IVUS: From Image Interpretation to Clinical Practice

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By

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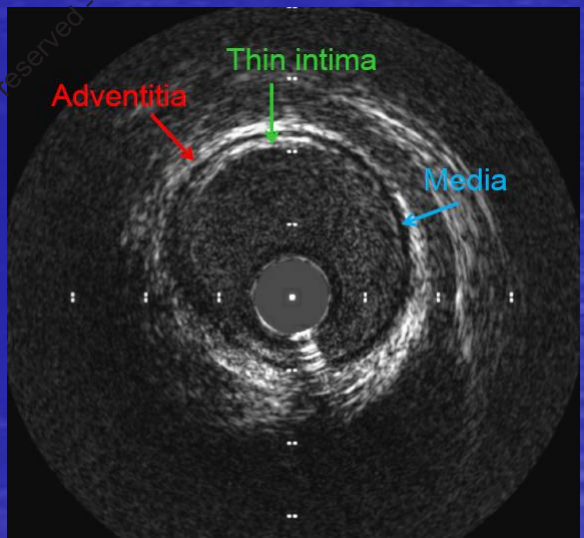
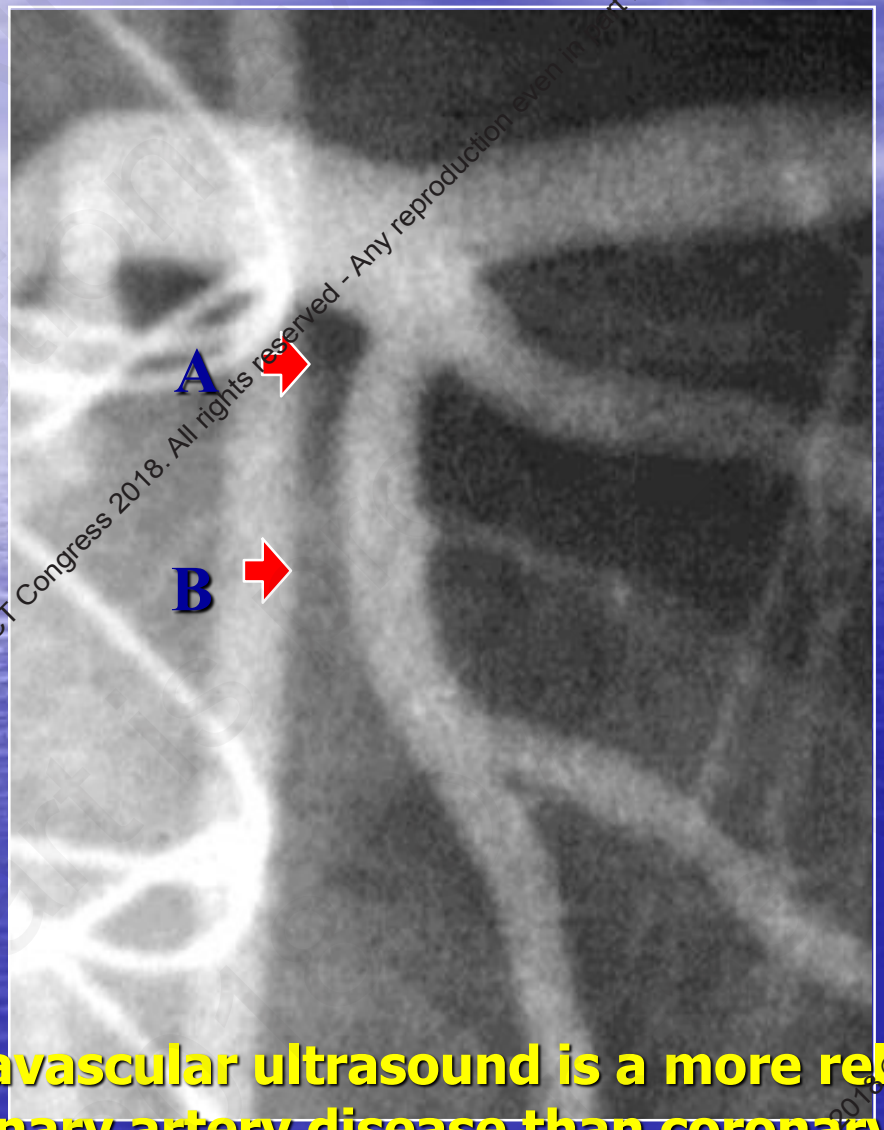
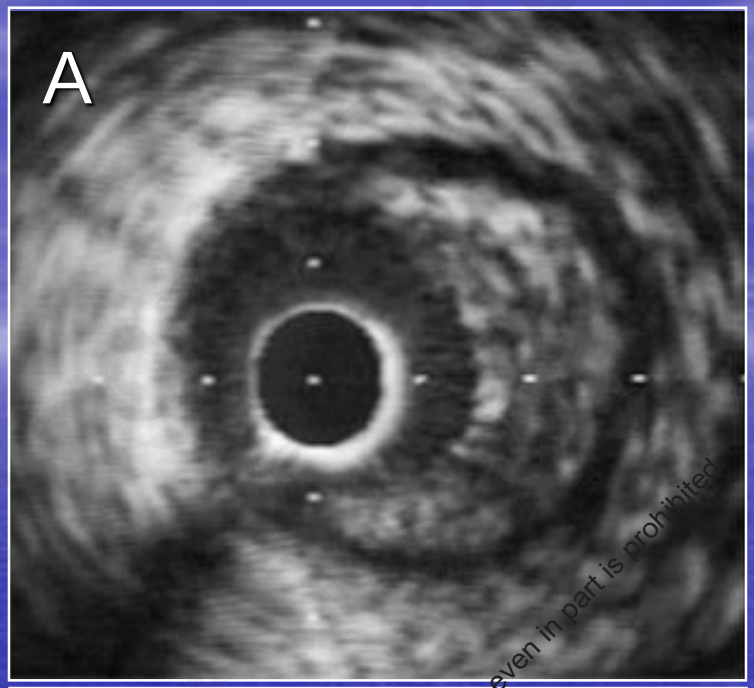
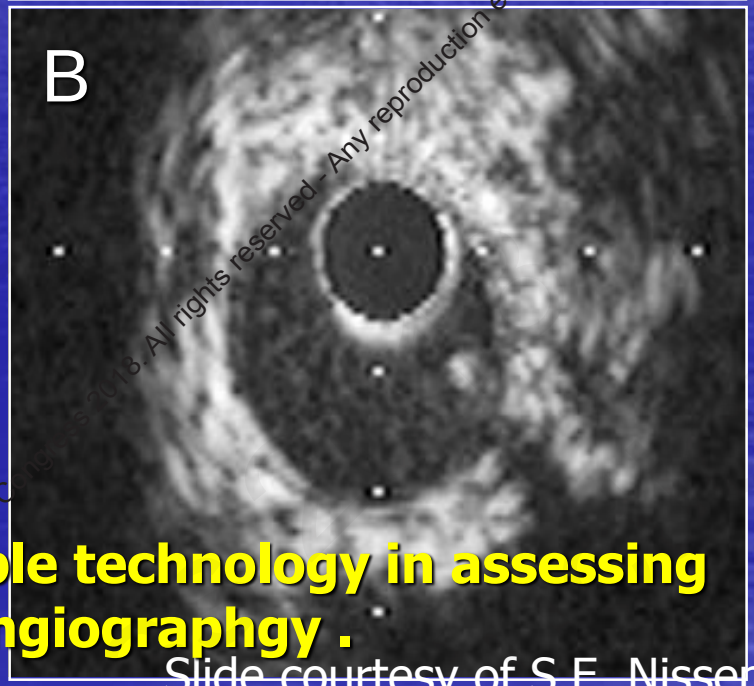


