Evaluation of Sum Absolute QRST Integral as a Clinical Marker for Ventricular Arrhythmias

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Group 11

Selected Paper

Ventricular arrhythmia is predicted by sum absolute QRST integral but not by QRS width

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Abstract

Background: There is a controversy regarding the association between QRS width and ventricular arrhythmias (VAs). We hypothesized that predictive value of the QRS width could be improved if QRS width were considered in the context of the sum magnitude of the absolute QRST integral in 3 orthogonal leads sum absolute QRST integral (SAI QRST). We explored correlations between QRS width, SAI QRST, and VA in primary prevention implantable cardioverter-defibrillator (ICD) patients with structural heart disease.

Methods: Baseline orthogonal electrocardiograms were recorded at rest in 355 patients with implanted primary prevention ICDs (mean age, 59.5 ± 12.4 years; 279 male [79%]). Patients were observed prospectively at least 6 months; appropriate ICD therapies because of sustained VA served as end points. The sum magnitude of the absolute QRST integral in 3 orthogonal leads (SAI QRST) was calculated.

Results: During a mean follow-up of 18 months, 48 patients had sustained VA and received appropriate ICD therapies. There was no difference in baseline QRS width between patients with and those without arrhythmia (114.9 ± 32.8 vs 108.9 ± 24.7 milliseconds; $P = .230$). SAI QRST was significantly lower in patients with VA at follow-up than in patients without VA (102.6 ± 27.6 vs 112.0 ± 31.9 mV·ms; $P = 0.034$). Patients with SAI QRST (≤145 mV·ms) had a 3-fold higher risk of ventricular tachycardia (VT)/ventricular fibrillation (VF) (hazard ratio [HR], 3.25; 95% confidence interval [CI], 1.59-6.75; $P = .001$). In the univariate analysis, QRS width did not predict VT/VF. In the bivariate Cox regression model, every 1 millisecond of incremental QRS widening with a simultaneous 1 mV·ms SAI QRST decrease raised the risk of VT/VF by 2% (HR, 1.02; 95% CI, 1.01-1.03; $P = .005$).

Conclusion: QRS widening is associated with ventricular tachyarrhythmia only if accompanied by low SAI QRST.

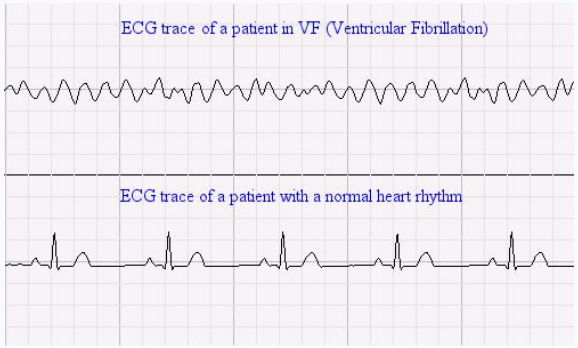
Keywords: Ventricular tachyarrhythmia; QRS; Risk stratification; Implantable cardioverter-defibrillator

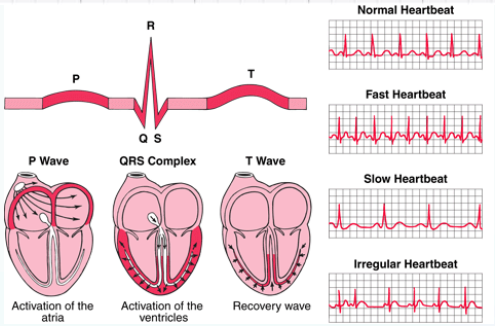
Outline

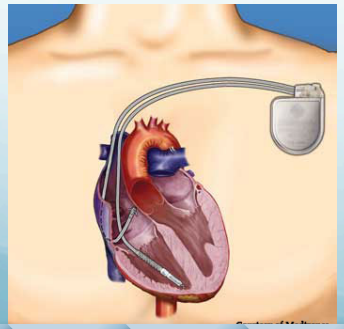
- Intro
- Background
- Paper Discussion
  - Intro of Paper
  - Methods of Paper
  - Results of Paper
  - Discussion of Paper
- My Opinion
- Future Research
- Questions

Ventricular Arrhythmia (VA) Terminology

- Ventricular Fibrillation – VF or V-Fib
  - Uncoordinated contractions of the ventricles
  - Quickly leads to sudden cardiac death if not treated with defibrillator and possibly with anti-arrhythmic drugs
- Ventricular Tachycardia – VT or V-Tach
  - Coordinated but rapid contraction of the ventricles
  - Can lead to VF and is usually treated with some combination of cardioversion, defibrillation, cardiac ablation, or anti-arrhythmic drugs
- Implantable Cardioverter-Defibrillator – ICD
  - Accomplishes same thing as external cardioversion device or defibrillator but is embedded internally







1,2: "Cricket Is Heartstoppingly Exciting after All !" Furious Purpose. Web. 14 Mar. 2012. <http://furiouspurpose.me/cricket-is-heartstoppingly-exciting-after-all/>.
3: "Merrimack Valley Cardiology Associates Defibrillator Therapy." Merrimack Valley Cardiology Associates Home Page. Web. 14 Mar. 2012. <http://www.mvcardiology.com/Services/ICD/ICD.htm>.

