ANGIOPLASTY SUMMIT
TCTAP 2011
TRANSCATHETER CARDIOVASCULAR THERAPEUTICS ASIA PACIFIC

Coronary Bifurcation Summit
CBS 2011
Nanjing Heart Center

Go Along With the Flow

---Role of computational flow dynamic

Jing Kan, MBBS

Nanjing First Hospital

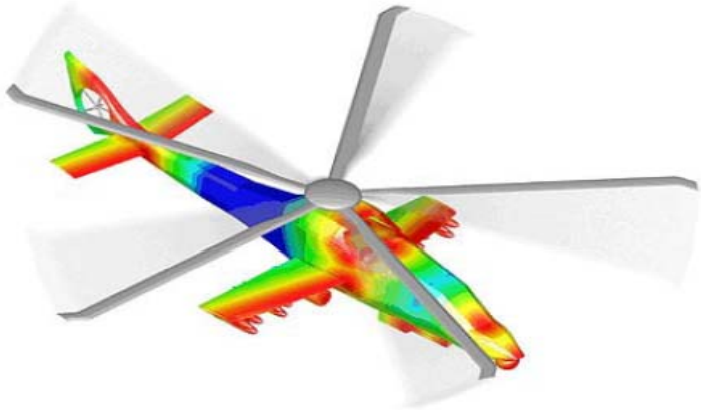
Nanjing Medical University

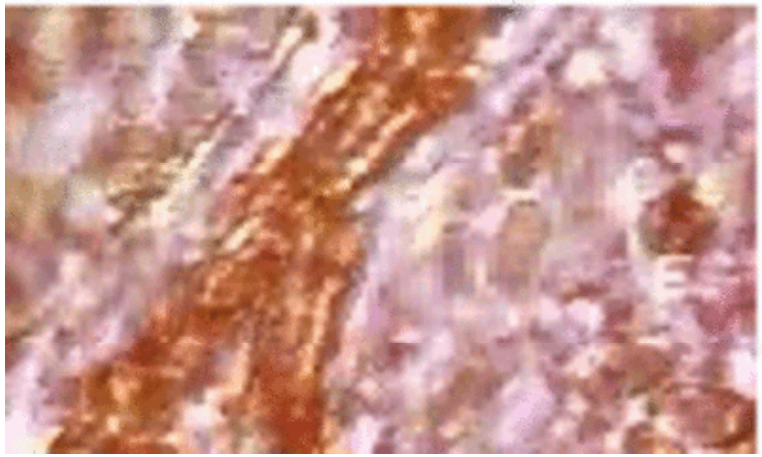
Subject

- **What is the CFD?**
- **The CFD and hemodynamics**
- **Role of wall shear stress**
- **Calculate wall shear stress**

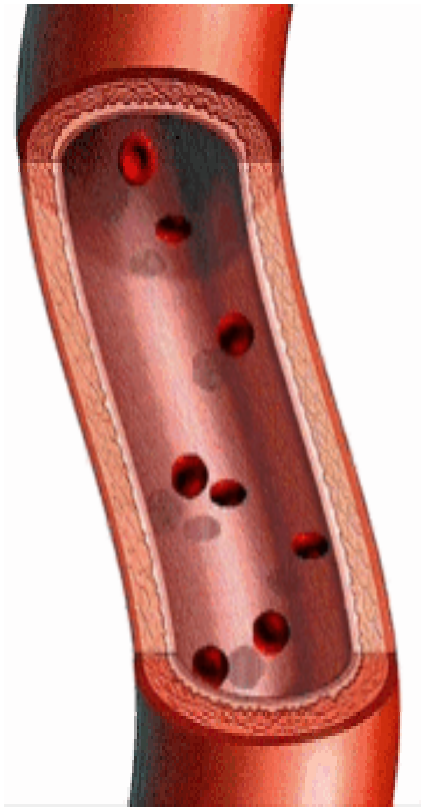
What is the CFD?

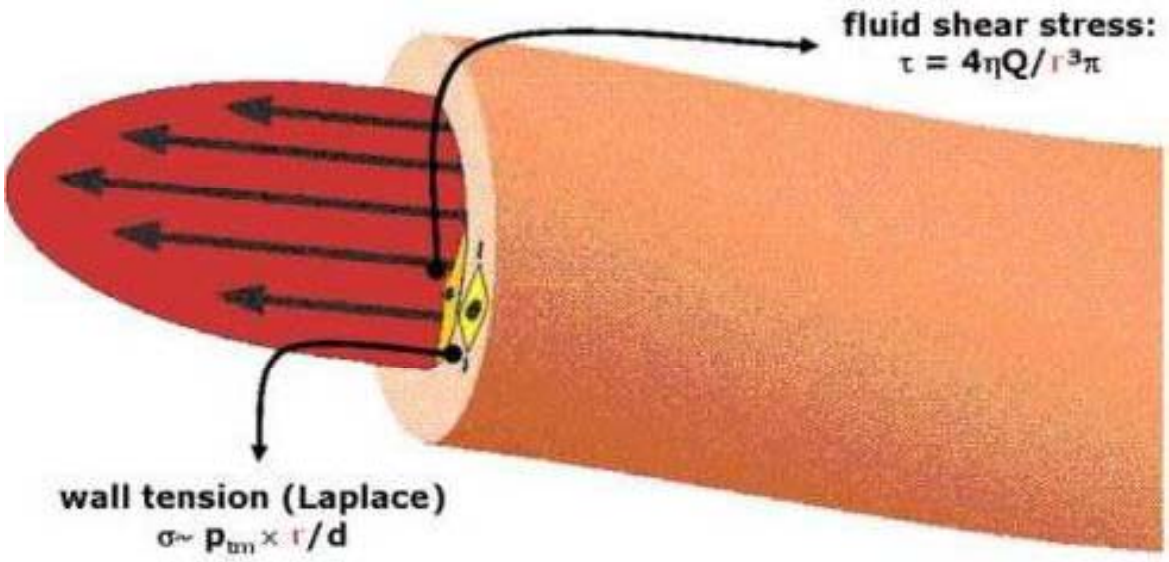
Using numerical method to solve the "flow" problems