Lumen vs. Vessel Wall



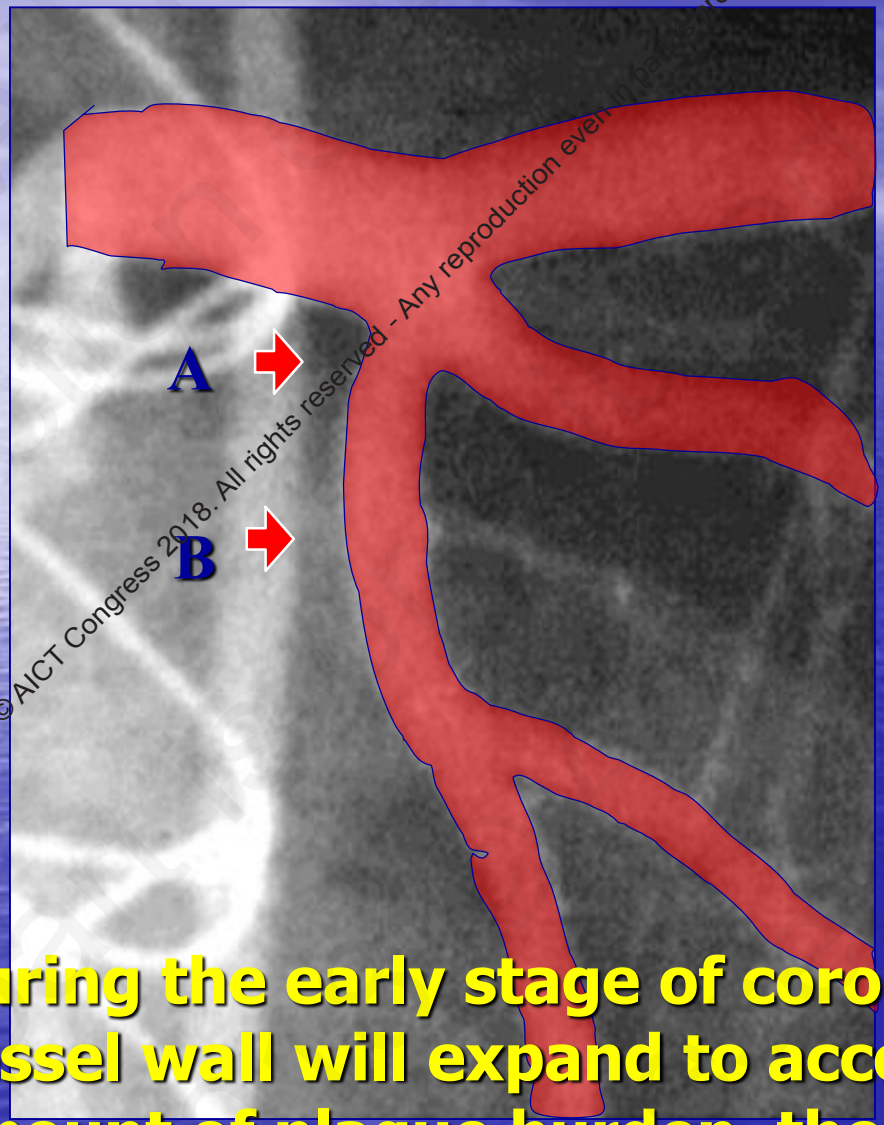


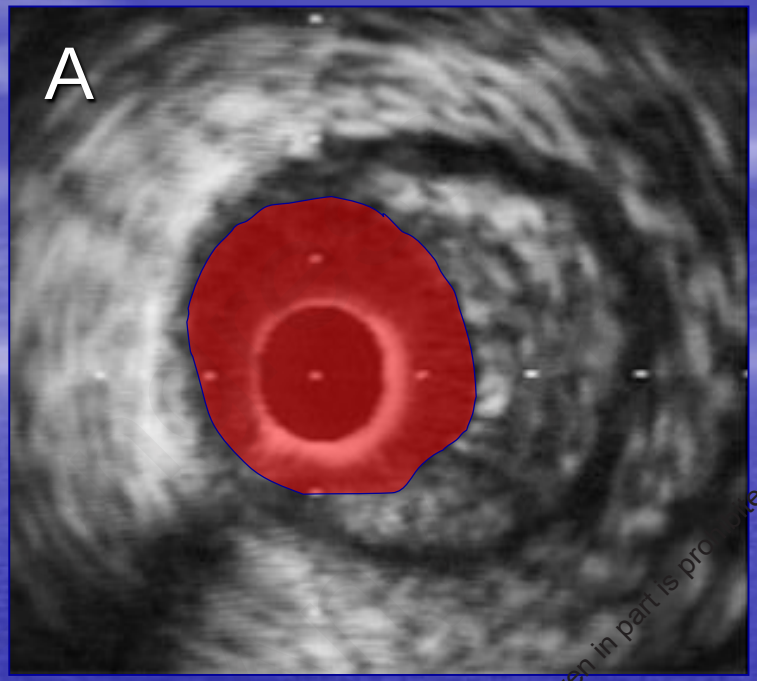


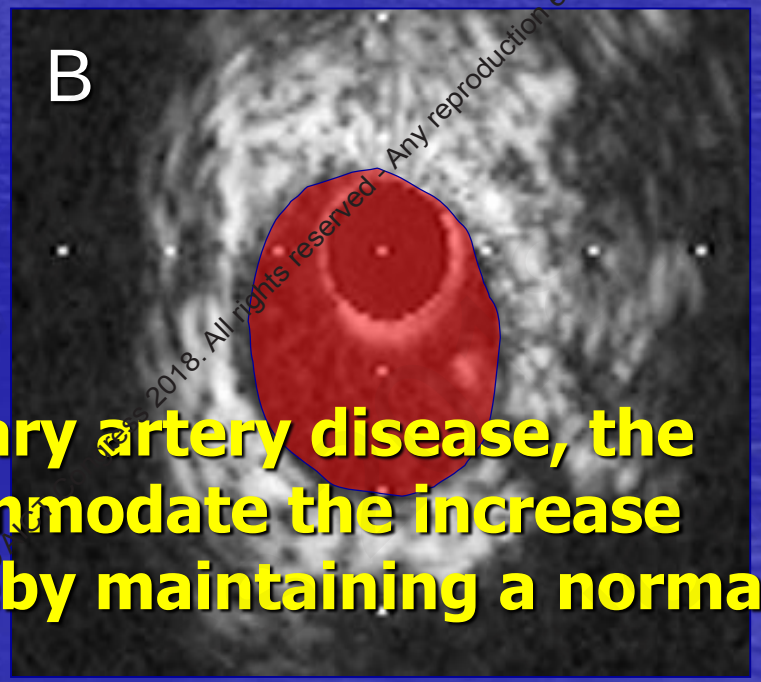
Intravascular ultrasound is a more reliable technology in assessing coronary artery disease than coronary angiographgy .

Slide courtesy of S.E. Nissen

Lumen vs. Vessel Wall

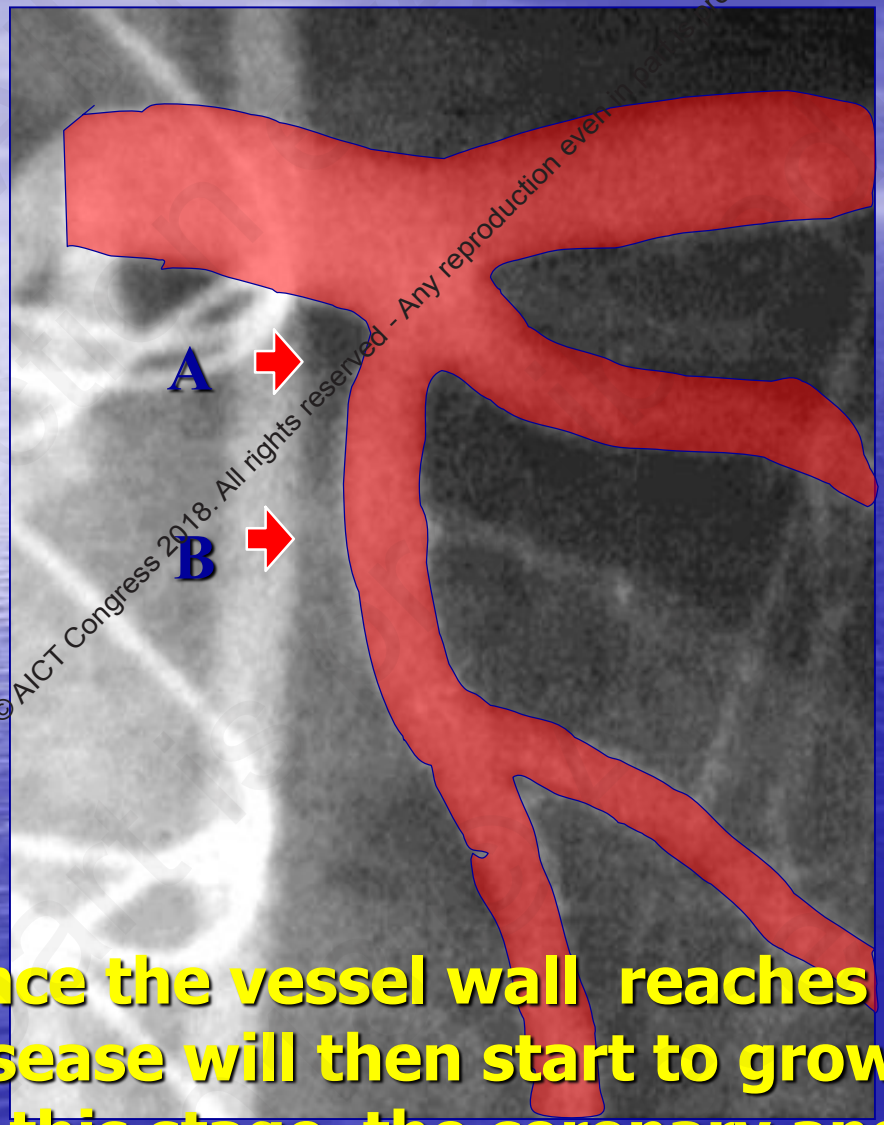


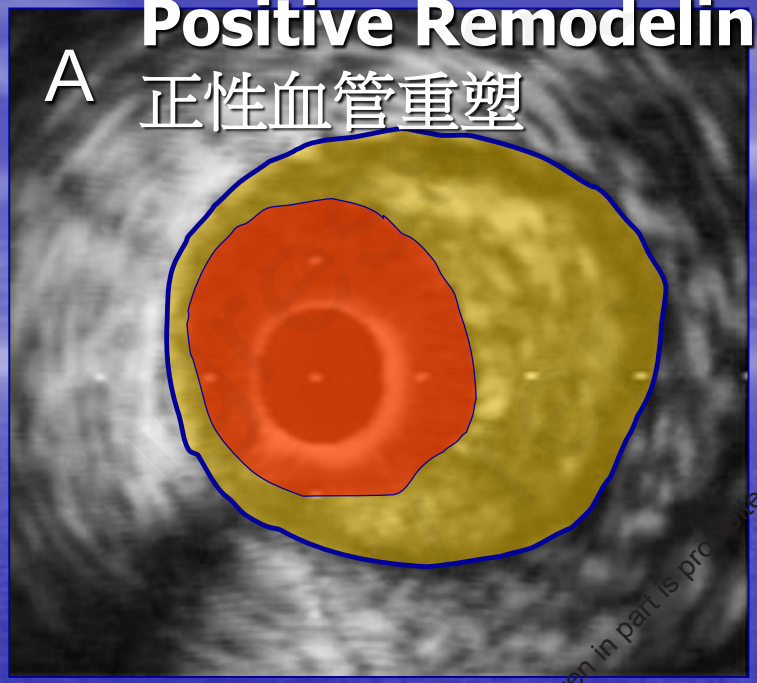


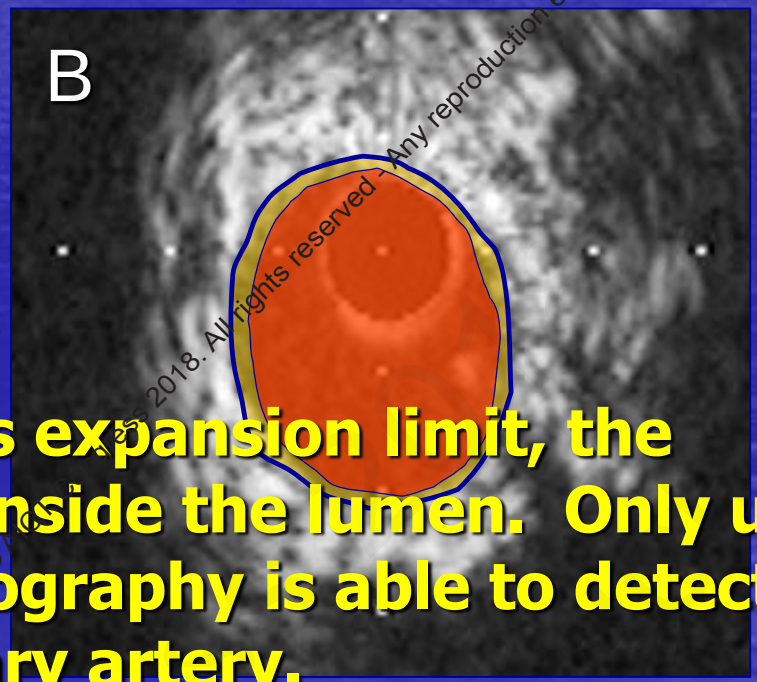


During the early stage of coronary artery disease, the vessel wall will expand to accommodate the increase amount of plaque burden, thereby maintaining a normal lumen size.

