

Numerical modeling of the electrical activity of the atria and the pulmonary veins

Simon Labarthe, Yves Coudière, Jacques Henry

▶ **To cite this version:**

Simon Labarthe, Yves Coudière, Jacques Henry. Numerical modeling of the electrical activity of the atria and the pulmonary veins. Workshop IHU Liryc, Oct 2013, Pessac, France. hal-00926441

HAL Id: hal-00926441
https://inria.hal.science/hal-00926441

Submitted on 9 Jan 2014

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Numerical modelling of the electrical activity of the atria and the pulmonary veins.

SIMON LABARTHE, YVES COUDIÈRE, JACQUES HENRY
simon.labarthe@u-bordeaux2.fr, yves.coudiere@inria.fr, jacques.henry@inria.fr

INTRODUCTION : NUMERICAL MODELLING FRAMEWORK

Pre-processing *Parameters setting* → **Numerical model** → **Post-processing** *Medical or biological ensight*

Monodomaine :

$$\underbrace{\alpha(C_m\partial_t V + I_{ion}(V))}_{\text{electrophy.}} + \underbrace{divD\nabla V}_{\text{coupling}} = \underbrace{I_{app}}_{stim}$$

INPUTS

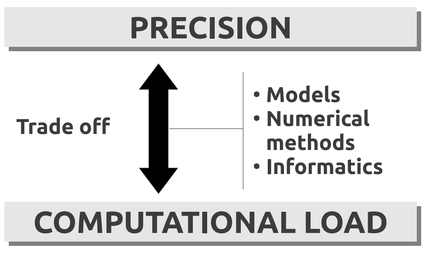
- **Electrophysiology** : ionic models
- **Tissue anisotropy and coupling**
- **Anatomy** : IRM, fibres.
- **Stimulation** : SAN, trigger, electrode...

OUTPUTS

- **Potential maps** : V_m, Φ_i, Φ_e.
- **Electrophysiolocial ensights** :

EGM / ECG	PA, $\partial V/\partial t_{max}$
Activation maps	Ionic currents
...	...

TRADE OFF

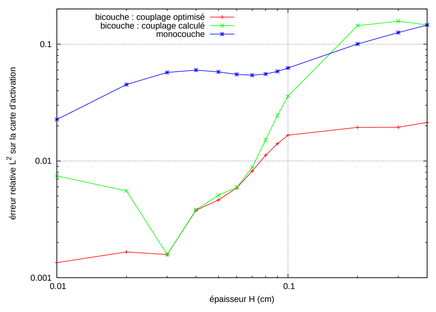


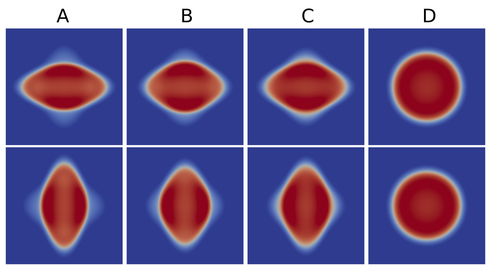
DERIVATION OF MATHEMATICAL MODELS

BILAYER SURFACE MODEL

- Three-dimensional behaviours for 2D computational load.
- Asymptotic analysis ⇒ Second order convergence.

$$\underbrace{\alpha(C_m\partial_t V_k + I_{ion}(V_k))}_{\text{electrophy.}} - \underbrace{divD\nabla V_k}_{\text{coupling}} + \underbrace{(-1)^k\hat{\sigma}\frac{V_2 - V_1}{h^2}}_{\text{coupling}} = \underbrace{I_{app}}_{stim}$$



