Coronary Angiogram : Tips and Tricks for doing procedures

"Independently and Safely"

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Conflicts of Interest

- I have ***NOTHING*** to disclose concerning this presentation

The First Selective Coronary Angiogram

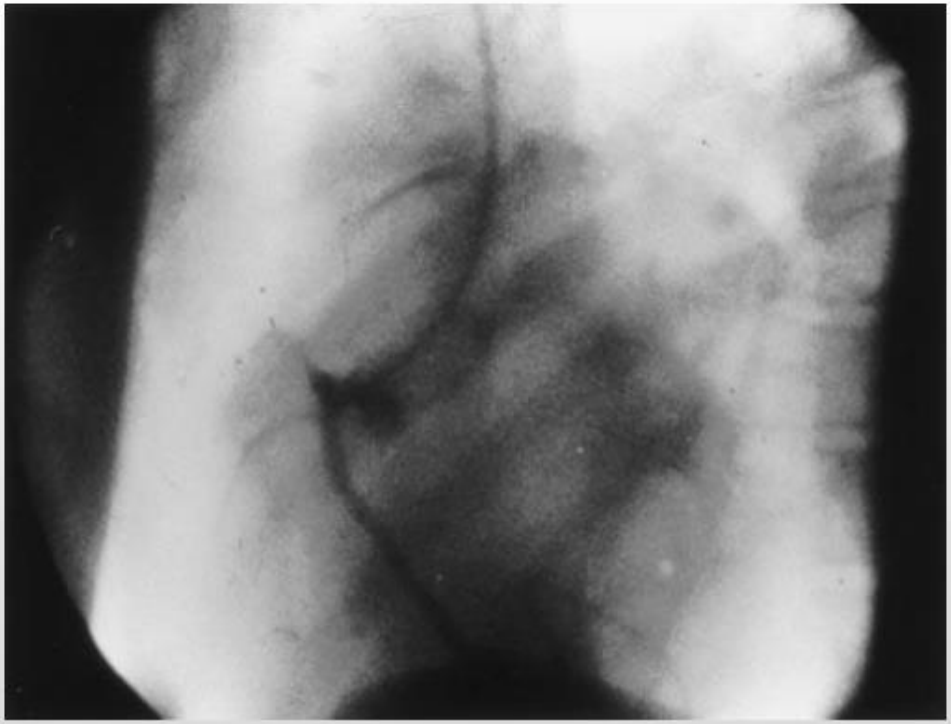


Figure 1. Cine frame from the first selective coronary arteriogram taken by F. Mason Sones, MD, on October 30, 1958.

Cleveland Clinic

- Coronary angiography remains the gold standard for detecting clinically significant atherosclerotic coronary artery disease

Indications for Coronary Angiogram

1/ Diagnosis of CAD in clinical suspected pats

2/Peri-interventional information to PCI

3/Study Coronary anomalies

4/Exclude CAD before non-coronary cardiac surgery
e.g. Valve surgery > 40 yrs of age

5/Determine pateny of CABG

6/NSTEMI- ACS with high risk features e.g.ongoing ischemia;
High Grace Score; unstable hemodynamics

7/ STEMI – to Primary PCI

Contraindication : Coronary Angiogram

- There are no absolute contraindications to cardiac catheterization

Relative contraindications include:

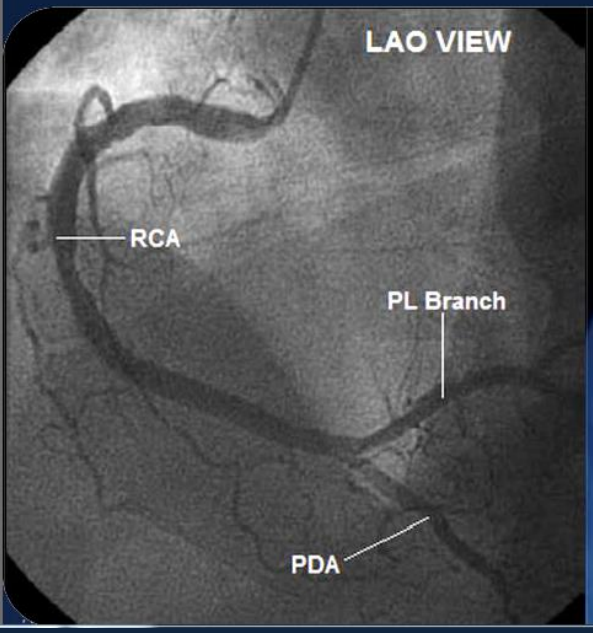
- Coagulopathy (Radial approach can be attempted based on urgency)
- Decompensated congestive heart failure
- Uncontrolled hypertension
- Pregnancy
- Unable to get patient cooperation
- Active infection
- Renal failure
- Contrast medium allergy

The BASICS

- **Standard VIEWS for Coronary Angiogram**

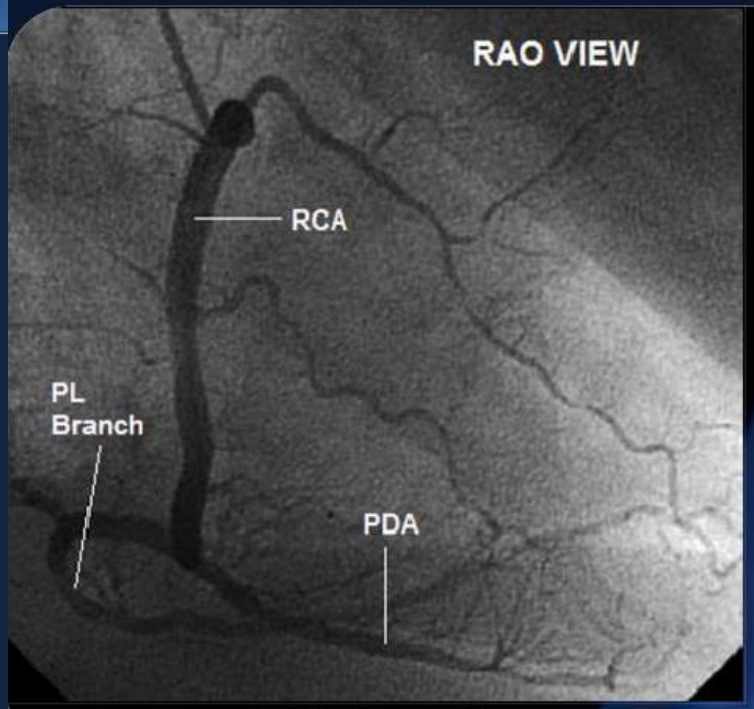
Rt System Imaging

RCA view



LAO View: Best for demonstrating :

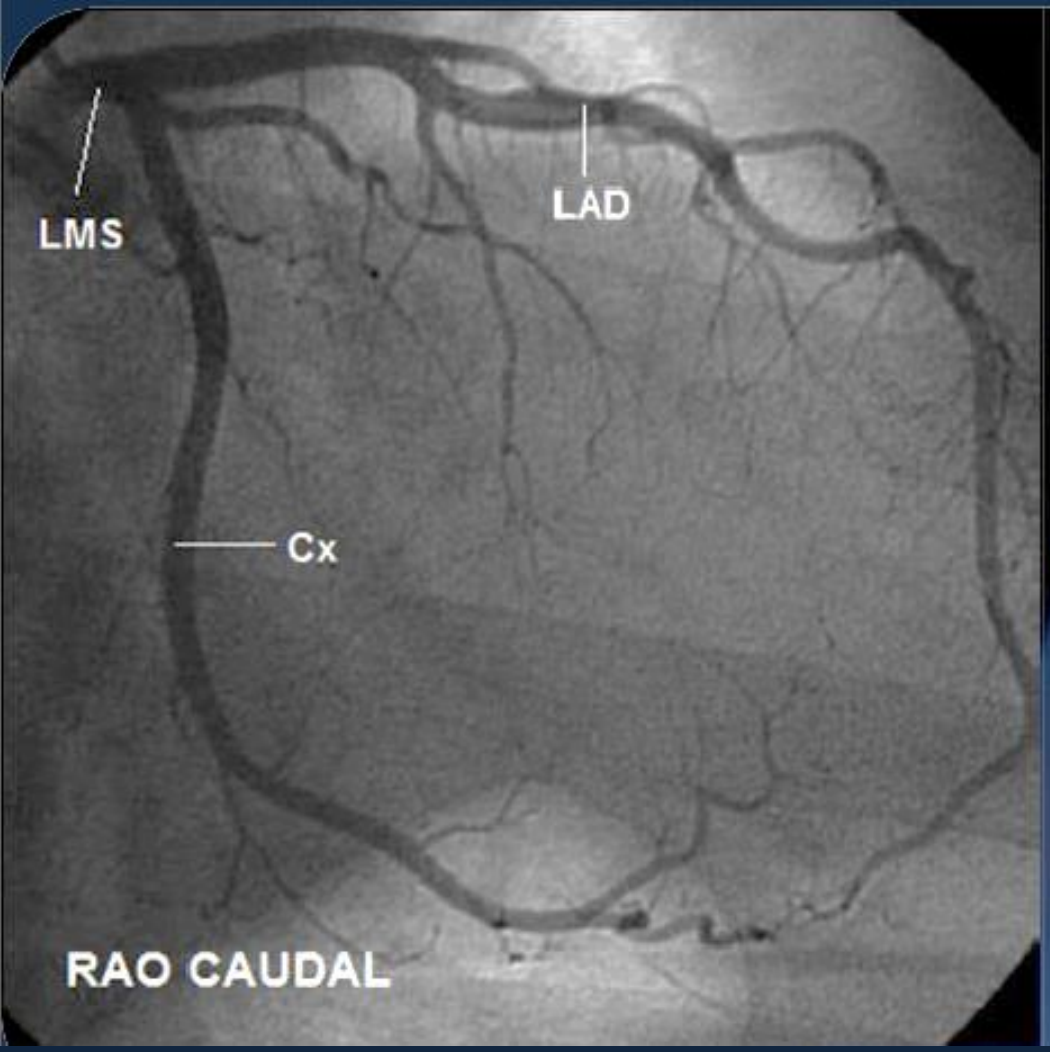
1. Ostium of the RCA
2. Mid-portion of RCA
3. Bifurcation of the posterolateral branch (PL) and the posterior descending branch (PDA)



RAO View: Best for demonstrating:

1. Mid-portion of the RCA
2. Extent of the PDA.
3. Ostium is not well imaged in this view.

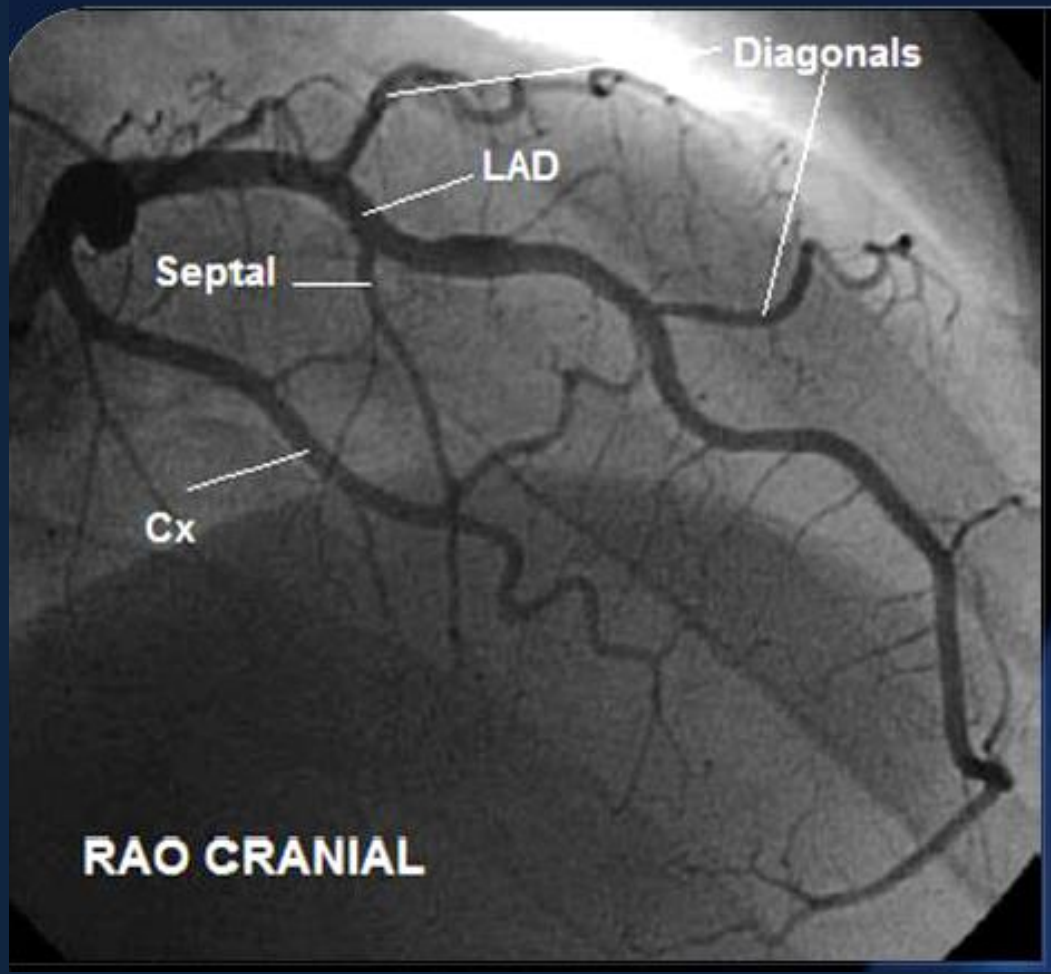
Left System Imaging



RAO Caudal view is best for

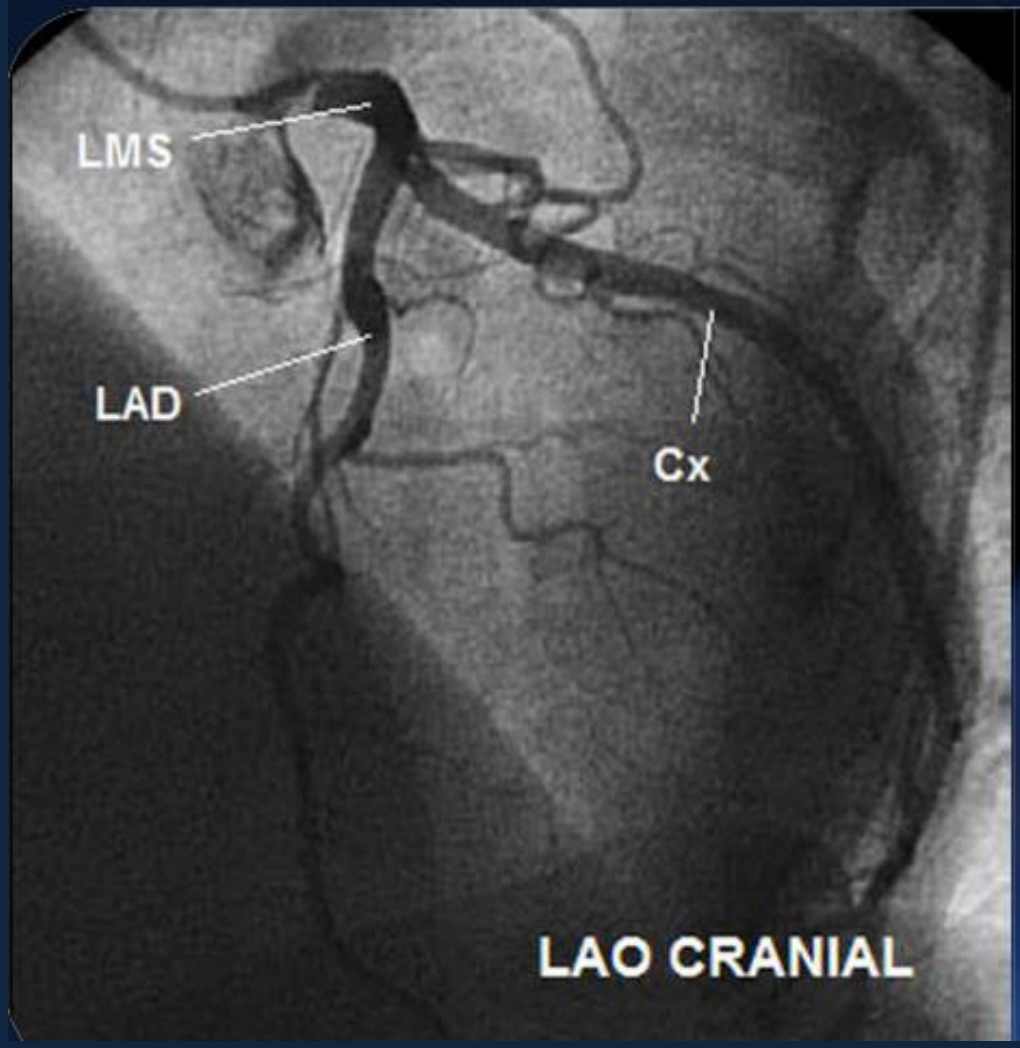
1. Distal Left Main Stem (LMS)
2. Proximal segment of the LAD
3. Circumflex artery (Cx) and its branches (OMs)

Left System Imaging



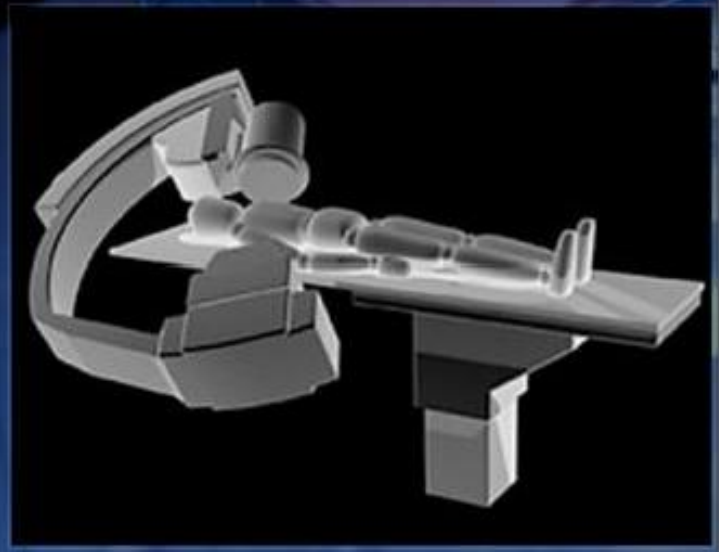
RAO Cranial view is best for the LAD and diagonal branches

Left System Imaging

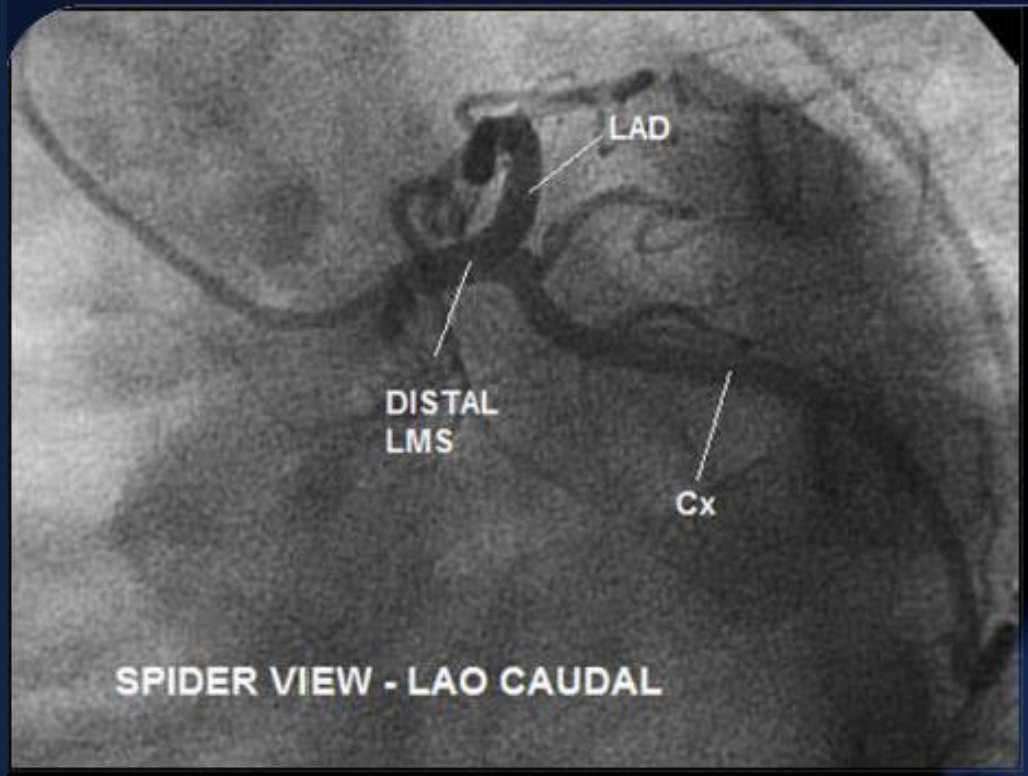


LAO Cranial View: Best demonstrating

1. Ostium of the LMS
2. Origin of the diagonals from the LAD



Left System Imaging

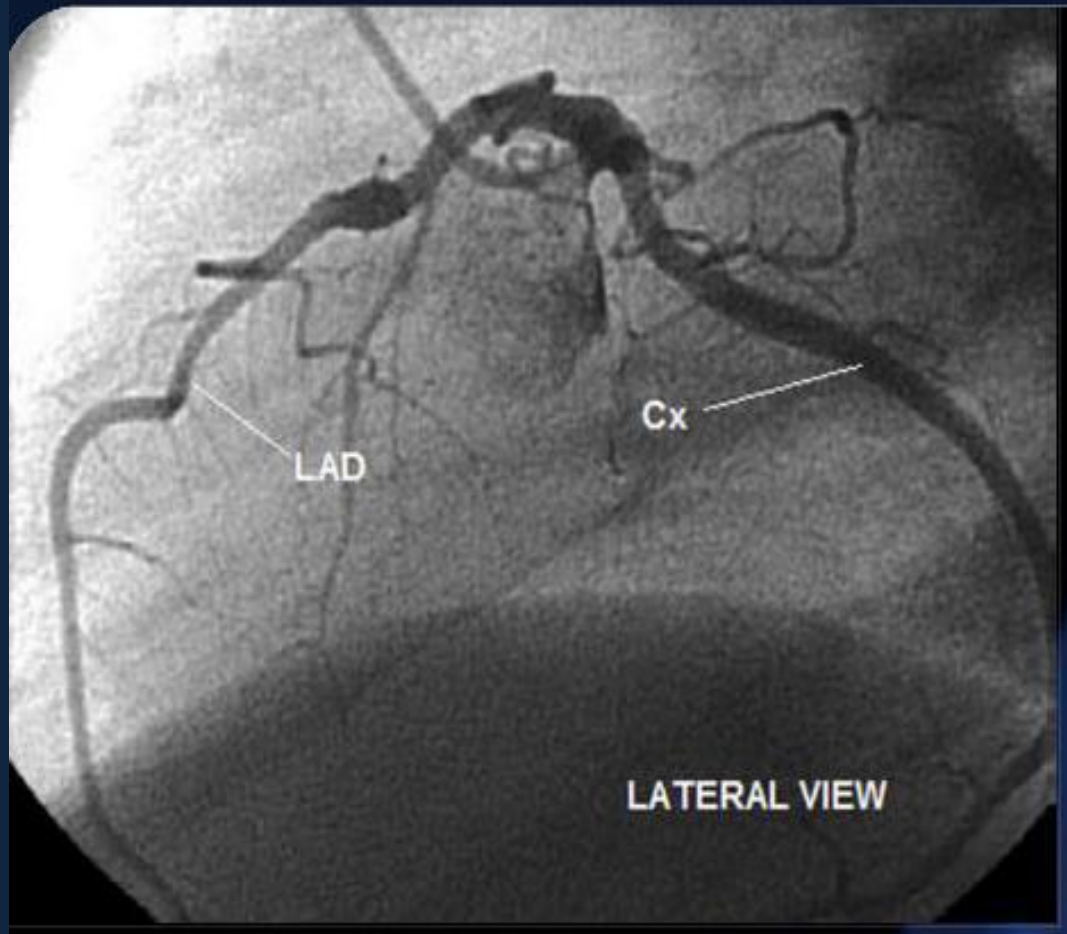


SPIDER VIEW - LAO CAUDAL

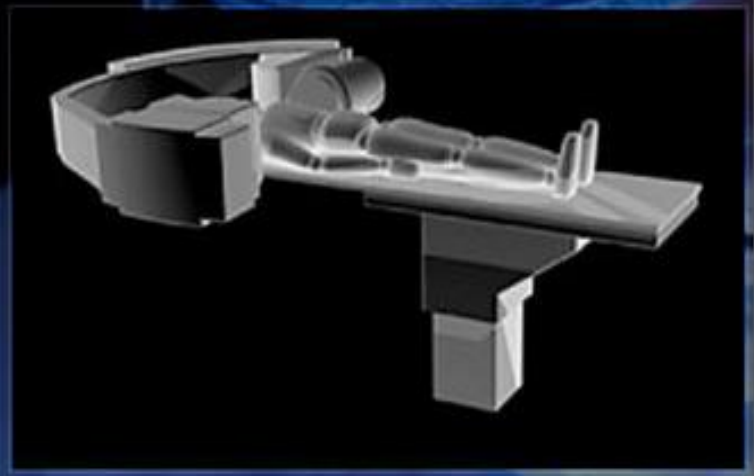
LAO Caudal View (SPIDER VIEW): Best for

1. Distal LMS
2. Proximal LAD
3. Proximal Circumflex artery
4. Ramus Intermedius branch (RI)

Left System Imaging



LAO (90°) Straight ~~(Lateral) View:~~ shows the Mid-LAD and the Circumflex arteries