Hemodynamics





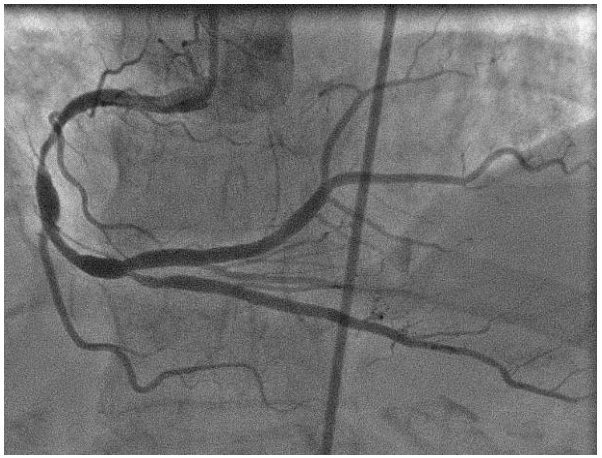
μ : **Blood viscosity**

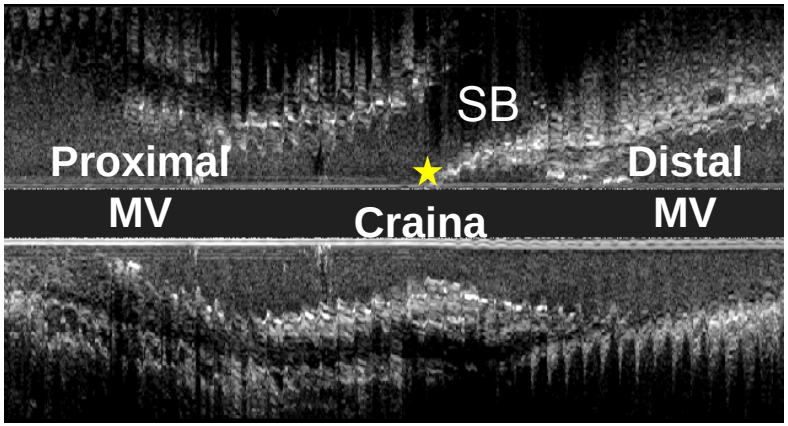
Q: **The total volume flow**

r: **The lumen radius**

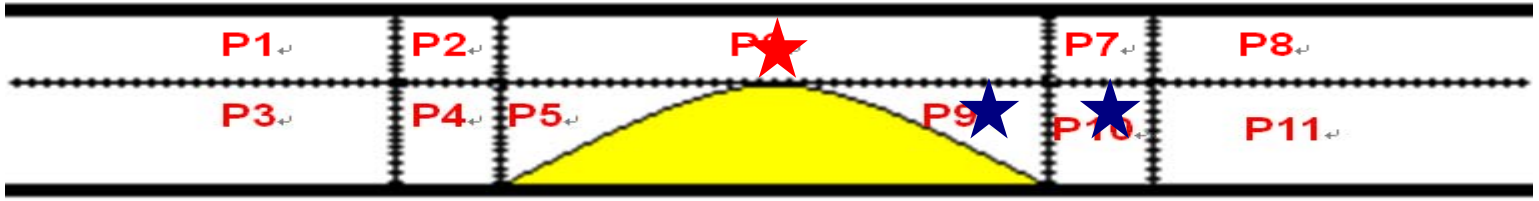
Role of Wall shear stress

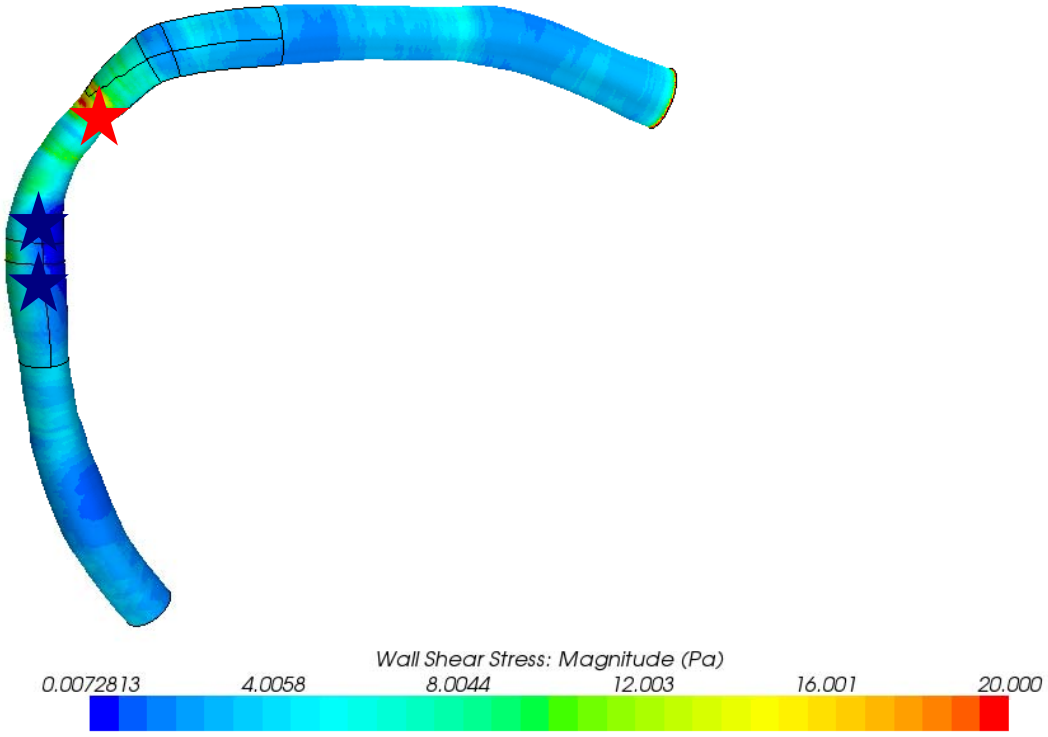
The low and oscillating wall shear stress in curved or bifurcated coronary artery increases intimal thickness and leads to development or progression of the atherosclerotic plaque





