Change in QRS Voltage-Time-Integral with CRT Predicts Clinical Outcomes

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Background

- In patients with left ventricular (LV) electrical dyssynchrony, cardiac resynchronization therapy (CRT) reduces heart failure symptoms, hospitalization and death.
- QRS 3D-voltage-time-integral (VTI_{QRS-3D}) or 3D QRS area is a novel summary marker of LV electrical dyssynchrony.
- The prognostic role of acute change in VTI_{QRS-3D} with CRT is unclear.

Research Question

Change in which ECG parameter after CRT is instituted best predicts long-term impact of CRT?

Methods and Materials

- 209 patients who received CRT between 2014 and 2016 at KUMC, who had baseline and post CRT ECG, and baseline and 3-12 months follow-up echocardiograms.
- ECGs were converted to orthogonal X, Y, Z leads using Kors matrix.
- $VTI_{QRS-X, Y, Z}$ and VTI_{QRS-3D} were obtained by voltage-time-integral from the orthogonal leads and root-mean-squared 3D ECG, respectively.
- Linear regression models were used to evaluate change in ECG parameters with institution of CRT as predictors of 3-12 month post-CRT improvement in LV ejection fraction (LVEF).

Table. Association of characteristics with change in LVEF after CRT

Variable	Distribution (N=209)		Δ LVEF, % (Overall 10.5 ± 10.5) Univariate models		Δ LVEF, % Multivariate models*
	Mean ± SD or %	p-value	β-coefficient	p-value	p-value
Age, years	68.2 ± 12.1		0.02/10-yr	0.97	
Female	34%		0.50	0.5	
Baseline LVEF, %	26.1 ± 8.3		-2.16/10%	**0.01**	
QRS morphology				**0.004**	
Left bundle branch block	46%		11.2 ± 10.5		
Right ventricular paced	14%		16.4 ± 10.5		
Other	40%		7.7 ± 9.7		
Baseline QRS duration, ms	151 ± 25		0.41/10-ms	0.16	
Δ QRS frontal plane axis, °	Median 65 (IQR 20-126)	**<0.0001**	0.18/ 10°	0.17	
Δ QRS duration, ms	-15.7 ± 25.1	**<0.0001**	-0.46/10-ms	0.11	
Δ QRS voltage-time-integral, □Vs					
X	-19 ± 48	**<0.0001**	0.19/10-□Vs	0.22	
Y	-1 ± 52	0.8	0.27/10-□Vs	0.053	
Z	-41 ± 55	**<0.0001**	-0.43/ 10-□Vs	**0.001**	**0.04**
3D	-31 ± 50	**<0.0001**	-0.48/ 10-□Vs	**0.0008**	**0.04**

LVEF, left ventricular ejection fraction
* Adjusted for age, sex, baseline LVEF, QRS morphology

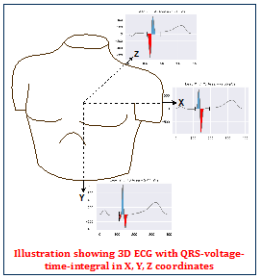
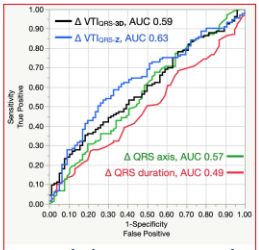


Illustration showing 3D ECG with QRS-voltage-time-integral in X, Y, Z coordinates



ROC curves for changes in ECG parameters after institution of CRT predicting post-CRT absolute improvement in LVEF ≥5%

Results

- Δ VTI_{QRS-Z} and Δ VTI_{QRS-3D} predicted improvement in LVEF, and remained significant after adjustment for age, sex, baseline LVEF, QRS morphology and duration.
- Both Δ VTI_{QRS-Z} and Δ VTI_{QRS-3D} further predicted heart failure hospitalizations
  - HR for ≥25 μVs reduction in Δ VTI_{QRS-Z} 0.42 (95% CI 0.26, 0.74, p=0.004)
  - HR for ≥20 μVs reduction in Δ VTI_{QRS-3D} 0.64 (95% CI 0.42, 0.97, p=0.04)

Conclusion

A larger reduction in QRS Z-axis or 3D-voltage-time-integral with CRT is associated with subsequent salutary LV reverse remodeling and reduced heart failure hospitalizations.

Acknowledgement

This research was supported by the KUMC Research Institute. The content is solely the responsibility of the authors and does not necessarily represent the official views of the KUMC Research Institute.

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Presented at: American College of Cardiology Scientific Sessions, Atlanta, GA, May 15-17, 2021