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Rheolitic Effects of Left Main Stenting

What is CFD?

Computational model of different forces and parameter involved in the fluid dynamic within a chamber or a vessel before and after surgical or interventional modification virtually simulated

The software is able to calculate any parameter, given an anatomic model, some physiologic parameters, and the interventional or sugical technique to be tested.

Why Computed flow dynamic?

Reasons to approach LM by CFD

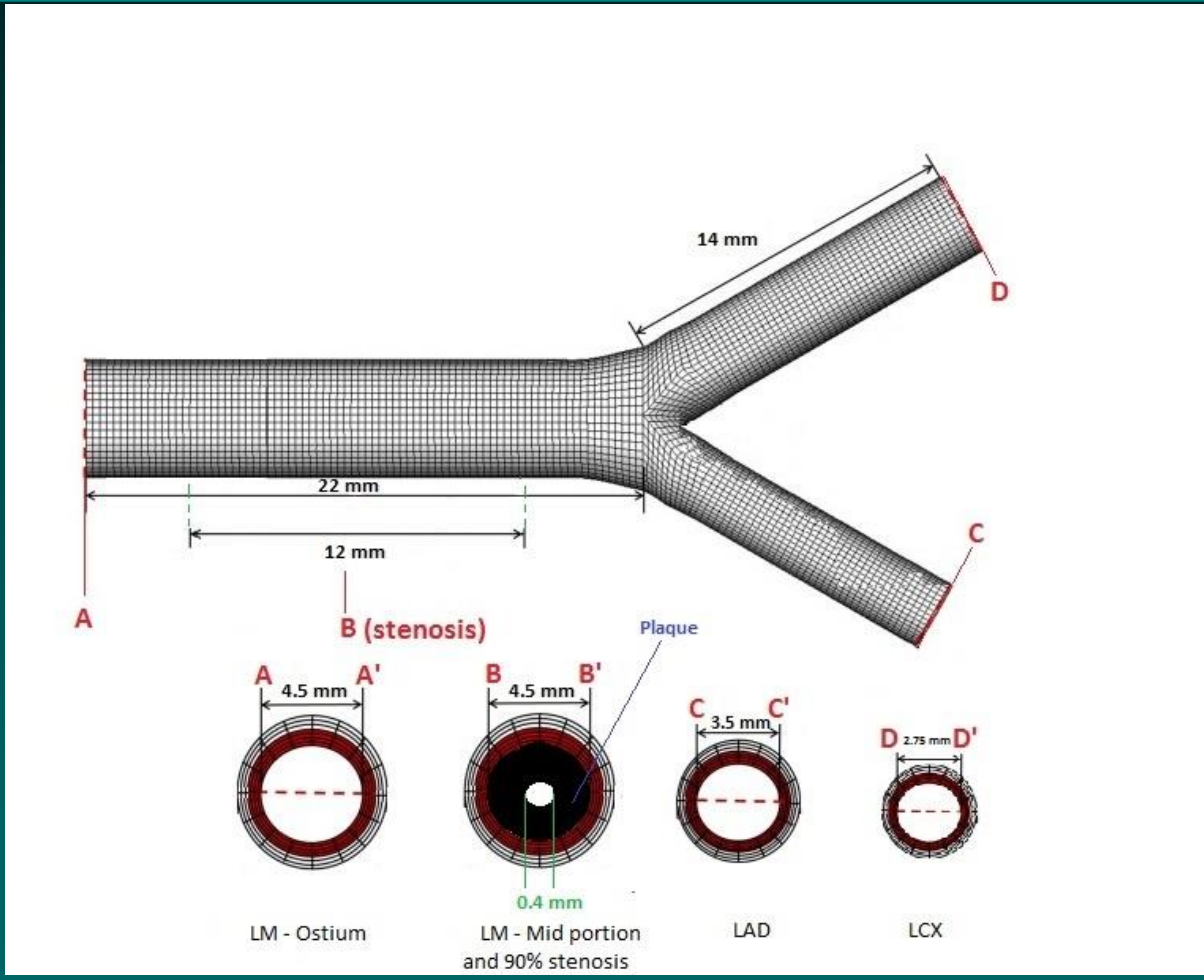
1. It is extremely difficult to assess flow dynamic in vivo

2. Randomized trial comparing different techniques in coronary LM stenting in vivo are extremely expensive and probably meaningless bacause of the extreme variability of anatomy/pathology

3. Deviation from the physiology may be assessed in a very cheap way with CFD

Computed flow dynamic in Left Main

Coronary Left Main Model



Computed flow dynamic in coronary Left main

Considered fluid parameters

- Static pressure (Pa)
- Reynolds number
- Vorticity magnitude (1/s)
- Stream function (Kg/s)
- Strain rate (1/s)
- Skin friction coefficient

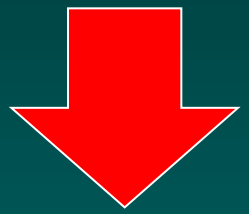
Absolute number

physiology

WALL SHEAR STRESS: HIGHER VALUES ARE BETTER

Computed flow dynamic in coronary Left Main

In case of mid-shaft/distal lesion, there is no consensus regarding the extension of the strut coverage up to the ostium or to stent only the culprit lesion.



