

# Change in QRS 3D-Voltage-Time-Integral Predicts Response to Cardiac Resynchronization Therapy in Pacing-Induced Cardiomyopathy



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## Background

- In patients with pacing-induced cardiomyopathy, cardiac resynchronization therapy (CRT) reduces heart failure symptoms, hospitalization and death.
- QRS 3D-voltage-time-integral (VTI<sub>QRS-3D</sub>) or 3D QRS area is a novel ECG summary marker of left ventricular (LV) electrical dyssynchrony.

## Research Question

Does change in VTI<sub>QRS-3D</sub> with CRT predict subsequent improvement in LV ejection fraction (LVEF)?

## Methods

- 114 patients who received CRT 2014 - 2018 at KUMC, who had baseline and post CRT ECG, and baseline and 3-12 month follow-up echocardiograms.
- ECGs were converted to orthogonal X, Y, Z leads using Kors matrix and VTI<sub>QRS-3D</sub> obtained from root-mean-squared 3D ECG.
- 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 LVEF.

## Results

- Increase in LVEF was predicted by larger baseline VTI<sub>QRS-3D</sub> (p=0.03) but not baseline QRS duration (p=0.2), see Table.
- Reduction in both QRS duration and VTI<sub>QRS-3D</sub> with CRT predicted increase in LVEF (both p=0.03), but only reduction in VTI<sub>QRS-3D</sub> remained statistically significant (p=0.02) in multivariable models.

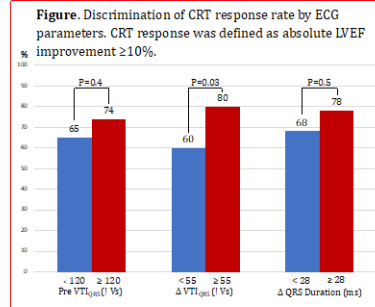
**Table.** Predictors of change in LVEF after cardiac resynchronization therapy upgrade in patients with pacing induced cardiomyopathy

Variable	Distribution (N=114) mean ± S.D.	Δ LVEF	
		Univariate models β - coefficient	Δ LVEF Multivariate models* p-value
Age, years	73.6 ± 11.0	-0.52 / 10 year	<b>0.06</b>
Female	30 (26%)	3.2	0.2
LVEF (baseline), %	29.2 ± 8.1	-3.8 / 10%	<b>0.001</b>
QRS duration (baseline), ms	168 ± 25	-0.52 / 10 ms	0.2
Δ QRS duration, ms	-28 ± 26	-0.85 / 10 ms	<b>0.03</b>
VTI <sub>QRS-3D</sub> (baseline), μVs	133 ± 52	0.23 / 10 μVs	<b>0.03</b>
Δ VTI <sub>QRS-3D</sub> , μVs	-61 ± 54	-0.41 / 10 μVs	<b>0.03</b>

LVEF, left ventricular ejection fraction; VTI<sub>QRS-3D</sub>, QRS 3D voltage time integral  
\*Adjusted for age, sex, baseline LVEF

## References

- Noheria, A., Sodhi, S. & Orme, G. J. The Evolving Role of Electrocardiography in Cardiac Resynchronization Therapy. *Curr Treat Options Cardiovasc Medicine* 21, 91 (2019).
- dePoorter, J. et al. Biventricular Paced QRS Area Predicts Acute Hemodynamic CRT Response Better Than QRS Duration or QRS Amplitudes. *J Cardiovasc Electr* 28, 192-200 (2017).
- Olafotun, O. et al. Changes in QRS Area and QRS Duration After Cardiac Resynchronization Therapy Predict Cardiac Mortality, Heart Failure Hospitalizations, and Ventricular Arrhythmias. *J Am Heart Assoc* 8, e013539 (2019).
- Ghoshsein, M. A. et al. Reduction in the QRS Area after cardiac resynchronization in therapy is associated with survival and echocardiographic response. *J Cardiovasc Electr* 32, 813-822 (2021).



## Conclusion

In patients with pacing-induced cardiomyopathy, the reduction in QRS 3D-voltage-time-integral with CRT independently predicts improvement in LVEF.