Lumen vs. Vessel Wall



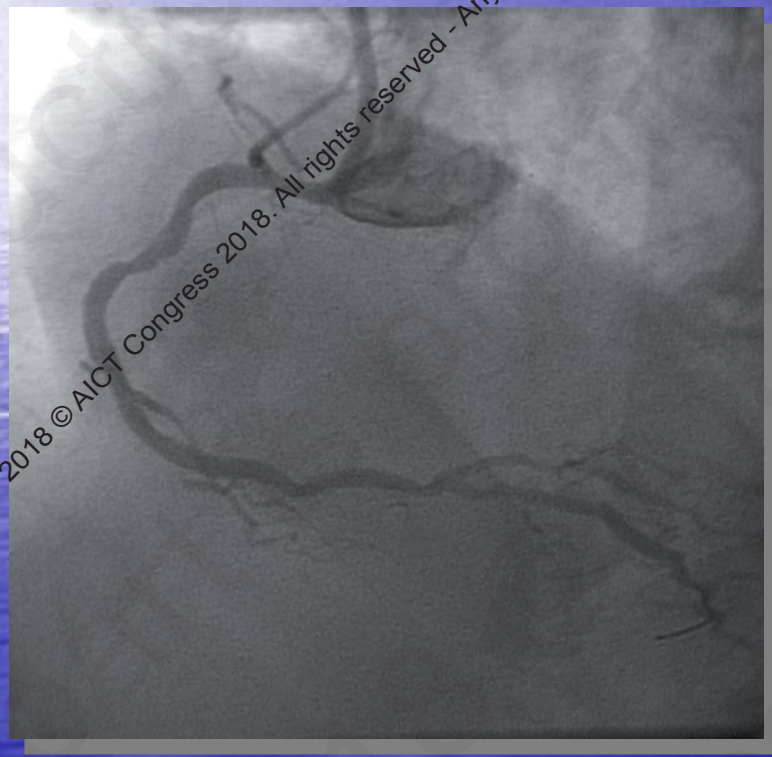


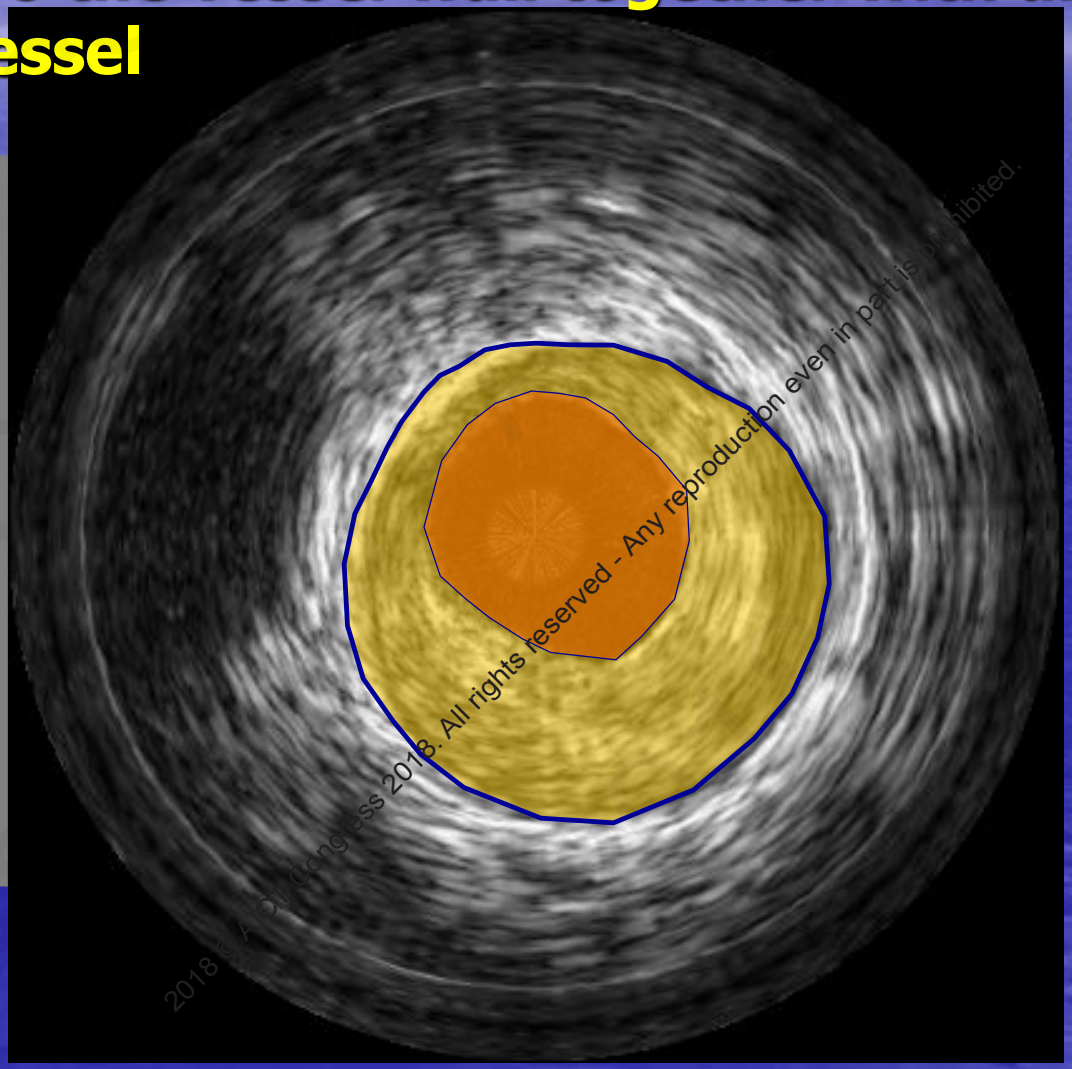


Once the vessel wall reaches its expansion limit, the disease will then start to grow inside the lumen. Only up to this stage, the coronary angiography is able to detect there is a problem in our coronary artery.

Coronary Angiography is only a luminology(轮廓的显像), it only shows us the contrast filling lumen and nothing else.

Intravascular ultrasound not only allow us to visualize the vessel lumen but also the vessel wall together with all the disease inside the vessel





Boston Scientific Co.

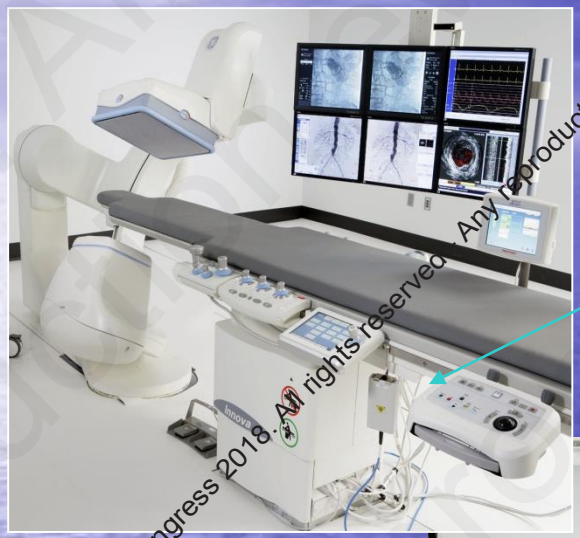
iLab

ACIST HD-IVUS

Feature	ACIST HDi™ Kodama®	
Frequency or Wavelength	**60 MHz**	40 MHz
Energy		Ultras
Axial Resolution	**0.04 mm**	0.06 mm
Lateral Resolution	**0.09 mm**	0.14 mm
Soft Tissue Penetration	> 2.5 mm	> 3.0 mm
Blood Penetration	> 3.4 mm	> 4.0 mm

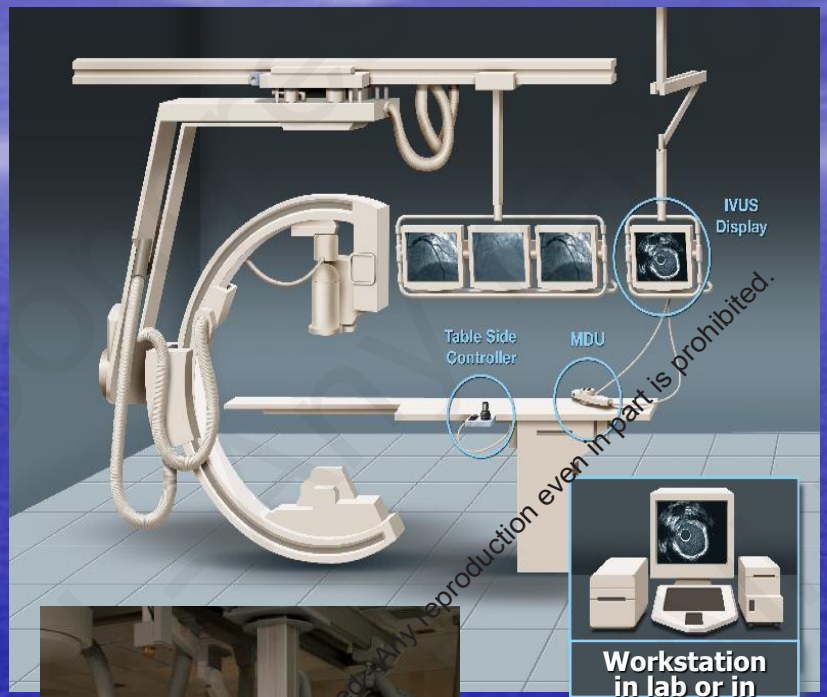
	Speed (mm/s)	Density (F/mm)	Spacing (mm)
System Pullback Capabilities:	0.5	60	0.017
	1.0	30	0.033
	2.5	**24**	**0.042**
	5	**12**	**0.084**
	10	**6**	**0.167**
Pullback Length	120 mm		

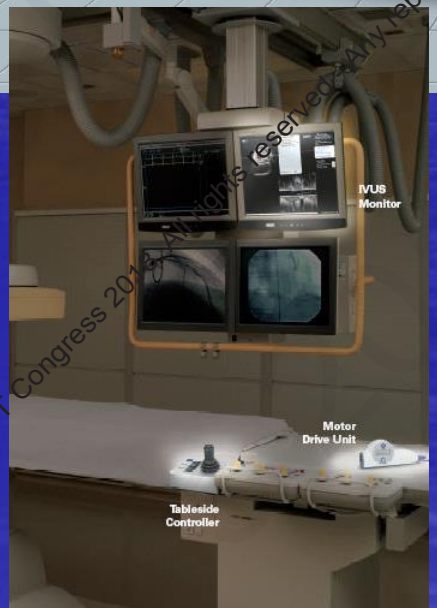
Full System Integration – the IVUS work flow is much more simple and easy.



PIM

(Volcano S5i)





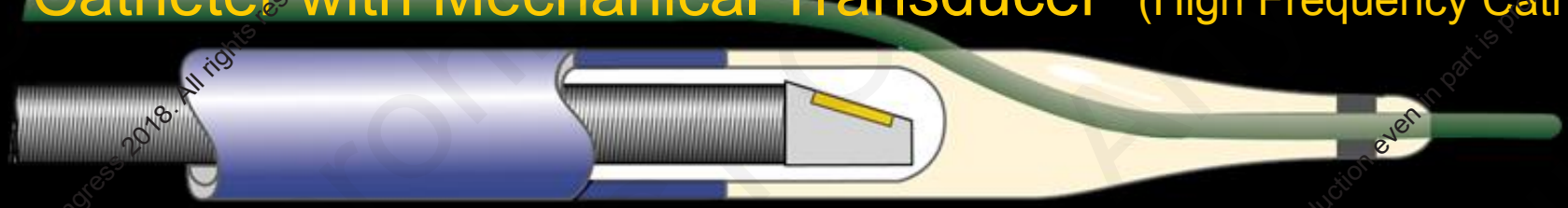
(BSC iLab)

- Controls can be bedside or in the control room
- CPU located in the control room

Transducers: Solid-State vs. Mechanical

(Volcano) (Volcano, Boston, InfraReDx, SVMI & Terumo)

Catheter with Mechanical Transducer (High Frequency Catheter)

