INVESTIGATING THE EFFECT OF ANATOMICAL VARIABILITY ON THE ECG USING MRI-BASED COMPUTER MODELS OF THE HUMAN HEART AND TORSO

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INTRODUCTION

The most used, non invasive clinical tool is the 12-lead electrocardiogram (ECG) that records the electrical activity of the heart over time. However, the impact of anatomical and structural human heart differences on the ECG biomarkers is not well understood

Aim

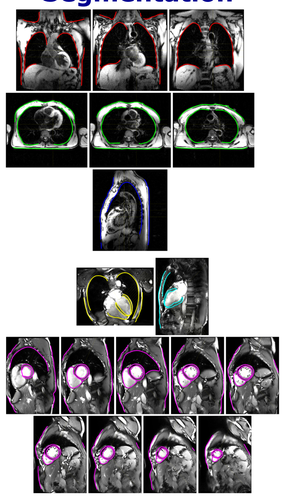
To investigate how anatomical variability of the heart/torso in a cohort of normal subjects affects QRS complex.

Hypothesis

The QRS complex in control subjects is affected by shape and orientation of the heart within the torso.

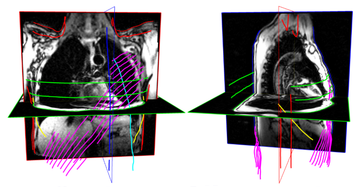
METHODS: FROM MRI TO HEART AND TORSO ANATOMIES AND ELECTROPHYSIOLOGICAL SIMULATIONS

Segmentation

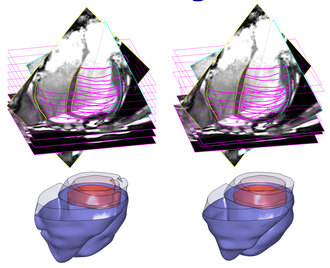


Segmentation of the torso and LV and RV of the heart

3D arrangement

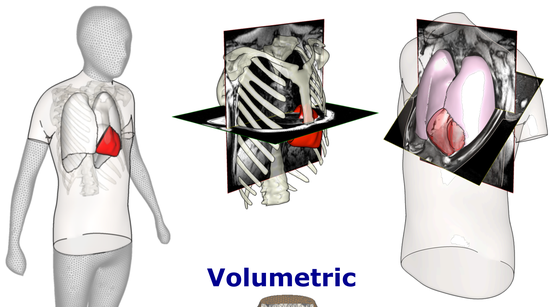


Contours Alignment

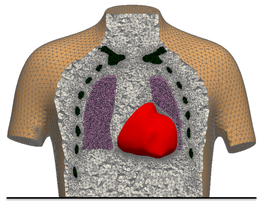


Heart contours are corrected for breath-induced misalignments

Surface and Volumetric Meshes



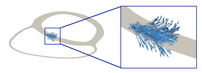
Volumetric



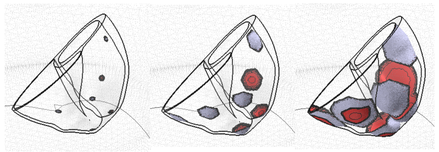
Geometries showing good agreement with the MRI

Fixed parameterization of the electrical simulations

- Membrane kinetics: O'Hara Rudy model
- Transmural, apex-to-base and interventricular heterogeneities