Why Do We Need to Measure Ventricular Arrhythmias?

- Half of all deaths caused by heart disease (leading cause of death in the US) are sudden death[1]
  - Approximately 350,000 people die of sudden cardiac death every year in the United States
- Known that ventricular arrhythmias are linked to sudden death
  - Most common cause is ventricular tachycardia that degenerates into ventricular fibrillation and without intervention this often leads to death (roughly 95%)[2]

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
2. "Sudden Cardiac Death: Primary and Secondary Prevention." – *Wake Forest Baptist Medical Center.* Web. 15.Mar.2012. http://wakehealth.edu/Health-Central/Sudden-Cardiac-Death-Primary-and-Secondary-Prevention.

Motivation and Goals for 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
  - Prognostic and diagnostic information
  - Better marker for ICD implantation
    - Current markers are ejection fraction or QRS width
    - Medicare has elected to only fund ICD implantations for patients with QRS duration over 120ms

1. "Sudden Cardiac Death: Primary and Secondary Prevention." – *Wake Forest Baptist Medical Center.* Web. 15.Mar.2012. http://wakehealth.edu/Health-Central/Sudden-Cardiac-Death-Primary-and-Secondary-Prevention.

Introduction

Ventricular arrhythmia is predicted by sum absolute QRST integral but not by QRS width

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- Still controversy about whether QRS width is associated with ventricular arrhythmias and sudden cardiac death
  - In the initial analysis of a large multicenter study on ICD implantation, there was a greater benefit for patients with QRS > 150ms rather than <120 ms
  - Future studies didn't show any relation between QRS width and arrhythmias but did show a relation between QRS width and sudden cardiac death
- Because of this controversy, the sum absolute QRST integral was proposed as a marker for VA susceptibility and a prospective cohort study was conducted to further understand the associations between SAI QRST, QRS width and ventricular arrhythmias.

Methods

- Population Studied
  - PROSE-ICD study – multicenter prospective cohort study for patients with either ischemic or nonischemic cardiomyopathy who because of their risk for SCD have an implanted ICD
    - Inclusion Criteria
      - Ejection Fraction ≤ 35%
      - Myocardial infarct > 4 weeks old
      - Nonischemic cardiomyopathy for at least 9 months
    - Exclusion Criteria
      - If ICD was implanted for secondary prevention
      - Patient with permanent pacemaker or needed pacing
      - New York Health Association class IV (severe heart failure)
      - Patients that were pregnant

Methods

- Surface ECG – before ICD implantation the QRS width was measured from standard 12-lead ECG system
- QRST integral measurement – QRS onset and end of T wave were identified by hand and then average SAI QRST was calculate from best quality lead
- End Points – Usual ICD therapies were used based on electrophysiologist's clinical evaluations and an episode of VT or VF was determined from the data recorded on the ICD

- Statistical Analysis
  - Patients were categorized into cohorts by their baseline SAI QRST value
    - Low: ≤ 69 mV·ms
    - Intermediate: 70 – 145 mV·ms
    - High: ≥ 145 mV·ms
  - Linear Regression to find correlation between QRS width and SAI QRST
  - Kaplan-Meier curves for patients with low, intermediate, and high SAI QRST values

Results

- General Patient Population Characteristics
  - Average: male, age 60, ischemic cardiomyopathy, NYHA class II-III, and narrow QRS width of 100ms
  - No noticeable difference between three strata of SAI QRST other than QRS duration which increased incrementally
  - Within 18 months, roughly 14% experiences sustained VT and ICD was used accordingly
- SAI QRST and QRS width relation
  - SAI QRST was significantly lower in patients with VA than with patients without. QRS width was roughly the same however

Results

- Survival Analysis
  - Patients with low and intermediate SAI QRST values had ~3x higher risk of VT/VF
  - QRS width did not predict ventricular arrhythmias
  - For bivariate case, each increase of QRS width by 1 second coupled with a 1mV·ms decrease in SAI QRST led to a 2% higher risk of arrhythmia
- Low and intermediate SAI QRST values predicted arrhythmia with 82% sensitivity, 41% specificity, 14% positive predictive value, and 95% negative predictive value.
- Low and intermediate SAI QRST values coupled with QRS width ≥ 124ms predicted arrhythmia with 25% sensitivity, 90% specificity, 28% positive predictive value, and 88% negative predictive values