- **Interpretation of Coronary Angiogram**

Coronary Angiogram- Proper Interpretation

- A systematic interpretation of a coronary angiogram would involve:
  - Evaluation of the extent and severity of coronary calcification just prior to or soon after contrast opacification
  - Lesion quantification in at least 2 orthogonal views:
    - Severity
    - Calcification
    - Presence of ulceration/thrombus
    - Degree of tortuosity
    - ACC/AHA lesion classification
    - Reference vessel size
    - Distal vessels (graftable or not)
  - Bifurcation/trifurcation stenosis
  - Grading TIMI myocardial perfusion blush grade
  - Identifying and quantifying coronary collaterals

Coronary Artery Dominance

- **Coronary arterial dominance** is defined by the vessel which gives rise to the POSTERIOR DESCENDING ARTERY(PDA),which supplies the myocardium, the area of the inferior 1/3rd of the interventricular septum.
- Most hearts (80-85%) are *right dominant* where the PDA is supplied by RCA. The remaining 15-20% of hearts are divided between left dominant and codominant.

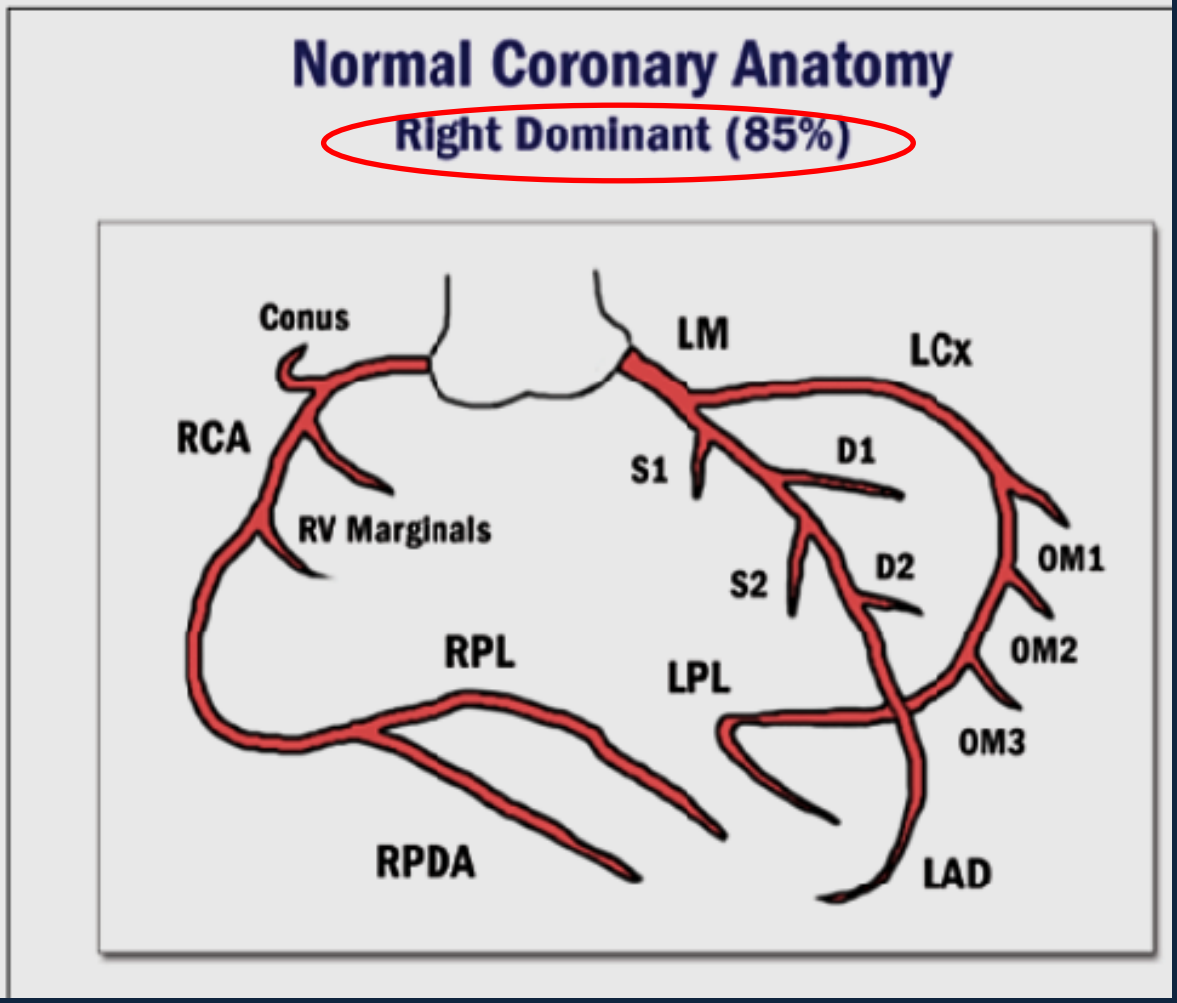
Right Dominicance

Figure 3
Normal Coronary Anatomy
Right Dominant (85%)

Right Coronary Dominant Illustration

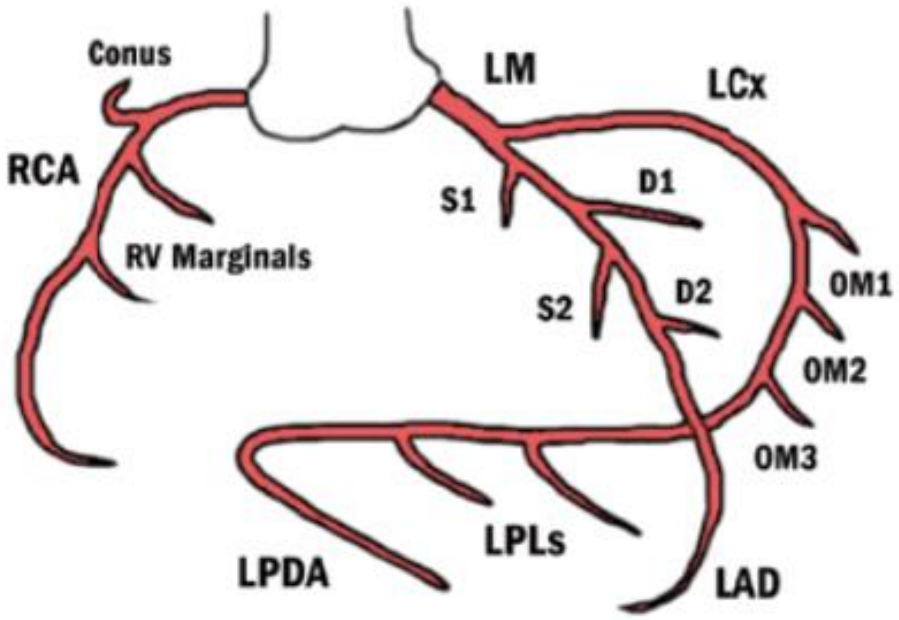
RCA = right coronary;
RPDA = right posterior descending;
RPL = right posterior lateral;
LM = left main;
LPL = left posterior lateral;
LAD = left anterior descending;
LCx = left circumflex;
D = diagonals;
S = septals;
OM = obtuse marginals.

Courtesy of Cathsource. Temple, TX.



Normal Coronary Anatomy

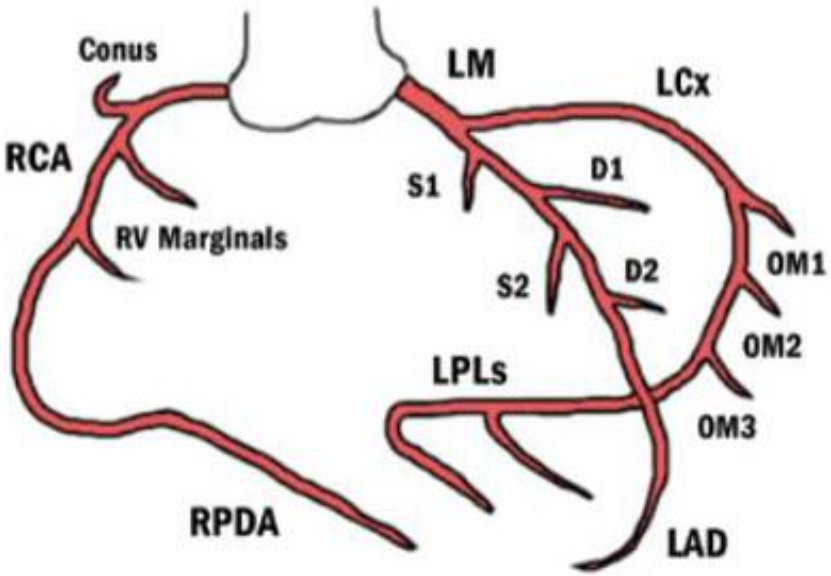
Left Dominant (7%)



CO- DOMINANCE

Normal Coronary Anatomy

Co-Dominant (8%)



TIMI – Flow grade

- **TIMI –0- No perfusion** – No antegrade flow beyond occlusion
- **TIMI -1- Penetration without perfusion** – Contrast hangs up beyond the obstruction and fails to opacify the distal bed during cine
- **TIMI -2- Partial perfusion-** Contrast fills the distal tree but clearance is slower when compared to normal neighbouring arteries
- **TIMI -3- Complete perfusion-** Antegrade flow is as prompt as proximal bed and clearance as rapid as uninvolved bed

Myocardial Perfusion Score – The BRUSH 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.

AHA/ACC- Lesion Classification

Characteristics of ACC/AHA Type A, B and C lesions

TYPE A LESIONS: (High success, > 85%; low risk)

- Discrete (<10 mm length)
- Concentric
- Readily accessible
- Nonangulated segment <45 degrees
- Smooth contour
- Little or no calcification
- Less than totally occlusive
- Notostial in location
- No major branch involvement
- Absence of thrombus

TYPE B LESIONS (Moderate success, 60 to 85%; moderate risk)

- Tubular (10-20 mm length)
- Eccentric
- Moderate tortuosity of prox.segment
- Moderately angulated, 45-90°
- Irregular contour
- Moderate to heavy calcification
- Ostial in location
- Bifurcation lesions requiring double guidewires
- Some thrombus present
- Total occlusion < 3 months old

TYPE C LESIONS (low success, < 60%; high risk)

- Diffuse (>2 cm length)
- Excessive tortuosity of prox.segment
- Extremely angulated, >90 degrees
- Inability to protect major side branch
- Degenerated vein grafts with friable lesions.
- Total occlusion > 3 months old

Rentrop– Collaterals GRADING

Grade	Appearance
0	No collateral vessels seen
1	Very weak (ghostlike) reopacification
2	Re-opacified segment, less dense than the feeding vessel, filling slowly
3	Re-opacified segment as dense as the feeding vessel and filling rapidly

TIMI Grade of Collateral Filling

- **TIMI Grade 1 Collaterals (Absent)**

absence of any collaterals to occluded vessel supplying the area of infarct

- **TIMI Grade 2 Collaterals (Minimal)**

collaterals resulting in faint opacification to a diameter not exceeding 1 mm in occluded vessel or its branches, visualized distal to the obstruction in occluded vessel supplying the area of infarct

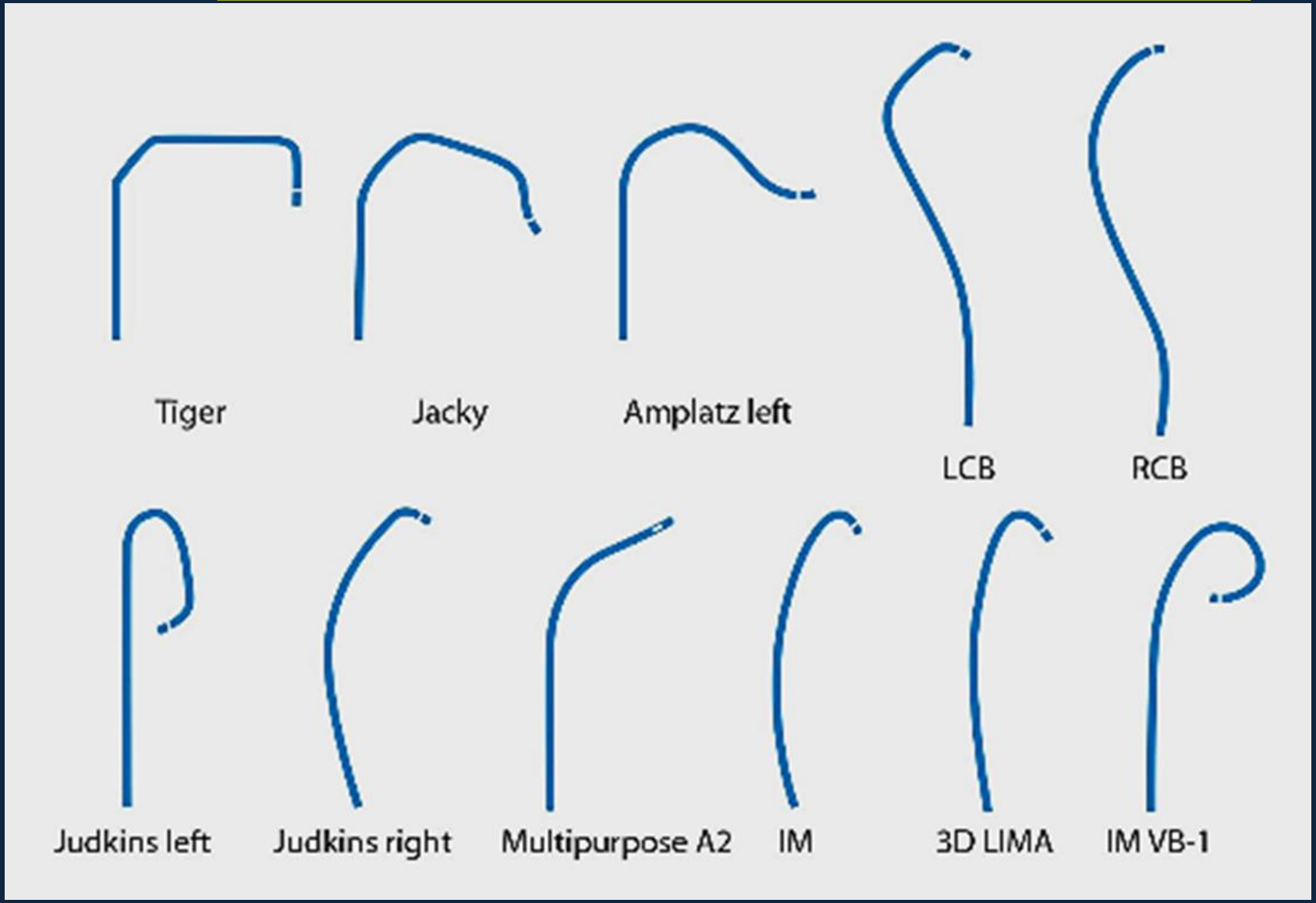
- **TIMI Grade 3 Collaterals (Well Developed)**

collaterals resulting in full opacification to a diameter > 1 mm in occluded vessel or its branches, visualized distal to the obstruction in occluded vessel suppling the area of infarction

TIPS and Tricks for Performing Good Coronary Angiogram

- **Proper Catheters Selection for Cannulation**
- **Understand the Anatomy and Variation**

Frequently used catheters for diagnostic trans-radial coronary angiogram



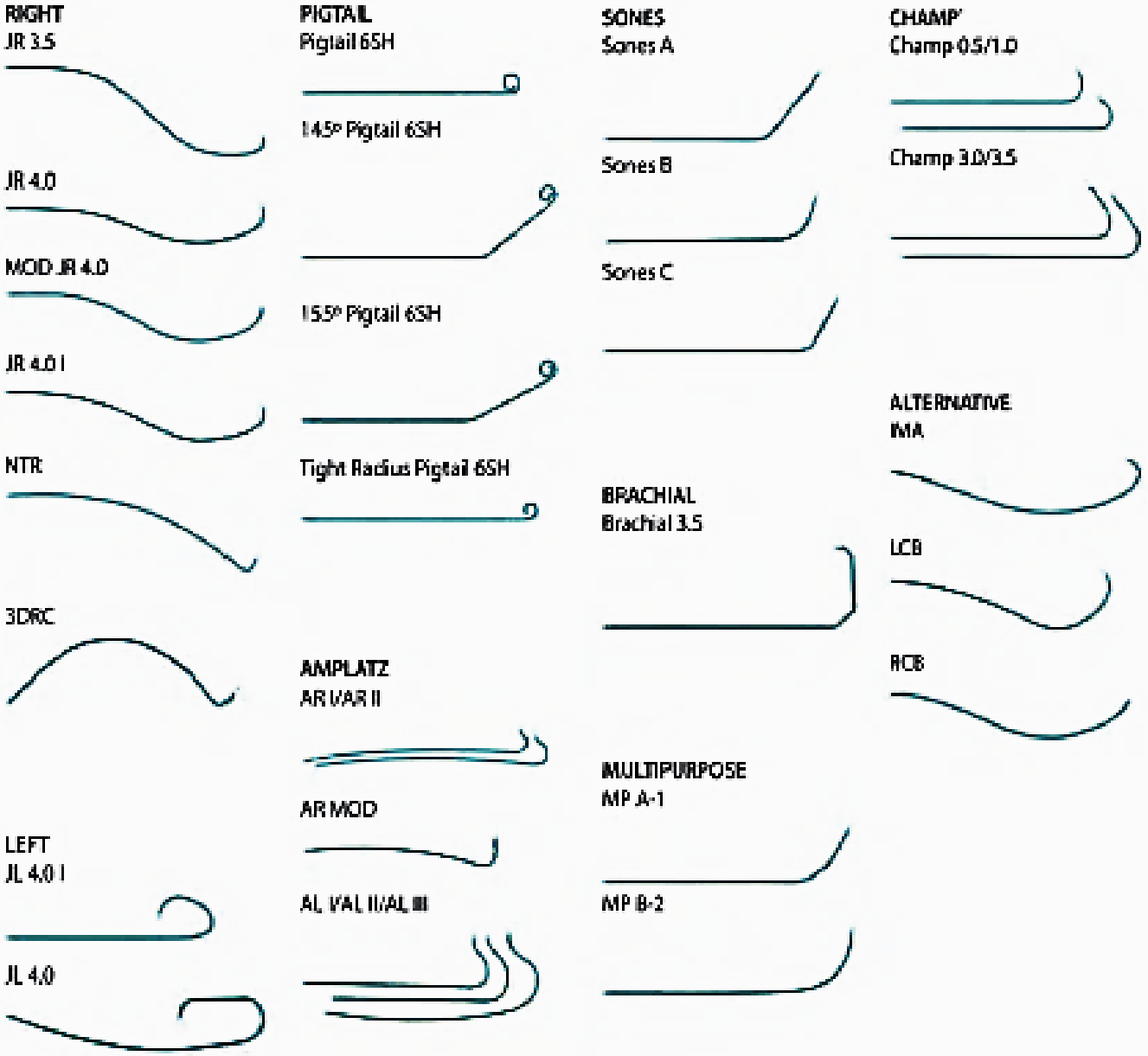


Fig. 7. Diagnostic catheter curves, picture courtesy of Medtronic

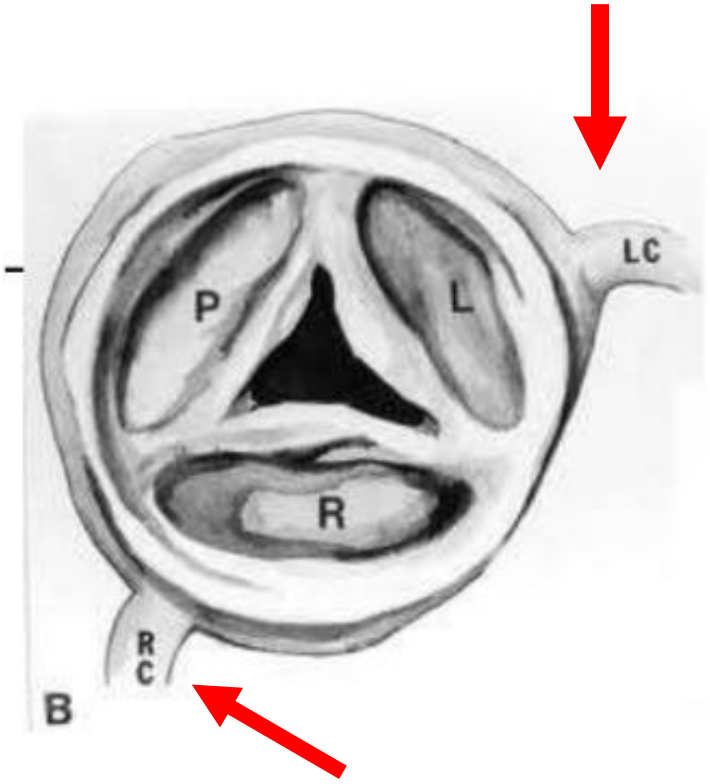
More than 250 Catheters !