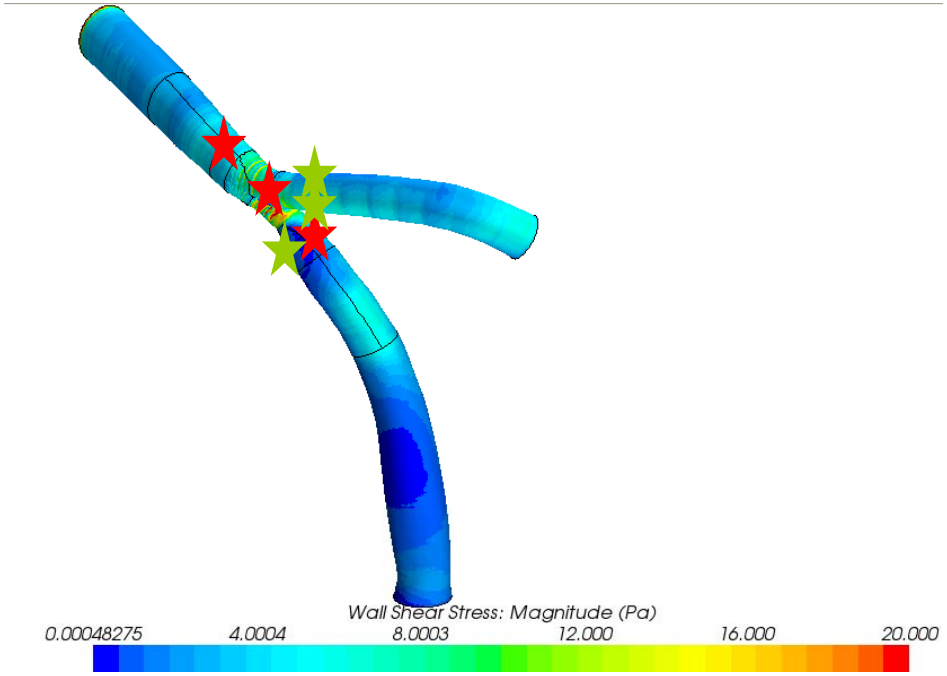
Role of Wall shear stress

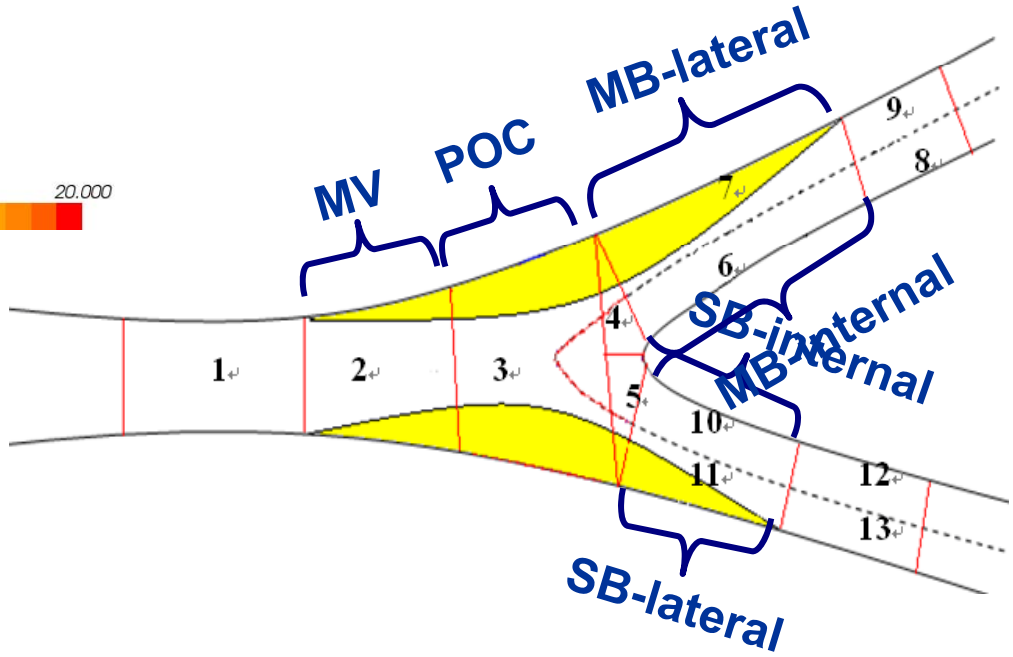




Chen et al, J Interven Cardiol 2010; 12:123-128

Role of Wall shear stress



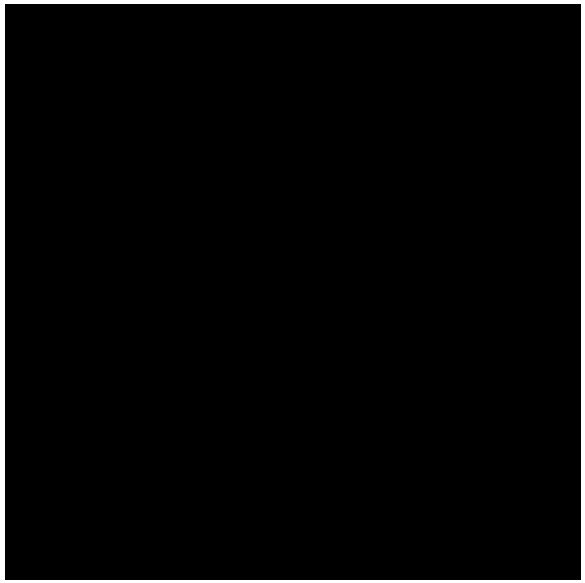


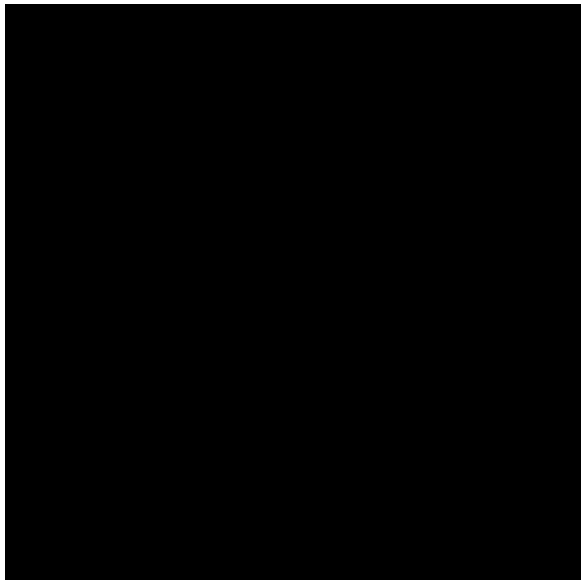
Chen et al, J Interven Cardiol 2010; 12:130-135

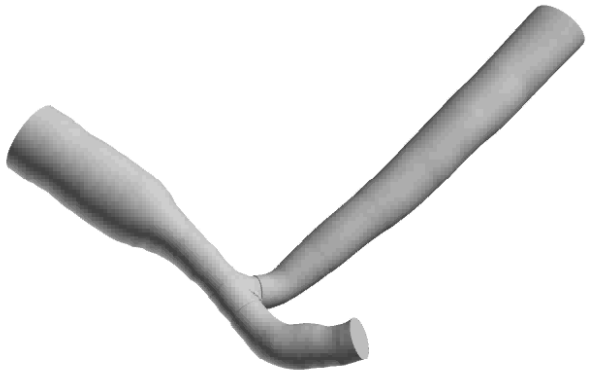
Calculate WSS

- **Select boundaries to analyse**

How Does It Work?







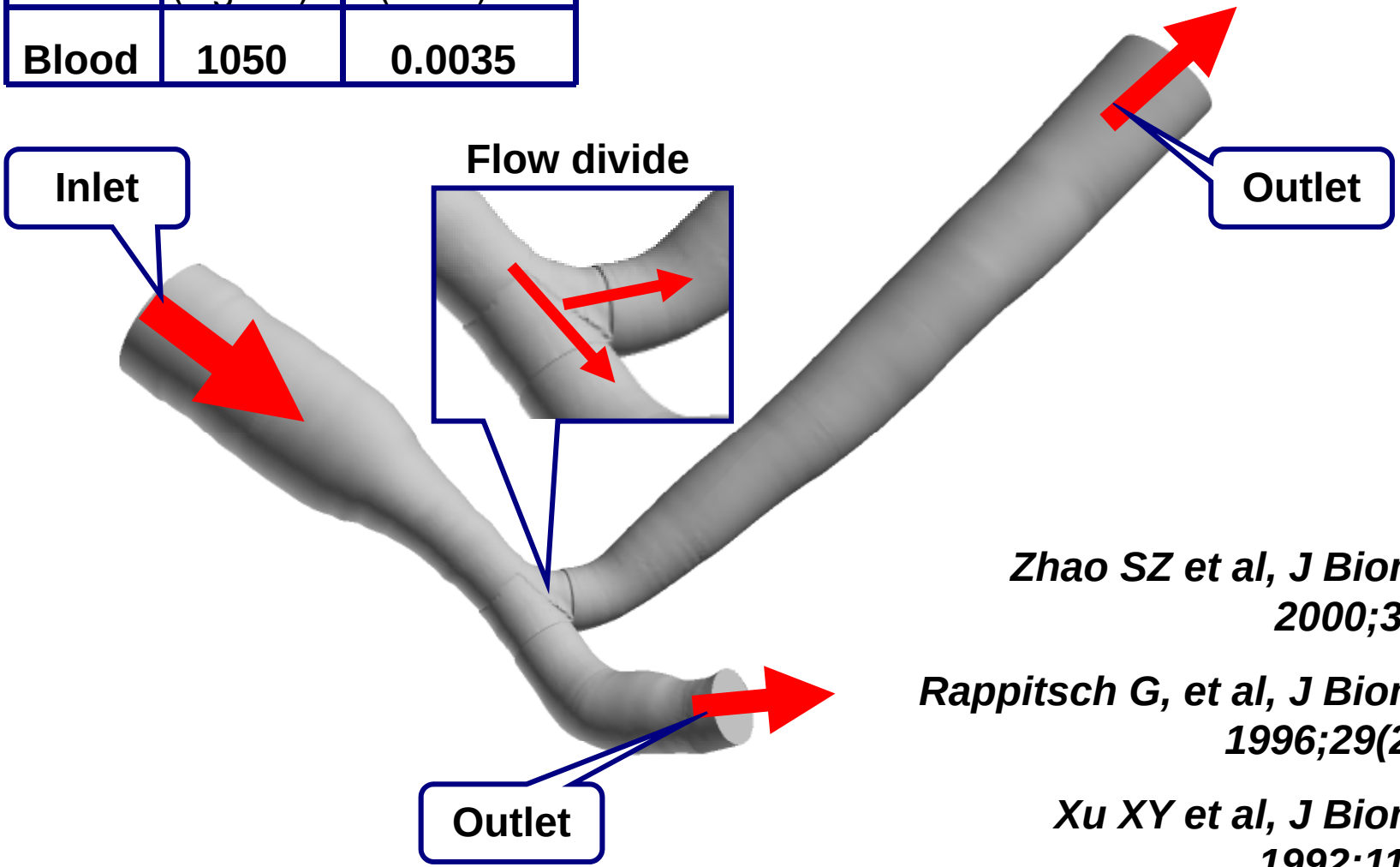
CAAS QCA 3D 5.8 computed a 3-dimensional model of the vessel segment under investigation based on two different projection images of the coronary bifurcation. The angle between the two images had to be at least 30 degrees