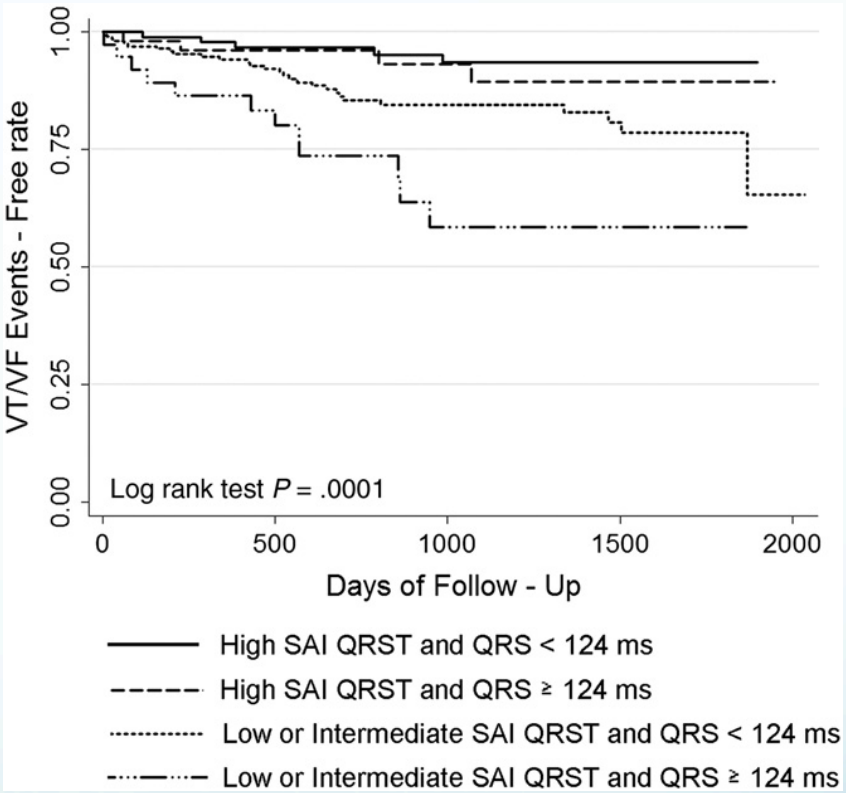

Fig. 3. Kaplan-Meier curves for freedom from VA events in patients with low, intermediate, and high SAI QRST, adjusted by QRS width.

1.Tereshchenko, L. G., Cheng, A., Fetics, B. J., Marine, J. E., Spragg, D. D., Sinha, S., Calkins, H., et al. (2010). Ventricular arrhythmia is predicted by sum absolute QRST integral but not by QRS width. Journal of Electrocardiology, 43(6), 548-52. Elsevier Inc. doi:10.1016/j.jelectrocard.2010.07.013

Discussion

- Concisely stated: “The major finding of our study is that QRS width is associated with ventricular tachyarrhythmia only if accompanied by low SAI QRST.”
- Patients without arrhythmia showed 1ms of QRS widening associated with 3mV-ms increase in SAI QRST
- Every 1ms of QRS widening accompanied with 1mV-ms SAI QRST decrease raises the risk of VT/VF by 2%.
- SAI QRST as novel predictor of VT/VF
  - 95% negative predictive power
  - 82% specificity
  - Reduced QRST value may represent cancellation of action potentials in the heart*

Follow Up Papers and Work

- Tereshchenko, et. al (2011)
  - showed SAI QRST < 69 mV-ms had 100% sensitivity and 100% negative predictive value
  - Similar conclusion that SAI QRST could be used for screening patients with low risk of VA so that they do not have an ICD implanted
    - Currently ICD implantation is over-recommended but it would be unethical to withhold ICDs to further study the death rate
  - Speculation about what low SAI QRST means
  - Patients with CRT-D (pacing and ICD capabilities) were at lower risk for VT/VF from bundle branch block over patients with ICD

My Thoughts

Pros

- Very clearly stated intro to discussion and conclusion
- Well written
  - Clear what the results were
  - Explained what could be done with the results
  - Honest about when something was unsure

Cons

- May have been lacking in methods (technical approach)
- How to implement this method for others without "customized software"
  - Essentially what our project is accomplishing
- Didn't explain Kaplan-Meier Curve "issue"
  - Appears that at long follow-up times the QRS width played no role

Future Research Ideas

- Using some corrected amplitude or variation of ECG trace as marker for arrhythmia
  - Very difficult due to patient's variations
    - Size, edema, etc.
- More research on specific conduction disorders
  - Bundle branch block, etc.
- Further elucidate relationship between SAI QRST and action potential canceling causing arrhythmias

Questions!