Paper Presentation: Measuring Left Ventricular Dyssynchrony Using ECGi

**Project:** Implementation of Inverse Heart Map of Absolute QRST Integral

**Sindhoora Murthy**

**Group 11**

**Mentors:** Dr. Fady Dawoud, Dr. Larisa Tereschenko, Dr. Al Lardo
Paper Selection

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

Subham Ghosh, PhD, Jennifer N.A. Silva, MD, Russell M. Canham, MD, MCS, Tammy M. Bowman, MSN, Junjie Zhang, BS, Edward K. Rhee, MD, FACC, Pamela K. Woodard, MD, Yoram Rudy, PhD, FHRS
Background for Our Project

• Approximately 350,000 people die of sudden cardiac death every year in the United States

• Half of all deaths caused by heart disease are sudden death

• 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

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
CT image stack

Heart-torso geometry

Computer-generated images

Multiple surface ECG recordings

Body surface potentials

Wavefront map of electrical activation

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 \(^2\)

---

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 (\(\geq 130\)), it helped
  - In separate study improvement with patients with QRS < 120
  - Moderate range QRS it is not clear

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

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

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

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 assess 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 ?