Calculate WSS

- **Select boundary to analyse**
- **Description of blood physics**

How Does It Work?

	Density (Kg/m^3)	Viscosity (Pa·s)
Blood	**1050**	**0.0035**



Zhao SZ et al, J Biomechanics 2000;33:975-984.

Rappitsch G, et al, J Biomechanics 1996;29(2):207-215.

Xu XY et al, J Biomechanics 1992;114:504-511.

How Does It Work?

Estimation of turbulent or laminar modle

$Re = \rho v L / \mu$

ρ: Blood Density

v: Blood velocity

L: The lumen diameter

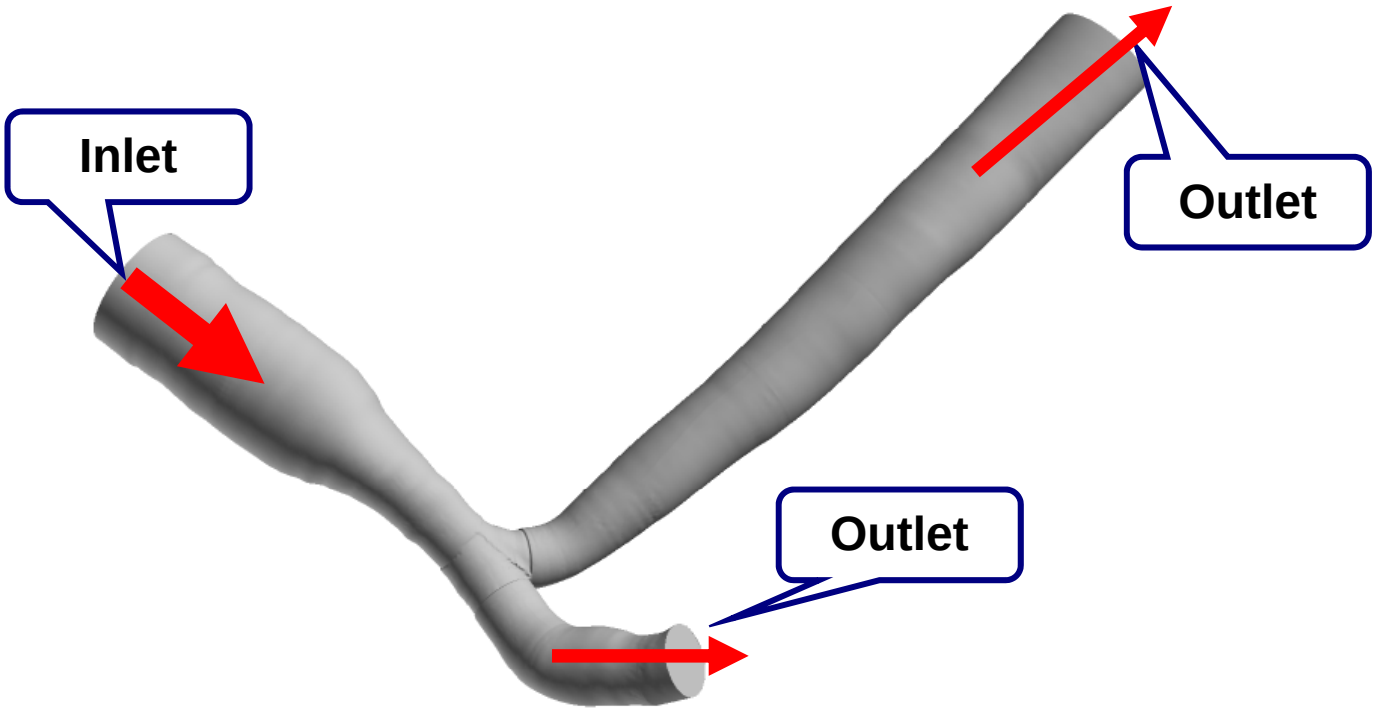
μ: Viscosity

A typical Reynolds number ＜2000, defined as steady laminar flow

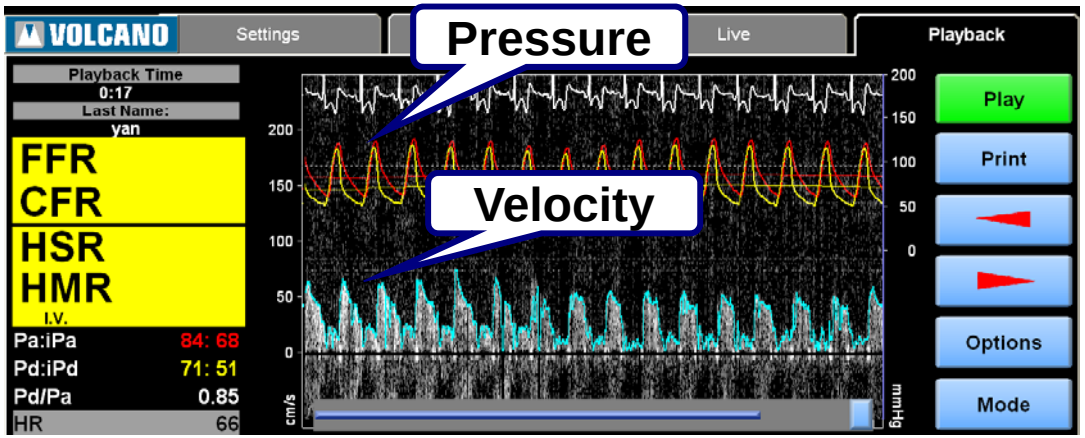
Calculate WSS

- Select boundary to analyse
- Description of blood physics
- Set boundary conditions

How Does It Work?

