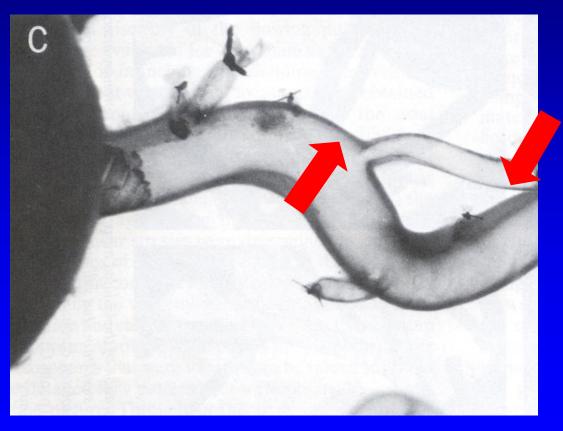
Shear Stress in Bifurcation Lesions: Manipulation of Shear Stress during Intervention

Thach Nguyen, M.D. FACC FSCAI

St Mary Medical Center Hobart IN USA

Common Locations of Atheroslerotic Plaques Caused by Disturbed Flow

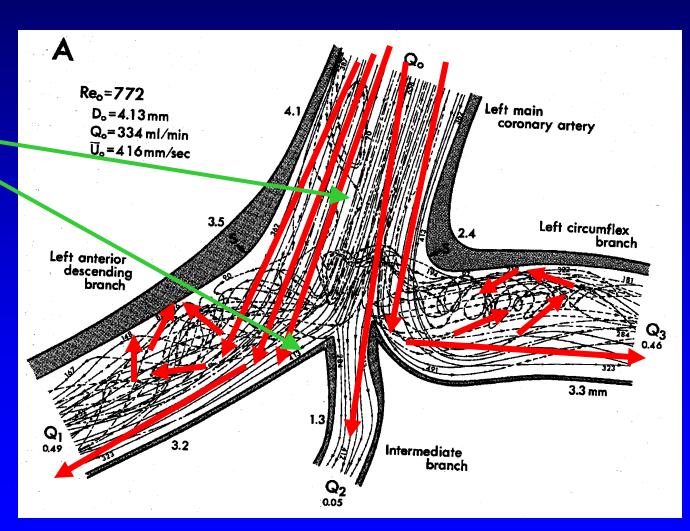


(Asakura and Karino. Circ Res 1990;66:1045)

Why Disturbed Flow at Bifurcation?

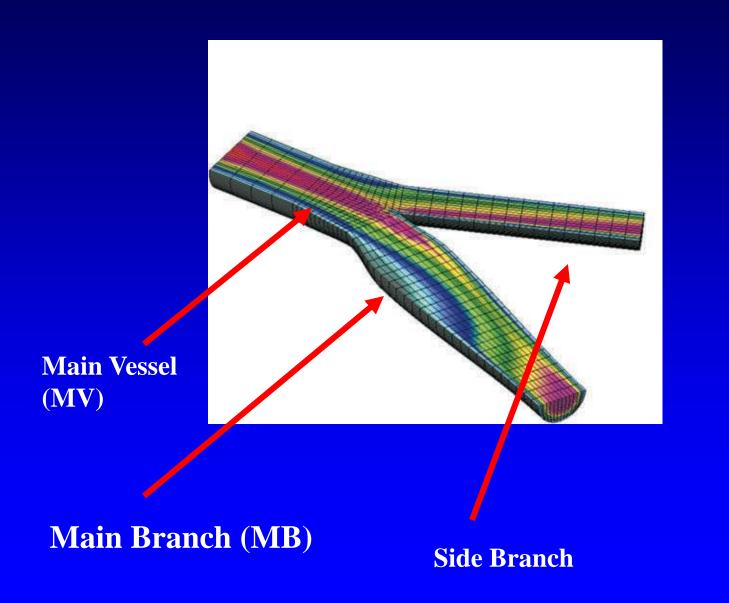
Undisturbed laminar flow

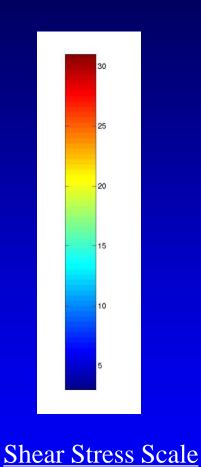
Low and oscillatory disturbed laminar flow



(Asakura and Karino. Circ Res 1990;66:1045)

