Intravascular Ultrasound for Complex Cases

The Practical Value of IVUS

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Intravascular ultrasound imaging provides short axis information about the vessel. Image quality is not as clear as for angiography, which perhaps explains why the majority of interventional cardiologists don’t like it, but reviewing the IVUS tapes enables you to see what you missed under angiography and you can learn lot from IVUS .

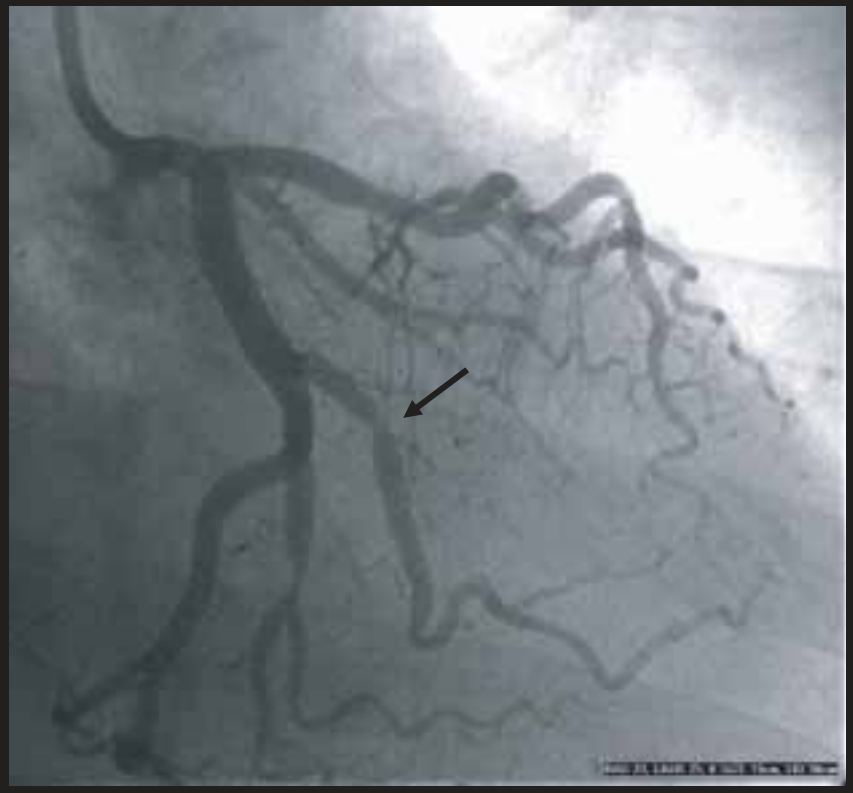
An operator trying to improve his/her coronary interventional skills must be familiar with IVUS…..

What IVUS gives us:
Lumen area
Vessel
Plaque (soft?, calcified?, location?)

(1) Using IVUS to find lesions

Angiography provides longitudinal information, and sometimes misses very short lesions (“napkin ring” stenosis).

Intermediate stenosis by angiography

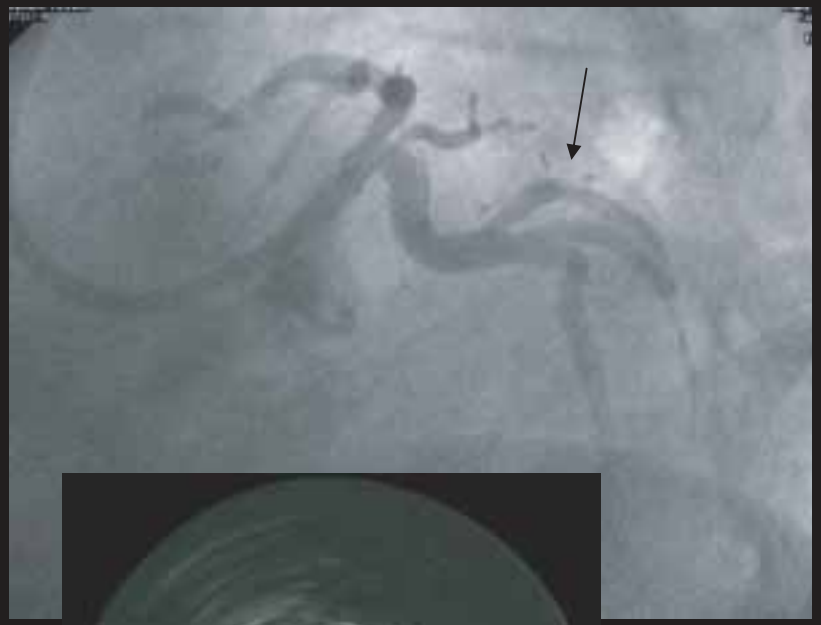


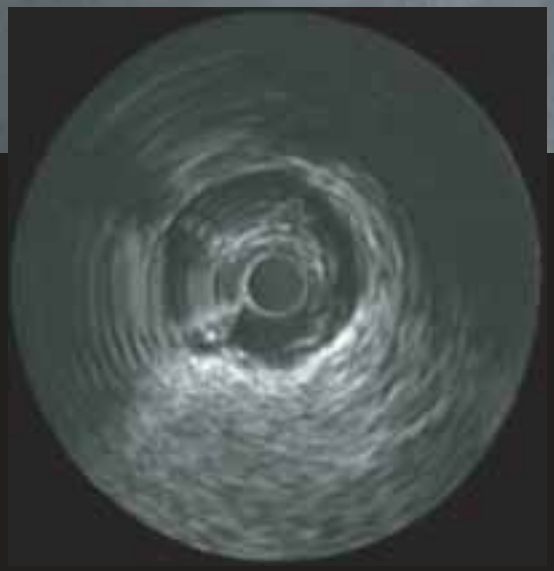
RAO caudal projection

Straight caudal projection

LAO caudal view

IVUS





Lesion

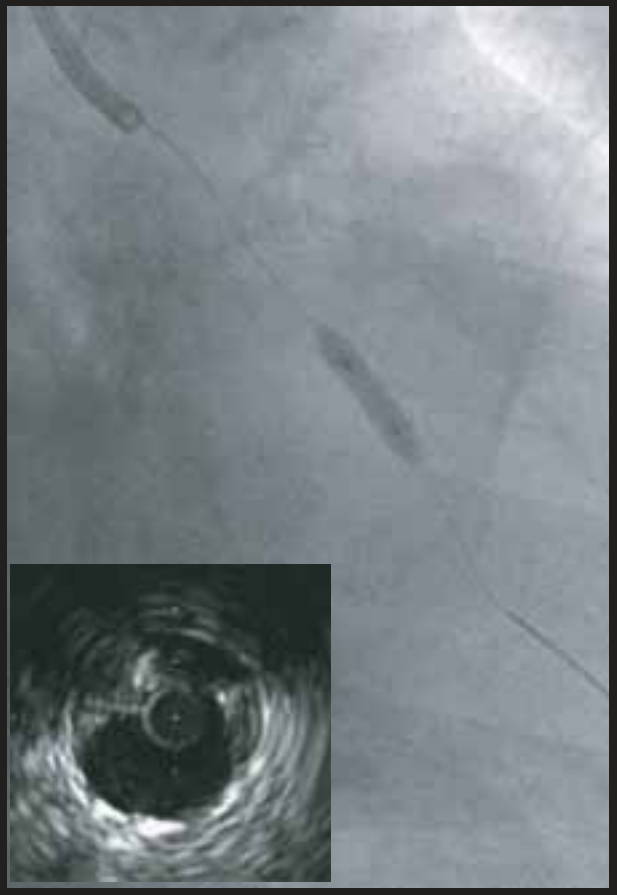
Angioscopy

~~Movie.1~~

~~Movie.2~~

Lesion treated with a 9.0x 3.5mm NIR stent

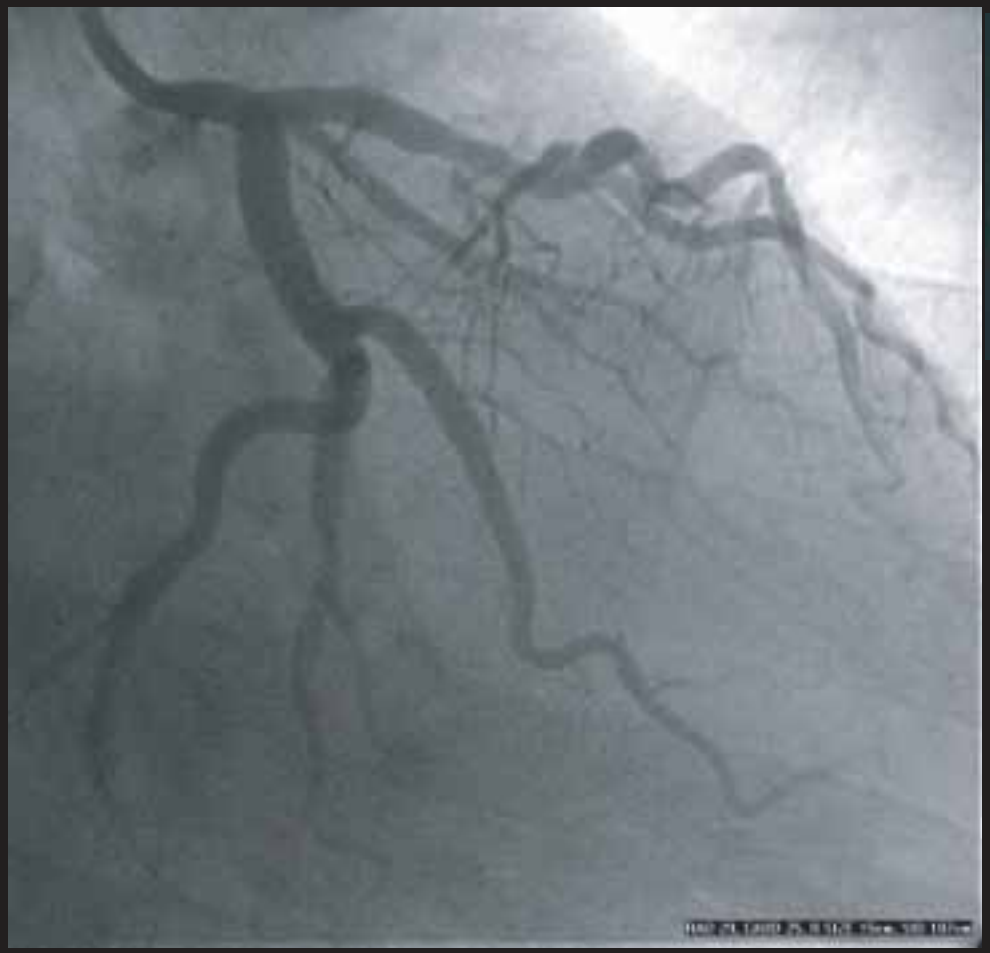
15atm

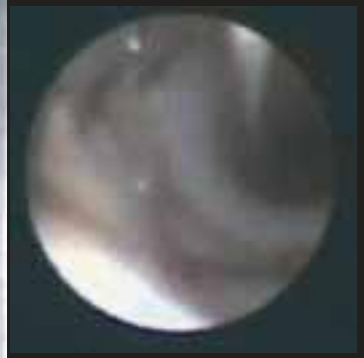


18atm

1st dilatation at 15atm, then IVUS, then 2nd dilatation up to 18atm.

Final angiography

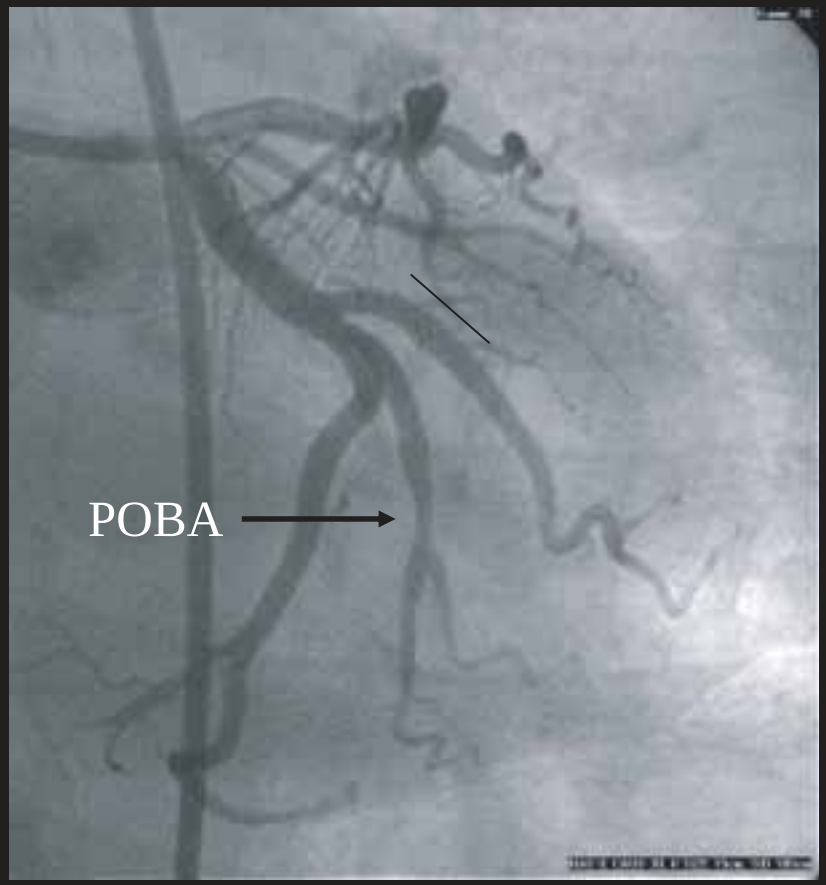




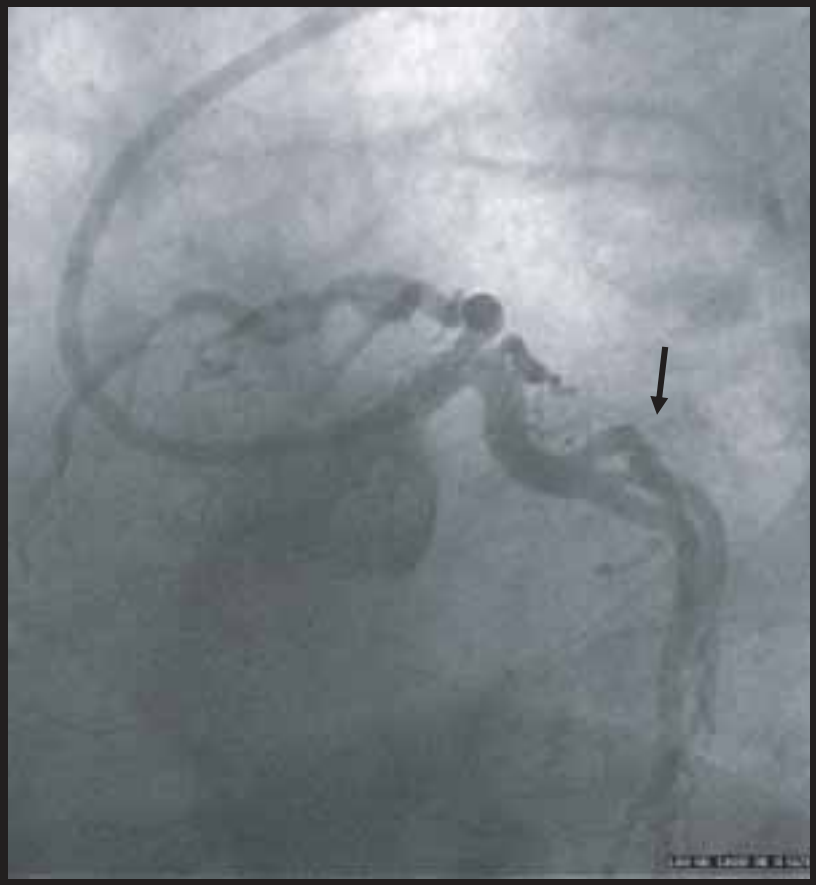
Angioscopy

~~Movie.3~~

RAO caudal



Straight caudal



LAO caudal

Angiography merely shows intermediate stenosis while IVUS reveals critical eccentric low hypo-echoic plaque. Angioscopy showed yellow eccentric plaque.

A short 3.5mm NIR stent was implanted at 15atm. IVUS showed poor stent-expansion. Inflation pressure increased to 18 atm.

Final angiography suggested a good result; IVUS revealed plaque is still not adequately compressed. Angioscopy showed protrusion from the stent struts.

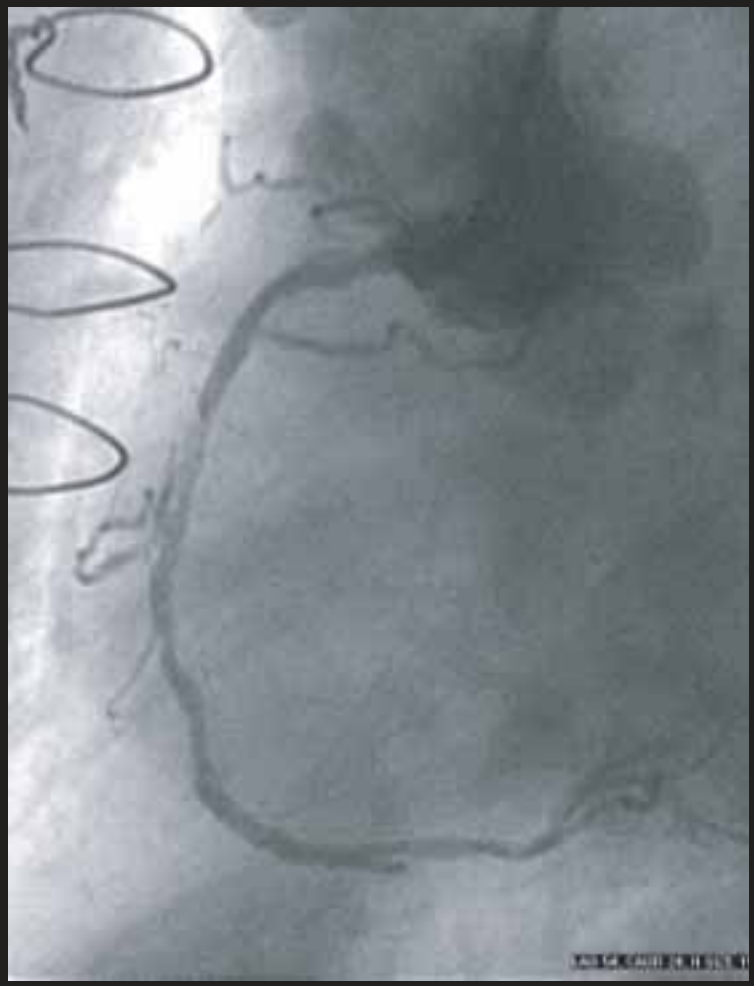
(2) Which is the true lumen?

The patient had undergone rotablation and balloon dilatation 3 months previously. There is a parallel channel in the mid RCA. Before stenting, we made sure the wire was in the true lumen. Also there is an eccentric stenosis at the RCA ostium, which we stented with a 3.5mm Multilink at 18atm. The mid RCA was stented with a 3.5mmx 24mm S670 at 12atm.

