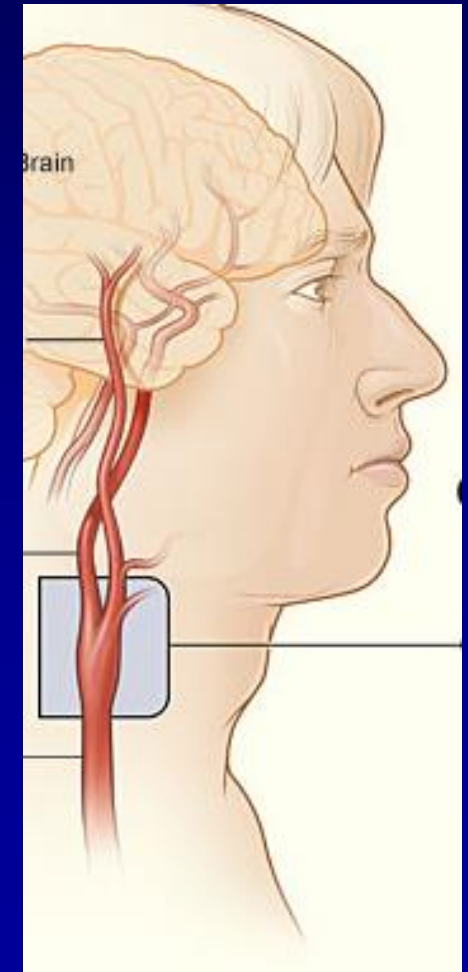
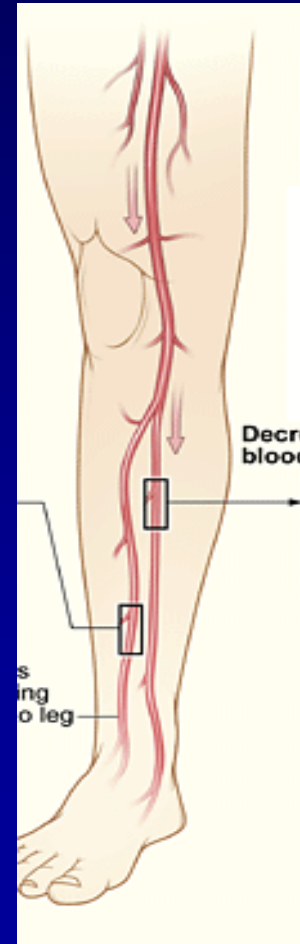
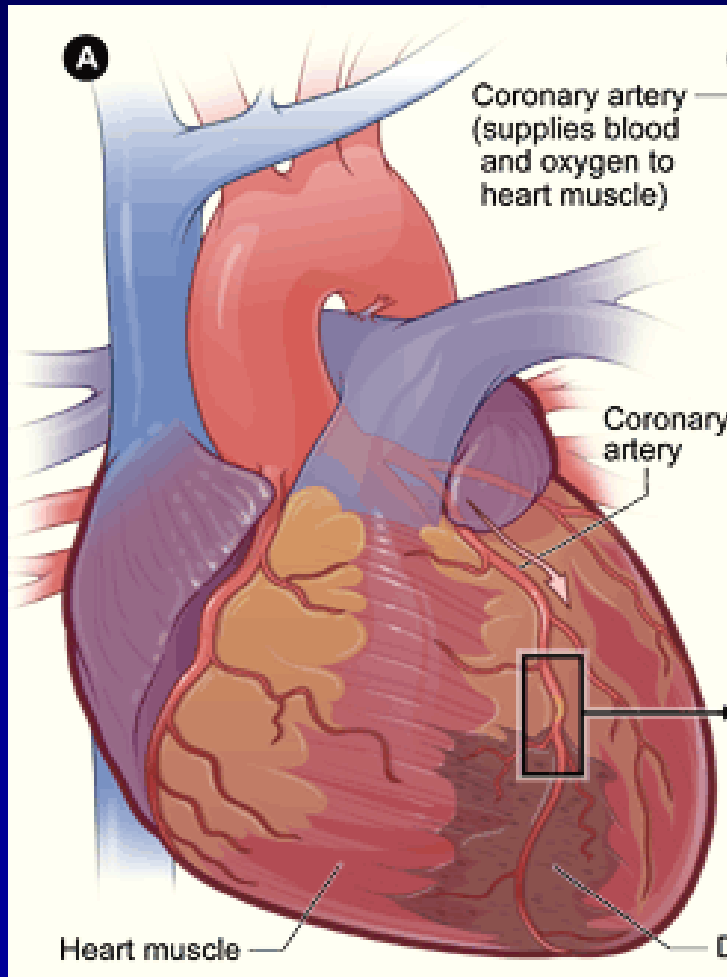


Mechanism of Formation of Atherosclerotic Plaque Based on Hydraulic Studies

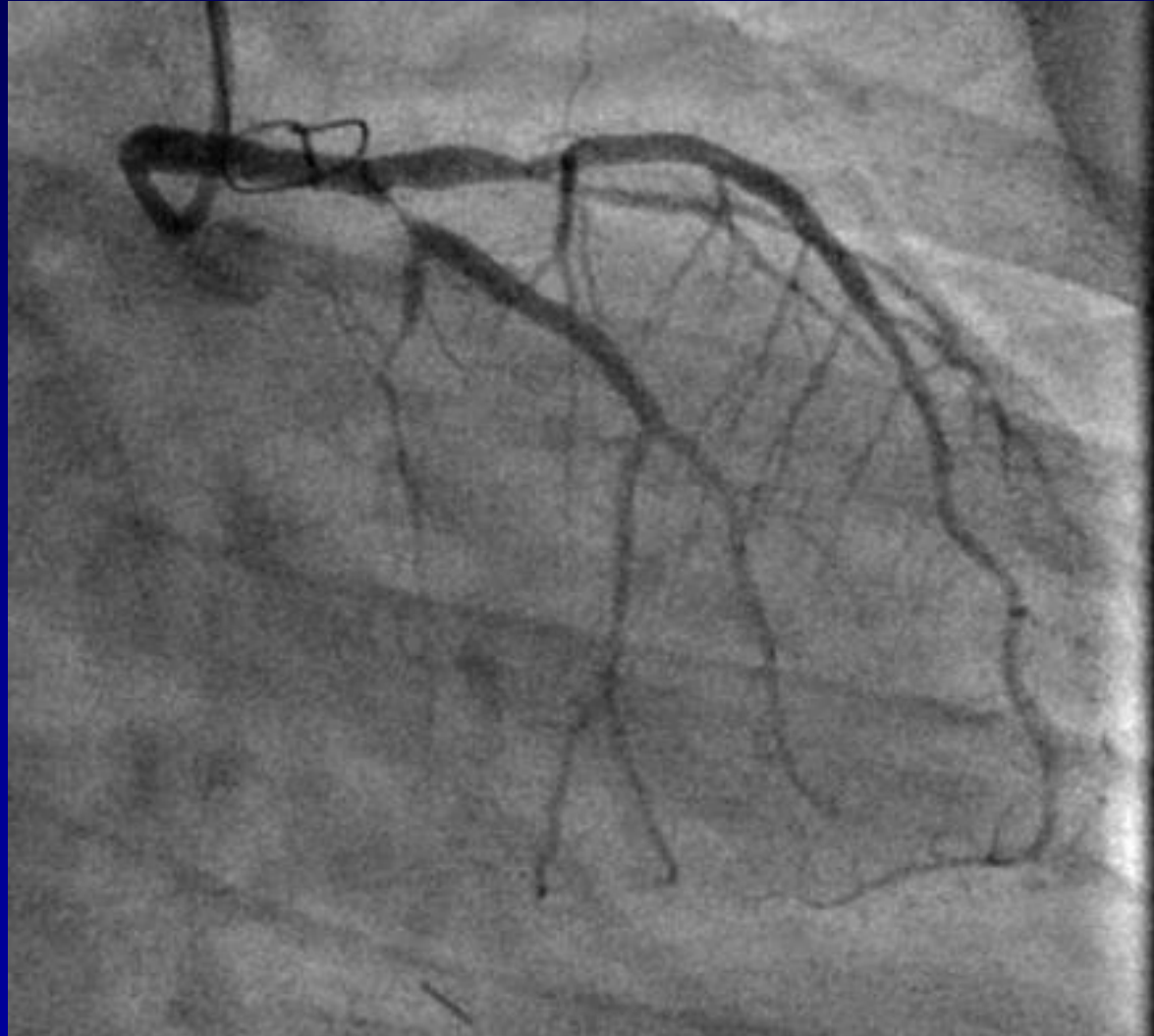
**Thach Nguyen MD FACC FSCAI
Methodist Hospital, Merrillville IN
December 8th, 14:00**

QUESTIONS

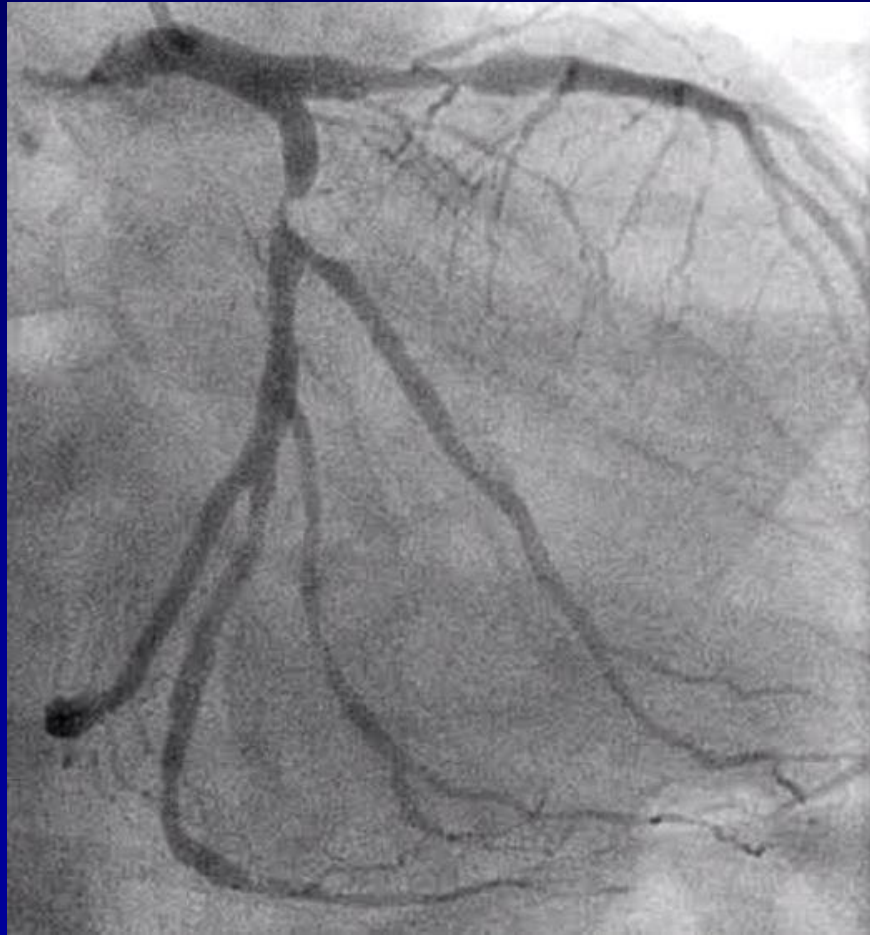
1. ALL exposed to systemic risk factors and only a few arteries develop plaques



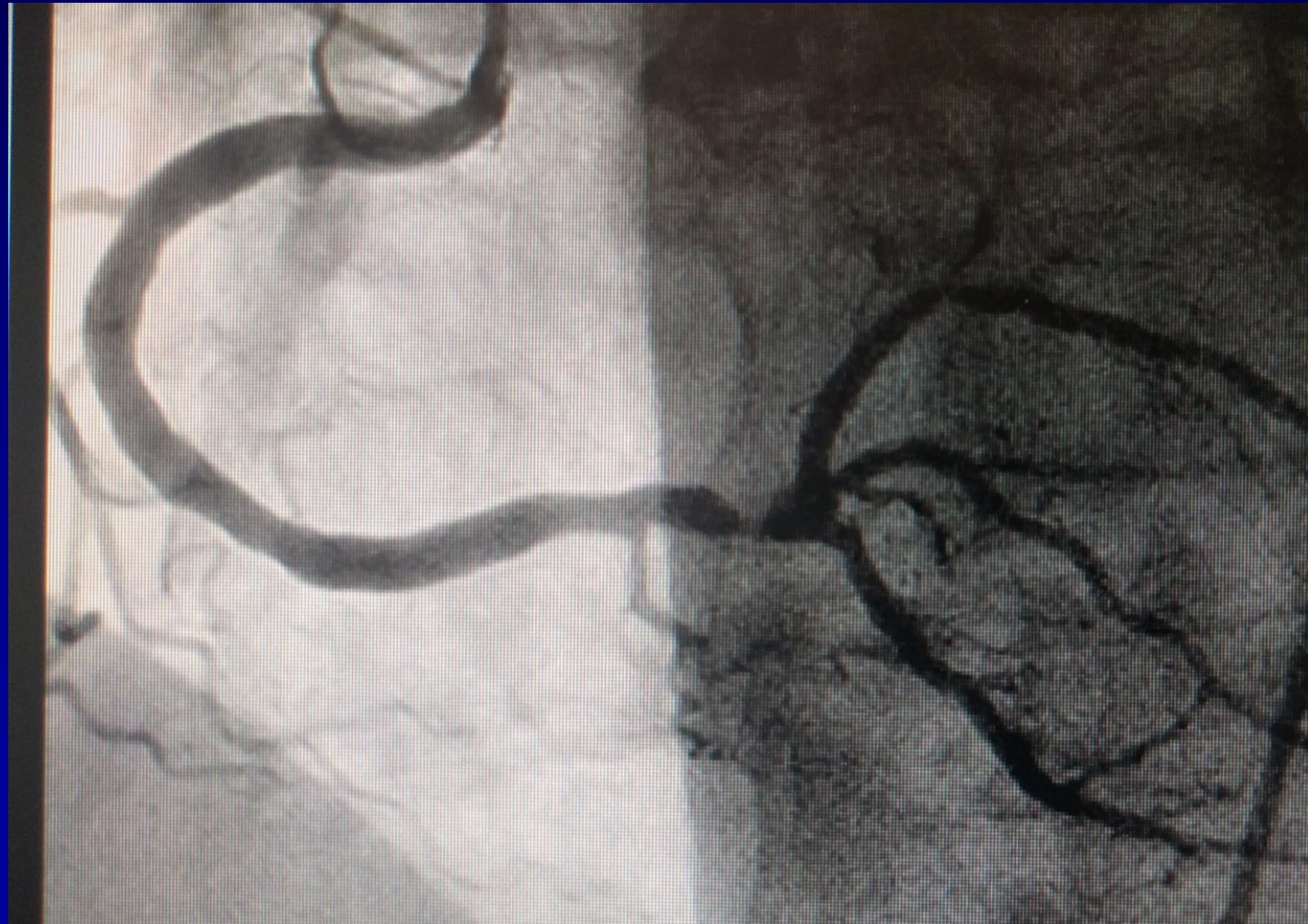
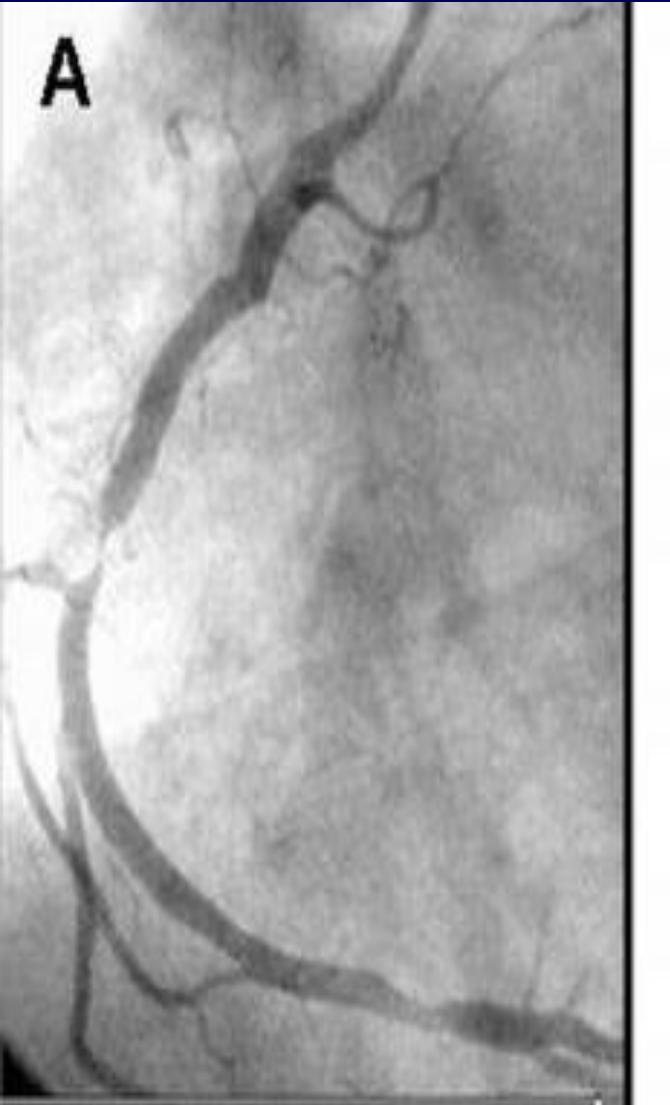
2. Why at the outer wall of the side branch after a bifurcation?



