# Basic Coronary Angiography

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# Basic Coronary Angiography: Take Home Points
## *Cardiovascular Medicine Boards and Clinical Practice*

- Understand normal coronary anatomy
- Understand different imaging views/projections
  - Understand how to optimize imaging (ie 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

# Basic Coronary Angiography: Take Home Points
## *Cardiovascular Medicine Boards and Clinical Practice*

- 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

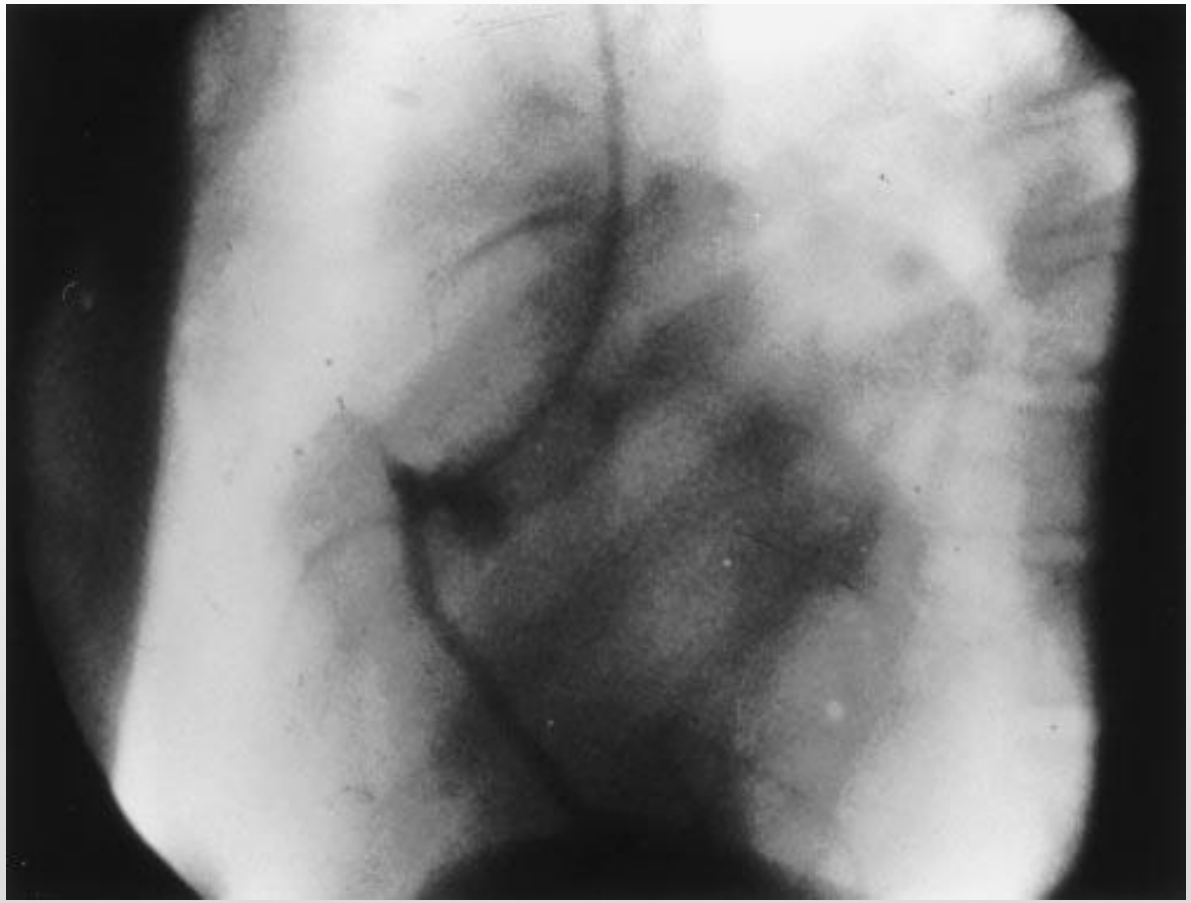


**Figure 1. Cine frame from the first selective coronary arteriogram** taken by F. Mason Sones, MD, on October 30, 1958.

# 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

# Right Coronary Artery: other branches

- 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

# Left Anterior Descending Artery or LAD

- 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

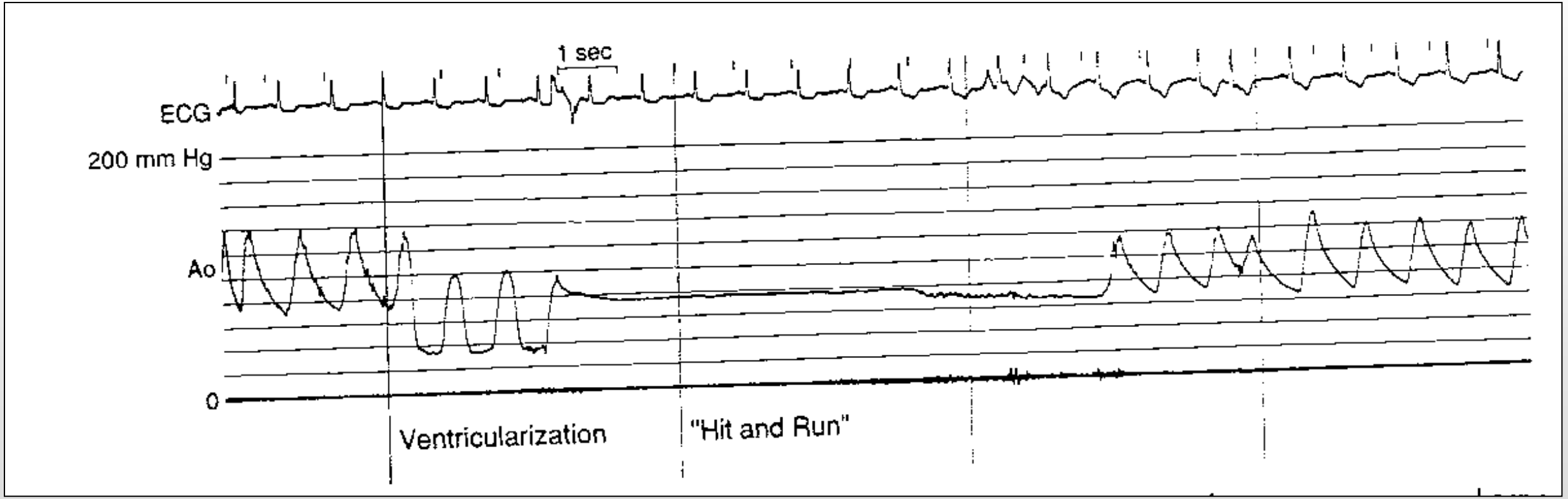
# Coronary Angiography: Using the Manifold

