• Understand normal coronary anatomy

• Understand different imaging views/projections
  ▪ Understand how to optimize imaging (i.e., how do I see a lesion in the LAD better?)

• Interpret coronary angiograms: normal, normal variants, mild/moderate and severely diseased vessels, vessel occlusions AND bypass and LIMA angiography

• Be able to estimate percent stenosis as mild, moderate and severe and complete occlusion

• Understand the concepts of TIMI flow, myocardial blush and collaterals

• Interpret ventriculograms: normal and abnormal; assessment of wall motion, chamber size, systolic function [EF], mitral regurgitation, aneurysms, ventricular septal defects
It will take 1 year of Fellowship to feel comfortable with interpreting coronary angiograms

- Remember, in the setting of severe CAD (CTOs, post bypass, etc.) interpreting a coronary angiogram is more difficult
- Approximately 100 coronary angiograms need to be reviewed to be comfortable with angiographic projections and the assessment of disease severity

- Take every opportunity to review coronary angiograms – during all rotations, cardiac catheterization conference, angiographic review sessions and when seeing patients in the Cardiology Clinic
The First Coronary Angiogram

Figure 1. Cine frame from the first selective coronary arteriogram taken by F. Mason Sones, MD, on October 30, 1958.
Right Coronary Artery

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% to 35% of Left Ventricle
- Conus Artery – Anterior course
  usually very proximal; (~50% have a separate origin)-courses anteriorly and upward over the RV outflow tract toward the LAD. May be an important source of collaterals.

- SA Nodal Artery – Posterior course
  (~60%) usually 2nd branch of RCA-courses obliquely backward through upper portion of atrial septum and anteromedial wall of the RA-supplies SA node, usually RA and sometimes LA.

- Right Ventricular (Acute Marginal) Branches
  Arise from mid RCA; supply anterior RV; may be a collateral source.

- AV Nodal Artery
  Arises at or near crux; supplies AV node.

- Posterior Descending Artery (PDA)
  Supplies inferior wall, ventricular septum, posteromedial papillary muscle.
Right Coronary Artery: Engagement

- Judkins’ 4-right; clockwise rotation-works 90% of the time. Adjust catheter size to aorta.

- Other catheter—Amplatz (AL or AR), Williams, pigtail if unable to cannulate or using the JR4 coiled in the RCC
Left Coronary Artery System

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 of LAD and LCx).

- **Catheterization Technique**
  “The Judkins’ 4-Left coronary catheter will find the LCA orifice unless thwarted by the operator”. Just in case—other Judkins sizes for smaller or larger aortas. If a JL4 coils upon itself → JL4.5. Amplatz, XB or various guide catheters. If a JL4 is too long (can not form) → JL3.5.

- **Watch for “dampening”**.

- **For separate ostia—separate catheters, larger for Cx (JL4.5) and smaller for LAD (JL 3.5).**

- **Optimal Views**
  LAO caudal and cranial; AP-caudal, cranial or flat. Limit views. May need IVUS
Course
down the anterior interventricular groove-usually reaches apex. In 22% of cases does not reach apex (short LAD).

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; ~45%-55% of left ventricle.
Left Circumflex Artery or LCx

- **Origin**
  from distal LMCA.

- **Course**
  down distal left AV groove.

- **Branches**
  obtuse marginal and posterolaterals-supply posterolateral LV, anterolateral papillary muscle. SA node artery ~ 38%.

- **Supplies**
  15%-25% of LV, unless dominant (supplies 40-50% of LV).
The Definition of Coronary Dominance

- **Definition 1:** the coronary artery which reaches the crux of the heart and then gives off the PDA
- **Definition 2:** (Allows for codominance) the artery which gives off the PDA as well as a large posterolateral branch
Manifold vs Medrad/Automatic Injection System

- Manifold
  - Traditional method
  - 3 ports: pressure, flush and contrast
  - Requires meticulous attention to air bubbles

- Medrad or Automatic Injection System (Acist)
  - Ensure normal pressure
  - Ensure appropriate settings
  - Control the amount of testing and injection volume
  - Benefits debated – minimize contrast, single operator, easier
Coronary Angiography: Using the Manifold