Understand and Familiar with YOUR Workhorse Diagnostic catheters

NORMAL Coronary Artery

- The coronary artery arises just superior to the aortic valve and supply the heart

- The aortic valve has three cusps - #left coronary (LC), #right coronary (RC) #posterior non-coronary (NC) cusps.



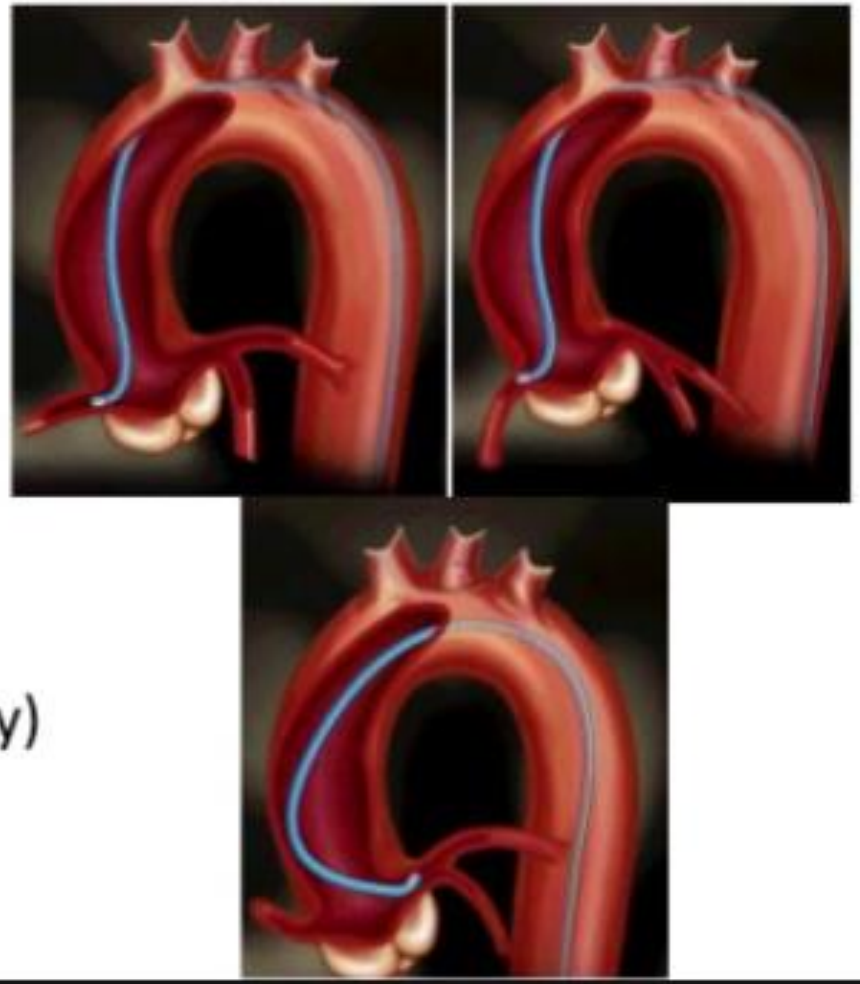
Coronary Artery OSTIUM – Anatomical Variation

Coronary ostial location:

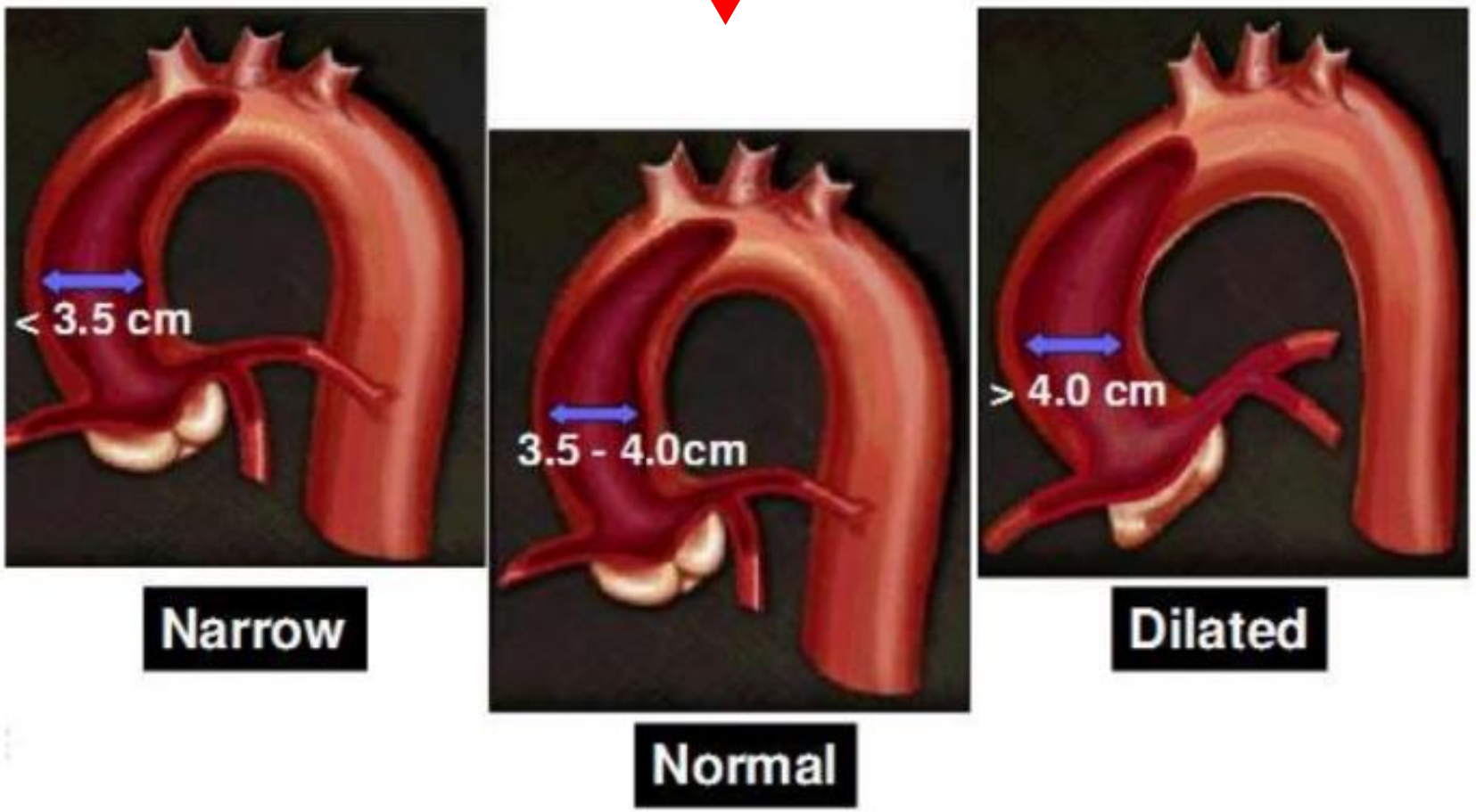
- high
- low
- anterior
- posterior

Coronary ostial orientation:

- superior
- horizontal
- inferior
- shepherd's crook (RCA's only)



Aortic width

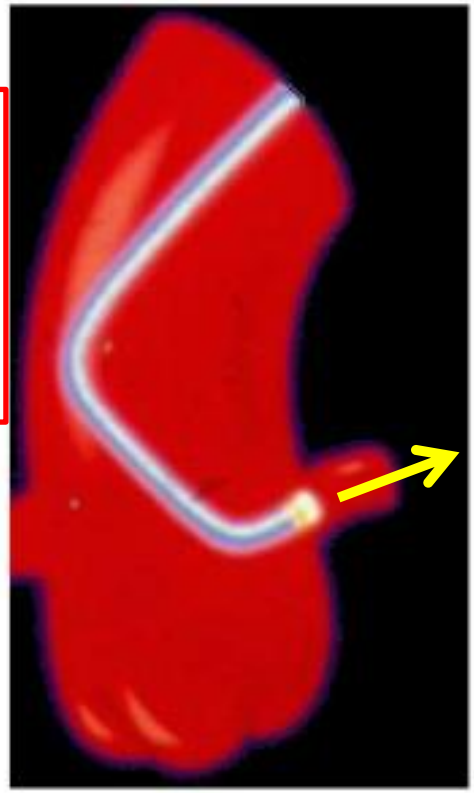


Selection of Catheters

- * MOST IMPORTANT REQUIREMENT: CO-AXIAL ALIGNMENT

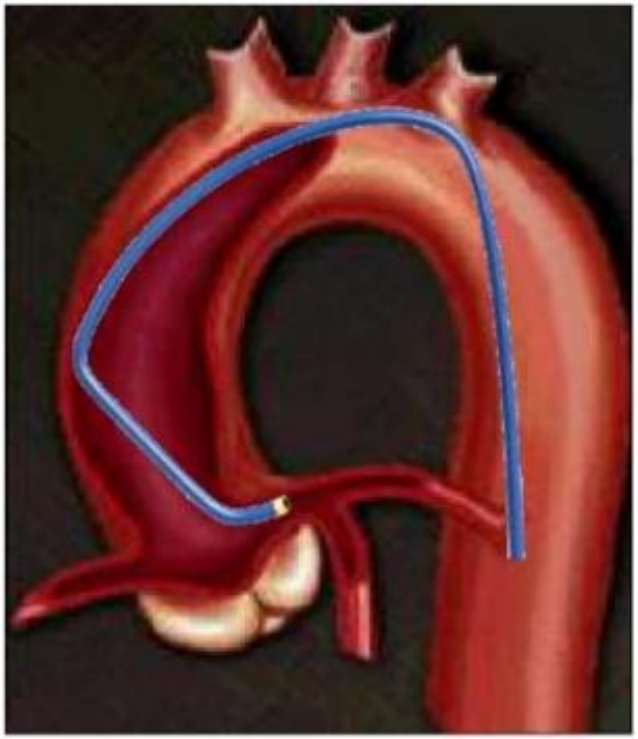
Non-Coaxial

VITAL PRINCIPLE

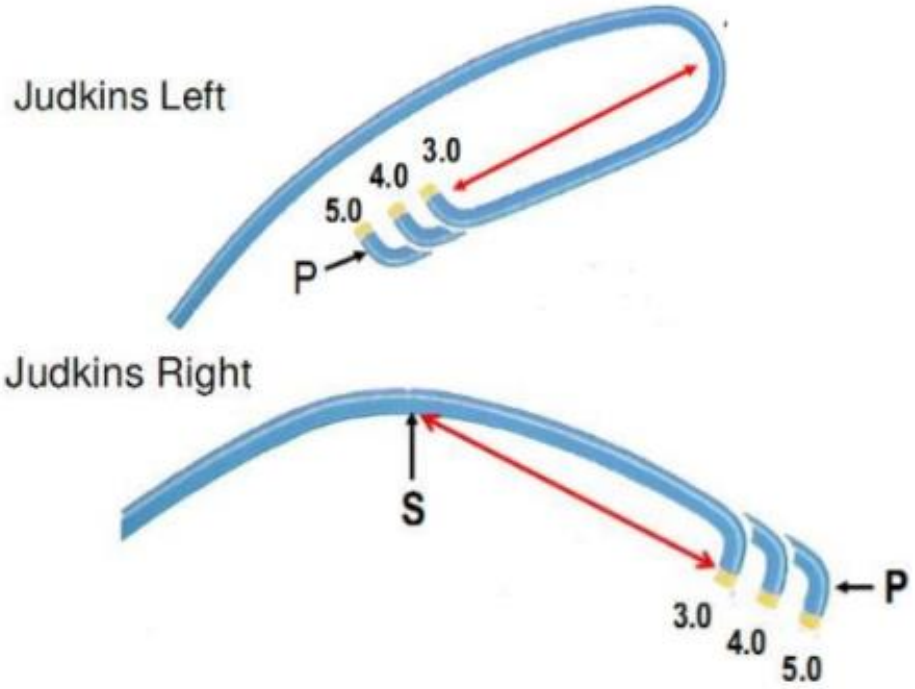


Coaxial

AORTIC WIDTH determine the CURVE



Co-axial alignment with 45^0 at the primary curve and the secondary curve buttressing at the C/L wall

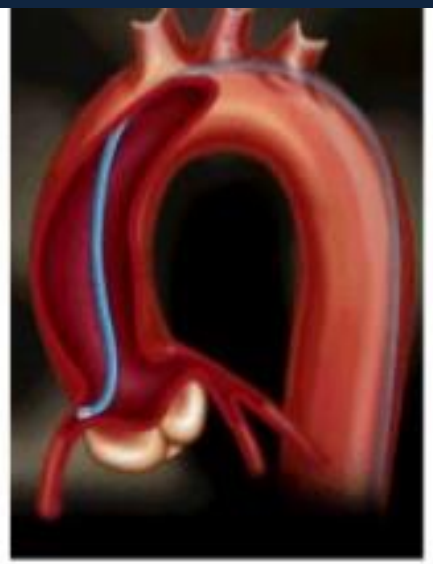


Curve length = distance between P (primary curve) & S (secondary curve)

- Aortic diameter determines the curve length

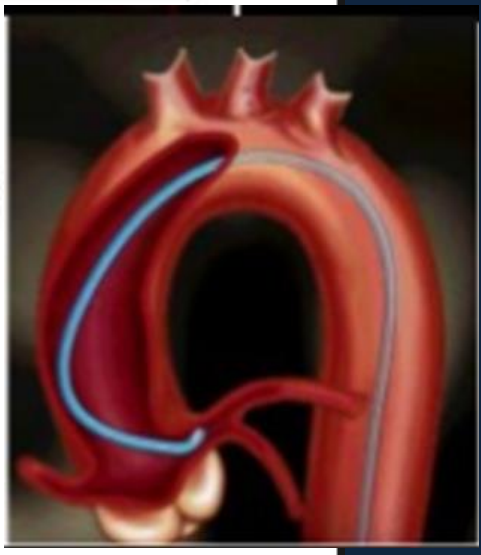
JUDKINS Catheters

- Selected according to
  - width of the ascending aorta
  - location of the ostia to be cannulated
  - orientation of the coronary artery segment proximal to the target lesion

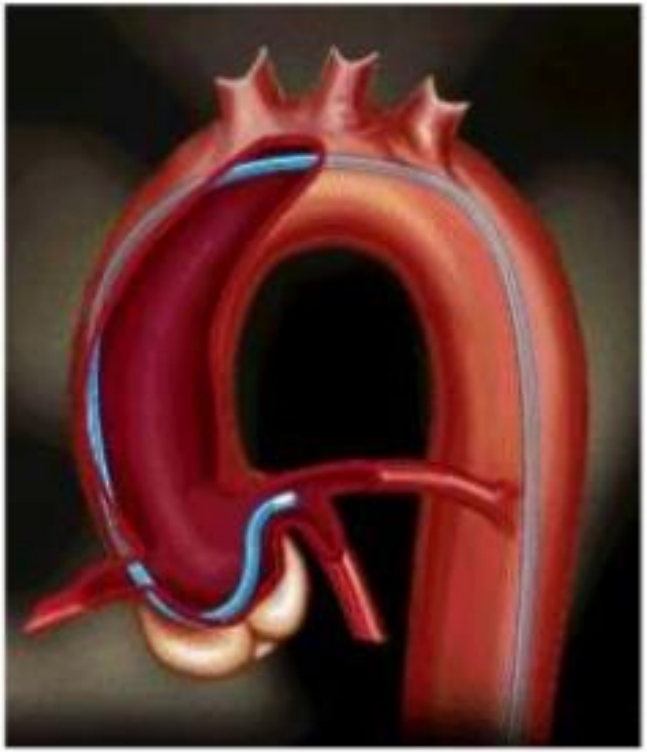


- Segment between the primary and secondary curve of Judkins left guide should fit width of ascending aorta

  ex:3.5 cm,4 cm, 4.5 cm



LCA- HIGH Left TAKEOFF

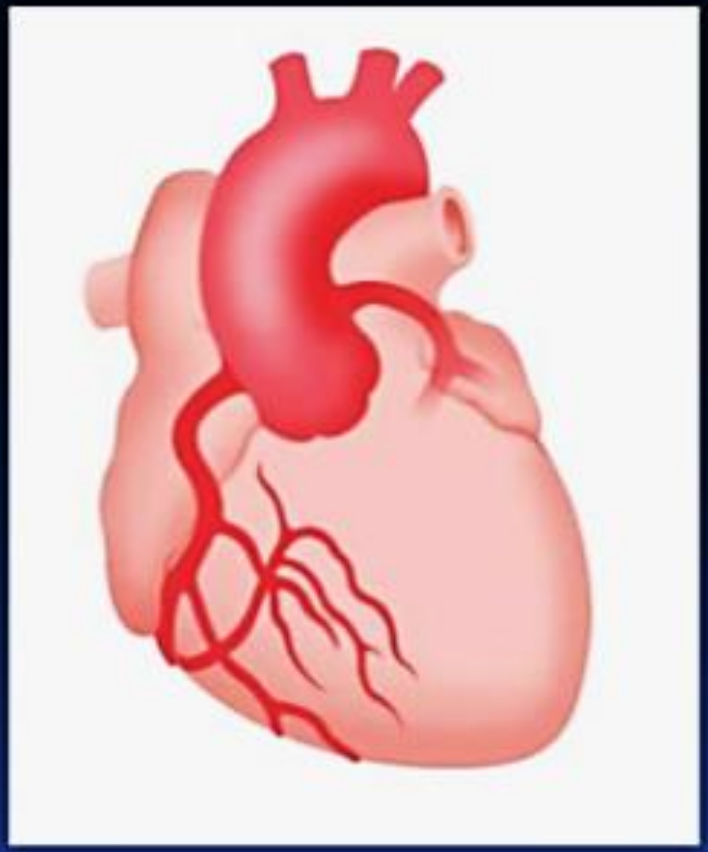


AL 1.5

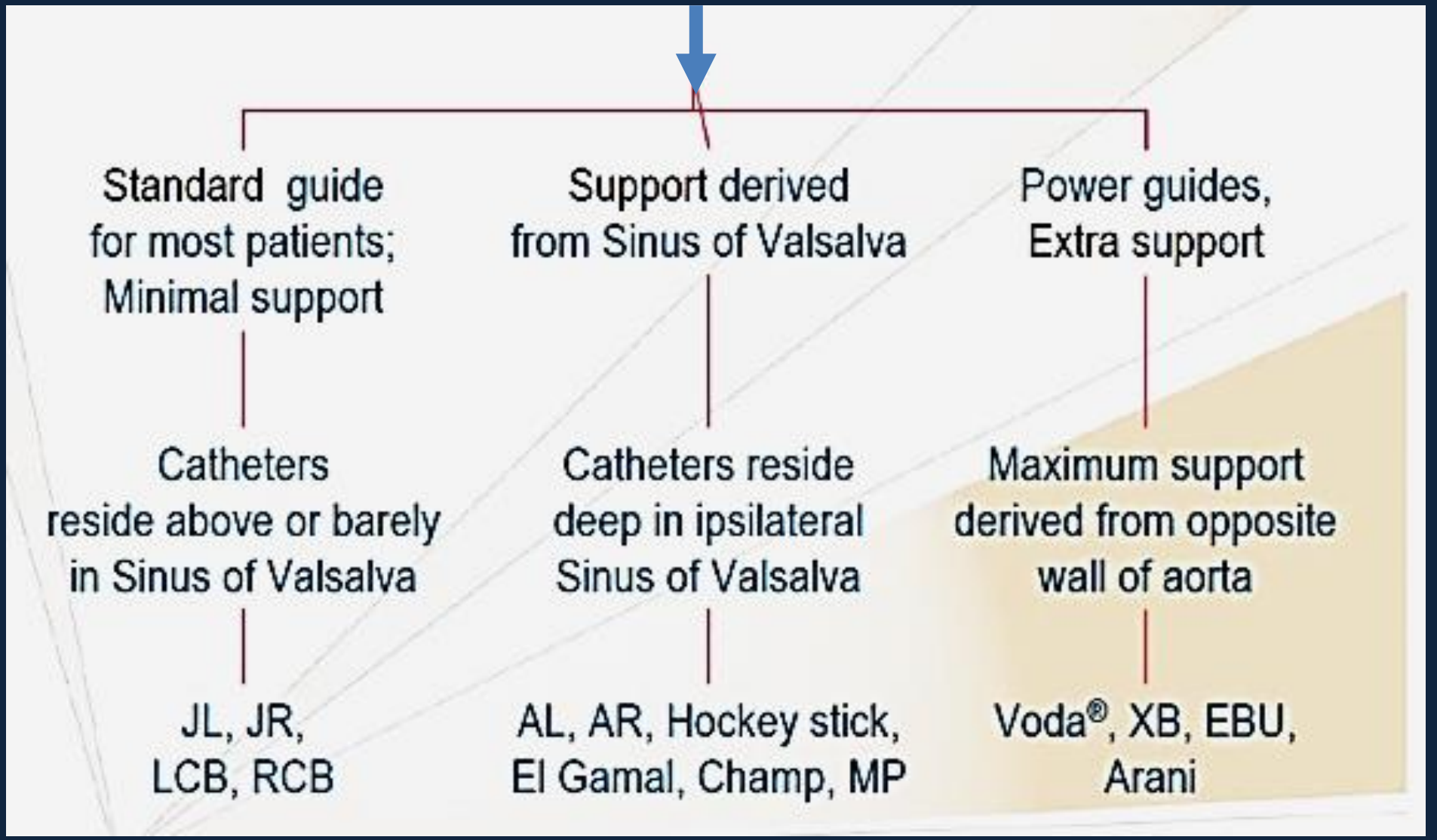
EBU 3.5

RCA- Diagnostic Catheters Selection

- Judkins Right
  - JR3
  - JR3.5
  - JR4, JR4ST (Short Tip)
  - JR5
  - JR6
- Amplatz
  - AR1, AR2
- Hockey Stick
- Multi Purpose (MPA)



Selection and Support of Guide Catheters (More x PCI)

