Paper Presentation: Measuring Left Ventricular Dyssynchrony Using ECGi

Project: Implementation of Inverse Heart Map of Absolute QRST Integral

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Group 11

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Paper Selection

Electrophysiologic substrate and intraventricular left ventricular dyssynchrony in nonischemic heart failure patients undergoing cardiac resynchronization therapy

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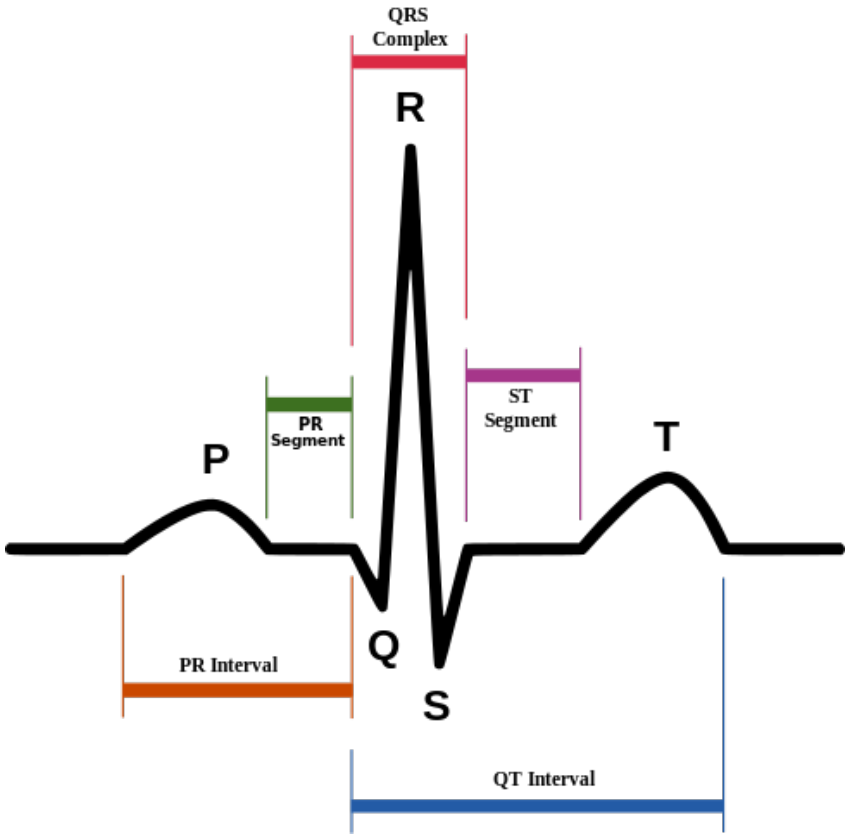
Background for Our Project