3D Bifurcation Model with Areas of SS in Color

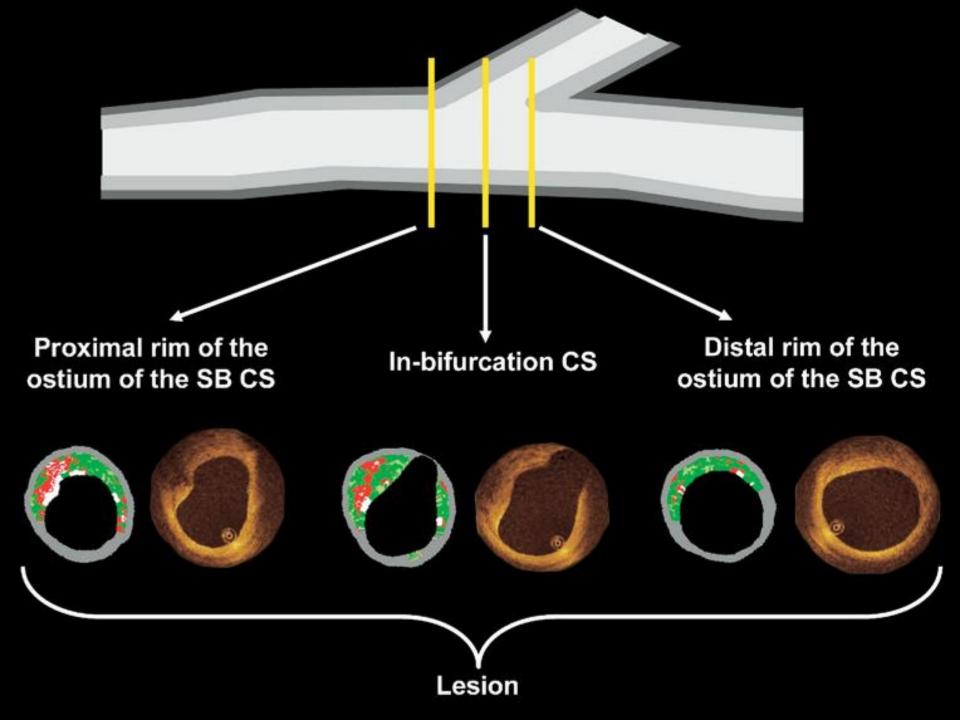




(dynes/cm²)

(1) ARE WE CONVINCED YET?

2.Location of Necrotic Core Plaques

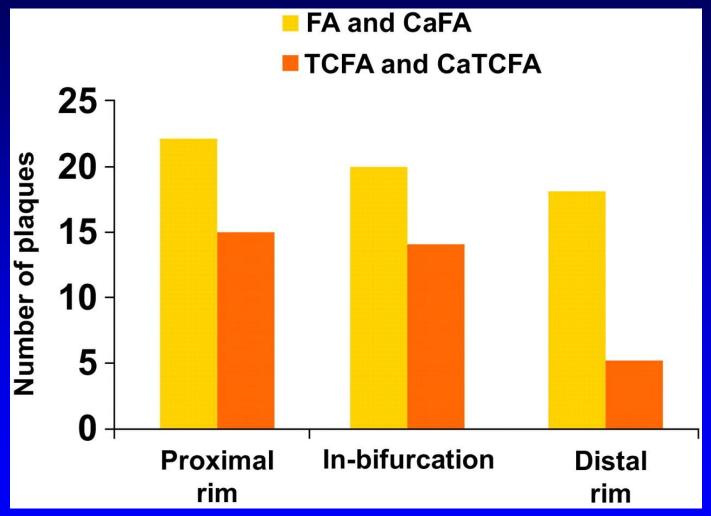


• The IVUS-VH allows the detection and quantification of NC, one of the main components of high-risk plaques. However, the limited axial resolution of IVUS (approximately 200 micron) does not permit an accurate evaluation of the fibrous cap.

• On the contrary, OCT has a very high resolution (10 to 20 micron), allowing a very precise measurement of the fibrous cap.

Distribution of the High-Risk Plaques in the Proximal Rim of the Ostium of the Side Branch, In-Bifurcation, and Distal Rim Cross-Sections



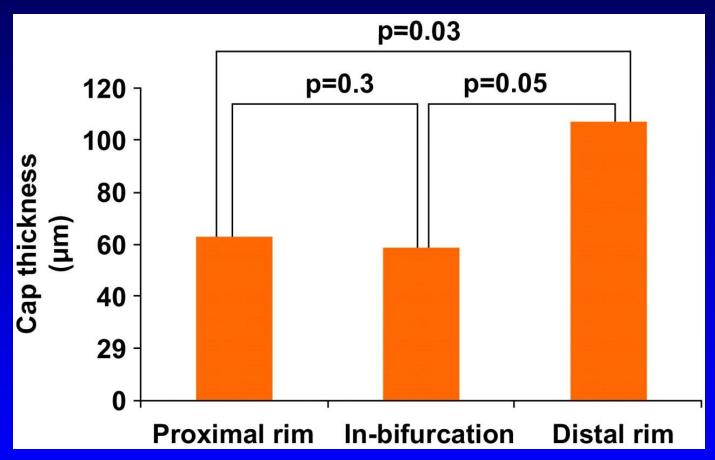


Gonzalo, N. et al. J Am Coll Cardiol Img 2009;2:473-482



Cap Thickness Distribution in Thin-Cap Fibroatheromas TCFA纤维帽厚度的分布情况

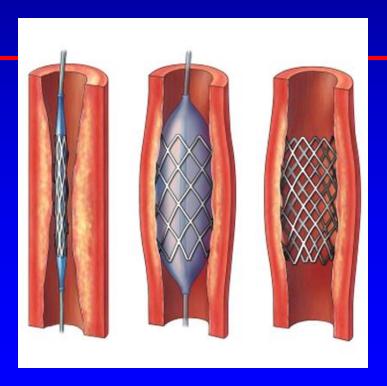




Gonzalo, N. et al. J Am Coll Cardiol Img 2009;2:473-482



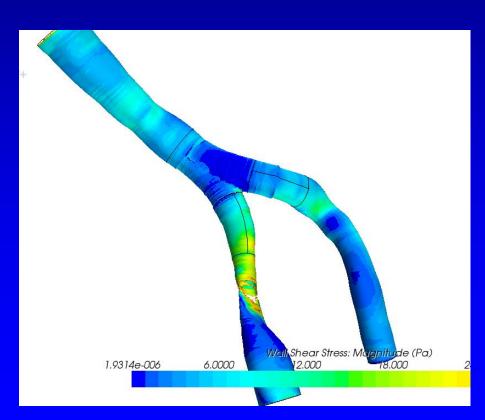
2. Shear Stress after Stenting

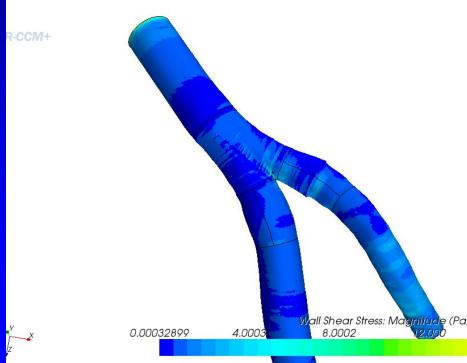


(2) ARE WE CONVINCED YET?