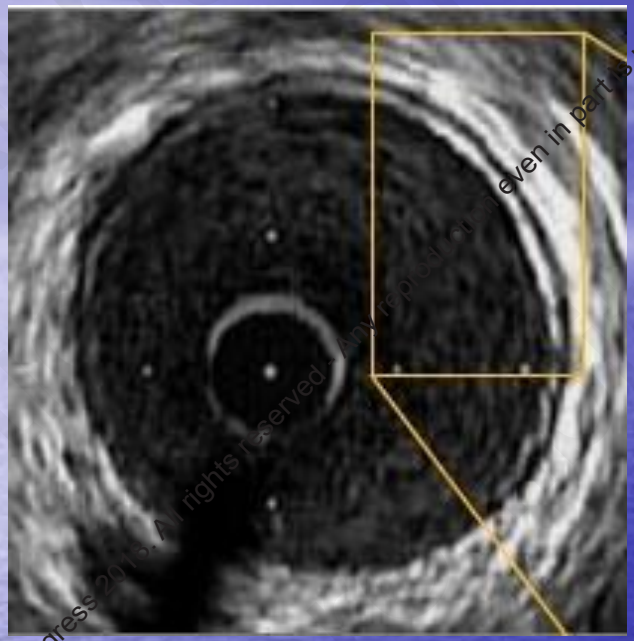


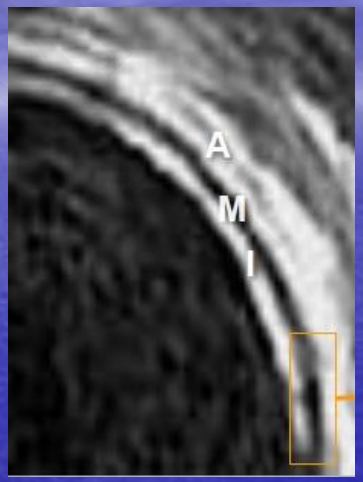
Catheter with Solid-State Transducer (Low Frequency Catheter)

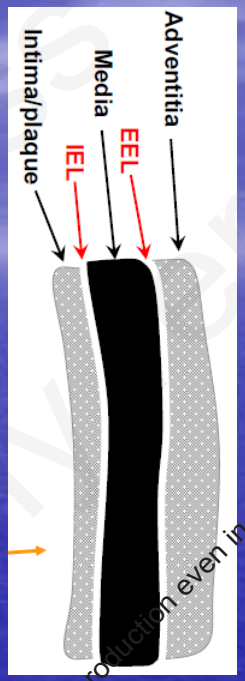
Even though, there are differences in catheter handling, system controls and image presentation; both catheter designs provide similar useful clinical information.

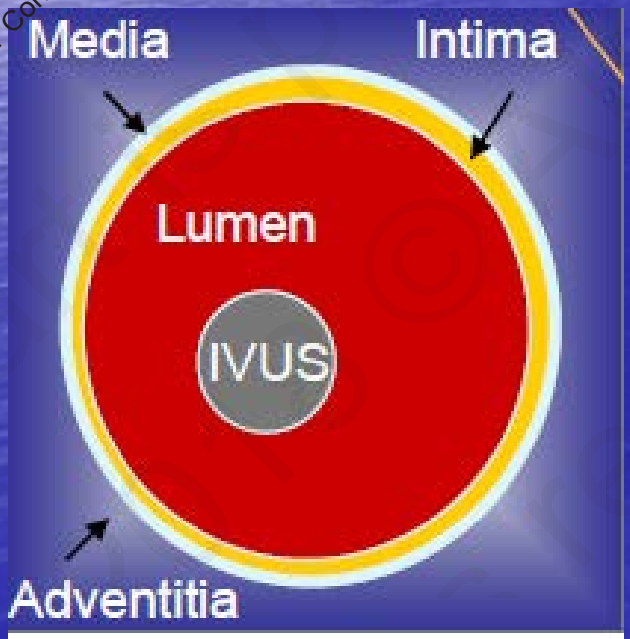
- Dr. Gary Mintz

Normal Arterial Anatomy by IVUS









Intima - Thin non-echogenic (低反射性) layer and thickness is about 100 μm.

Media - The middle layer of an artery which is composes of smooth muscle cells (平滑肌肉细胞), contains very low collagen. Echolucent (低反射性) or hypoechoic in nature and the thickness is about 200 –300 μm.

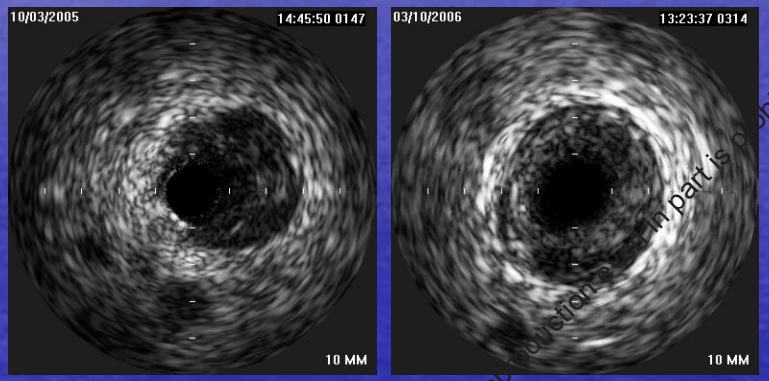
Adventitia - The outer layer of an artery which is composed of collagen (胶原纤维) and elastic fibers (弹力纤维).. Highly echogenic(高反射性).

Four types of plaque (斑块)

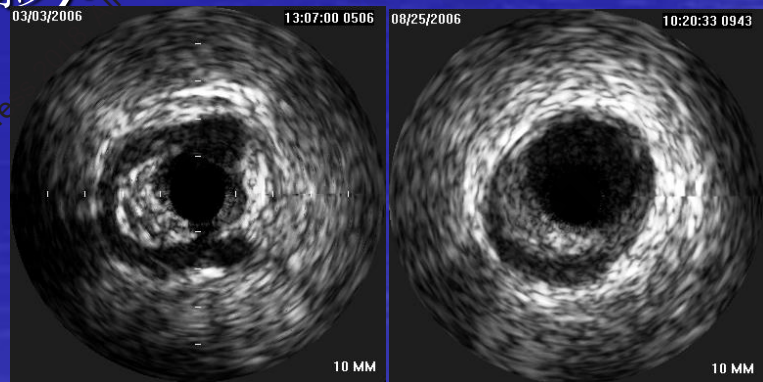
1. **Soft plaque**(多脂质性斑块) - Mainly lipid deposit, echolucent (低反射性) in nature.

   Eccentric (偏心性)

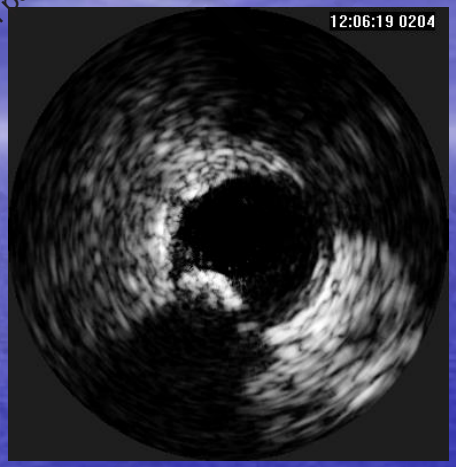
   Concentric (向心性)



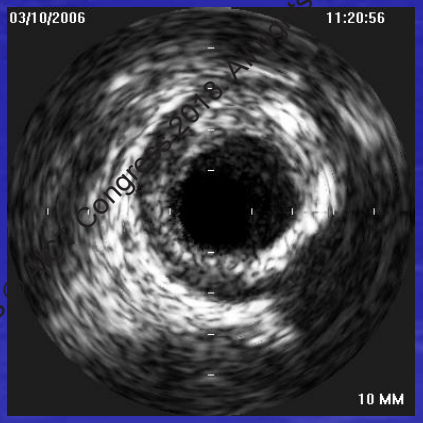
2. **Dense fibrous plaque** (多纤维性斑块) - Collagen rich fibrous tissue, produce dense and bright echoes (高反射性) without acoustic shadowing (回声伴声影).

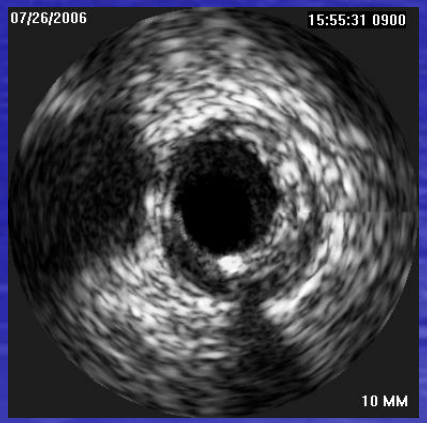


3. Calcific Plaque (钙化斑块) - Calcified tissue, produces bright echoes with acoustic shadowing(声影).

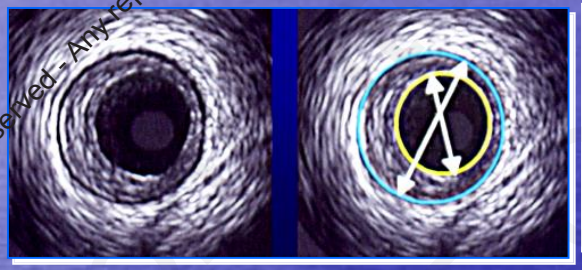


4. Mixed Plaque (混合性斑块) - Associates with soft and dense plaque, produces bright echoes (高反射性) with or with out acoustic shadowing (声影).

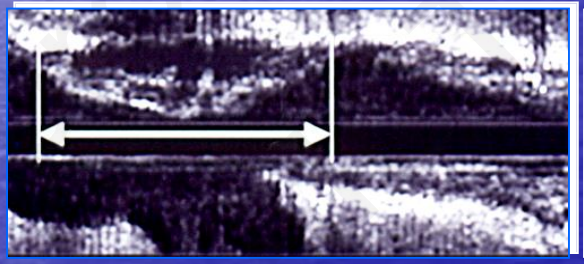




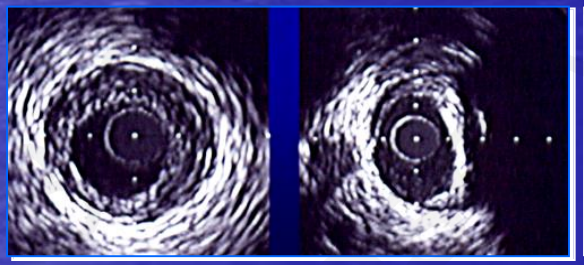
What are we looking for with IVUS?



Size



Plaque Length



Plaque Type

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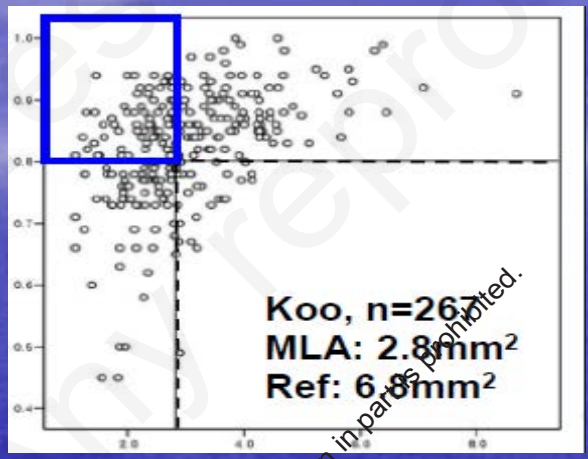
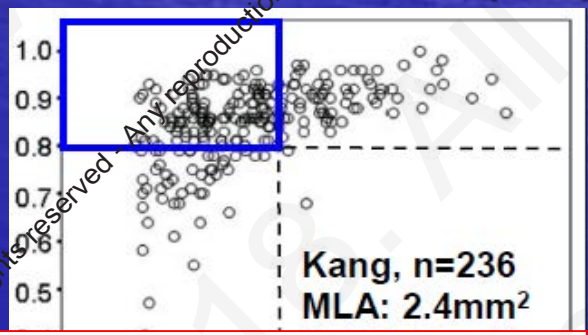
Can IVUS be used to assess intermediate lesion in non- left main for ischemia?