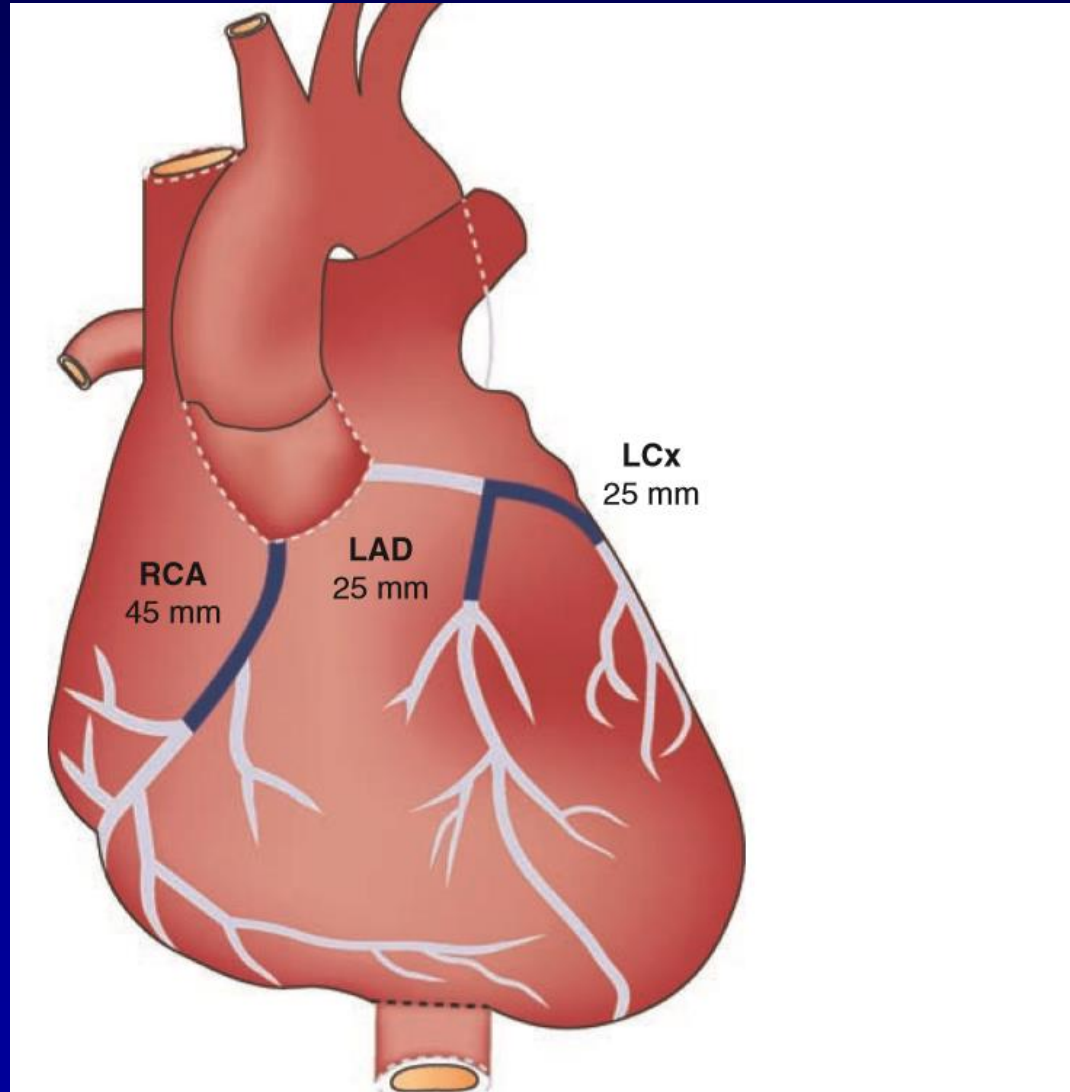
3. Not at the outer wall of the bifurcation side branch? Always at the proximal segment of the coronary arteries



4. Why mid-segment and not distal? Why distal and not mid-segment?



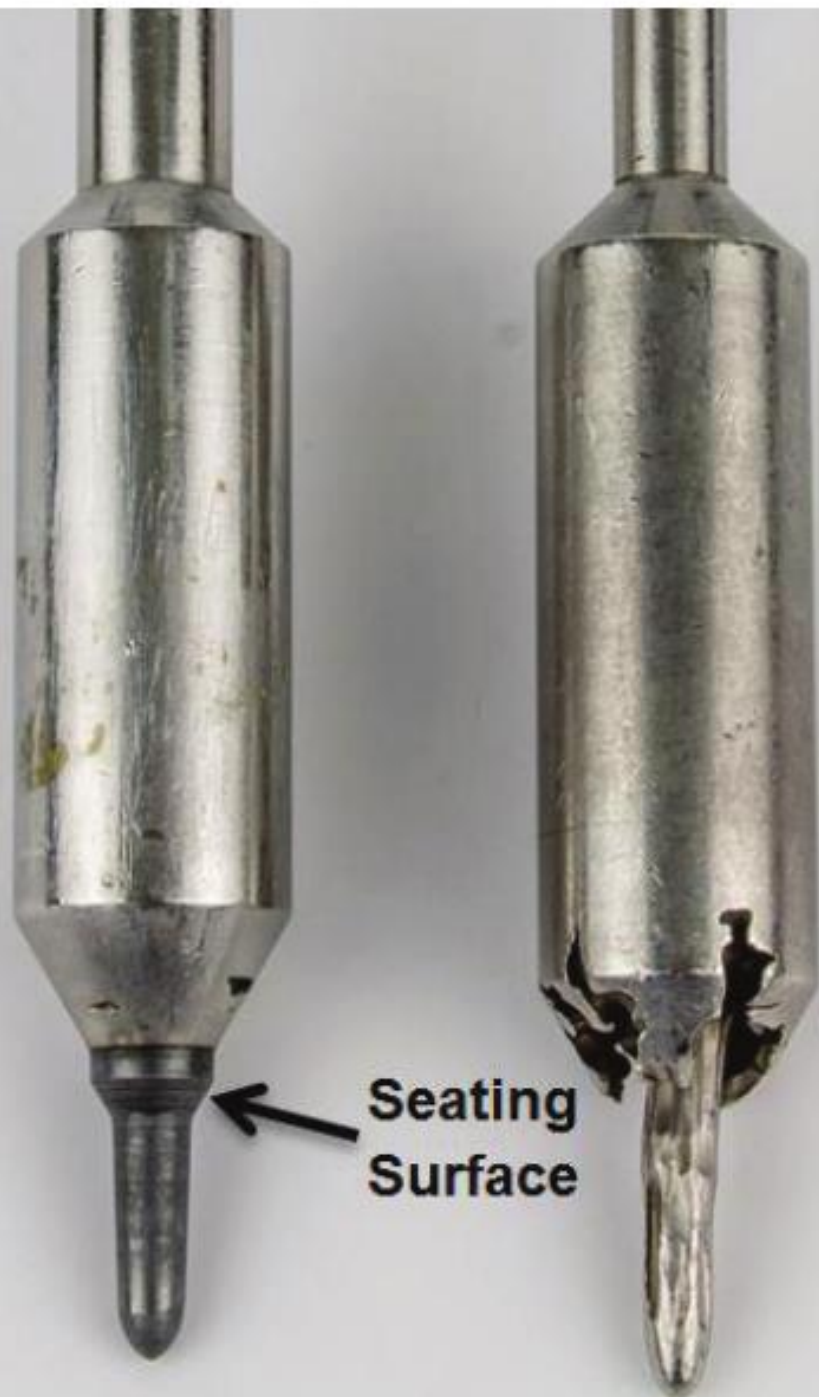
5. Why clustering in the proximal segment?



OBSERVATIONS from HYDRAULICS

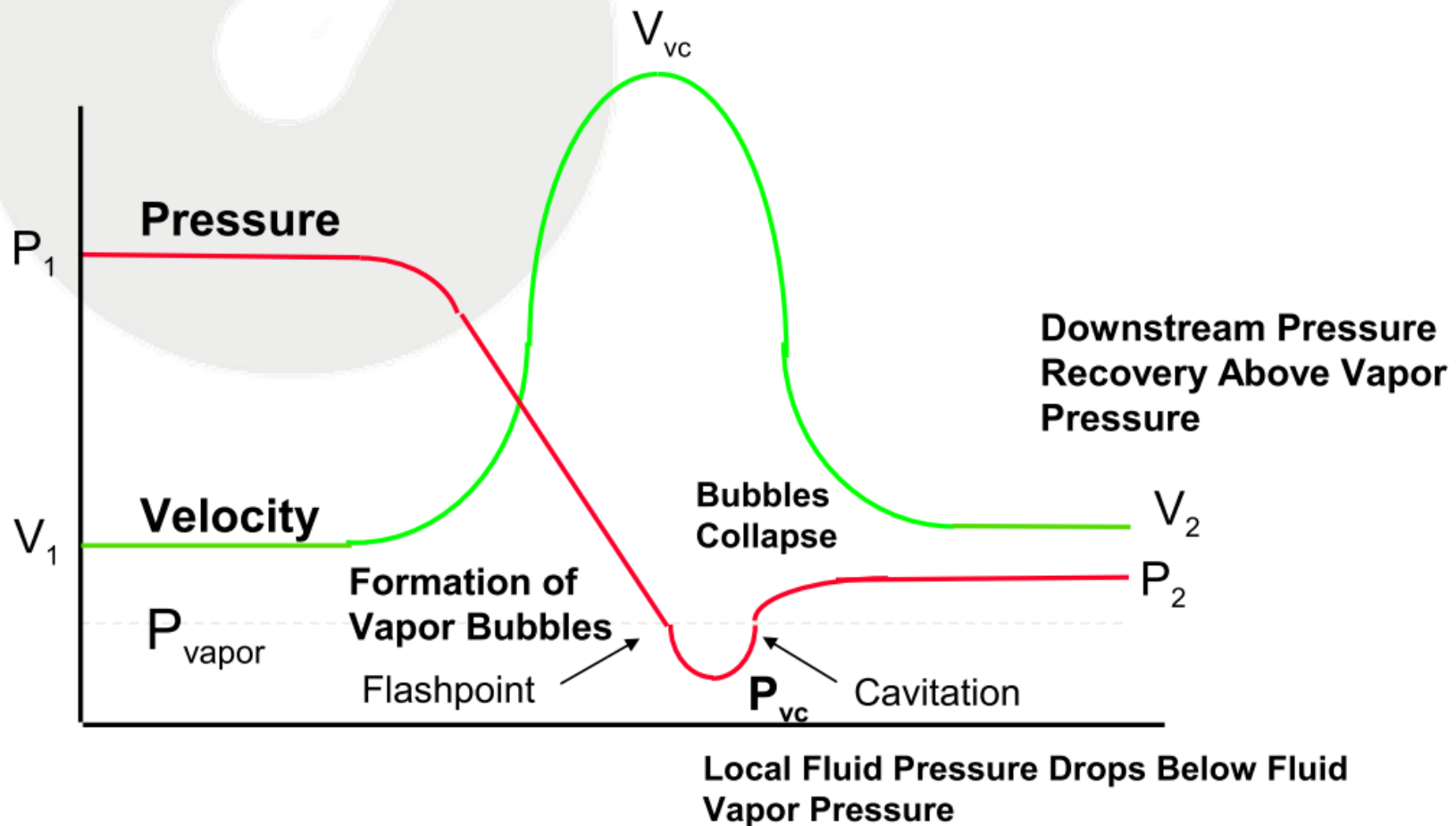




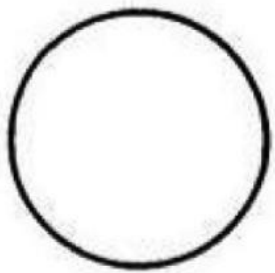


Seating
Surface

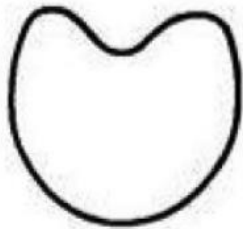
Cavitation Phenomena



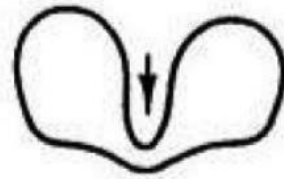
FLOW DIRECTION →



Initial spherical bubble



Perturbation of side away from surface



Upper fluid penetrating flattened side



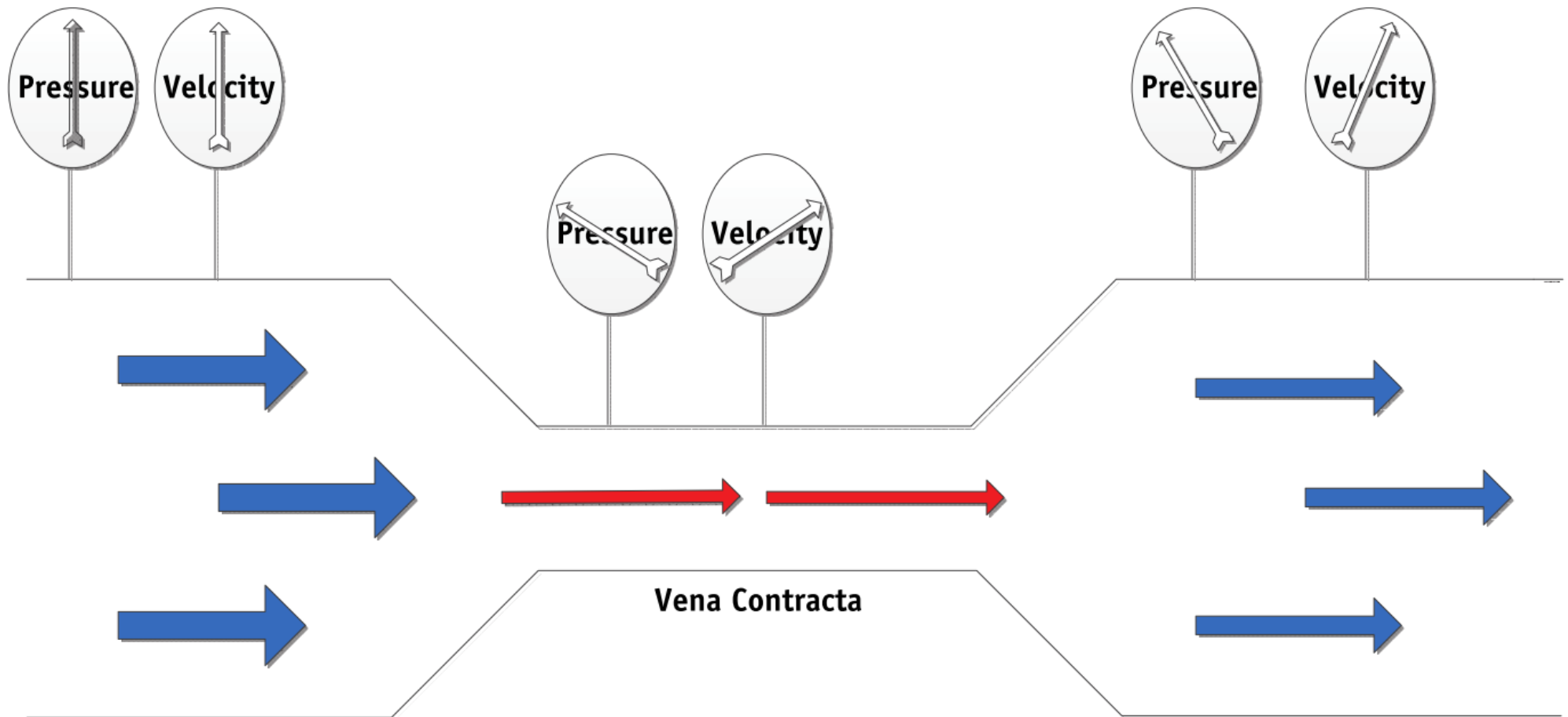
Formation of jet

□ Figure 7. Vapor bubble collapsing as static fluid pressure recovers to above PV