- Catheter flushed with saline. Ensure good quality pressure waveform. If not – what is wrong?
  - Proximal lesion, non-coaxial catheter, air in line, etc

- Manifold held at 30-40 degrees and ready for injection (filled with contrast)

- When artery is engaged
  - evaluate pressure: is it normal?
  - small ‘test’ of contrast

- Image Intensifier (I/I) moves to 1st view

- Repeat fluroscopy to allow image to be ‘set up’

- Cineangiography

- Fill manifold with contrast and repeat for 2nd view
Engaging the Coronary Artery

▪ Flush the system

▪ Assess pressure – look at the pressure waveform
  ▪ Normal pressure waveform
  ▪ Abnormal pressure waveform
    ▪ Why is it abnormal?
    ▪ Normal pressure → move catheter

▪ Engage coronary artery
  ▪ Is pressure normal?
  ▪ Do NOT Inject Contrast until you confirm the pressure is normal
An example of what you should NOT do
Cranial and Caudal Angulation
RAO and LAO Angulation

R^{60^\circ}_{AO}  60^\circ  L^{40^\circ}_{AO}  40^\circ
Left Coronary System

- Standard Views – 4 (4 corners)
  1. LAO 40/Cranial 20  LAD, Dx
  2. LAO 40/Caudal 20  prox LAD, prox LCx, distal LM
  3. RAO 20/Caudal 20  LM, prox/mid/disal LCx
  4. RAO 10/Cranial 40  prox/mid LAD

- Supplemental Views
  - AP/Cranial 30-40  LAD
  - AP/Caudal  LM, LCx
Right Coronary System

- **Standard Views - 2**
  - 1. LAO 40/Cranial 20 prox, mid RCA
  - 2. RAO 30/Cranial 20 prox, mid RCA

- **Supplemental Views**
  - AP/Cranial 30-40 distal RCA
  - LAO 50/Cranial 30 distal RCA
RAO with caudal angulation
LAO with cranial angulation

1. Left main coronary artery
2. Middle part of the LAD
3. Proximal circumflex artery
4. Obtuse marginal artery
5. First diagonal artery
6. Septal perforating artery
Steep LAO (> 60 degrees)
Lateral or True Lateral (90 degrees)

Very good LIMA to LAD insertion view
Arms up
LAO with Cranial (40/20 degrees)

Makes a ‘C’
In most patients, Cranial angulation is needed to see bifurcation to PDA. PDA runs on ‘floor’ or bottom of heart – look for septals (diagram 5, 11)
LAO/Cranial
RAO/Cranial

Note: LCx is high – out of way of LAD
LAO/Caudal or Spider View

- LAD
- LM
- LCx
- OM
LCX – high in cranial views
LCx – low in caudal views
LCX – high in cranial views
LCx – low in caudal views
LAO/Cranial

RCA

PDA

Posterolateral (PLVEB)
LAO/Cranial

RCA

PDA

Posterolateral (PLVEB)
RAO without Cranial

RCA

RVM

? PDA

? Posterolateral (PLVEB)
What is this View?
What is this View?

RAO Caudal
What is this View?
What is this View?

LAO Cranial
What is this View? What is this vessel?
What is the View? What is the vessel?

LAO Caudal

Famous Ramos
## ACC/AHA LESION CLASSIFICATION

<table>
<thead>
<tr>
<th>TYPE A</th>
<th>TYPE B</th>
<th>TYPE C</th>
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<tbody>
<tr>
<td>Discrete</td>
<td>Tubular</td>
<td>Diffuse</td>
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<tr>
<td>Concentric</td>
<td>Eccentric</td>
<td>Excessive tortuosity</td>
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<td>Readily Accessible</td>
<td>Moderate tortuosity</td>
<td>Extremely angulated</td>
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<tr>
<td>Smooth Contour</td>
<td>Moderately angulated (45-90)</td>
<td>Total occlusion (&gt; 3 mos)</td>
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<tr>
<td>Little or no calcification</td>
<td>Irregular contour</td>
<td>Inability to protect major side branch</td>
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<tr>
<td>Non-ostial</td>
<td>Moderate-heavy calcification</td>
<td>Degenerated SVG</td>
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<tr>
<td>No major side branch</td>
<td>Total occlusion (&lt; 3 mos)</td>
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<td>involved</td>
<td>Ostial</td>
<td></td>
</tr>
<tr>
<td>Absence of thrombus</td>
<td>Bifurcation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thrombus present</td>
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ULCERATED PLAQUE
THROMBUS