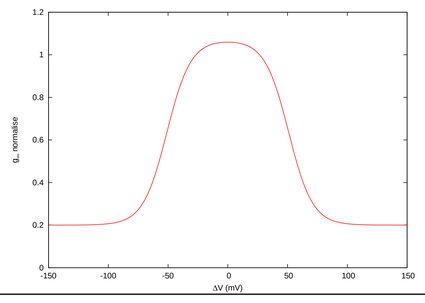


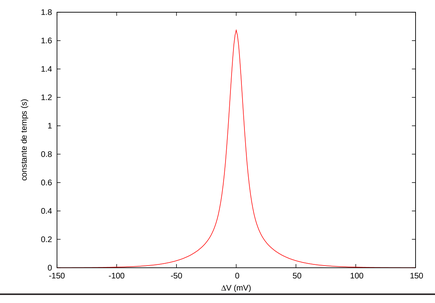
HOMOGENIZATION WITH GAP JUNCTIONS NON LINEAR DYNAMICS

- GJ conductance:

$$G_{GJ} = G_{max}w_0$$
$$\partial_t w_0 = \frac{w_\infty(V) - w_0}{\tau(V)}$$

$$\beta\left(C_m\partial_t\phi_0 + I_{ion}(\phi_0)\right) - \partial_x\left(\tilde{\sigma}(w_0)\partial_x\phi_0\right) = 0$$
$$\partial_t w_0 + H\left(\mu(1-\tilde{\sigma}(w_0))\partial_x\phi_0, w_0\right) = 0$$