- 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

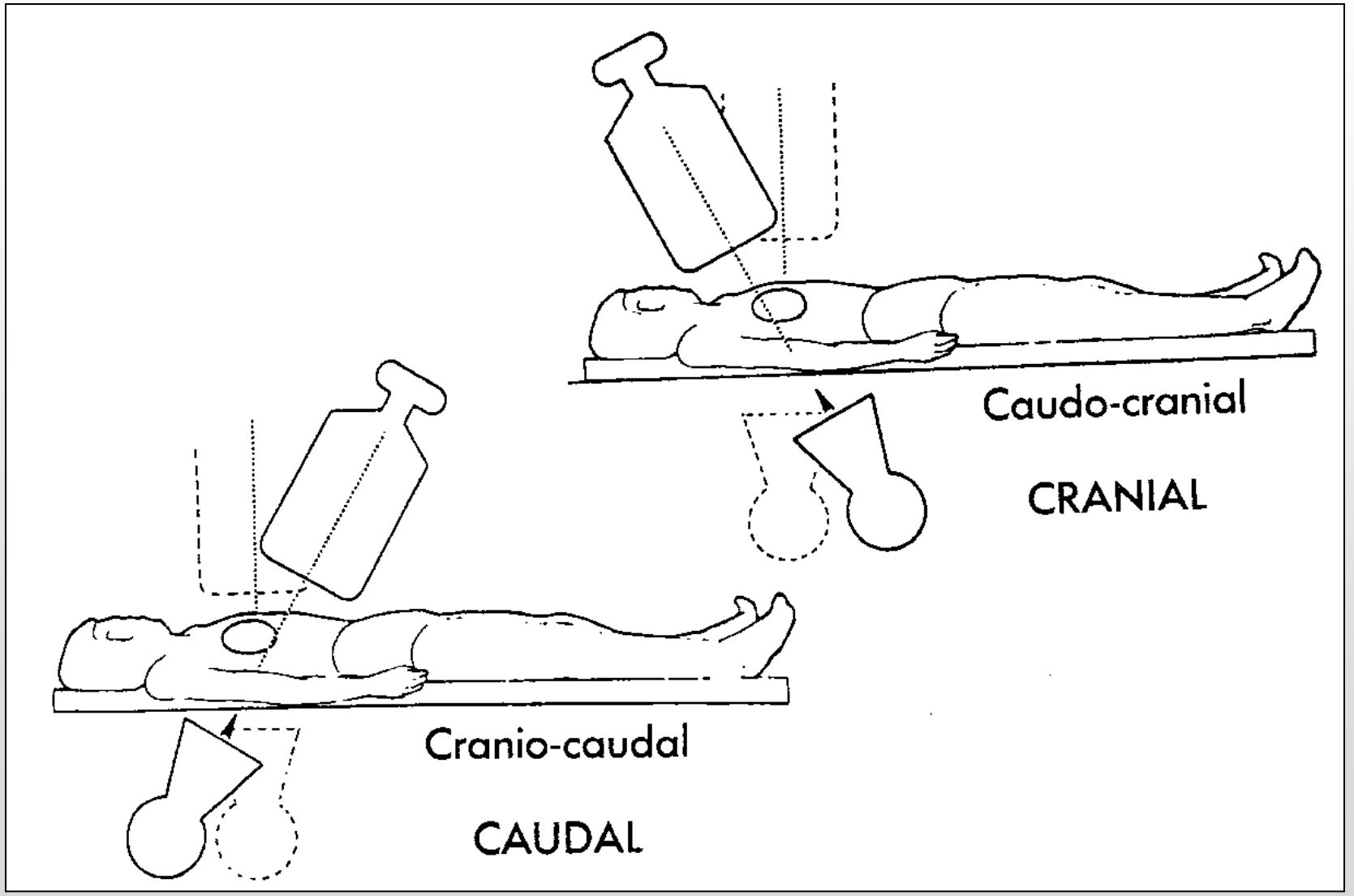
# Engaging the Coronary Artery

- 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

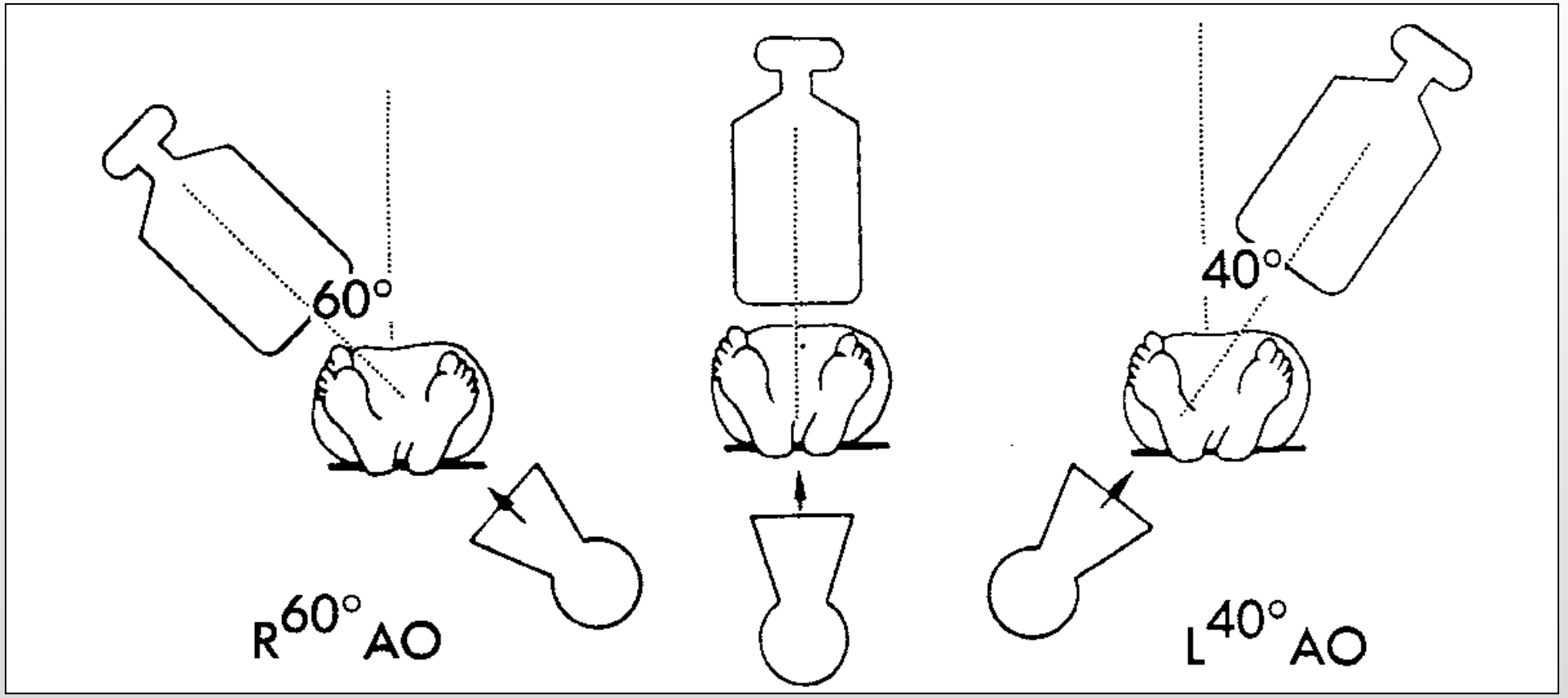
# An example of what you should NOT do



# Cranial and Caudal Angulation



# RAO and LAO Angulation



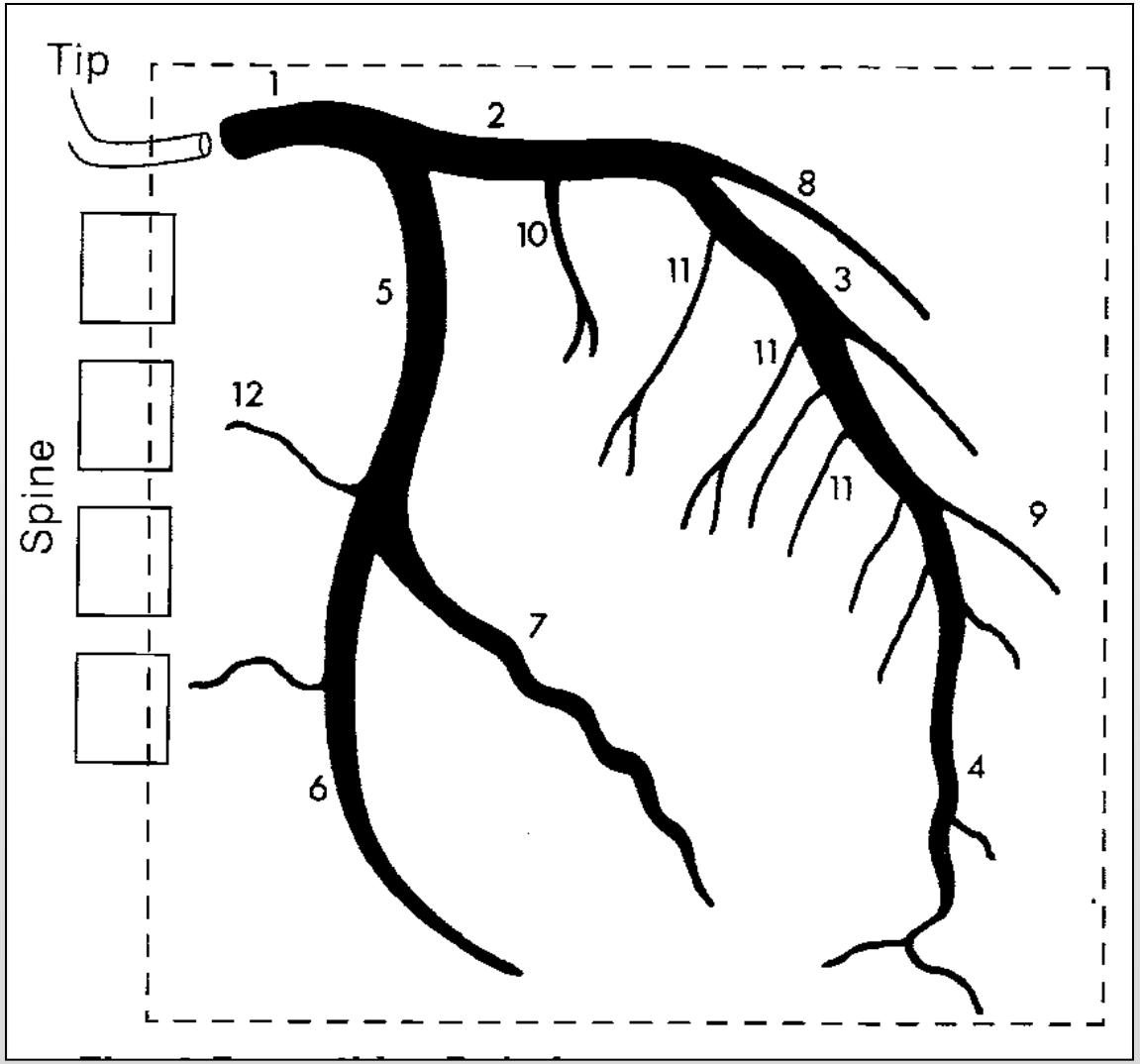
# Left Coronary System

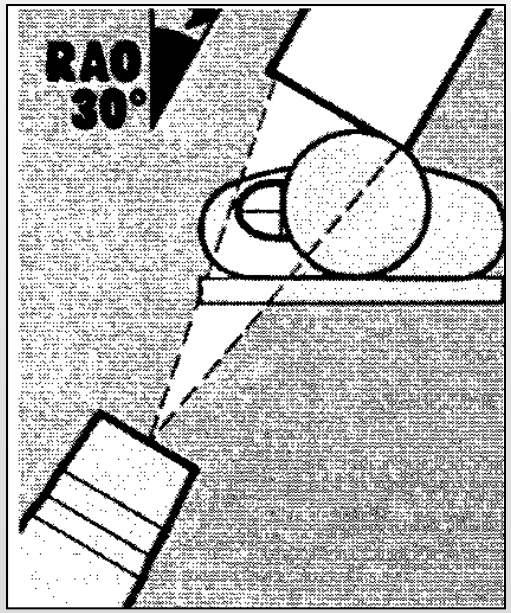
- Standard Views – 4 (4 corners)
  - 1. LAO 40/Cranial 20 — LAD, Dx
  - 2. LAO 40/Caudal 20 — prox LAD, prox LCx, distal LM
  - 3. RAO 20/Caudal 20 — LM, prox/mid/disal LCx
  - 4. RAO 10/Cranial 40 — prox/mid LAD
- Supplemental Views
  - AP/Cranial 30-40 — LAD
  - AP/Caudal — LM, LCx

# Right Coronary System

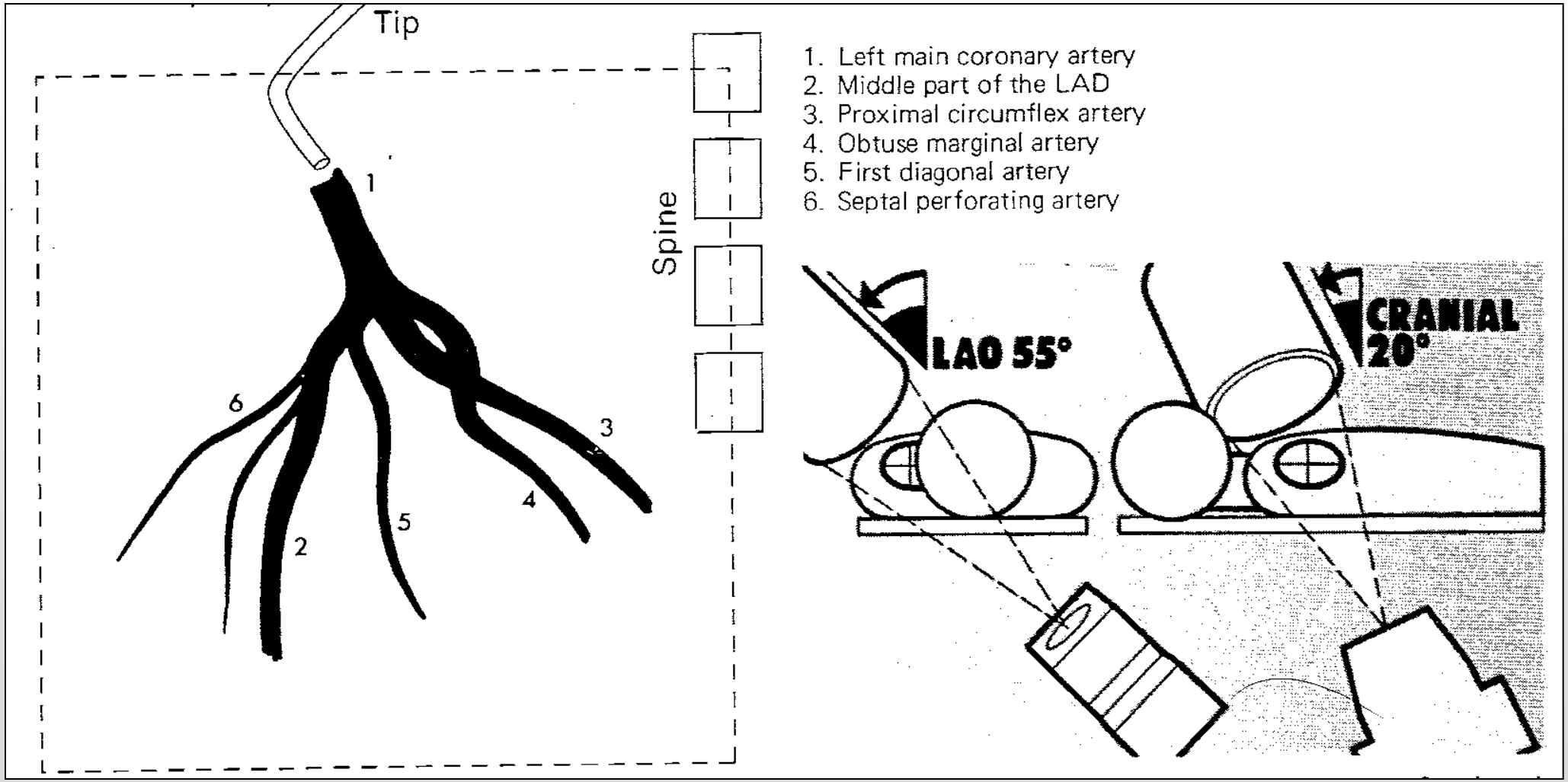
- Standard Views - 2
  - 1. LAO 40/Cranial 20 — prox, mid RCA
  - 2. RAO 30/Cranial 20 — prox, mid RCA
- Supplemental Views
  - AP/Cranial 30-40 — distal RCA
  - LAO 50/Cranial 30 — distal RCA