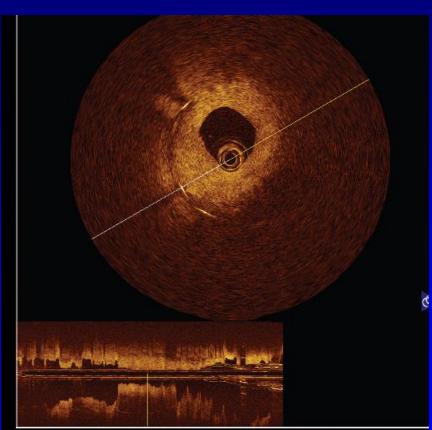
That in-stent restenosis is caused by low shear stress

After Stenting, the Shear Stress in all Stented Areas Becomes Low = Flow becomes More Turbulent due to Exposure to Struts

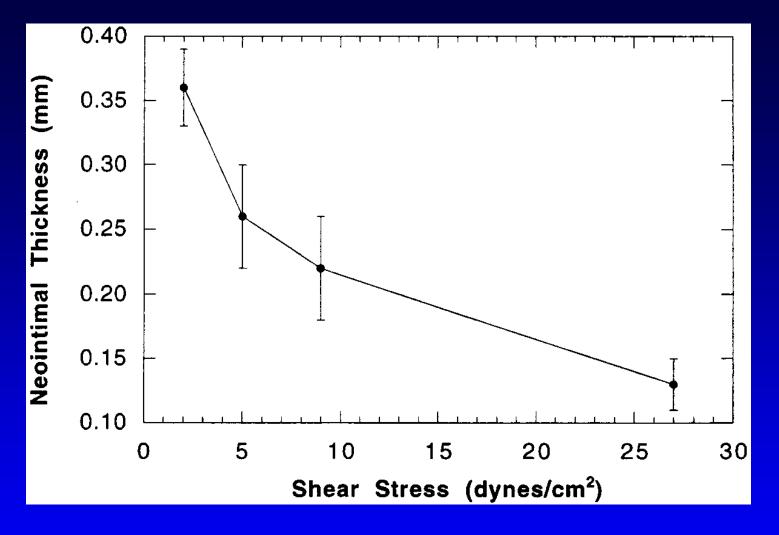




OCT image showing struts surrounded by hyperproliferative neointimal growth which led to restenosis 5 months after BMS stenting.



REF: B X Chen, F Y Ma, W Luo Neointimal coverage of bare-metal and sirolimus=eluting stents evaluated with optical coherence Tomography Heart 2008;94:566–570



Neointimal hyperplasia thickening after BMS stenting vs wall shear stress. The inverse relationship indicates more thickening at low shear stresses.

3. Why Do New Plaques Develop in Low Shear Stress Areas?





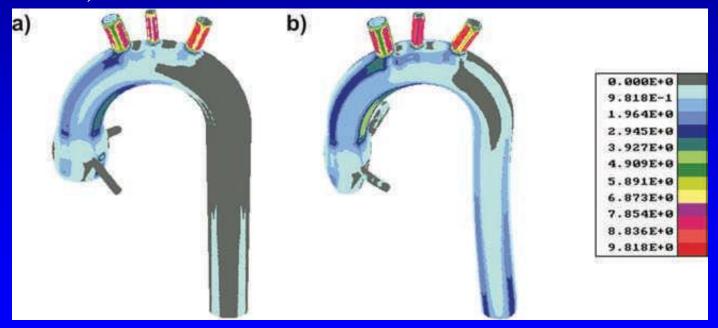
3.Does the areas with low shear stress develop plaques in patients low cholesterol level? The chance for developing plaques is extremely low



4. How to Make a Difference by Manipulating the Shear Stress?

A Young Aorta Avoids Low ESS by Vasoconstriction (Good vascular tone)

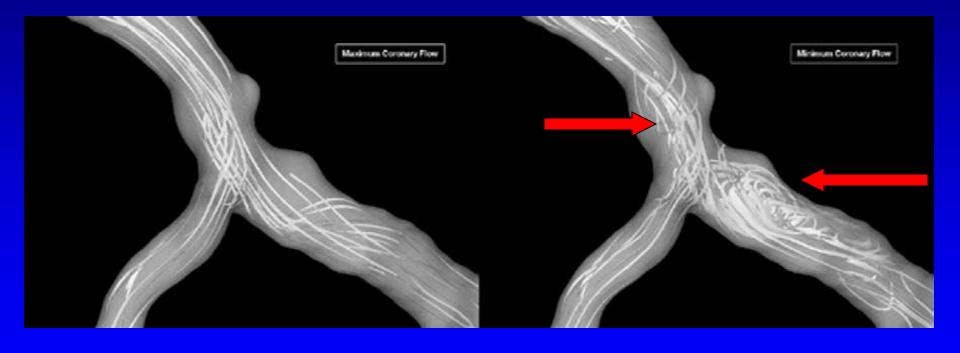
If the wall is flexible, not stiff from calcification, then the wall can constrict (smaller lumen, higher flow so higher ESS)



Diastole

Systole

High Flow Causes Higher SS (while awake and when exercise)



• Exercise with higher and steady flow

Resting with lower flow

Betablockers Slow the Heart Rate so Prolong Diastole and Make the Flow more Stable Promoting High Flow and Avoiding Stagnant Flow (Low Shear Stress)



