Interventional Cardiology
Board Review 2017
Coronary Anatomy, Physiology and Imaging

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Left Coronary Artery

Left Main Coronary Artery

• **Origin**: Upper portion of left aortic sinus just below the sinotubular ridge. Typically 0-10 mm in length. Rarely no LM (separate origins).

• **Catheterization technique**: “The Judkins’ 4-Left coronary catheter will find the LCA orifice unless manipulated by the operator”. Just in case – other Judkins sizes for smaller or larger aortas; Amplatz, XB type curves. Watch for “damping”; For separate ostia-separate catheters, larger for Cx, or counterclockwise rotation for LAD.

• **Optimal Views**: LAO caudal and cranial; AP-caudal, cranial or flat. Limit views. May need IVUS.
Sternocostal Aspect
Left Anterior Descending Artery

- **Course**: Down the anterior interventricular groove – usually reaches apex. In 22% of cases does not reach apex.

- **Branches**: Septals and diagonals – supply lateral wall of LV, anterolateral papillary muscle; 37% have median ramus (courses like 1st diagonal).

- **LAD**: Supplies anterolateral, apex and septum; approx 45 – 55% of left ventricle.
Left Circumflex Artery

- **Origin** – From distal LMCA.

- **Course** – Down distal left AV groove.

- **Lateral** – Obtuse marginal, posterolaterals - supply posterolateral LV, anterolateral papillary muscle.
  
  SA node artery – 38 %.

- **Supplies** – 15 - 25 % of LV, unless dominant (supplies 40 - 50% of LV).
Right Coronary Artery

Basic Anatomy

- **Origin**: Right aortic sinus (lower origin than LCA)

- **Course**: Down right AV groove toward crux of the heart (gives off PDA –85%– from which septals arise, continues in LAV groove giving off posterior LV branches (posterolaterals). PDA may originate more proximally, bifurcate early or be small with part of “its territory” supplied by an acute marginal branch

- **Supplies**: 25-35% of left ventricle
Left Coronary Artery

**Optimal Views**

- **AP (30) Caudal** – LMCA, proximal LAD, Cx, distal LAD. Poor for mid LAD-RAO may be useful.

- **AP (40) Cranial** – LMCA, LAD, diagonals, septals, distal Cx – may need RAO to separate LAD and Cx.

- **(45) LAO (35) Cranial** – LMCA, LAD, diagonals, septals and distal Cx

- **(45) LAO (30) Caudal** – LMCA, Cx and proximal LAD.

- **Laterals (cranial, caudal)** – may be helpful.
## Recommended Angiographic Views for Best Visualization of the Coronary Arteries

### AP/RAO cranial:
- Mid/distal LAD
- Diagonal and septals
- Distal OMs
- LPL segments
- Distal RCA – bifurcation

### RAO/AP caudal:
- Proximal LAD
- Apical LAD
- Proximal LCX
- Proximal segment of OMs
- Short left main
Match the following:

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1.</td>
<td>60° LAO, 25° caudal</td>
</tr>
<tr>
<td>2.</td>
<td>30° RAO, 20° cranial</td>
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<tr>
<td>3.</td>
<td>30° RAO, 25° caudal</td>
</tr>
<tr>
<td>4.</td>
<td>60° LAO, 25° cranial</td>
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With:

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<tr>
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<tbody>
<tr>
<td>A.</td>
<td>Mid &amp; dist LAD and diagonals</td>
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<tr>
<td>B.</td>
<td>Mid &amp; dist RCA, bifurcation</td>
</tr>
<tr>
<td>C.</td>
<td>Prox LM, prox LAD, prox LCX</td>
</tr>
<tr>
<td>D.</td>
<td>LCX and marginal branches</td>
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</tbody>
</table>

1-C  2-A  3-D  4-B
Question: 2

In order to obtain a “spider view” to better visualize the left main, proximal left anterior descending and left circumflex views, the radiographic technician should be directed to position the image intensifier:

A. 15 degrees RAO, 30 degrees cranial
B. 30 degrees RAO, 30 degrees caudal
C. 50 degrees LAO, 35 degrees cranial
D. 50 degrees LAO, 20 degrees caudal
All of the following regarding the angiography of left coronary system when the LMCA is absent are true, except:

A. Generally, LAD has a more anterior origin than LCX
B. When LAD has an anterior take off, it can be engaged with the left Judkins catheter with counter-clockwise rotation
C. A catheter with a larger curve is useful to selectively engage LAD in this setting
D. A catheter with a shorter curve tends to engage selectively in LAD

Question: 3
A 62 yr woman requires coronary intervention to correct a severe stenosis in an anomalous circumflex that arises from the right aortic sinus and courses posterior to the aorta.