# RAO with caudal angulation

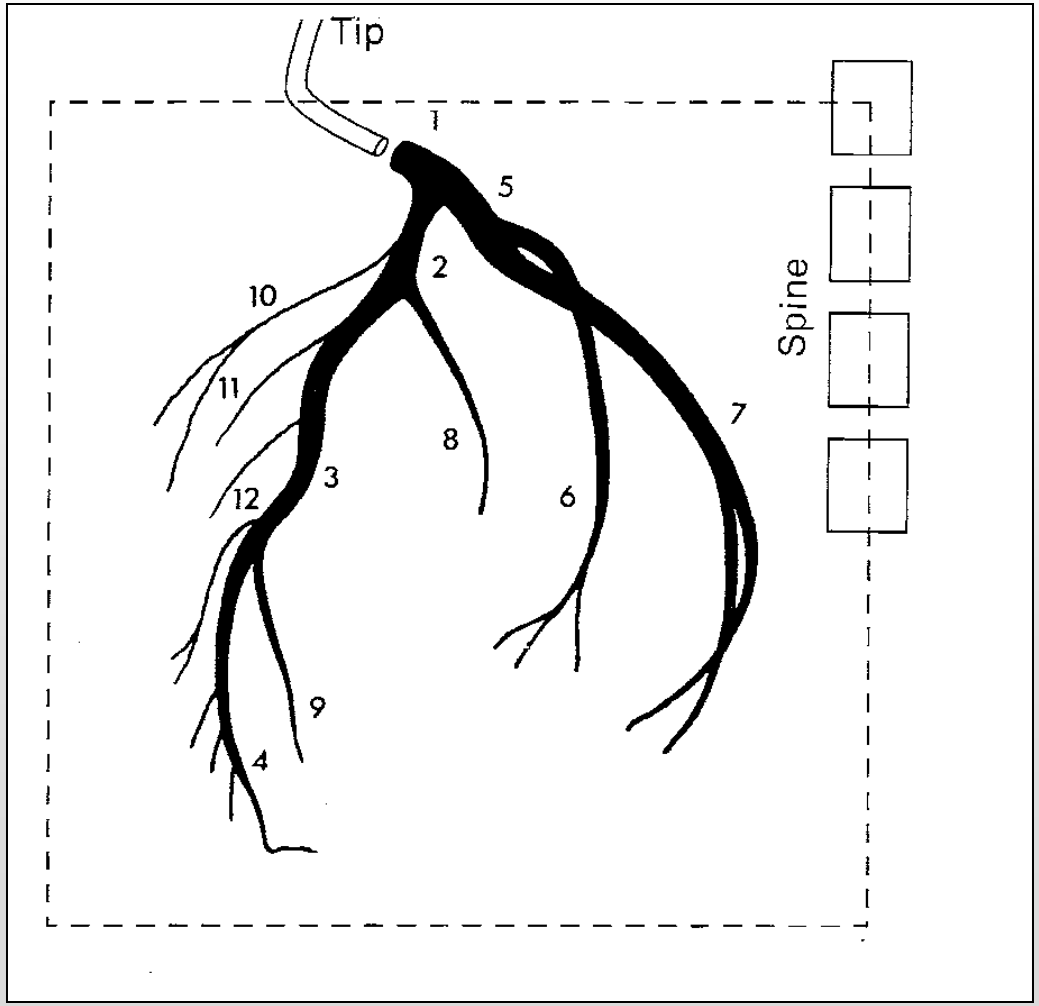


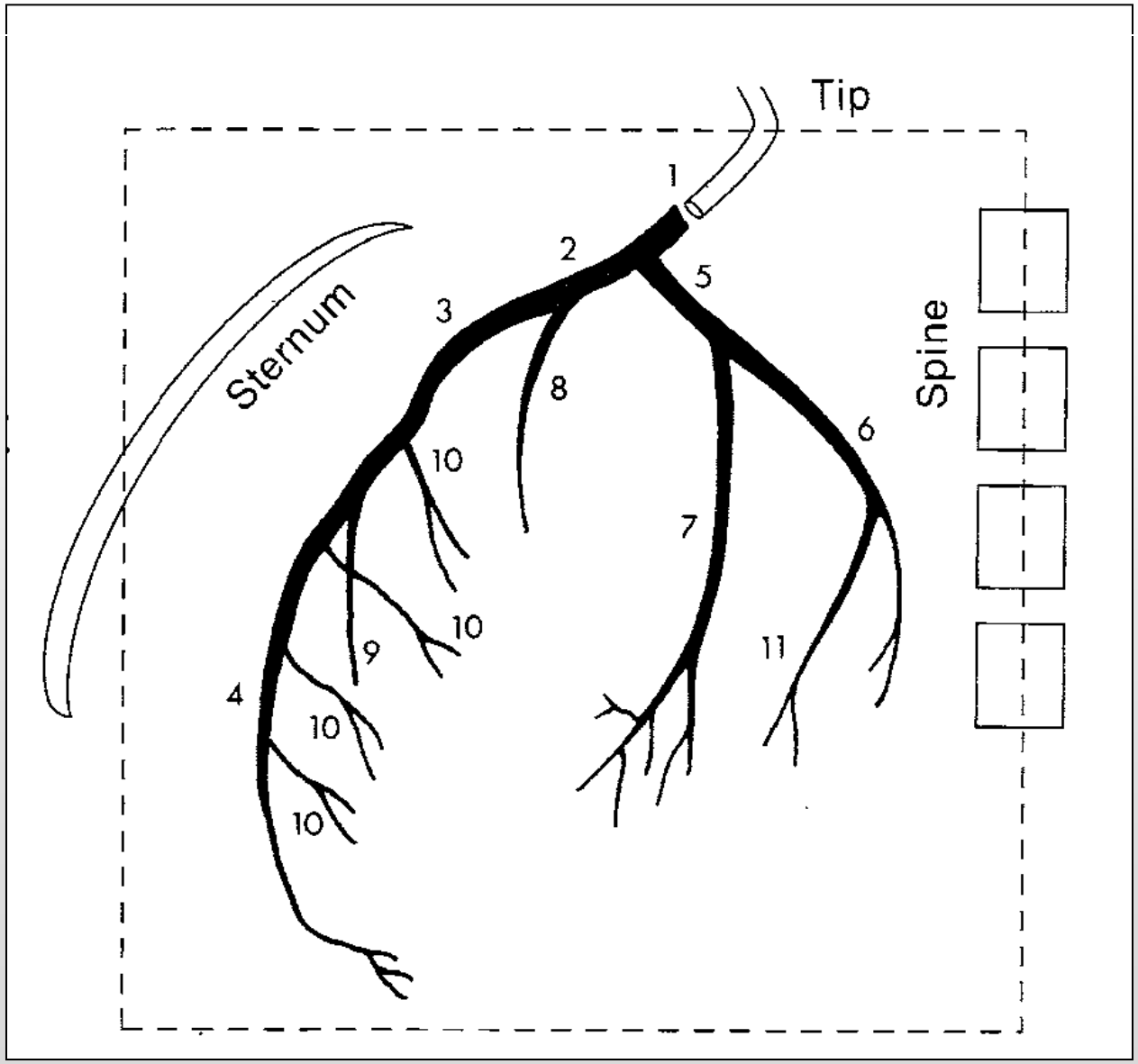
# LAO with cranial angulation



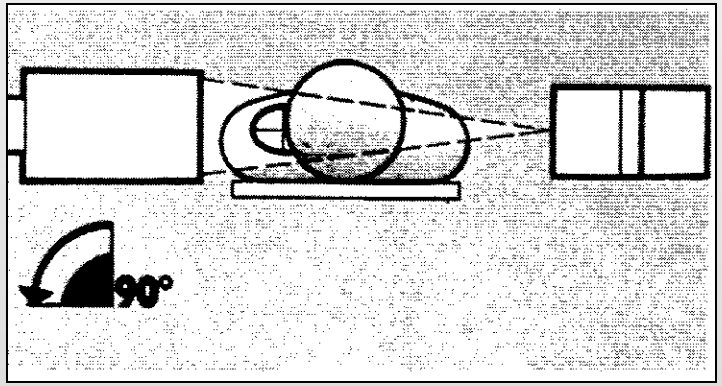
# Steep LAO (> 60 degrees)



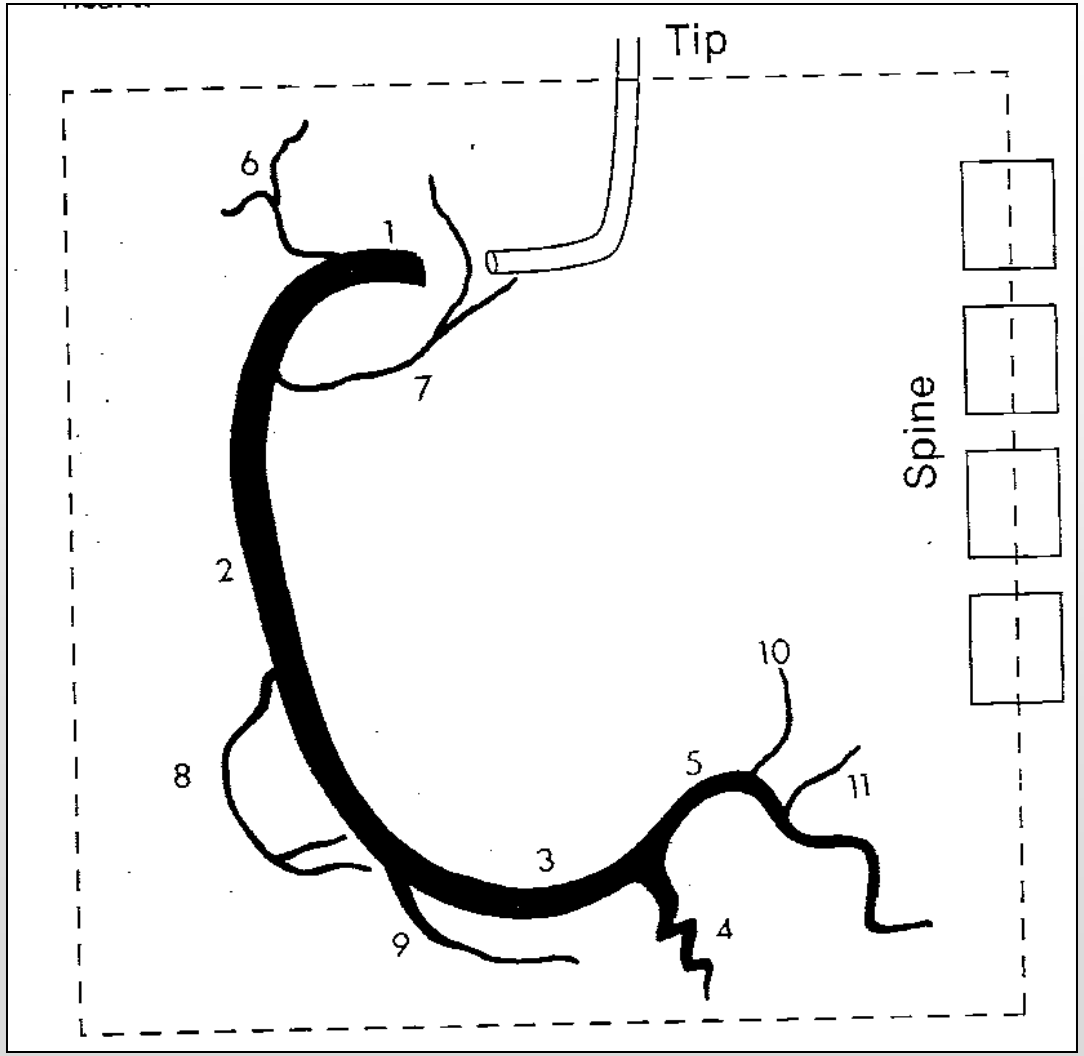
# Lateral or True Lateral (90 degrees)




Very good LIMA to LAD insertion view
Arms up

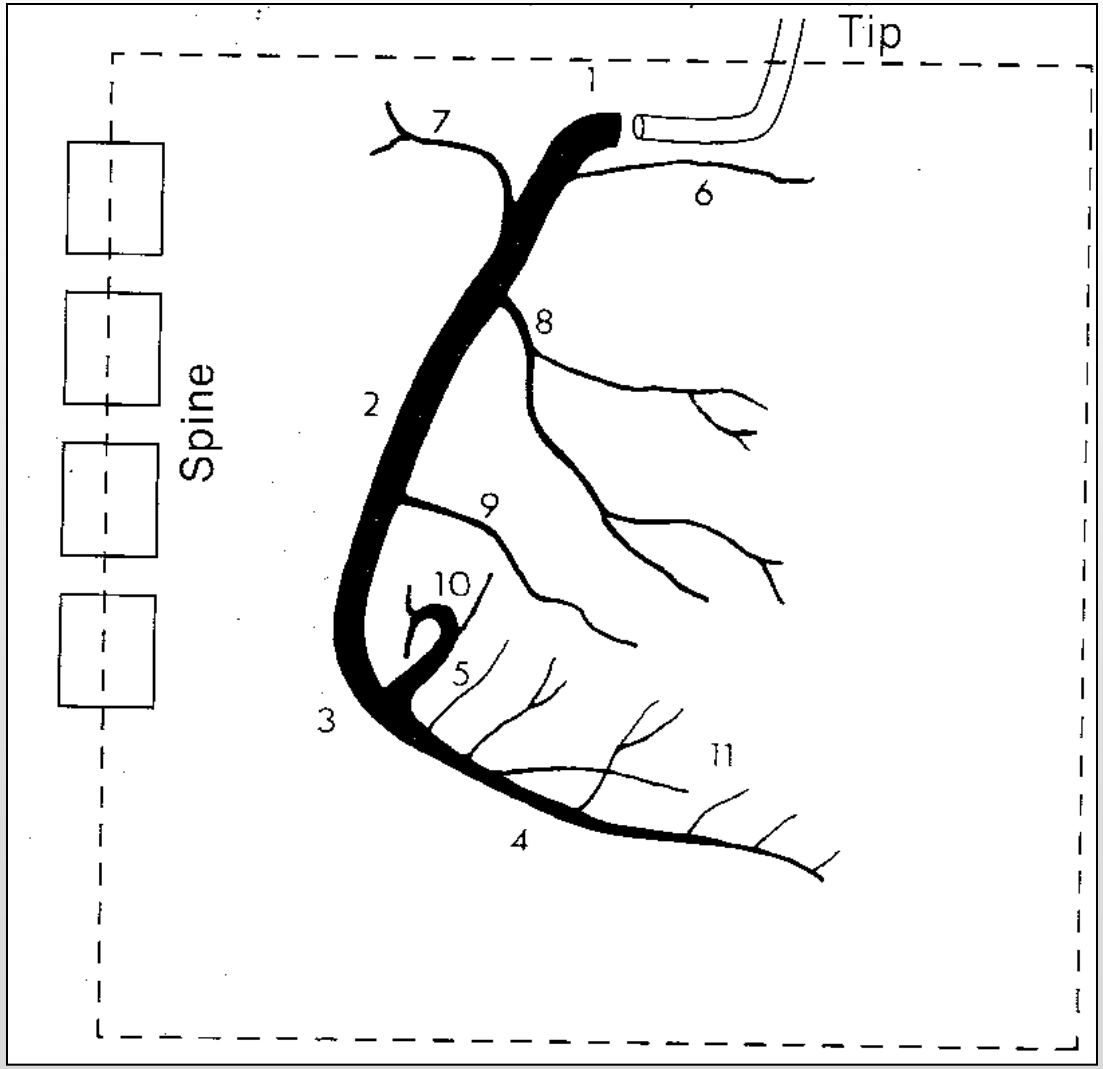


# LAO with Cranial (40/20 degrees)



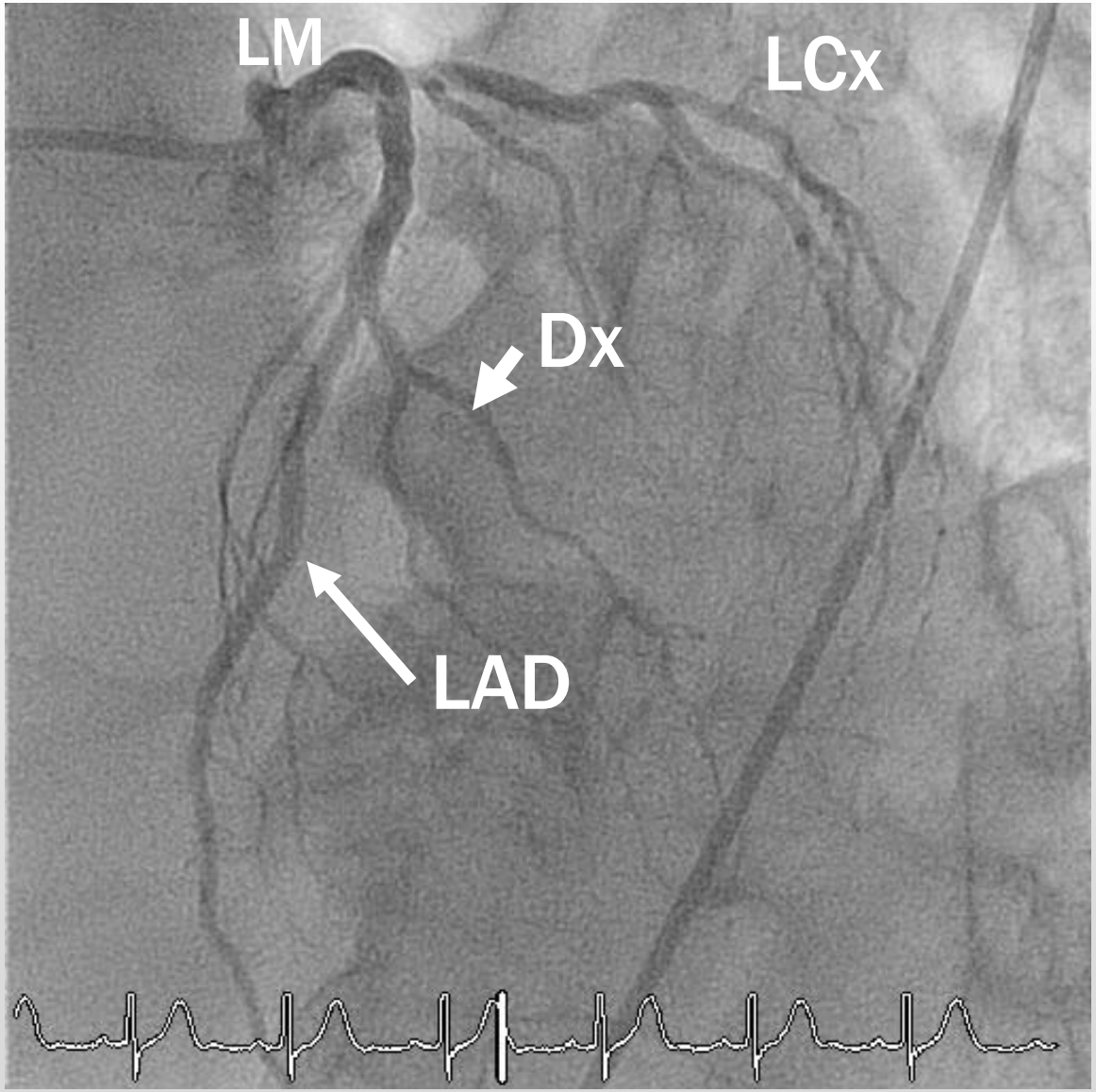

Makes a ‘C’