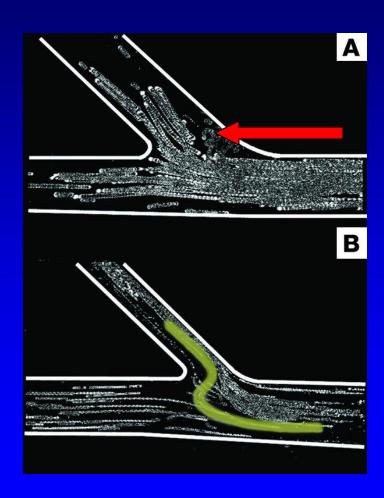
In Order to Have a Smooth Flow, the Size of the SB and distal MB Needs to Be:

	Dm (mm)	D _{d1} (mm)	D _{d2} (mm)	Coefficient
1 st Level	3.0	2.4	2.0	0.681
Left Main	4.5	2.8	2.9	0.789

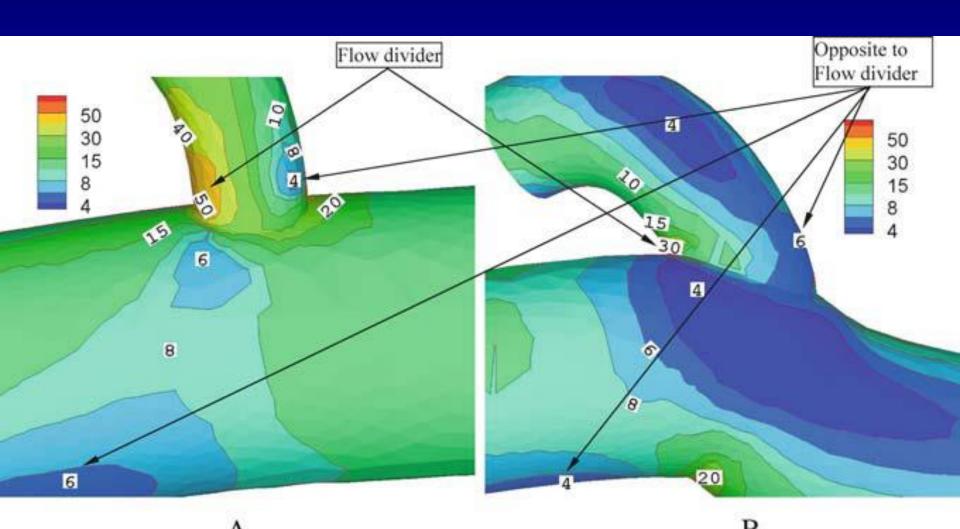


What Happens when Oversizing the SB and distal MB? BIGGER is not BETTER

• The larger the lumen the slower the velocity so the ESS will be lower (=higher chance for new plaques formation)

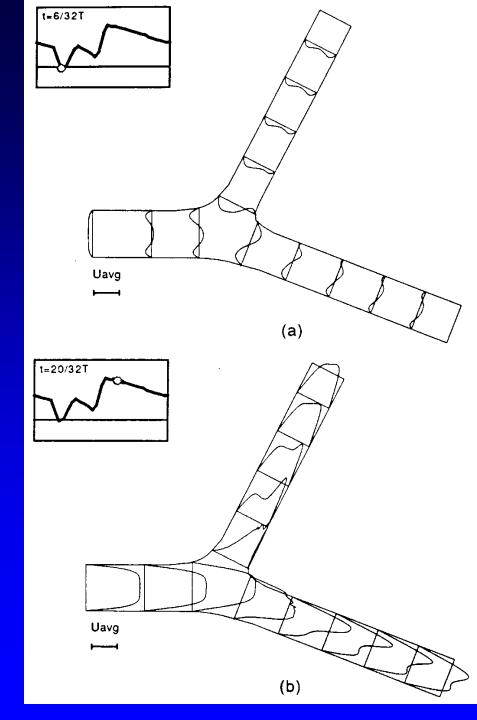


SS distribution at bifurcation with 90 degree angle (T type) or with lower degree angle (Y type)



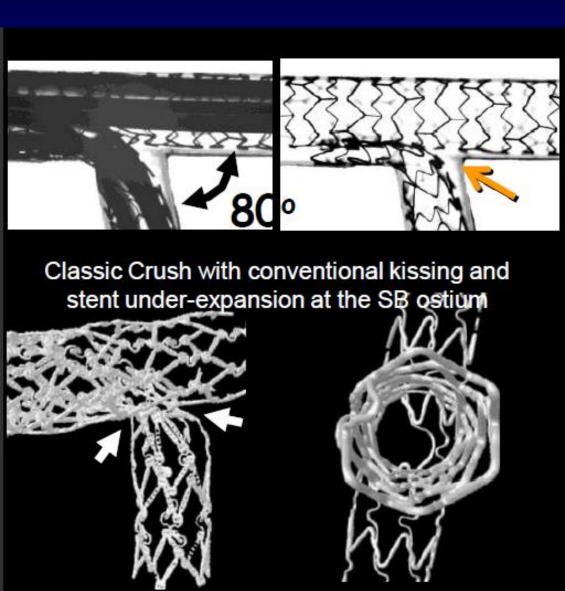
- (a) The profiles during systole show no flow reversal at the flow divider.
- (b) During diastole, the velocity profile is skewed toward the flow divider and develops a stair-step shape from the secondary flows.

The secondary flows do not become pronounced until several diameters downstream of the bifurcation.