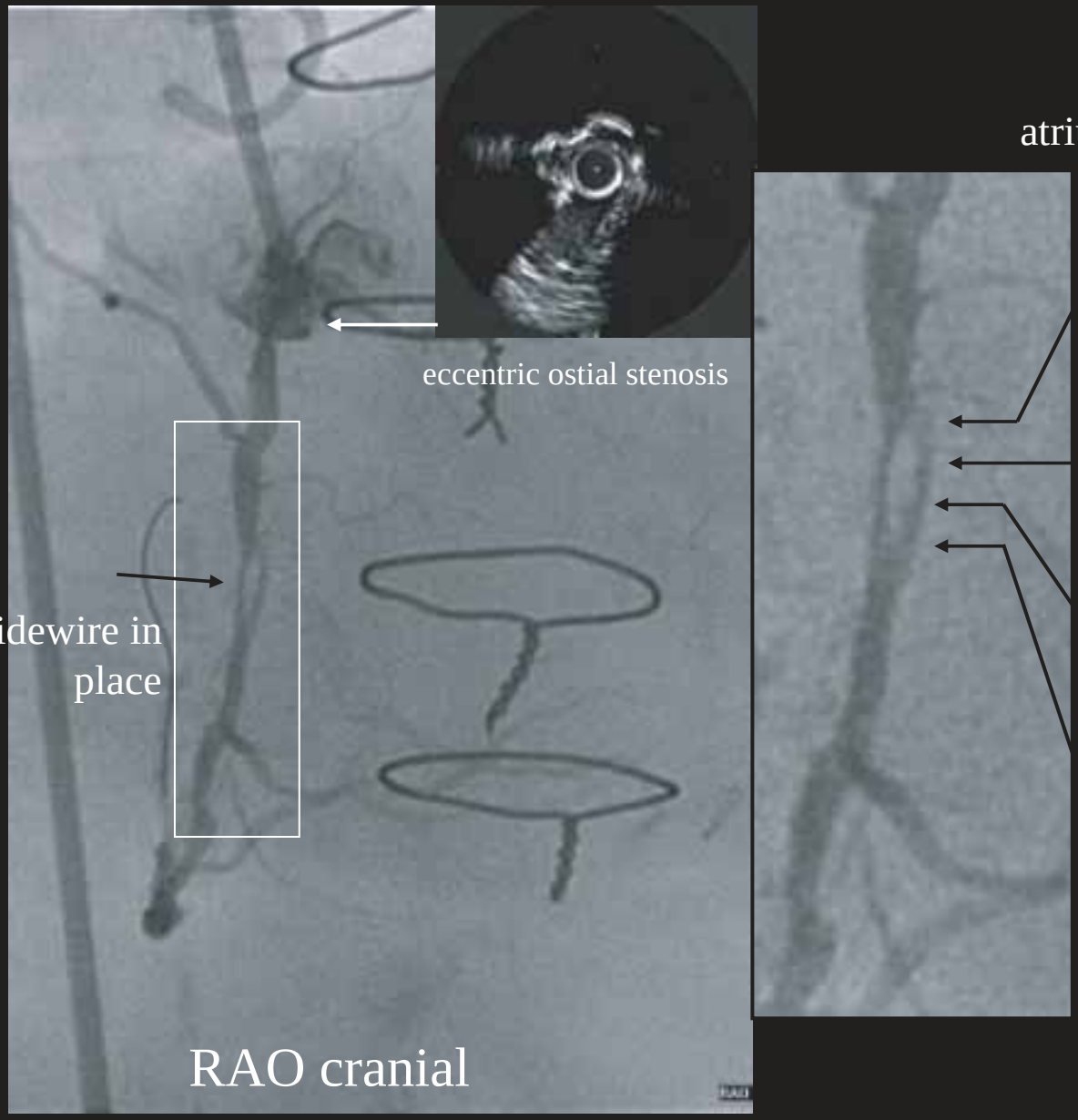
3 Months After Rota + Balloon

Which is the true lumen?

RAO



LAO

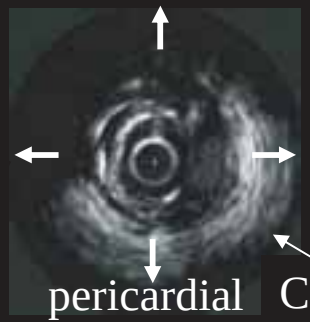


cardiac

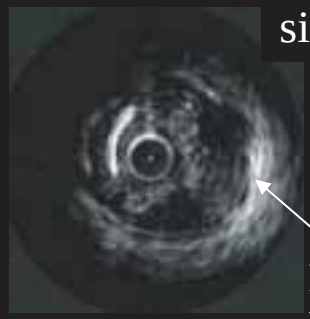
atrium

apex

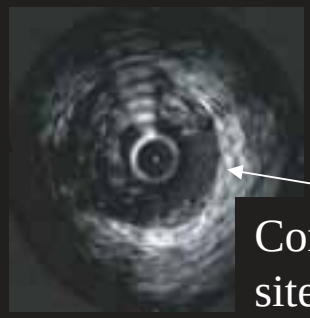
pericardial



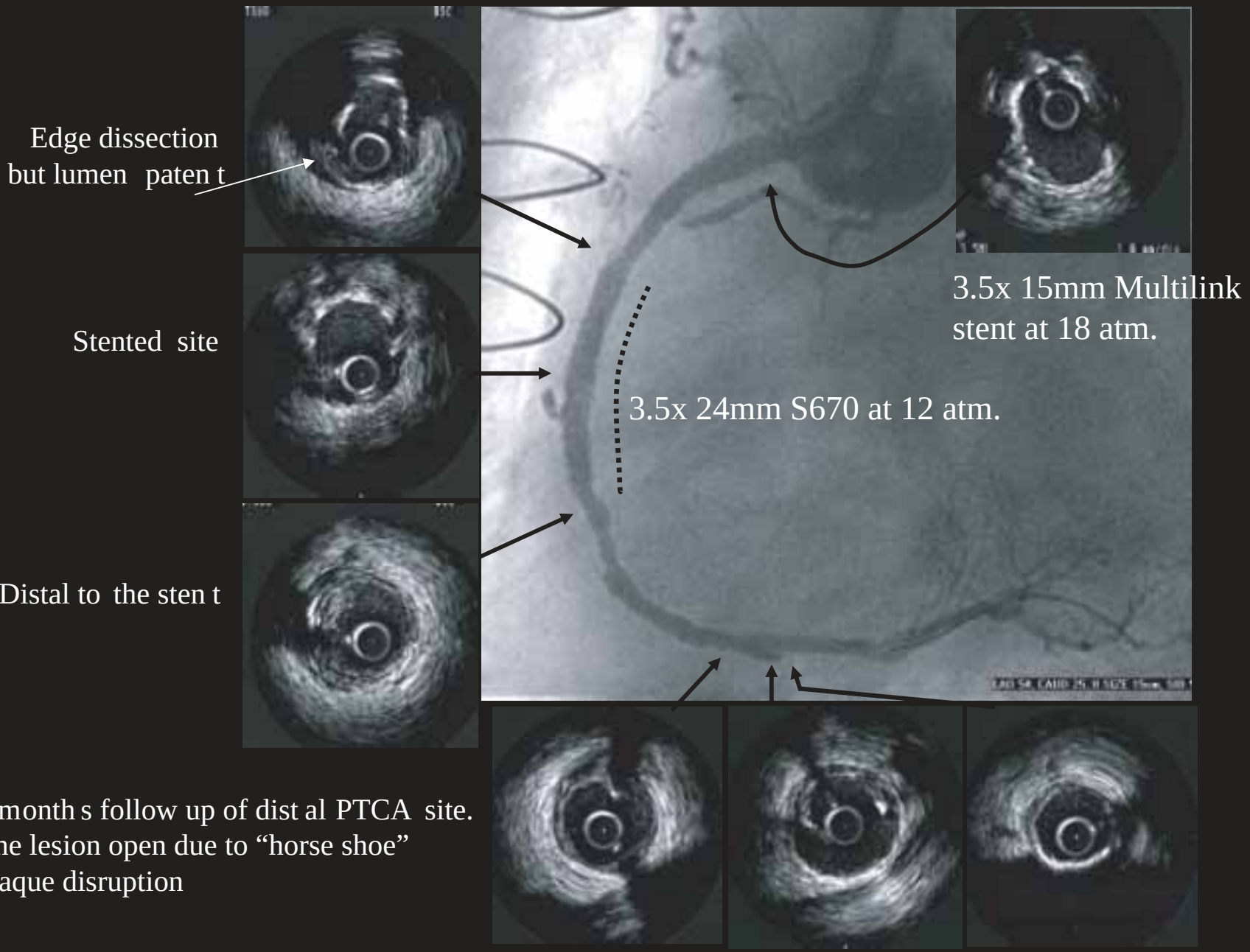
Connectio site



Pseudo-lume n



Connection site



3 months follow up of distal PTCA site. The lesion open due to “horse shoe” plaque disruption

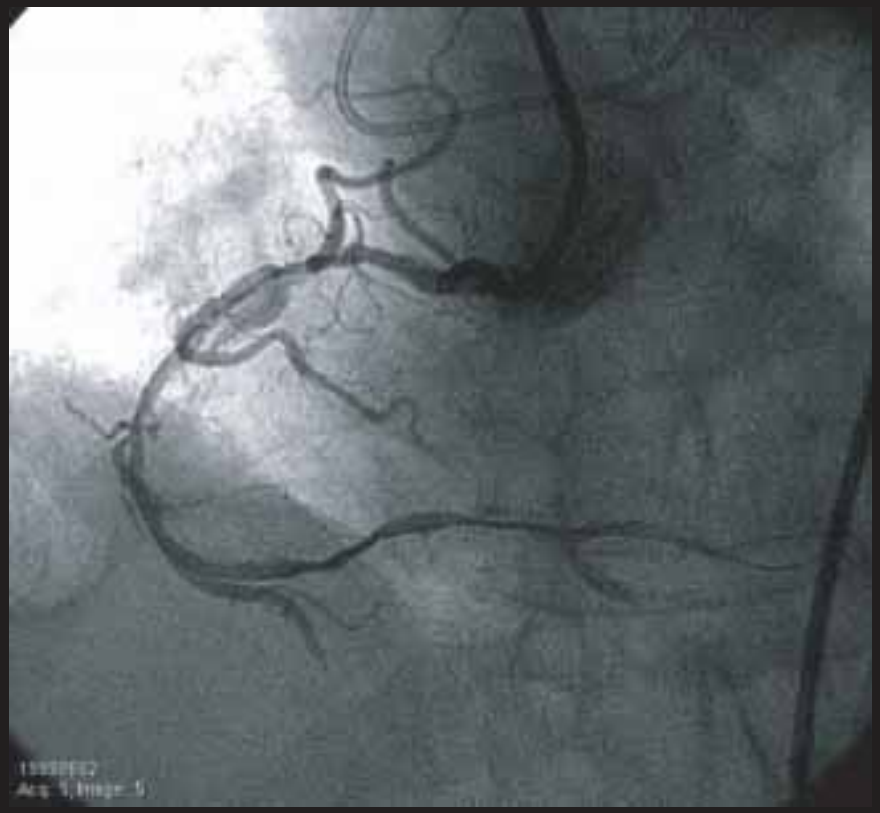
(3) Dissection

In this case, we “lost” the guiding catheter and system following recanalization of a CTO in the proximal RCA. There was a large spiral dissection from proximal to distal.

In order to ensure successful re-crossing with a guide wire, we have to make sure the wire in the true lumen.

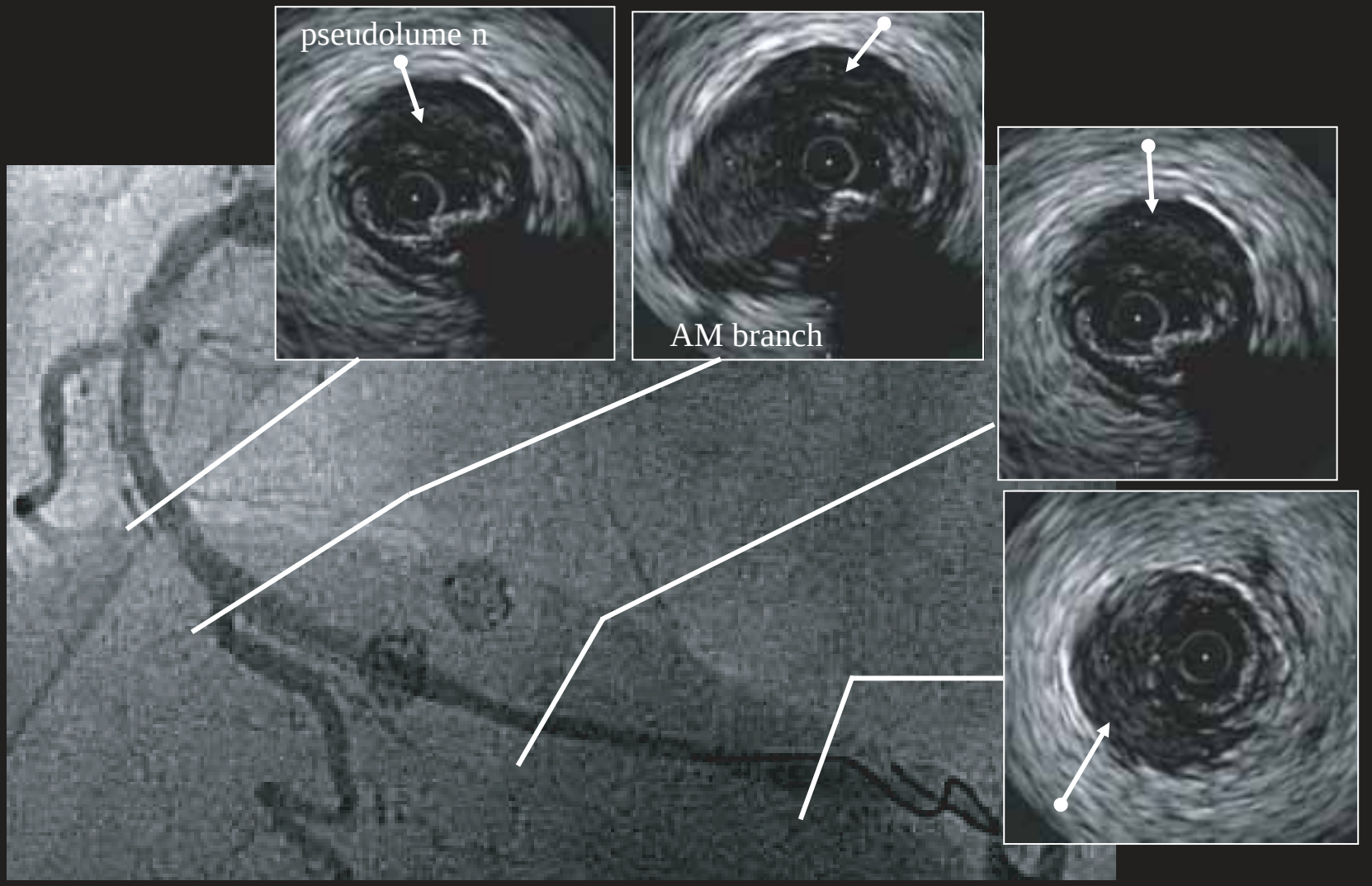
Are you in the true lumen?

Baseline



Post-recanalization spiral dissection

White arrow shows the pseudo-lumen. The sharp marginal branch lumen take-off, seen by IVUS, shows the wire is in the true lumen.

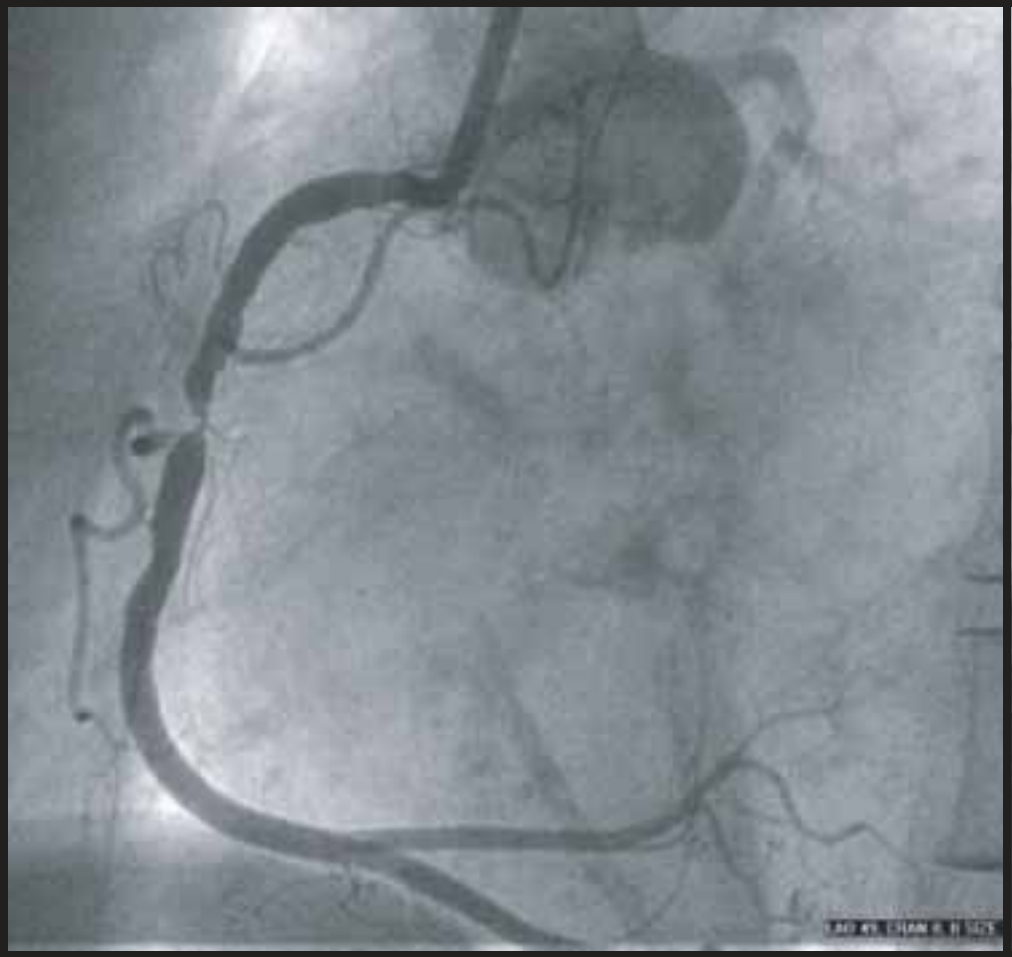


The lesion was successfully treated with two long stents. When you need to re-cross a spiral dissection, you can use IVUS to check whether or not your wire is in the true lumen.

(4) Stenting Constricted Lesions

A simple lesion in the mid RCA, with vessel “shrinkage” or constriction.