The violent implosion of cavitation bubbles can lead to the generation of shock waves, high-velocity liquid jets, free radical species, and strong shear forces that can damage the nearby tissue

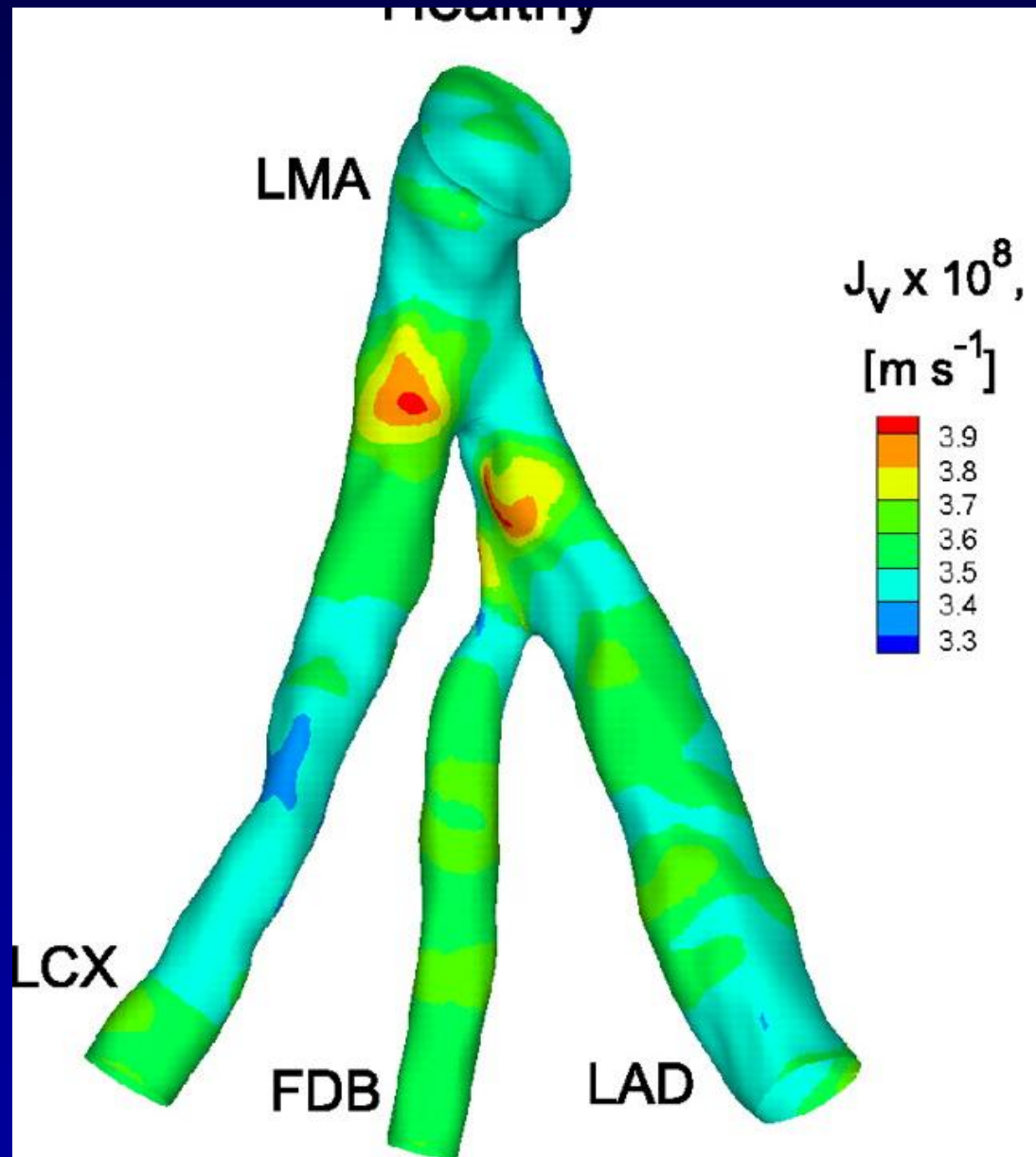
**QUESTION: How can Cavitation Happen
in Coronary Arteries?**

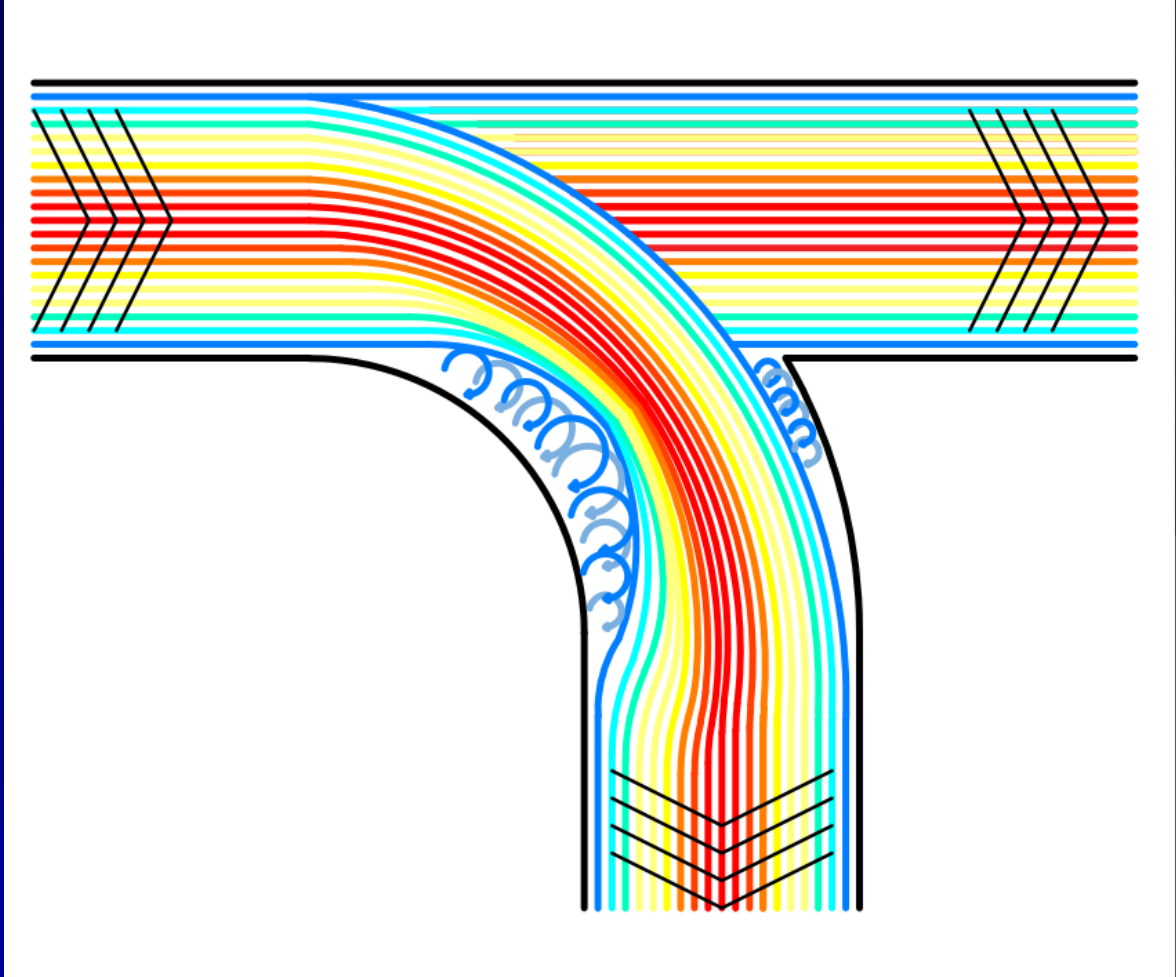
High velocity is RED and low velocity is BLUE



□ Figure 4. Bernoulli's principle and the impact of velocity on static pressure

Fluid Velocity and Pressure at a Curve



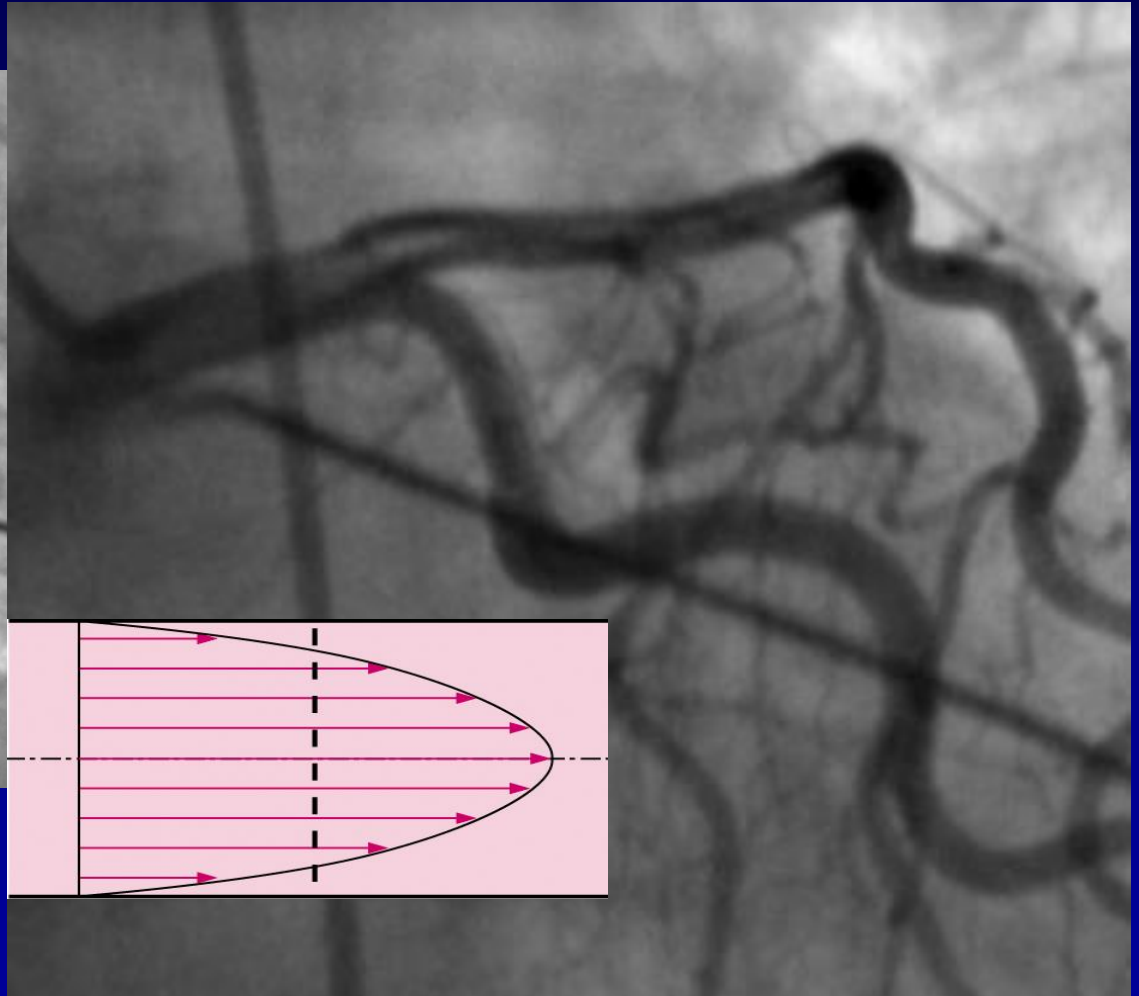
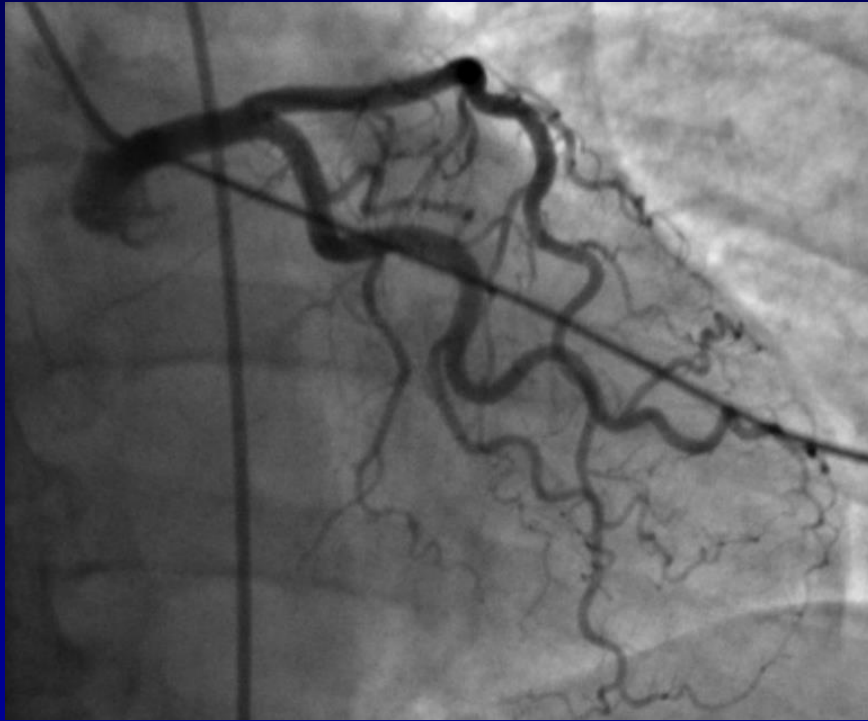


2 Questions 2 b solved

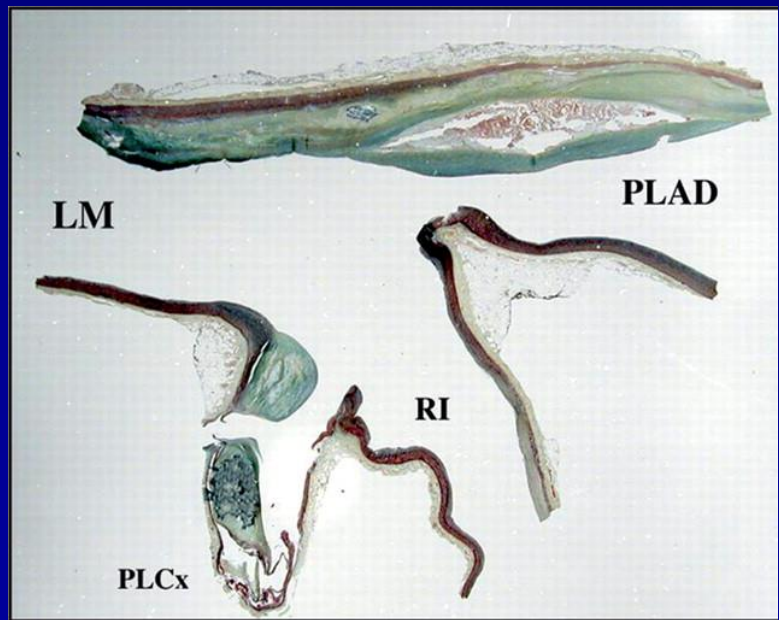
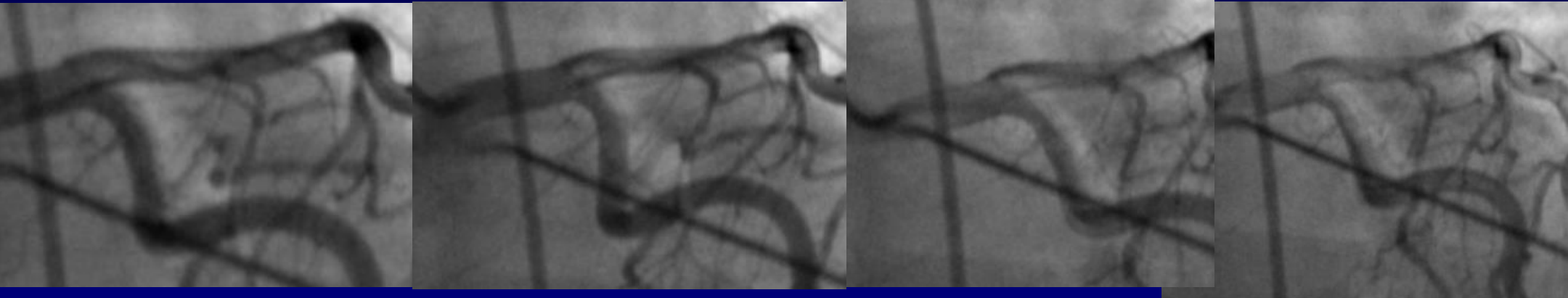
- a. Can bubbles form in the LM?
- b. Can the bubbles grow and subsequently burst?