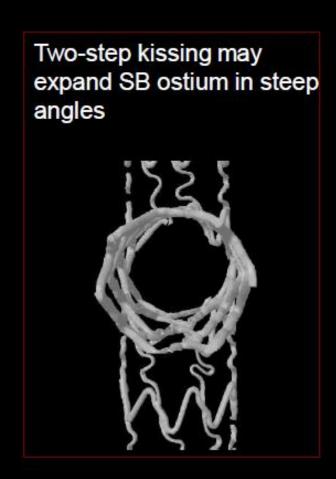


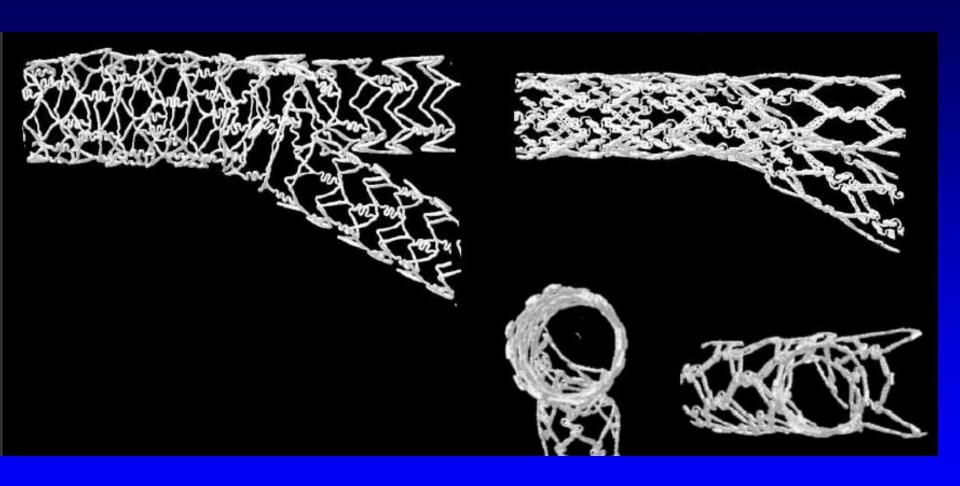
Technical Aspects of Perfect Stenting

Is Complex Stenting Perfect Stenting?



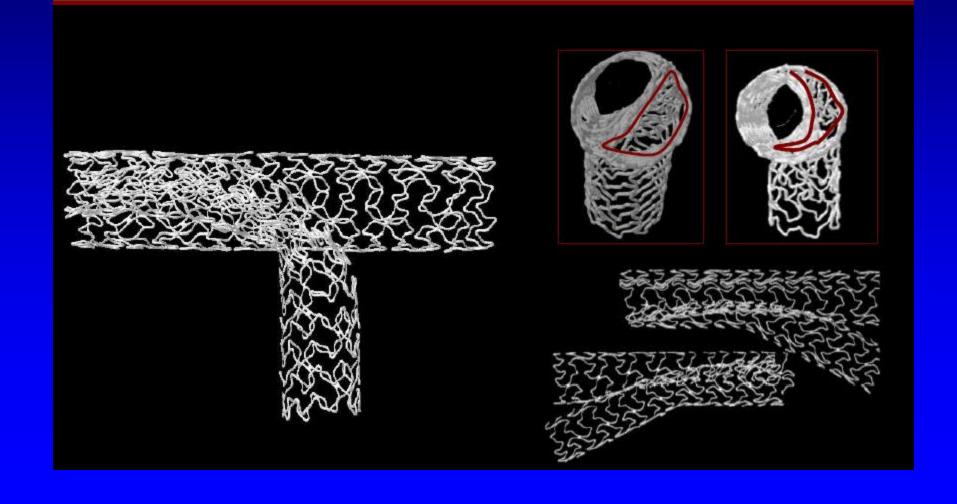
Ormiston CCVI 2004 Ormiston JACC Int 2008



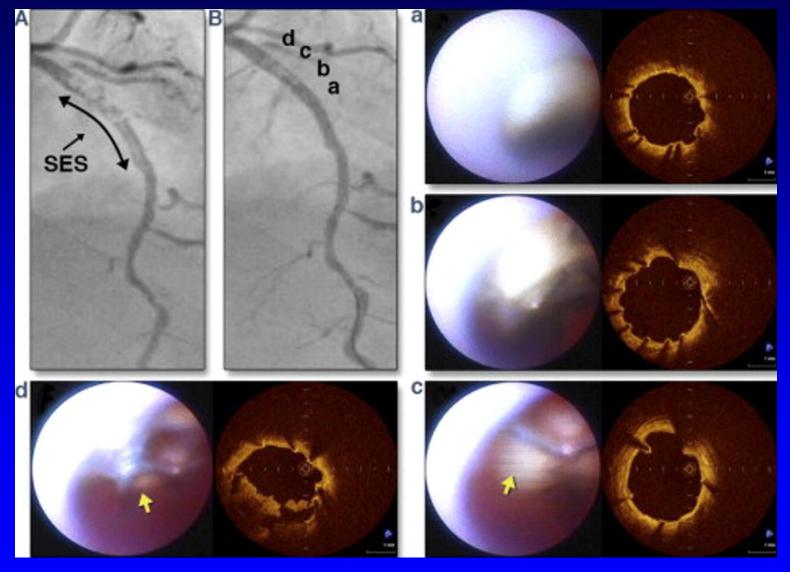


SKS simultaneous kissing stents

Considerable intraluminal metal-potential thrombosis risk Asymmetric lumina-challenges with repeat wiring