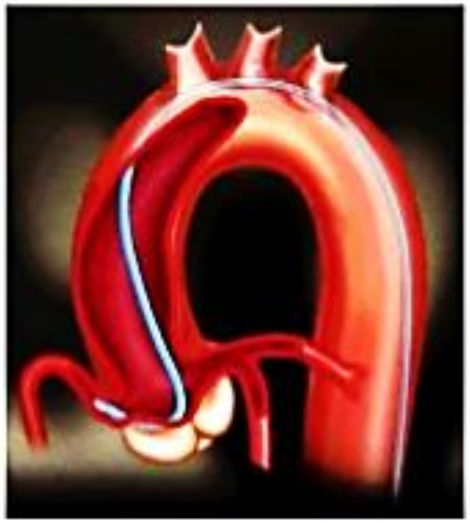


Support of Various Guiding Catheters

JR4

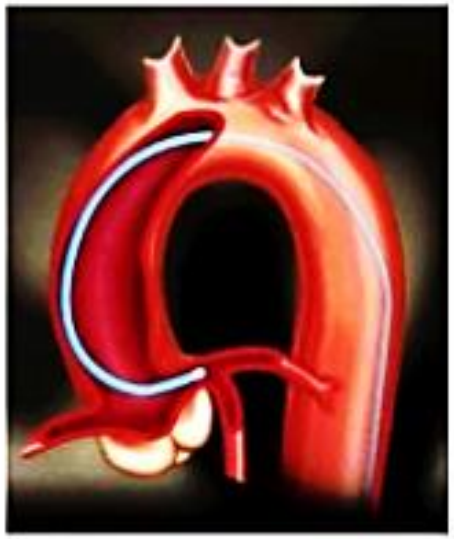
Simple coaxial alignment, without support

Hockey Stick



Coaxial alignment, with extra support from Sinus of Valsalva

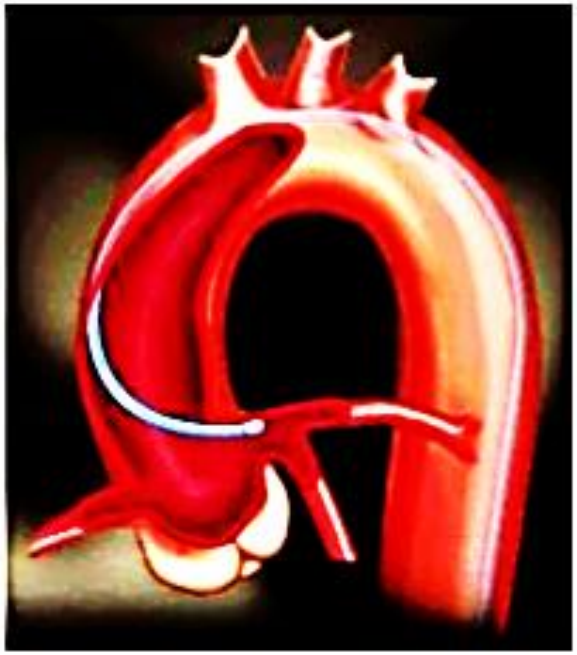
EBU

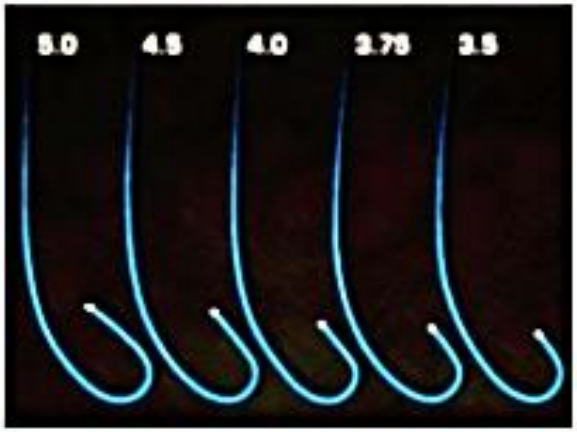


Coaxial alignment, with power support from opposite wall of aorta

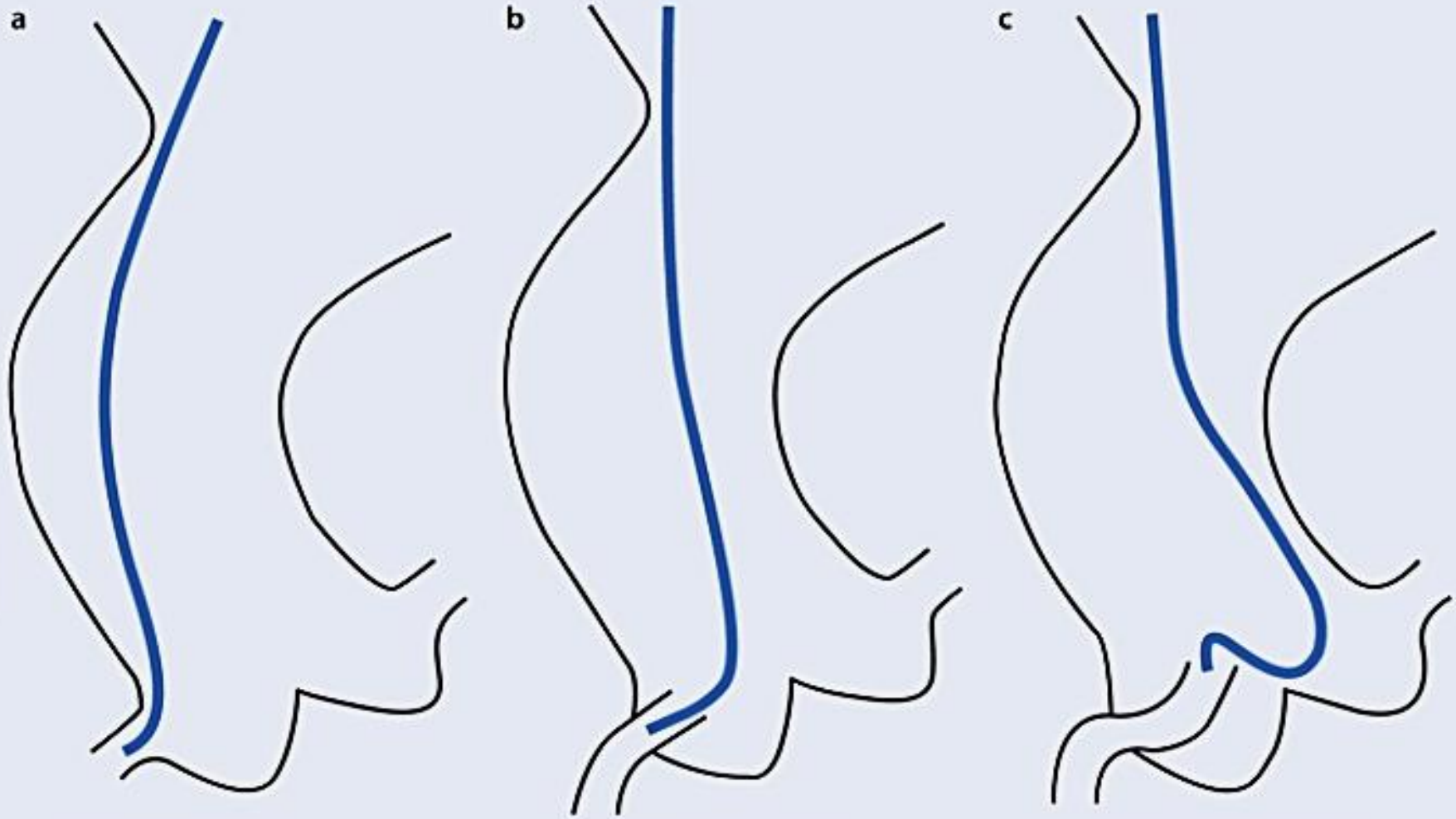
GUIDE Catheter with Extra Backup Support

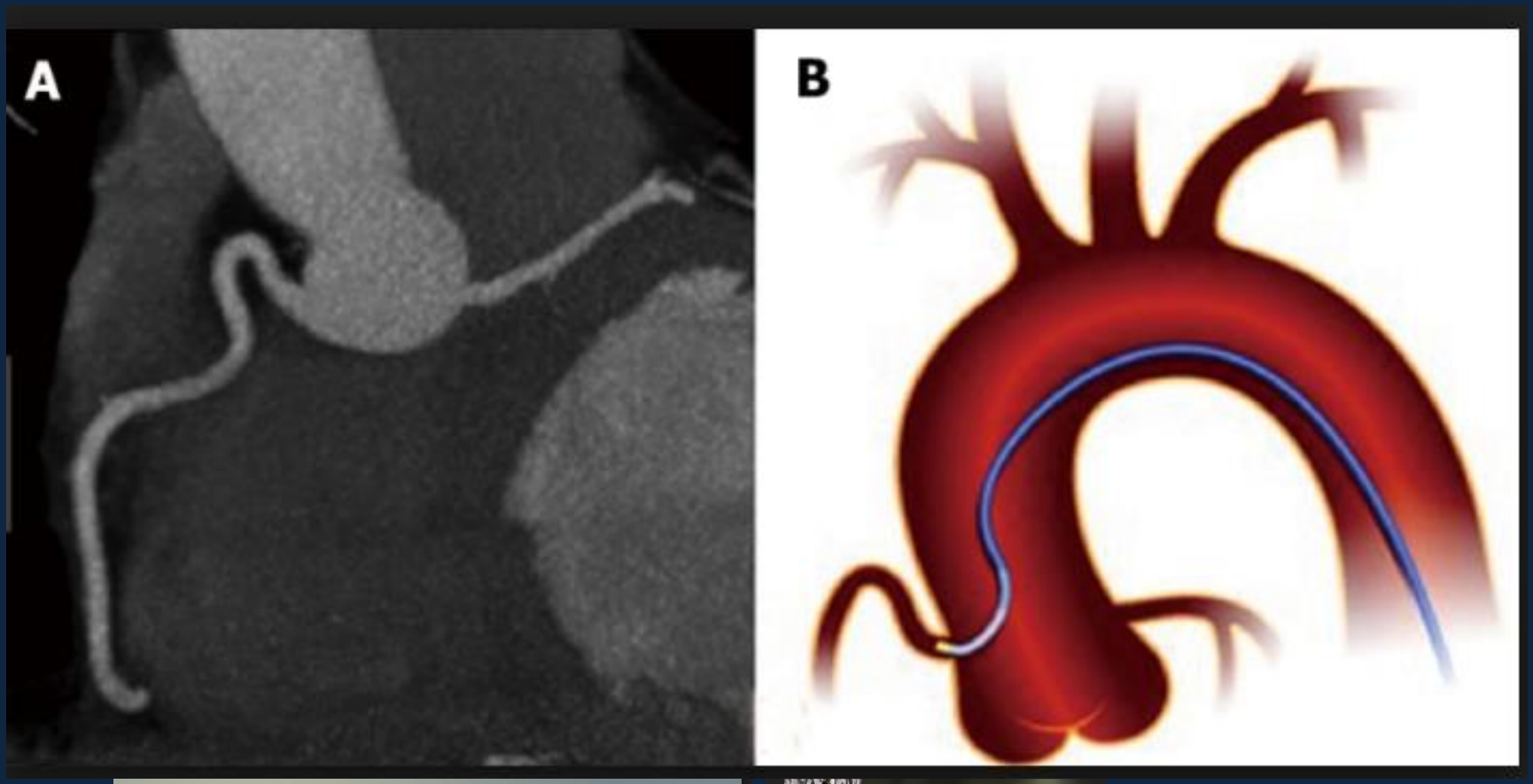
- Long tip forms a fairly straight line with the LM axis or the proximal ostial RCA
- Long secondary curve - abut the opposite aortic wall
- So tip in the coronary artery is not easily displaced
- Provide a very stable platform





Solution to Difficult RCA Cannulation

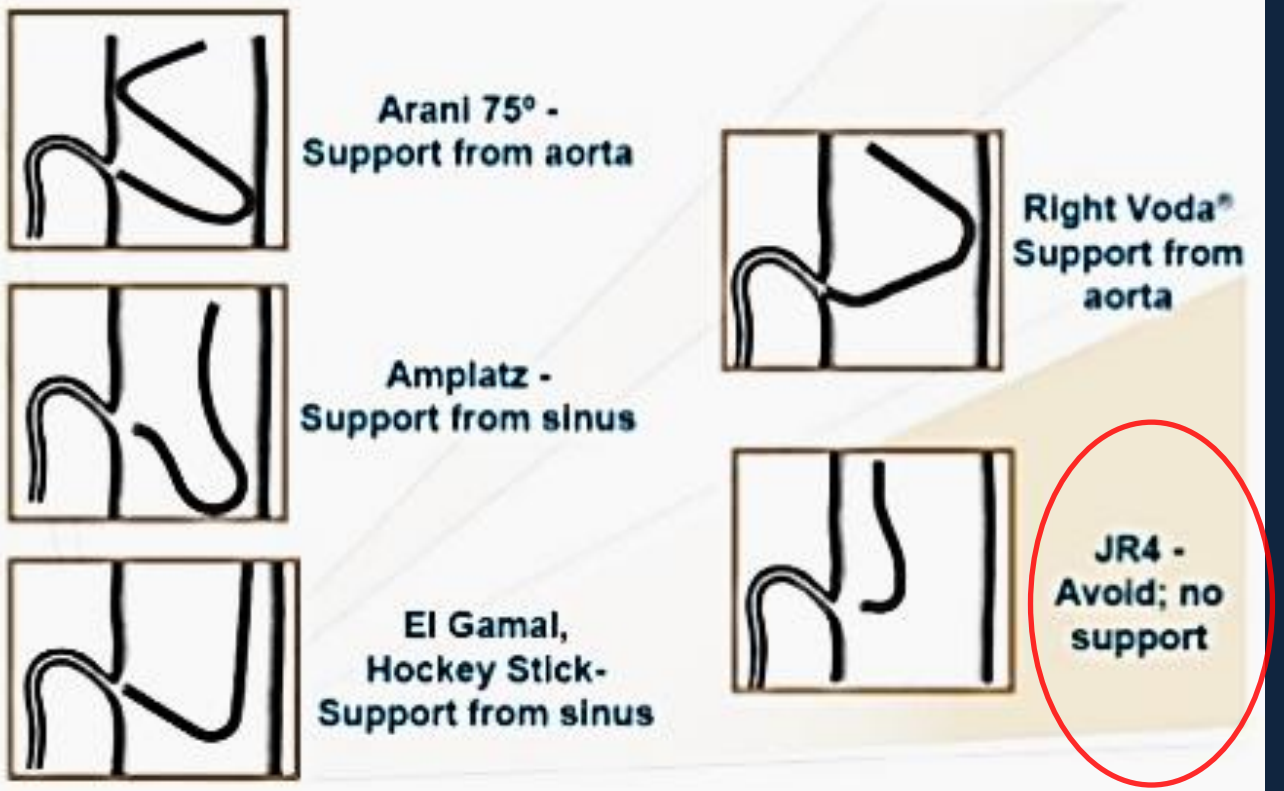




SHEPHERD'S CROOK

Shepherd's crook deformity of RCA

Dramatic upturn with
a near 180 degree
switch back turn



HOCKEY STICK
Catheter

Techniques for Cannulating CABG Grafts

Saphenous Vein Bypass Grafts

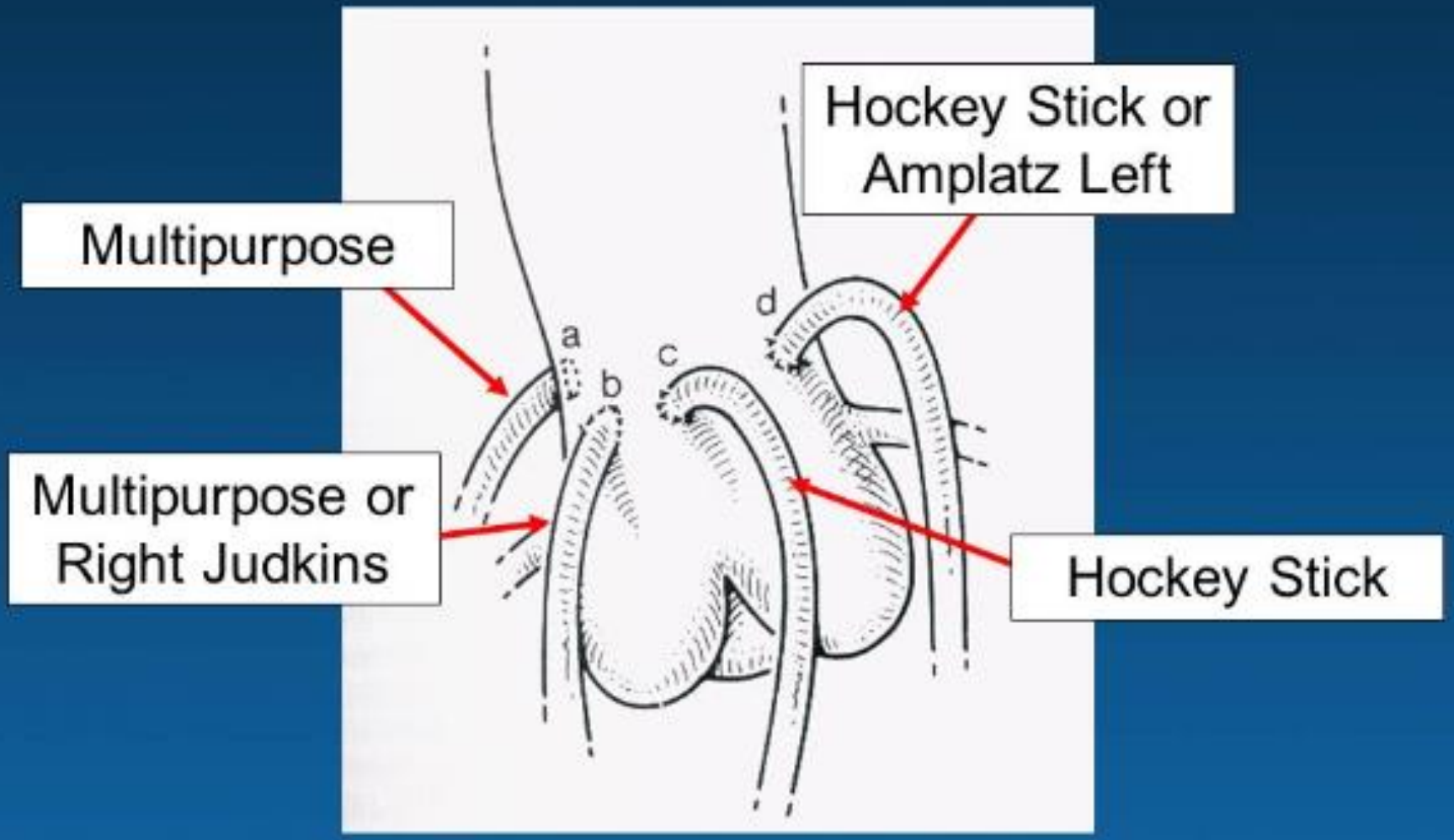
In general, saphenous vein bypass grafts are anastomosed to the anterior wall of the ascending Aorta.

The right coronary artery graft usually is anastomosed a few centimeters above and anterior to the right coronary orifice.

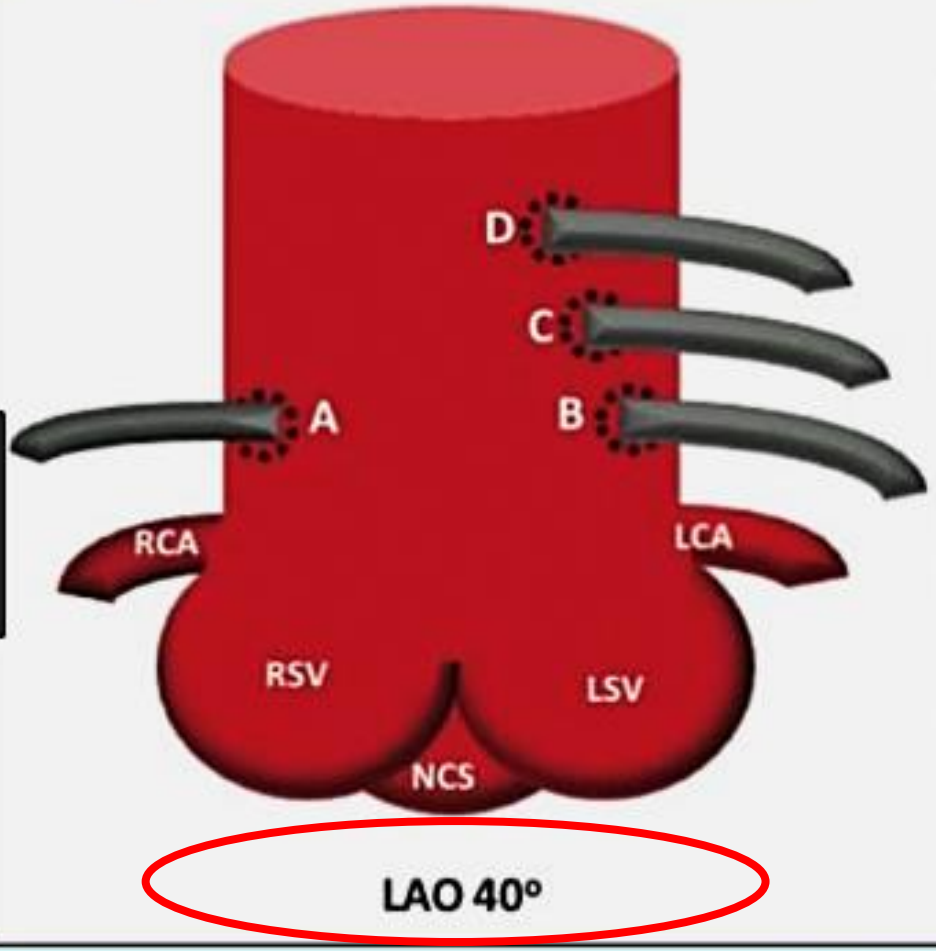
Left anterior descending and diagonal grafts usually are anastomosed somewhat higher and slightly to the left.

Obtuse marginal grafts are usually the highest and furthest left.

Catheters for Saphenous Vein grafts



Catheters for Saphenous Vein grafts



Optimal guide catheter selection for vein grafts to the distal right coronary artery or distal left dominant circumflex artery

- Primary: Multipurpose
- Alternate: Judkins Right (JR), Amplatz Left (AL), Right Bypass

If graft has more anterior take-off:

- Primary: AL
- Alternate: JR, Multipurpose, Hockey Stick

Optimal guide catheter selection for vein grafts to the left coronary artery:

- Primary: JR, Hockey Stick
- Alternate: AL, Left Bypass, Multipurpose

If graft has more anterior take-off:

- Primary: AL, Hockey Stick
- Alternate: JR, Left Bypass, Multipurpose

Techniques for Cannulating IMA Grafts

Internal Mammary Artery Graft Cannulation

The left internal mammary artery (IMA) originates anteriorly from the caudal wall of the subclavian artery distal to the vertebral artery origin.