Laminar Flow in the Left Main



White Area = High Velocity and Low Pressure
Black Area = Low Velocity and High Pressure



SURROGATES

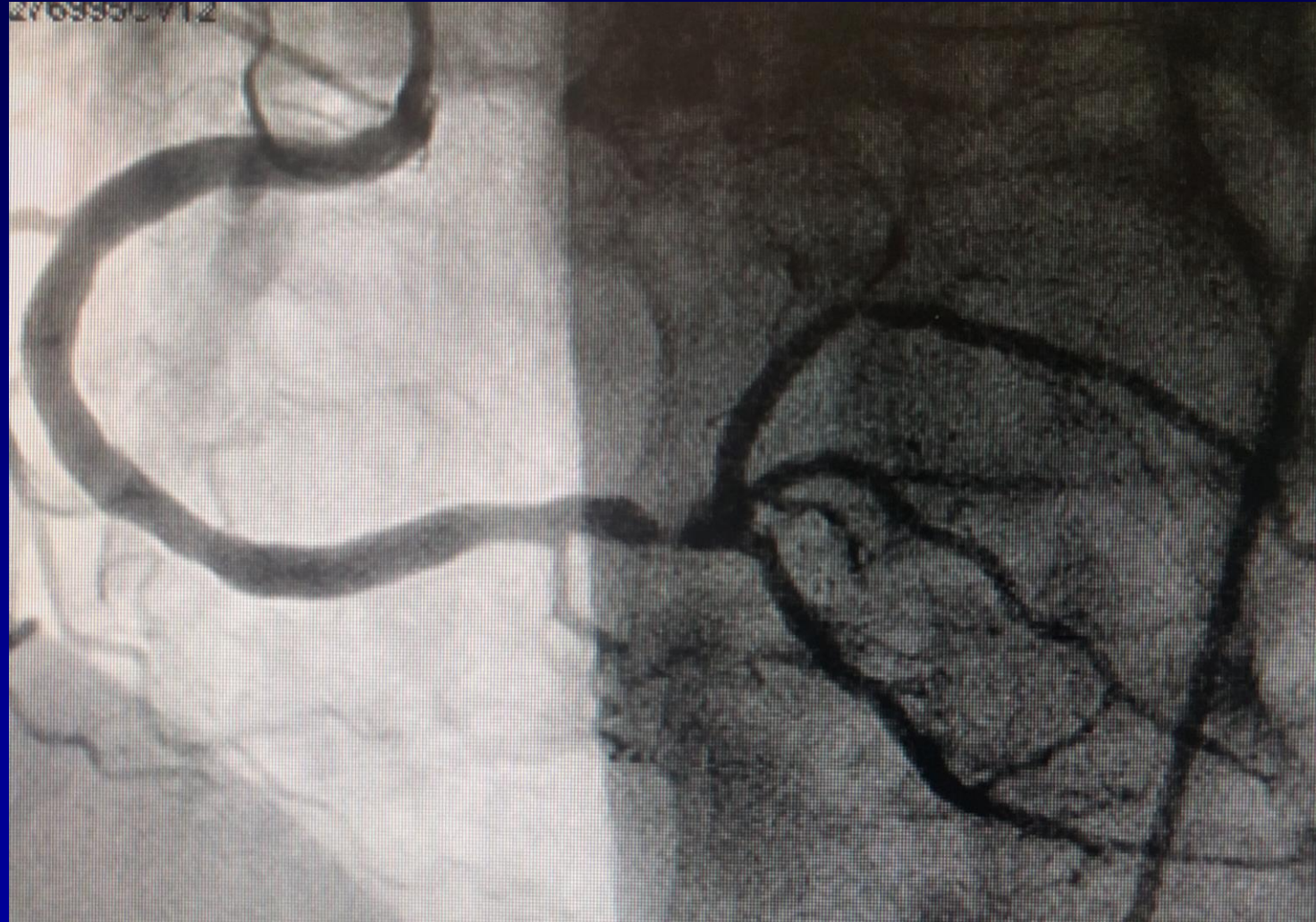
1. Lesion on angiogram
2. Velocity on CFD
3. Velocity reflects the pressure
Low pressure (blue)= bubbles grow
High pressure (red) = bubbles burst
4. On angio at the middle of the arterial phase:
high speed = low pressure= white
low speed = high pressure = black

EXERCISES:

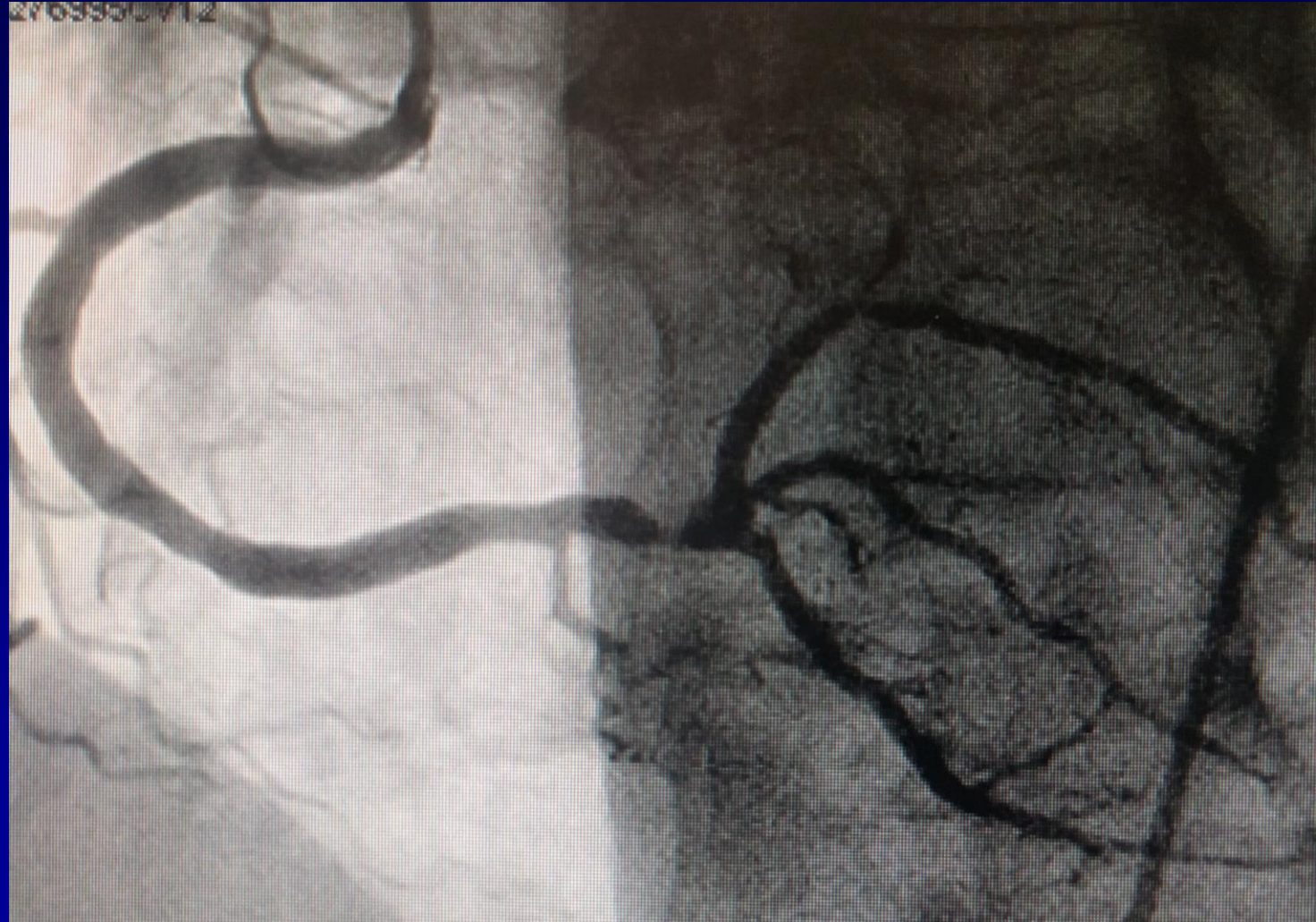
Where Do the Bubbles Form?

Where Do they Burst?

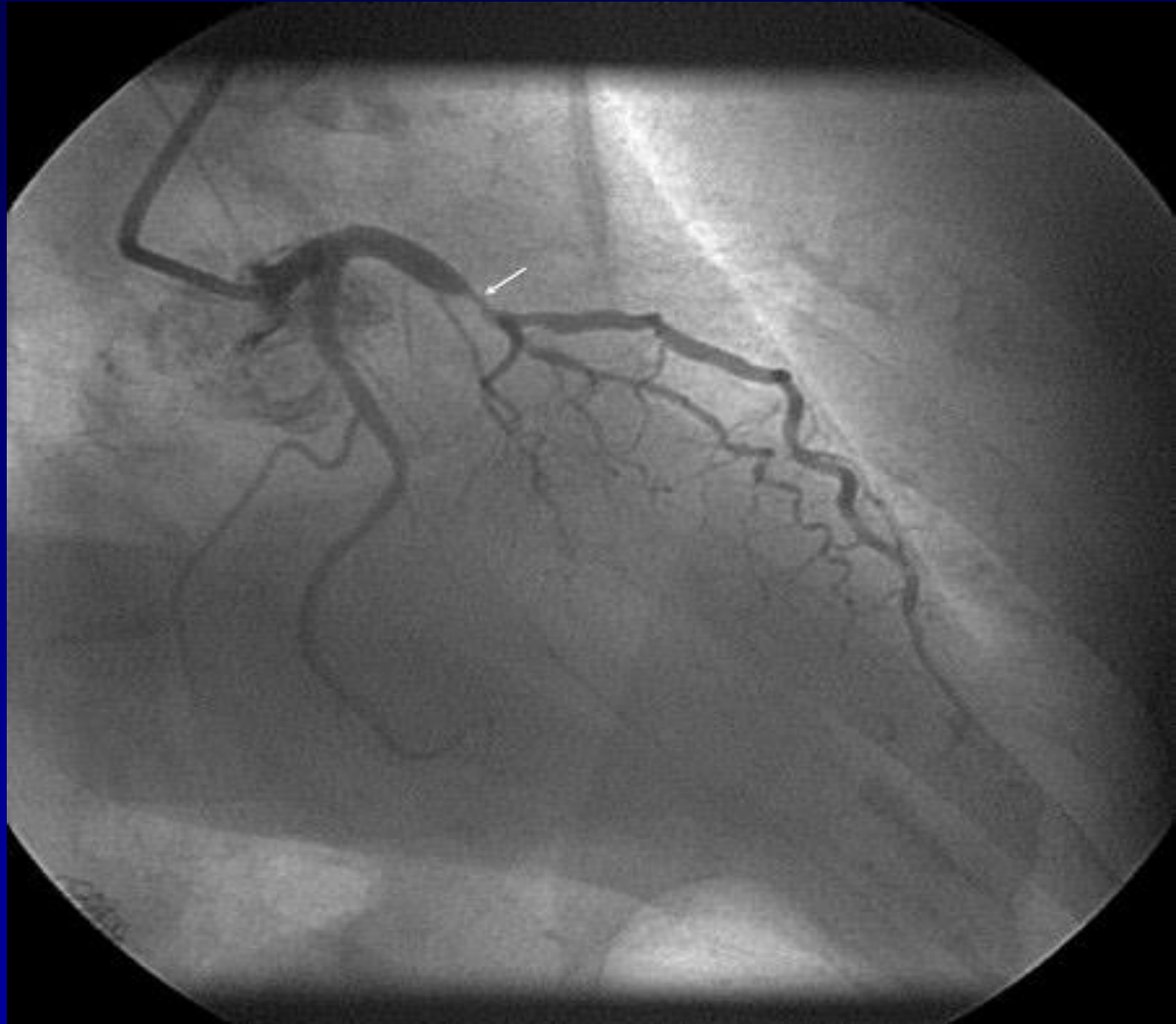
1. Why is the lesion so distal?