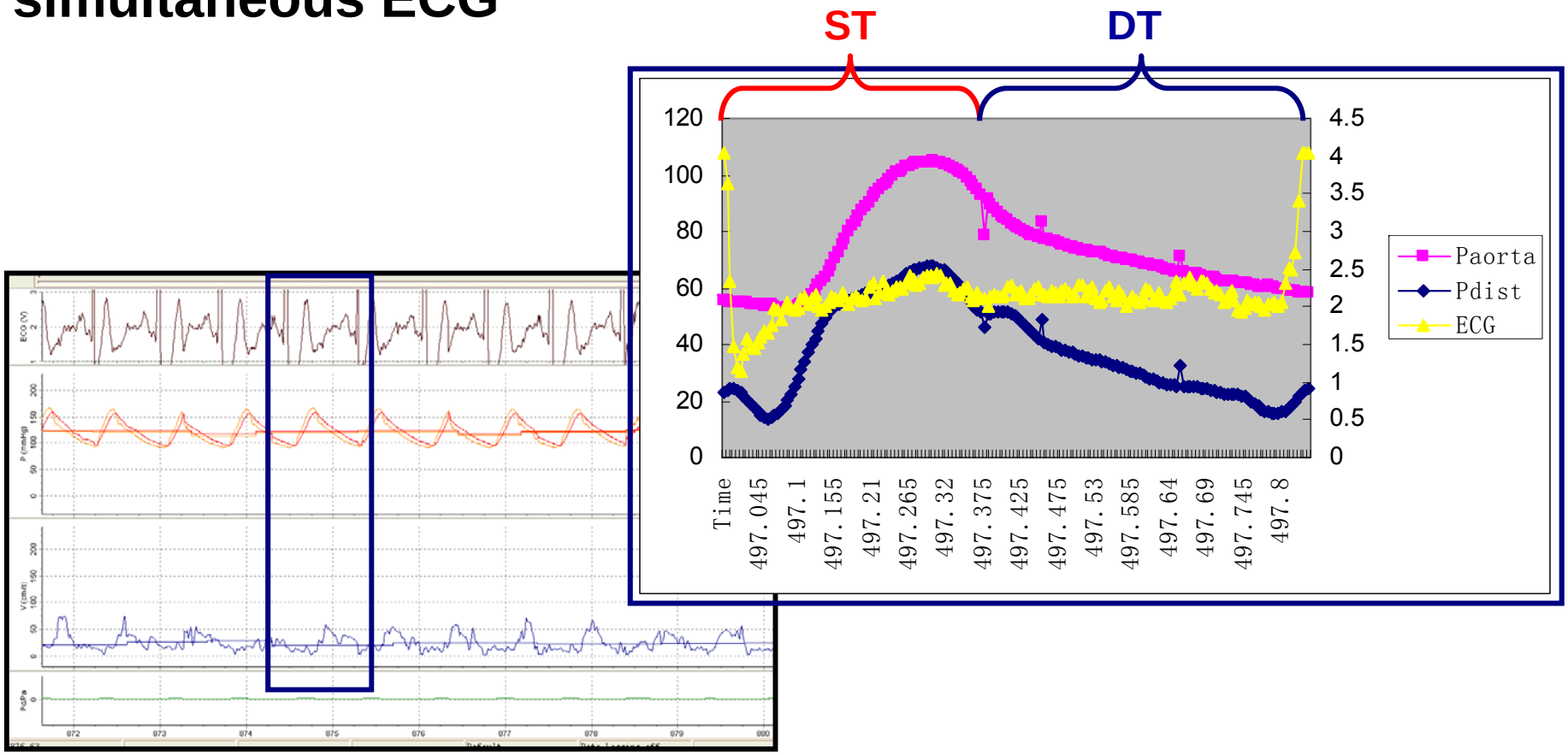


A non-slip condition was assumed at the wall. The velocity value was at the inlet, pressure value was at the outlet



How Does It Work?

Collect continuous flow velocity and pressure, along with simultaneous ECG



Diastolic and systolic peak flow velocity was measured

Calculate WSS

- Select boundary to analyse
- Description of blood physics
- Set boundary conditions
- Generate volume mesh

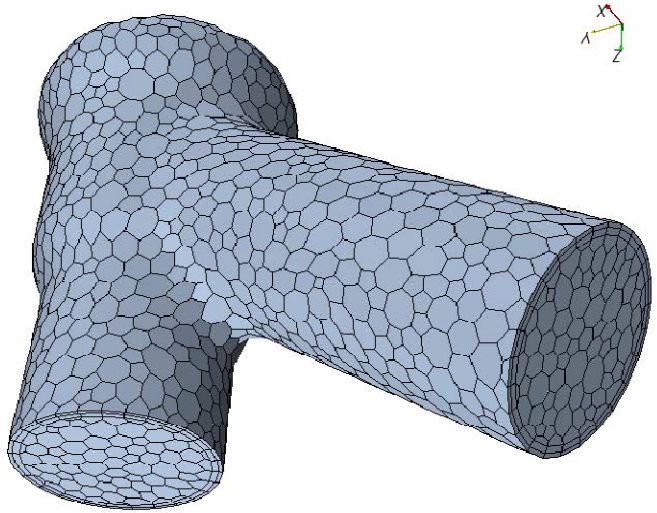
How Does It Work?

