

Vorteces in left atrial appendage

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Outline



What is LAA?



CC Patrick Lynch and Carl Jaffe ale University, 2006







Four types of morphology

Thrombi

complex geometry.

Atrial fibrillation



AF disrupts coordinated contraction in the LAA,

leading to blood stasis and creating ideal conditions for thrombus formation, which can lead to strokes.









Motivation

Prevalence of Atrial Fibrillation in Older Adults (85-89 years)



1997-2017 Next 30 Years

Marked increase in Projected continued AF incidence rise in AF cases

- Expensive treatment
- Predictive models

Goals

01 Segment patients Get 3D LAA models - we had 24 patients data

Simulate Solve models for LAA with Q-criterion

03

02

Prediction Quantify Q-criterion and try predicting strokes



Methods





- 24 patients
- -All AF
- -All with heightened risk factors -Some of them had stroke
- -two cardiologists agreed on 7/80 morphologies





After manual segmentation

Automatic segmentation of blood in heart

Geometry adjustments



Process of preparing ports A creating edge B smoothing edge C cutting the course part D and E remashing

> After several iterations of smoothing, remeshing and manually fixing mesh problems



Simulation in COMSOL (finally)

- Simplifications:
- 10 l/min
- Walls dont move at all
- No heartbeat
- No-slip BC
- Time dependent study
 - Step function for 1 s
 - 6 seconds simulated



Simulation in COMSOL (finally)

- Model settings:
- Turbulent model (SST)
- Extruded inlets/outlets
- Inlets Simple velocity
- Outlets Simple pressure





Mesh

- Biology structures are difficult to mesh
- No boundary layers





Q-criterion

- We take the volume where Q > 70 and divide it with the volume of the LAA
- Additionally, we find the maximum velocity of the blood inside the LAA and

$$\Omega = \frac{1}{2} (\nabla u - \nabla u^T)$$

$$S = \frac{1}{2} (\nabla u + \frac{1}{2})$$

$$Q = \frac{1}{2} (|\Omega|^2 - |S|^2)$$

 ∇u^T)

1.5 1.4 1.3 1.2 1.1

$$Q = 0.5 \cdot (spf.rr^2 - spf.sr^2)$$



Results



How much of LAA volume is filled with vortexes above specific Q value?

K-means clusters dependent on velocity and Q volume above Q>70



Results

- Velocity inside the LAA is minimal compared to the rest of the atrium
- Different geometries tend to have different main currents
- Currents interact with LAA







Conclusion





Seems to vary wildly with the same initial conditions and does differentiate well the LAAs



4 Morphologies

The usual anatomical morphologies does not seen to have relevance on the Q-criterion



Maximum speed

Maximum speed does not correlate with Q-criterion and can be used as additional measure



Bad news

We like science so we do not know if the predictions were correct.

Thanks



Do you have any questions?

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