**If the artery is
large, smooth
transition and no
large side branch**

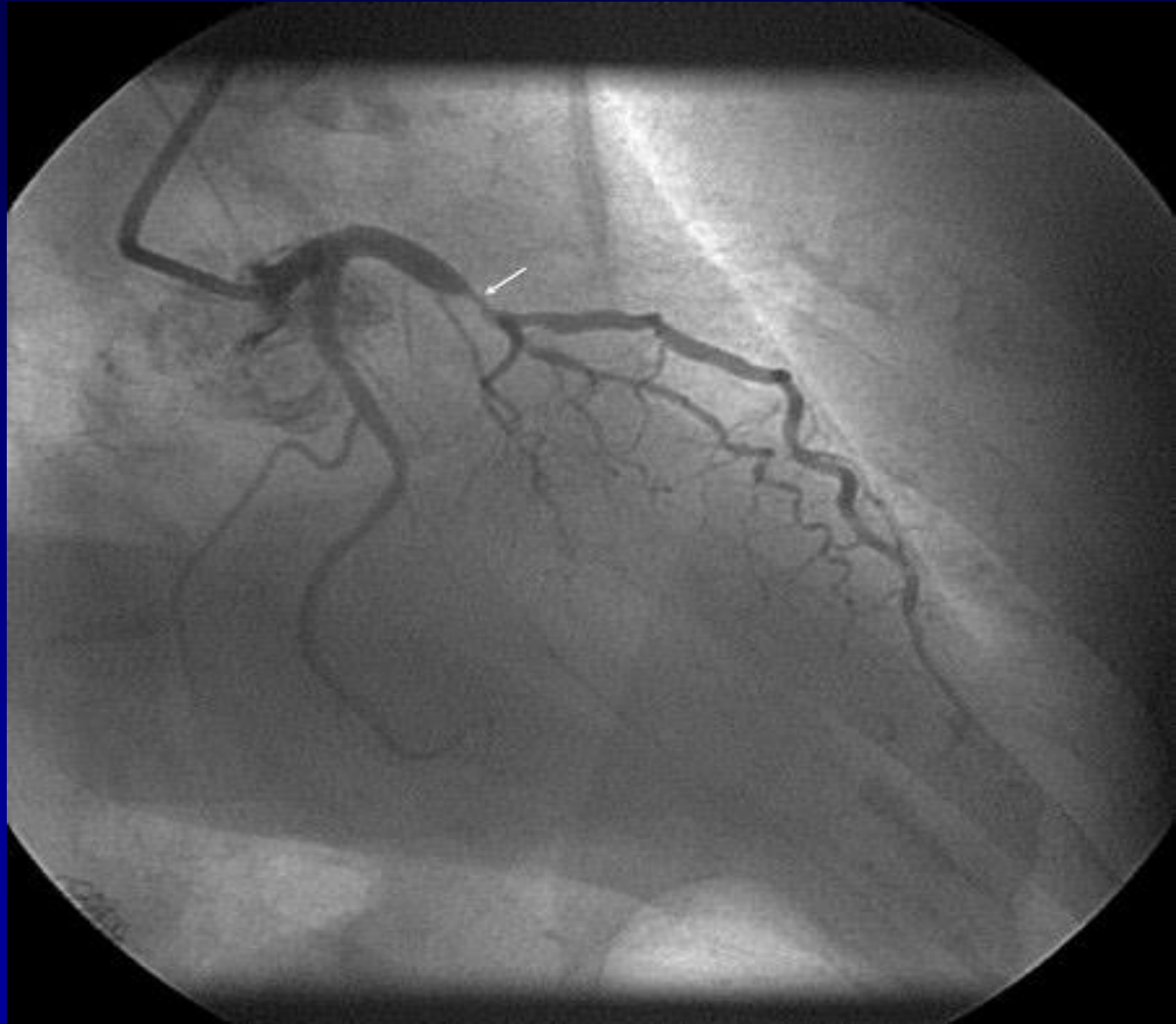


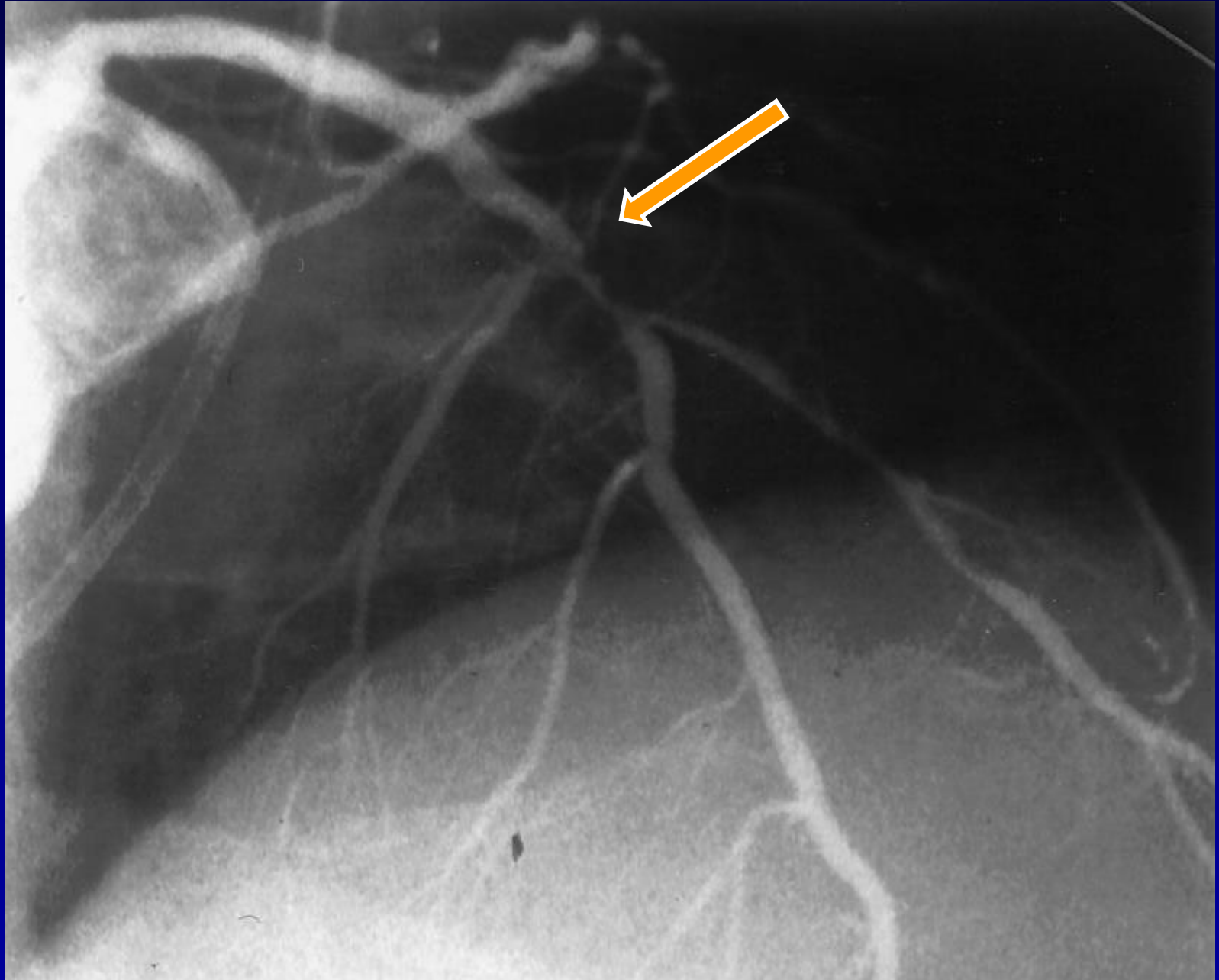
**2. Why is there no lesion in the LCX?
Why does the lesion happen in the mid LAD?**

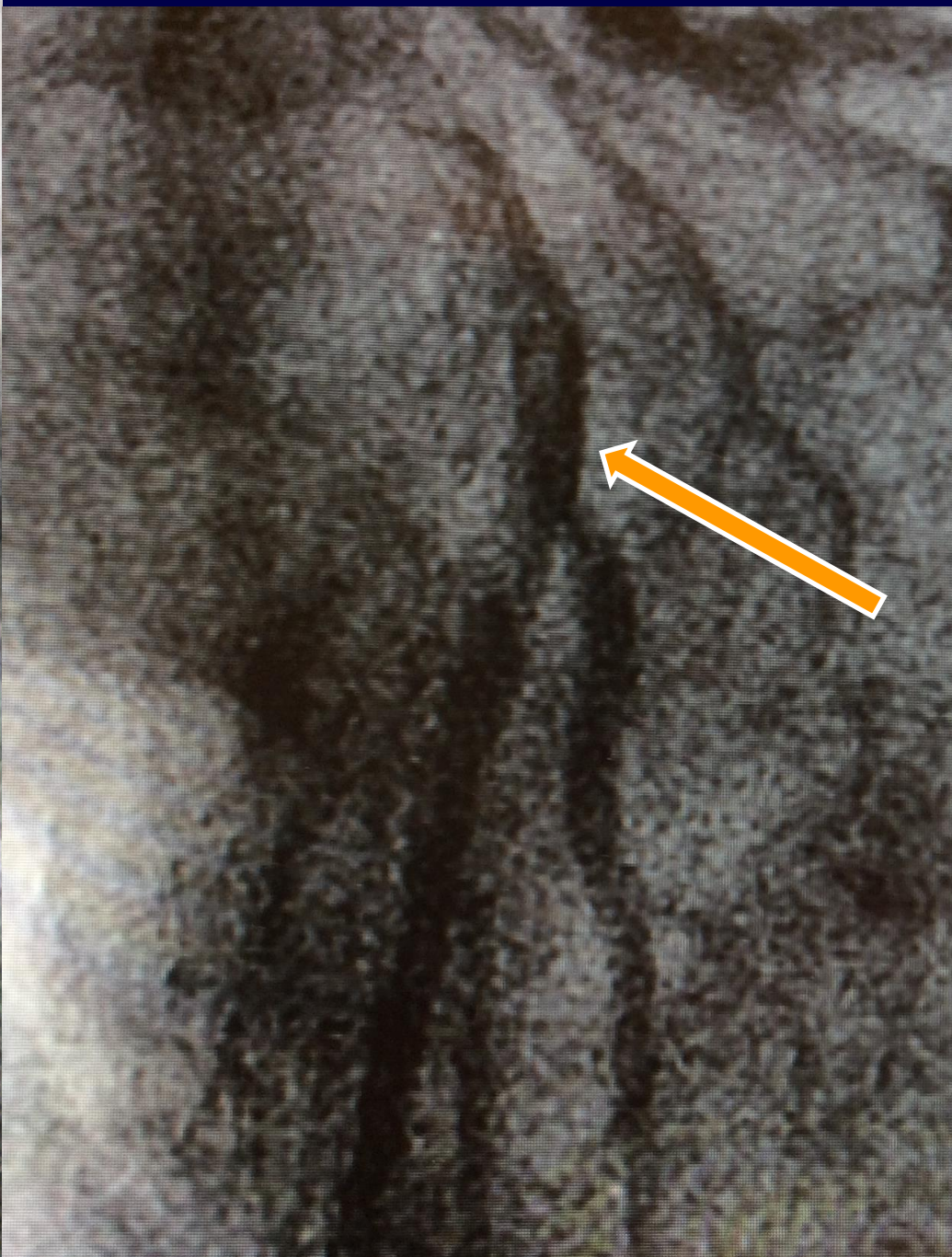


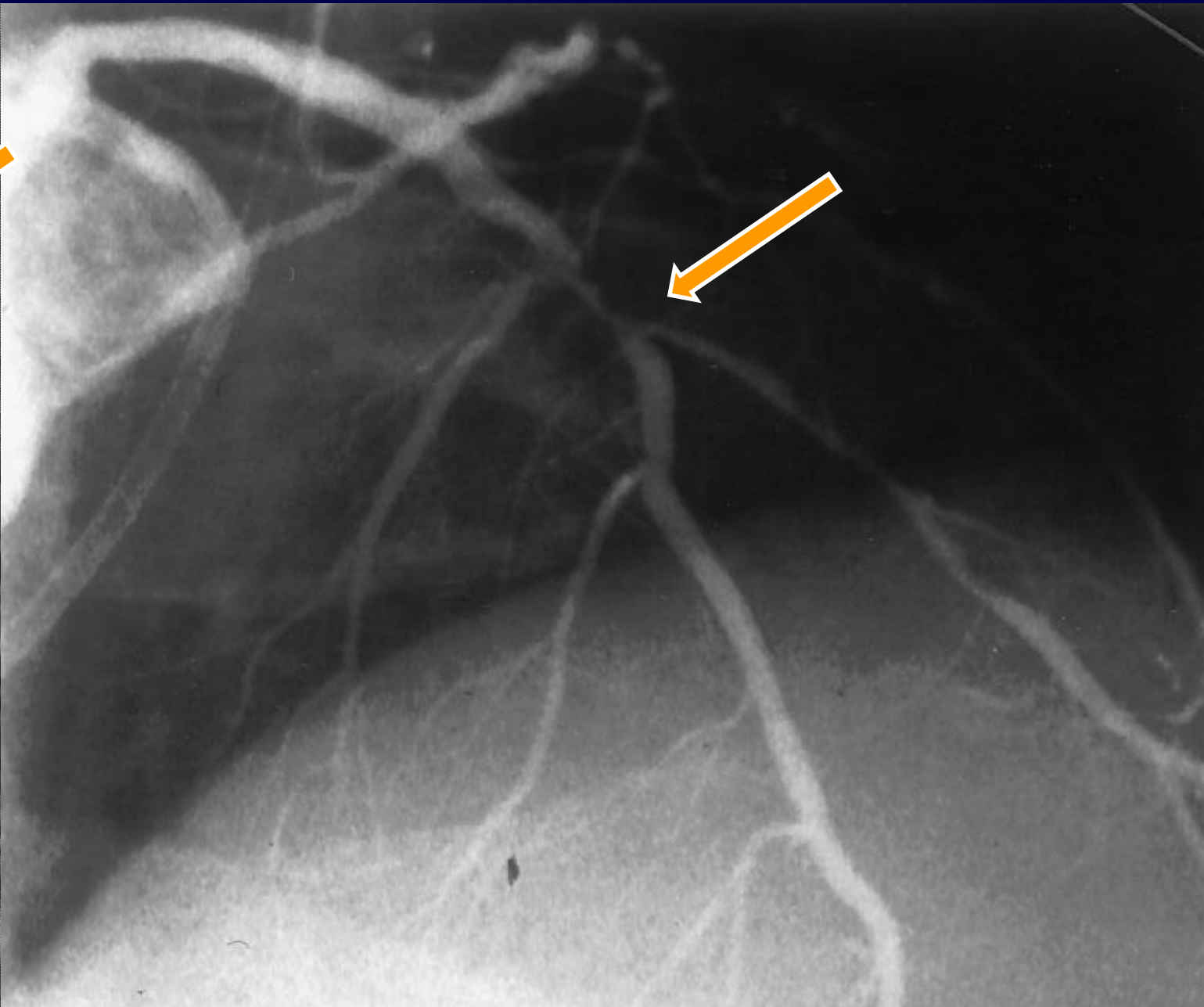
**Small LCX, no side
branch**

**The lesion is the
proximal LAD,
same side with the
sidebranch**









QUESTION

Had the interventional cardiologist ever used bubbles rupture to break the cholesterol plaque?

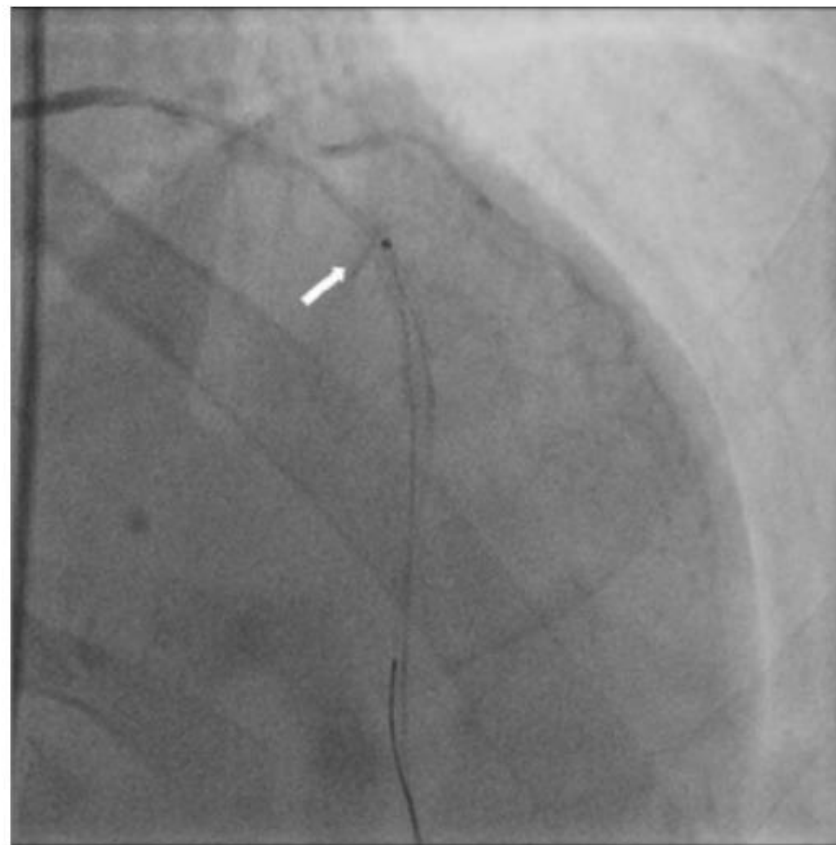


Fig. 3. Tip of 0.9 mm ELCA Lasercatheter (Spectranetics, Colorado Springs, CO) was advanced to the underexpanded stent portion.

- High-energy excimer laser works by vaporization of refractory plaque beneath the stent struts and by the accousto-mechanical effects of rapidly exploding micro-bubbles generated within the contrast media.

Laser Angioplasty for Stent Underexpansion

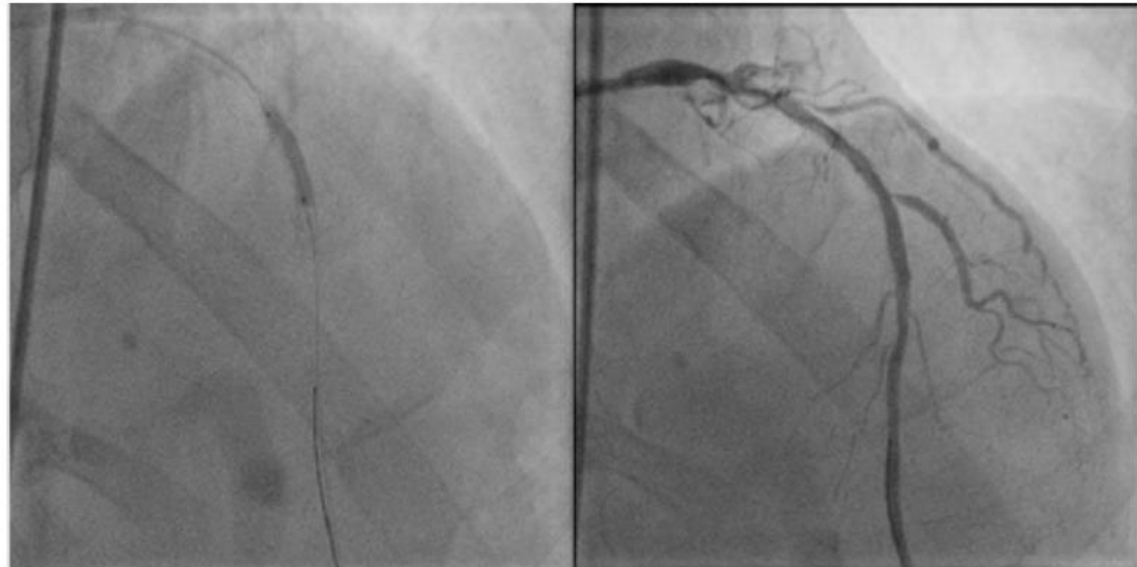


Fig. 4. Good stent expansion was achieved after laser angioplasty with further balloon dilatation.