	N	FFR	MLA	AUC	Sens	Spec	PPV	NPV	Accura
Takagi (1999 Circ)	51	0.75	3.0	–	83%	92%	–	–	–
Briguori (2001 AJC)	53	0.75	4.0	–	92%	56%	38%	96%	64%
Ben-Dor (2012 *)	205	0.80	3.09	0.73	69%	72%	–	–	70%
Kang (2011 Circ int)	236	0.80	2.4	0.80	90%	60%	37%	96%	68%
Kang (2012 AJC)	784	0.80	2.4	0.77	84%	63%	48%	90%	69%
Koo (2011 JACC int)	267	0.80	2.75	0.81	69%	65%	27%	81%	67%
Gonzalo (2012 JACC)	47	0.80	2.36 IVUS	0.63	67%	65%	67%	65%	66%
Gonzalo (2012 JACC)	61	0.80	1.95	0.70	82%	63%	66%	80%	72%





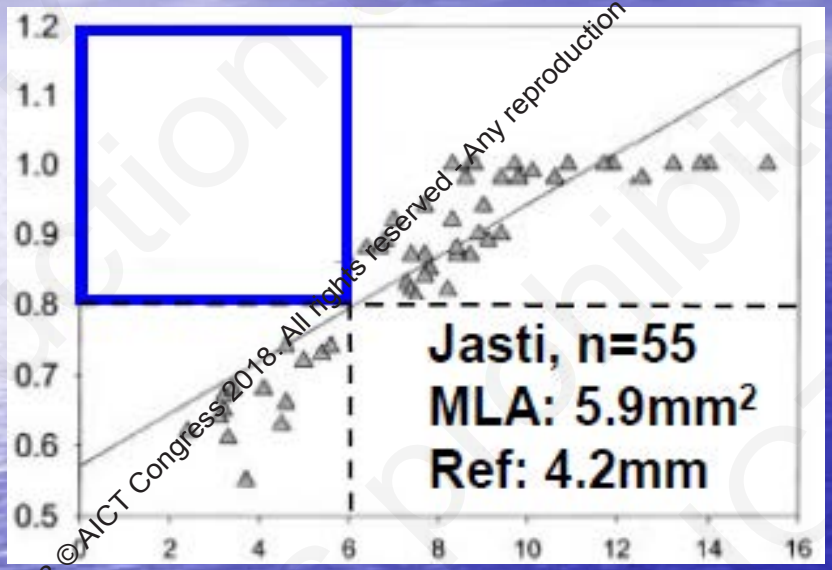
When it comes to assessing the physiological significant of a non-LM lesion, the best technology is FFR not IVUS.

Bas
MLA

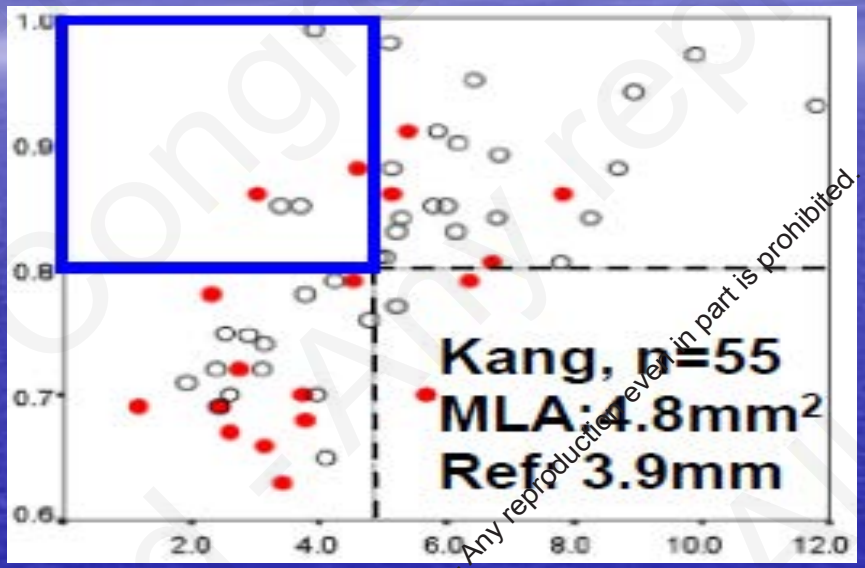
How
lesion will definitely causing Ischemia。

Can IVUS to be use to confirm if the Left Main Lesion is Significant?

IVUS determinants of LMCA FFR <0.8



Jasti et al. Circulation 2004;110:2831-6



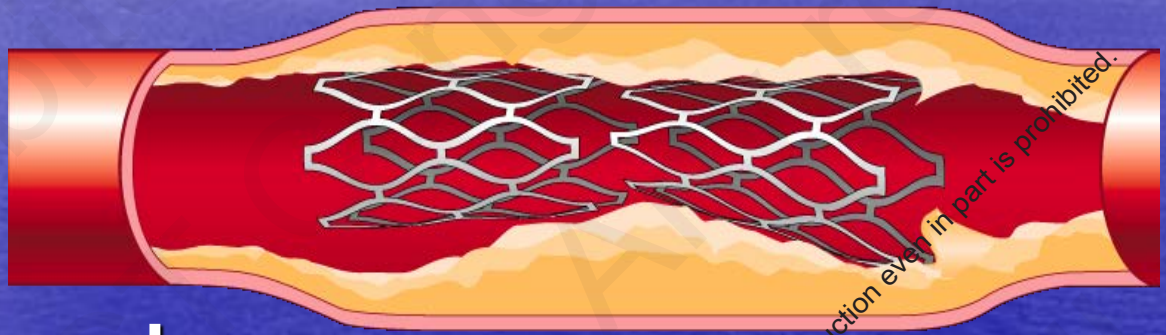
Kang et al. JACC CI 2011; 11:1168-1174

The IVUS LM-MLA cutoff values are different between the two studies, can be because of the body weight and size are different among the Caucasian and the Asian. As the heart weight correlates directly with the body weight, thus, a smaller LM-MLA is enough for the Asian but not for the Caucasian.

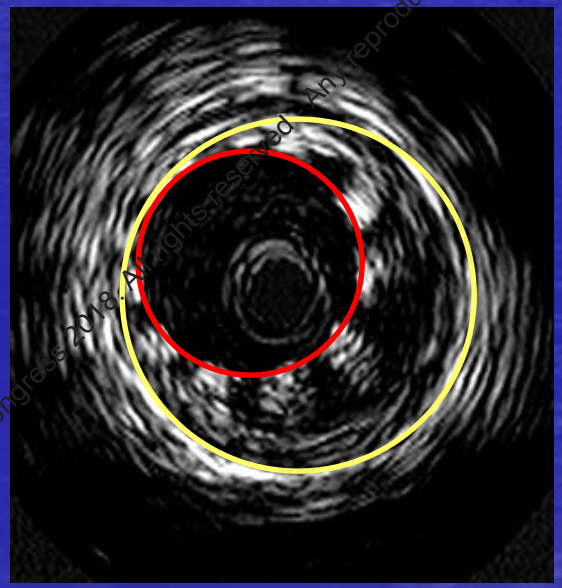
- LMCA is large in size

The most important interventional application of IVUS are vessel sizing and stent implantation guidance.

- **IVUS can confirms <u>good stent expansion</u>**
  - optimal blood flow



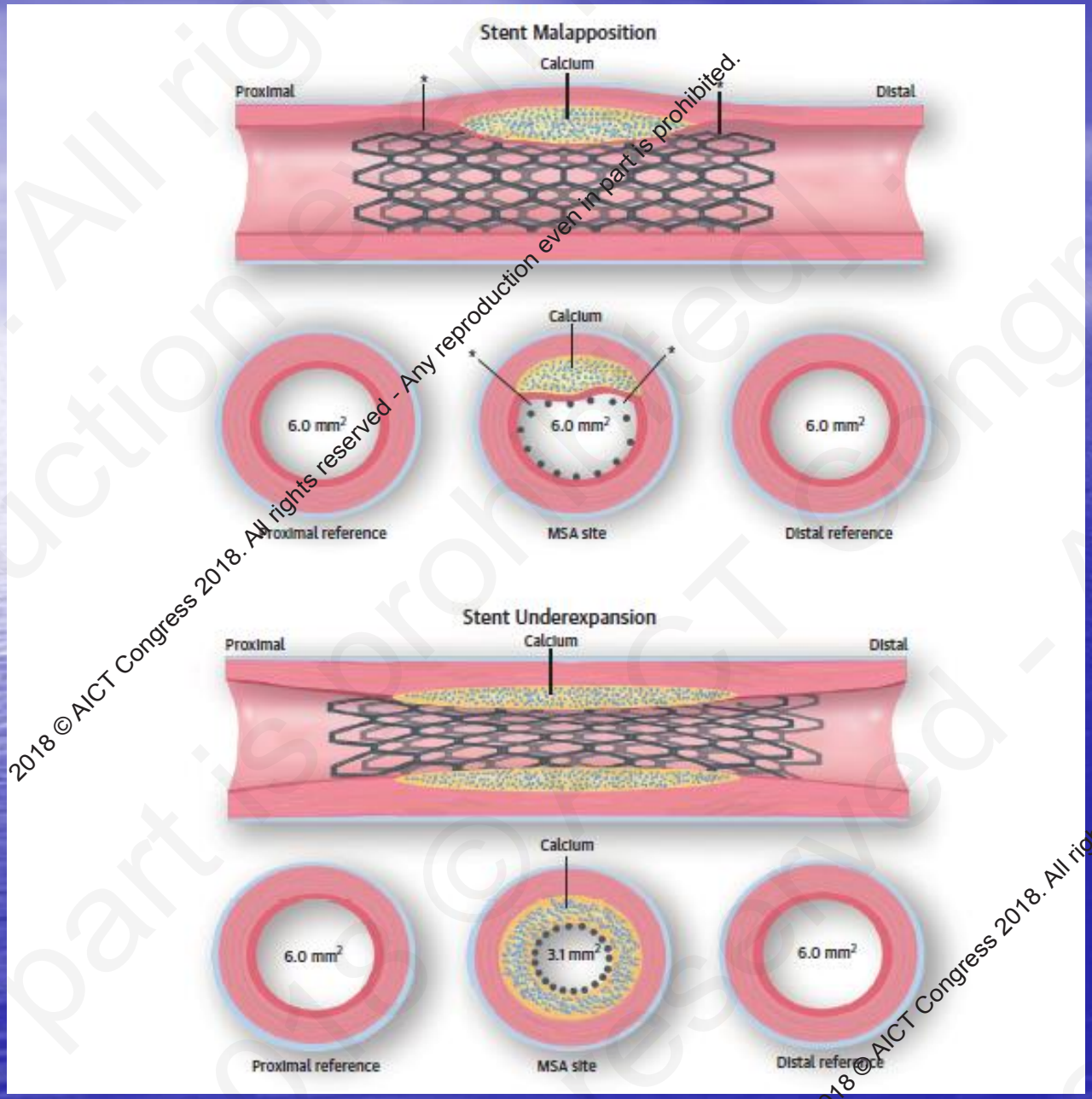
- **IVUS can confirms <u>good stent apposition</u>**
  - –no "floating" struts
  - –drug from DES can delivery to the surrounding tissue



What is consider good stent expansion based IVUS? 怎么才算扩张良好?