Which of the following is the most reasonable initial guiding catheter to select?

A. Left coronary bypass graft catheter  
B. Internal mammary catheter  
C. Multipurpose catheter  
D. Left Voda or Geometric shape  
E. Hockey stick.

**Question:** 4

**Answer:** C
Question: 5

Which of the following statements about PCI of the LAD are true:

A. The LAD normally arises in an anterior and superior position
B. A Judkins Left 4.0 is the guide catheter of choice in the majority of cases
C. If the ostium of the left main is high or the aortic root is small, a JL 4.5 catheter may be preferred
D. Once in the left main, gentle clockwise rotation of the guiding catheter will frequently direct it anteriorly

E. a, b, d
F. a, b
The left circumflex coronary artery supplies the sinoatrial node in what percentage of individuals?

A. 90%
B. 60%
C. 40%
D. 10%
What is a Kugel’s artery?

A. Anomalous origin of the left anterior descending coronary artery (LAD) from the pulmonary artery

B. Coronary arteriovenous fistula

C. Conus artery branch

D. Right-to-right collateral (from proximal to distal RCA through the AV node branch)
Left ventriculography in the 30 degrees right anterior oblique (RAO) projection shows a “button” projecting from the aortic root (see following figure). This suggests the patient has:

A. Occlusion of the proximal right coronary artery (RCA)
B. Ulceration in the proximal ascending aorta
C. Anomalous origin of the left circumflex artery
D. Focal aortic root dissection
Coronary circulation

Figure 1 Systemic and coronary vascular beds that influence FFR. Ao, aortic pressure; Pa, arterial pressure proximal to stenosis; Pd, coronary pressure distal to epicardial stenosis; Pv, venous pressure; Qc, collateral blood flow; Rc, collateral resistance; Rs, epicardial coronary stenosis; FFR, fractional flow reserve; IMR, index of microvascular resistance; CFR, coronary flow reserve.
FFR: Definition Under Maximal Hyperemia

$$FFR = \frac{(P_d - P_v)}{(P_a - P_v)} \sim \frac{P_d}{P_a} \text{ when } P_v = \text{CVP is near 0}$$

- $P_d$ = mean distal coronary pressure; $P_a$ = mean Aortic pressure; $P_v$ = RA = CVP
- May need to factor in RAP ($P_v$) if >10-15 mm Hg

Hau et al. EHJ 2004
Fractional flow reserve:

A. Ratio of distal coronary flow and aortic pressures in the presence of stenosis measured during maximal hyperemia

B. Is a lesion-specific index of stenosis severity measured using pressure wire

C. Reflects myocardial perfusion both antegrade and collateral rather than mere trans-stenotic pressure

D. Is independent of driving pressure – HR and SBP

E. Normal value is 1.0 and < 0.8 is abnormal
Coronary flow reserve:

A. Defined as ratio of hyperemic blood flow to resting blood flow

B. Measured using Doppler wire

C. Normal is >2.5

D. Is dependent on HR, SPB and microvasculature status
   (abnormal in LVH, chronic/acute ischemia, diabetes)
Hemodynamic Values

**FFR:**

- $< 0.75$ - intervention
- $0.75 - 0.9$ - questionable: if after balloon place stent
- $> 0.9$ - no intervention

**CFR:**

- $> 2.0$ and residual $< 30$ %, leave it
- $> 2.5$ is excellent after PTCA
A 60-year old male, six weeks after transmural inferior wall infarction, and having akinesia of the inferior wall segments on the echocardiogram, has a 85 % residual stenosis in the proximal part of the dominant RCA. FFR equals 0.88 and CFR equals 1.2. Most likely:

A. This stenosis is functionally significant and should be dilated.
B. FFR is false negative.
C. CFR is false positive.
D. There is extensive necrosis and little viable tissue and dilating the stenosis does not make much sense.

C
A 64-year old woman presents with stable angina CCS Class II. Coronary angiography shows a 50% ostial RCA lesion and minimal CAD elsewhere. Which is the most appropriate next test to guide revascularization?