# RAO (30 degrees)

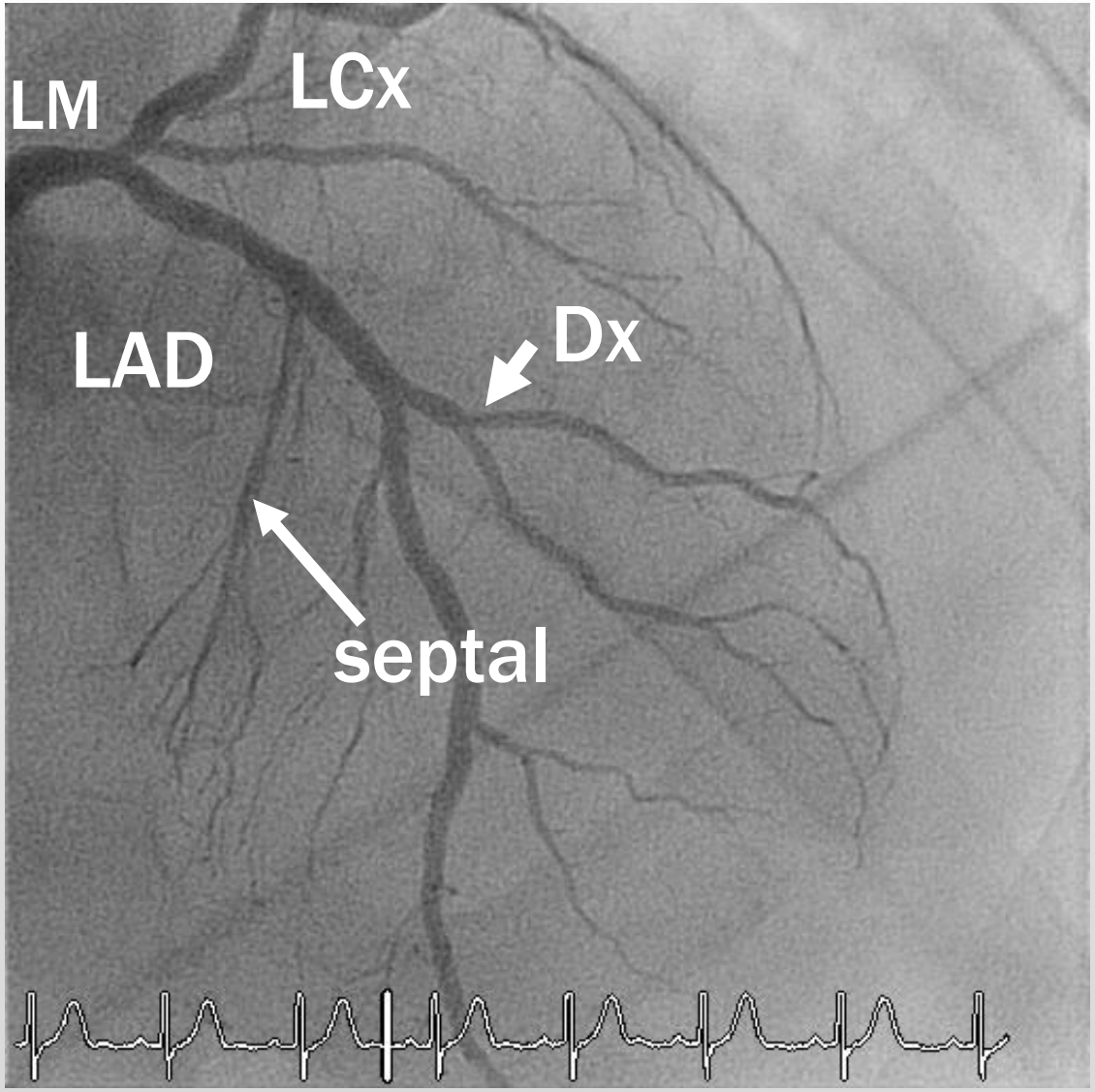



In most patients, Cranial angulation is needed to see bifurcation to PDA PDA runs on ‘floor’ or bottom of heart – look for septals (diagram 5, 11)