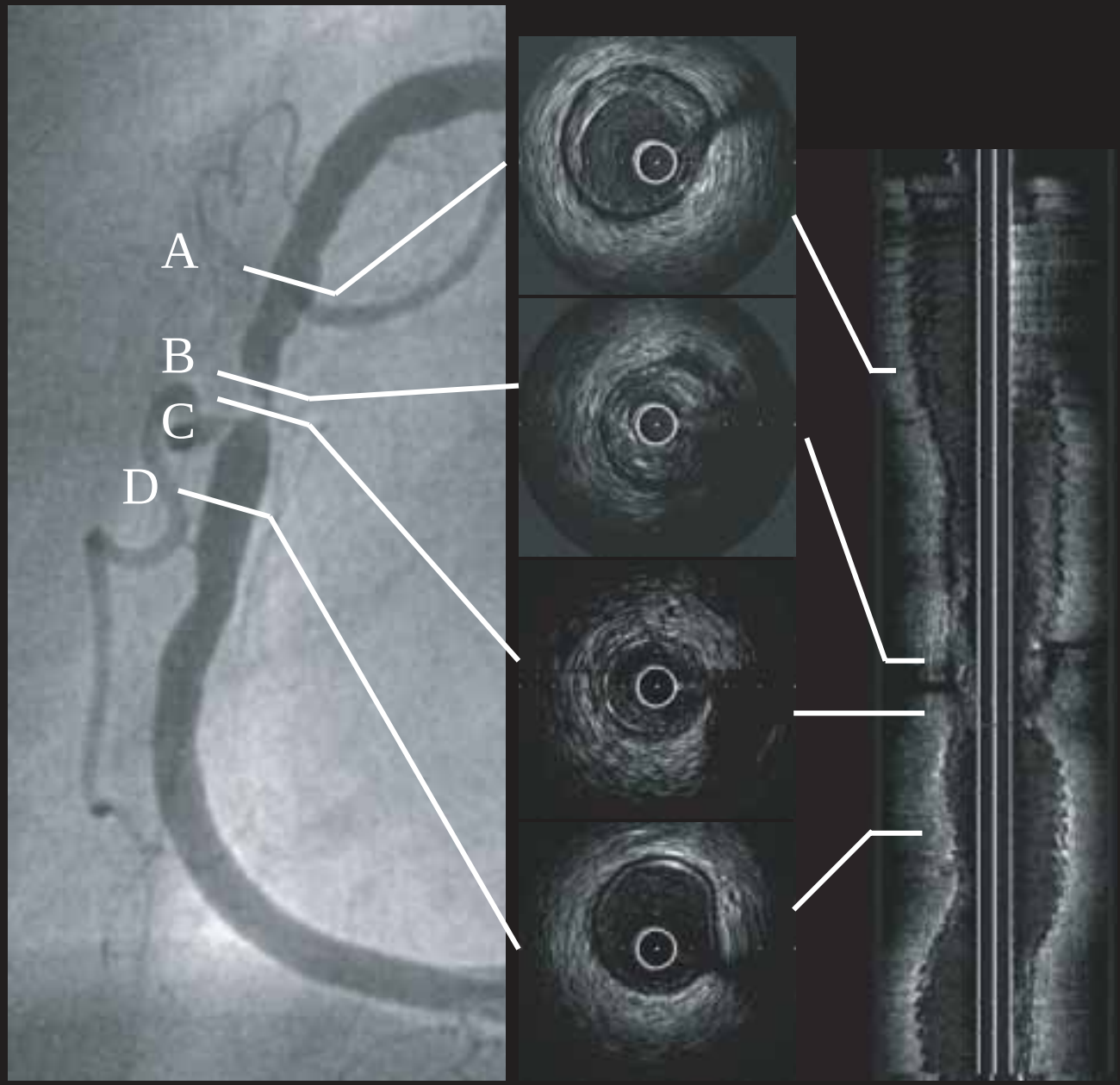
Baseline angiography



LAO

RAO

A: Proximal reference
B: Lesion
C: Constriction site
D: Distal reference



Pre-dilatation

2.5mm, 10atm.

Side-branch dilatation

2.5mm, 10atm.
For RV branch

Wire kept in the RV

Multilink plus.
3.5mm,9atm

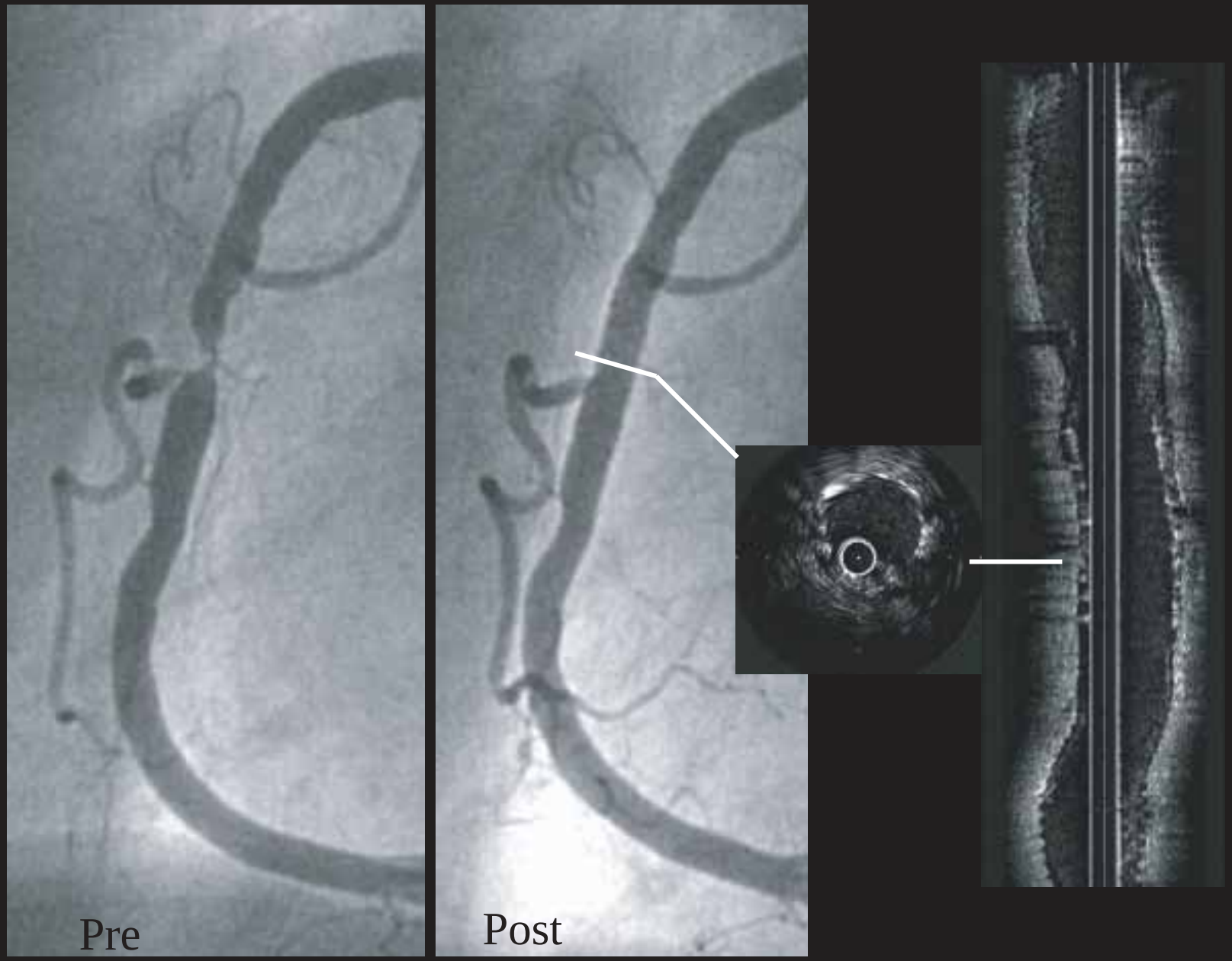
Post-dilatation

3.5mm,14atm

Final angiogram

LAO

RAO

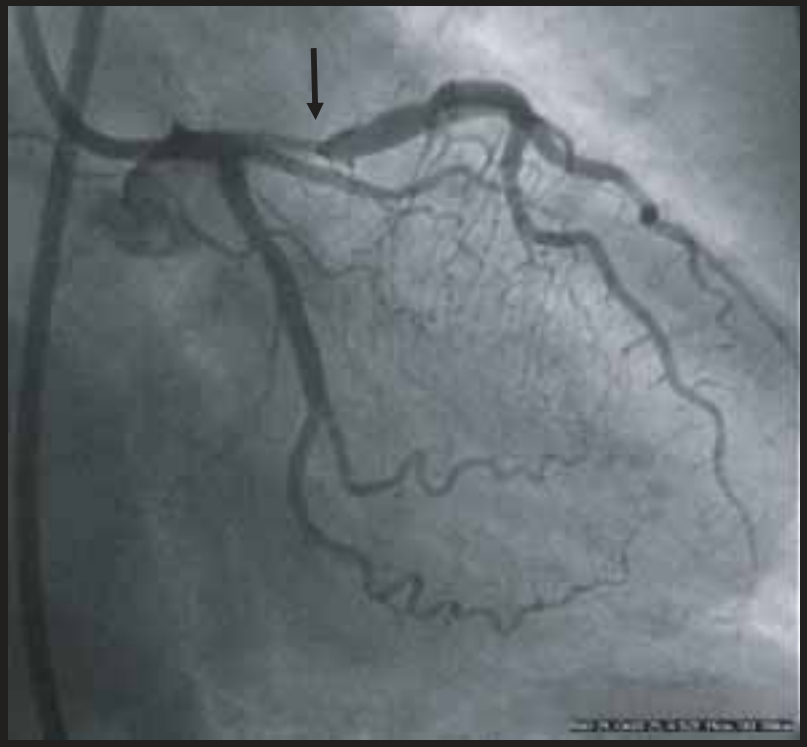

Pre
Post

(5) Negative Contrast Method

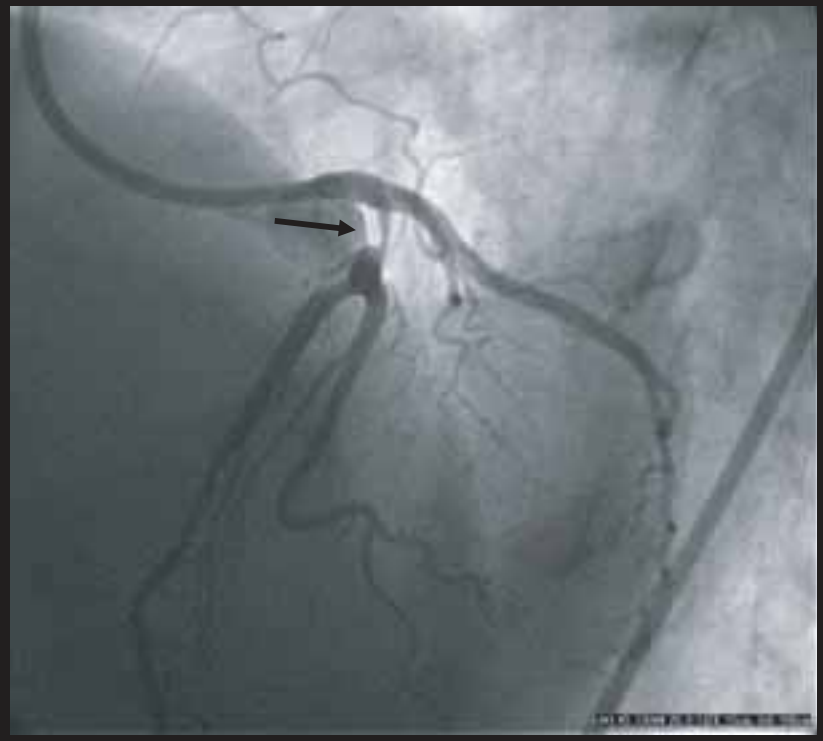
The recently-developed Atlantis catheter gives 40MHz imaging that picks up red blood-cell reflections. It can be difficult however to recognize the lumen surface.

In this situation, using contrast injection or saline flush should provide a clearer image.

Proximal LAD lesion



RAO caudal



LAO cranial

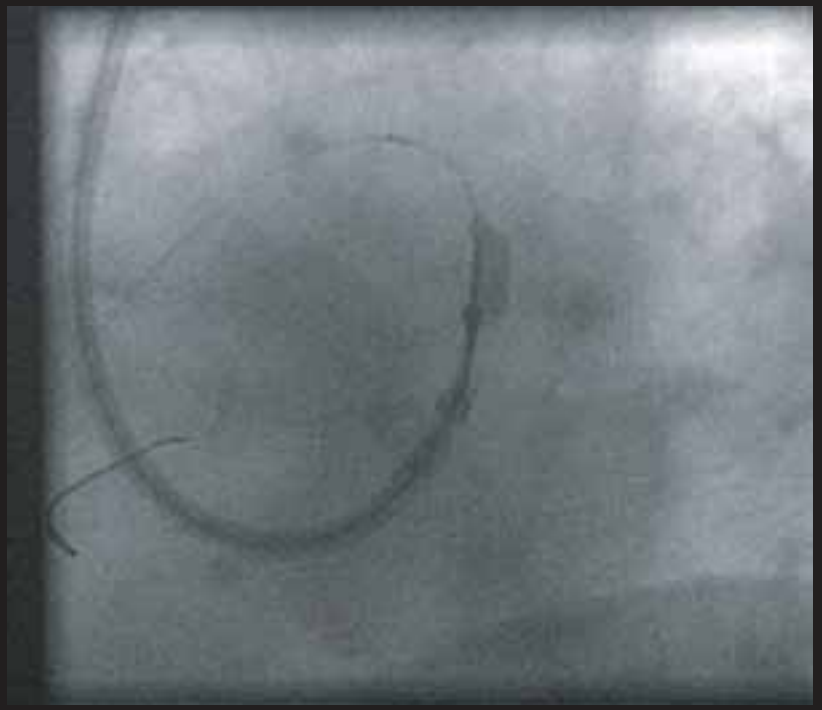
Tightest Site of lesion

Standard image

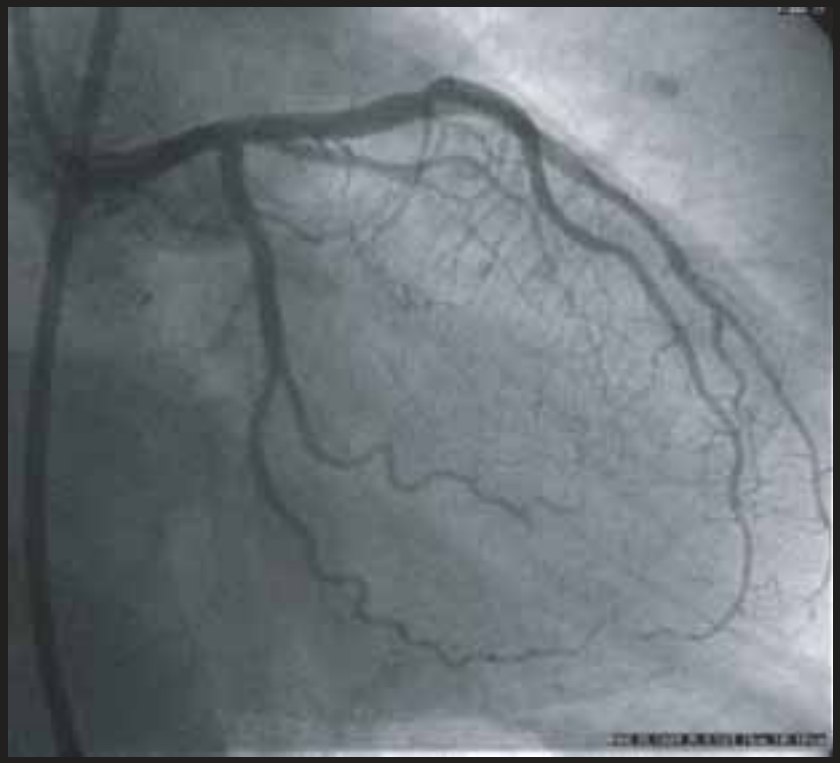
Saline flush

CVIS Atlantis IVUS catheter

LAO caudal



Flexi-Cut L



RAO caudal

LAO cranial

LAO caudal

Post-DCA by Flexi-Cut L

Final IVUS Image of Lesion

Standard image

Saline flush ~~Movie.4~~

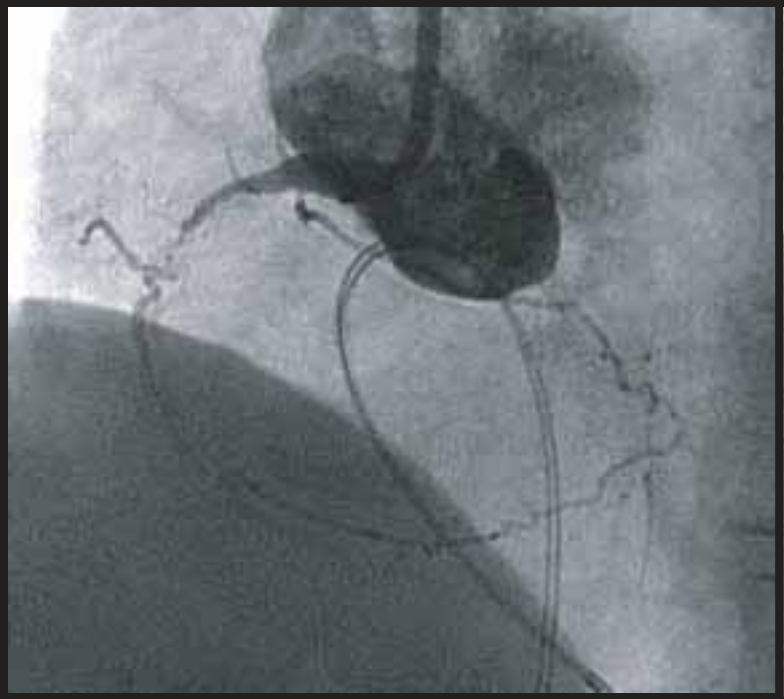
When using negative contrast, catheter position is sometimes affected by the force of the flushing motion.

To avoid this problem, hold the IVUS catheter.

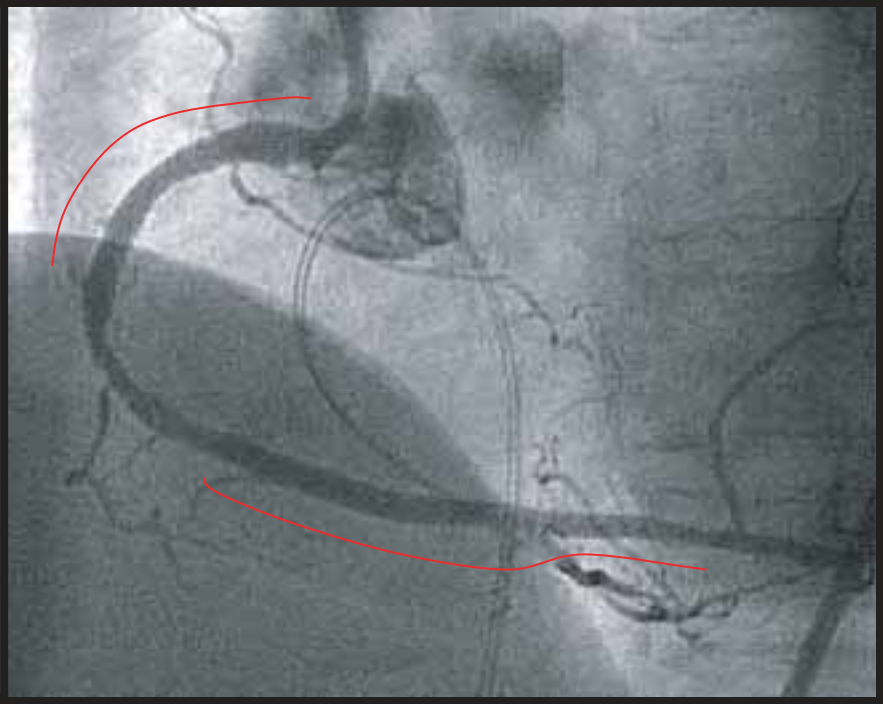
(6) Stent-edge dissection

Stent-edge dissection can be very difficult to be treat.