QUESTION

**Does the arterial architecture predispose
the human race to CAD?**

**The coronary
anatomy is
predisposed to
have plaques**

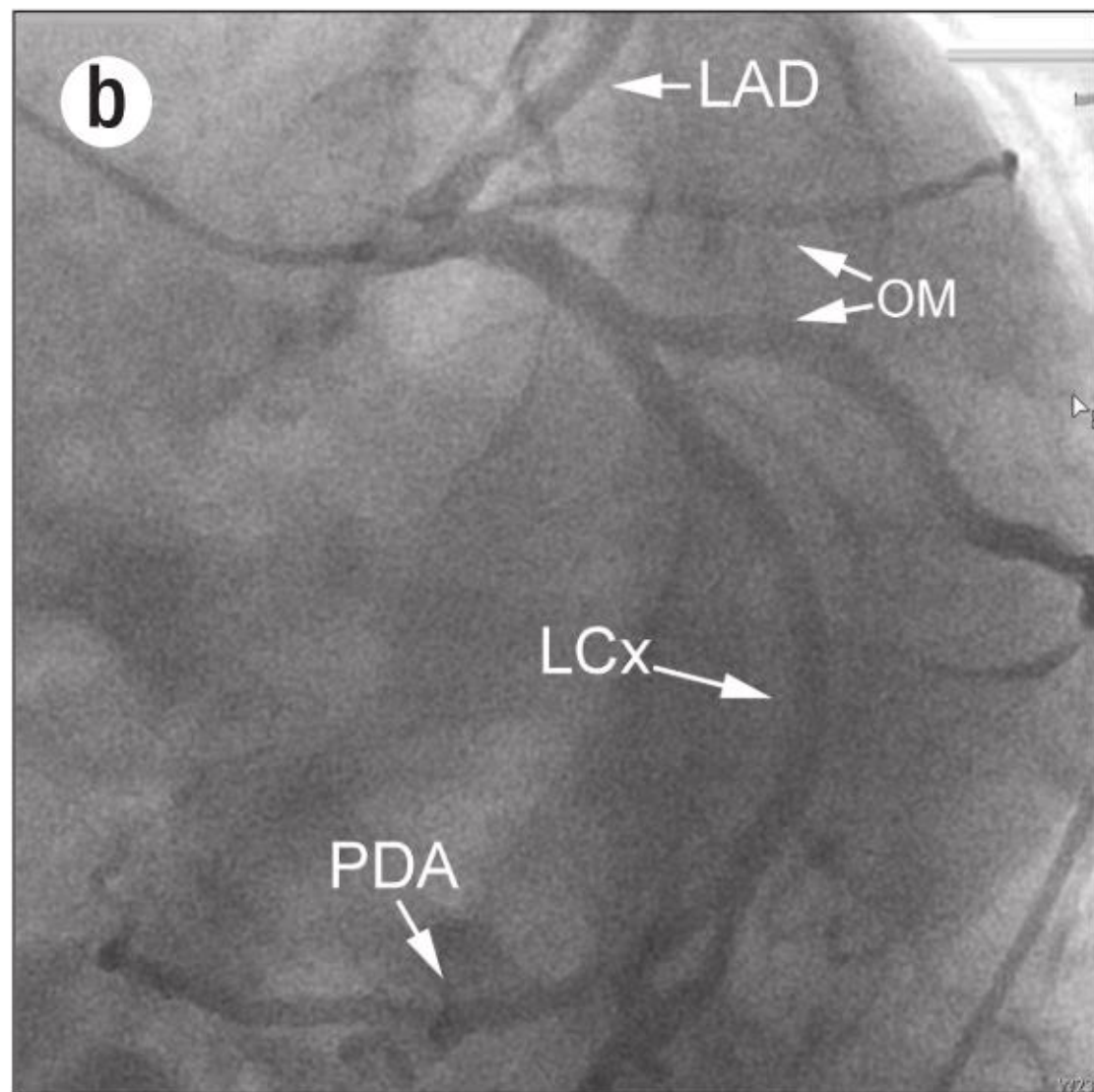
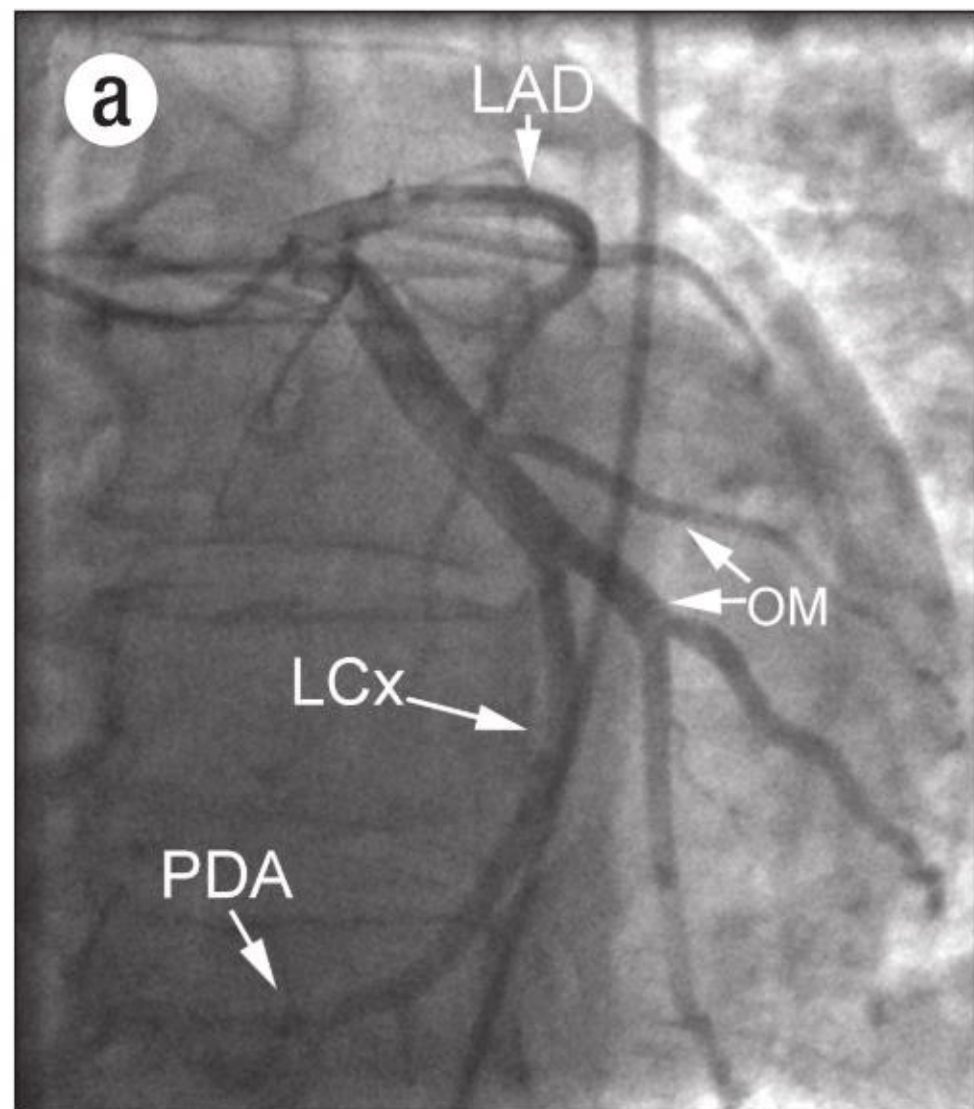


Figure 1. Right anterior oblique caudal view of high-grade ostial circumflex artery and moderate left anterior descending artery stenoses.

<http://www.vascular diseasemanagement.com/content/radial-access-pci-children-obstructive-coronary-artery-disease>

QUESTION

If two hearts have the same coronary architectural design, can they have the same lesions?



CAD in Twins

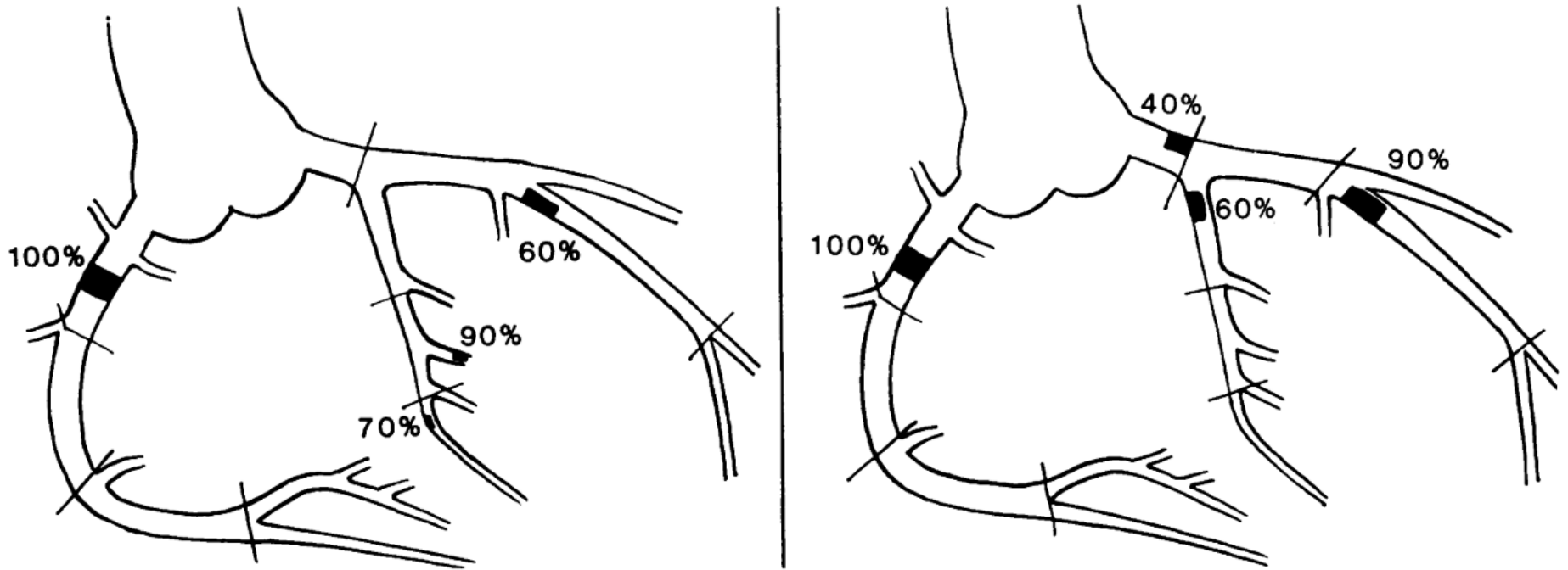
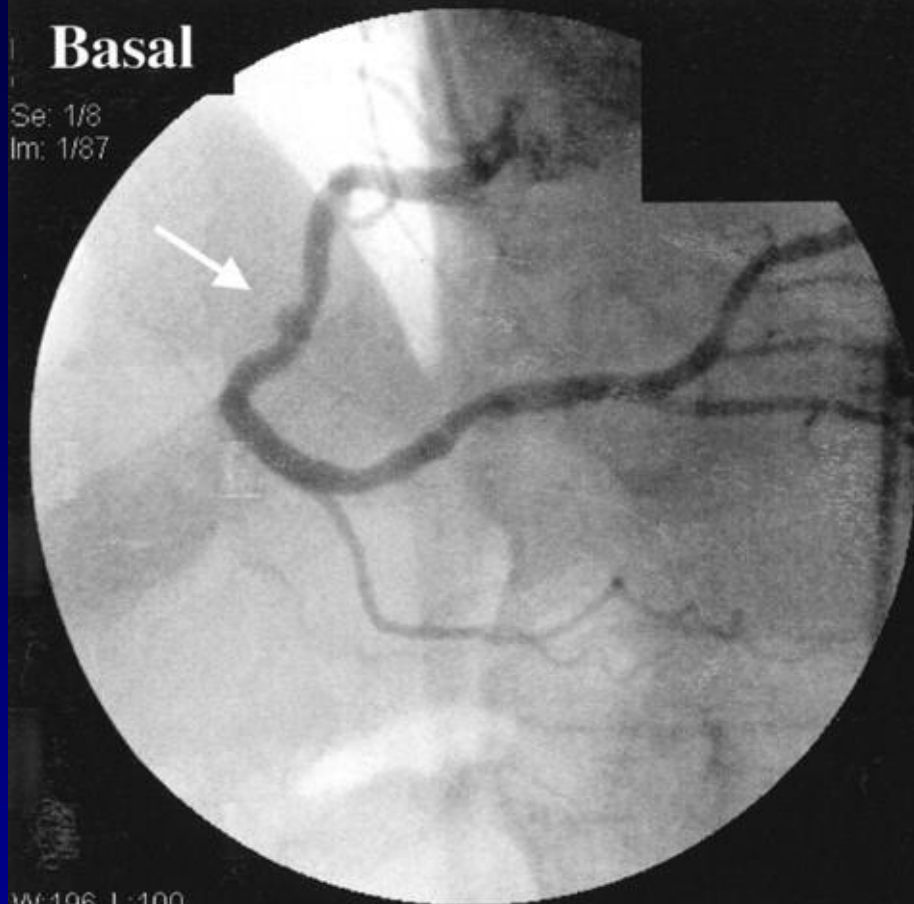


Fig. 2 Schematic representation of coronary anatomy in the second twin pair. Left, case 3. Right, case 4.