# LAO/Cranial

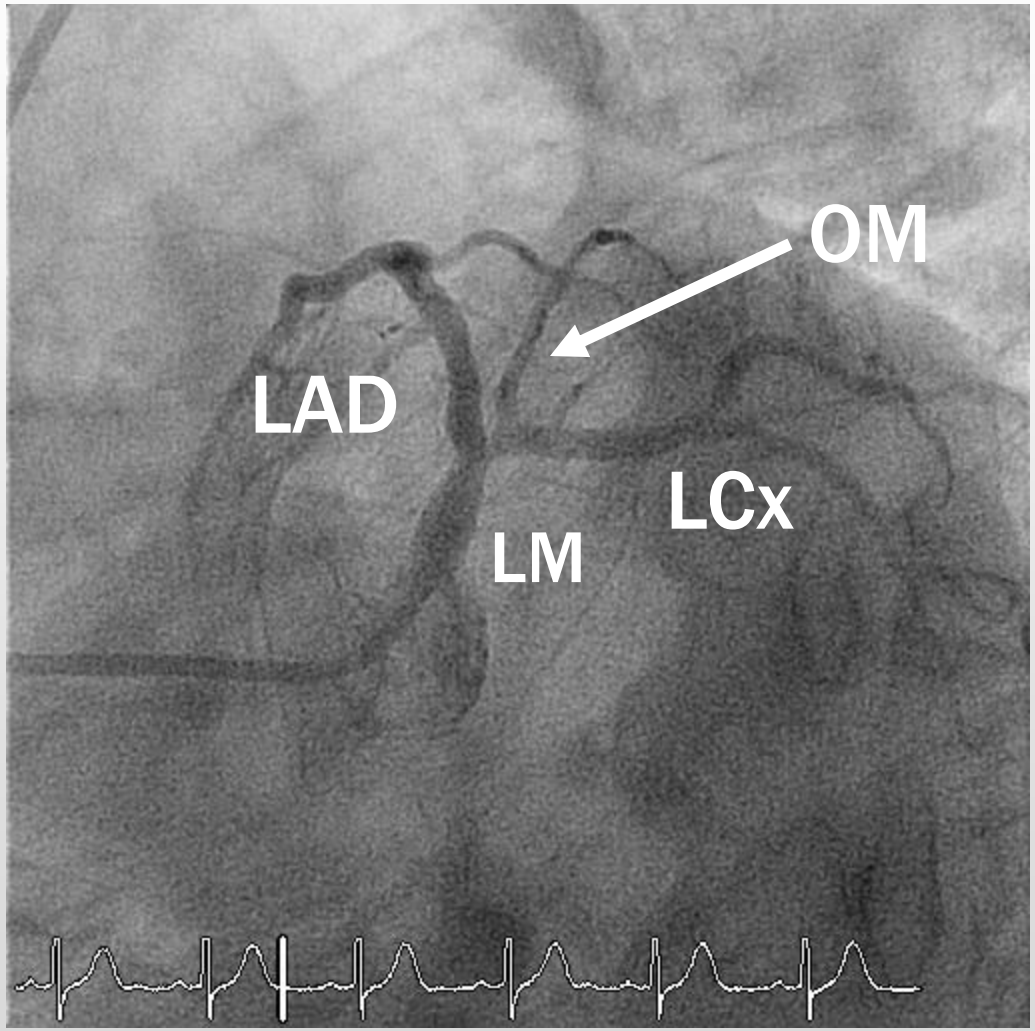


# RAO/Cranial



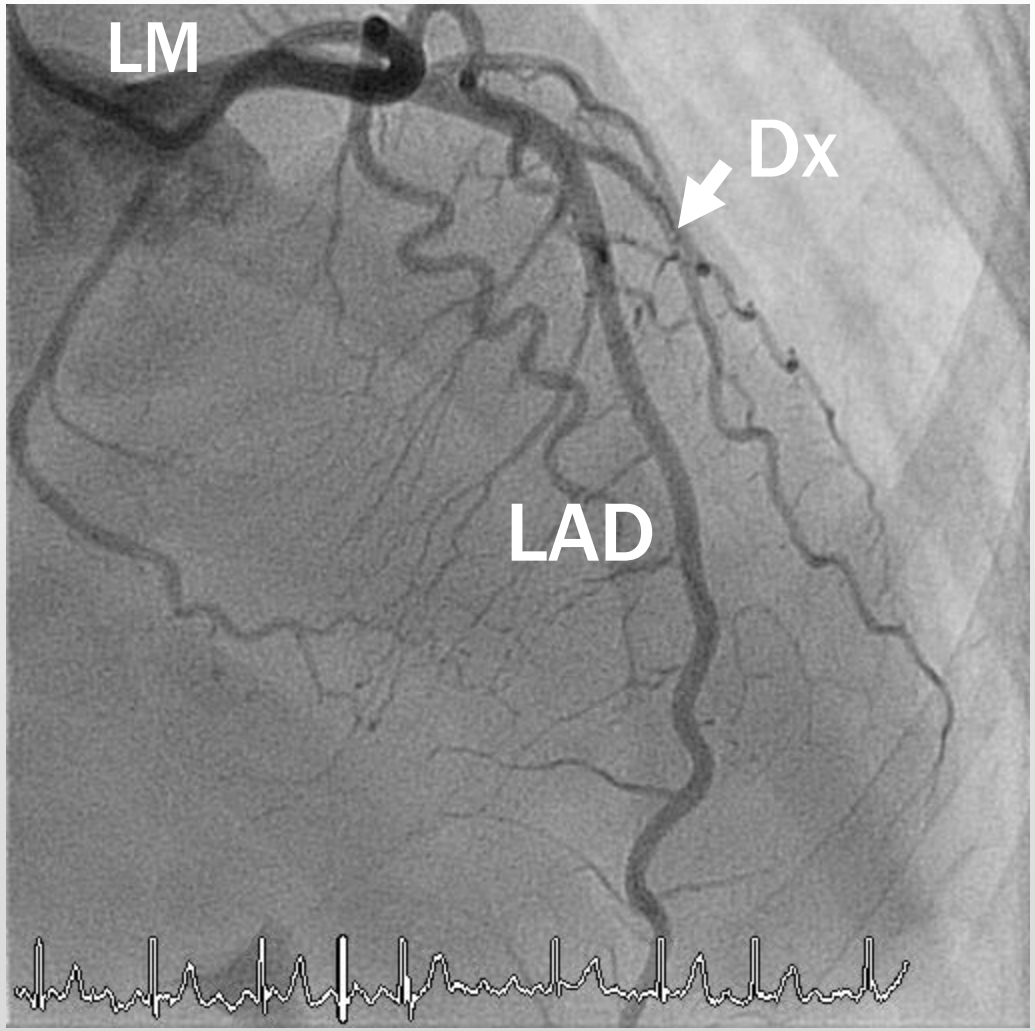

Note: LCx is high – out of way of LAD

# LAO/Caudal or Spider View



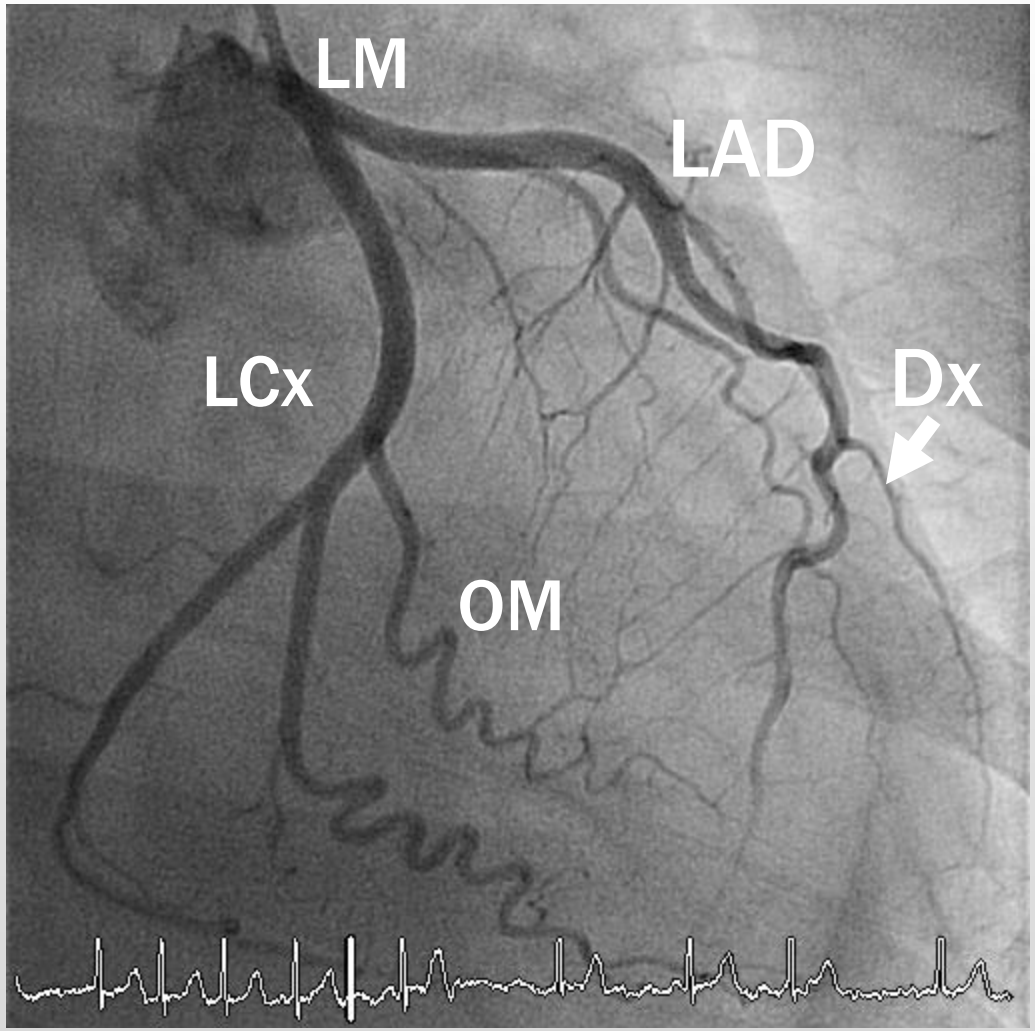
# RAO/Cranial

LCX – high in cranial views
LCx – low in caudal views

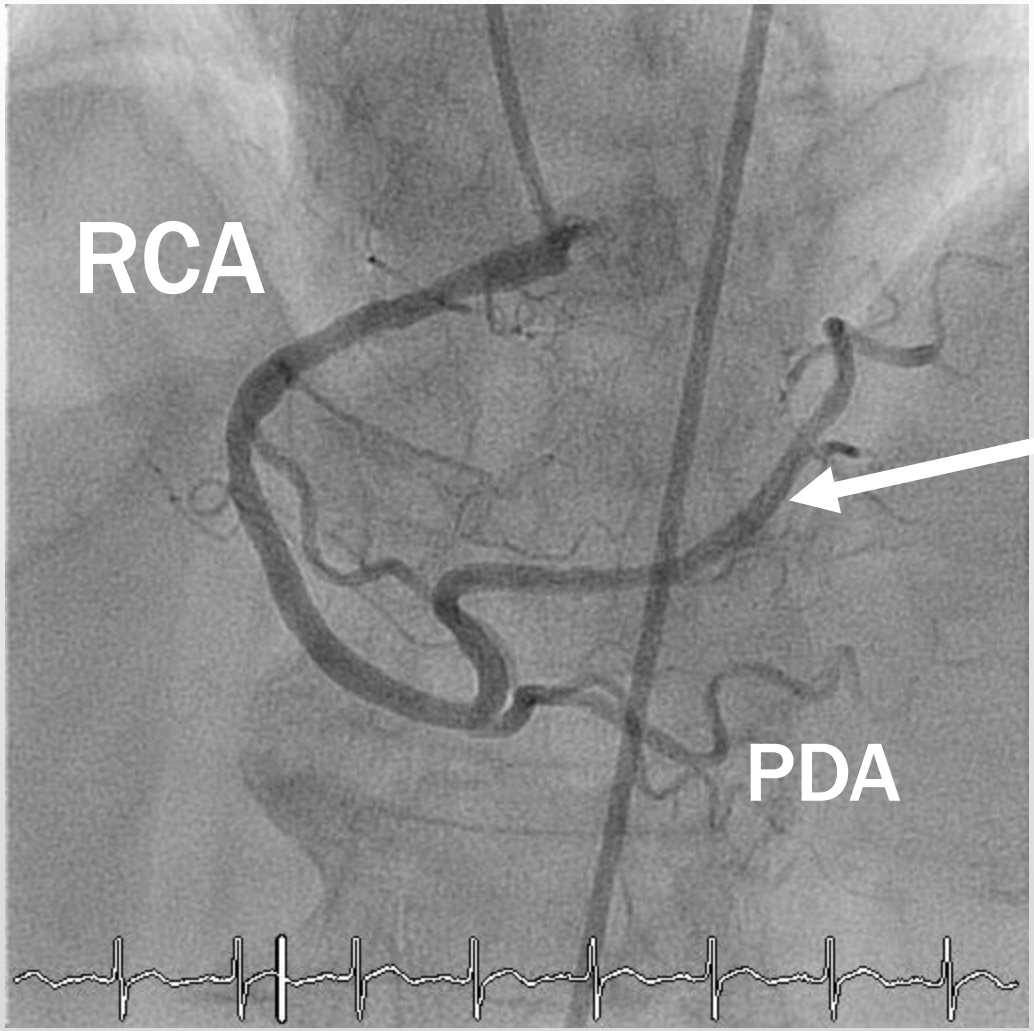


# RAO/Caudal

LCX – high in cranial views
LCx – low in caudal views

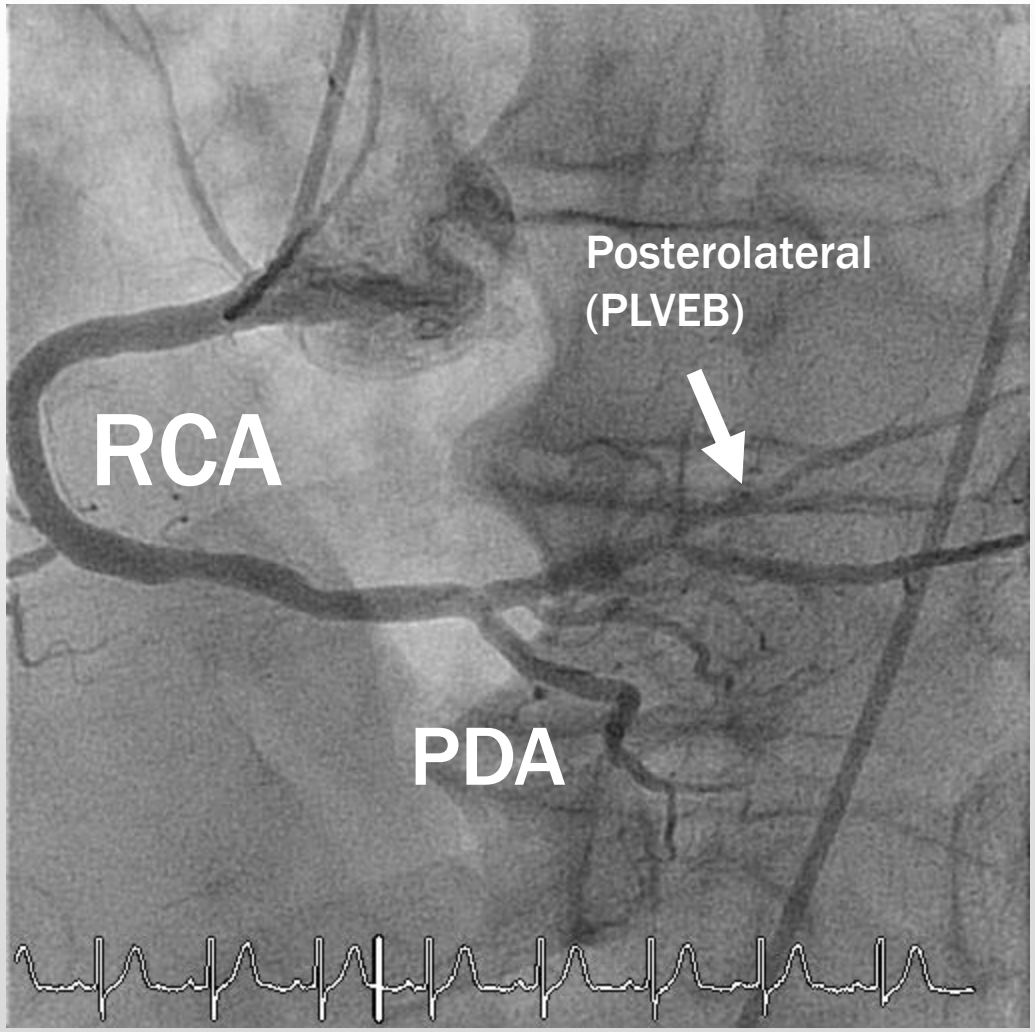


# LAO/Cranial

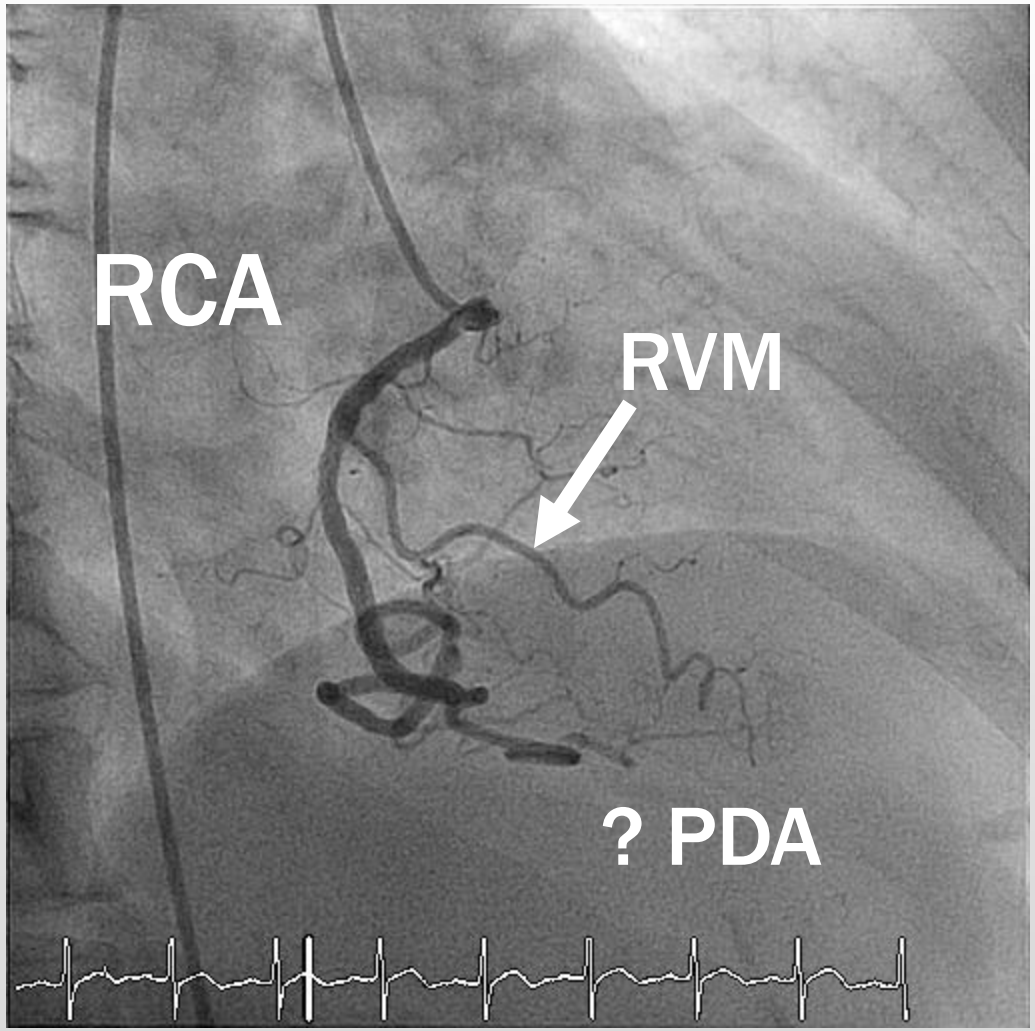



Posterolateral
(PLVEB)