Stenting a CTO in a diffusely-diseased RCA

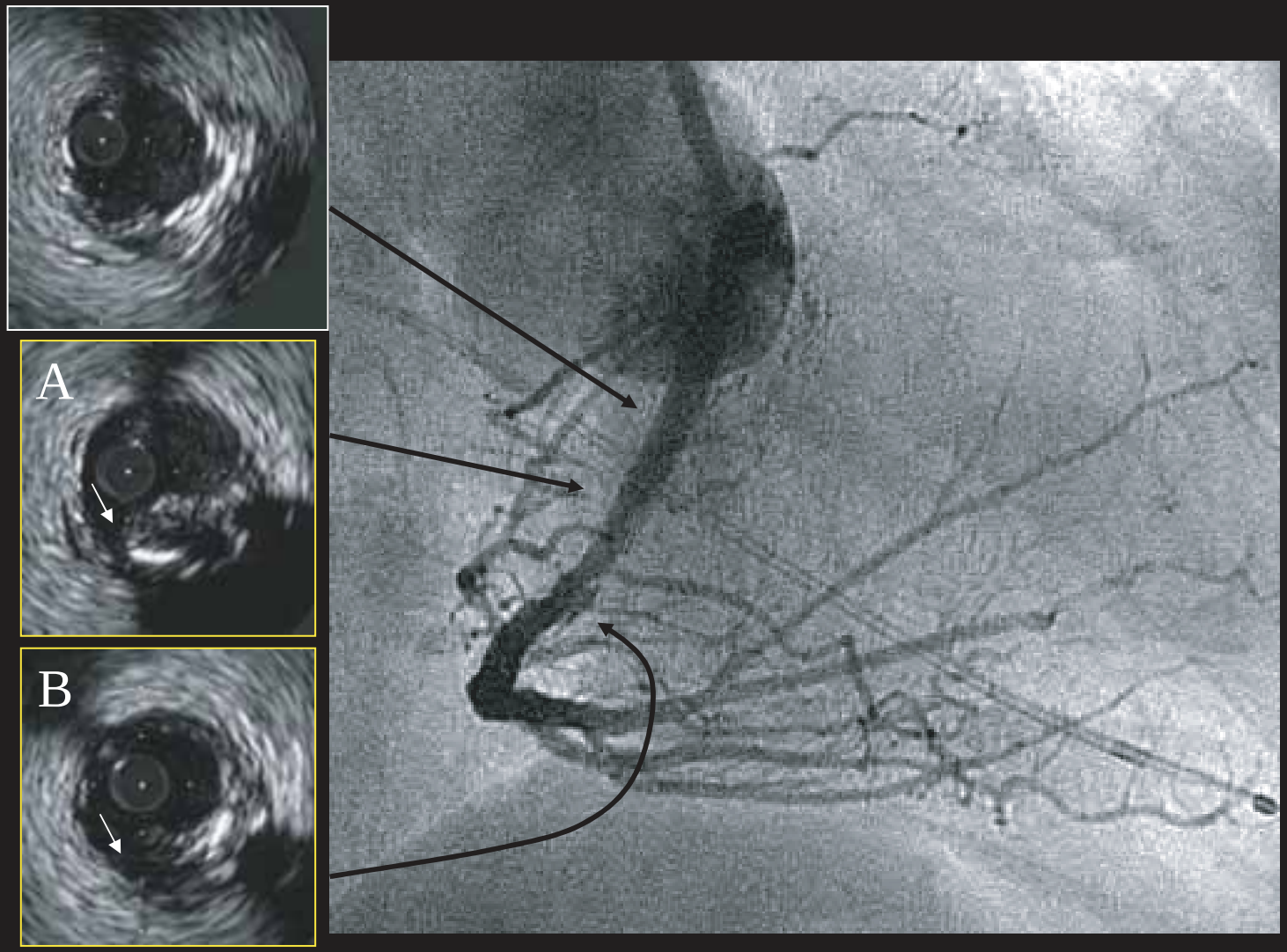


LAO



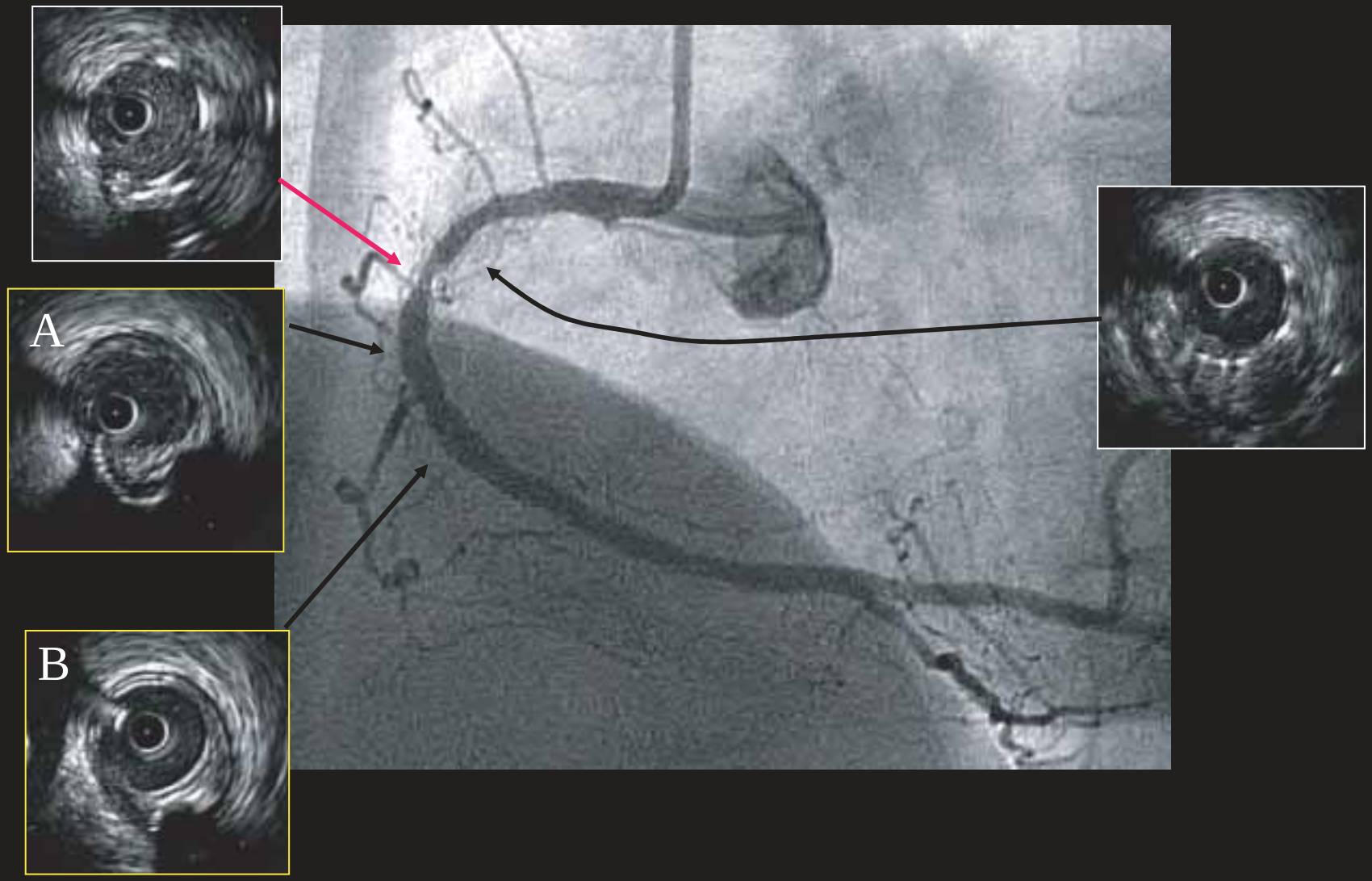
After stenting

Visible edge-dissection between stents



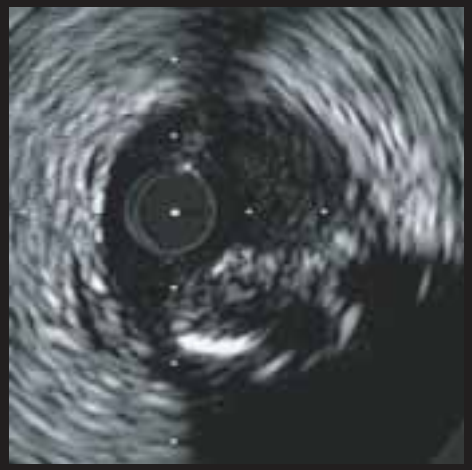
RAO view

Follow up angiography shows stent-restenosis at 3 months



Distal-edge dissection

Dissection extending to the neo-intima.
At follow up, enlarged vessel size reveals vessel remodeling.



(1) ↗ noontime

(2) * : proliferatio n

(3) Remodeling

(7) IVUS-guided Stent Implantation

Key points for IVUS-guided stenting

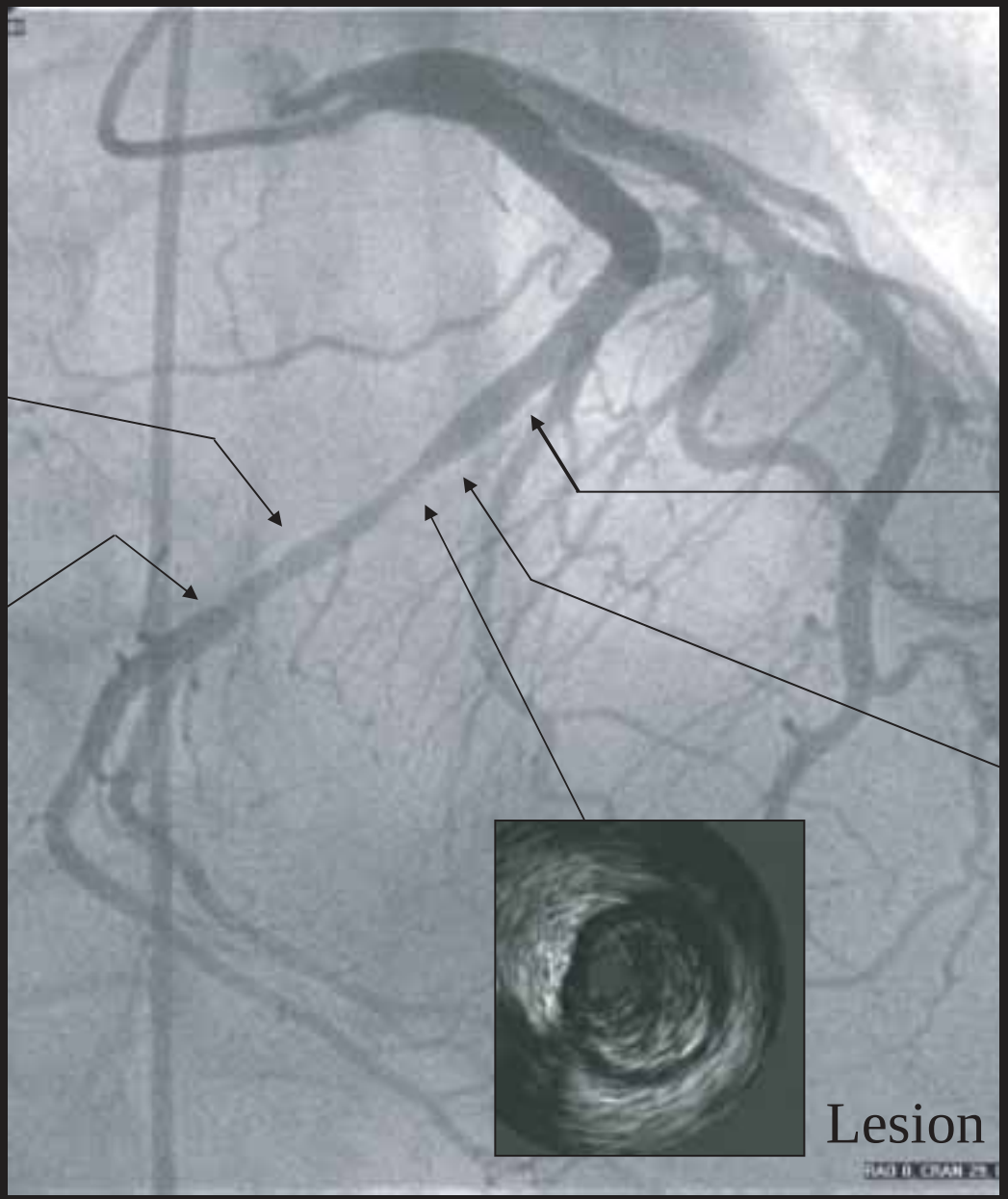
1) Complete apposition of stent struts to the vessel wall.
2) Stent-lumen CSA larger than the distal reference lumen area.
3) Symmetric expansion.

But how do you get symmetric expansion?

Baseline IVUS imaging

Irregular lumen surface

Distal ref.

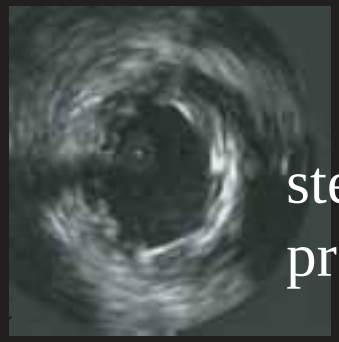


Proximal ref.

Lesion

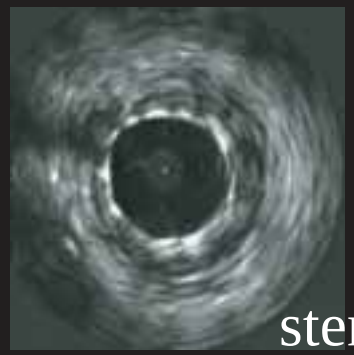
Stent Implantation

Multilink stent
4.0mm at 10atm.



stent
proximal

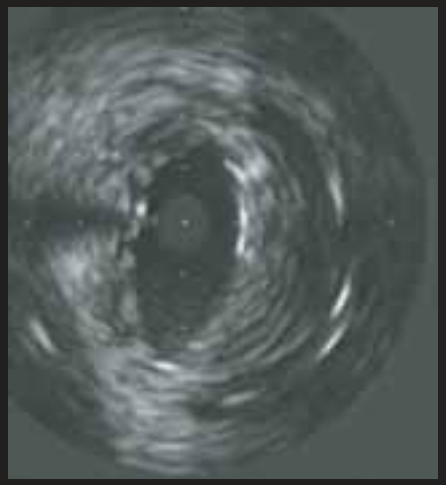
stent
center



stent
distal

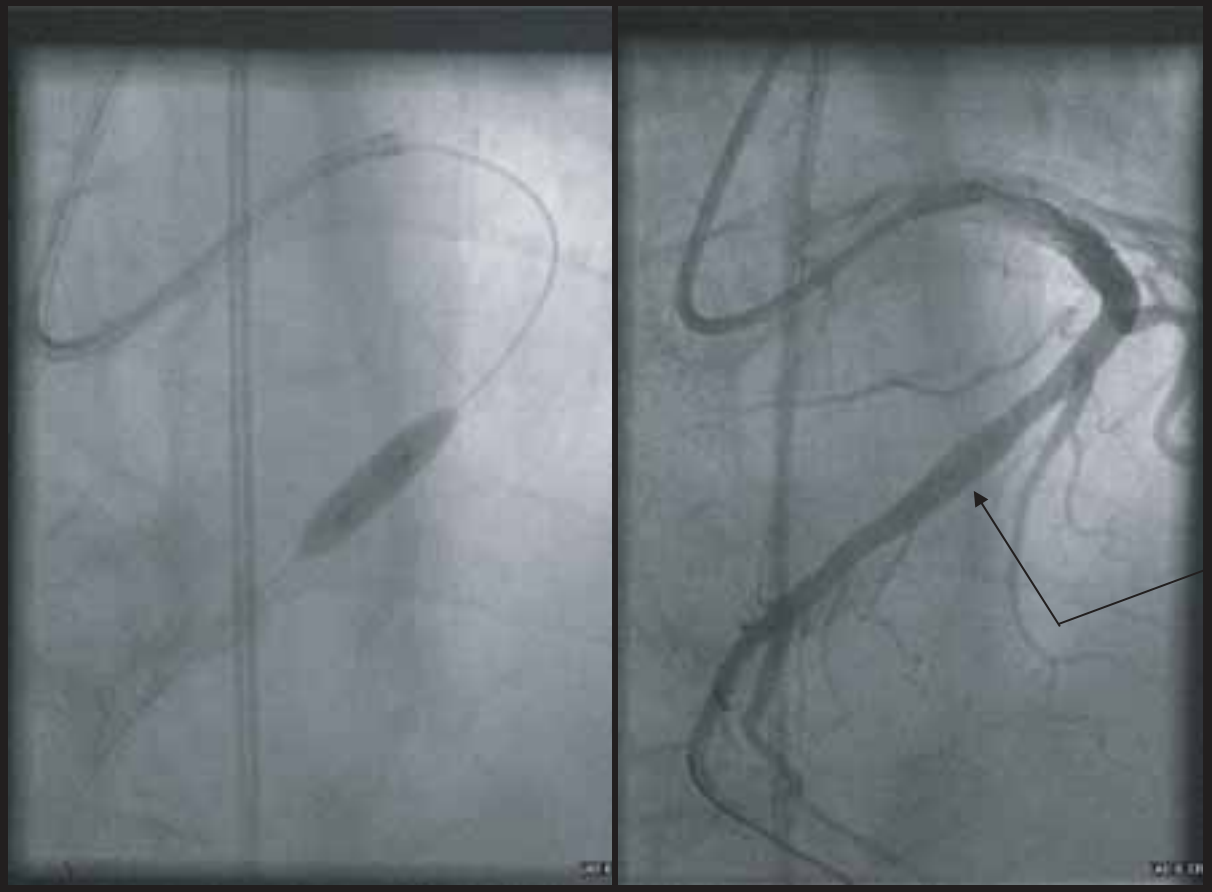
IUVS showed asymmetric stent-expansion.
Higher pressure deployed (16atm).

4.0mm at 16atm.