The left subclavian artery can be entered using a right Judkins catheter but a more sharply angled catheter tip on the mammary artery catheter is preferred.

The right Judkins or IMA catheter is advanced into the aortic arch up to the level of the right brachiocephalic truncus with the tip directed caudally.

Subsequently, the catheter is withdrawn slowly and rotated counterclockwise.

Techniques for Cannulating IMA Grafts

Internal Mammary Artery Graft Cannulation

The catheter tip is deflected cranially, usually engaging the left subclavian artery at the top of the aortic knob in the anteroposterior projection.

Once the subclavian artery is engaged, the catheter is advanced over a J-tipped or flexible straight tip guidewire beyond the internal mammary orifice.

After the catheter has been advanced beyond the internal mammary artery takeoff, the guidewire is withdrawn slowly and small contrast injections are given to visualize the internal mammary artery orifice.

Because of the peculiar tip configuration, the internal mammary curve catheter and especially the C-type IMA catheter usually engages into the IMA ostium without much difficulty.

Techniques for Cannulating IMA Grafts

Right Internal Mammary Artery Graft Cannulation

Right internal mammary artery cannulation is less common and more difficult than left internal mammary artery cannulation.

The right brachiocephalic truncus is entered using a right Judkins catheter by deflecting the tip with a counterclockwise rotation at the level of the brachiocephalic truncus.

The catheter is advanced into the subclavian artery.

The rest of the manipulation is similar to that described for left internal mammary artery graft cannulation.

Techniques for Cannulating IMA Grafts

Right Internal Mammary Artery Graft Cannulation

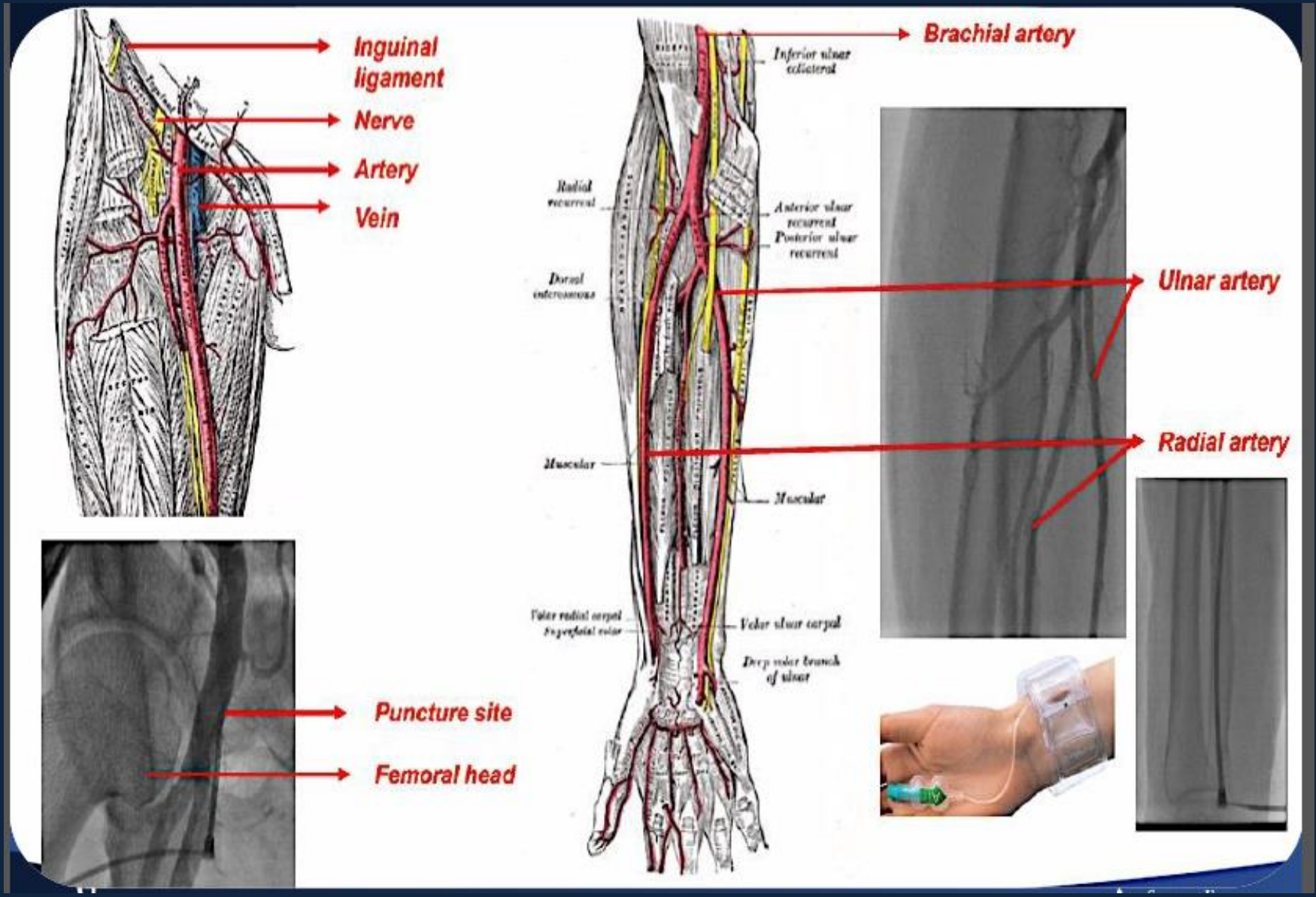
In patients for whom cannulation of the internal mammary artery is not possible because of excessive tortuosity or obstructive lesions, an internal mammary artery catheter can be introduced through the ipsilateral radial artery.

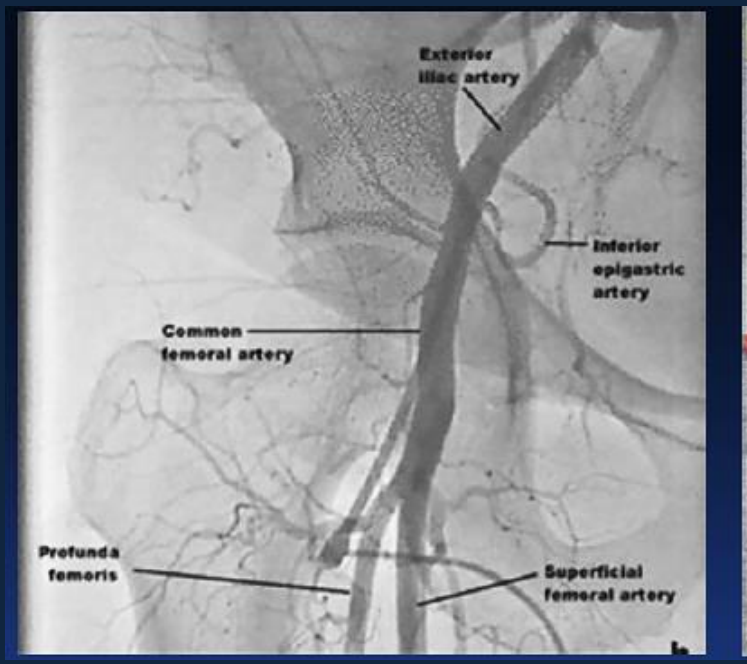
The catheter is advanced beyond the mammary artery orifice over a guidewire.

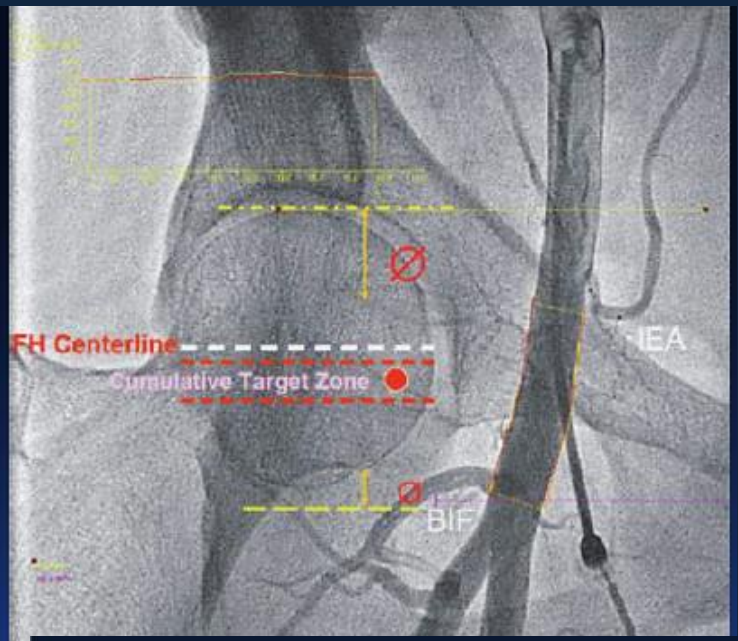
Withdrawing it slowly and making frequent, small contrast injections engage the catheter.

A technique for cannulation of the contralateral internal mammary artery from the arm approach using a Simmons catheter also has been described.

Understand the Vascular Access Anatomy





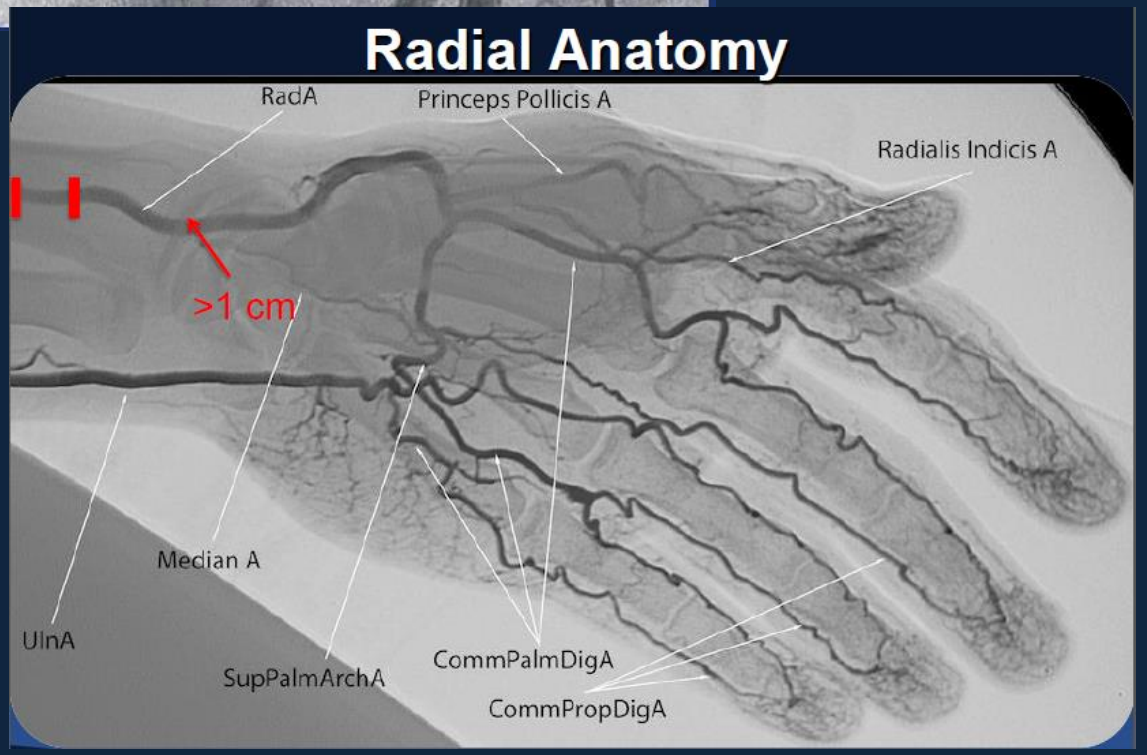


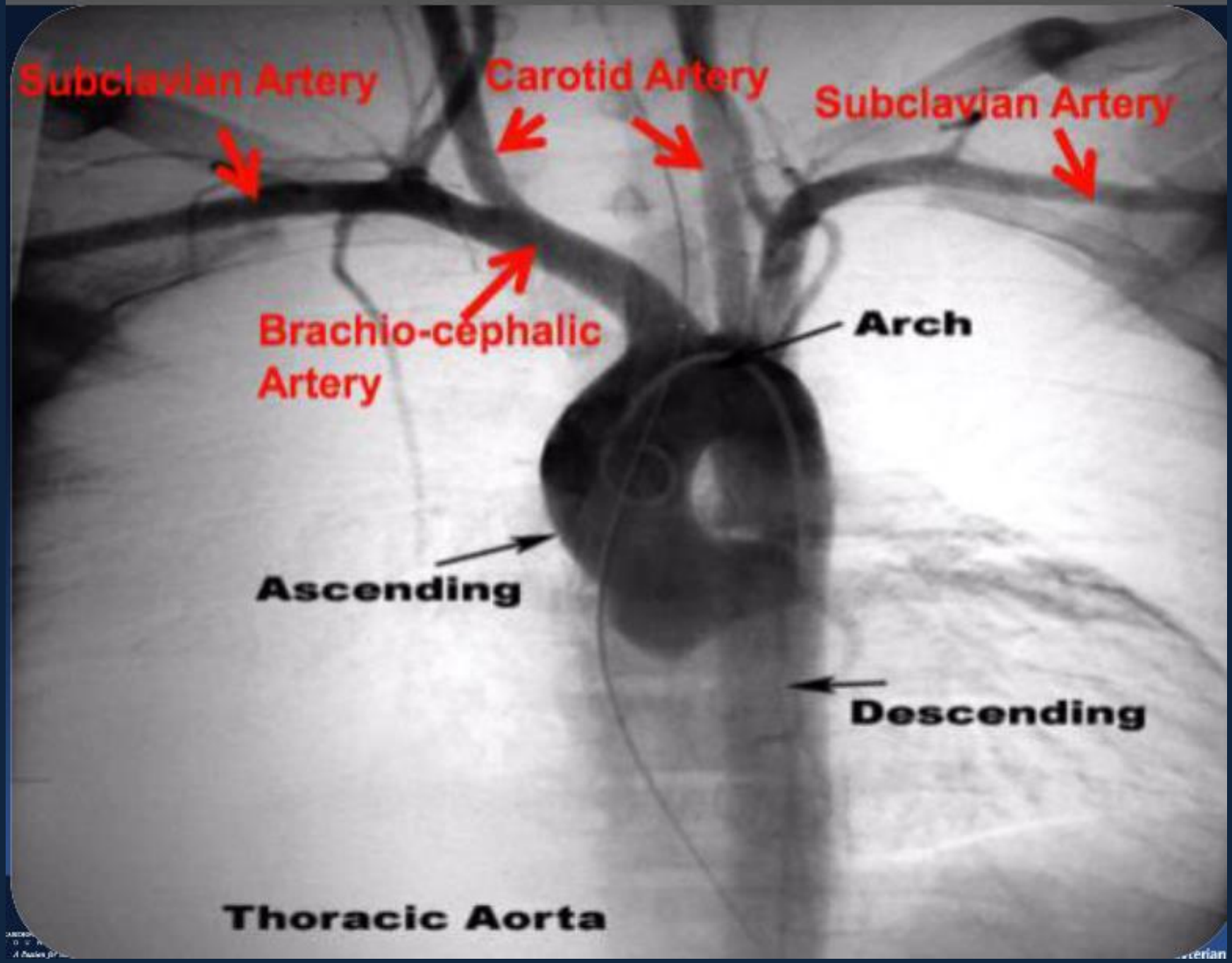
Femoral Anatomy

Fluroscopy Guided
or
USG Guided

Others :

Ulnar / Brachial
Snuffbox
Slender Club etc




Subclavian Artery
Carotid Artery
Subclavian Artery
Brachio-cephalic Artery
Arch
Ascending
Descending
Thoracic Aorta

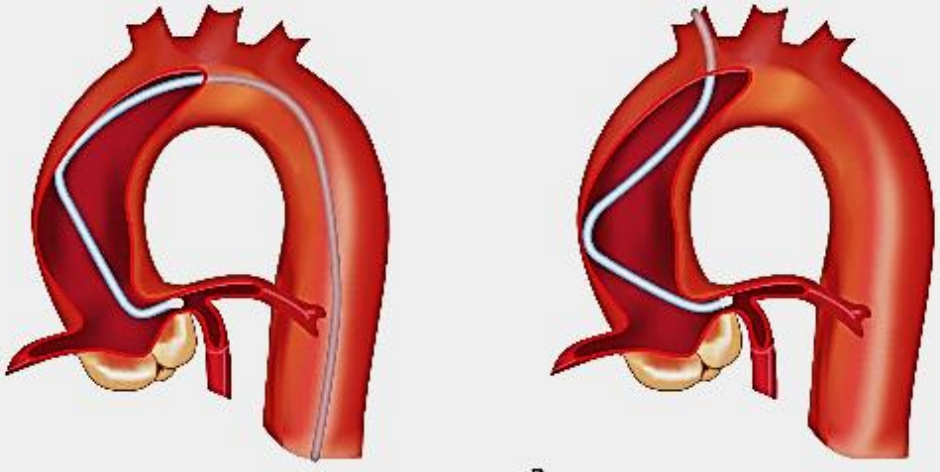


FIGURE 7-2 Differential catheter course through transfemoral **(A)** and transradial **(B)** vascular access. Because of the curvature between the brachiocephalic trunk and the ascending aorta, a shorter secondary curve, usually by 0.5 cm, is needed for successful cannulation of the LCA with a JL catheter. The operators should use a JL 3.5 **(B)** instead of a JL 4.0 **(A)**. (Courtesy of Medtronic.)

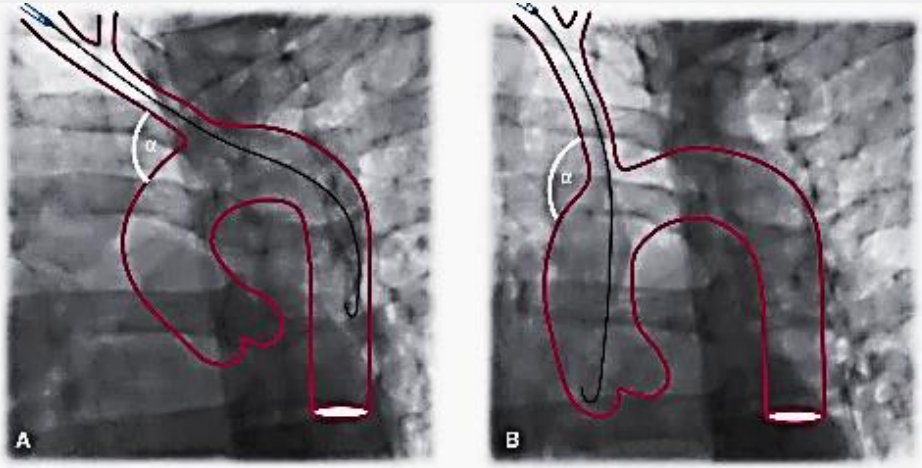
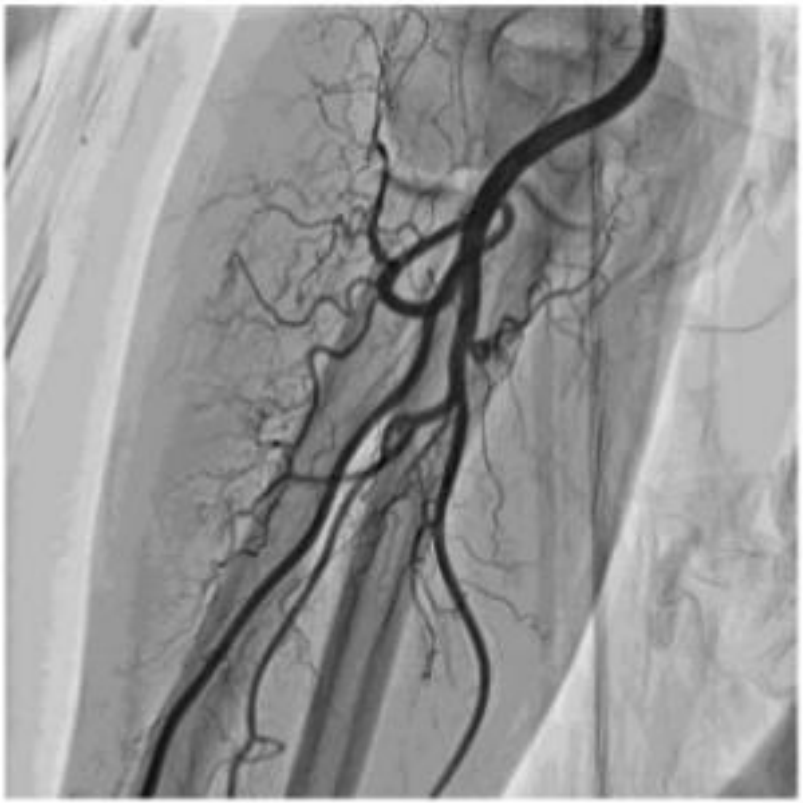


FIGURE 7-3 Effect of Inspiration. **A:** During expiration there is a more acute angle (a) between the brachiocephalic trunk and the ascending aorta; therefore, the wire takes a more horizontal direction toward the descending aorta. **B:** During deep inspiration, the diaphragm lowers the heart and straightens the angle (a) between the brachiocephalic trunk and the ascending aorta. The wire takes a more vertical direction toward the ascending aorta.