# LAO/Cranial

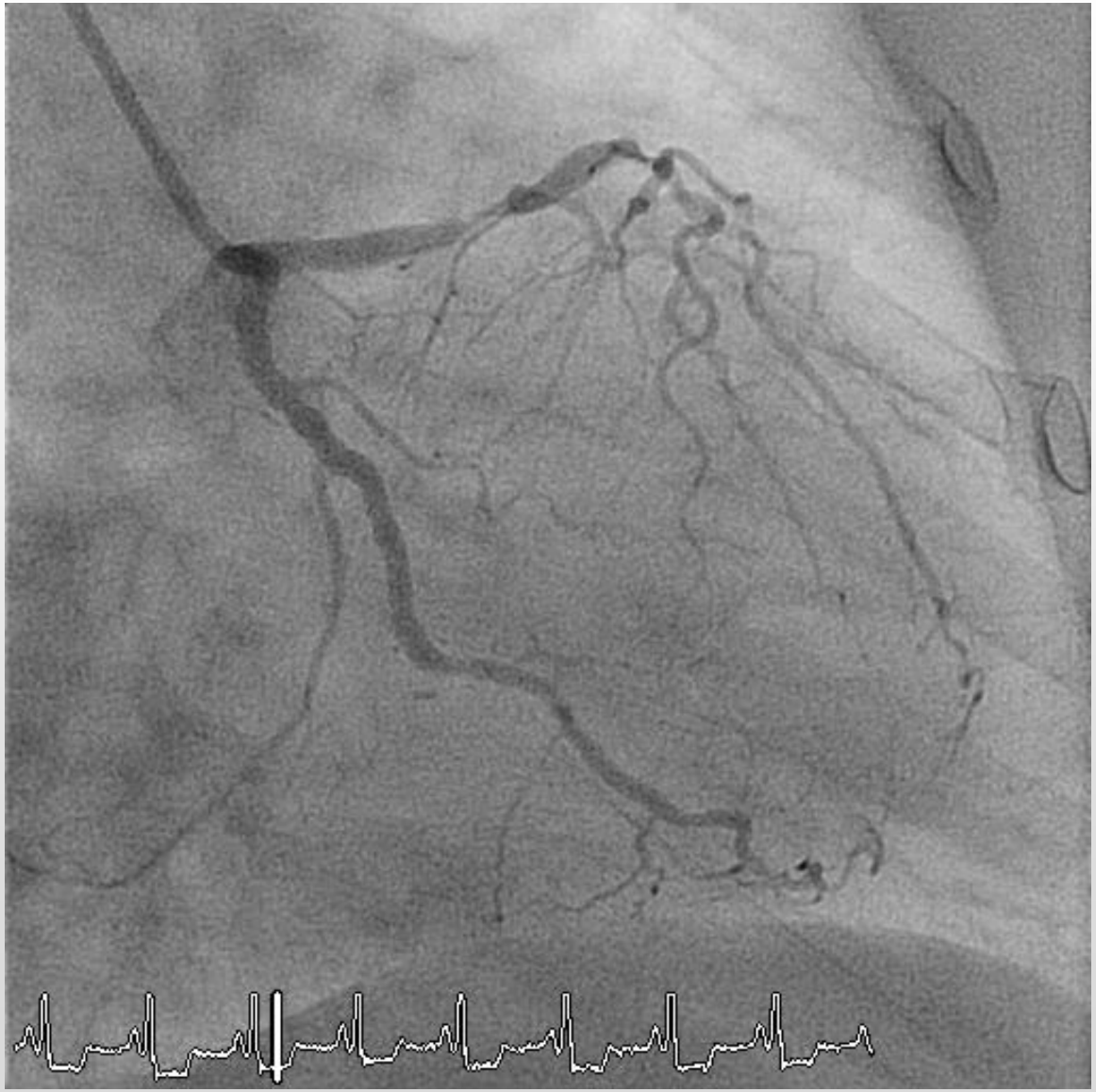


# RAO *without* Cranial



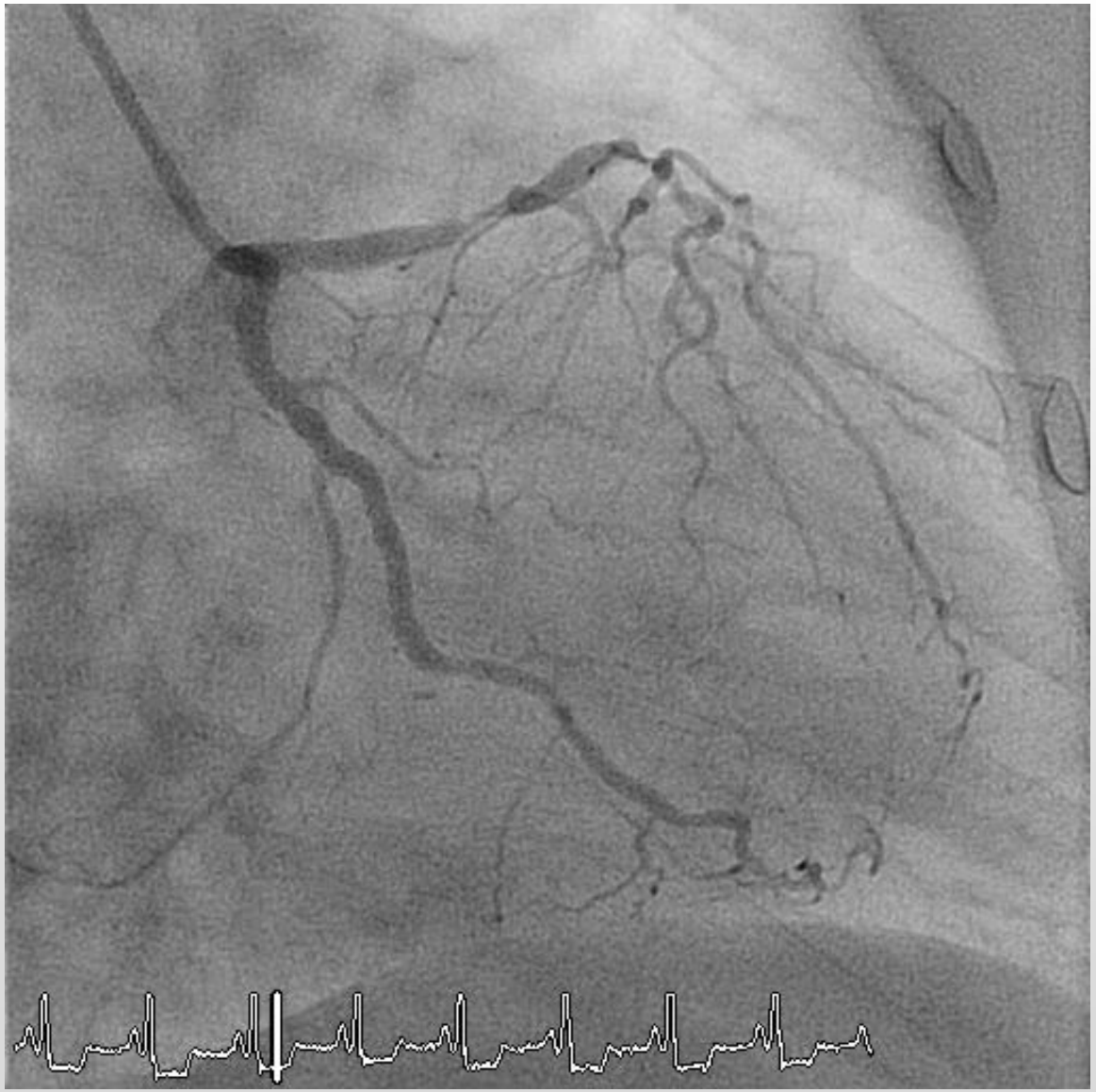

? Posterolateral (PLVEB)

# What is this View?



# What is this View?

**RAO**
**Caudal**

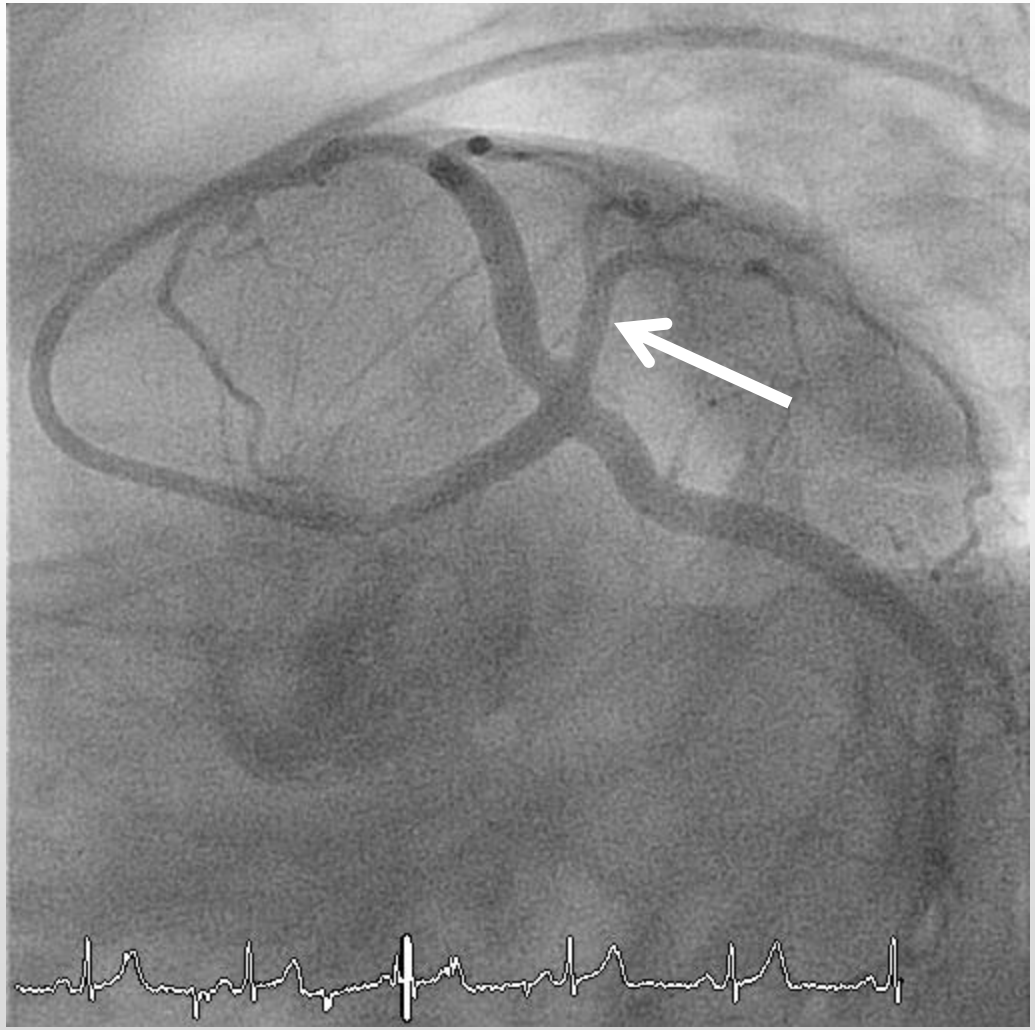


# What is this View?

# What is this View?

**LAO**
**Cranial**

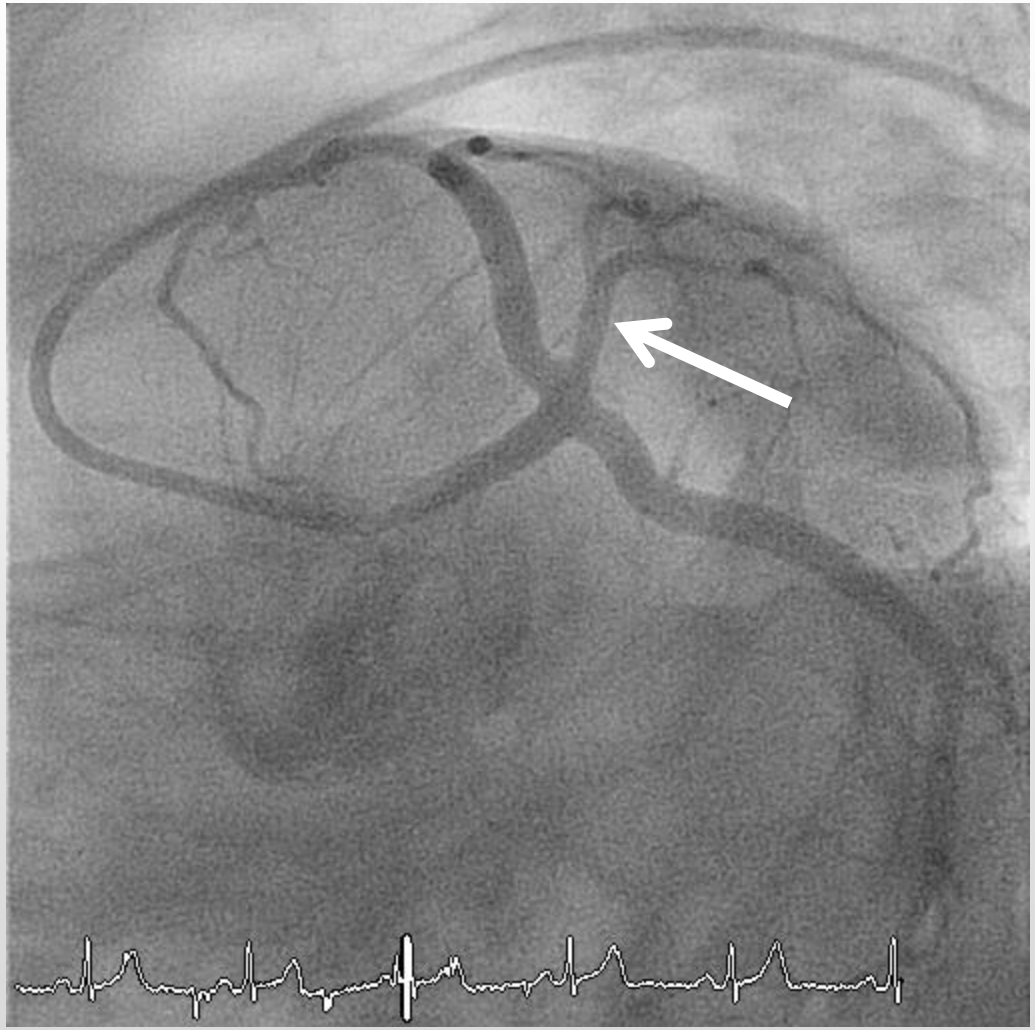
# What is this View? What is this vessel?



# What is the View? What is the vessel?

**LAO**
**Caudal**

**Famous**
**Ramos**



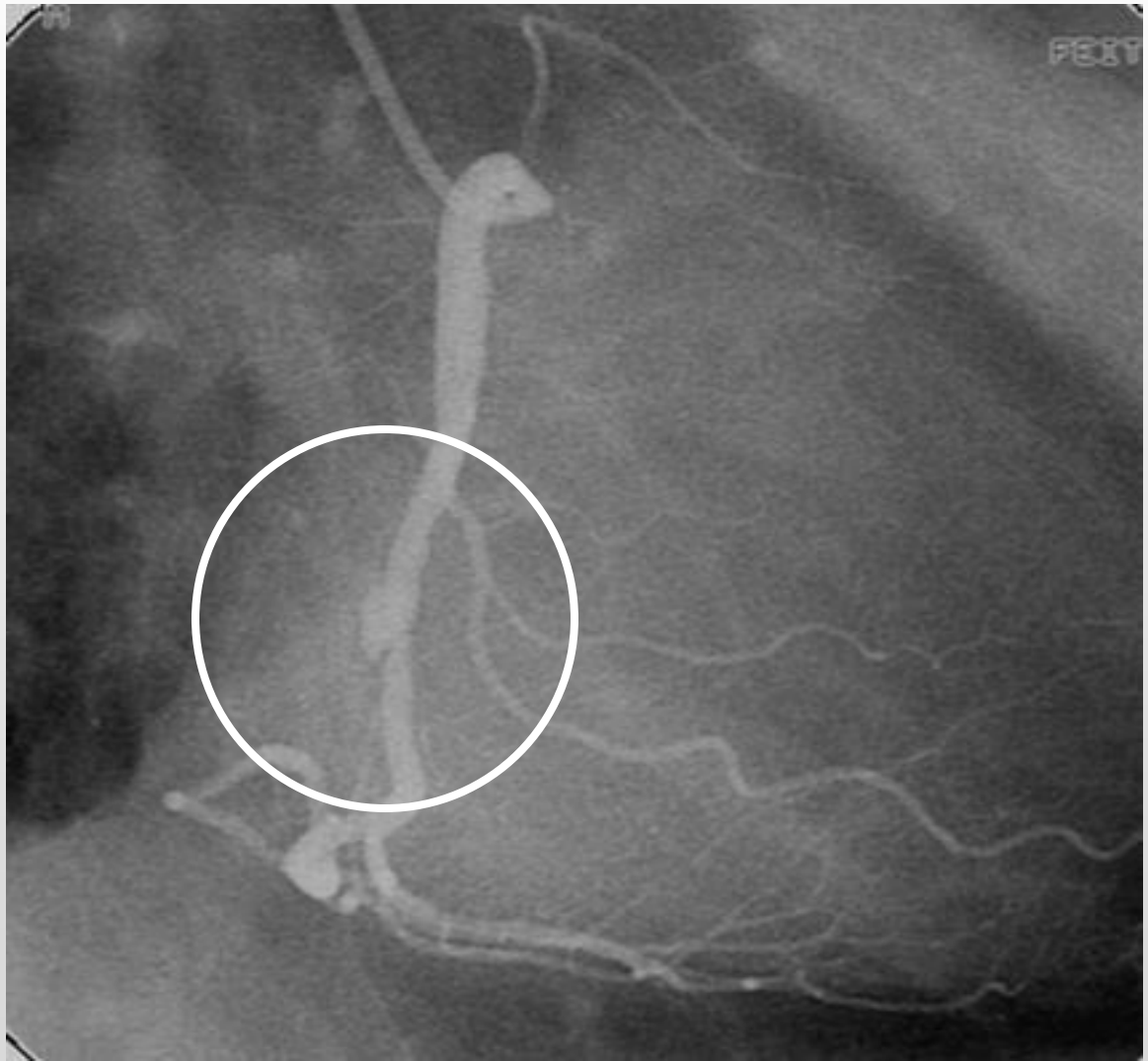
# ACC/AHA LESION CLASSIFICATION

**TYPE A**
- Discrete
- Concentric
- Readily Accessible
- Smooth Contour
- Little or no calcification
- Non-ostial
- No major side branch involved
- Absence of thrombus