A. Intravascular ultrasound (IVUS)
B. Fractional flow reserve (FFR)
C. Coronary flow reserve (CFR)
D. SPECT myocardial perfusion imaging
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A. Intravascular ultrasound (IVUS)

B. Fractional flow reserve (FFR)

C. Coronary flow reserve (CFR)

D. SPECT myocardial perfusion imaging
Which of the following FFR values is least likely to correlate with an ischemia-producing lesion?

A. 0.70  
B. 0.74  
C. 0.80  
D. 0.85
Which of the following FFR values does **NOT** indicate an ischemia-producing lesion?

A. 0.70
B. 0.74  (significant threshold defined by DEFER)
C. 0.80  (significant threshold defined by FAME)
D. 0.85
Intravascular ultrasound (IVUS)

- Oscillatory movement of a piezoelectric transducer in order to produce sound waves when electrically excited.
- Generated sound waves propagate through the different tissues and are reflected according to the acoustic properties of the tissue.

Normal coronary artery
Plaque morphology by IVUS

Soft (echolucent)  
Fibrous  
Calcific plaque

(Limited ability of plaque characterization)
Normal coronary artery wall by OCT

3-layered structure:

- Signal-rich intima
- Low backscattering/signal-poor media
- Heterogeneous and frequently highly backscattering adventitia
Plaque morphology by OCT

Fibrous

Fibroatheroma

Fibrocalcific
OCT imaging of the bioresorbable scaffolds and metallic platform stents
Optical Coherence Tomography (OCT) uses near-infrared light reflectance to produce high-resolution *in vivo* images of vessel anatomy, tissue microstructure and stents.

<table>
<thead>
<tr>
<th></th>
<th>OCT</th>
<th>IVUS</th>
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<tbody>
<tr>
<td>Axial Resolution</td>
<td>10 – 15 µm</td>
<td>100 – 200 µm</td>
</tr>
<tr>
<td>Frame Rate</td>
<td>180 frames/s</td>
<td>30 frames/s</td>
</tr>
<tr>
<td>Pullback Speed</td>
<td>36 or 16 mm/s</td>
<td>0.5 - 1 mm/s</td>
</tr>
<tr>
<td>Max. Scan Diameter</td>
<td>10 mm</td>
<td>15 mm</td>
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<tr>
<td>Tissue Penetration</td>
<td>1.5 - 3.0 mm</td>
<td>10 mm</td>
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<tr>
<td>Blood Clearing</td>
<td>Required</td>
<td>Not Required</td>
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## OCT vs. IVUS

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<thead>
<tr>
<th>Strength</th>
<th>OCT</th>
<th>IVUS</th>
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<tbody>
<tr>
<td></td>
<td>Good resolution</td>
<td>Good tissue penetration</td>
</tr>
<tr>
<td></td>
<td>High speed pullback</td>
<td>No need for blood clearing</td>
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<table>
<thead>
<tr>
<th>Weakness</th>
<th>OCT</th>
<th>IVUS</th>
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<tr>
<td></td>
<td>Poor penetration</td>
<td>Poor resolution</td>
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<tr>
<td></td>
<td>Need for blood clearing</td>
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<table>
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<th>Measurement</th>
<th>OCT</th>
<th>IVUS</th>
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<tbody>
<tr>
<td></td>
<td>Fibrous cap thickness</td>
<td>Plaque burden</td>
</tr>
<tr>
<td></td>
<td>Plaque composition</td>
<td>Atheroma volume</td>
</tr>
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<td>Vessel remodeling</td>
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## Recommendation

### PRE-INTERVENTION ASSESSMENT

<table>
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<tr>
<th>Question</th>
<th>Preferred Technique</th>
<th>Alternative Technique</th>
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<tbody>
<tr>
<td>Is this non-left main coronary artery (LMCA) stenosis significant?</td>
<td>Fractional flow reserve (FFR)</td>
<td>Intravascular ultrasound (IVUS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>May be used to exclude a stenosis, but should not be used to justify percutaneous coronary intervention (PCI)</td>
</tr>
<tr>
<td>Is this LMCA stenosis significant?</td>
<td>Intravascular ultrasound (IVUS)</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Fractional flow reserve (FFR)</td>
<td></td>
</tr>
<tr>
<td>Where is the culprit lesion?</td>
<td>Optical coherence tomography (OCT)</td>
<td>n/a</td>
</tr>
<tr>
<td>Is this a vulnerable plaque?</td>
<td>Virtual histology intravascular ultrasound (VH-IVUS)</td>
<td>n/a</td>
</tr>
<tr>
<td>What is the likelihood of distal embolization or periprocedural myocardial infarction (MI) during stent implantation?</td>
<td>Intravascular ultrasound (IVUS)</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Virtual histology intravascular ultrasound (VH-IVUS)</td>
<td></td>
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<tr>
<td></td>
<td>Optical coherence tomography (OCT)</td>
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<td></td>
<td>Near-infrared spectroscopy (NIRS)</td>
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### PCI GUIDANCE

