BioCFD Tutorial: part 1

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CFD implementation of a carotid bifurcation model in Ansys Fluent

1. Setup a CFD steady state model using Fluent for the carotid mesh given
2. Build a finer mesh using the grid adaption tool in Fluent
3. Implement the following BC settings:
   - Vin=0.25 [m/s]
   - Pout=0 [Pa]
   - No-slip at the wall
4. Perform a sensitivity analysis for the two mesh (use the gold-standard.txt file as reference values)

Notes

- Consider the starting mesh as small and the new adapted one (8x) as the medium
- The reference mesh is 64x the small one
- Data to monitor:
  - Pressure drops
  - Mean wss at the wall boundary
  - Mean velocity at the in/out boundary

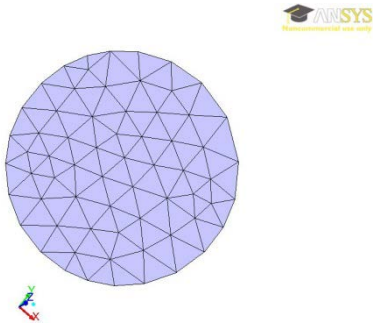
Proposed solution

Sensitivity analysis

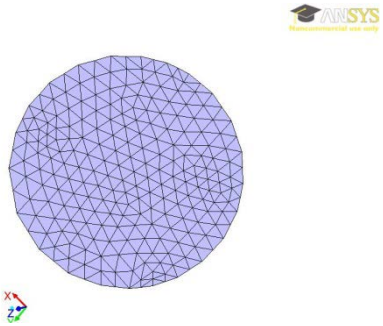
3 mesh size starting from small and adapting the mesh (preserving mesh topology):

- 200000 cells (small)
- Small x8 (medium) about 1.5 milions cells
- Small x64 (large) about 13 milions cells

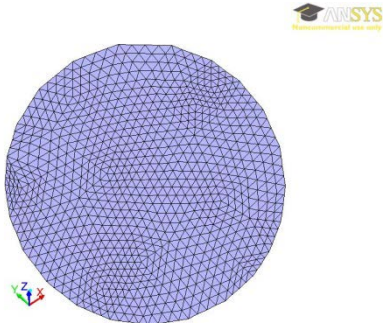
CCA SECTION



small



medium



large

Steady bc setup

cca=0.25 m/s velocity inlet (flat profile)

NOTE:
Over the cycle the cca velocity waveform measure in vivo give these values:
Vmean=0.22
Vmax=0.42
Vmin= 0.14

ica=60% CCA mass-flow-inlet (unkwnon profile)

eca= stress-free pressure-outlet

Solver:
Relaxation

Variable	Relaxation Factor
Pressure	0.69999999
Density	1
Body Forces	1
Momentum	0.30000001