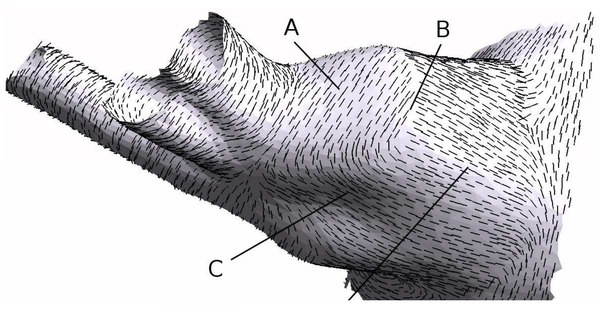


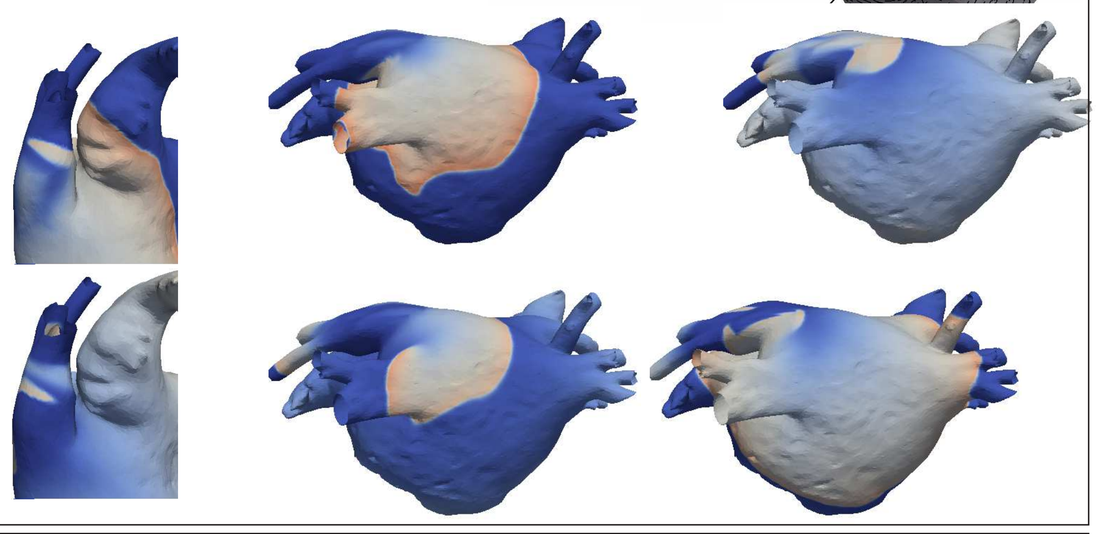


ARRHYTHMIA TRIGGERS IN THE PV

FIBRES DISCONTINUITY

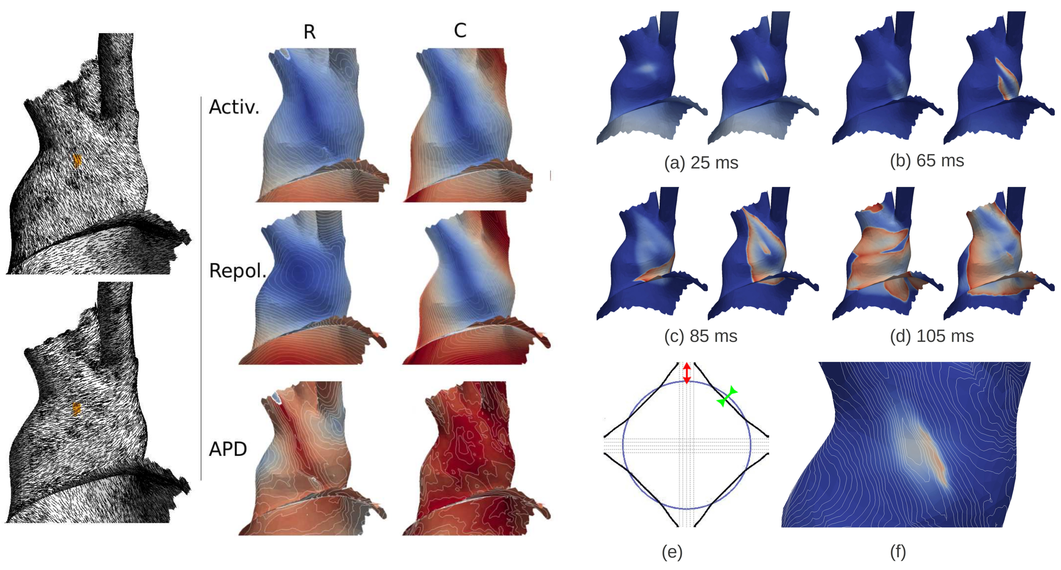
- Bloc in LSPV
- Micro reentry in LSPV ⇒ Macro reentry in LA.





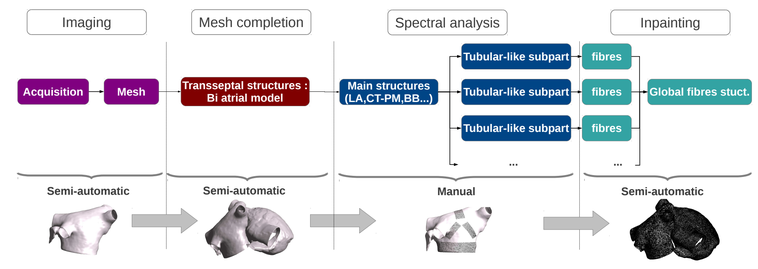
TRANSMURAL FIBRES DISCTONTINUITY

Different dynamics during depolarization and repolarization ⇒ APD gradient ⇒ functional substrate of arrhythmia.

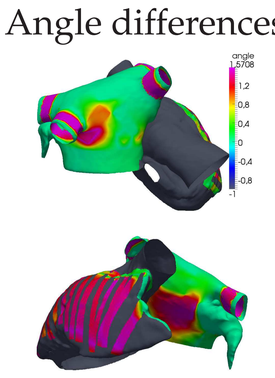


ARRHYTHMIA PERPETUATION IN THE ATRIA

BIATRIAL BILAYER MODEL OF HUMAN ATRIA



Angle differences

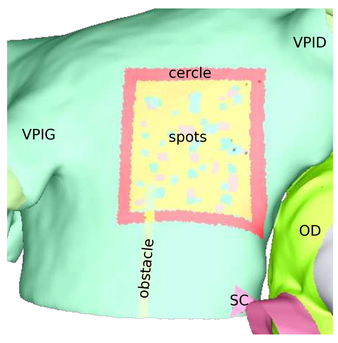


Activation times differences



Mono. vs. bilayer — Endo vs epi

EFFECT OF TRANSMURAL FIBROSIS AND ABLATION.



- Transmural fibrosis ⇒ Stabilization effect on a macro-reentry.
- Ablation protocol. Most efficient: surrounding line or line bloc to the closest natural obstacle. Less efficient: ablation spots.
- Non transmural ablation are still efficient.

PERSONALIZATION