Most operators usually stent also the ostium for a number of reason:

-potential damage of the ostium by guiding catheter nopt visible with angiography

-difficult to precisely avoid ostium coverage

-disease extension often to the ostium

Computed flow dynamic in coronary Left main

Stent simulation

the strut design and linkage pattern of a third-generation, everolimus-elunting stent (Orsiro stent, Biotronik IC, Bulack, Switzerland), used in our institution. In particular, the strut thickness is characterized by a very ultrathin strut (60 μm up to 3.0 mm diameter stent and 80μm up to 4.0 mm stent)

Virtual implantation

After placed the stent model in the correct position, according to the different stenting techniques, material removal, depending on the considering techniques was applied.
Using Boolean operation, the modified solid model is subtracted from the bifurcation model to obtain the final geometry

Computed flow dynamic in coronary Left main

Virtual implantation Steps

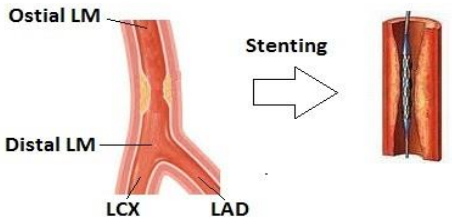
After placing the stent model in the correct position, the stenting procedure was performed following the real procedural steps.

Lesion only:

- Predilation with non-compliant Euphora (Medtronic Inc, USA) balloon 3.0 x 12 mm at 16 atm;
- Stent implantation: Orsiro 4.0 x12 mm at 18 atm;
- Over –dilation with 4.5x 12 mm non-compliant Euphora (Medtronic Inc, USA) balloon at 20 atm.

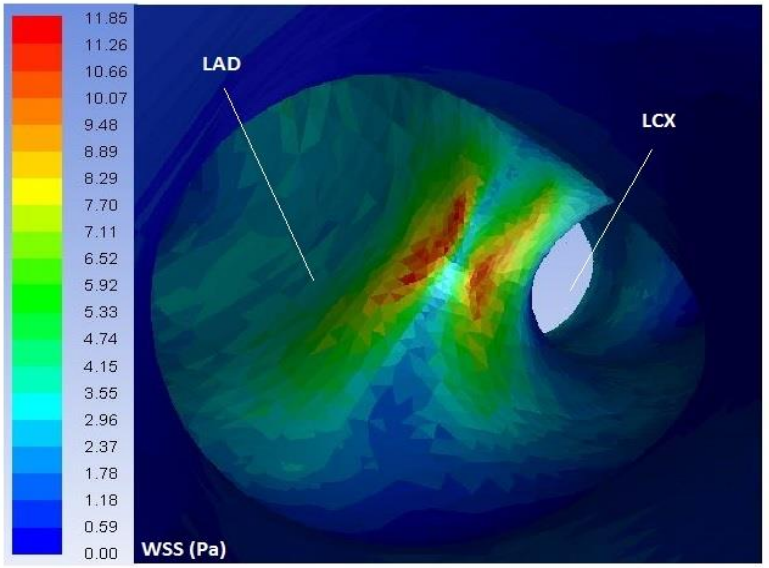
Up to the ostium

- Predilation with non-compliant Euphora (Medtronic Inc, USA) balloon 3.0 x 12 mm at 16 atm;
- Stent implantation:Orsiro 4.0 x 15 mm at 18 atm;
- Over –dilation with 4.5x 15 mm non-compliant Euphora (Medtronic Inc, USA) balloon at 20 atm;

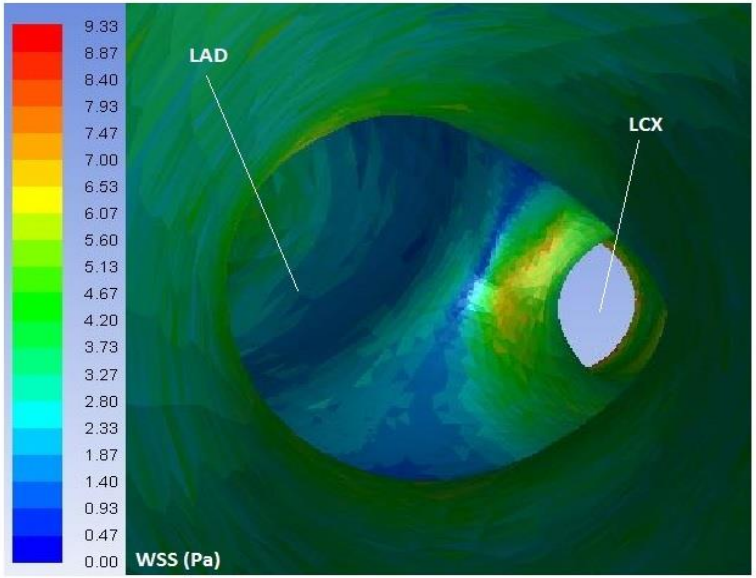


Stenting

1:1 (only lesion)