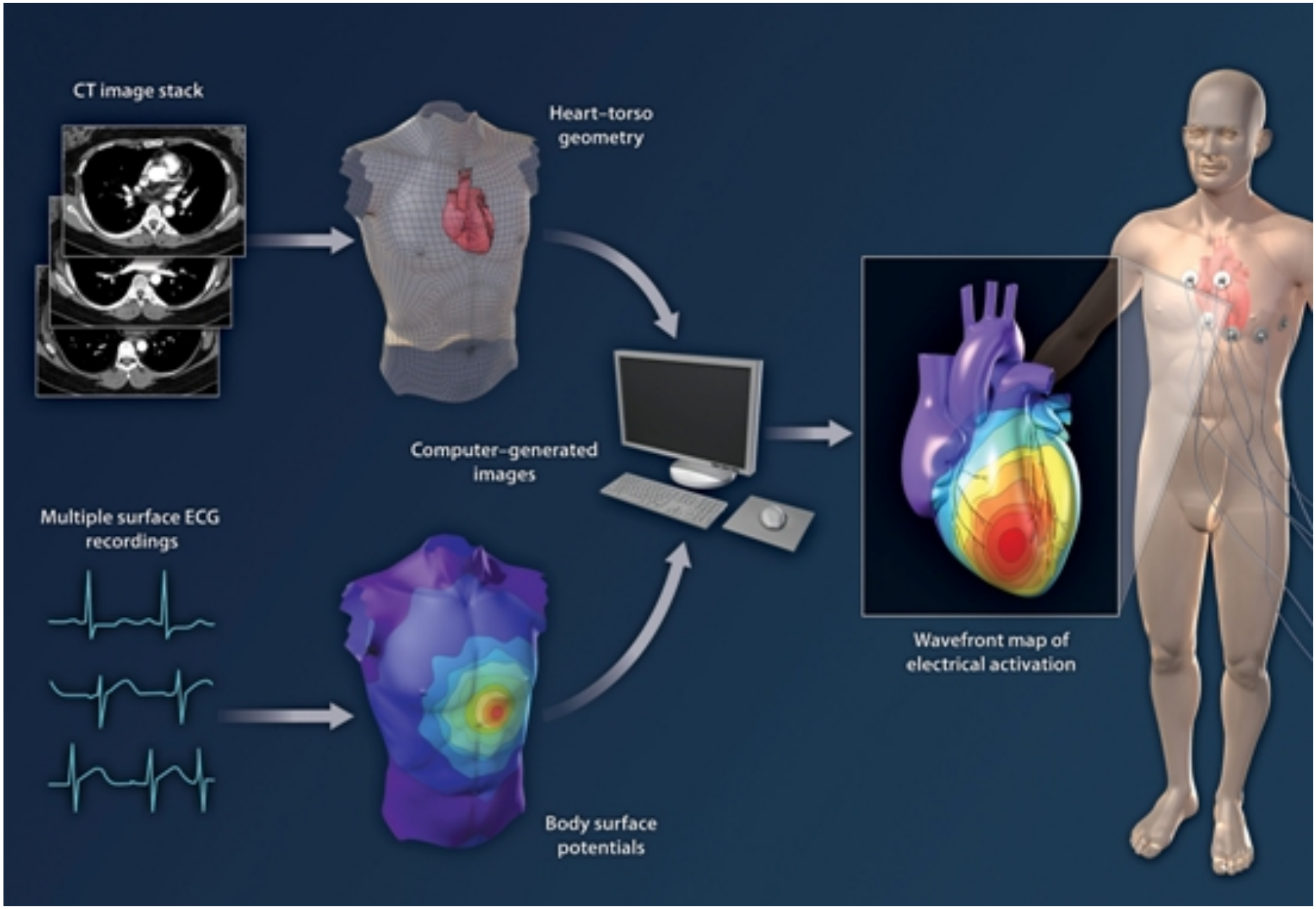
- Approximately 350,000 people die of sudden cardiac death every year in the United States [1]
- Half of all deaths caused by heart disease are sudden death [1]
- Known that ventricular arrhythmias are linked to sudden death
  - Ventricular Tachycardia: rapid coordinated contraction of the ventricles
  - Ventricular Fibrillation: rapid uncoordinated contraction of the ventricles
  - Often Ventricular Tachycardia leads to Ventricular Fibrillation which can quickly lead to sudden cardiac death

1. Lloyd-Jones D, Adams R, Carnethon M, et al. Heart disease and stroke statistics—2009 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation 2009;119:480

Background-ECGs and QRST

- ECGs are regularly used by doctors to diagnose patients with heart problems
- Normal ECG waveform:
  - P – depolarization as signal moves through atria
  - QRS – depolarization as signal moves through ventricles
  - T – repolarization of ventricles