Basal

Se: 1/8
Im: 1/87



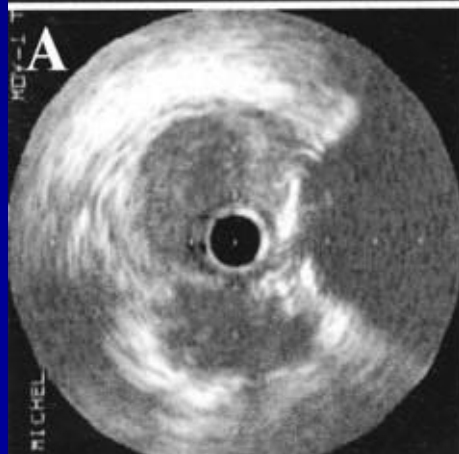
W:196 L:100

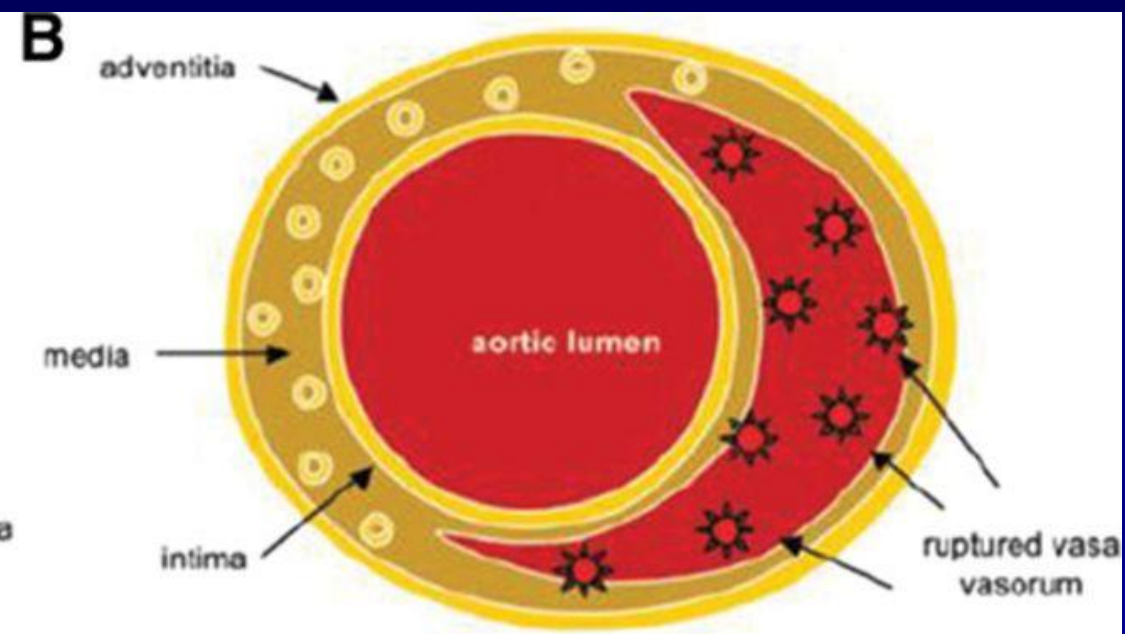
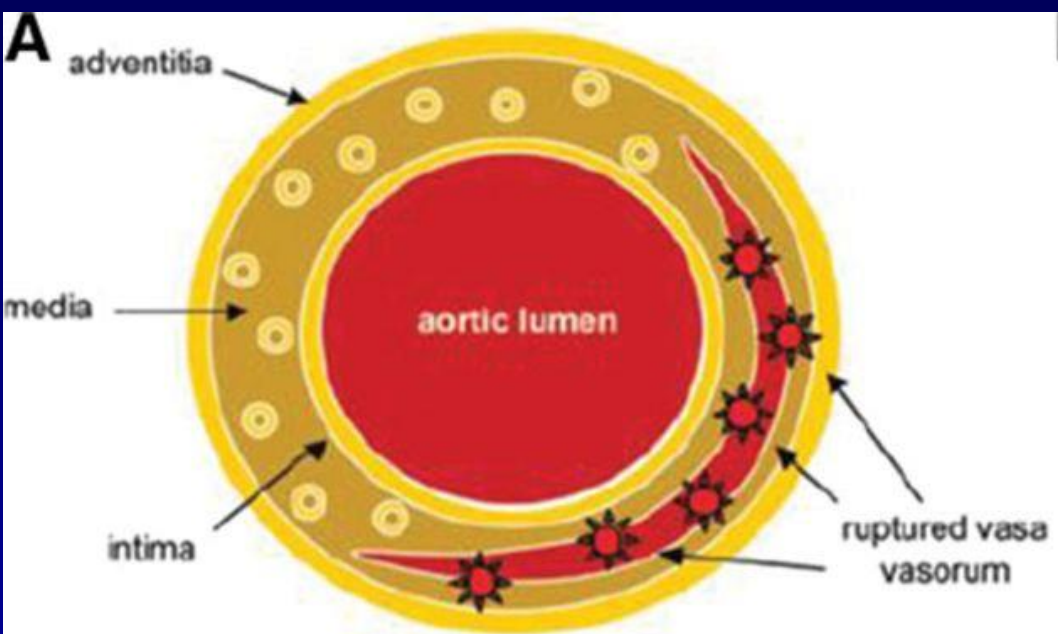
21 month-FU

Se: 1/17
Im: 1/6



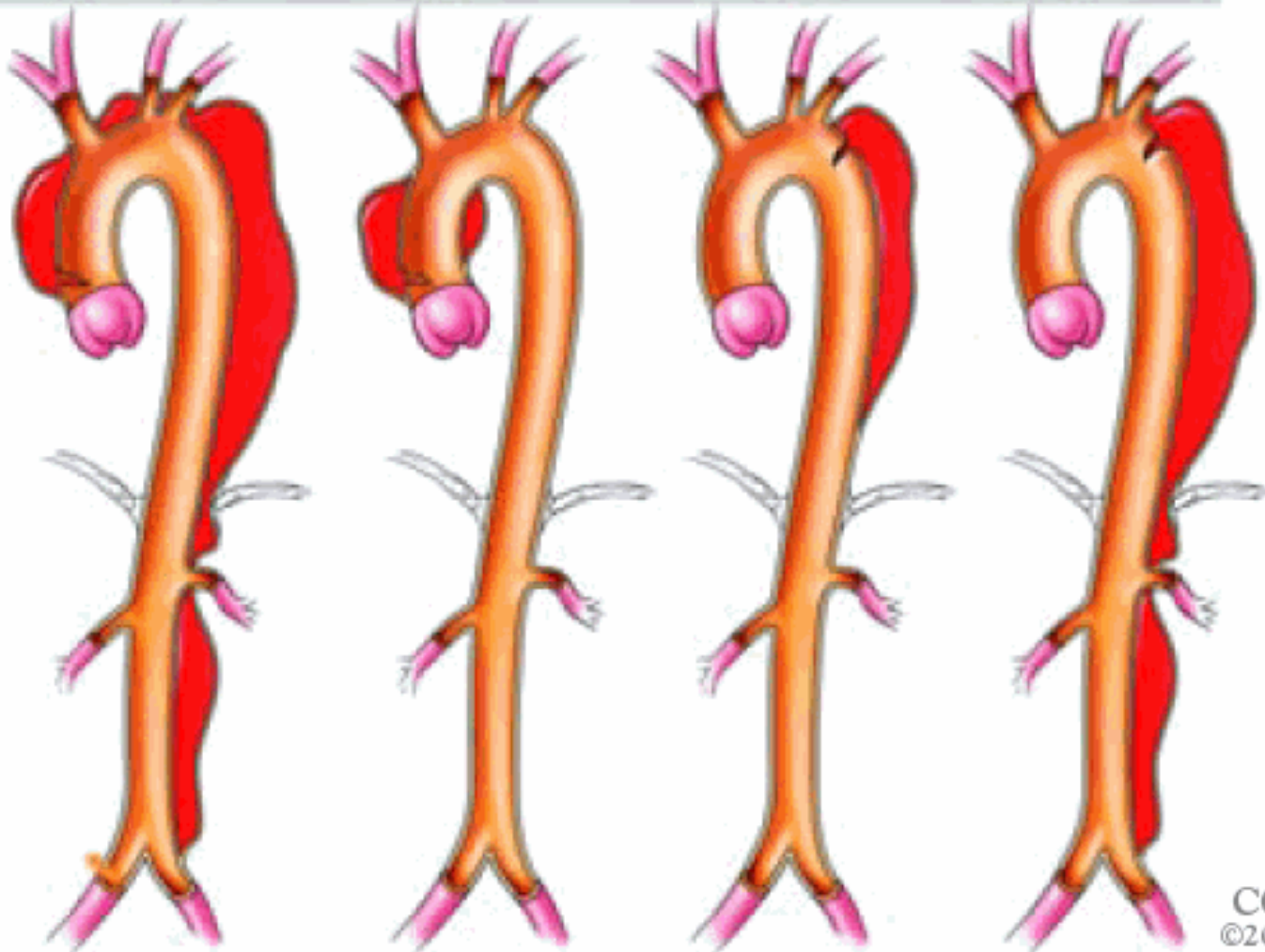
W:190 L:97





Two systems for classifying aortic dissections

DeBakey	I	II	IIIa	IIIb
Stanford	A	A	B	B



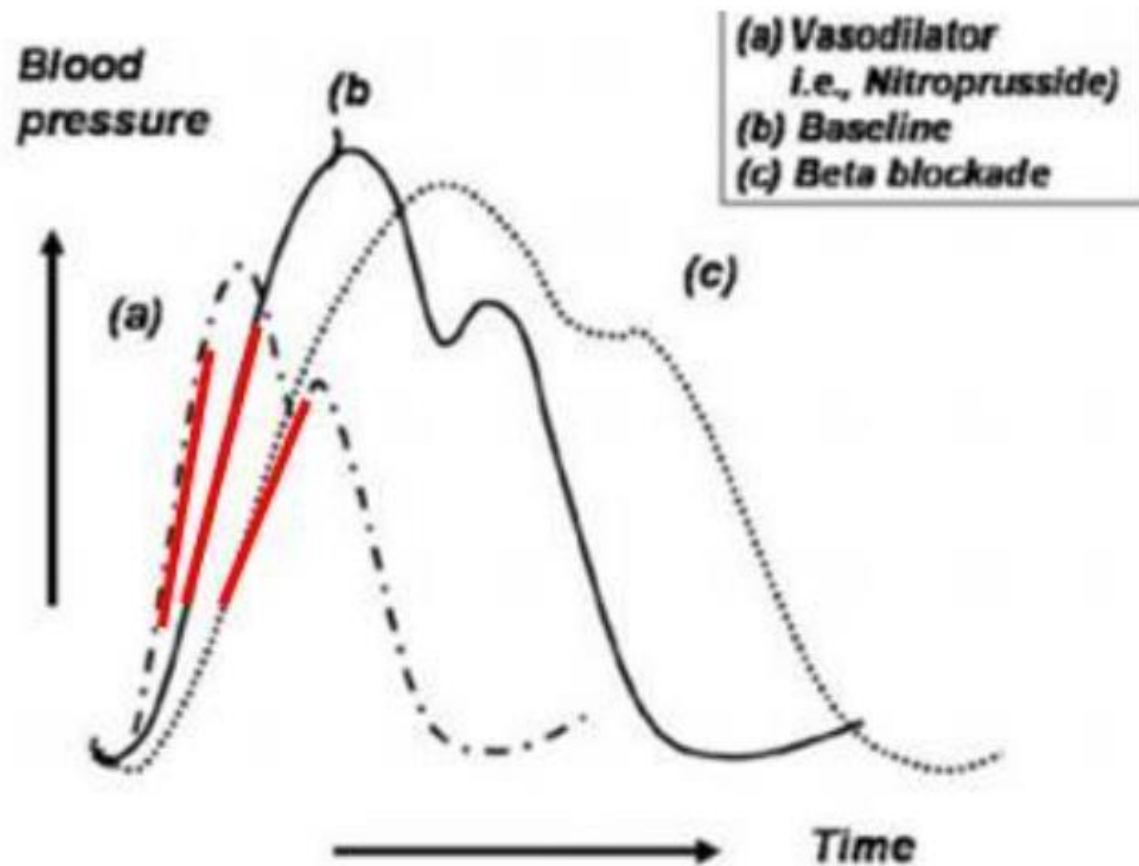
CCF
©2008

FIGURE 3. The DeBakey and Stanford systems



QUESTION

Why does Betablocker Prevent Heart Attack?



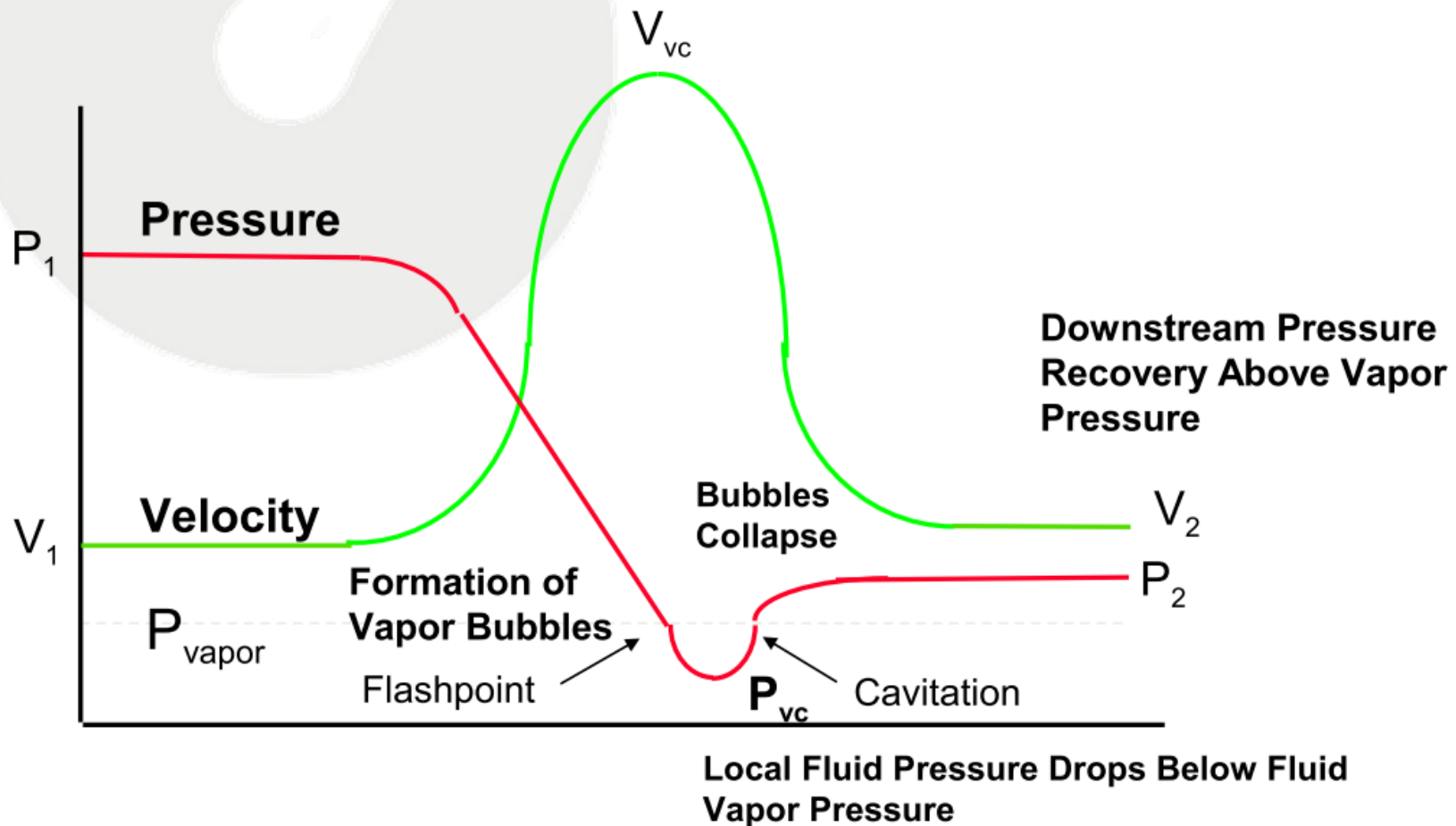
Reproduced from Sanz J et al. (2007)³¹⁾

Fig. 7. Aortic pressure curves under various conditions.

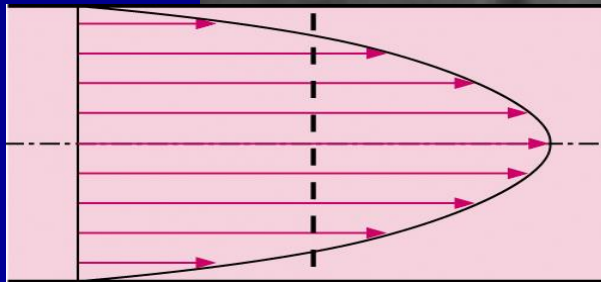
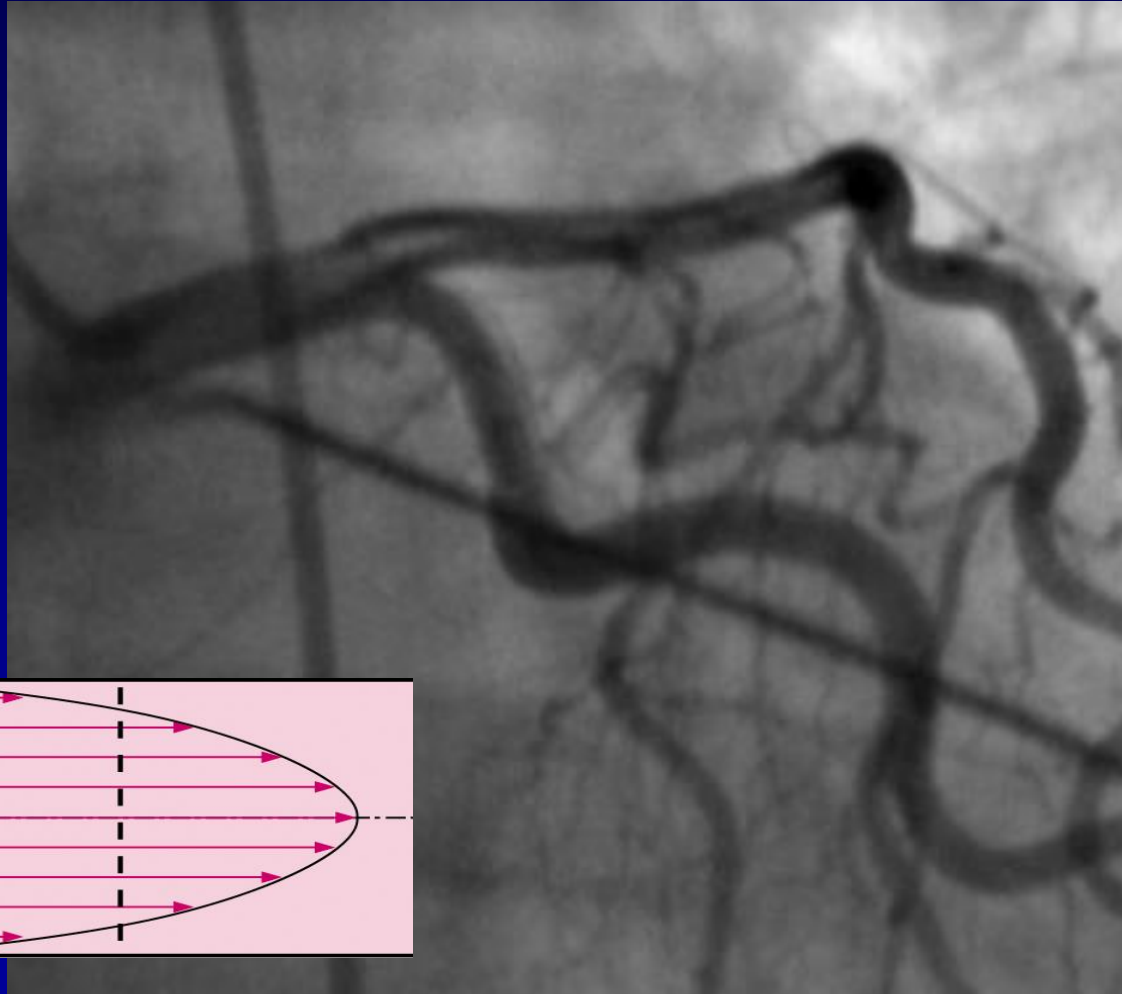
Curve (a), the administration of a vasodilator agent such as nitroprusside; curve (b), the baseline state; curve (c), β -blockade administration.