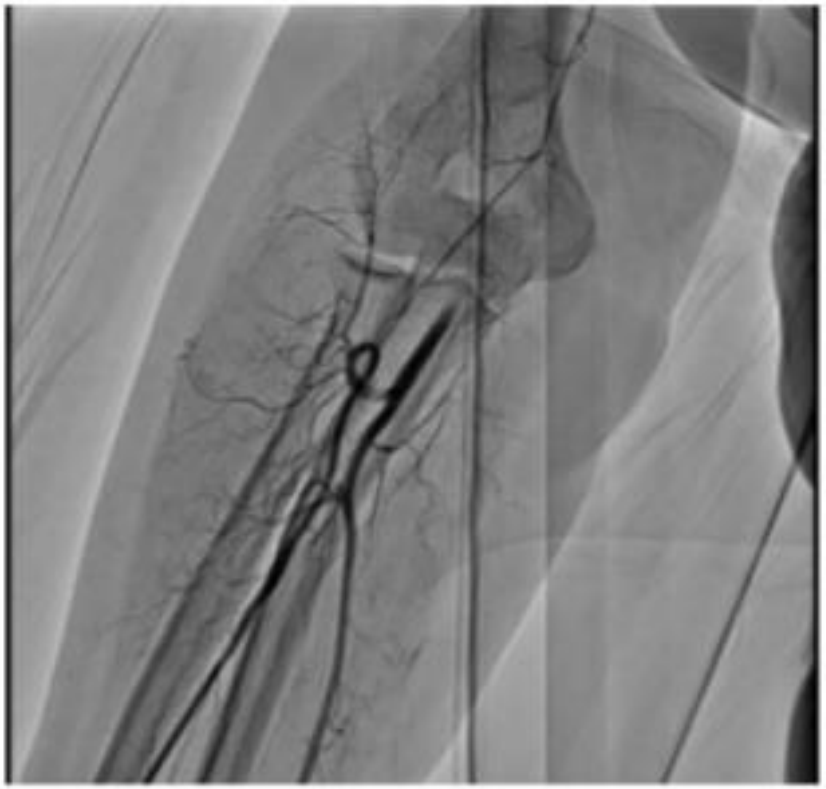
Anatomical Variants – Radial Artery

Anatomical variants	Number of patients
Total Number of patients with anomalies	1114 (10,6%)
High bifurcating origin of the radial artery from the brachial or axillary arteries	733 (7%)
Radial artery loop (360°)	105 (1%)
Radial artery tortuosity	152 (1,4%)
Hypoplastic radial artery	17 (0,16%)
Loop of the brachial/axillary/subclavian artery	113 (1,0%)
Anomalies of the aortic arch Retroesophageal right subclavian artery (a.Lusoria)	6 (0,05%)

Radial artery loop

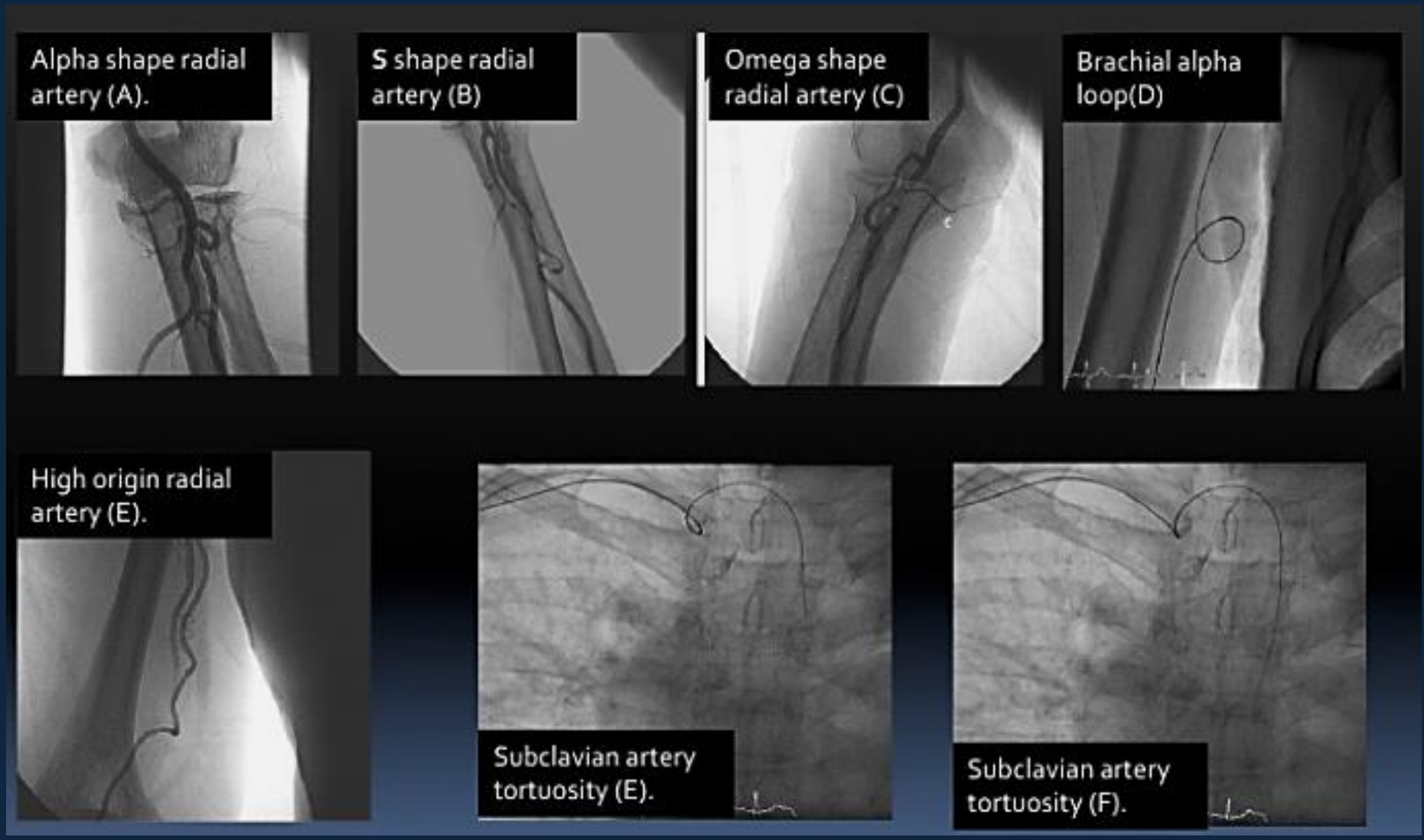


- 1% according our data



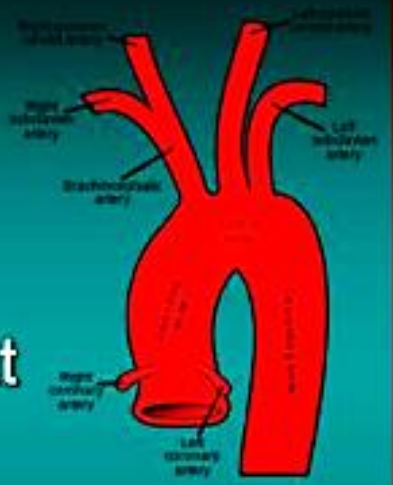
- The loop consists of a tight retrograde bend of the radial artery before joining the ulnar artery in the forearm

Radial Artery –Anatomical Variation



The Learning Curve: Transradial Pitfalls

- Getting access
- Radial Artery Spasm
  - ✓ Prevention and management
- Anatomical Variations
  - ✓ Tortousity, vascular anomalies
- Transversing the subclavian – Rt vs. Lt
  - ✓ Respiration maneuvers
  - ✓ Need for TF conversion **(Trans-Femoral)**
- Catheter shape selection for cannulation
- Catheter control and backup support
- "Patent Haemostasis" after pulling out the sheath



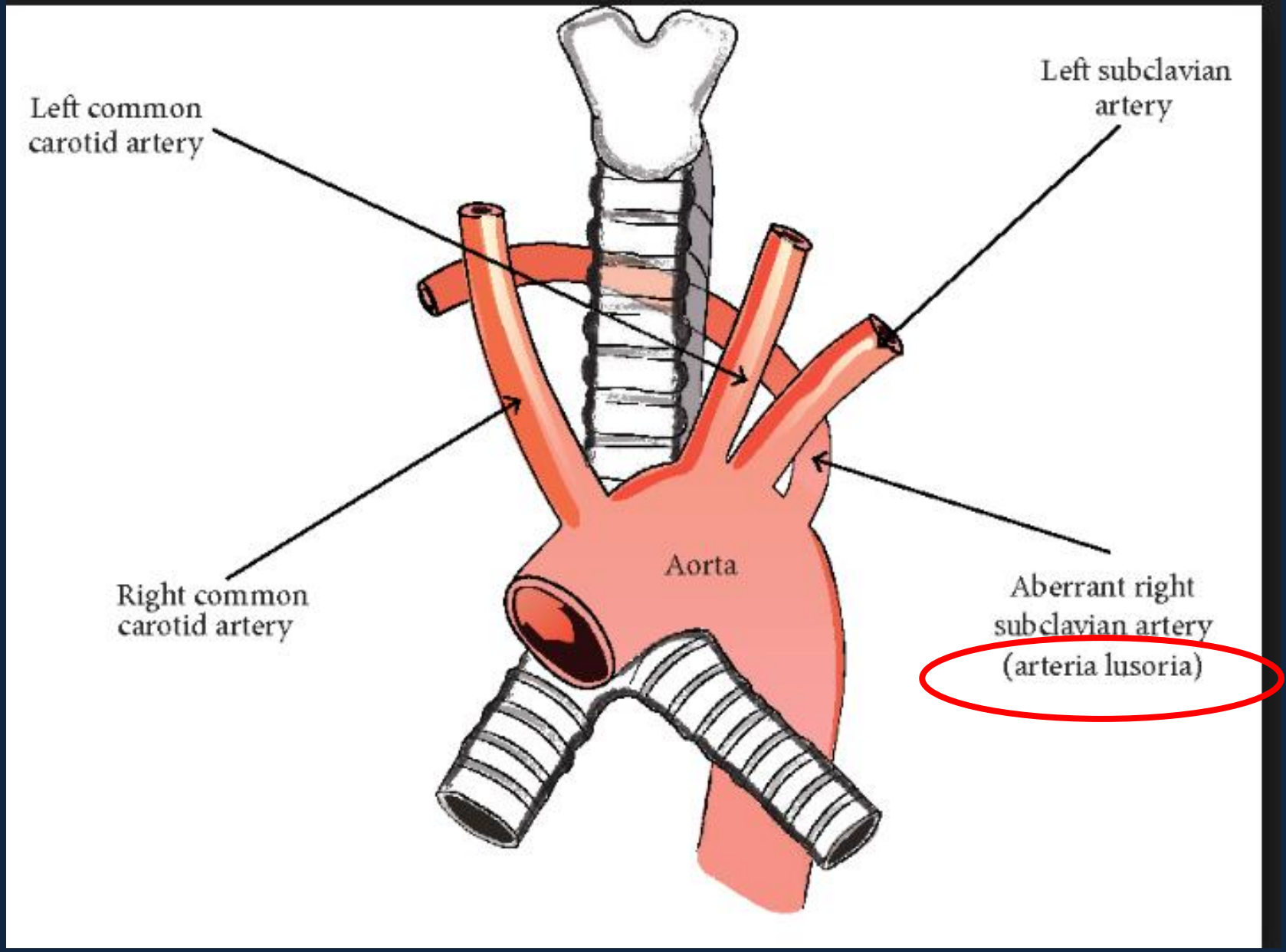
Trans-radial is not feasible in ~5-10%
(Reduce wrist to femoral crossover to~0.3%*)

1. **Anatomical variations**: hypoplastic radial artery
2. **Loops** (radial, brachial, axillary, innominate)**tortuosity**
3. **Stenosis & calcifications**
4. **Spasm or Pain** (females with larger sheaths & guides)
5. **Occluded / stenosed radial** from previous PCI
6. **Planned radial shunt or radial CABG**

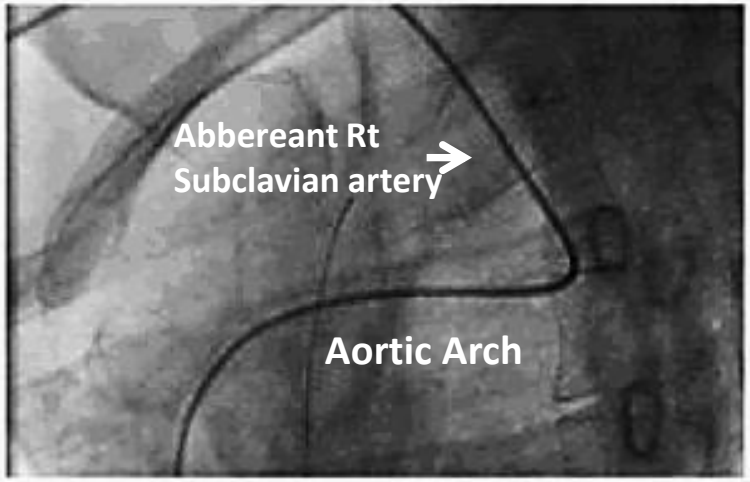
*Baumann F, Roberts JS. Evolving Techniques to Improve Radial/Ulnar Artery Access: Crossover Rate Catheterization and/or Percutaneous Coronary Intervention via the Wrist. J Interv Cardiol. 2015 Aug;28(4):396-404 0.3% in 1,000 Consecutive Patients Undergoing Cardiac.

Arteria Lusoria

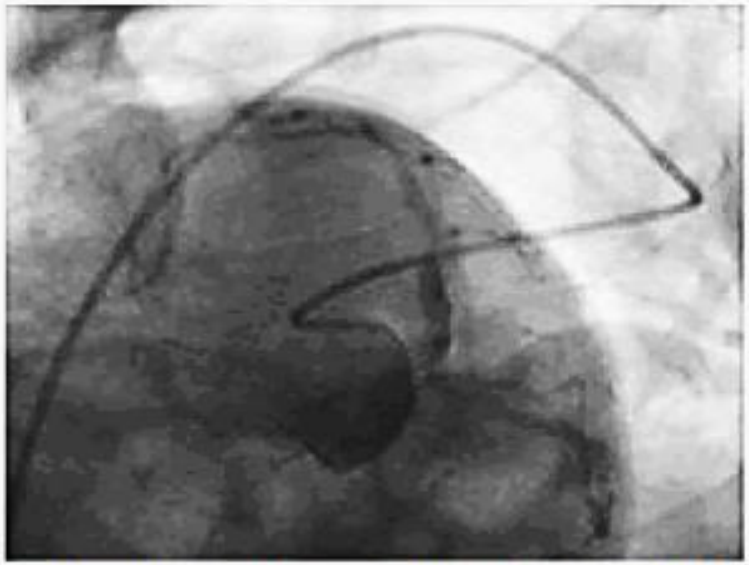
- Most common **Aortic ARCH Anomaly**
- In 0.5 to 2.5%
- **Aberrant** Rt subclavian artery- course upwards and to the right in posterior mediastinum
- Usually **Asymptomatic**
- Or dysphagia lusoria; dyspnea, chronic cough
- Treatment is indicated for symptomatic relief of dysphagia lusoria and prevent complications due to aneurysmal dilatation



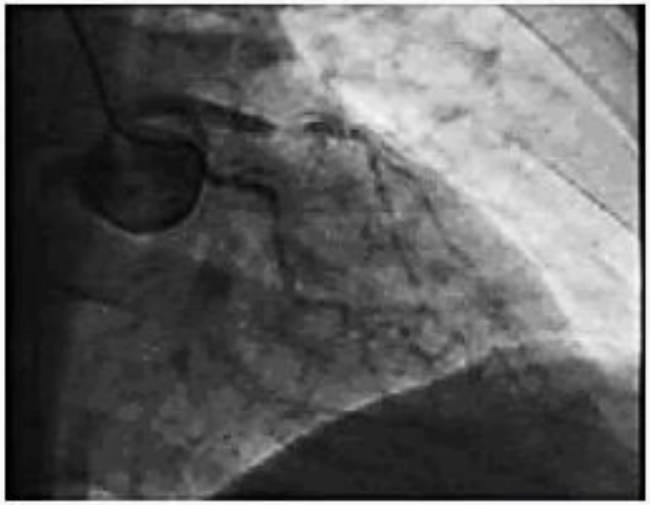
Arteria Lusoria



Angiographic image of 5Ftigercatheter



Left main ostial hook with EBU 3.5 in LAO caudal view



Mid LAD lesion

primary PCI through right trans ulnar access for a case of arteria lusoria

7

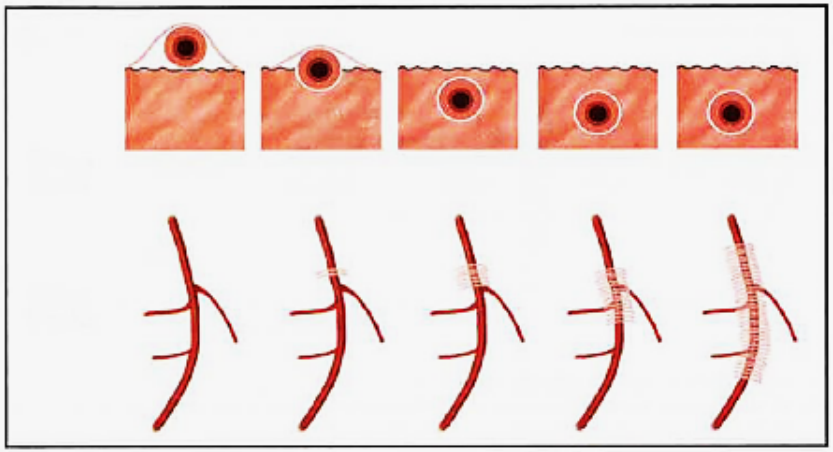
ARTERIA LUSORIA

Figure 1: Primary PCI through right trans ulnar access for a case of arteria lusoria.

Myocardial Bridging

Intramyocardial Segment

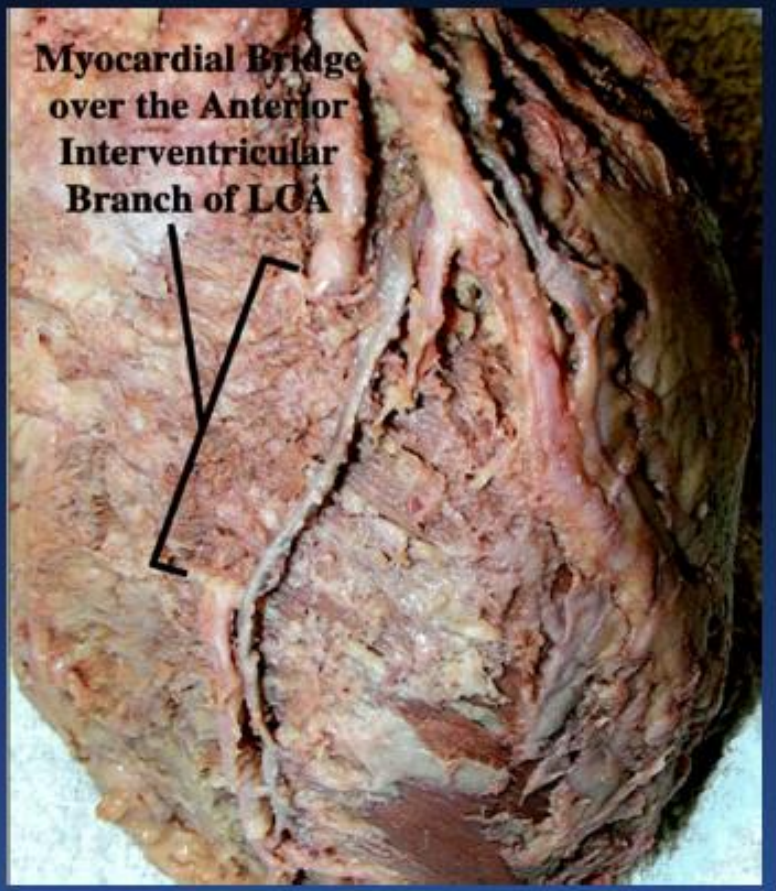
- Almost always LAD
- Systolic compression of the vessel, diastolic relaxation of the vessel
- Occurs in 5-12% of patients
- Usually NOT hemodynamically significant
- Usually NOT the cause of chest pain



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.

Myocardial Bridge

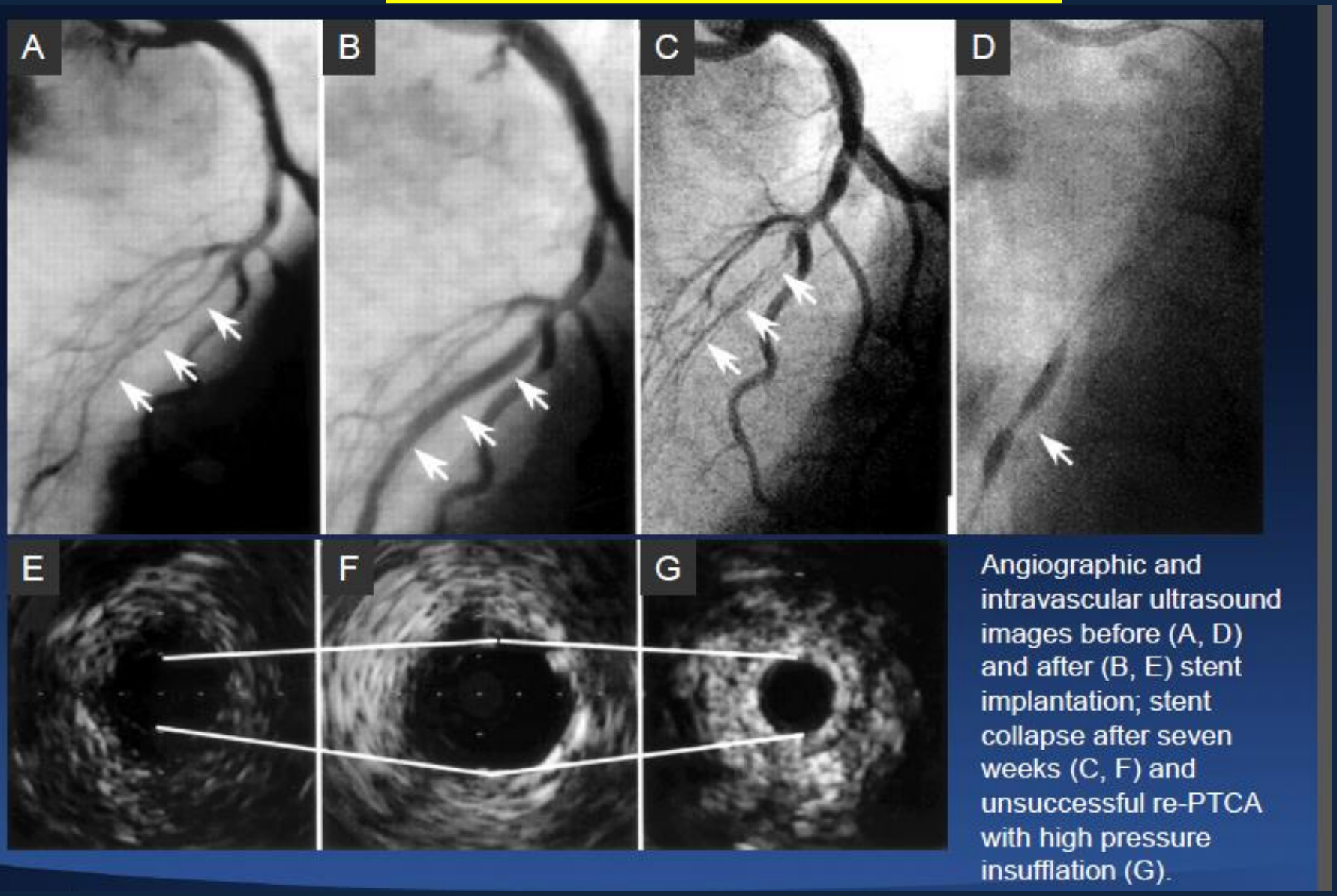
- Segment of a major coronary epicardial coronary artery that *dives intramurally* through the myocardium beneath the muscle bridge.[1]
- Generally involving ***LAD*** and its diagonal branches
- Frequency
  - Coronary angiographic series: ***0.5-16%***
  - Pathological series up to 85%. [1,2]
- Superficial and deep variants



Loukas et al Journal of Anatomy 2006; 209(1): 43-50.