- 2.0 mm = 3.1 mm^2
- 2.25 mm = 4.0 mm^2
- 2.5 mm = 4.9 mm^2
- 3.0 mm = 7.1 mm^2
- 3.5 mm = 9.6 mm^2
- 4.0 mm = 12.6 mm^2

$Area = \pi r^2$



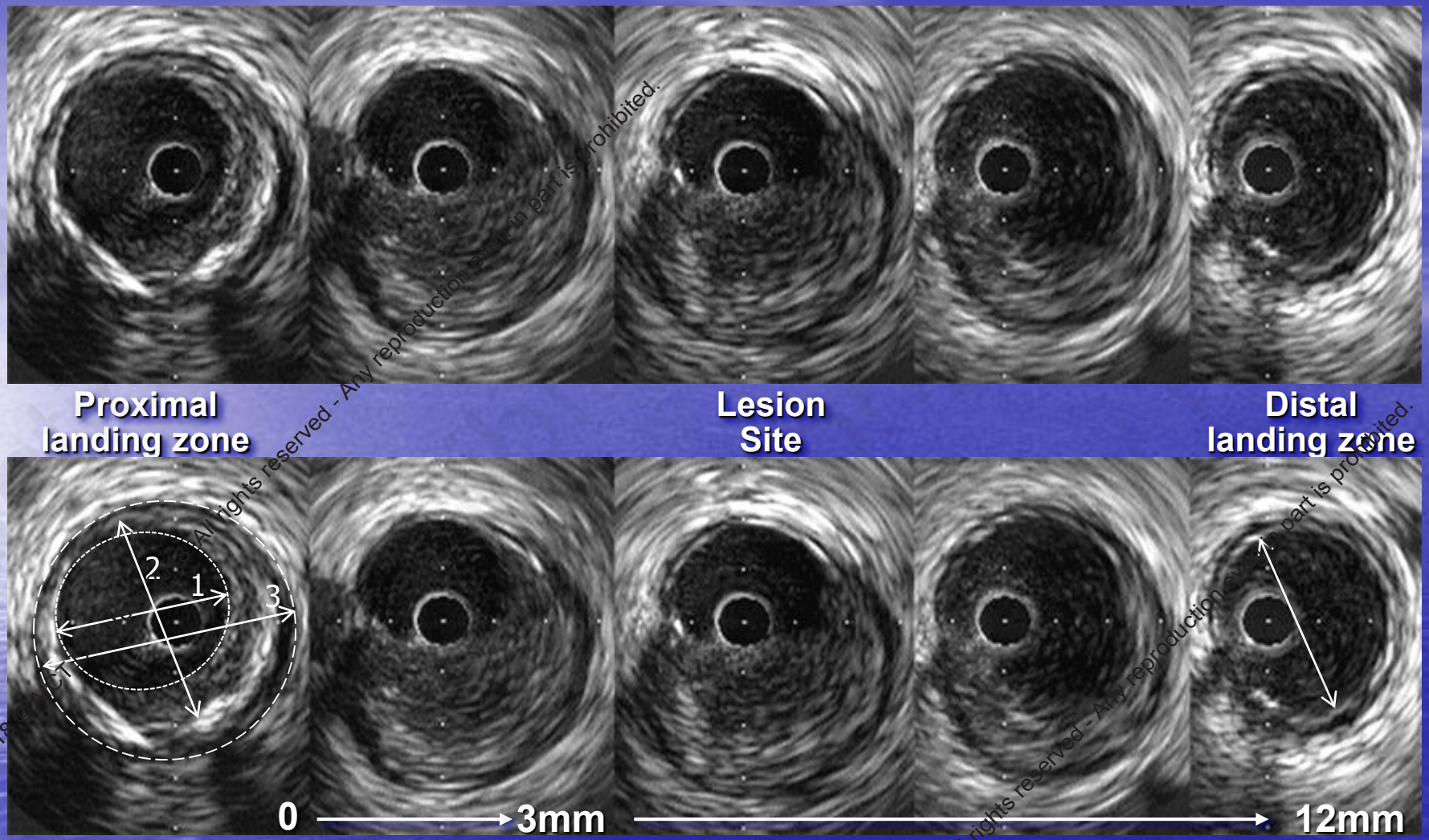
Good Expansion, Poor Apposition
扩张良好，贴壁不良。

Stent is too small

Good Apposition Poor Expansion
贴壁良好，扩张不好。

Stent under-expansion

Mintz GS JACC 2014, vol.64, pp207-222.



1) Largest reference lumen whether proximal or distal
2) Mid-wall
3) Media-to-media (although this is often "discounted" by approximately 0.5mm)
4) For vessel smaller than 3.0mm, 100% distal or 90% proximal
5) For vessel larger than 3.0mm, 90% distal or 80% proximal

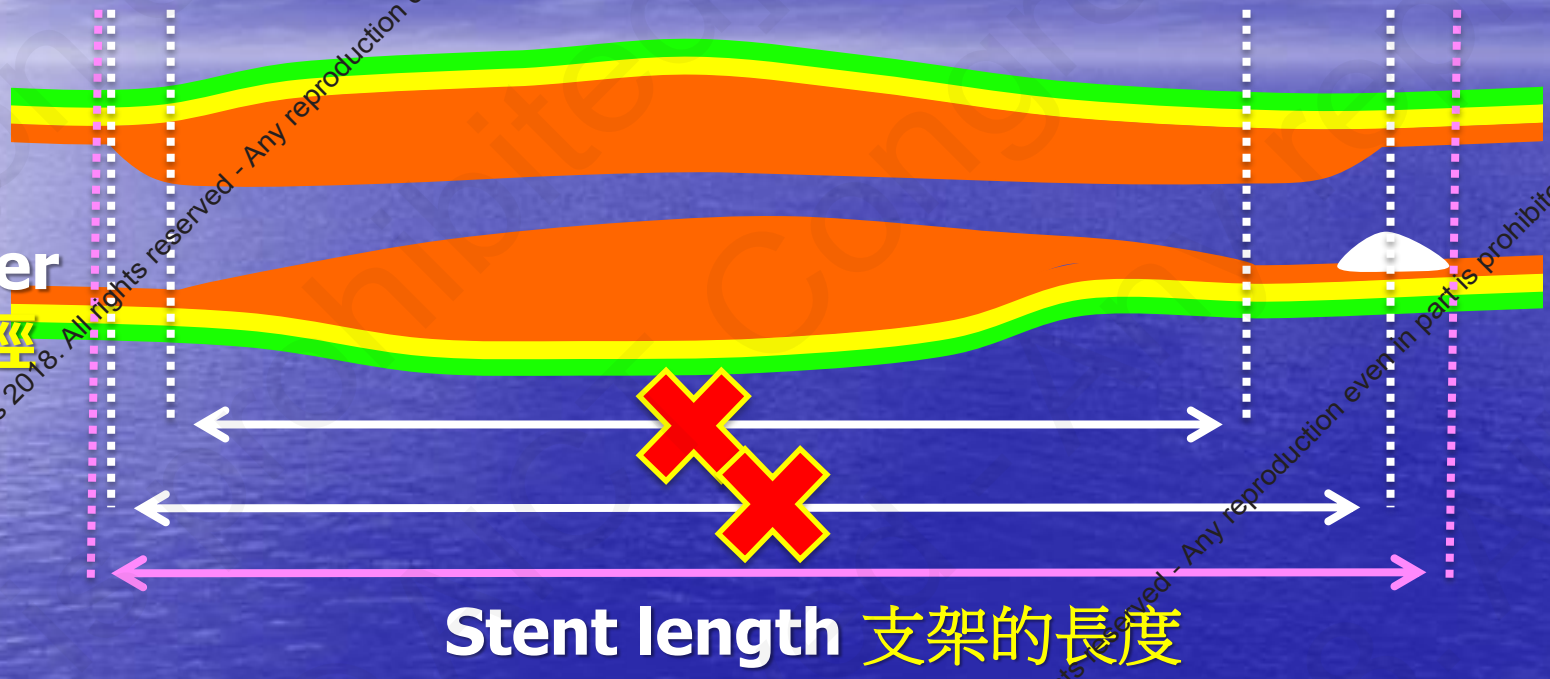
IVUS Predictors of DES Thrombosis & Restenosis

	DES Thrombosis	DES Restenosis
Un… St… sm…		…ll …S …J …vasc
Ed… (ge… se… plaque burden, etc)	•Liu et al. JACC Cardiovasc Interv. 2009;2:428-34	…rdiol •Costa et al, Am J Cardiol, 2008;101:1704-11

So you need to use IVUS after stent implantation, to make sure the stent is fully expanded with good apposition, and also make sure you have good lesion length coverage, otherwise the chance of getting ISR or late-stent thrombosis is going to be very high.

Baseline IVUS

Decide where stent edges should be 选择支架的長度

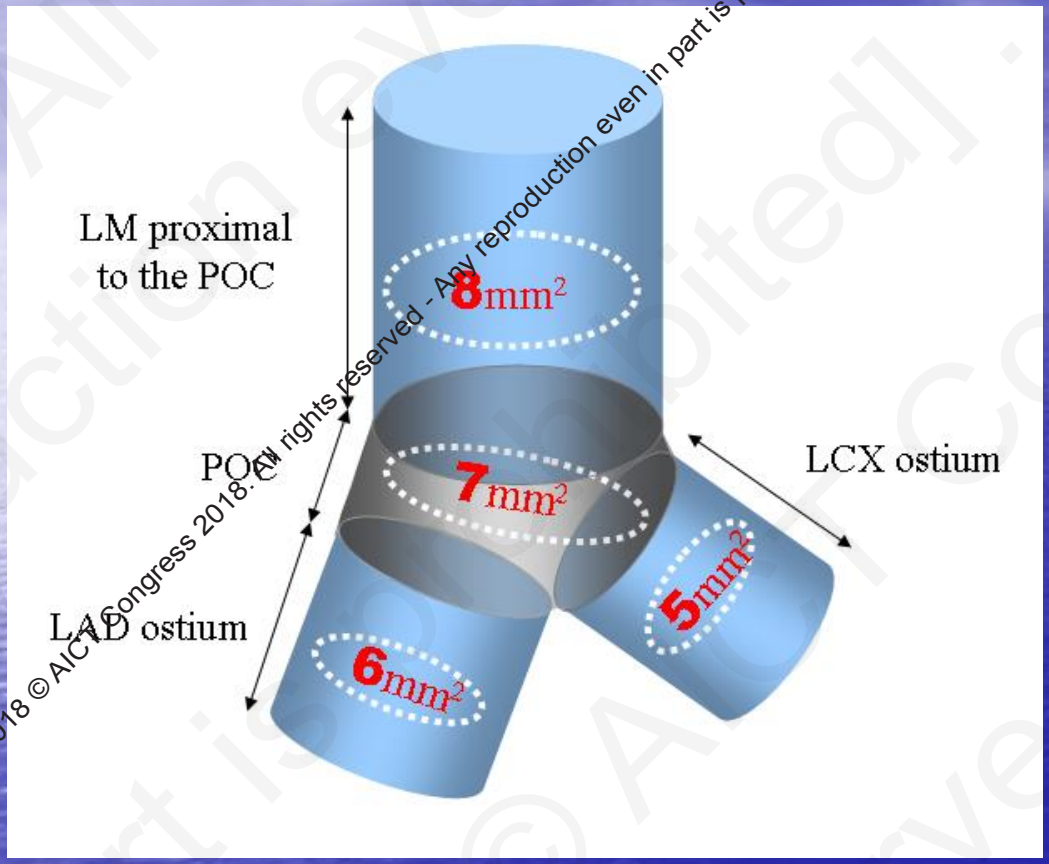


Avoid…

a. % plaque volume > 50% → risk of edge restenosis
支架边缘夹层，再狭窄

b. localized calcium → risk of edge dissection支架边缘夹层

IVUS Criteria for good stent expansion at the distal LMCA bifurcation (n=403)



- ***MACE-free survival was lower in pts with underexpansion vs those without underexpansion (89.4% vs 98.1%)***
- ***TLR-free survival was lower in pts with underexpansion vs no underexpansion (90.9% vs 98.5%).***
- ***Although acute malapposition was observed in 28 pts, malapposition was not related to MACE at follow-up.***

We have data from Korea showing that for LM bifurcation, we need to achieve at least stented area of 5, 6, 7 and 8mm2 on ostial LCX, ostial LAD, distal / proximal LM based on the IVUS findings, otherwise the clinical outcome is going to be very poor.

