A Multi-Scale Investigation of Global Electrical Heterogeneity: Effects of Body Habitus, Respiration, and Tissue Conductivity.

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Extracardiac factors such as respiration, fluid overload and body habitus have an important effect on the electrocardiogram (ECG) voltage. Vectorcardiographic (VCG) Global Electrical Heterogeneity (GEH) parameters are associated with sudden cardiac death (SCD). Risk of SCD is especially high in end-stage renal disease patients (ESRD) on dialysis. However, extracardiac factors challenge ECG interpretation in ESRD patients. The effects of extracardiac factors on GEH have not been fully studied.

In this study, we use a multi-scale (in silico and clinical observational cohort) approach to investigate the effects of extracardiac factors such as respiration, tissue conductivity and body habitus on VCG and GEH in ESRD patients on dialysis. First, the prospective cohort Predictors of Arrhythmic and Cardiovascular Risk in End-stage renal disease (PACE) data was analysed. Overall, 254 subjects from the PACE cohort (mean age 54.6±13.5y; 56% male; 79% African American) were included in this study. Then, a previously developed three dimensional biophysically detailed heart-torso human computational model was used to simulate VCG and GEH under various conditions. To assess the effects of extracardiac factors, tissue conductivity and heart position (body habitus) were varied in the computational model.

GEH parameters (spatial QRS-T angle, spatial ventricular gradient (SVG) magnitude, azimuth, and elevation, and SAI QRST) were calculated for both experimental and simulated data. GEH software code and equations are provided at: https://physionet.org/physiotools/geh./

The table summarizes and compares relative percentage of changes for both experimental and simulated effects on respiration, tissue conductivity and heart position on GEH parameters and QRS and T-wave VCG magnitude. Non-linear effects on the QRS and T-wave VCG amplitude versus tissue conductivity were observed and warrant further investigation.

Extracardiac factors have main effects in the ECG voltage and direction of the vectors obtained from the VCG loops. Therefore, they must be taken into account in future ECG studies.

Table. Relative percentage of changes on the GEH parameters due to respiration, heart position and tissue conductivity.

	Respiration		Body type	Thorax conductivity
	Experimental	Simulated	Simulated	Simulated
SAI	3.5%	3.8%	50%	48%
QRST	2.4%	4.6%	81%	13%
Wilson-SVG mag	5.7%	9.4%	22%	7.3%
SVG elev	1.3%	9.3%	42%	2.6%
SVG azi	18%%	3.7%	80%	6%
QRS mag	6.4%	7.6%	2.9%	32%
T mag	1.9%	3.3%	7.7%	36%