[1] Alegria et al Eur Heart Journal 2005; 26:1159-1168
[2] Ge et al Eur Heart Journal 1999; 20:1707-1716

Myocardial Bridging



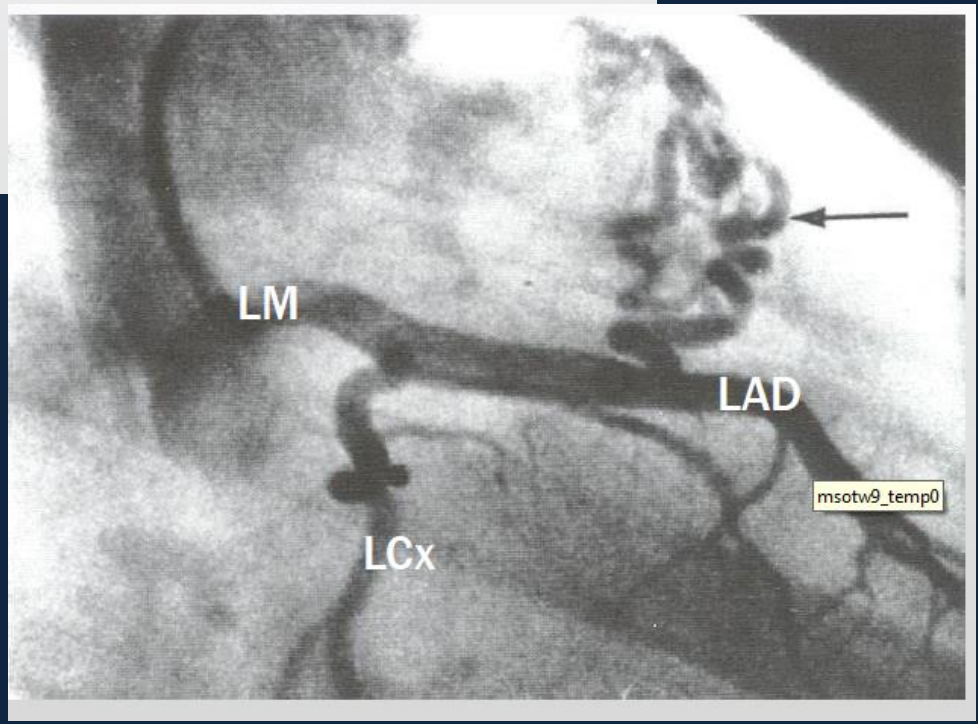
Angiographic and intravascular ultrasound images before (A, D) and after (B, E) stent implantation; stent collapse after seven weeks (C, F) and unsuccessful re-PTCA with high pressure insufflation (G).

Haager et al. Heart 2000;84 ;403-8

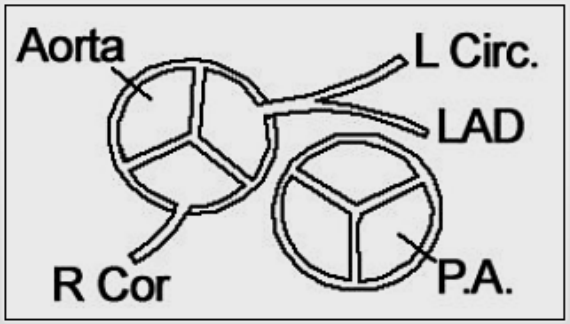
Coronary Arterial Fistula

- 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

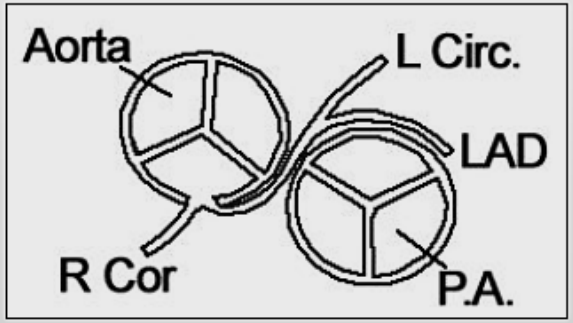
LAD to PA Fistula



Anomalous Coronary Arteries

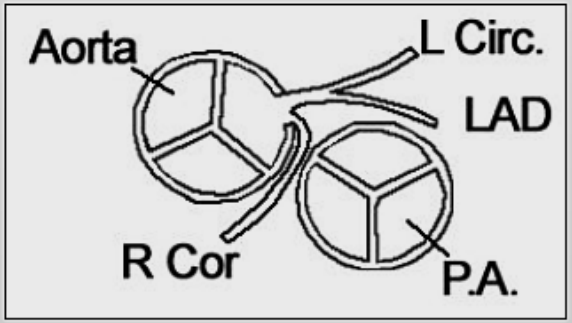


Normal



LM from RCC

RCA from LCC



Coronary Anomalies

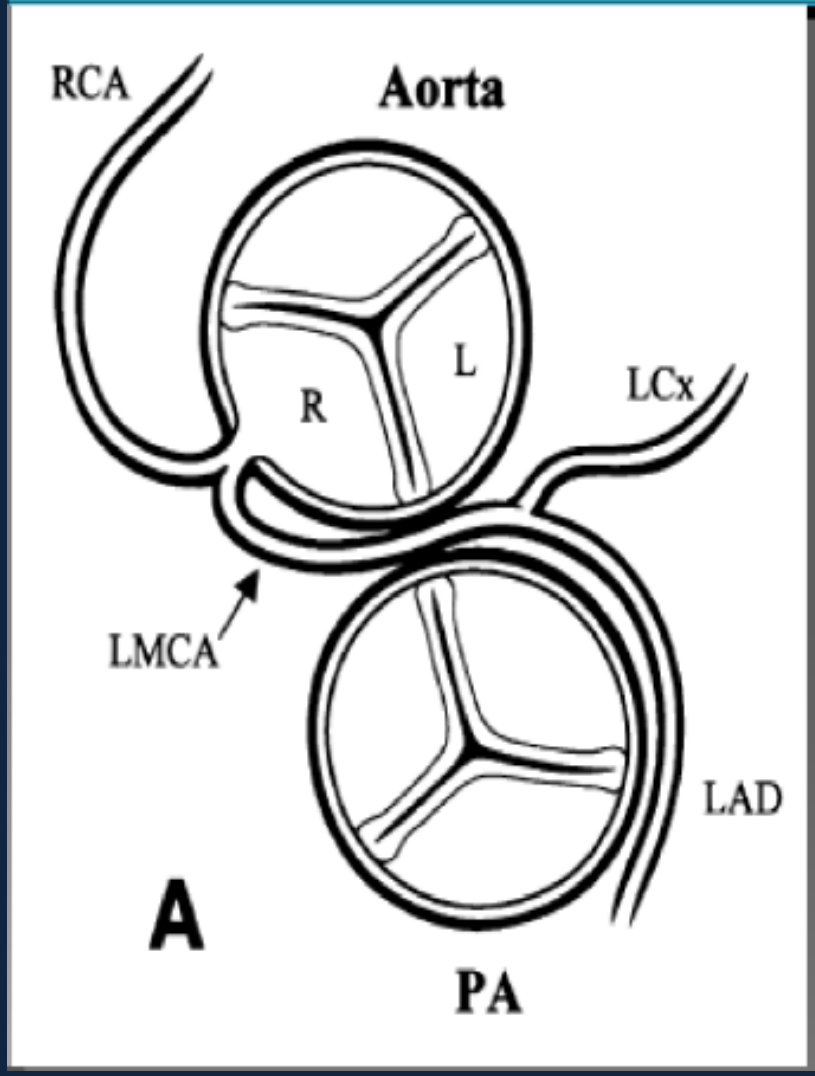
Incidence

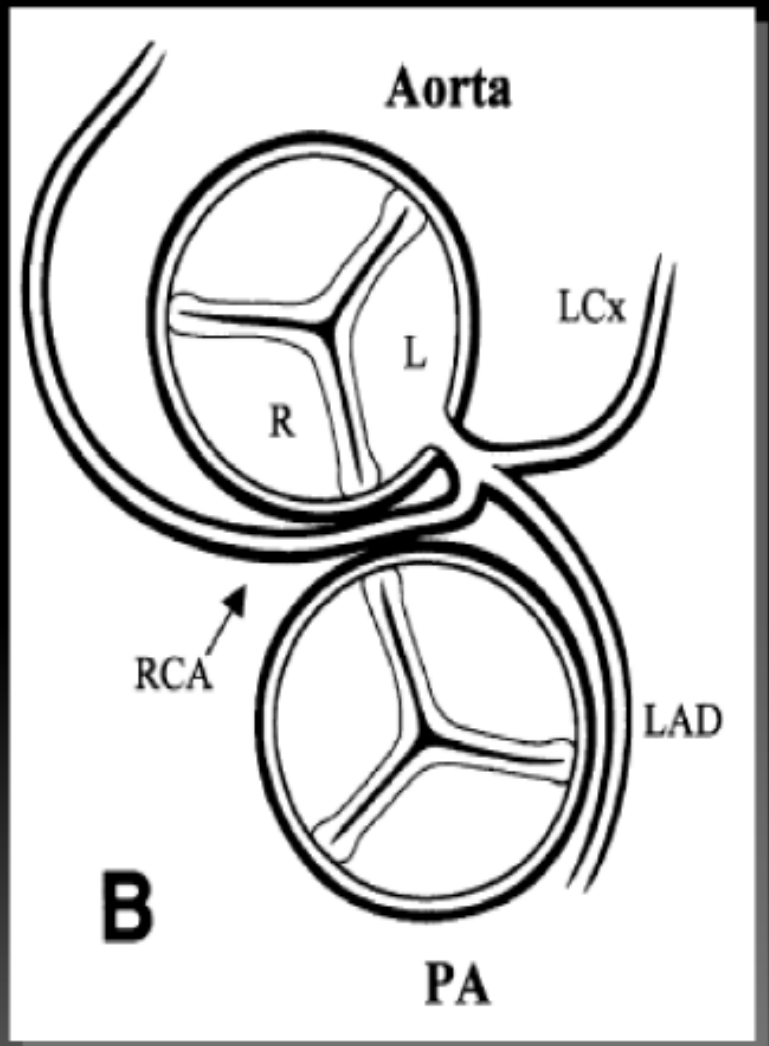
	Number	Percentage
Coronary anomalies (total)	110	5.64
Split RCA	24	1.23
Ectopic RCA (right cusp)	22	1.13
Ectopic RCA (left cusp)	18	0.92
Fistulas	17	0.87
Absent left main coronary artery	13	0.67
Circumflex arising from right cusp	13	0.67
LCA arising from right cusp	3	0.15
Low origination of RCA	2	0.1
Other anomalies	3	0.27

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

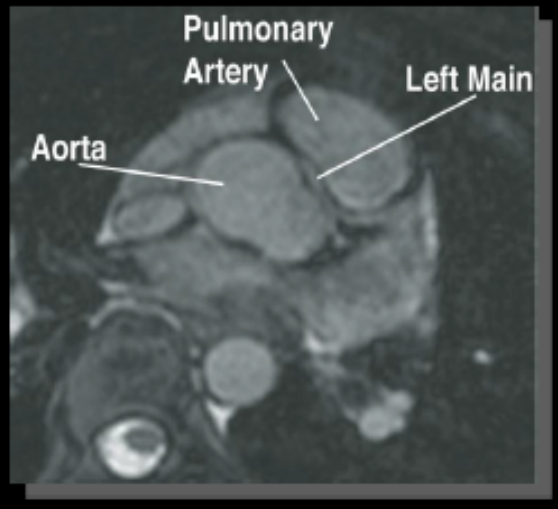
Threatening Anatomy

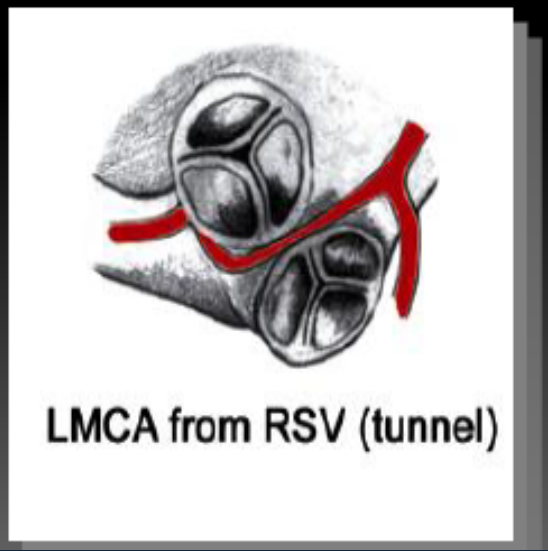




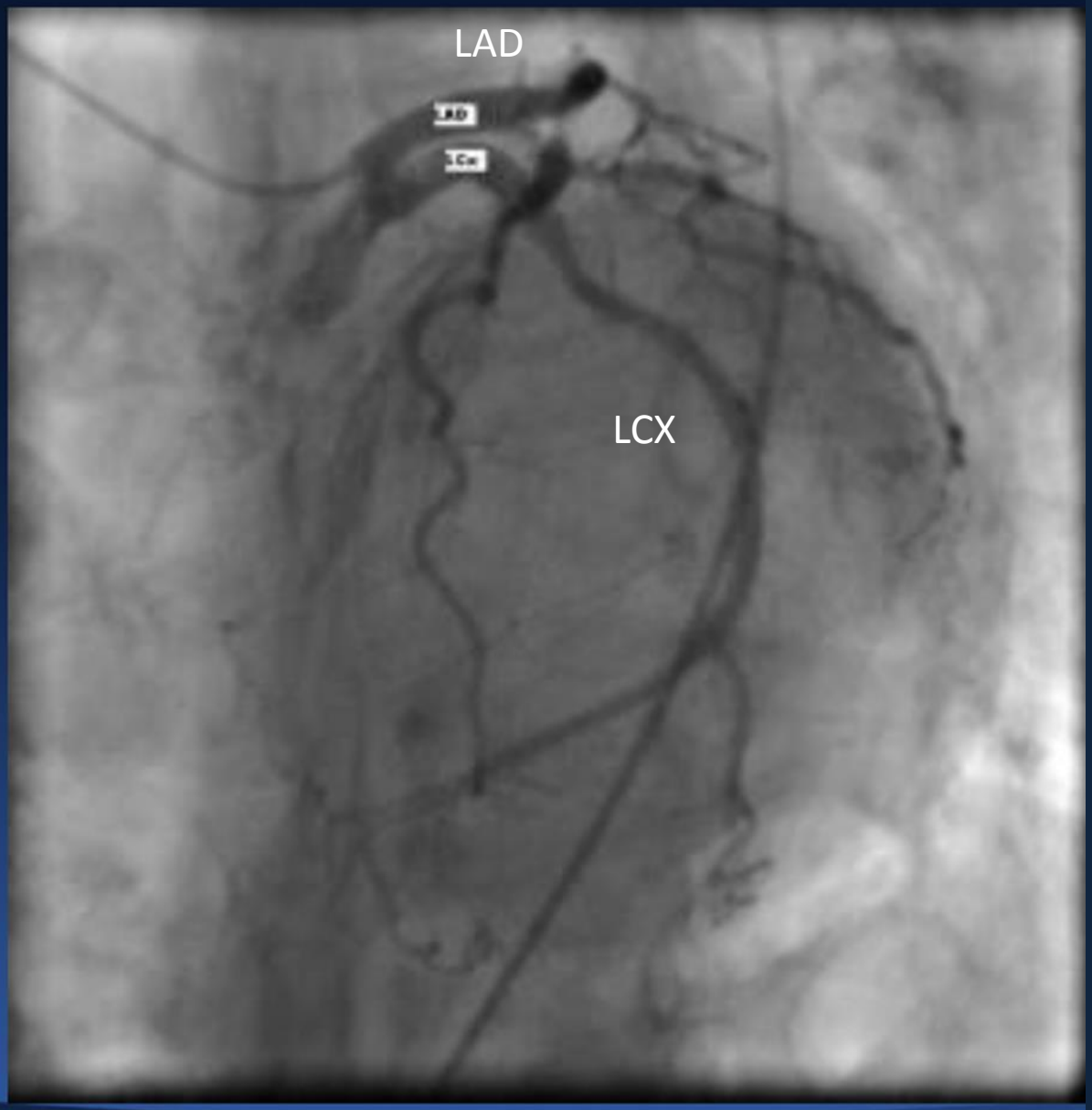
Left Main From The Right Coronary Cusp

- Classified according to the course of the left main
- 60% will go between the aorta and pulmonary artery
  - Anatomy clearly associated with sudden death



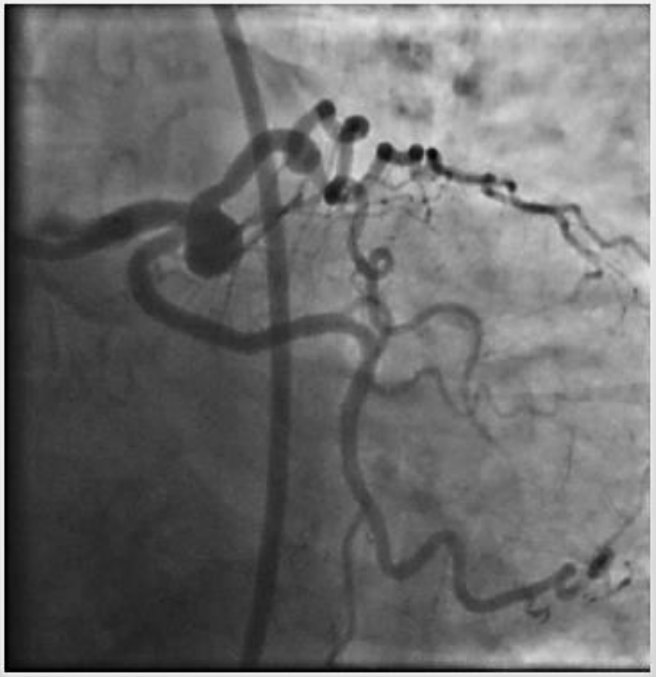


Dual Coronary Ostia



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

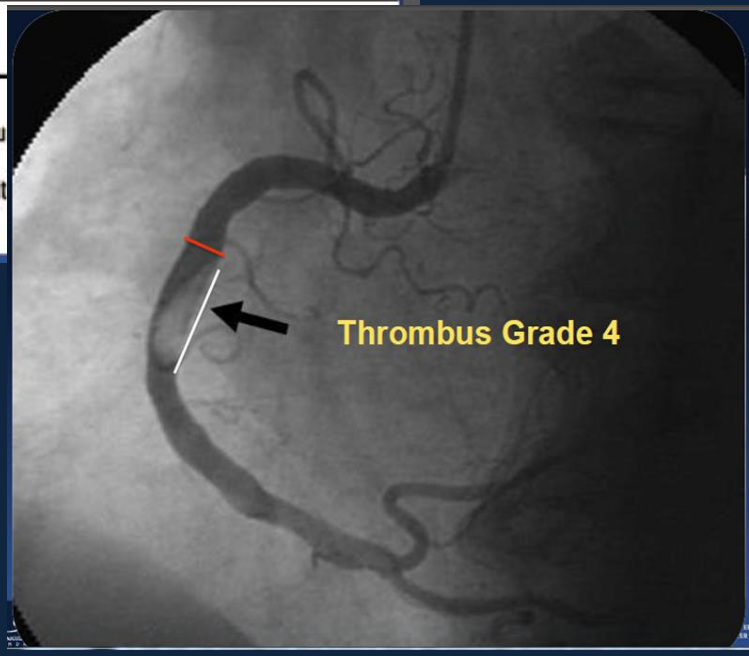


Thrombus

Table 2. TIMI Thrombus Grade

0	No cineangiographic characteristics of thrombus present.
1	Possible thrombus present. Angiography demonstrates characteristics such as reduced contrast density, haziness, irregular lesion contour or a smooth convex "meniscus" at the site of total occlusion suggestive but not diagnostic of thrombus.
2	Thrombus present, small size: Definite thrombus with greatest dimensions less than or equal to 1/2 vessel diameter.
3	Thrombus present, moderate size: Definite thrombus but with greatest linear dimension greater than 1/2 but less than 2 vessel diameters.
4	Thrombus present, large size: As in Grade 3, but with the largest dimension greater than or equal to 2 vessel diameters.
5	Total occlusion.

Sources:
1. The TIMI-IIIA Investigators. Early effects of tissue-type plasminogen activator added to conventional therapy on the cu
ing with ischemic cardiac pain at rest. *Circulation* 1993;87:38–52.
2. van't Hof AW, Liem A, Suryapranata H, et al. Angiographic assessment of myocardial reperfusion in patients treated wit
dial infarction: myocardial blush grade. Zwolle Myocardial Infarction Study Group. *Circulation* 1998;97: 2302–2306.



- **Prevention and Management of Complications due to** Coronary Angiogram

Coronary Angiogram Complications

- Death
- AMI
- Arrhythmia
- CVA
- Bleeding
- Hematoma (Retroperitoneal)
- Vascular Injury
- Contrast induced AKI
- Allergy/ Anaphylaxis
- Pulmonary odema
- AIR/ CLOT embolism
- Vagal reaction ……..

Risk of cardiac catheterization and coronary angiography (based on 59,792 patients)

	Percent
Mortality	0.11
Myocardial infarction	0.05
Cerebrovascular accident	0.07
Arrhythmia	0.38
Vascular complications	0.43
Contrast reaction	0.37
Hemodynamic complications	0.26
Perforation of heart chamber	0.28
Other complications	0.28
Total of major complications	1.70

Reproduced with permission from: Noto, TJ Jr, Johnson, LW, Krone, R, et al. Cardiac catheterization 1990: A report of the Registry of the Society for Cardiac Angiography and Interventions (SCA&I). Cathet Cardiovasc Diagn 1991;

Coronary Angiogram- Mortality

- Rare – less then 0.1%[1]
- High risk group
  - Age >60 years and <1year
  - Female
  - NYHA IV heart failure (10 times increase risk than Class I and II
  - Severe LMCA (20 times higher than SVCAD)[2]
  - LVEF <30%
  - Patient with valvular heart disease, CKD, DM requiring insulin therapy, peripheral arterial disease, pul insufficiency, cerebrovascular disease

1. Noto TJ, Johnson LW, Krone R, et al. Cardiac catheterization 1990: a report of the registry of the Society for Cardiac Angiography and Interventions. Cathet Cardiovasc Diagn 1991;24:75.
2. Kennedy JW. Complications associated with cardiac catheterization and angiography. Cathet Cardiovasc Diagn 1982;8:5.

MAJOR COMPLICATIONS

- The risk of producing a major complication (death, myocardial infarction, or major embolization) during diagnostic cardiac catheterization is generally less than 1%
- Risk of adverse events depends upon
  - Demographic (age, gender)
  - Cardiovascular anatomy (left main coronary artery disease, severe AS, diminished LV function)
  - Clinical situation (Unstable angina, Acute MI, cardiogenic shock)
  - Comorbids
  - Experience of operator
  - Peripheral arterial disease

MAJOR COMPLICATIONS

- The risk of producing a major complication (death,

ASK FOR HELP PLEASE IF MAJOR COMPLICATION OCCUR !!