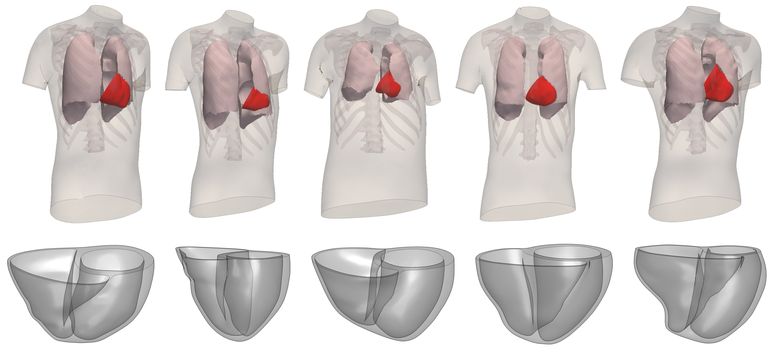
Streeter-based fibre directions



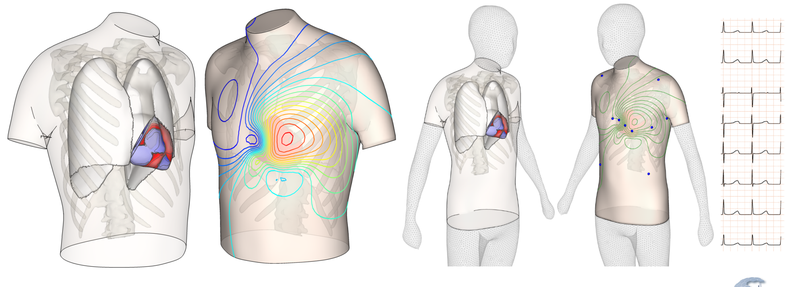
Fixed Activation Sequence mapped for each heart

RESULTS

Personalized Geometrical Models



Electrophysiological Simulations

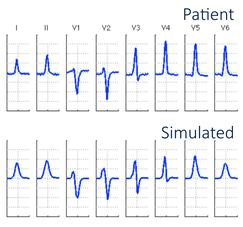


Simulations from ionic level to whole organ and to body surface potentials and ECG using Chaste software

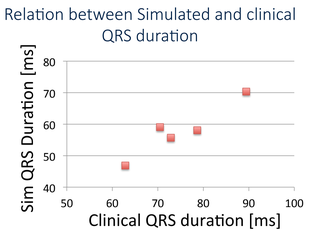
Chaste

Relation between Clinical and Simulated ECGs

ECG example

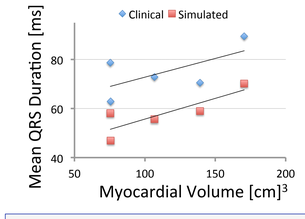


Clinical vs Simulated

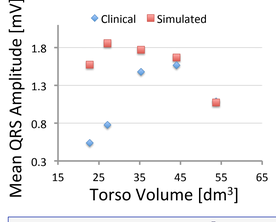


Good correlation between QRS duration in simulations and experiments based only on anatomy.

Effect of anatomical features on QRS



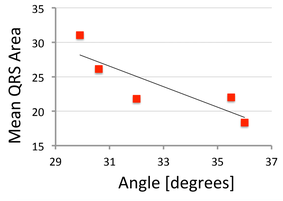
↑Heart Volume → ↑QRS width



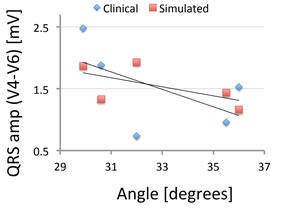
↑Torso Volume → ↓QRS amp

Larger myocardium volume results in prolonged QRS

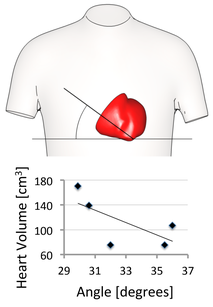
Effect of heart orientation on QRS



↑Vertical → ↓QRS area



↑Vertical → ↓QRS amp



A more vertical heart results in smaller QRS area and QRS peak-to-peak amplitude

CONCLUSIONS

This study investigates the dependency of the QRS complex with the MRI-based heart/torso geometries using personalised computer models.

- Increase in Heart Volume results in a higher QRS duration in both simulations and Clinical data
- The orientation of the heart affects the QRS morphology.
- More vertical hearts are related to smaller heart volumes.

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