From the ostium to the lesion



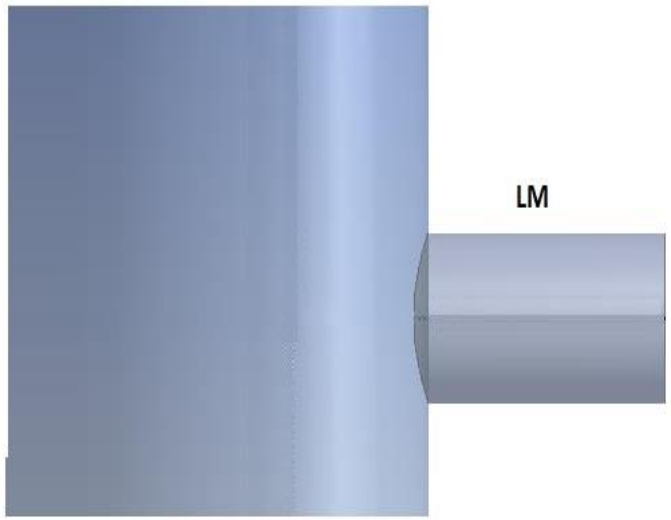
Computed flow dynamic in coronary Left main

Answer to question

-the net area averaged wall shear stress (WSS) of the model and the WSS at the LCA-LCX bifurcation resulted higher when the stent covered the culprit mid-shaft lesion only compared to the extension of the stent covering the ostium (3.68 vs 2.06 Pa, $p=0.01$ and 3.97 vs 1.98 Pa, $p<0.001$, respectively.

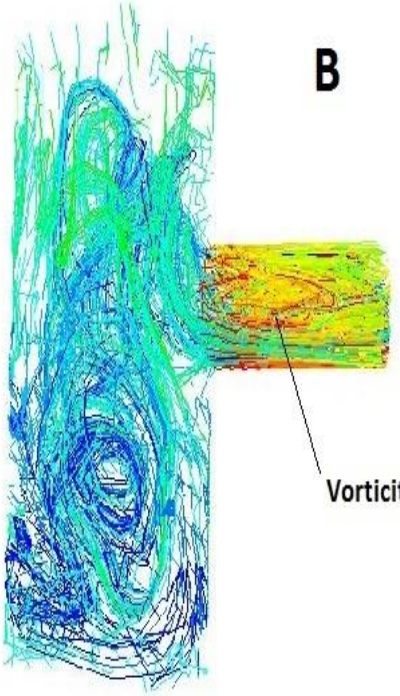
-similarly, the static pressure and the Reynolds number were significantly higher after stent implantation covering up the ostium.

-At the ostium, the flow resulted more laminar when stenting only the mid-shaft lesion than including the ostium.

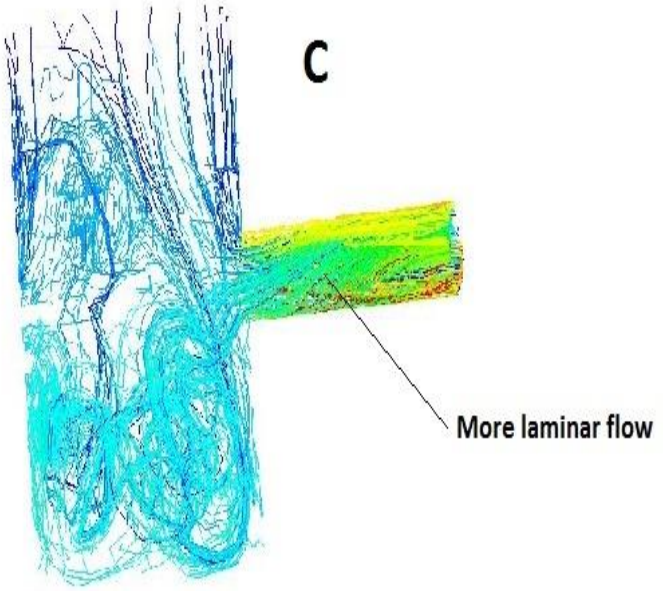


A *not in scale

Ostial stenting



1:1 Lesion Stenting



CONCLUSIONS….

✓ALTHOUGH OF LIMITED PRACTICAL VALUE, CFD GIVE AT LEAST AN IDEA OF HOW MUCH THE INTERVENTIONAL TECHNIQUES ARE ADHERENT TO PHYSIOLOGY

✓OSTRIUM COVERAGE POTENTIALLY MAY CREATE SUBSTRATUS OF RESTENOSIS/THROMBOSIS AT BIFURCATION

✓CFD IN LEFT MAIN SUGGESTS TO AVOID TO COVER THE OSTIUM WHEN POSSIBLE