DBP: Image Analysis for Atrial Arrhythmias

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The CARMA Team
CARMA = Comprehensive Arrhythmia Research and Management
What We Know About AF

- Substrate Triggers
  - Pulmonary Veins
  - Left Atrium

- Myolysis
  - SR
  - AF

- Dedifferentiation
  - SR
  - AF

- Connexins
  - SR
  - Cx40
  - Cx43

- Ultrastructure
  - SR
  - AF
What We Do Not Know about AF: Everything Else

Mechanisms  Time Course  Environmental Factors  Genetics
The Million $ Mechanistic Question

Afib begets Afib

Afib is a tissue disease
Structure is Important
The CARMA Mantra

“AF is a heart tissue disease”

Normal  Early stage  Mid stage  Late stage

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

“Fibrotic Atrial Cardiac Myopathy (FACM)”

Kottkamp H: J Cardiovasc Electrophysiol 2012;23:797-799
Effective Treatment of AF
Eventually Involves Intervention

- **Triggering Foci**
  - Atrial Septum
  - Superior Vena Cava
  - Inferior Vena Cava
  - Left Atrium
  - Pulmonary Veins
  - Right Ventricle
  - Left Ventricle
  - Right Atrium

- **Ablation Catheter**
- **Mapping Catheter**
- **Superior Vena Cava**
- **Inferior Vena Cava**

- **Cardioversion patches**

Atrial fibrillation
Normal EKG

- **Atrial Fibrillation**
- **Normal EKG**
- **Cardioversion patches**
- **Rx icon**

- **Ablation Catheter**
- **Mapping Catheter**
- **Superior Vena Cava**
- **Inferior Vena Cava**

- **Pulmonary Veins**
- **Triggering Foci**

- **Left Atrium**
- **Right Atrium**
- **Left Ventricle**
- **Right Ventricle**

- **Atrial Septum**
CARMA Started Here

Enhanced (fibrosis?)

Low-voltage

Normal

Enhanced (fibrosis?)

Low-voltage

Normal
Utah Scoring Scheme: 2011

- < 5%
- 5-20%
- 20-35%
- > 35%

Fibrosis Predicts Outcome of Ablation Therapy

Recurrence by Pre-Ablation Delayed Enhancement

- Utah I
- Utah II
- Utah III
- Utah IV

Proportion of Patients in Sinus Rhythm vs. Days since Ablation

- <5% SRM
- 5-20% SRM
- 20-35% SRM
- >35% SRM
Utah Stages: Latest Edition

The graph shows the recurrence free proportion over follow-up days, with different stages indicated:

- **Utah I**
- **Utah II**
- **Utah III**
- **Utah IV**

A Log rank test indicates a statistically significant difference with a p-value less than 0.01.

Legend:

- SRM stage I (<10%)
- SRM stage II (10-20%)
- SRM stage III (20-30%)
- SRM stage IV (>30%)
It is MRI but is it Real?
Blue is Normal

Chris McGann

Amit Patel
epi
dero
Green is Fibrosis
Histology Summary

Control  AF-mix  AF-fibrosis

1a  2a  3a

1b  2b  3b

1c  2c  3c
Not All Lesions Can Be Effective

Likely Effective

Potentially Effective

Epicardial Not Effective
DE-MRI Determinant of Successful Catheter Ablation of Atrial Fibrillation (DECAAF)
Late Breaking Abstract
at
American College of Cardiology Meeting
Along Came NAMIC
### AF Specific Aims

**Registration**

- **Year 1**: Evaluate existing algorithms
- **Year 2**: Integrate linear and nonlinear registration into prototype workflow
- **Year 3**: Optimize tools, tests, and validation, documentation

**Segmentation**

- **Year 1**: Evaluate existing and implement new tools for atrial wall segmentation and for tissue characterization
- **Year 2**: Joint segmentation of pre- and post-treatment data; efficient implementations through software and hardware acceleration
- **Year 3**: Refine segmentation tools, tests and validation, integrate post-treatment image segmentation into clinical workflow, documentation

**Quantification**

- **Year 1**: Design of segmentation and registration workflow and application-specific GUI
- **Year 2**: Prototype workflow system for integrated registration and segmentation, pre-/post-analysis and visualization. Tests on existing database.
- **Year 3**: Tests on image data shared with other labs, establish database also with nonimage information for prototypical scoring system, training, and dissemination.
The CARMA AF Workflow
Implementing the Workflow
Corview to Slicer

Commercialization

Research
Slicer: Intensity Correction
Slicer: Registration
Slicer: Scar Detection
Slicer: Pulmonary Vein Removal
Slicer: CARMA Workflow

**Inputs**
- 2D Dilation
- Segment Wall
- PV Antrum Cut

**Visualization**
- Scar Detection

3DSlicer
CARMA Makes Data Available!

60 Patients with multiple MRI scans

http://www.insight-journal.org/midas
What Does CARMA Bring to NA-MIC?
Access to Image Based Medicine
Access to Data
Real World Testing

- GATECH: Segmentation of the Endocardial Wall of the Left Atrium using Local Region-Based Active Contours and Statistical Shape Learning, Gholami, et al., 2010
Dissemination

CARMA

Sixth Annual Western Atrial Fibrillation Symposium
