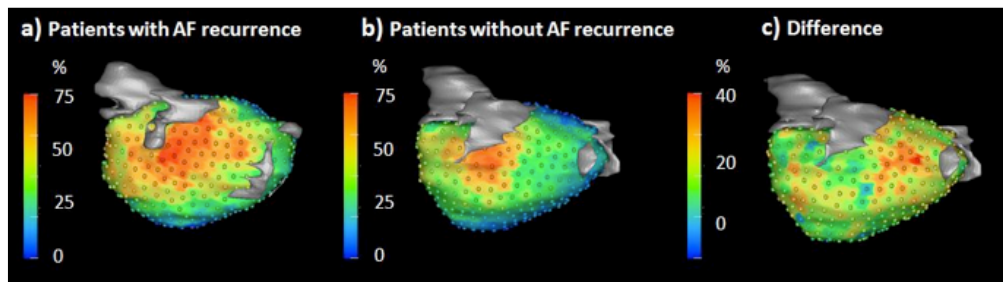
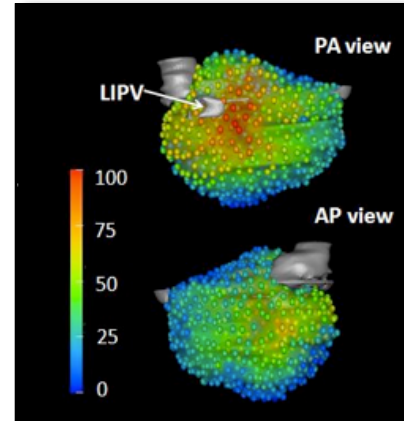
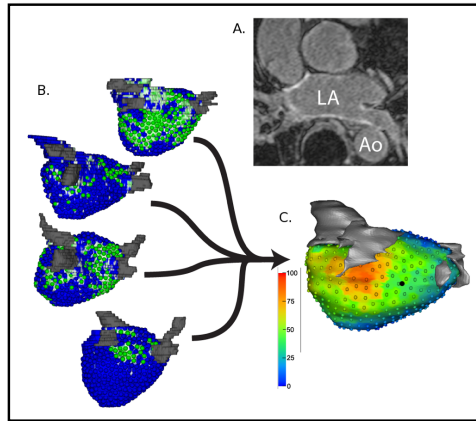
Koji Higuchi



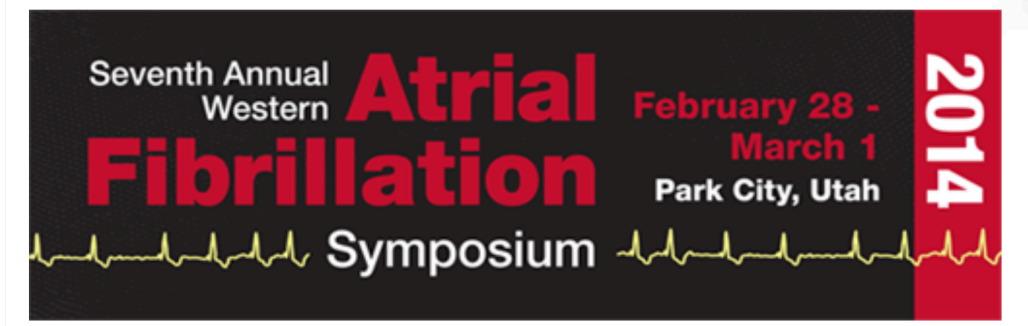
Alan Morris



Josh Cates

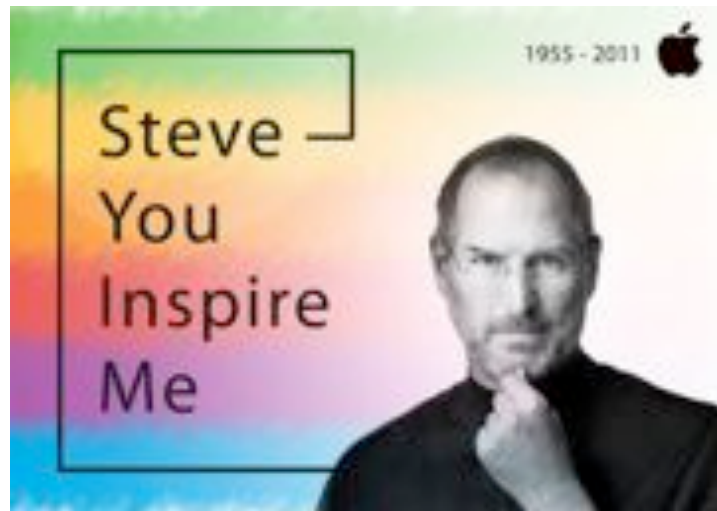


## Seventh Annual Western Atrial Fibrillation Symposium



<http://healthsciences.utah.edu/carma/education/waf>

# Visionaries



# Visionaries



**Thanks Ron!**