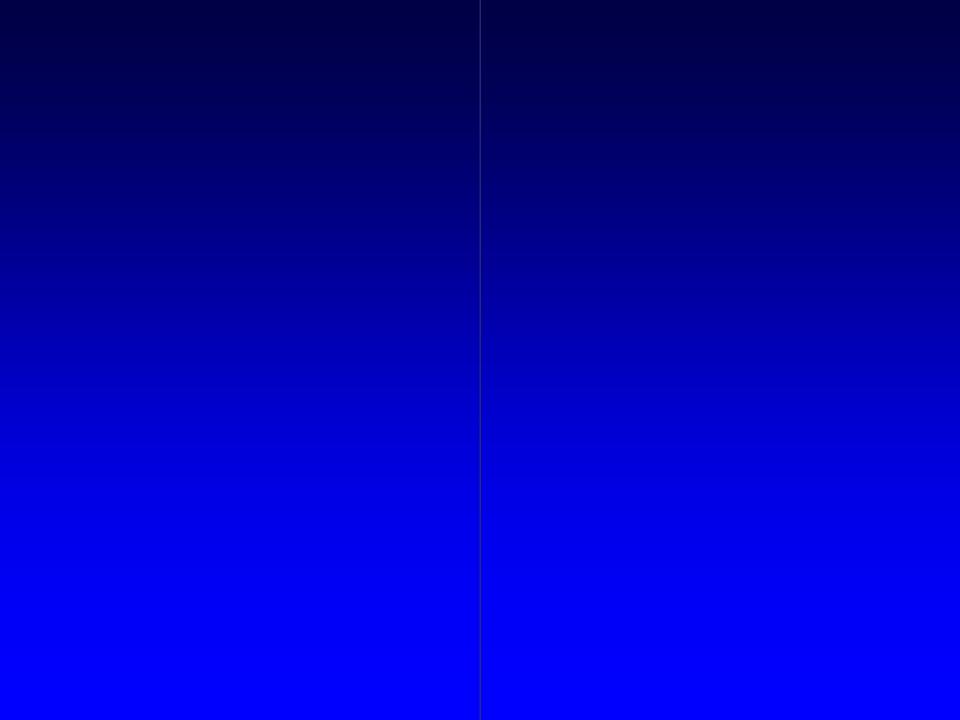


Uncovered and Malapposed Stent Struts

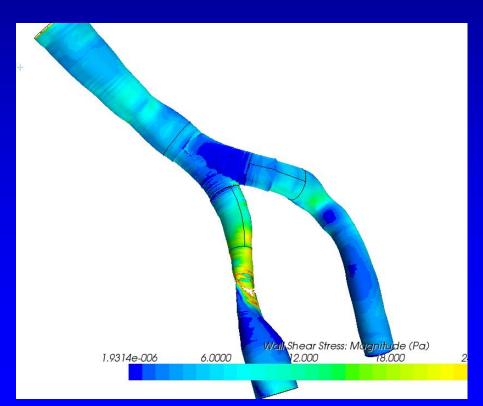


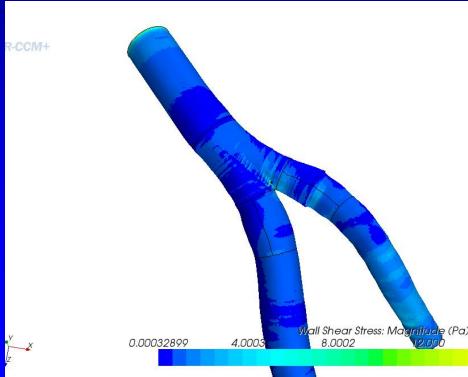




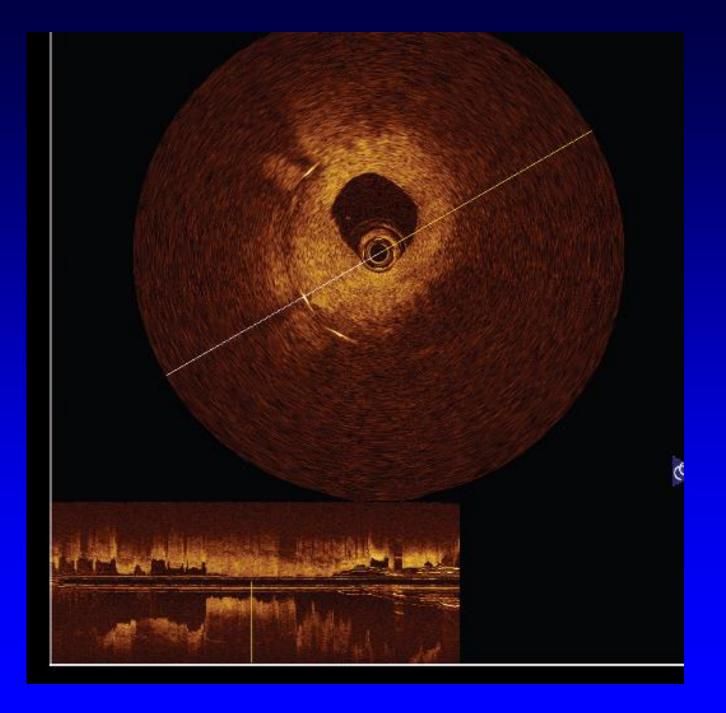






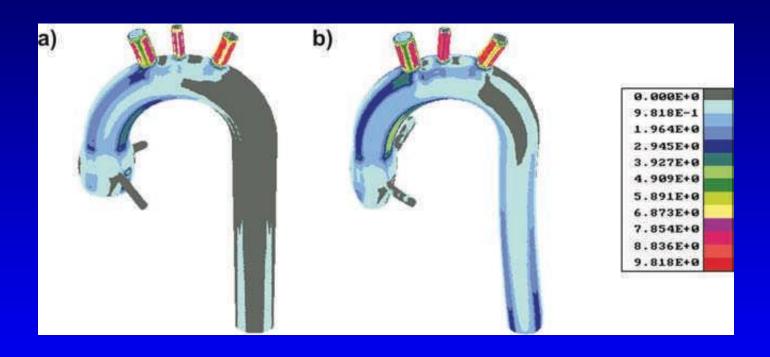








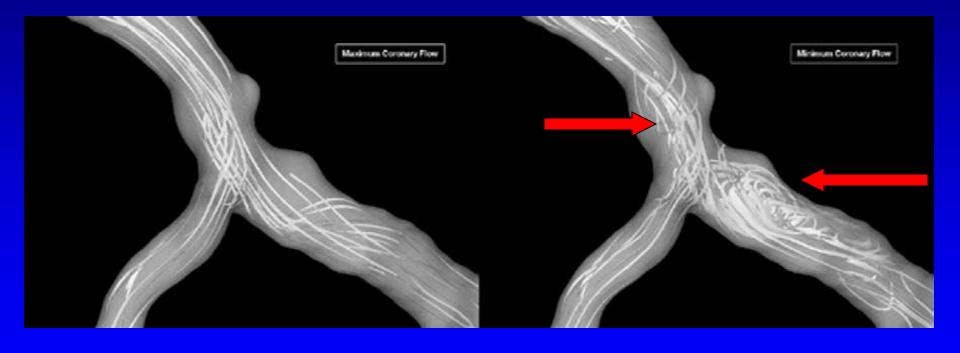
A Young Aorta Avoids Low ESS by Vasoconstriction (Good vascular tone)