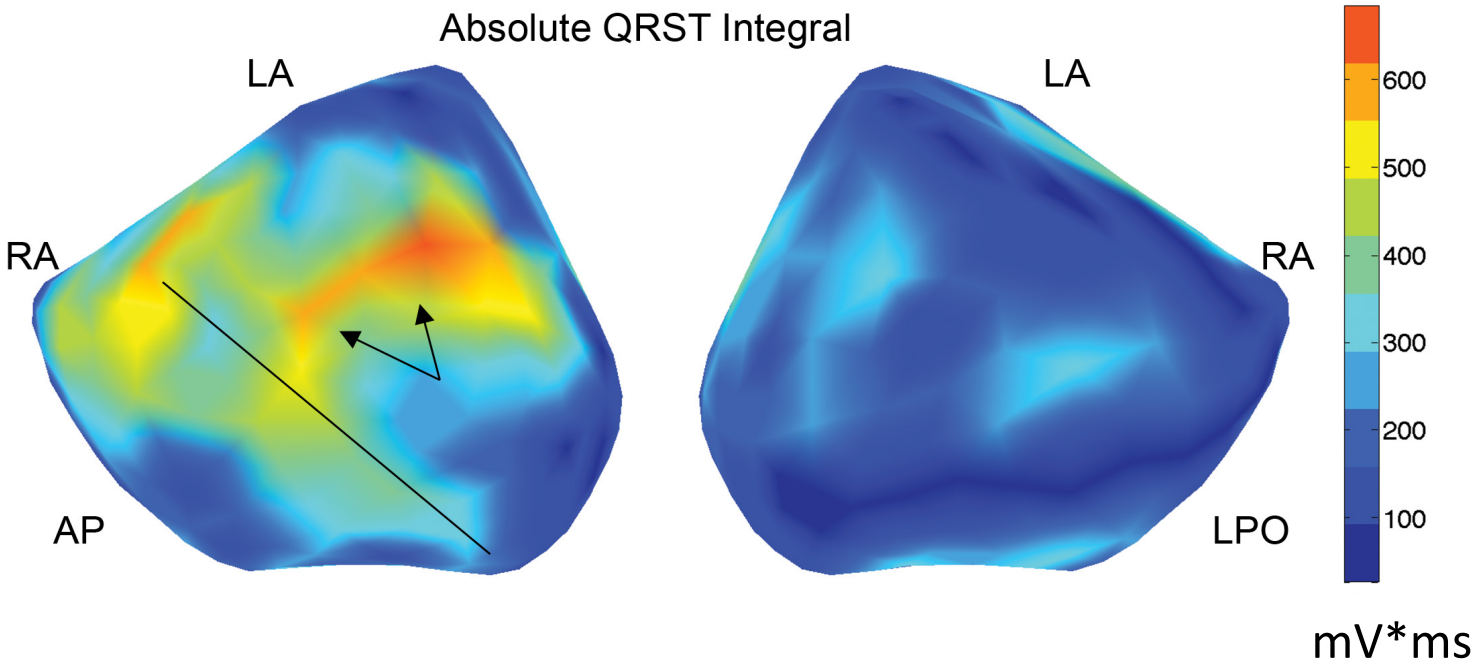




http://www.diagnosticimaging.com/cardiac/content/article/113619/1939793

Aim of Our Project

- Combine SAI QRST and body surface mapping for 120 lead data to provide a better marker for risk of ventricular arrhythmias



Potential Applications

- **Cardiac Resynchronization Therapy**
- **Better marker** for ICD implantation
  - Medicare/Medicaid use QRS duration as a measure for who they reimburse [2]

2. Highlights of Heart Rhythm 2004, the Annual Scientific Sessions of the Heart Rhythm Society J Am Coll Cardiol, 2004; 44:1550-1556, doi:10.1016/j.jacc.2004.07.039

Why ?

Our Research

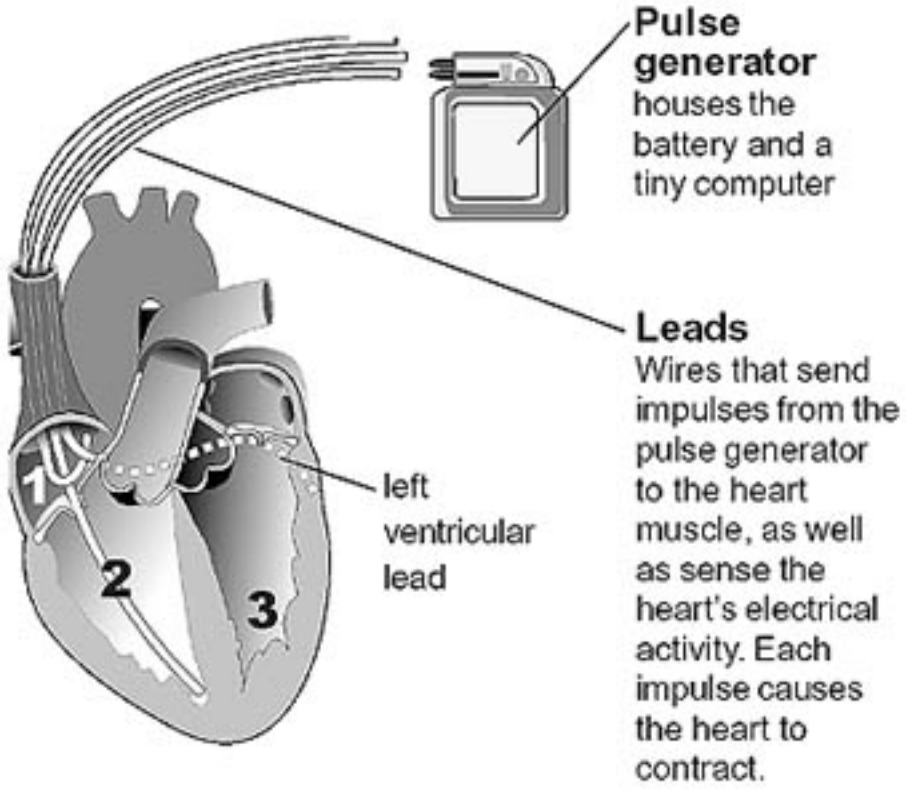
- Patients with left bundle branch block
- Heart failure (Ischemic)
- ECGi
- Measured absolute QRST