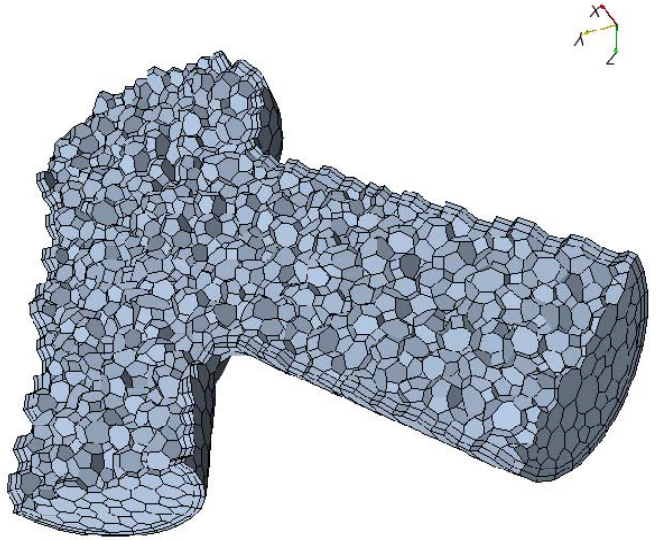
Surface Mesh: Surface Remesh,

Surface Mesh: Surface Wrapper,

Volume Mesh : Polyhedral Mesher

Optional Meshing Models : Prism Layer Mesher

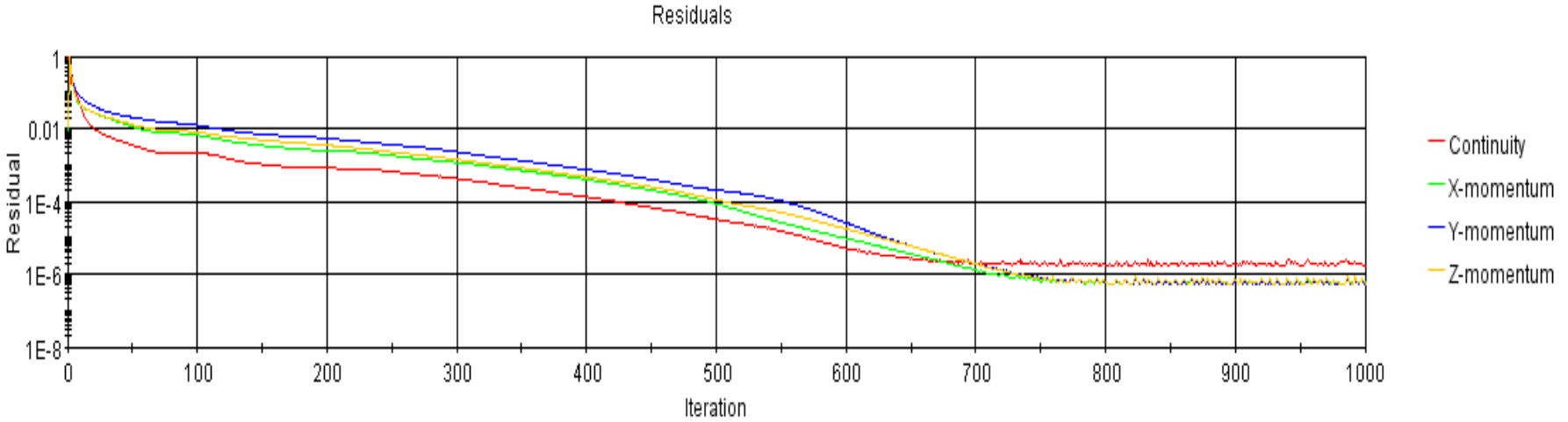




Calculate WSS

- Select boundary to analyse
- Description of blood physics
- Set boundary conditions
- Generate volume mesh
- Perform simulation

How Does It Work?

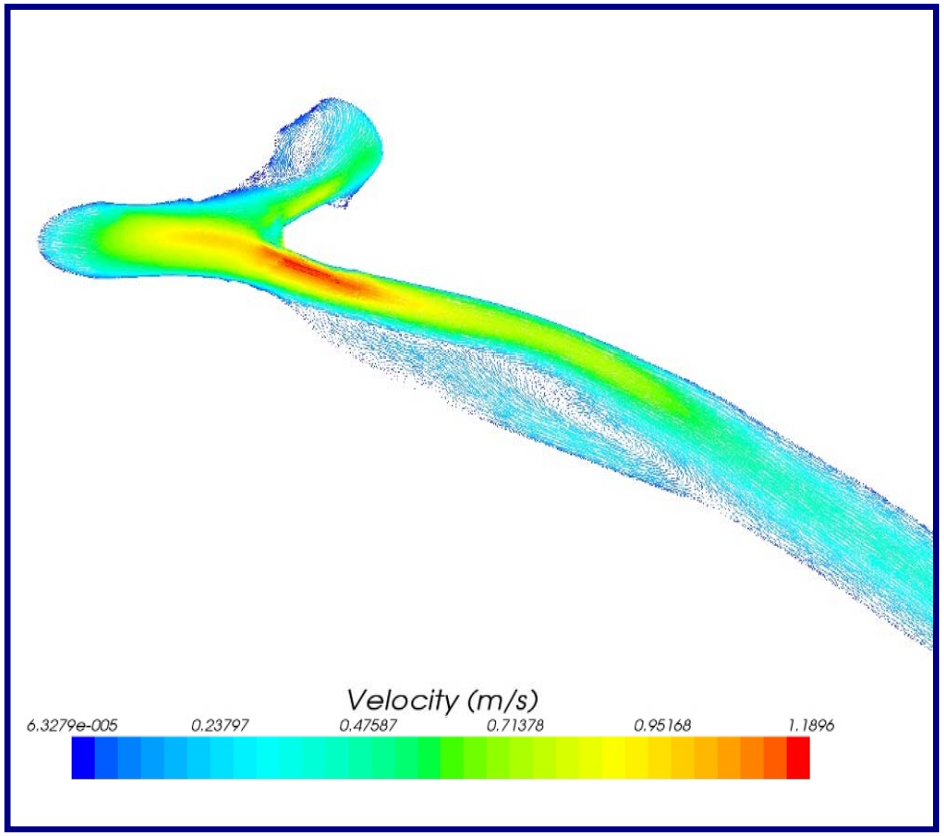


Iterative residual <10^5, consider the convergence

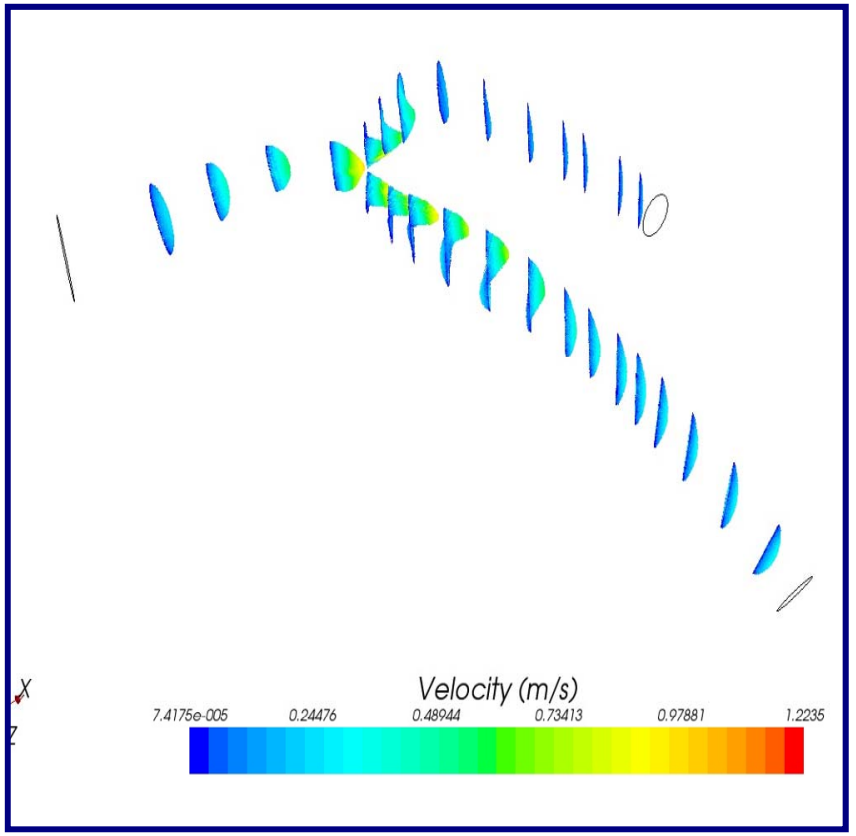
Calculate WSS

- Select boundary to analyse
- Description of blood physics
- Set boundary conditions
- Generate volume mesh
- Perform simulation
- Output results in order to follow-up use

How Does It Work?

