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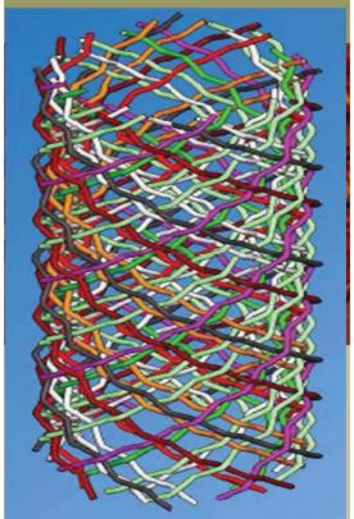


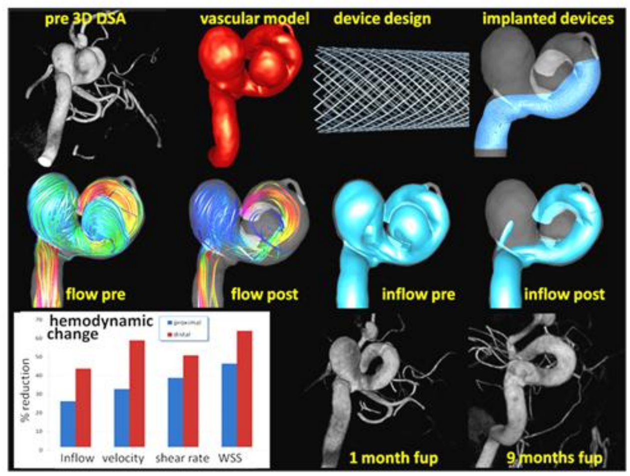
CARDIATIS—TEHMED

Computational Flow Analysis—patient customized treatment

Cardiatis/TehMED

Why should we consider Computational Flow Analysis ahead of the actual stenting therapy?

The effects of the Cardiatis flow modulators on aneurysmal hemodynamics has been studied with in vitro, in animals and in computational models. These studies have shown that placement of one (or more) flow diverting devices in the parent artery cause: a) reduction of the total inflow rate entering the aneurysms, b) decrease of average flow velocity within the aneurysm, c) decrease in the wall shear stress on the aneurysm wall, and d) reduction of the rotation or swirling of the blood flow inside the aneurysm, and in some cases reversal of the direction of intra-aneurysmal flow circulation. All these effects combined create a hemodynamic environment that favors the formation of an intra-saccular thrombus that eventually occludes and seals the aneurysms. A patient-specific vascular model was created from 3D images acquired prior to treatment, and used to model the blood flow before and after placement of the flow diverting stents. The picture below shows the workflow used to calculate flow alteration in a cerebral aneurysm after placement of a flow modulator. Visualizations of the flow pattern and high speed blood flow streams illustrate the reduction in flow speeds and simplification or smoothing of the flow pattern after treatment. Interestingly, it was observed that the flow alteration effects of the stents were larger (i.e. larger reduction) in the most distal aneurysm than in the most proximal aneurysm. Follow up 3D images revealed that the most distal aneurysm was completely occluded at 1 month while the proximal aneurysm remained open, and that at 9 months both aneurysms were completely occluded. This suggests that the largest the flow modification induced by the flow modulators the shortest the aneurysm occlusion and healing time.



Local Aortic Biomechanics

A patient tailored approach should be used for calculation of aortic aneurysm rupture or dissection in order to provide for optimal treatment management.

From the perspective of the local aortic biomechanics, the aneurysm rupture or dissection will occur when the vessel wall stresses exceed the local vessel wall strength. The pre-existing disorders and patho-biologic mechanisms are big contributors to aneurysm wall weakening, in addition to increased blood pressure and increased aneurysm size. This cycle of events repeat itself until rupture or dissection occurs.

Inside this issue:

Special points of interest:

- *Cardiatis Aortic Aneurysm Service provides for sizing of required flow modulators and modeling of blood flow shear stress distribution ahead and after modulator deployment*
- *Cardiatis Aortic Aneurysm Service requires 3D data sets acquired on CT (preferably) or MR scanners.*

TEHMED

Neubergerjeva 7
Ljubljana
Slovenija

Phone: +386 (0)31 659 040
Fax: +386 (0)59 974 522
E-mail: info@tehmed.si

TechnoMed, certified distributor of Cardiatis products for Slovenia

We are on the web:

www.tehmed.si

TehMED— Who Are We?

TehMED is a young and dynamic company based in Ljubljana - Slovenia. TehMED is the certified distributor of the Cardiatis (Isnes, Belgium) products for the Slovenian market. The company is primarily focused at the distribution of the medical products, used in the interventional radiology and minimally invasive surgery.

Presentation of the Cardiatis product range can be done upon request to the Commercial and Marketing Department of the TehMED company (see the contact data to the left).

AAA Size - Rupture Relationship

AAA growth results in ever increasing wall shear stress and hemodynamic disturbances. Healthy aorta geometry is relatively identical in all individuals leading to very little difference in terms of wall shear stresses. However large differences occur when aortic aneurysm starts developing, leading in great distribution of wall shear stresses.

AAA rupture risk is in the daily medical practice correlated to the aneurysm axial diameter, which is used as the criteria for the treatment execution. Currently 5-5,5 cm is the threshold value. However, the aneurysm size is just one parameter and the rupture risk is multifactorial: aneurysm shape (saccular vs. fusiform), tortuosity, presence of thrombus and/or calcium in the sack, local inflammation, aneurysm growth over time etc should be considered before taking the final treatment management decision. All those patient specific characteristics have to be taken into consideration in addition to the co-existing and pre-existing co-morbidities as well as the patient-specific blood hemodynamic. Even though several studies have shown that the larger aneurysm have larger expected rupture rate, there is ever increasing level of evidence showing that small aneurysms rupture as well. Currently only those small aneurysms that show progressive enlargement rate get treatment. The mortality rate though is approximatelly at the same level in both the treatment groups (around 70%). Several aortic aneurysm hemodynamic studies showed that small aneurysms can have stress level equivalent to the stress level of large aneurysm, making them as prone to rupture as in the population of big aneurysms.

There are two mechanisms that seem to be responsible for aneurysm weakening and subsequent rupture:

- Stress-mediated wall weakening
- Hypoxia-mediated wall weakening

The stress-mediated wall weakening is a results of wall shear stress elevation that will in turn results in endothelial injury. This will initiate vessel wall remodeling and degeneration that will lead to imbalance between the blood pressure and the internal wall stresses and hence causing local vessel wall dilation of the arterial wall.

The hypoxia-mediated wall weakening results in a local blood stasis against the vessel wall, causing endothelial dysfunction as well as adhesion and accumulation of platelets and leukocytes along the intimal surface. This leads to intimal damage and inflammation. Subsequently thinning of the vessel wall and the final vessel wall tearing will occur.

The implantation of a stent-graft reduces stresses in the aneurysm sack, by protecting it from the blood inflow entirely (apart from closing all the side branches that may cause retrograde aneurysms filling). However, in the same time, the stent graft is prone to very high stresses at the neck level, being the reason of endo-leaks into the aneurysm sack.

Flow modulator approach differs from the stent graft technology in the following characteristics:

- Side branches remain patent
- No endoleaks between the graft and the vessel wall as a consequence of the elevated wall shear stress around that level
- Vessel wall is reinforced and the local hemodynamics through the aorta is restored
- Reduces vortex velocity inside the aneurysm and allows for generation of organized thrombus
- Transforms the turbulent blood flow into the laminar flow