<table>
<thead>
<tr>
<th>Question</th>
<th>Preferred Technique</th>
<th>Alternative Technique</th>
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</thead>
<tbody>
<tr>
<td>How do I optimize acute stent results?</td>
<td>Intravascular ultrasound (IVUS)</td>
<td>Optical coherence tomography (OCT)</td>
</tr>
<tr>
<td>Is this jailed sidebranch significant?</td>
<td>Fractional flow reserve (FFR)</td>
<td>n/a</td>
</tr>
<tr>
<td>FOLLOW UP</td>
<td></td>
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<tr>
<td>Why did this stent thrombose or restenose?</td>
<td>Optical coherence tomography (OCT)</td>
<td>Intravascular ultrasound (IVUS)</td>
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(Reference)
Question: 12

Which of the following statements is NOT recommended in the use of IVUS?

A. To assess angiographically indeterminant left main CAD
B. To determine the mechanism of stent restenosis
C. To identify stent underexpansion
D. To detect a large red thrombus
Which of the following statements is **NOT** recommended in the use of IVUS?

A. To assess angiographically indeterminant left main CAD
B. To determine the mechanism of stent restenosis
C. To identify stent underexpansion
D. To detect a large red thrombus
2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention

5.4.2. IVUS: Recommendations

CLASS IIa
1. IVUS is reasonable for the assessment of angiographically indeterminate left main CAD (489–491). (Level of Evidence: B)
2. IVUS and coronary angiography are reasonable 4 to 6 weeks and 1 year after cardiac transplantation to exclude donor CAD, detect rapidly progressive cardiac allograft vasculopathy, and provide prognostic information (492–494). (Level of Evidence: B)
3. IVUS is reasonable to determine the mechanism of stent restenosis (495). (Level of Evidence: C)

CLASS IIb
1. IVUS may be reasonable for the assessment of non–left main coronary arteries with angiographically intermediate coronary stenoses (50% to 70% diameter stenosis) (489,496,497). (Level of Evidence: B)
2. IVUS may be considered for guidance of coronary stent implantation, particularly in cases of left main coronary artery stenting (490,495,498). (Level of Evidence: B)
3. IVUS may be reasonable to determine the mechanism of stent thrombosis (495). (Level of Evidence: C)
Which of the following combinations about intravascular imaging resolution is appropriate?

A. OCT-1 μm/ IVUS-10 μm
B. OCT-10 μm/ IVUS-100 μm
C. OCT-100 μm/ IVUS-1000 μm
Question: 13

Which of the following combinations about intravascular imaging resolution is appropriate?

A. OCT-1 µm/ IVUS-10 µm
B. OCT-10 µm/ IVUS-100 µm
C. OCT-100 µm/ IVUS-1000 µm
Match plaque morphology of the following OCT and IVUS images.

**Question: 14**

A  
B  
C  

a  
b  
c  

A  
B  
C  

a  
b  
c
<table>
<thead>
<tr>
<th>OCT</th>
<th>IVUS</th>
<th>Question: 14</th>
</tr>
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<tbody>
<tr>
<td><strong>Fibroatheroma</strong></td>
<td><strong>Fibrocalcific plaque</strong></td>
<td><strong>Fibrous plaque</strong></td>
</tr>
<tr>
<td><img src="image1.png" alt="A" /></td>
<td><img src="image2.png" alt="B" /></td>
<td><img src="image3.png" alt="C" /></td>
</tr>
<tr>
<td><img src="image4.png" alt="b" /></td>
<td><img src="image5.png" alt="a" /></td>
<td><img src="image6.png" alt="c" /></td>
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Question: 15

Which of the following parameters is NOT measured to report the extent of the coronary atherosclerosis using IVUS?

A. Total atheroma volume
B. Percent atheroma volume
C. Lumen cross-sectional area
D. Minimum cap thickness
Which of the following parameters is NOT measured to report the extent of the coronary atherosclerosis using IVUS?

A. Total atheroma volume
B. Percent atheroma volume
C. Lumen cross-sectional area
D. Minimum cap thickness
Thank you!!!