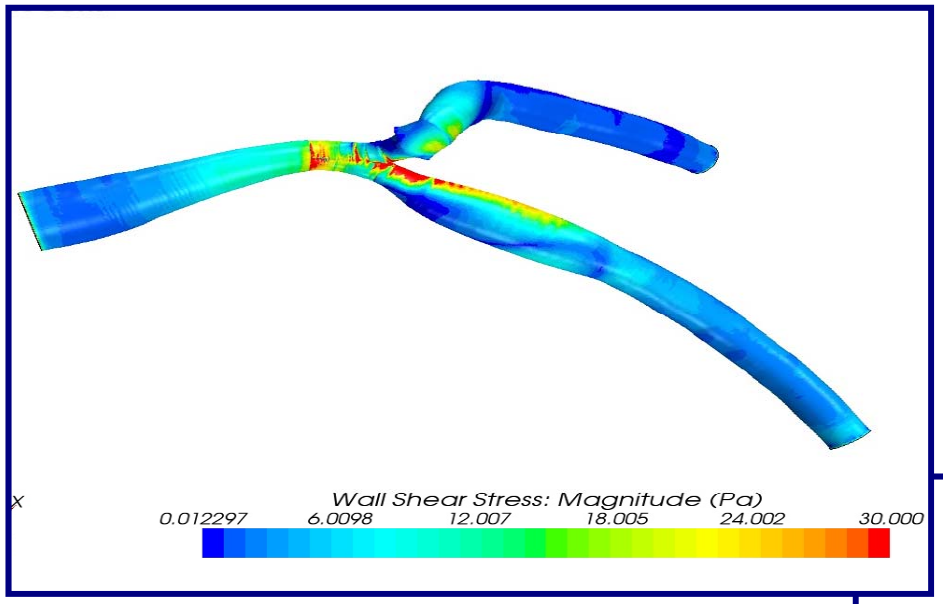


Velocity distribution nephanalysis

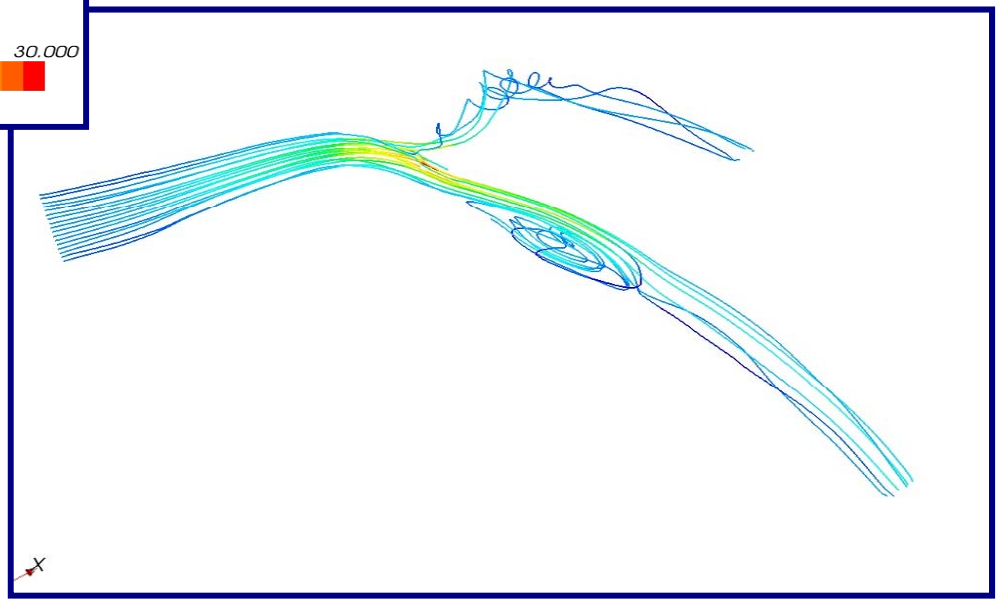


Velocity vector

How Does It Work?