Diastole

Systole

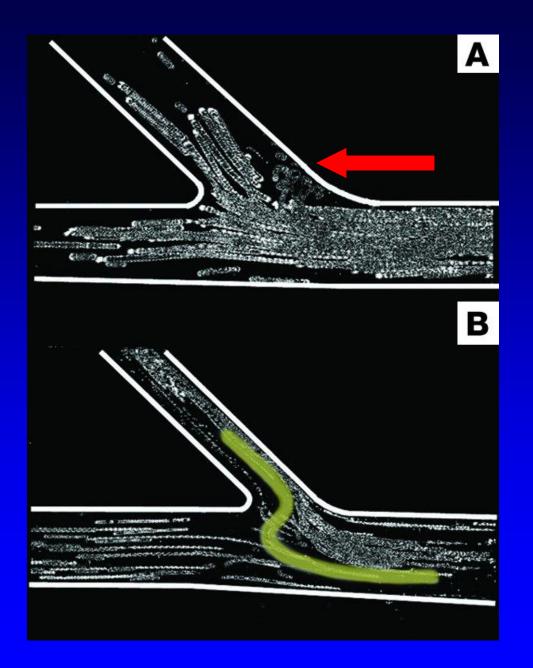
High Flow Causes Higher SS (while awake and when exercise)