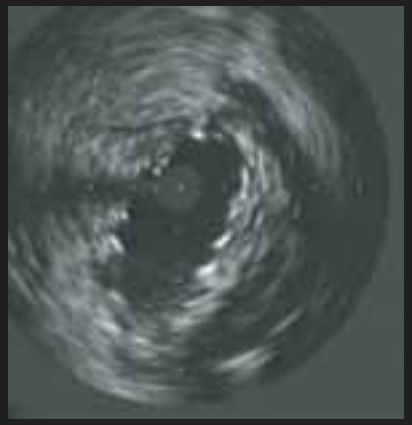


Still insufficient expansion

Additional inflation with short non-compliant balloon.

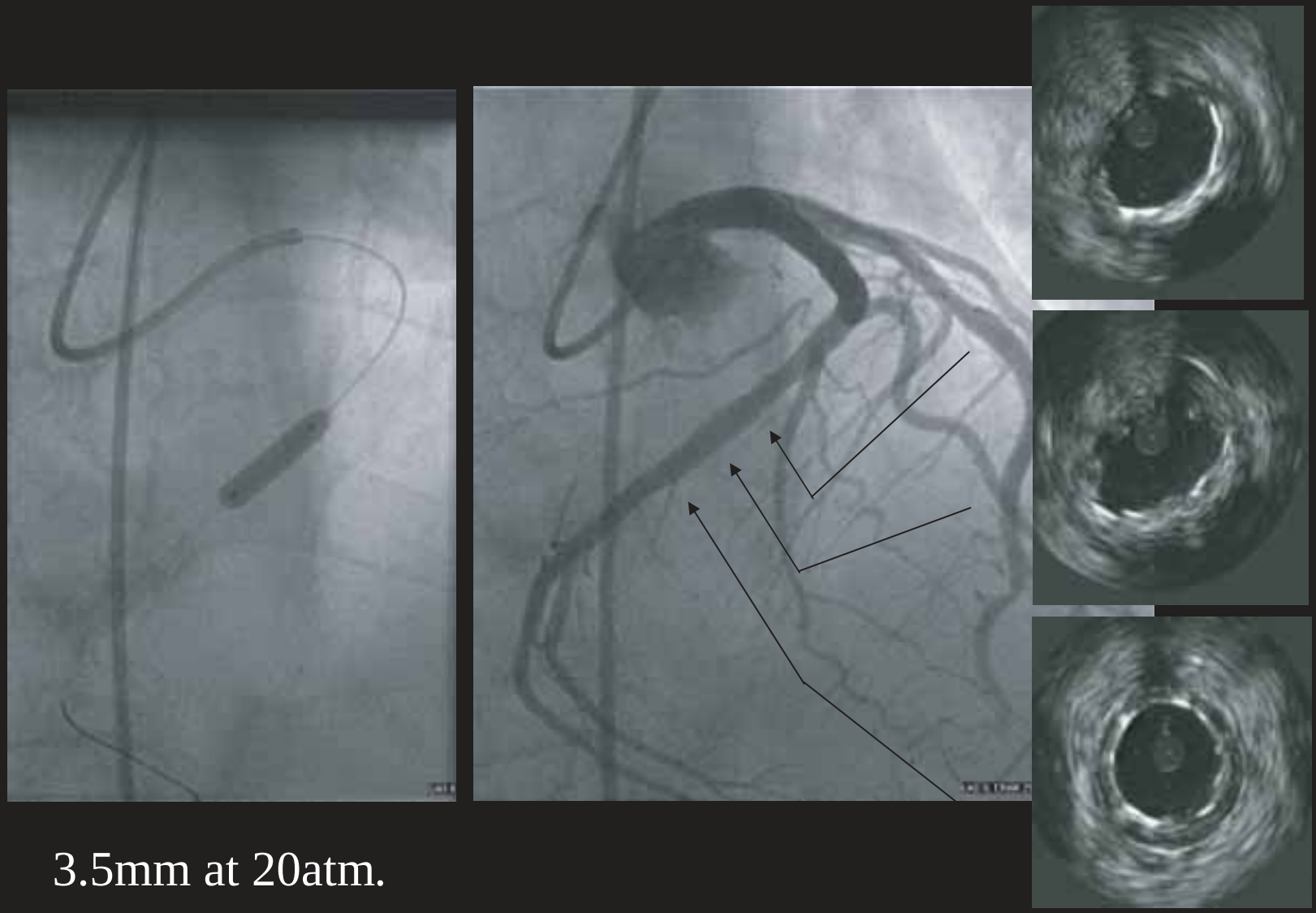


4.0x 9.0mm non-compliant balloon at 18atm.



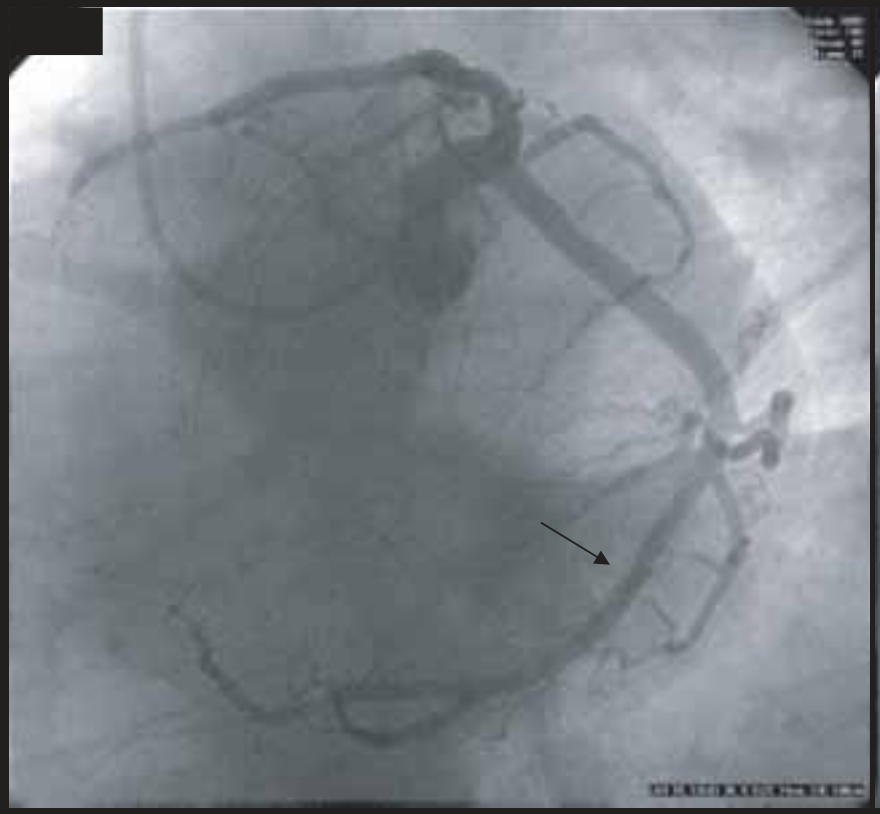
Worse expansion than before

Balloon downsized to improve symmetry of expansion

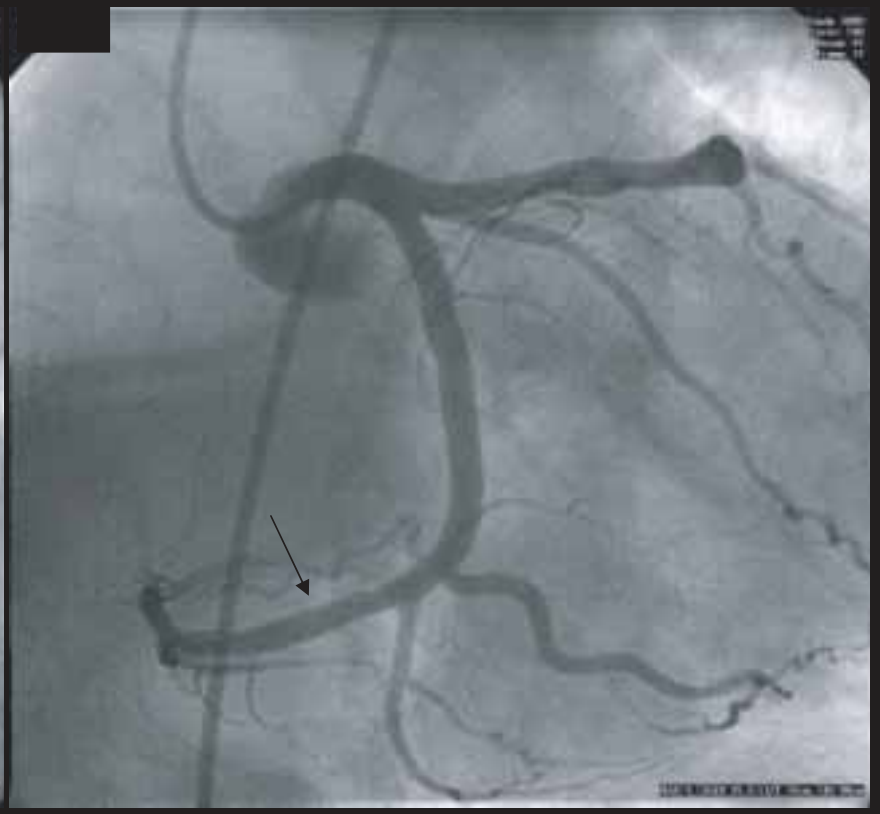


3.5mm at 20atm.

Final angiogram

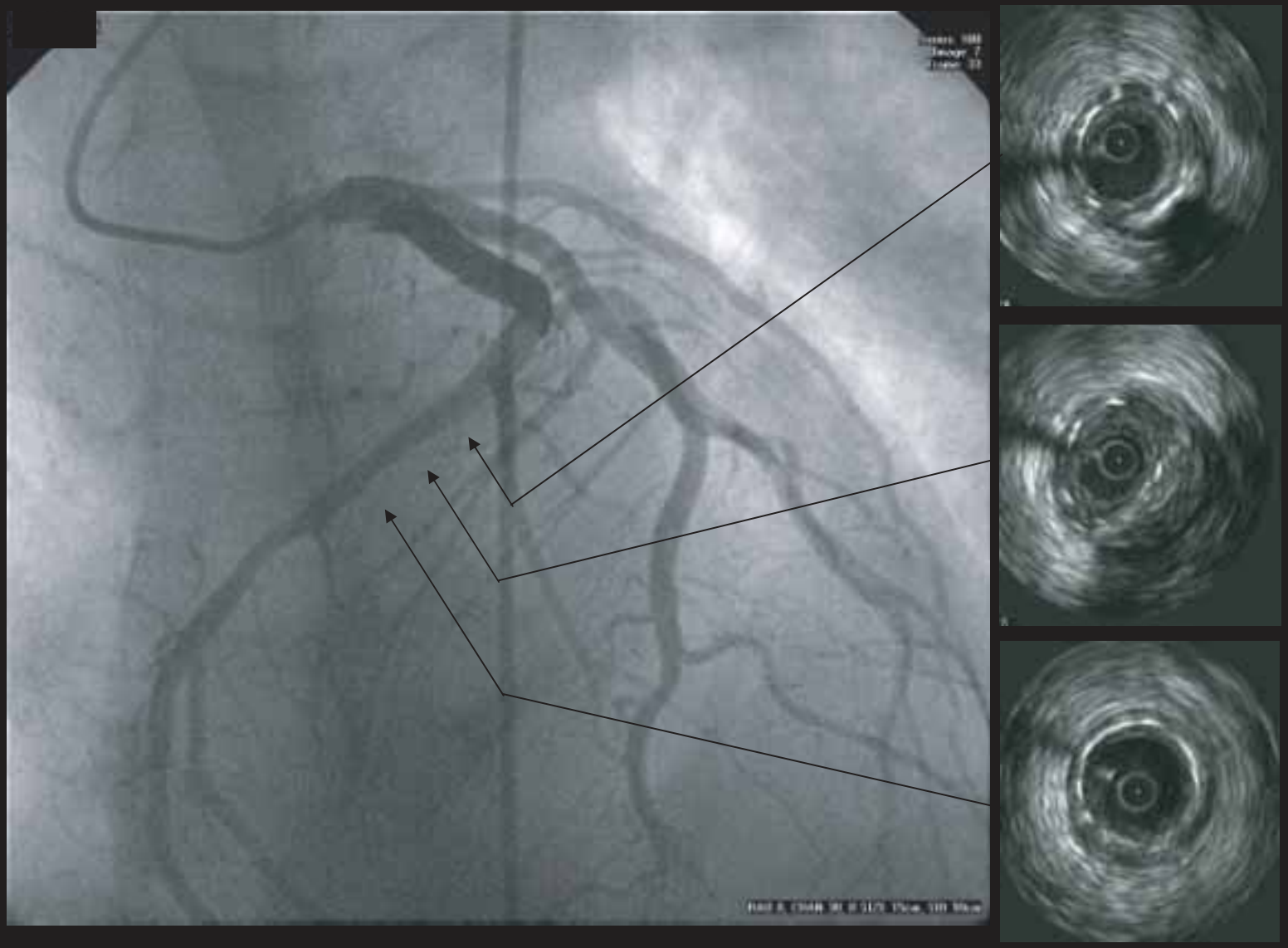


Spider view shows indentation at the stented site.

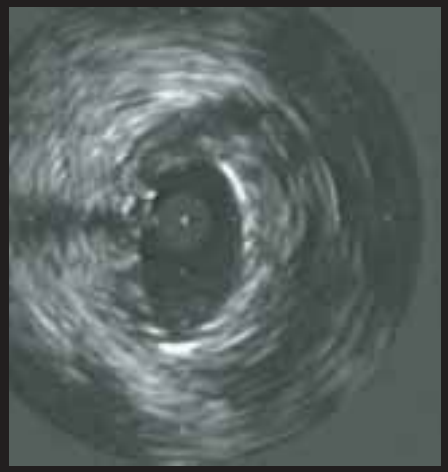


RAO caudal shows good dilation

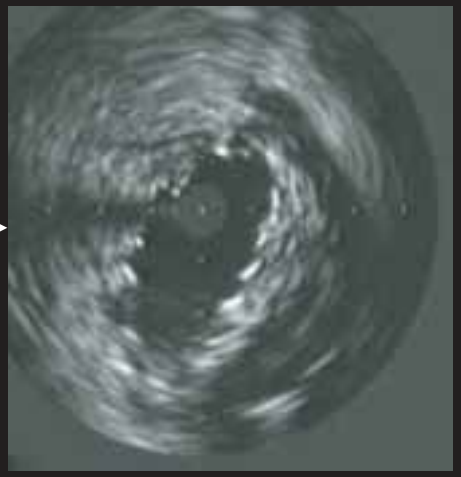
6 months follow up angiography



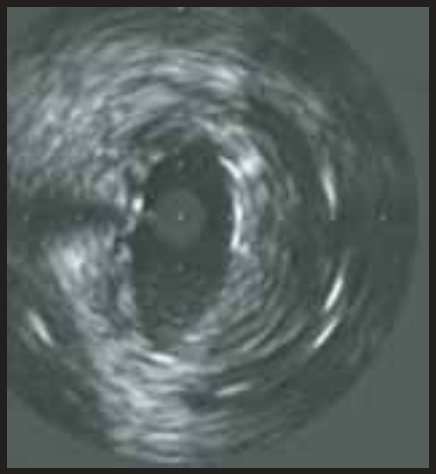
Pre-



ML 4.0mm,10atm

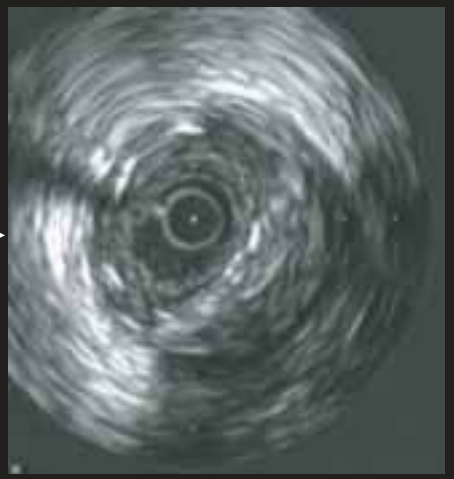


4.0mm,16atm



4.0mm, 18atm

3.5mm, 20atm



6 months f/u

Baseline IVUS shows eccentric non-calcified plaque.
4.0mm Multilink stent implanted at 10atm resulted in asymmetric expansion and poor luminal area.

Use of a 4.0 non-compliant balloon at 18 atm only resulted in worse symmetry. A 4.5mm balloon would risk a perforation.

Downsizing the balloon and increasing the pressure improves stent symmetry but not the lumen area. This is the step-back method of eccentric expansion.

Follow up angiography showed no restenosis.
IVUS showed neo-intimal proliferation.

IVUS-guided DCA

(8) Understanding plaque location in the LAD

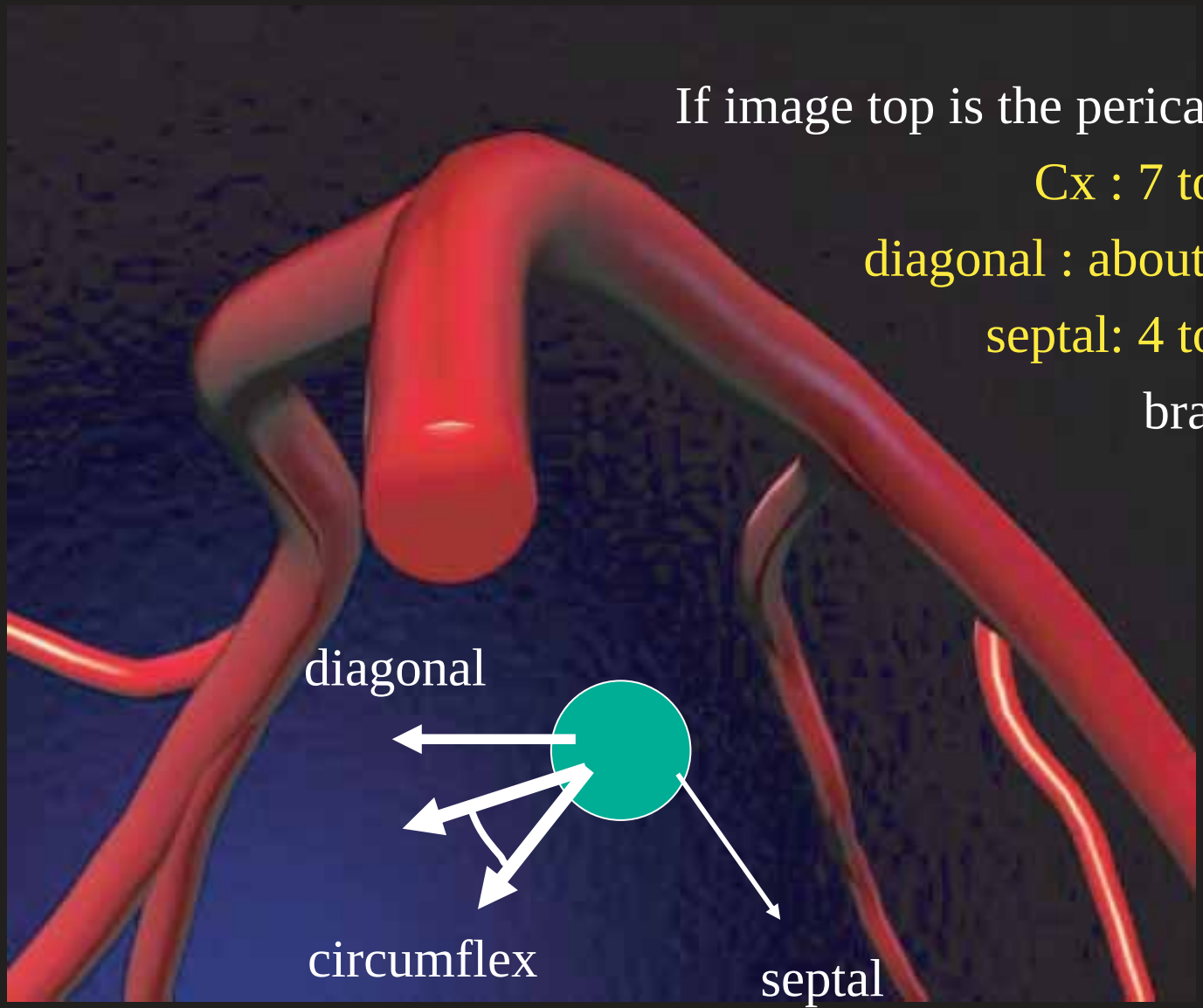
How to use IVUS Guidance

IVUS imaging gives a view along the artery from proximal to distal.