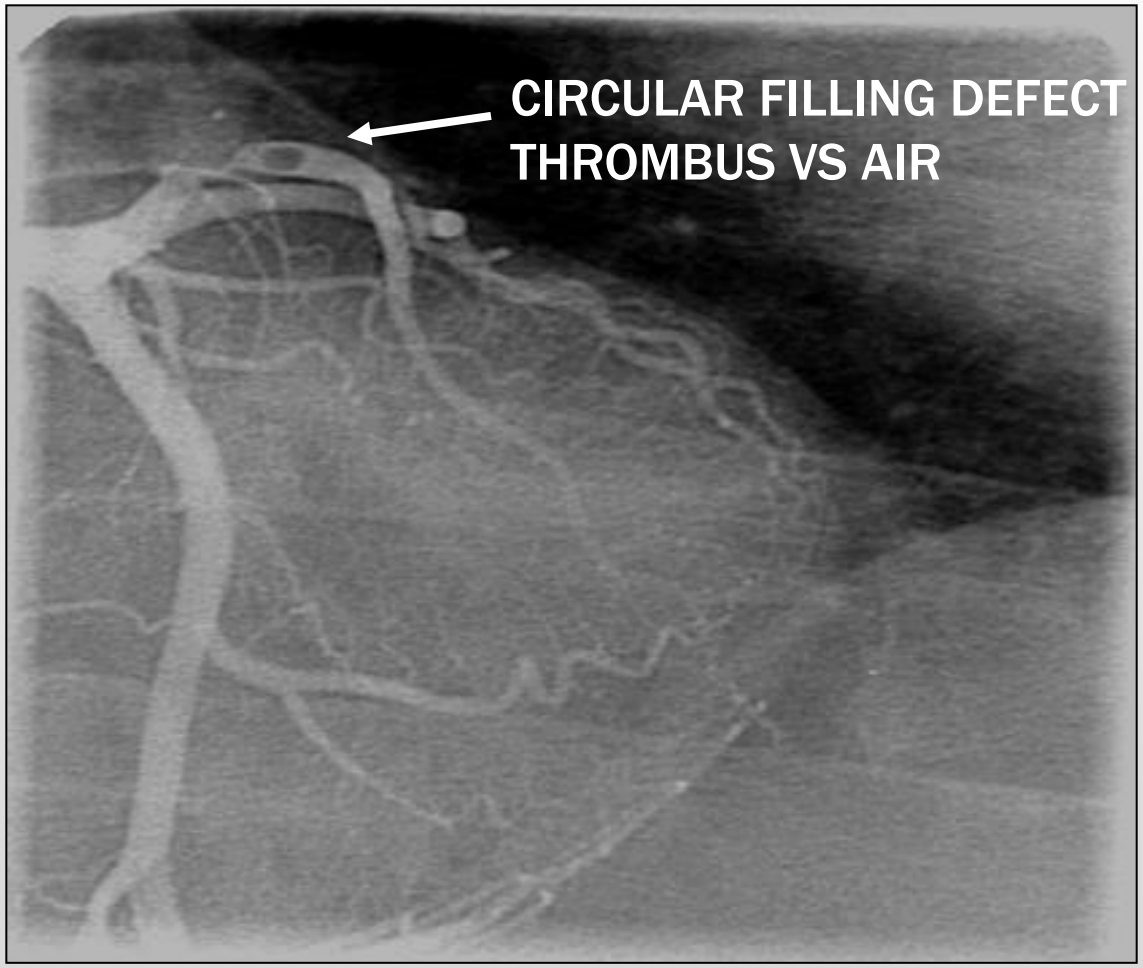
**TYPE B**
- Tubular
- Eccentric
- Moderate tortuousity
- Moderately angulated (45-90)
- Irregular contour
- Moderate-heavy calcification
- Total occlusion (< 3 mos)
- Ostial
- Bifurcation
- Thrombus present

**TYPE C**
- Diffuse
- Excessive tortuousity
- Extremely angulated
- Total occlusion (> 3 mos)
- Inability to protect major side branch
- Degenerated SVG

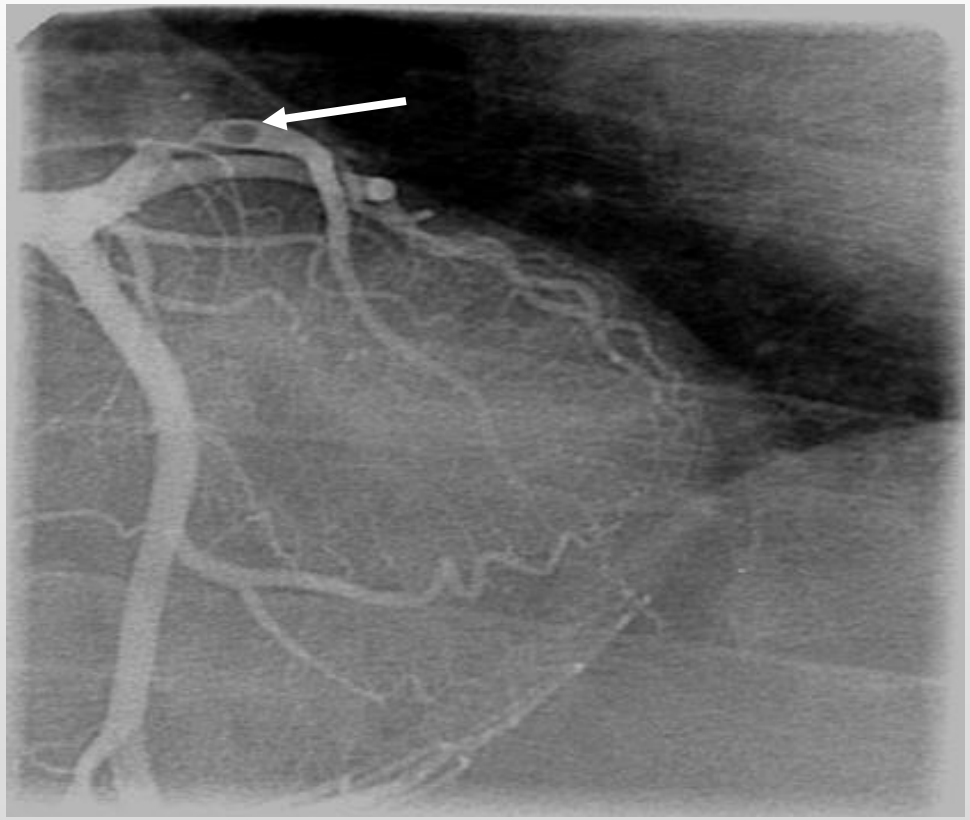
# ULCERATED PLAQUE

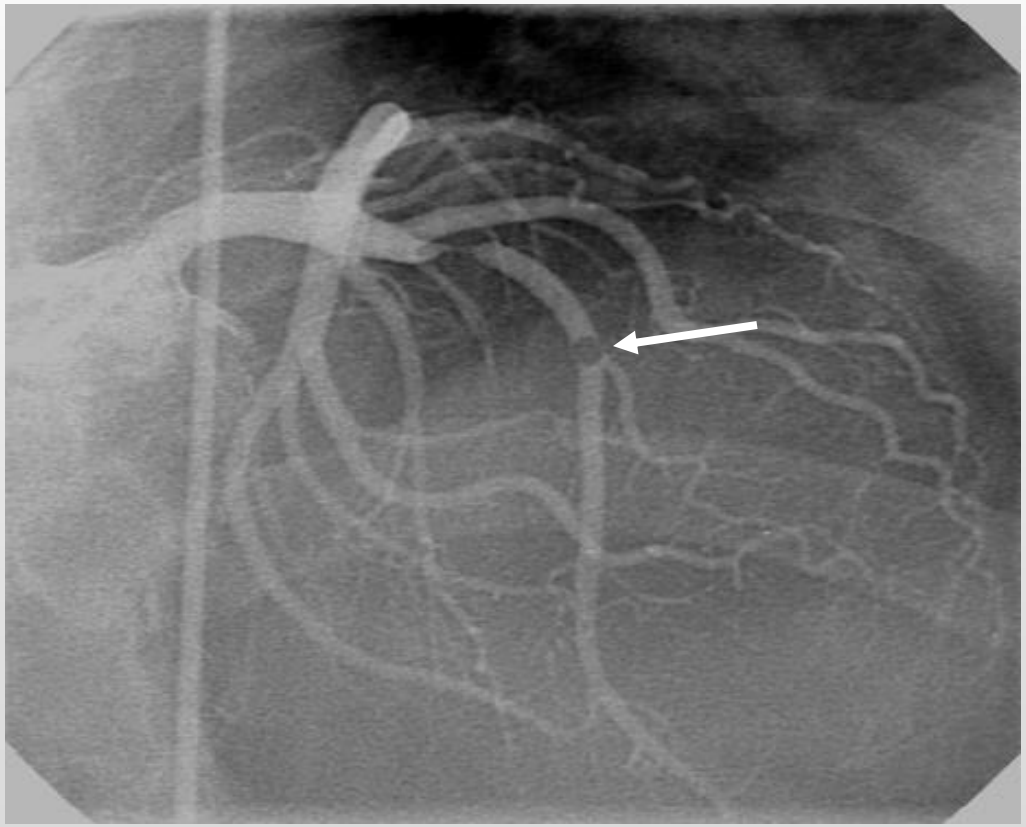


# THROMBUS



# EMBOLIZATION: AIR VS THROMBUS

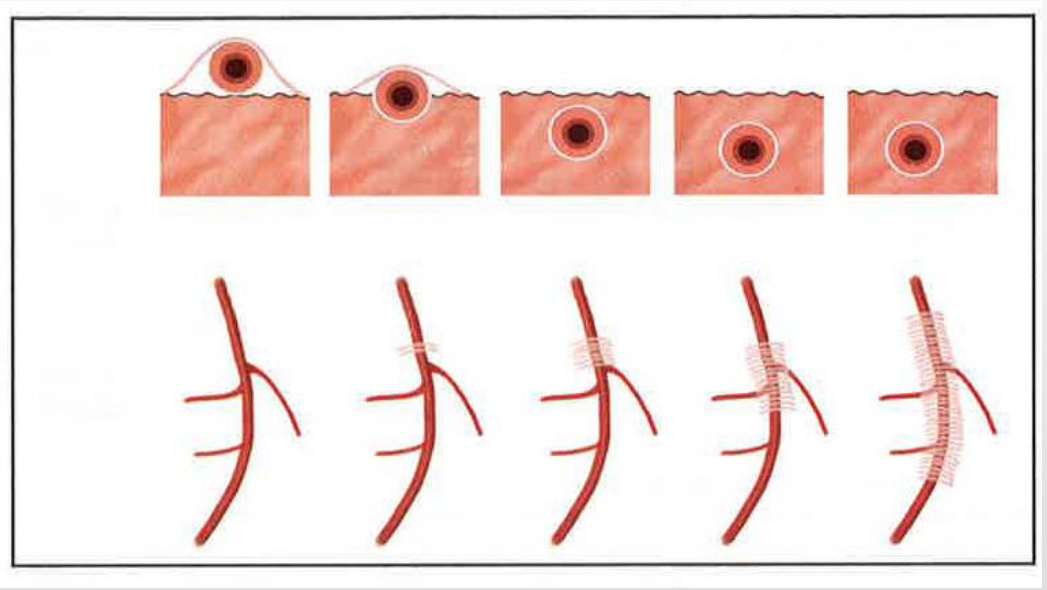




# MYOCARDIAL BRIDGING

## 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

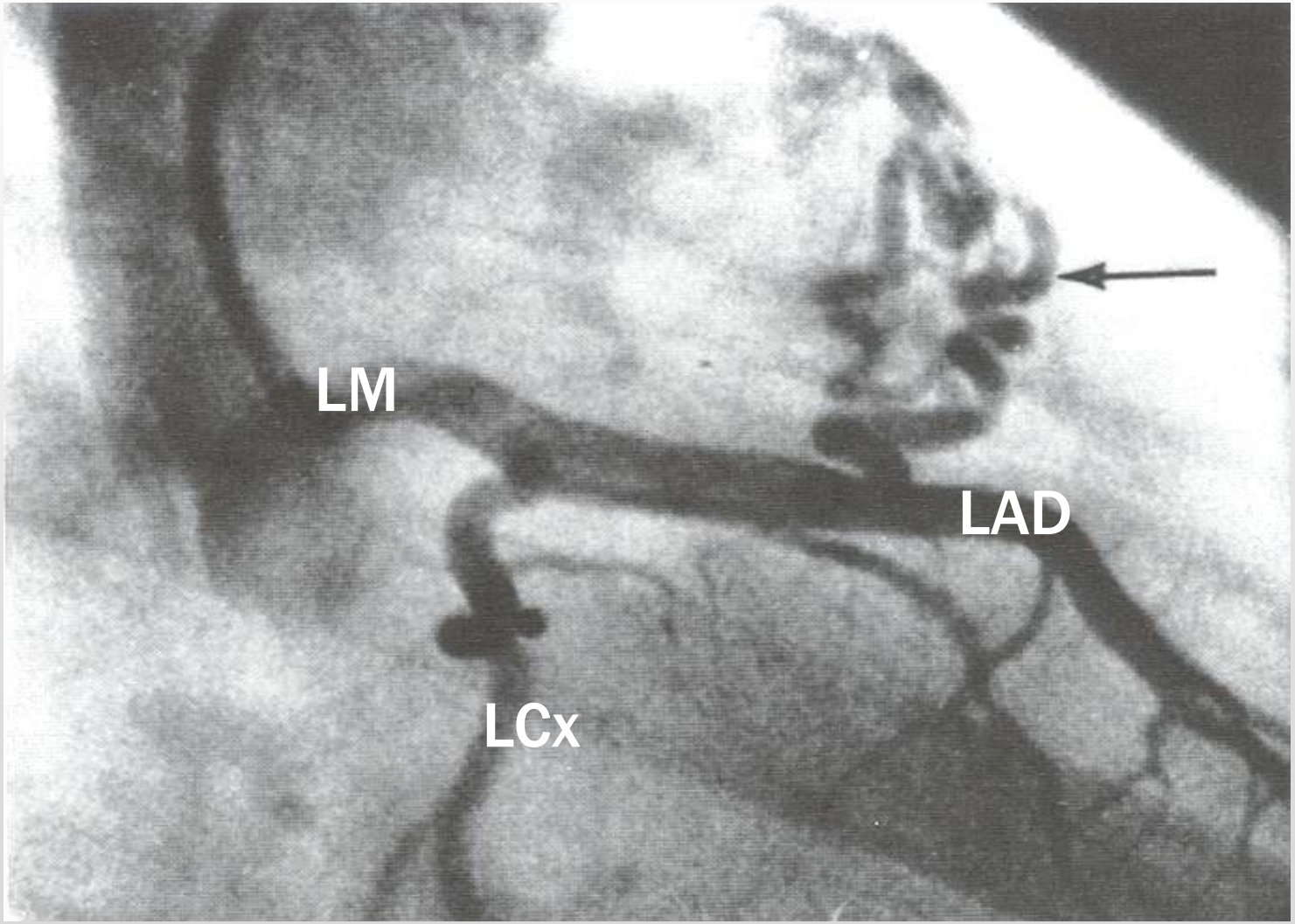


Tarantini G, Migliore F, Cademartiri F, Fraccaro C, Iliceto S. Left Anterior Descending Artery Myocardial Bridging: A Clinical Approach. *J Am Coll Cardiol*. 2016 Dec 27;68(25):2887-2899.