Their Research

- Patients with left bundle branch block
- Heart Failure (Non-ischemic)
- ECGi
- Measured metric of dyssynchrony

Background

- Cardiac Resynchronization Therapy
  - Biventricular pacing
  - Restore synchrony to improve mechanical performance of heart
  - Congestive heart failure patients
  - Effective in 60-70 %



http://my.clevelandclinic.org/heart/services/tests/procedures/biventricular_pm.aspx

Background

- PROSPECT[3] trials show none of echocardiographic methods are a good way to predict success CRT implants
- QRS duration deemed most relevant feature to CRT
  - Those with really long QRS (>= 130), it helped
  - In separate study improvement with patients with QRS < 120
  - Moderate range QRS it is not clear

3. Chung ES, Leon AR, Tavazzi L, et al. Results of the predictors of response to CRT (PROSPECT) trial. Circulation 2008;117:2608–2616.

Goals of study

1. **Find left ventricular (LV) substrate causing dyssynchrony in a population of nonischemic cardiomyopathy patients with CRT devices**
2. Quantitative index for LV electrical dyssynchrony and its relationship with QRS duration (QRSd)

ECGi performed the following way

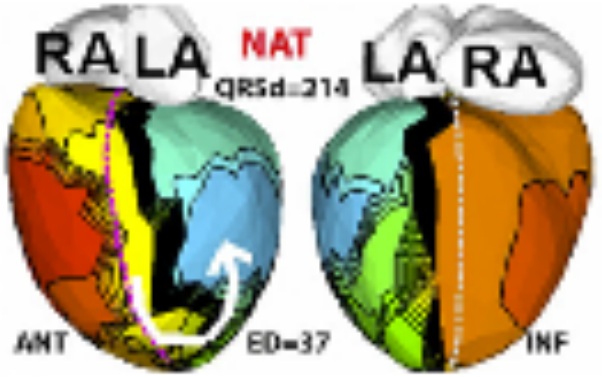
- (1) Biventricular CRT pacing
- (2) Left ventricular (LV) pacing
- (3) Right ventricular (RV) pacing
- (4) Nonpaced native rhythm (if applicable)

Methods

- The epicardial surface taken from computed tomography scan, digitized 500 points.
- Measured “degree of dyssynchrony” electrical dyssynchrony index (ED) as the standard deviation of activation times

Methods: Determining Substrate

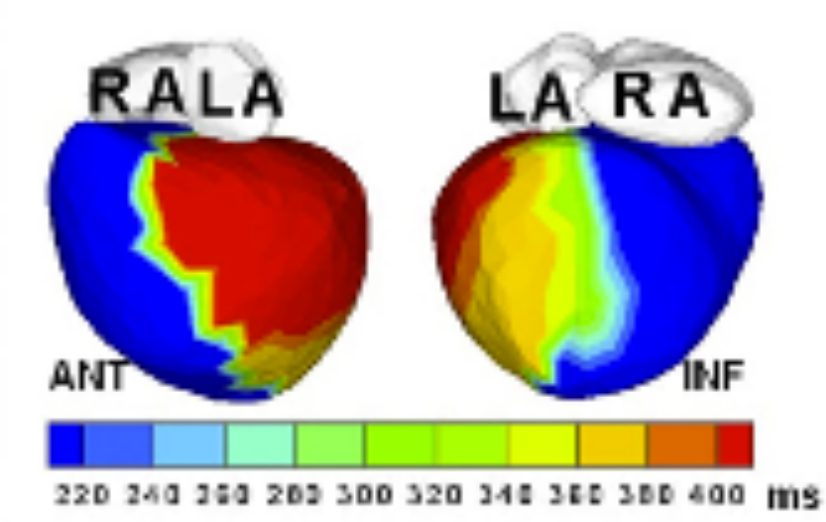
- Region of conduction block is determined if the activation times on its opposite sides differ by more than 40 ms
- Slow conduction are identified by crowding of activation isochrones



Ghosh S, Silva JN a, Canham RM, et al. Electrophysiologic substrate and intraventricular left ventricular dyssynchrony in nonischemic heart failure patients undergoing cardiac resynchronization therapy. Heart rhythm : the official journal of the Heart Rhythm Society 2011;8(5):692-9.