The upper side of the IVUS image is not necessarily the surface of the heart. The image may be upside-down or rotated.

Anatomical landmarks (side branches) are very important for understanding plaque location. Understanding the theory of branching is crucial for DCA.

Anatomical Theory of Branching in the Left Coronary Artery



If image top is the pericardium site,

Cx : 7 to 8 o’clock

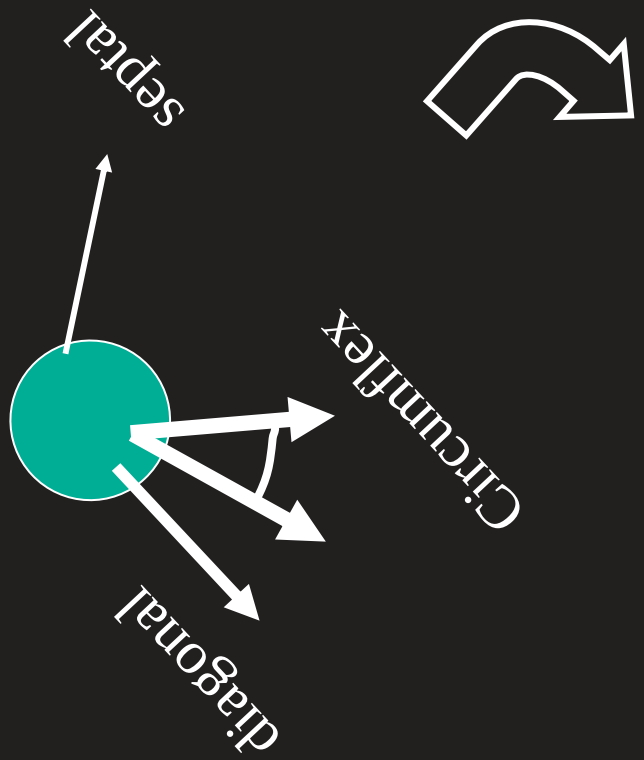
diagonal : about 9 o’clock

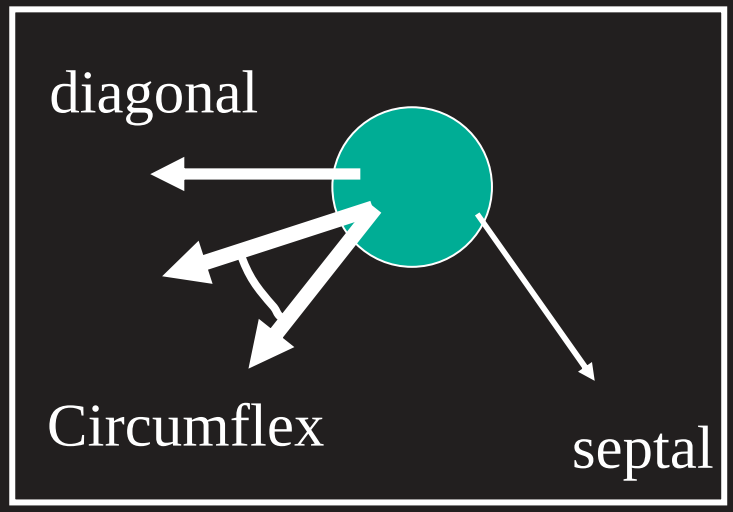
septal: 4 to 5 o’clock

branching off

The pericardial site is not always at the top of the IVUS image. The operator must rotate his/her own mental image to match rotation of the IVUS image.

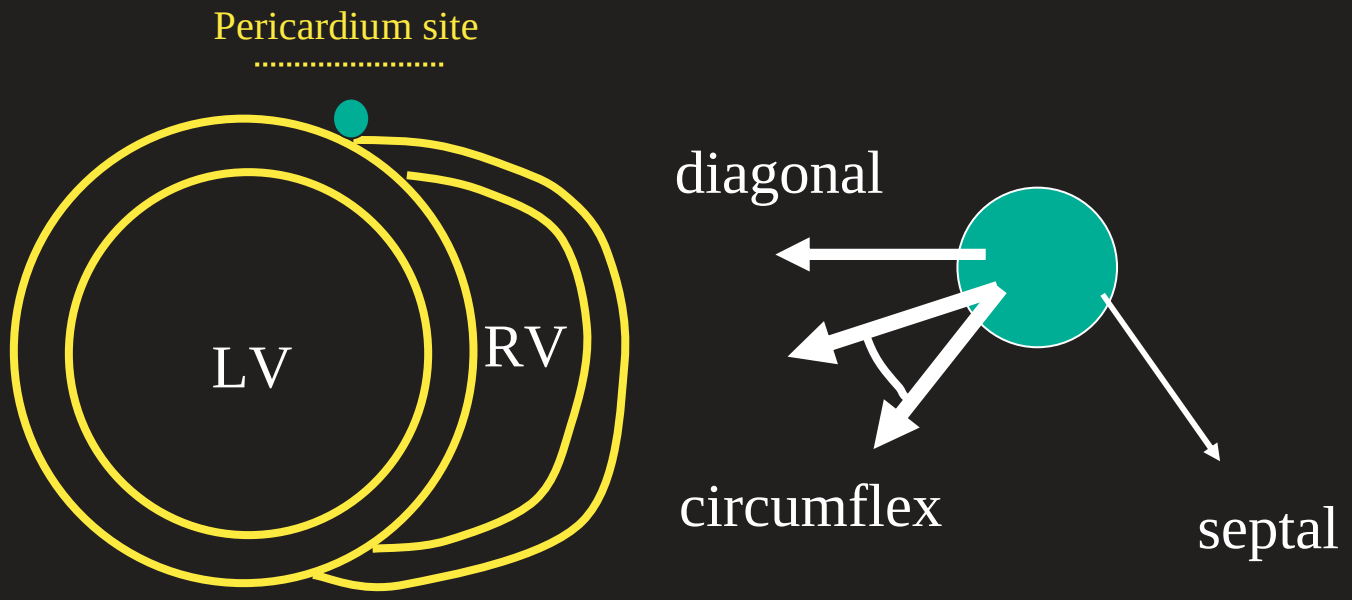
Picture the diagonal branch at 9 o’clock.





Key IVUS Image in the LCA is the diagonal branch.

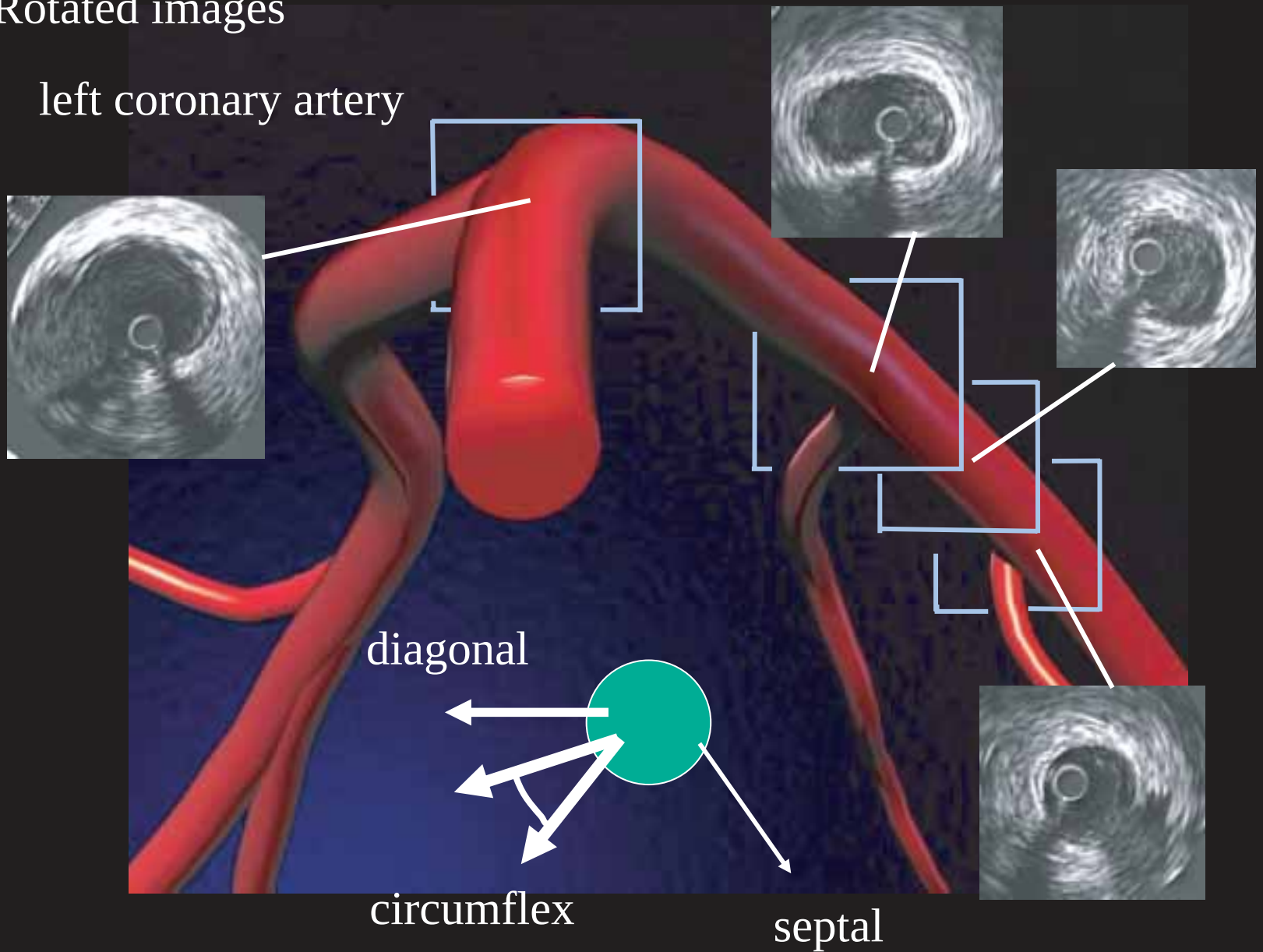
The diagonal and the LAD branch off along the same geometric plane. This plane is almost parallel to the pericardium.
Orient the diagonal ostium at 9 o'clock in your mind and for all other IVUS imaging.
Now the pericardium is at the top, the cardiac site is at the bottom, RV on the right , and LV on the left.



Stenosis in the mid LAD but where exactly is the plaque?

Rotated images

left coronary artery



circumflex

pericardium site

LV site

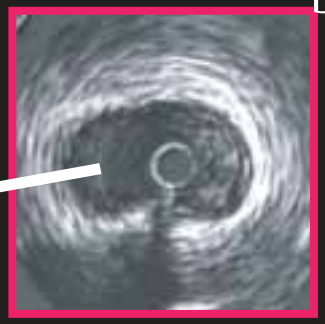
RV site

diagonal

Key image

Cha mb er site

8 o’clock



9^{o}’clock

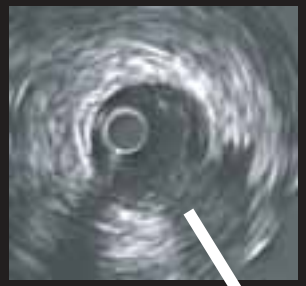
Image the diagonal branch at 9 o’clock.

Plaque location is at a 130^{o} (clockwise) rotation from the diagonal branch.

In the same direction as the septal branch.