CIRCULAR FILLING DEFECT
THROMBUS VS AIR
EMBOLIZATION: AIR VS THROMBUS
MYOCARDIAL BRIDGING

Intramyocardial Segment

- Almost always LAD
- Systolic compression of the vessel, diastolic relaxation of the vessel
- Occurs in 5-12% of patients
- Usually NOT hemodynamically significant
- Usually NOT the cause of chest pain

CORONARY ARTERY FISTULA

- Origin ~ 50% from the RCA.
- Clinical Syndromes: CHF, endocarditis, ischemia, and rupture of aneurysmal fistula. 50% are asymptomatic.
- Drainage: RV-41%; RA-26%; PA-17%; LV-3%, and SVC-1%.
- Be able to recognize the presence of a fistula on a coronary angiogram
LAD to PA Fistula
LAD to PA Fistula

How could you evaluate an LAD to PA Fistula in terms of hemodynamic significance?
Anomalous Coronary Arteries

- Normal
  - Aorta
  - L Circ.
  - LAD
  - R Cor
  - P.A.

- LM from RCC
  - Aorta
  - L Circ.
  - LAD
  - R Cor
  - P.A.

- RCA from LCC
  - Aorta
  - L Circ.
  - LAD
  - R Cor
  - P.A.
Benign Anomalous Coronary Arteries (0.5 to 1 %)

- Left Circumflex from right Sinus of Valsalva
  - Most common “benign” anomaly
  - Circumflex courses behind aorta

- High Anterior Origin of RCA
  - Above sinotubular ridge
ANOMALOUS ORIGIN OF LCX FROM RCC (PROXIMAL RCA)
Collaterals

A. RAO-RC Injection (28)
B. RAO-LC Injection (27)
C. LAO-LC Injection (17)
D. RAO-RC Injection (15)
E. LAO-LC Injection (6)
F. RAO-RC Injection (3)
G. RAO-RC Injection (3)
Coronary Artery Aneurysms

- **Coronary Aneurysm**: Vessel diameter > 1.5x neighboring segment
- **Incidence**: 0.15%-4.9%; very rare in LMCA
- **Etiology**: mainly atherosclerosis; other causes include Kawasaki’s, PCI, inflammatory disease, trauma, connective tissue disease
- **Treatments**: include observation, surgery, occlusive coiling, covered stents
TIMI flow grade

- **TIMI 0 flow**: absence of any antegrade flow beyond a coronary occlusion

- **TIMI 1 flow**: (penetration without perfusion) faint antegrade coronary flow beyond the occlusion, with *incomplete* filling of the distal coronary bed

- **TIMI 2 flow**: (partial reperfusion) delayed or sluggish antegrade flow with *complete* filling of the distal territory

- **TIMI 3 flow**: (complete perfusion) is normal flow which fills the distal coronary bed *completely*
Myocardial Perfusion Grade

◆ Grade 0: Either minimal or no ground glass appearance (“blush”) of the myocardium in the distribution of the culprit artery

◆ Grade 1: Dye slowly enters but fails to exit the microvasculature. Ground glass appearance (“blush”) of the myocardium in the distribution of the culprit lesion that fails to clear from the microvasculature, and dye staining is present on the next injection (approximately 30 seconds between injections)

◆ Grade 2: Delayed entry and exit of dye from the microvasculature. There is the ground glass appearance (“blush”) of the myocardium that is strongly persistent at the end of the washout phase (i.e. dye is strongly persistent after 3 cardiac cycles of the washout phase and either does not or only minimally diminishes in intensity during washout).

◆ Grade 3: Normal entry and exit of dye from the microvasculature. There is the ground glass appearance (“blush”) of the myocardium that clears normally, and is either gone or only mildly/moderately persistent at the end of the washout phase (i.e. dye is gone or is mildly/moderately persistent after 3 cardiac cycles of the washout phase and noticeably diminishes in intensity during the washout phase), similar to that in an uninvolved artery.
Thank You

27” striped bass
Wood’s Hole MA