Methods: Determining Substrate

- Activation-Recovery Intervals are used:
  - Activation = time max steepest negative slope in the QRS
  - Recovery = max positive slope in the T wave



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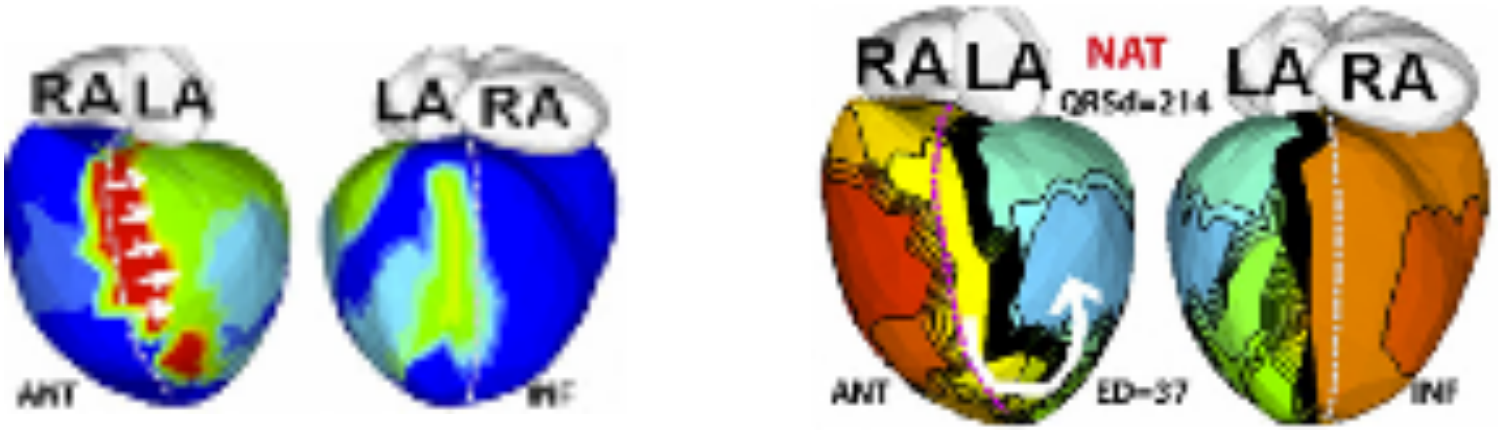
Classifying “Responders”

- Responders to CRT were identified by echocardiographic evidence of reverse LV remodeling:
  - manifest as reduction in LV volume by more than 10%
- New York Heart Association class improvement >= 1.

Results in Determining Substrate: Conduction in Responders

- Line of conduction block between septum and LV lateral wall
- Native Rhythm activation and ARI can be used to co-localize areas of conduction block



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Discussion of Determining Substrate

- Activation pattern of people with non-ischemic cardiomyopathy is similar
- Block of septum leads to slow LV activation
- Studies show invasive mappings of patients non-ischemic (dilated) cardiomyopathy similar to maps found from ECGi
- Block lines shift during pacing from RV to LV

Goals of study

1. Find left ventricular (LV) substrate causing dyssynchrony in a population of nonischemic cardiomyopathy patients with CRT devices
2. **Quantitative index for LV electrical dyssynchrony (ED) and its relationship with QRS duration (QRSd)**

Quantitative Index for Electrical Dyssynchrony

- QRSd is an estimate of the duration of global ventricular activation as reflected on the body surface ECG.
- ED is a measure of spatial dispersion of activation times across the LV

Discussion of Electrical Dissynchrony

- LV electrical dyssynchrony (ED) is high, **large QRSd**, all responders
- Low ED, **moderate QRSd**,were all four non-responders (4)
- High ED, **low QRSd**, were responders (2)
- QRSd should not be used alone as strict cut-off for CRT implantation, maybe used in conjunction with another measure such as ED.

Assessment: Significance of Results

- ECGi allows for “comparable” maps
- Maps can be used to co-localize region of block
- Maps can be qualitatively used to asses likelihood of CRT success
- ED is quantitative measure of spatial dispersion of activation
- Beneficial to use ED in conjunction with QRSd

Assessment: Critique

Good

- Detailed case-by-case maps
- Data correlates with many other similar studies done either invasively or not in humans
- Usefulness of ECGi more than one way

Bad

- Small sample (22 patients)
- Quantitative measure of location of substrate
- Not very strong correlation between QRSd and ED, the author attributed that to “the two quantities not being synonymous”

Assessment: Future Research

- Ischemic heart disease (not just non-ischemic) and ECGi
- Larger study population
- Evidence for clearer relationship between LV ED and QRSd
- LV ED is a new marker that can be used to assess CRT success ?

Questions ?