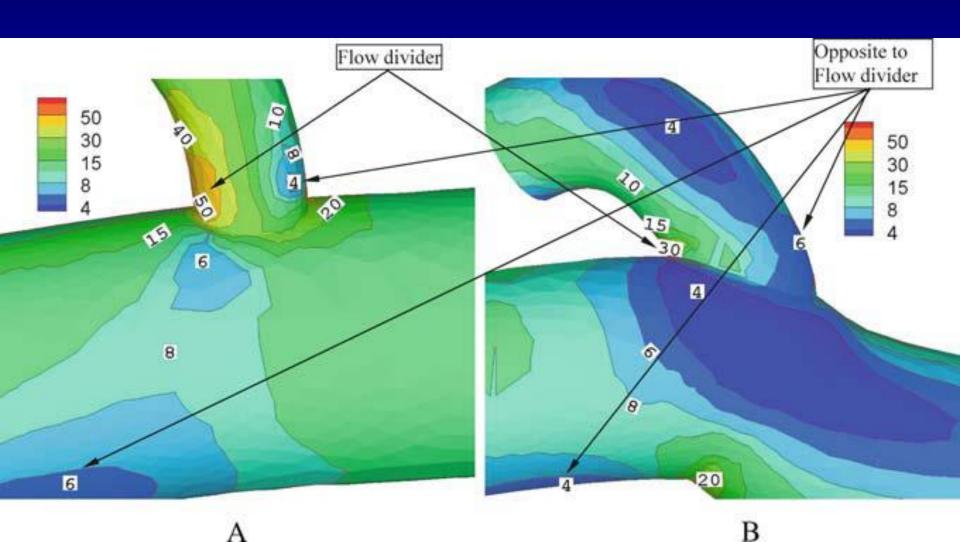


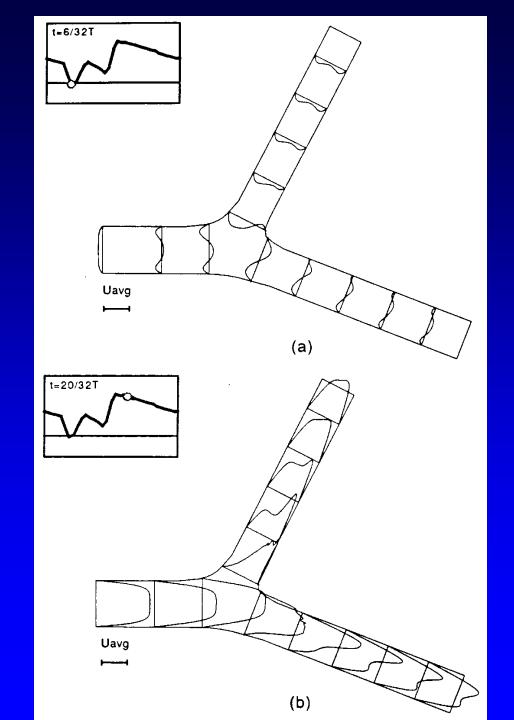
• Exercise with higher and steady flow

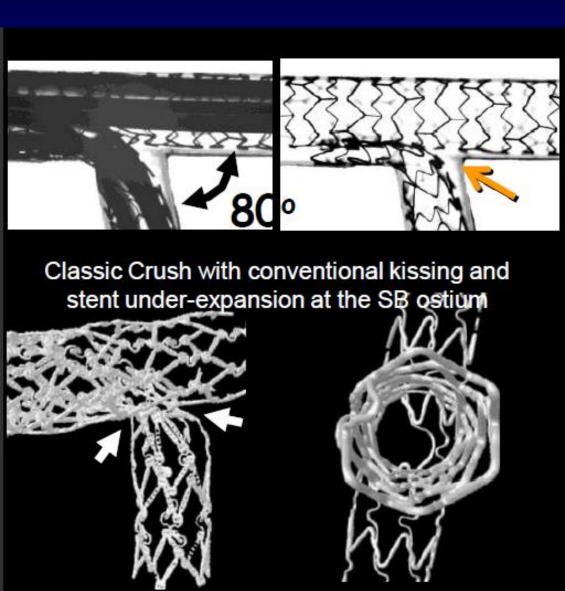
Resting with lower flow



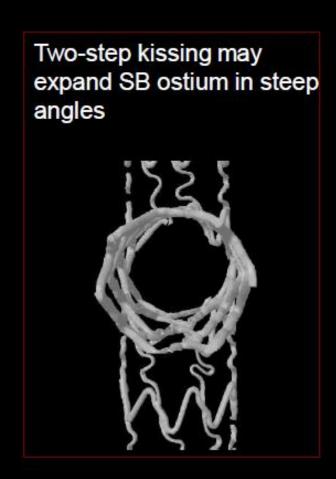


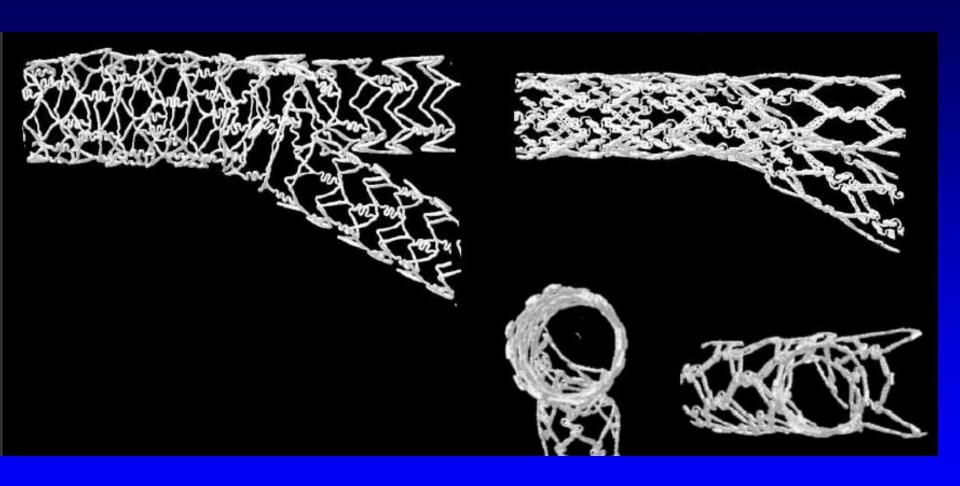






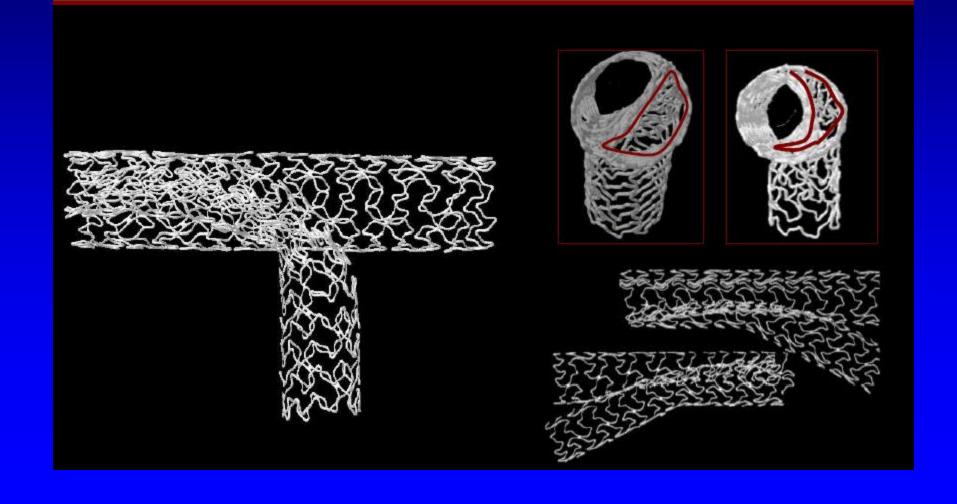
Ormiston CCVI 2004 Ormiston JACC Int 2008

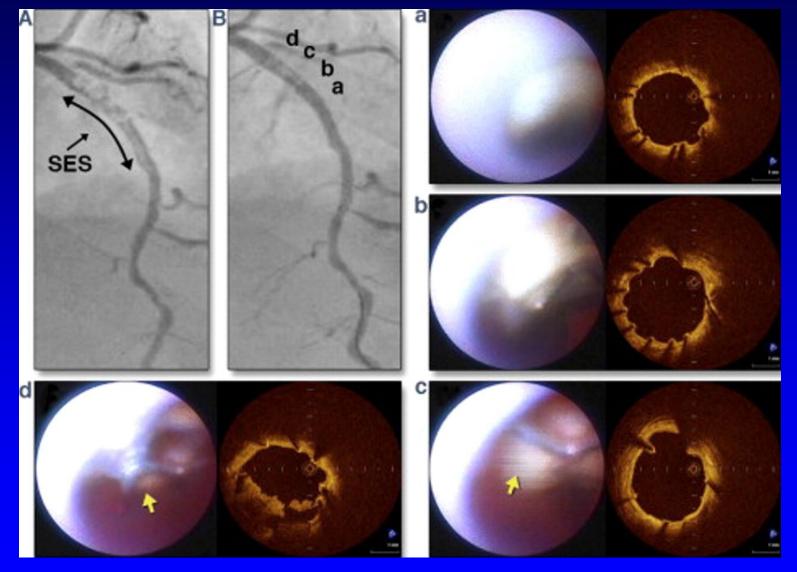




SKS simultaneous kissing stents

Considerable intraluminal metal-potential thrombosis risk Asymmetric lumina-challenges with repeat wiring





Ikenaga, H. et al. J Am Coll Cardiol Img 2011;4:1217-1219



Thank You