Pressure-Velocity Coupling

Parameter	Value
Type	SIMPLE

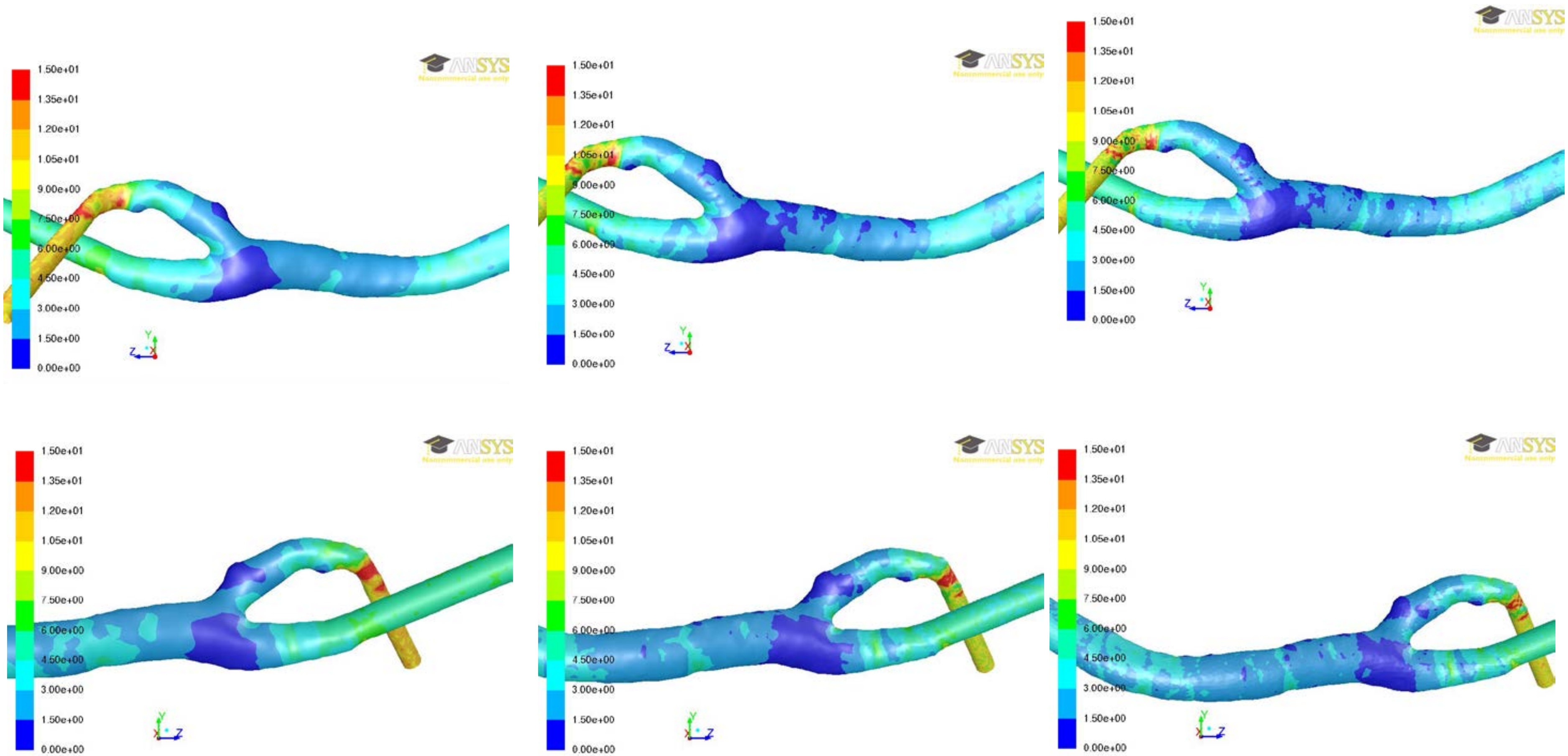
Discretization Scheme

Variable	Scheme
Pressure	Linear
Momentum	First Order Upwind

Blood modeled as Newtonian incompressible

section	area [m2]	Mass Flow Rate[kg/s]	flow-split [%]
cca	2,76E-05	0,001461937	100,00
eca	6,39E-06	-0,000344199	23,54
ica	1,43E-05	-0,001117742	76,46

Qualitative results: WSS contours



small

medium

large

Quantitative results: % differences

reference gs: large mesh

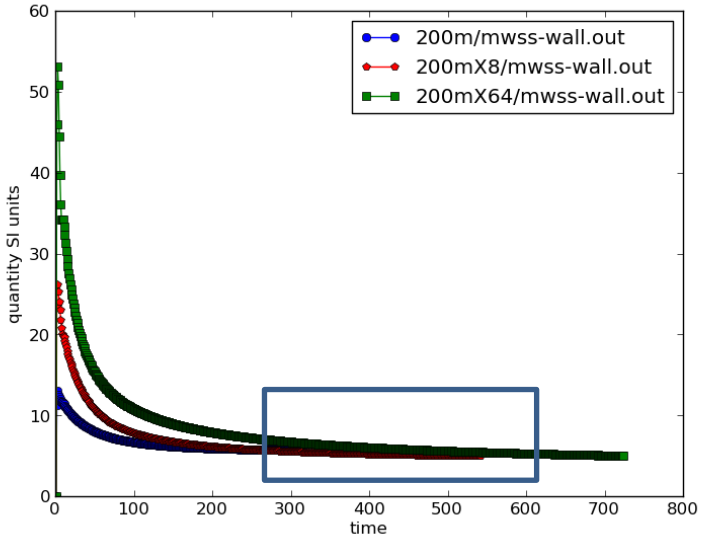
mwss-wall.out value: 5.02539491653 SI units
('13.971%', '1.0796%')

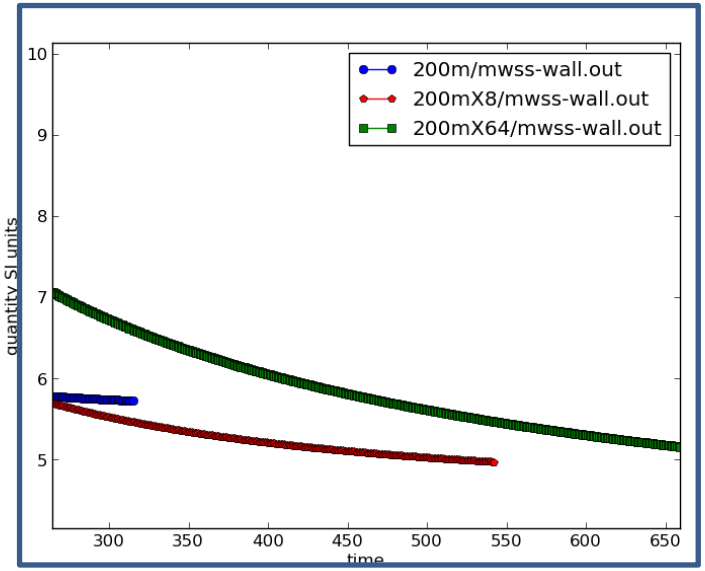
mp-ica.out value: 304.780517578 SI units
('8.6610%', '0.9809%')

mp-cca.out value: 671.123291016 SI units
('7.8149%', '3.0713%')

mfr-eca.out value: -0.00276838662103 SI units
('-0.000%', '-0.000%')

maxwss-wall.out value: 45.5586471558 SI units
('37.703%', '33.721%')





Result

The medium size mesh is a valid compromise between accuracy and feasability for WSS computations and study.

Verify flow split without imposing the 60/40 division (geometry is the driving parameter)