Kang et al. Circulation Cardiovasc Interv. 2011;4:562-9

The ADAPT-DES Study[1]

Significant Imaging Clinical Evidence

Large-scale, prospective, multi-center registry examining relationship between platelet responsiveness and stent thrombosis after DES; follow up at 30 days, 1 & 2 years

1

IVUS Guidance Improved Clinical Outcomes, both Acute (<30 days) and at 1-Year Follow-up

IVUS sub-study data at one year was associated with:

- 33% Reduction in MI (p=0.0022)
- 50% Reduction in ST (p=0.011)
- 38% Reduction in Ischemic driven TVR (p=0.0001)

2

Impact of IVUS Guided PCI on Procedures vs. Angio-alone

IVUS sub-study data at one year was associated with:

- Optimization or change in procedure in 74% of cases
- No additional stents
- IVUS guided group tend to use longer stent length and bigger stent size

3

Largest IVUS registry ever been conducted

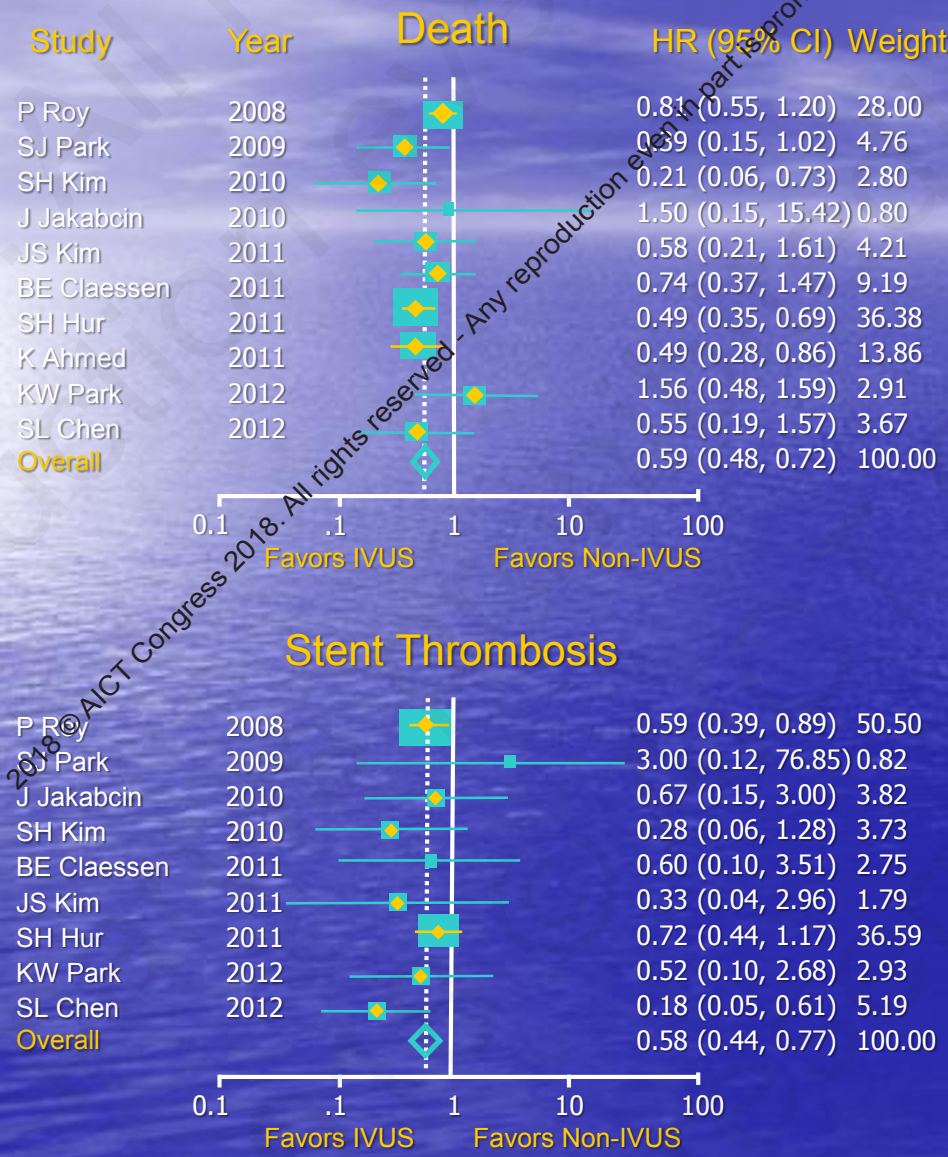
Multi-center global registry with >8,500 patients

- 3,349 patients with IVUS* guided PCI procedures.
- 64% Xience/Promus stents

PI: Gregg Stone MD, Columbia University Medical Center

Wizenbichler et al. Circulation 2014; 129:463-470.

Zhang et al. Eurointervention 2012;8:855-65



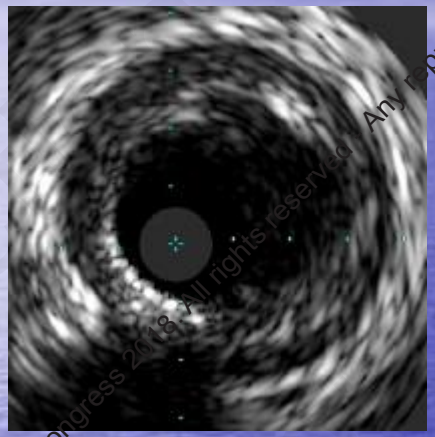
Meta-Analysis of 11 Studies (n=19,619 patients)

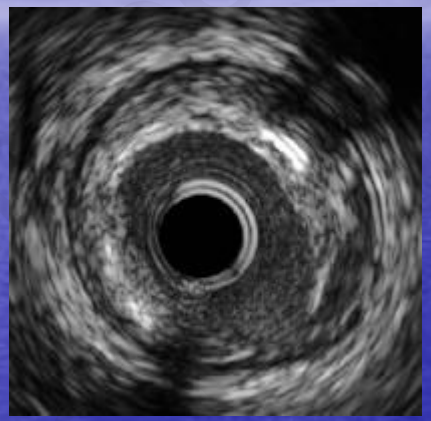
Compared with angiography-guidance, IVUS-guided DES implantation was associated with a reduced incidence of

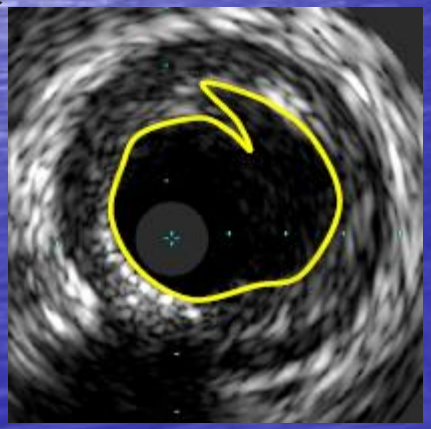
- Death (HR: 0.59, 95% CI: 0.48-0.73, $p<0.001$)
- Stent thrombosis (HR: 0.58, 95% CI: 0.44-0.77, $p<0.0001$)
- Major adverse cardiac events (HR: 0.87, 95% CI: 0.78-0.96, $p=0.008$)

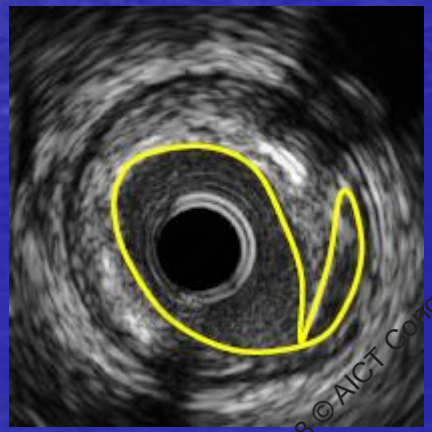
IVUS is very useful to assess PCI complications