# 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

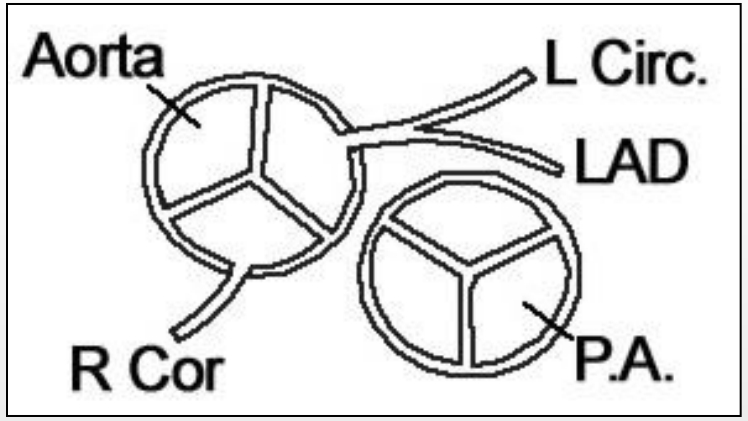
# LAD to PA Fistula



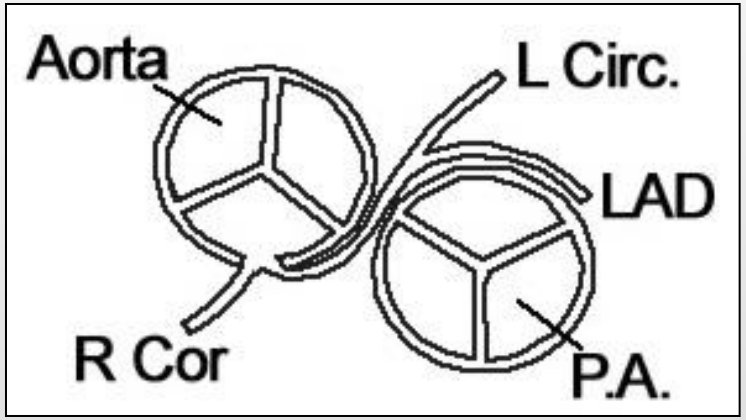
# LAD to PA Fistula

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

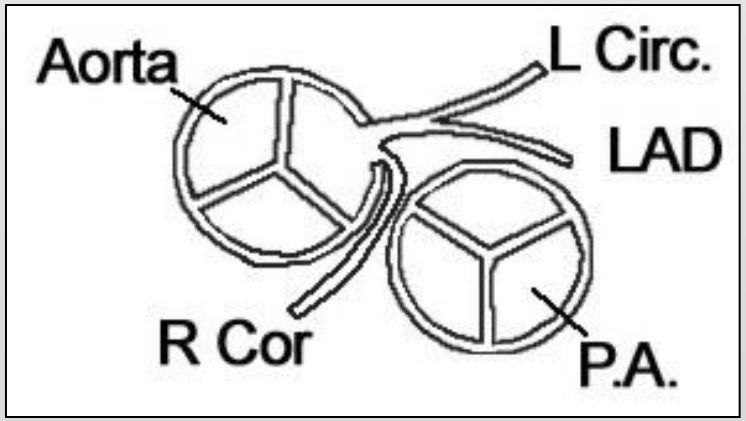
# Anomalous Coronary Arteries




Normal



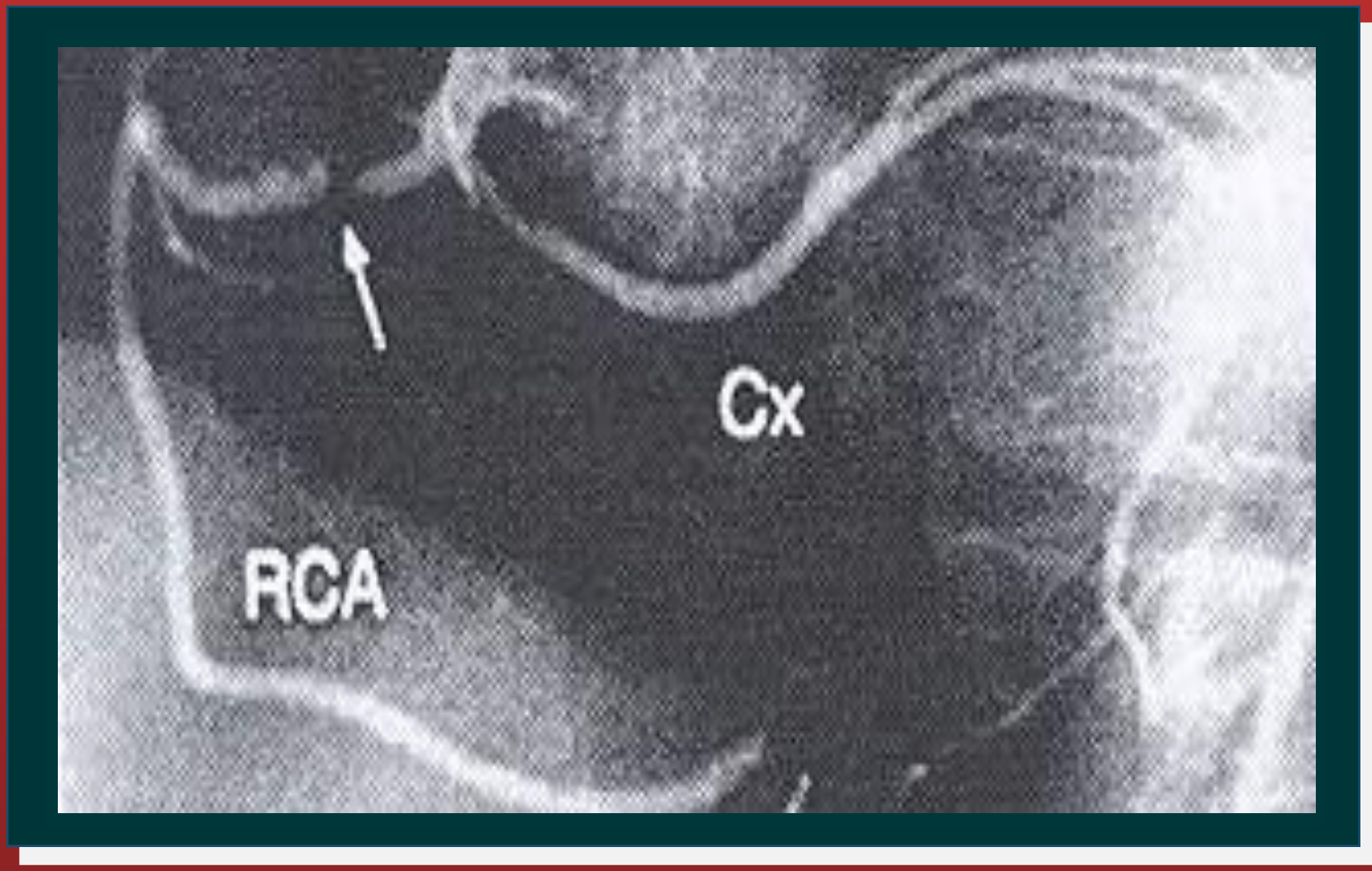

LM from RCC




RCA from LCC

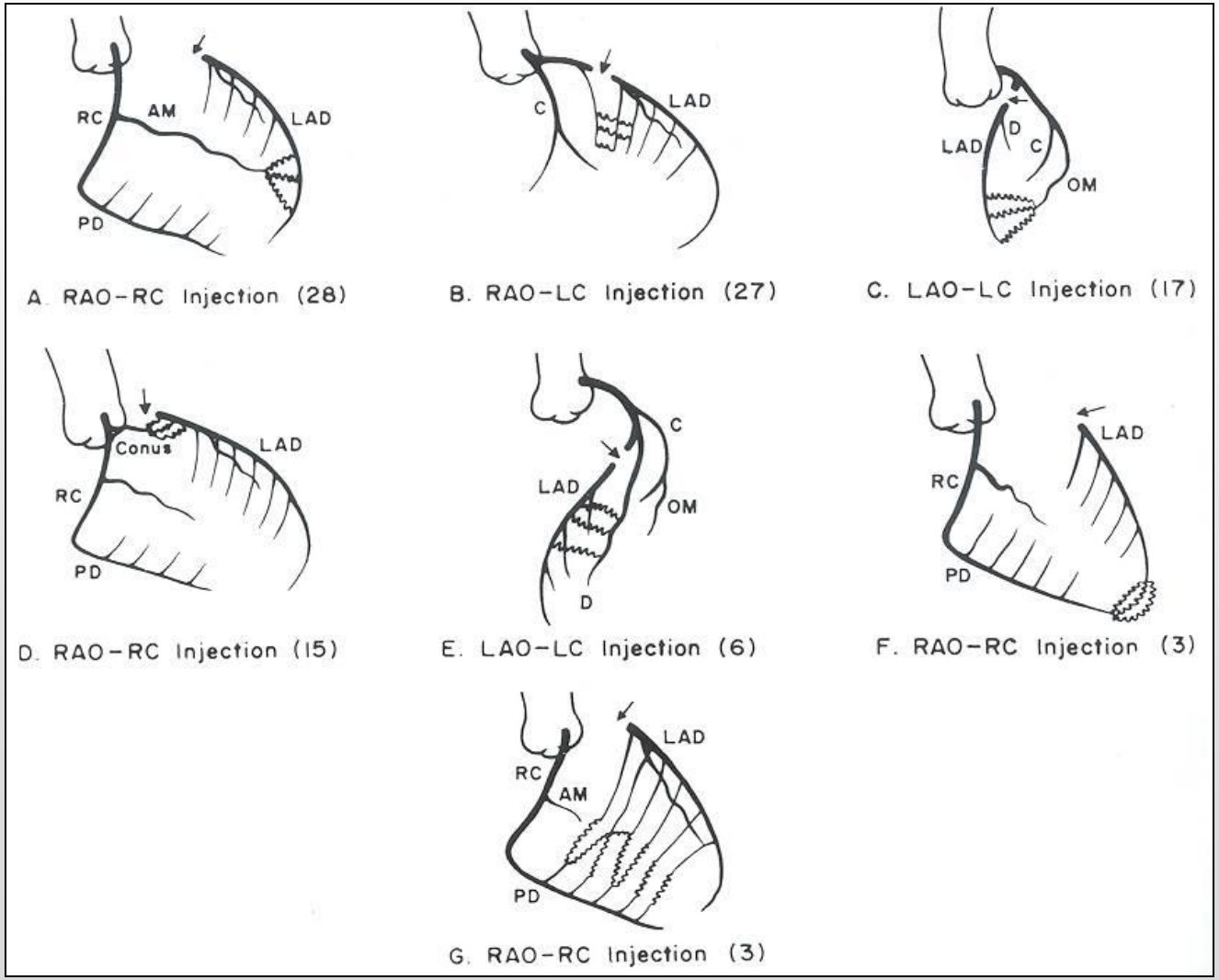
# Benign Anomalous Coronary Arteries (0.5 to 1 %)

- Left Circumflex from right Sinus of Valsalva
  - Most common “benign” anomaly
  - Circumflex courses behind aorta
- High Anterior Origin of RCA
  - Above sinotubular ridge



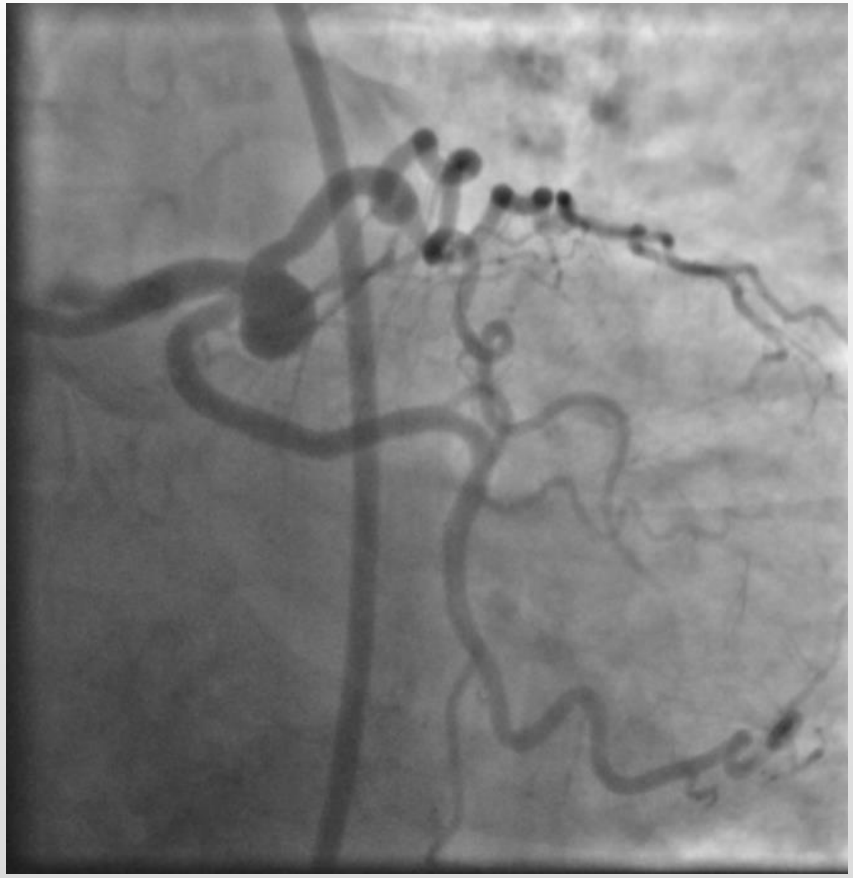

# ANOMALOUS ORIGIN OF LCX FROM RCC (PROXIMAL RCA)

# Collaterals



# 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