- How long is the LM should be to neutralize turbulence?
- How should the angle of the LM/ LCX or LAD should be?
- How big the OM should be?

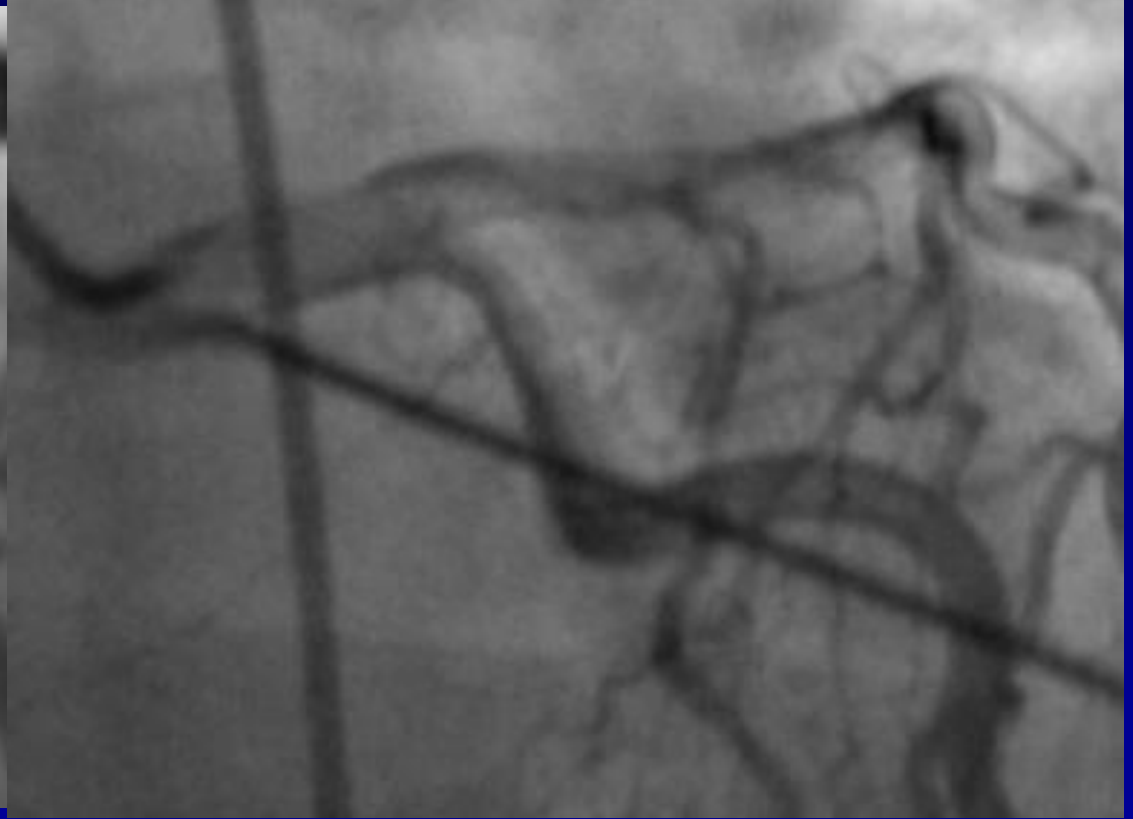
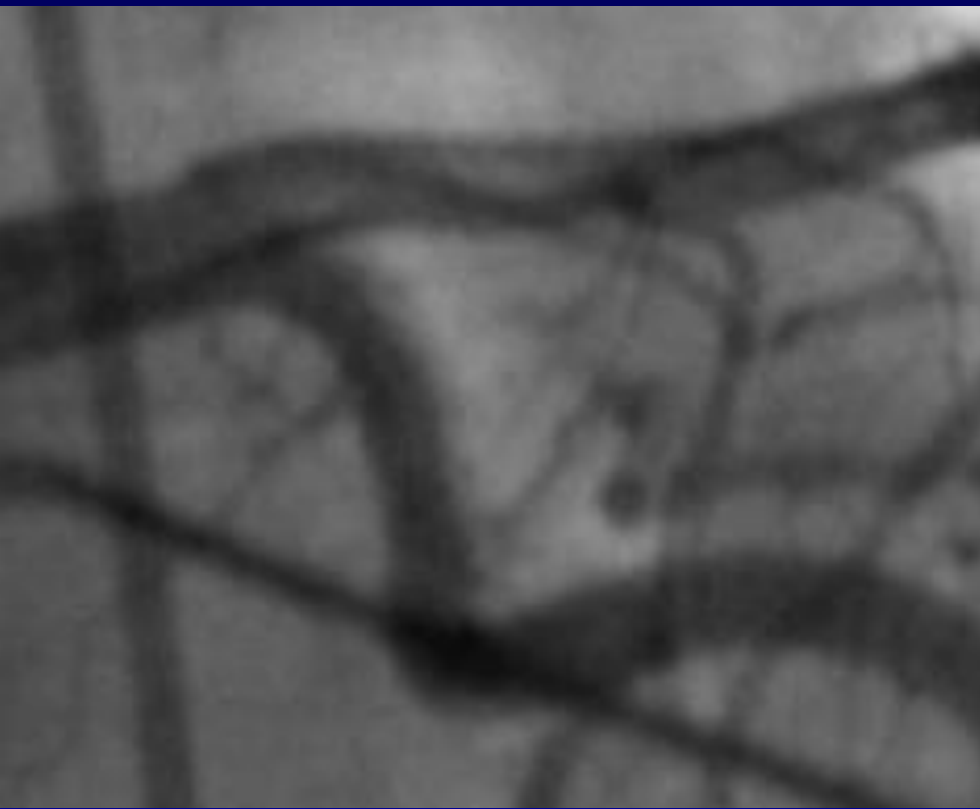
Cavitation Phenomena



Laminar Flow in the Left Main



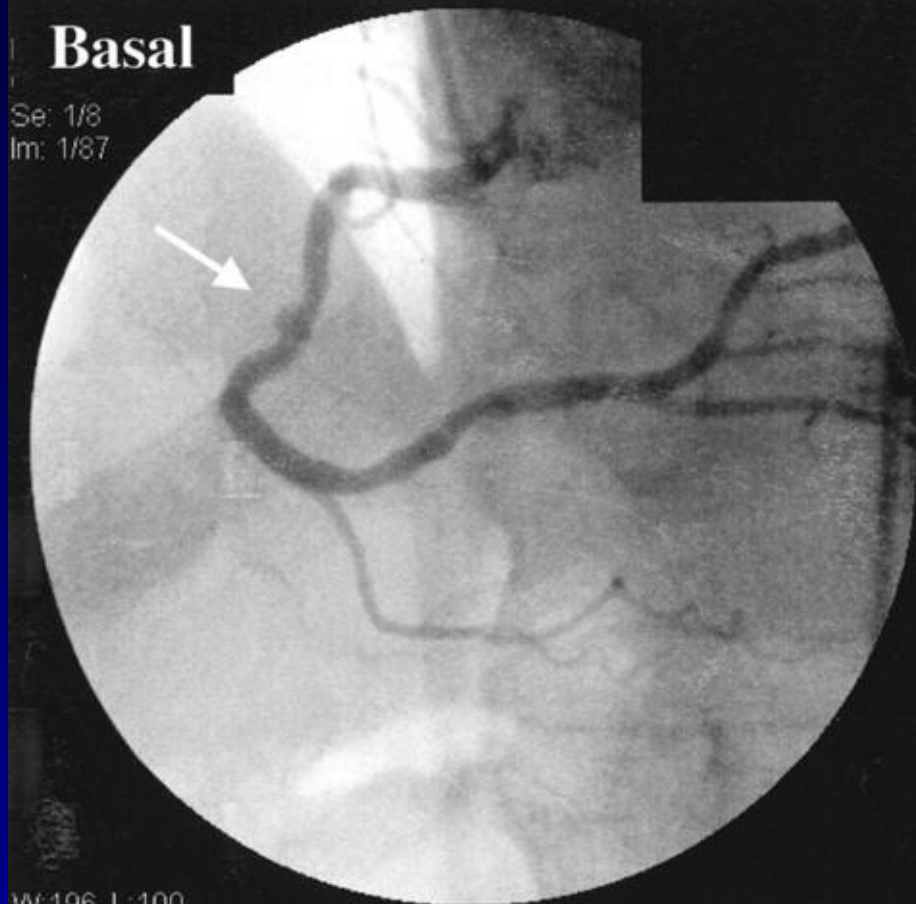
White Area = High Velocity and Low Pressure
Black Area = Low Velocity and High Pressure





Basal

Se: 1/8
Im: 1/87



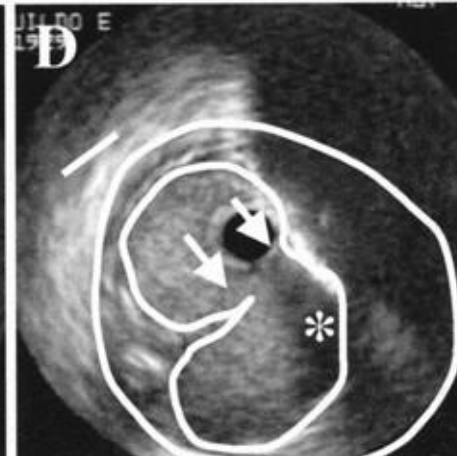
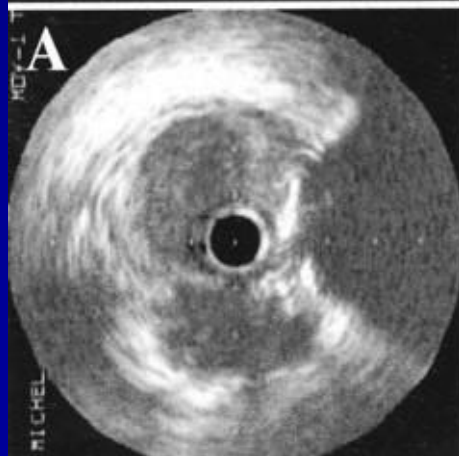
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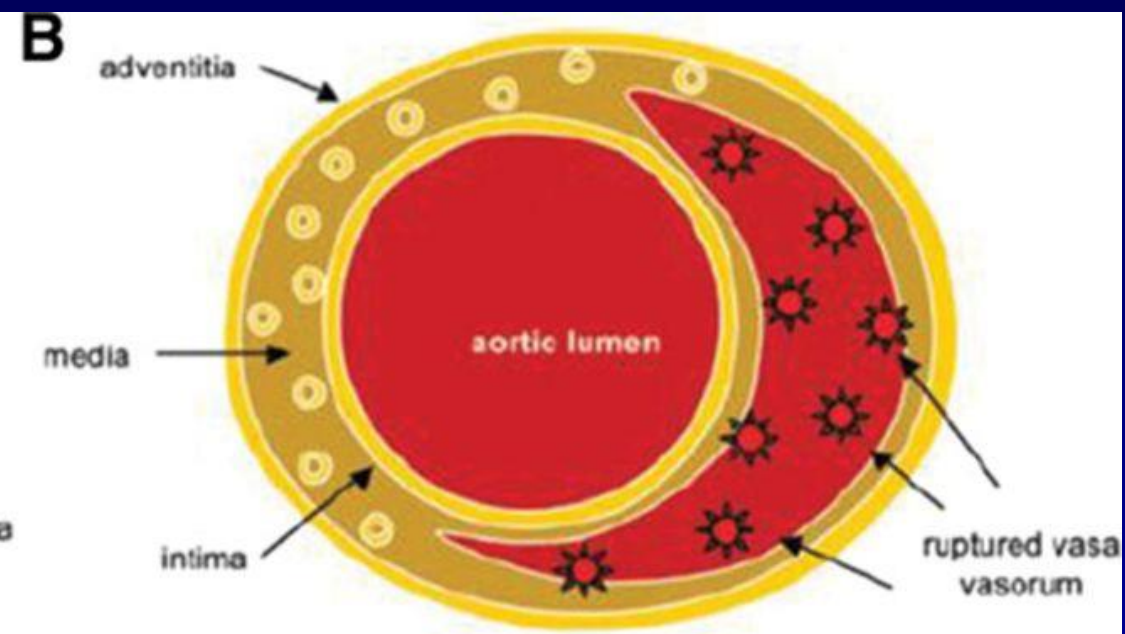
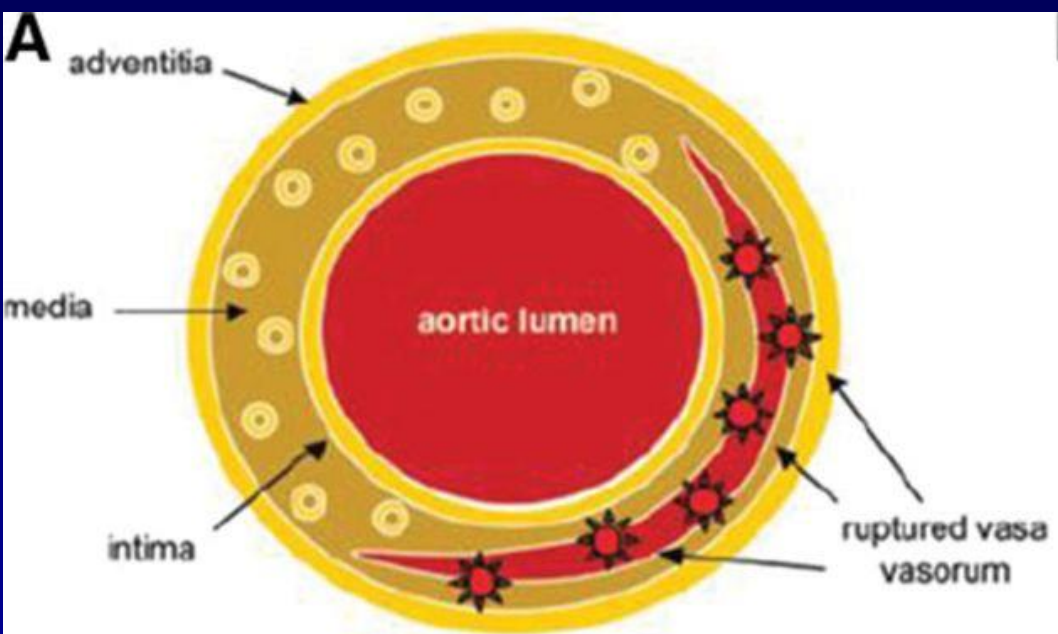
21 month-FU

Se: 1/17
Im: 1/6



W:190 L:97







Thank You