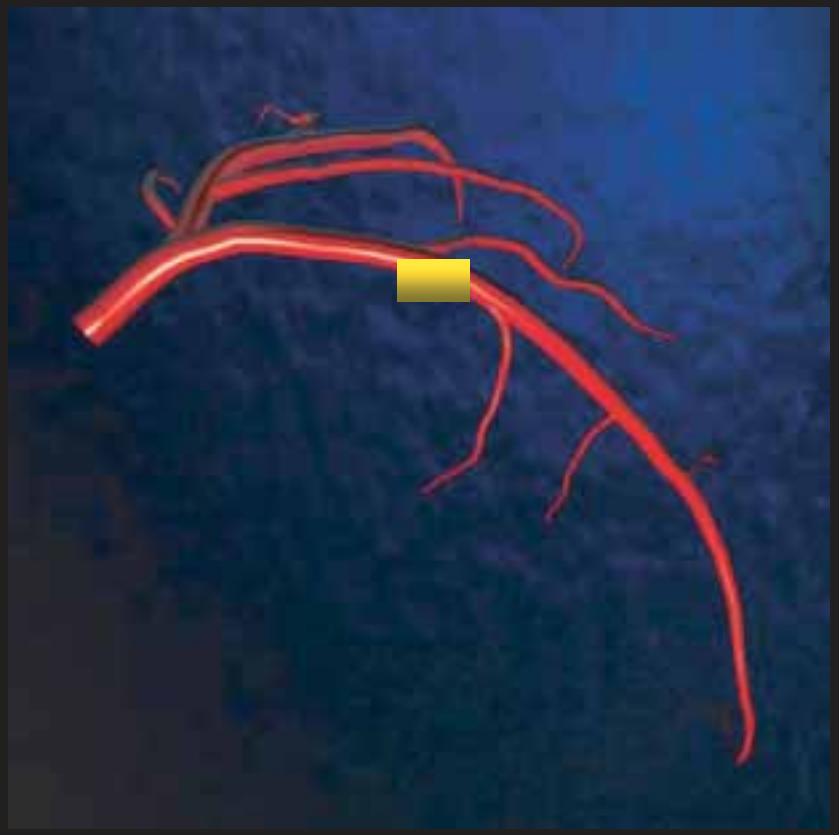
lesion

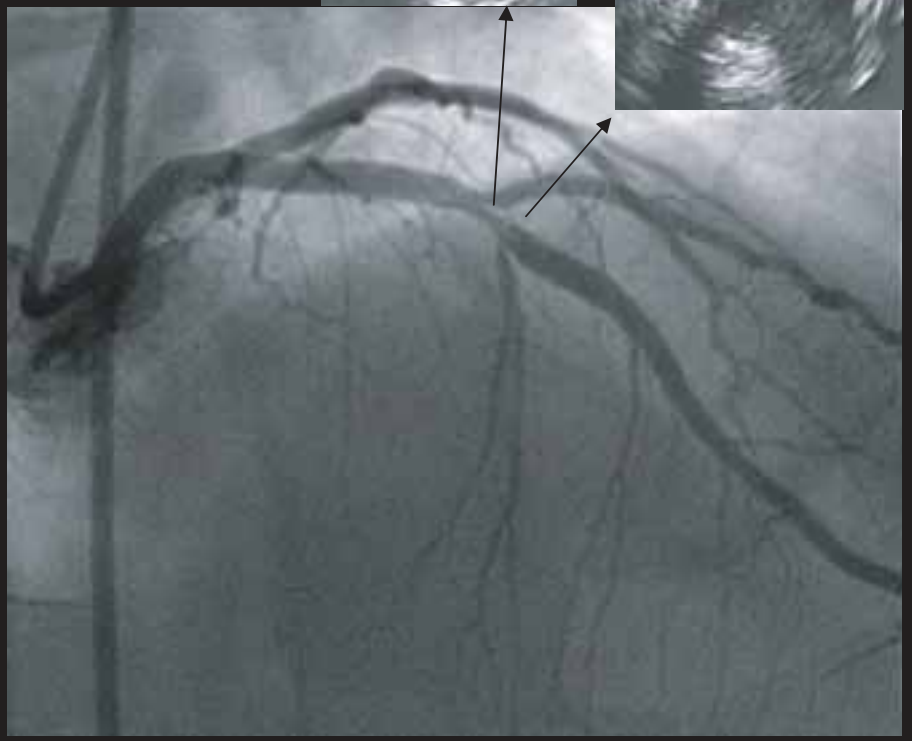
septal



5 o’clock

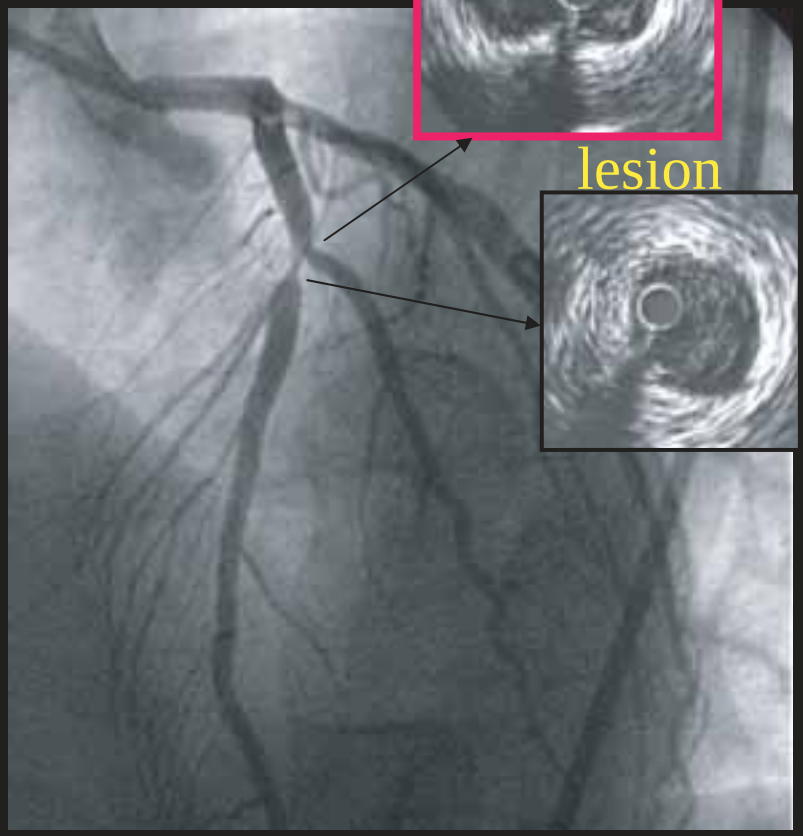
RAO 30 cranial 30





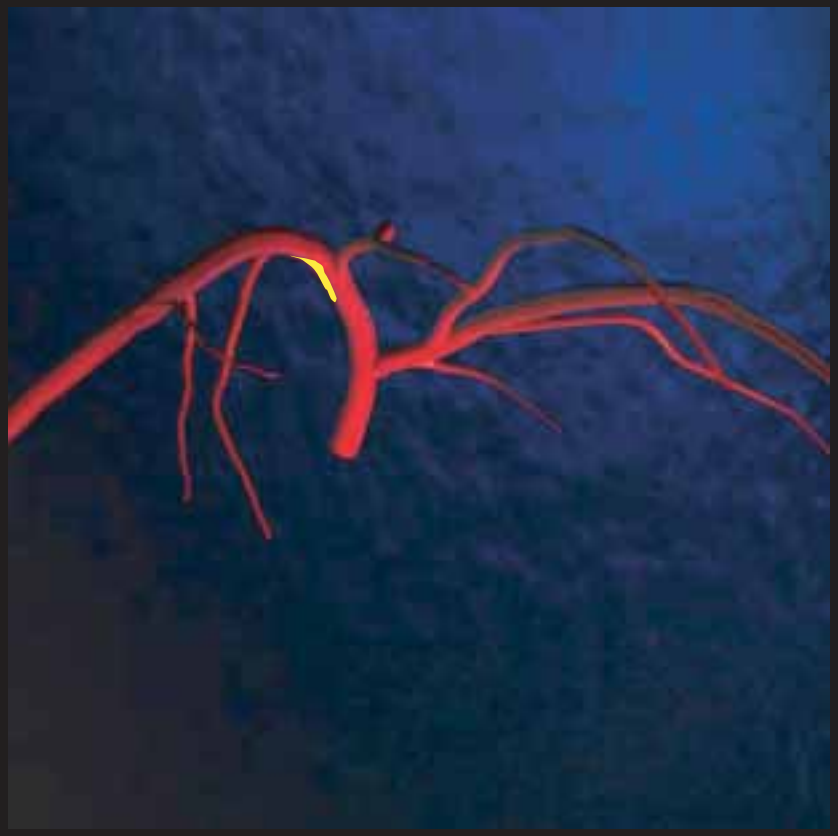
The plaque is on the septal side

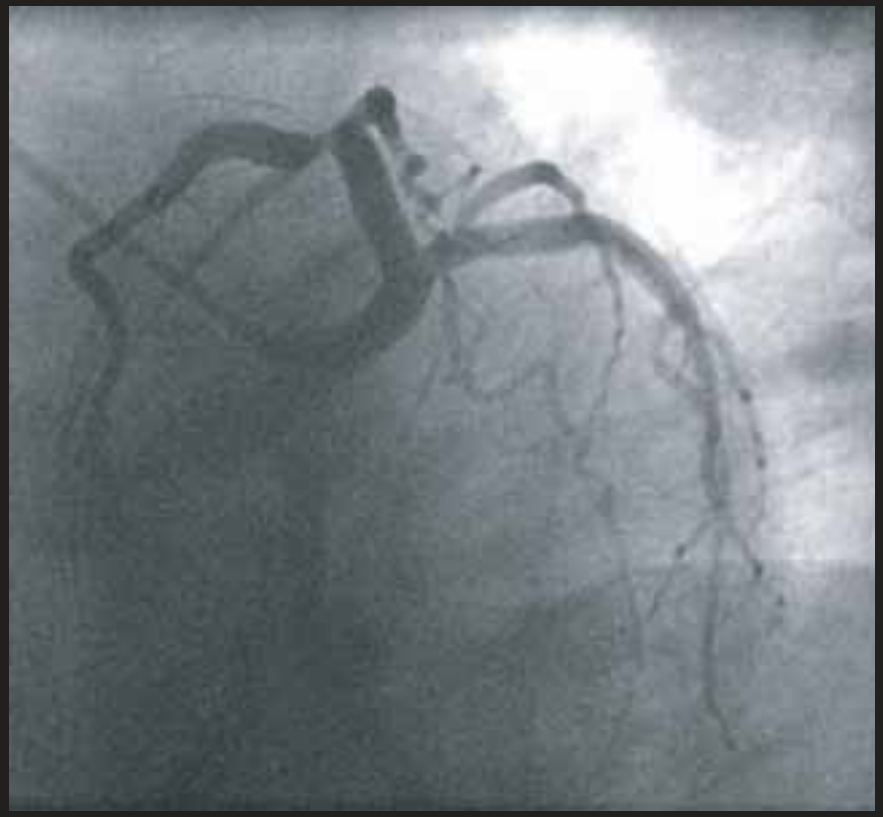
LAO 45 cranial 30



Plaque is opposite the diagonal

LAO 60 caudal 30





Plaque is opposite the diagonal

IVUS-guided DCA

(9) Understanding IVUS guidance in the RCA

Anatomical Theory of Branching in the Right Coronary Artery

LAO 50

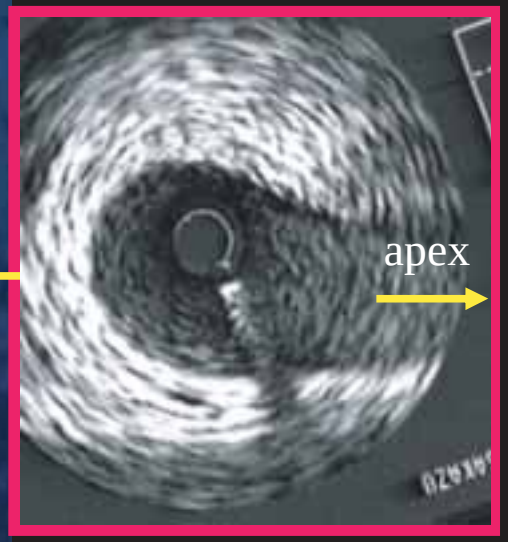
Distal RCA turning round tow ards the ostiu m

According to anatomy, imaging the upside of the artery will necessitate a different direction from coronary angiography

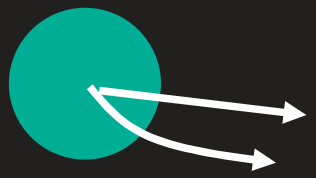
Using Key Branches

The posterior descending (PD) branch usually branches off almost perpendicular to the distal RCA. The PD is coming towards you when you image the RCA using the LAO projection on the angio-monitor.

Key Image of the RCA



Pericardium

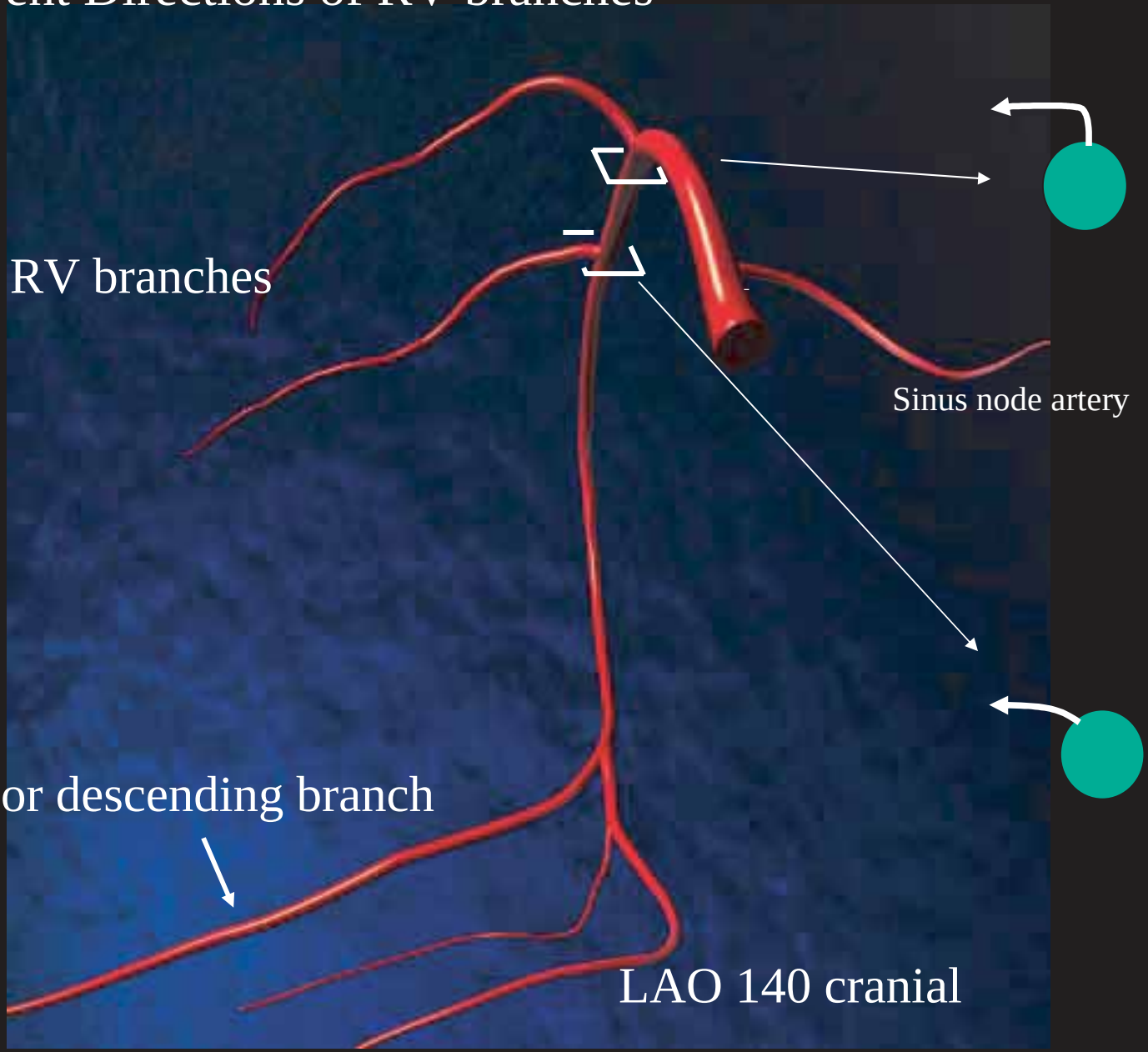


PD branching direction

Rotate the PD to 3 o’clock in your mind and for all IVUS images.

After rotation, the cardiac side is on top, the pericardium on the bottom, right apex on the right, and the atrium on the left

Different Directions of RV branches



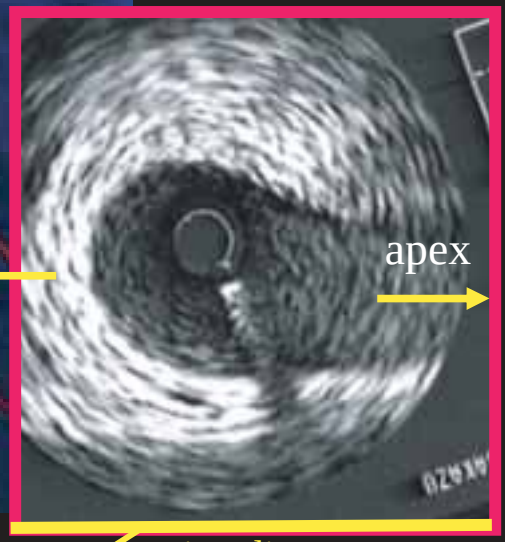
Rotated image with PD branch

set to 3o’clock

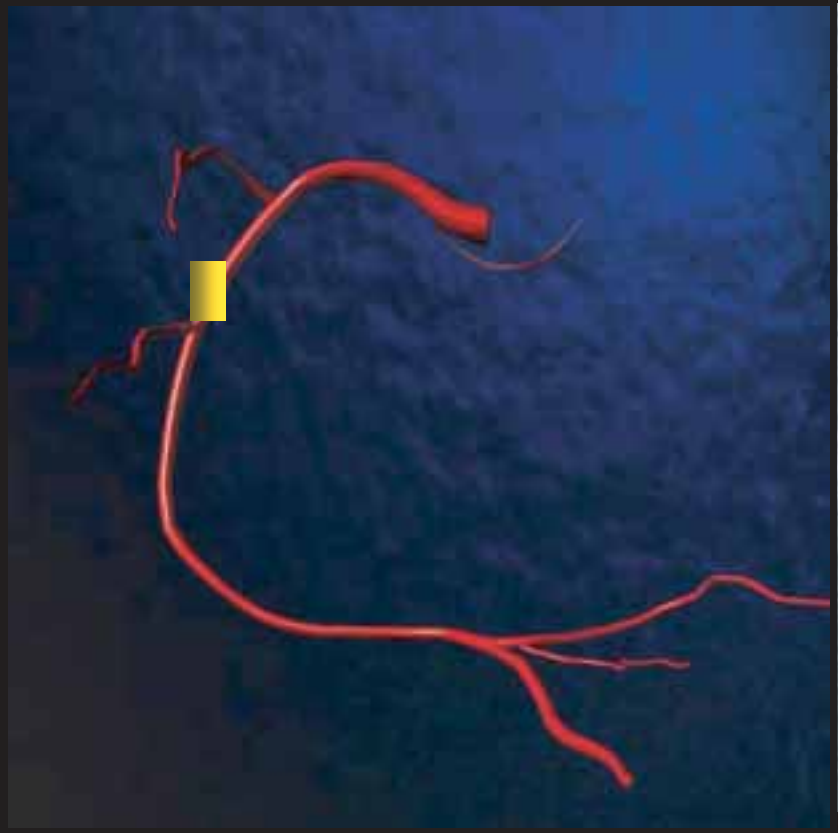
pericardiu m

pericardiu m

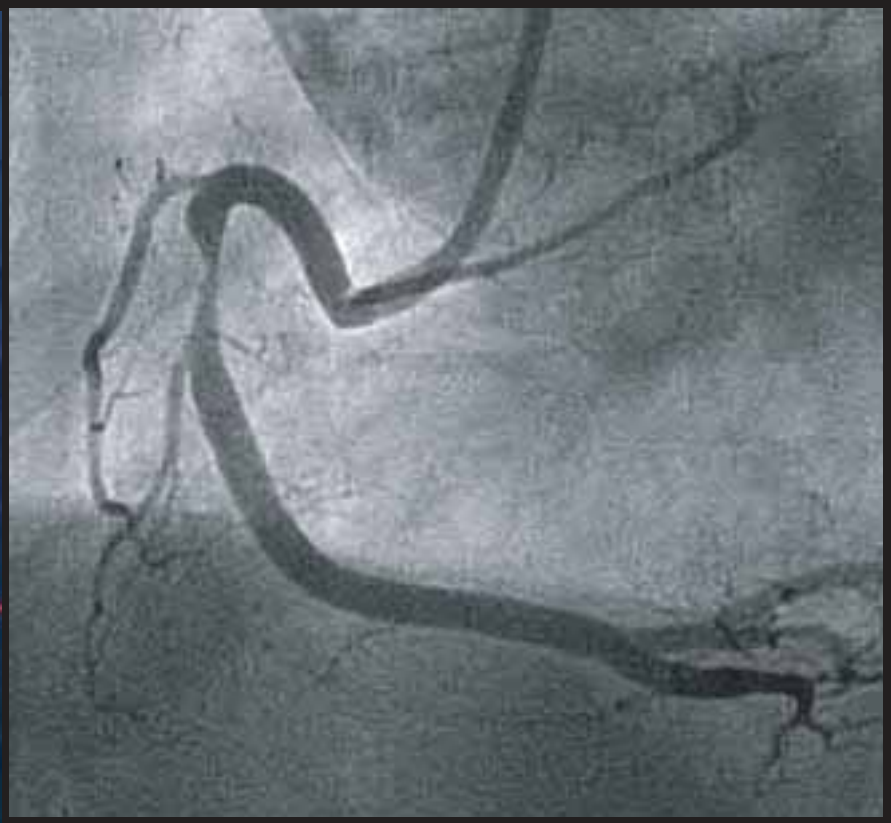
atrium



pericardiu m



Plaque is at the pericardial site

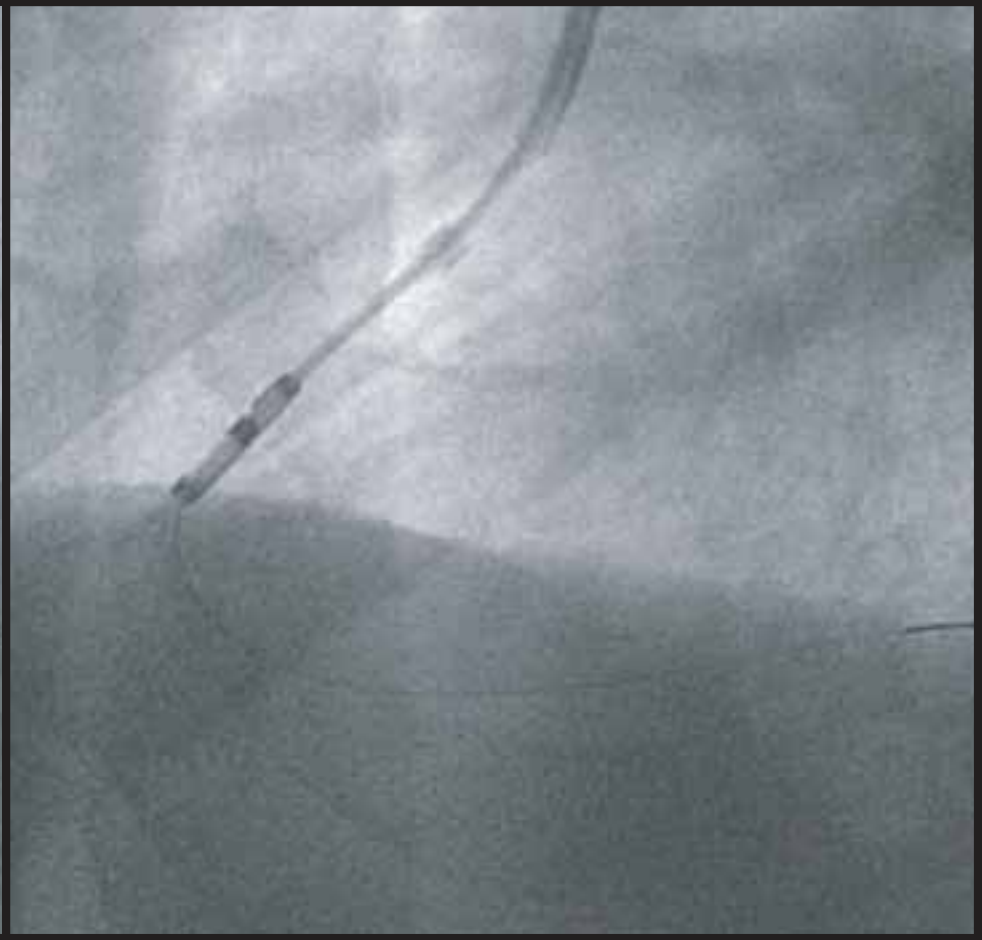


LAO 50

RAO 30

Orient the cutter-window towards the lateral branch. That is your start-position. Rotate 90^{o} clockwise. Also rotate 90^{o} anti-clockwise rotation from start-position.