Stent Edge Dissection





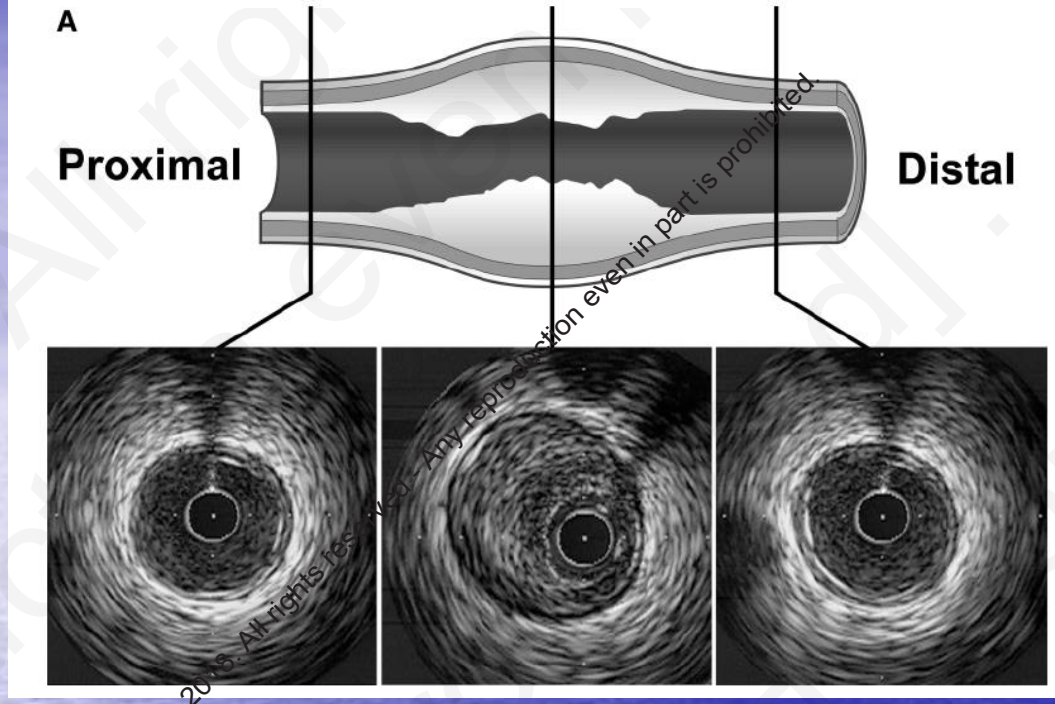


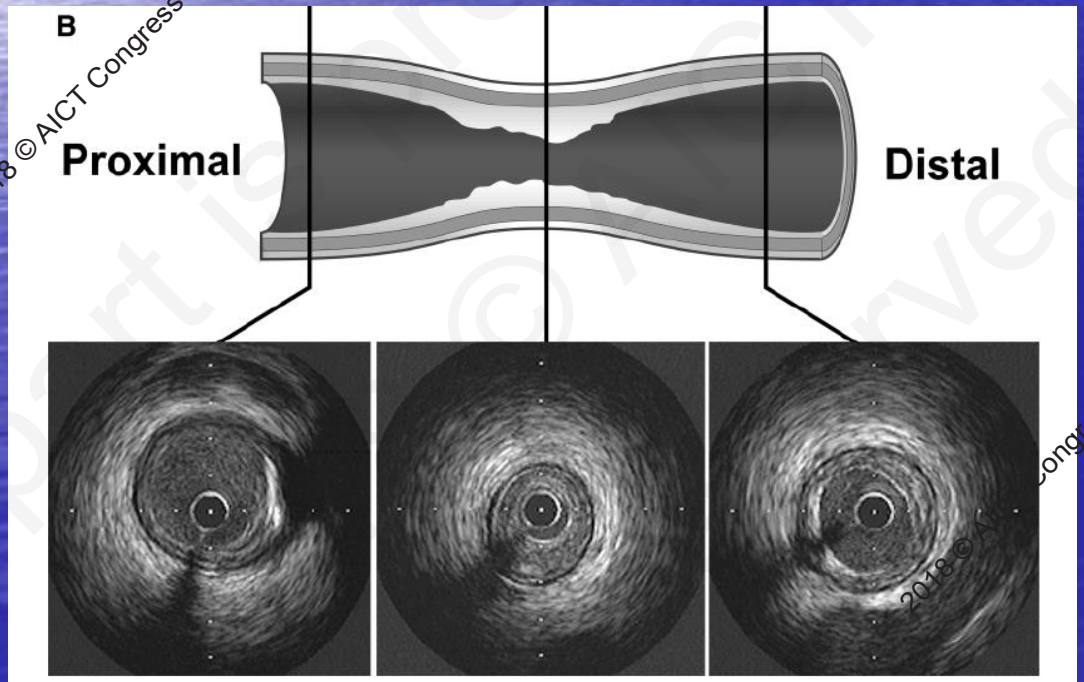


Intimal Dissection

Medial Dissection

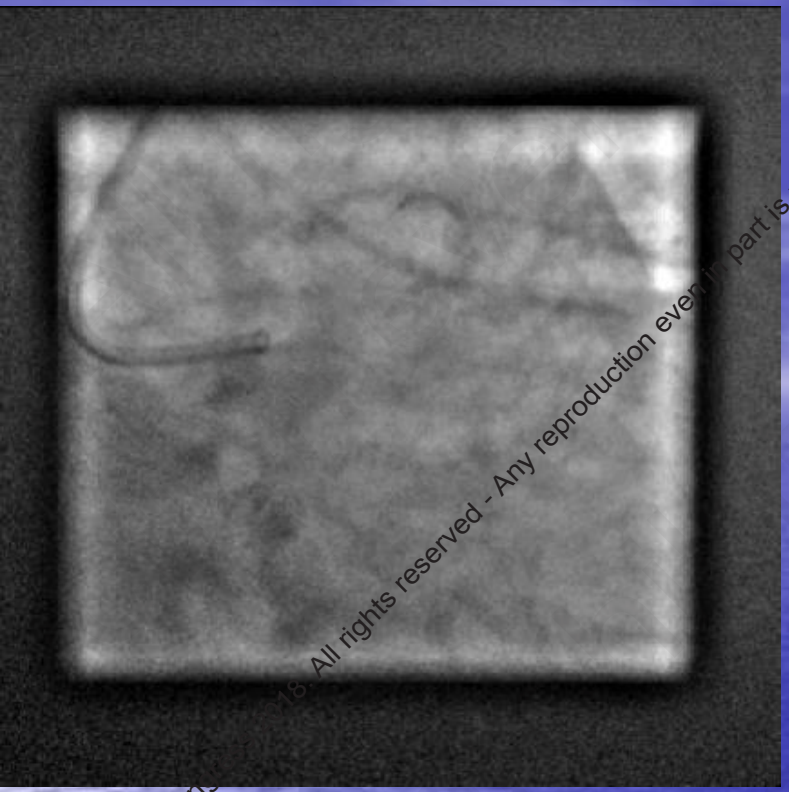
Intramural Hematoma

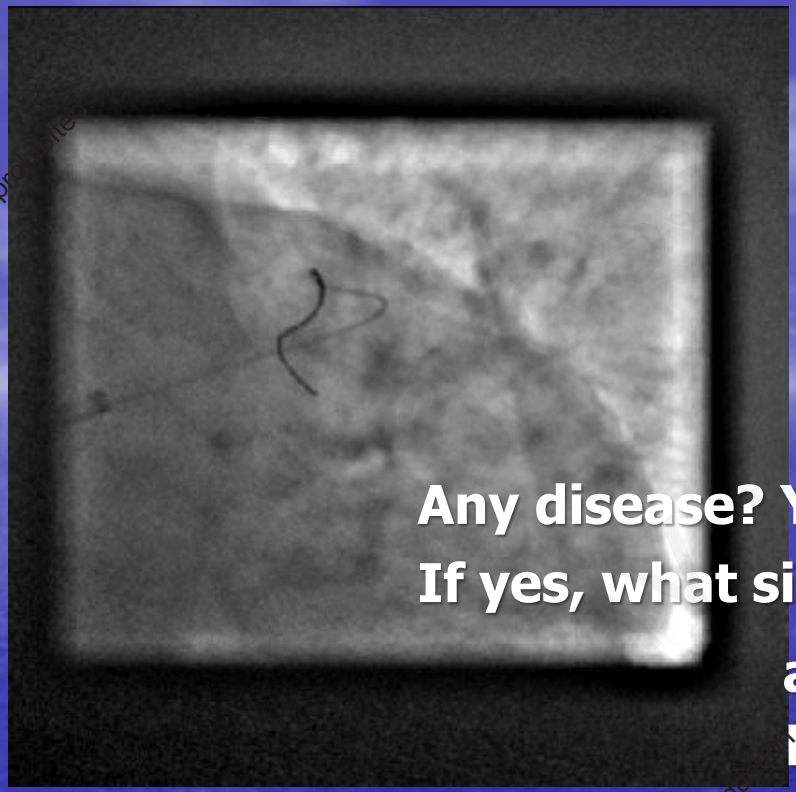




Positive Remodeling
Diameter of Vessel at Lesion Site / Diameter of Vessel at Proximal Reference > 1.05

Negative Remodeling
Diameter of Vessel at Lesion Site / Diameter of Vessel at Proximal Reference < 0.95





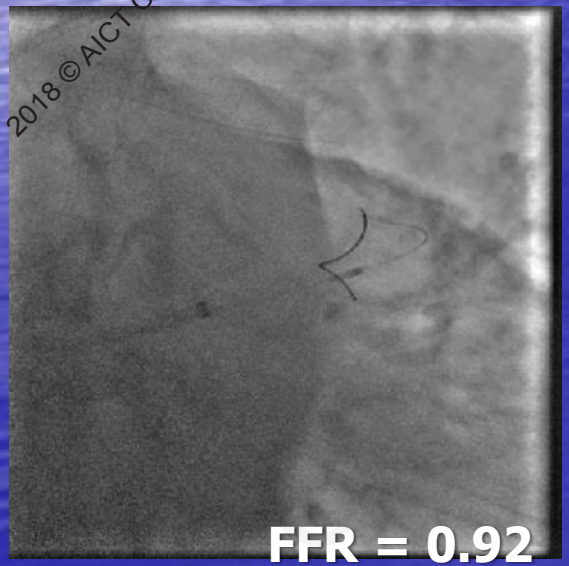
Any disease? Yes or No

If yes, what size of stent?

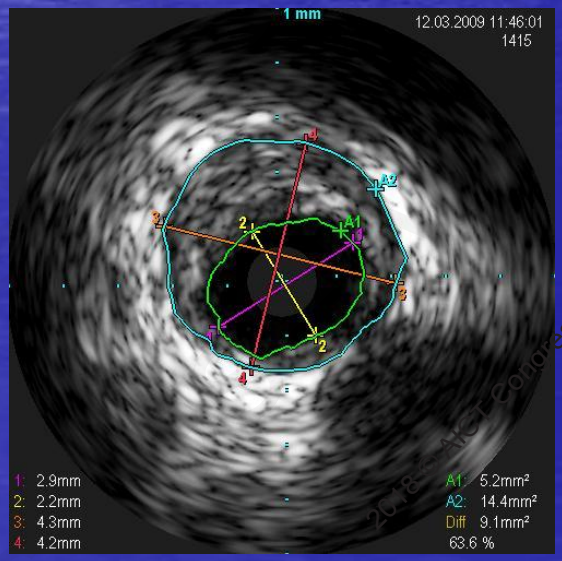
a. 3.0mm

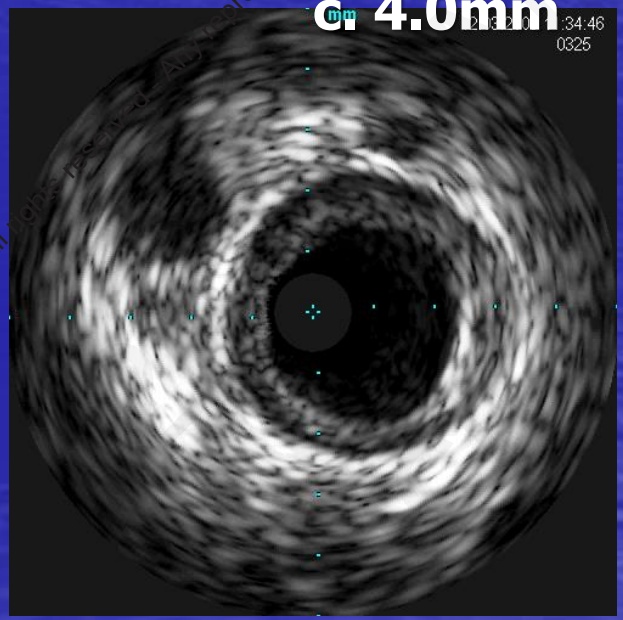
b. 3.5mm

c. 4.0mm



FFR = 0.92





In Summary

Pre-Intervention Assessment:

1. Lesion severity
2. Assess plaque morphology
3. Physiological significant Assessment (Only for Left Main lesion).
4. Identify reference segments
5. Choose stent size and length

During the Procedure:

1. Identify stent related problems:
   Stent under-expansion / stent Malapposition

Post Procedural Assessments:

1. Identify stent related complications
   Edge dissection
   Tissue protrusion
   Intramural Hematoma

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THE OFFICIAL CONGRESS OF APSIC

7 - 9th September 2018

Hong Kong

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