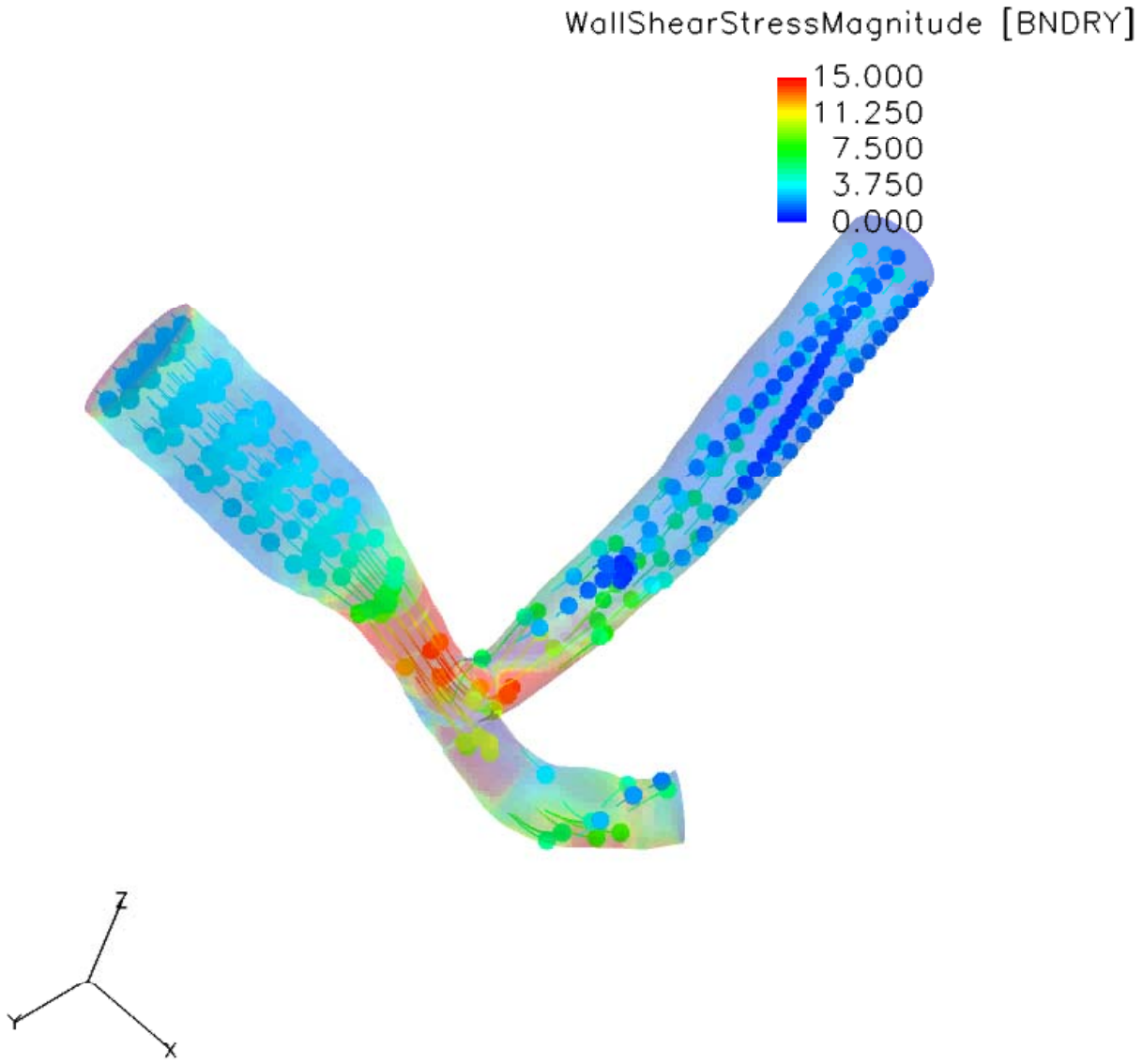


WSS distribution nephanalysis

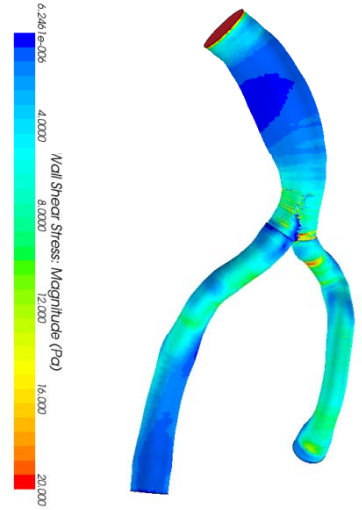


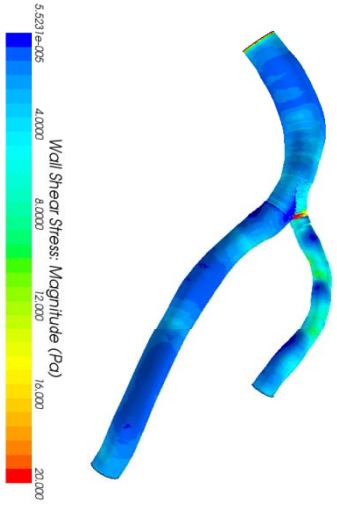
streamline pattern

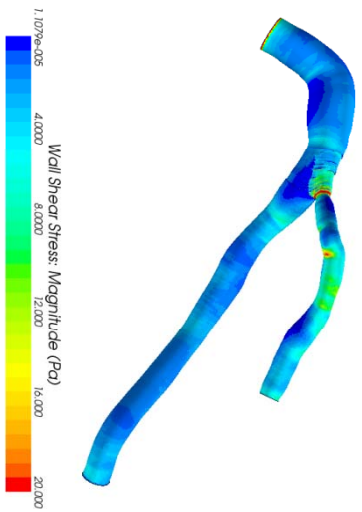
How Does It Work?

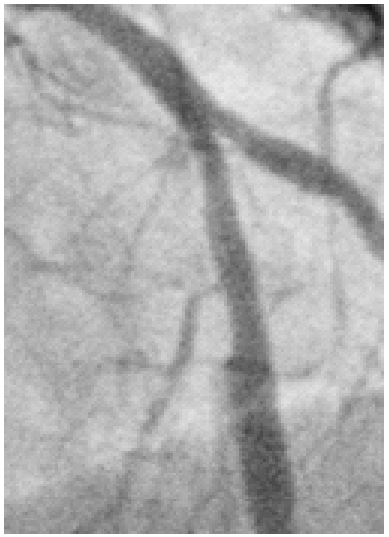


Real Case 1: provisional stenting







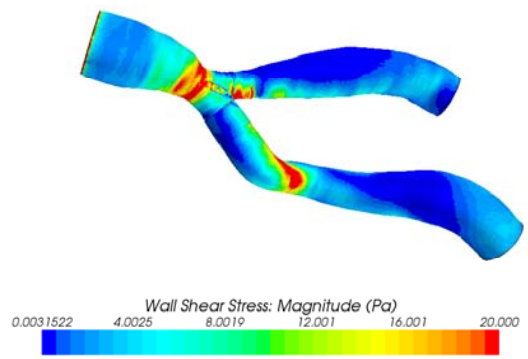


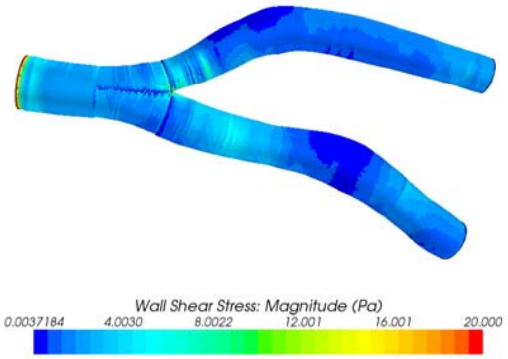
Before stenting

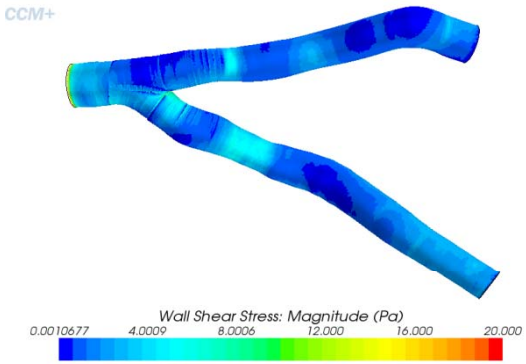
After stenting MV and FKBI

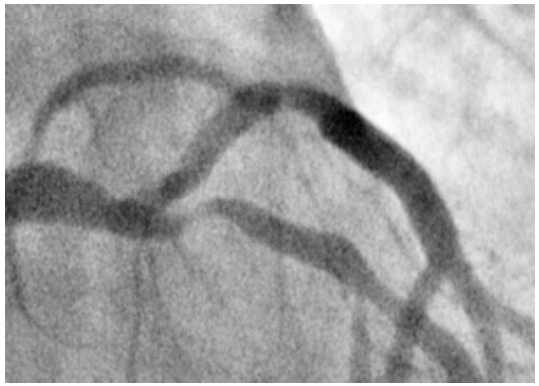
At 8-month follow-up

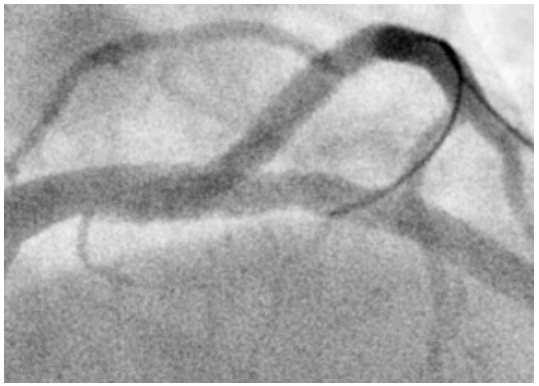
Real Case 2: DK crush stenting

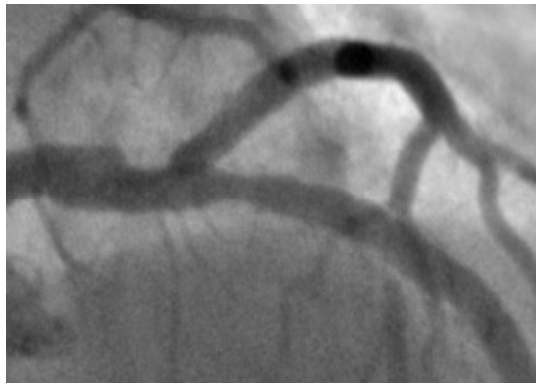












Before stenting

After DK crush stenting

At 8-month follow-up

In conclusion

- **CFD is a quantitative tool for the analysis of blood flow hymodynamic**
- **WSS is one key index of CFD**
- **The method for calculation of WSS is challenging and more complex, thus not providing real-time information**
- **However, WSS is thought to be clinical meaningful:**

  ----assessing the quality of coronary stenting

  ----analyzing the mechanisms attributive to atherosclerosis

  ----comparing the impact of different stenting approaches for complex coronary lesions

  ----guiding the design of new generation stent platform

  ----predicting the outcome after stenting coronary lesion