LAO 50



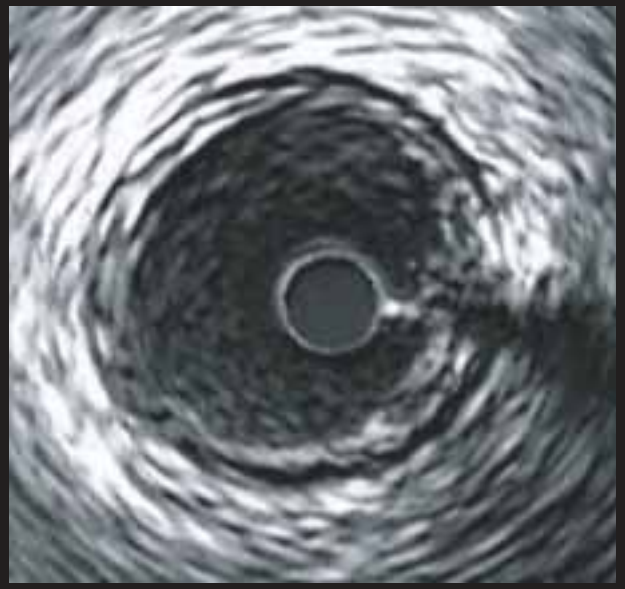
LAO 50

Post-DCA

LAO 50

Pre-

Post-DCA

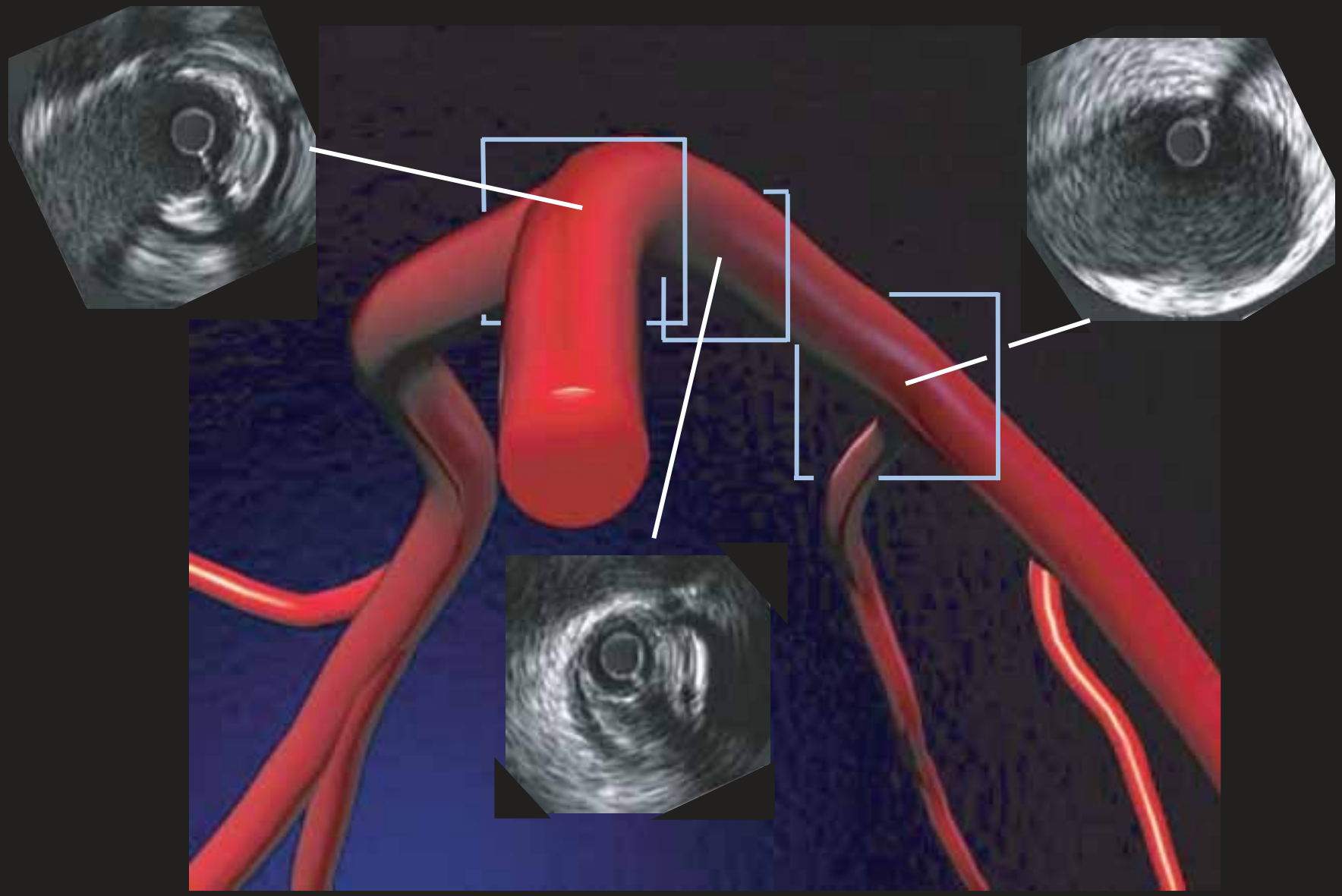


For DCA in the RCA, the support wire can alter artery shape.

Make sure you re-check the lesion using contrast.

(10) DCA in the ostial LAD

Severely-angled CX branches



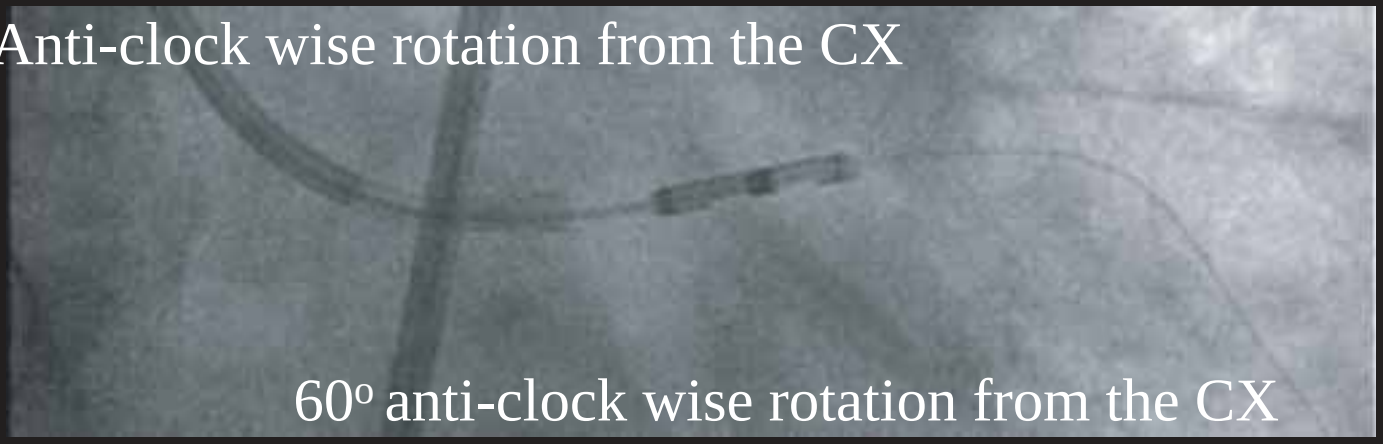
RAO 30 Caudal 25

LAO 60 Caudal 30

Pre DCA

LAO 45 Cranial 30

Anti-clock wise rotation from the CX

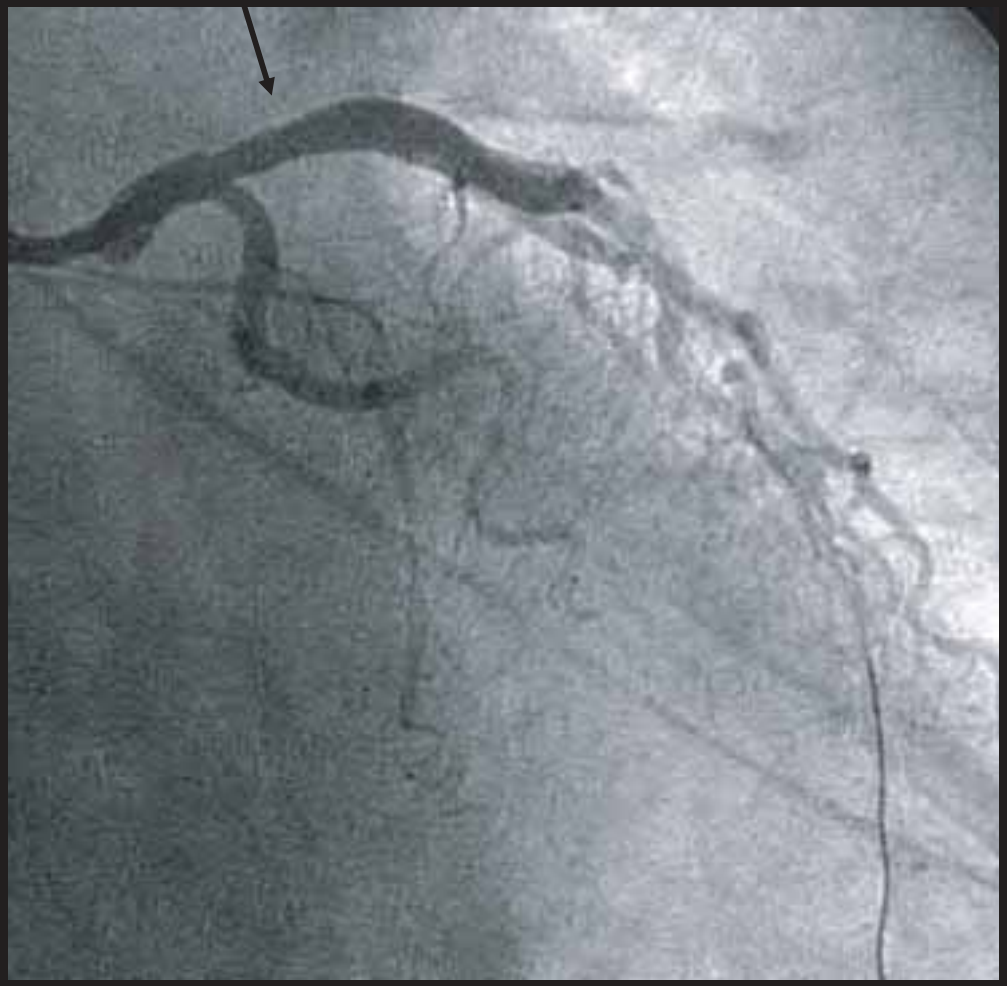


60^{o} anti-clock wise rotation from the CX

120^{o} anti-clock wise rotation from the CX

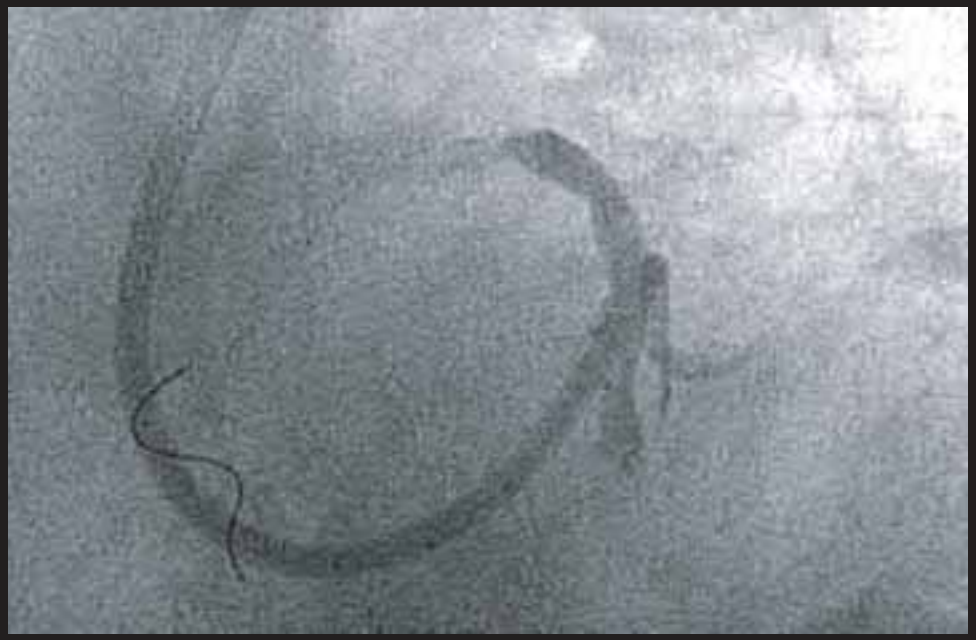
180^{o}counter clock wise rotation from the CX

First DCA

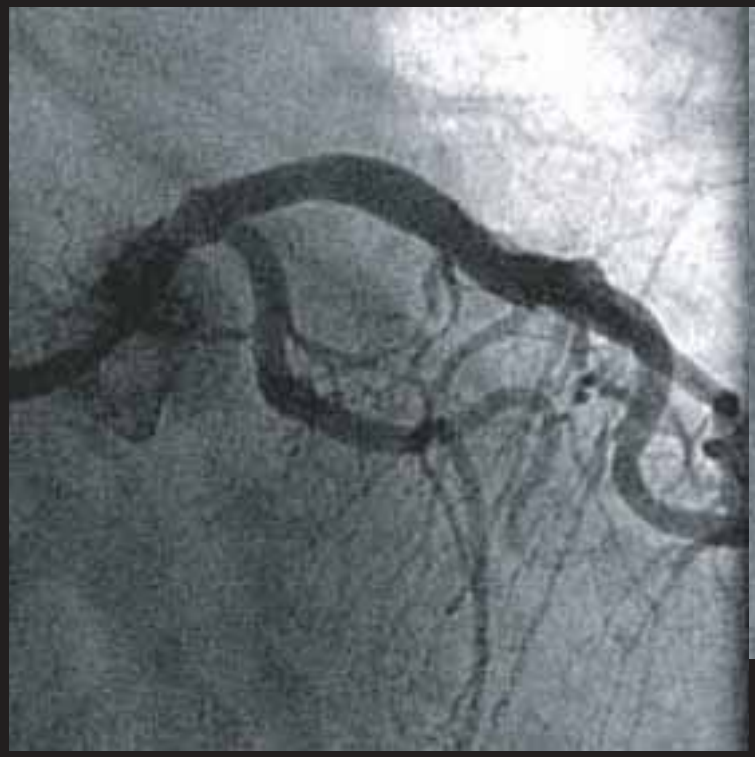


RAO 30 caudal 25

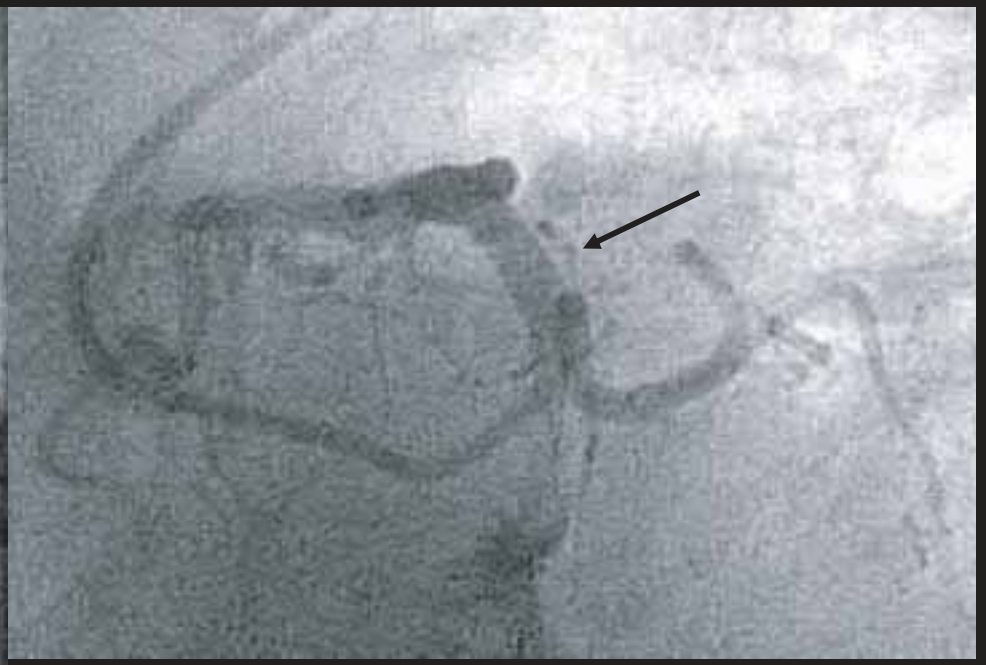
Repeat IVUS and repeat atherectomy



Face the cutter-window towards the circumflex
and rotate anti-clockwise for 180 ^{o}.



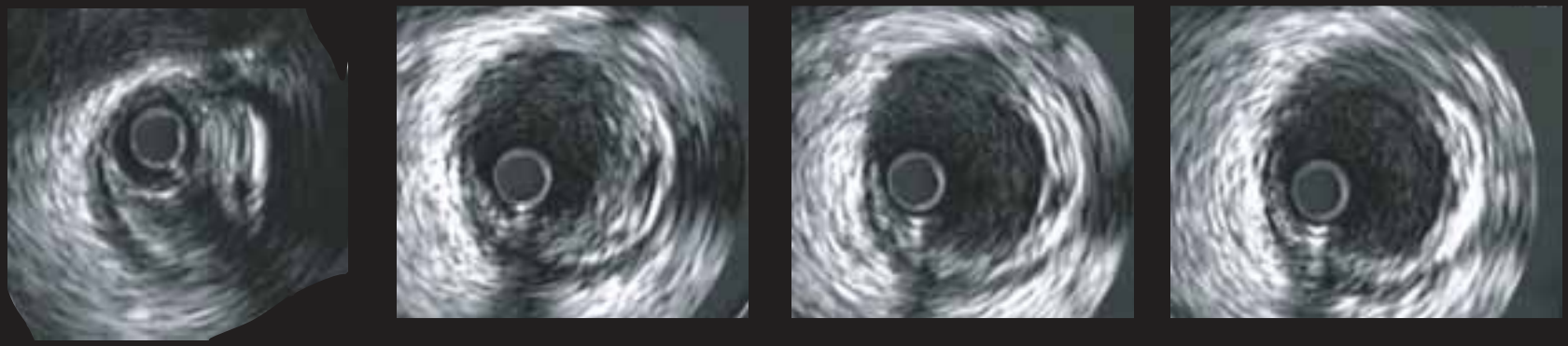
RAO 30caudal 25



LAO 60 caudal 30

IVUS Guidance enhances plaque removal.

ostial LAD plaque



Pre 1st. DCA 2nd DCA Final

LAD and Cx

IVUS will usually be used >3 times during your DCA procedure to check the evolving vessel situation.

IVUS is useful for verifying plaque removal and the direction of any additional atherectomy.

The new Flexi-Cut system removes more plaque than previous devices. One point of caution, however, is that it is harder to feel the plaque being cut, so be on your guard against coronary perforation.

Summary

IVUS is not necessary for all coronary interventions. But there is no question that it helps you understand what is happening during coronary intervention.

It really does take you “beyond angiography”.