  - Demographic (age, gender)
  - Cardiovascular anatomy (left main coronary artery disease, severe AS, diminished LV function)
  - Clinical situation (Unstable angina, Acute MI, cardiogenic shock)
  - Comorbids
  - Experience of operator
  - Peripheral arterial disease

Potential Access Site Complications eg . Trans-radial approach

- Radial artery occlusion
- Radial artery spasm
- Persistent post procedural pain
- Upper Limb – Loss of strength
- Haematoma
- Pseudo aneurysm/ AV Fistula
- Radial/ Brachial artery perforation
- Radial artery eversion during sheath removal
- Hand ischemia
- Compartment Syndrome

Pre-operative Assessment

- ***NEVER NEVER NEVER*** START a Procedure Without **KNOWING** the Patient

  (Study the Notes (Hx ; Relevant investigations ; EF; Indications/ Contraindications etc)
- Proper TIME In/ Out procedures
- **GOOD Planning**

Though procedures may seen " ROUTINE " ;

There is " **NO ROUTINE "** procedures

Practical Tips and Tricks

- Usg / Fluro guidance for vascular access
- Use of Terumo Radifocus GW to overcome tortuosity

  (**CAUTION** - NOT move Terumo GW within the puncture needle → **Unsheathing of polymer coating** and Embolization)

  - **MUST WATCH the TIP** of Terumo GW (It can go **ANYWHERE** !!!)
- Use 0.014/ 0.018 PCI Guidewires for difficult crossing +/- microcatheter
- Frequent regular flushing (**3 minutes rules**)

  - to Prevent Thrombus

Heparin in Diagnostic Coronary Angiogram

- Indicated in Radial / Brachial route
- For **Femoral access** :

  RCT compare heparin 5000u vs 2000u vs **NO** heparin (Speedy procedures < 30 mins)

  → **NO differences** in thrombotic Cxs

NB> Extreme Caution in Difficult / Lengthy Cases

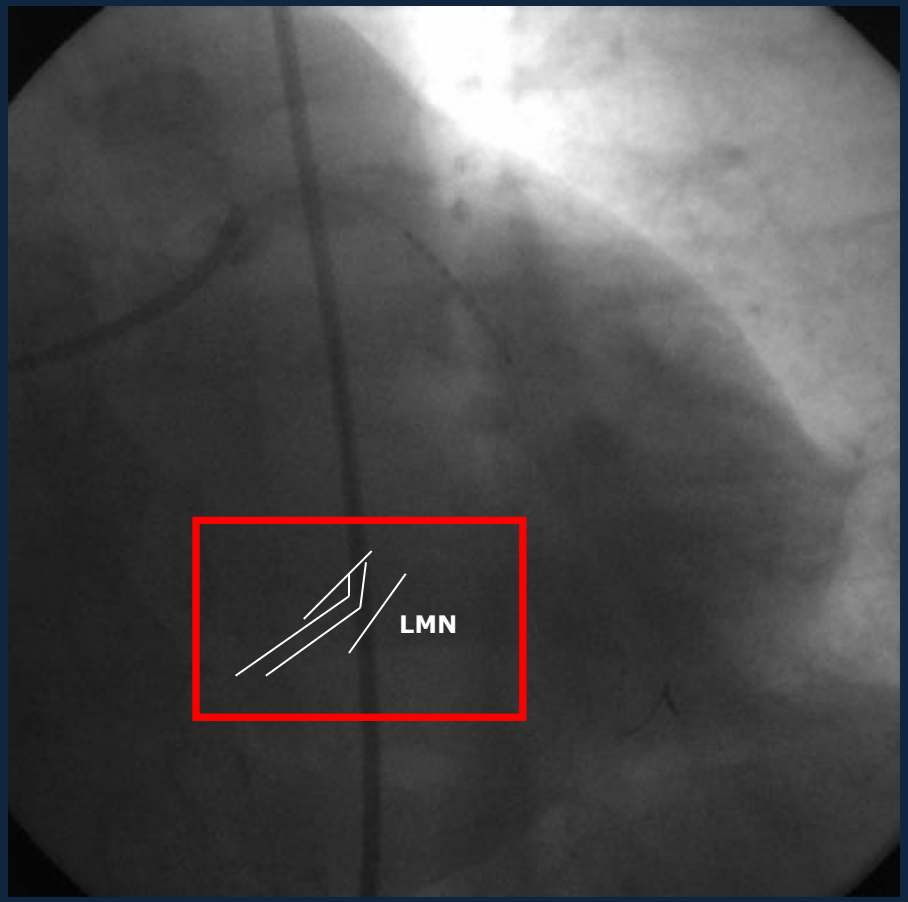
eg. CABG; Challenging anatomies; crossing AS

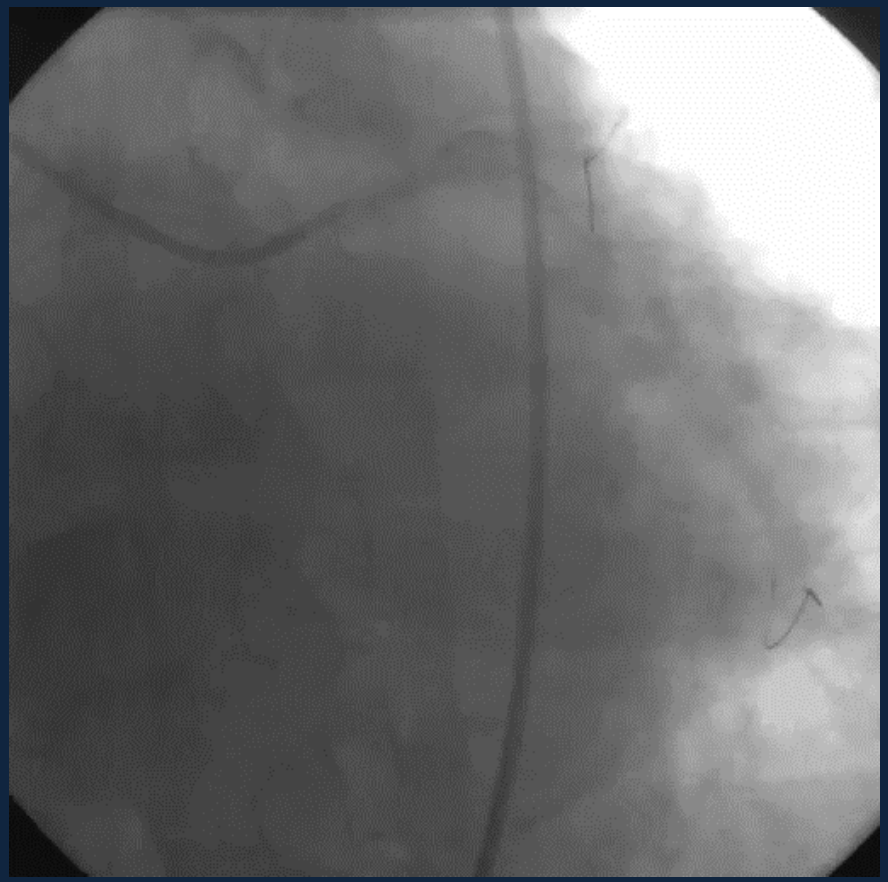
J. of First Military Med. University 2005, Nov; 25(11); 1429-1431. WangYQ, WongY, CaiBN, DY Jun, Y Da, Xue Bao. Clinical analysis of 1400 cases of coronary artery angiography without heparin

MOST Important Safety Concern

- It is essential that the catheter tip does not wedge into a narrow coronary ostium and cause occlusion of flow.
- The catheter tip must be axially oriented in proximal vessel rather than being angulated against the side wall, which may cause intimal damage.
- Contrast injection with catheter tip impacted to side wall of coronary artery can cause osital dissection.
- Above mentioned are the fatal complications.

Contrast Staining at LMN ?



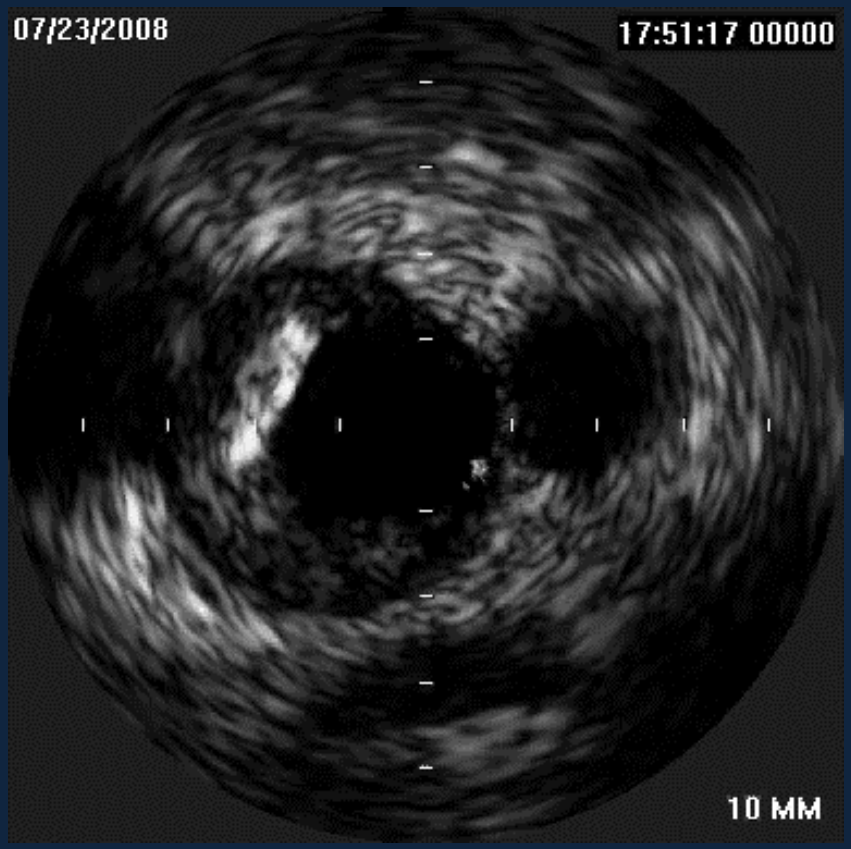


Guide Catheter – Deep seat

POOR alignment

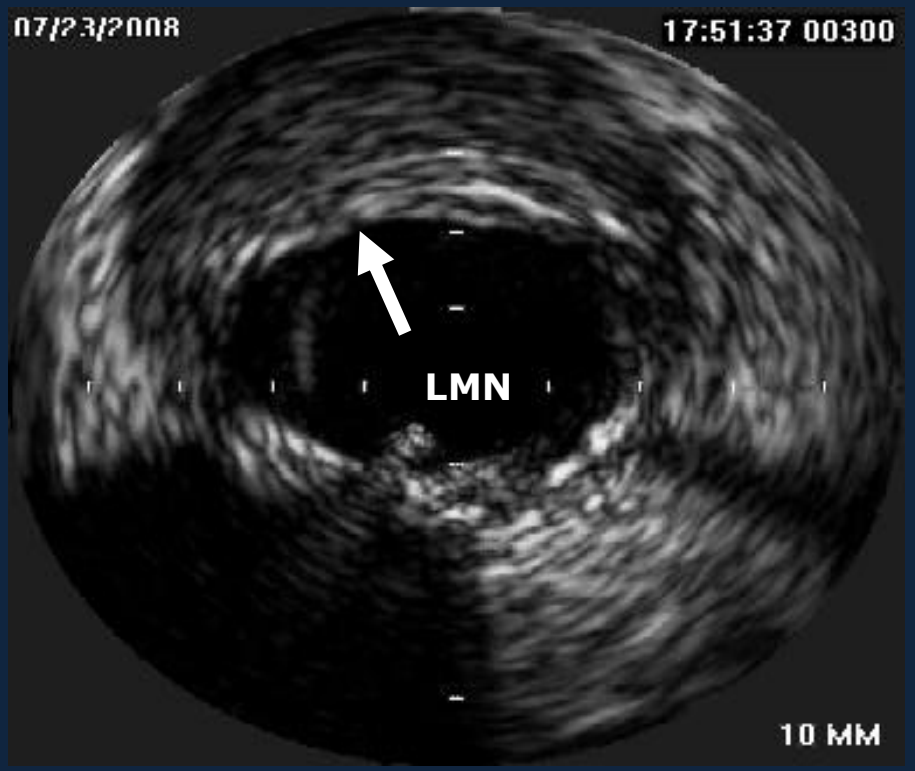
- Realign the Guide : Good Flow, No contrast staining
- Patient – NO Symptoms at all

IVUS to CLARIFY

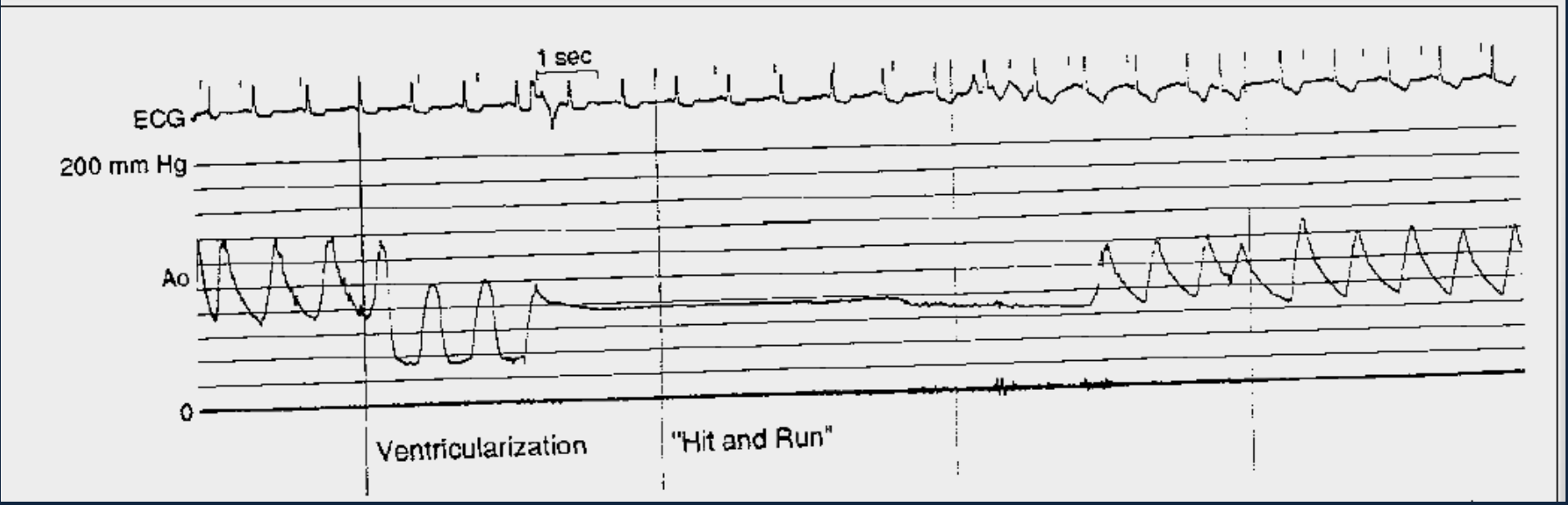


LMN INTRAMURAL HEMATOMA

What is the Diagnosis ?



An example of what you should NOT do

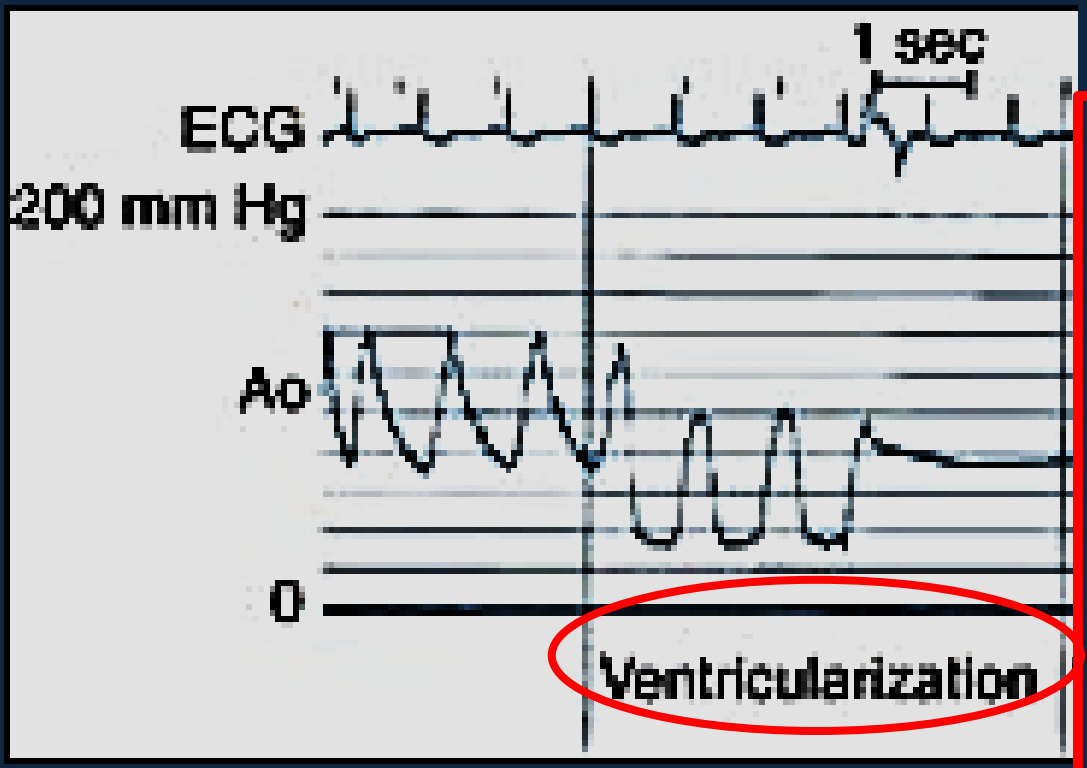


- **Must Be VERY OBSESSIVE / Meticulous about Pressure Tracing**

- **CAUTION : NEVER NEVER Inject WITHOUT LOOKING AT the PRESSURE Tracing !!**

PLEASE LOOK at Pressure TRACING

- Beware of **DAMPIMG or Ventricularization !!!!!**
- May be **Live and Death Issue**



BEWARE of Massive AIR EMBOLISM !!

- **in 0.2%**
- **Sentinel Event**
- VERY Meticulous in Preparation of Manifold (AIR –tight)
- Caution in Injection (upright syringe etc **)**
- Attention to Contrast Bottle
- **NEVER Give** up in Resuscitation

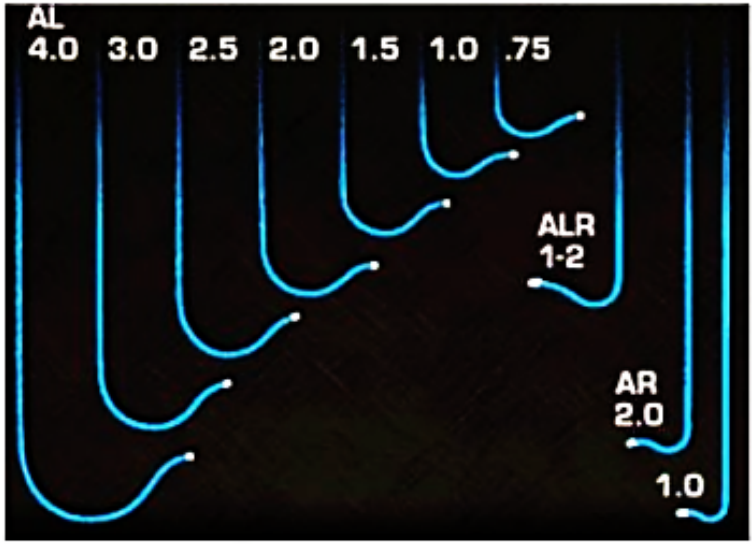
Caution with Amplatz Catheters / Guide

- Selection of the proper size for an Amplatz guide is essential
  - Size 1 is for the smallest aortic root
  - size 2 for normal
  - size 3 for large roots

- **Attempts to force engagement** of a preformed Amplatz guide that does not conform to a particular aortic root increase risk of complication
- If tip does not reach the ostium and keep lying below it - **guide is too small**

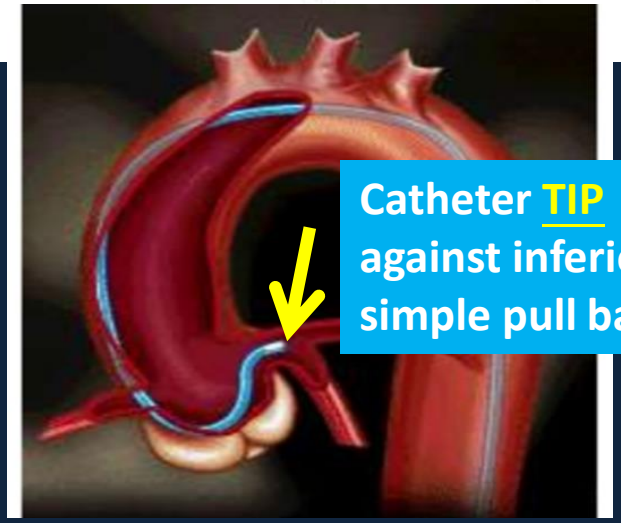
- If tip lies above the ostium - **guide is too large**

- When RCA ostium is very high - left Amplatz guide may be used to engage the right ostium



Caution- Amplatz Catheter Withdrawal

- Must be carefully disengaged from the coronary artery
- A simple withdrawal from the vessel can cause the tip to advance farther into the vessel and cause dissection
- **To disengage** - first advance guide slightly to prolapse the tip out of the ostium
- Then rotate the guide so that tip is totally out of the ostium before withdrawing it.



Catheter TIP DIVE in or hit against inferior wall if simple pull back

Retroperitoneal Hematoma

- Infrequent but **serious complication** of Transfemoral procedures
- Incidence of approximately 0.5%
- Mortality 4-12%
- Higher 30-day mortality in RPH after PCI
- Severe Morbidity
- **Risk Factors :**

  low body weight, female; emergency procedure, pre and post procedure heparin, pre-procedure IIb/IIIa inhibitors, and **HIGH Puncture** above the mid femoral head/ Inguinal ligament ; **DOUBLE wall** puncture

RPH - Clinical Features

- Presentation varies and may be vague
- Diagnosis delayed since retroperitoneum - non-compressible area where large amount of blood accumulate rapidly without causing obvious stigmata of underlying expanding hematoma
- No cutaneous bruising early in the course
- Common clinical features were lower abdominal pain and fullness, back or flank pain, diaphoresis abdominal tenderness, bradycardia, hypotension and anemia
- **High Index of Suspicion** Needed

RPH- Complications

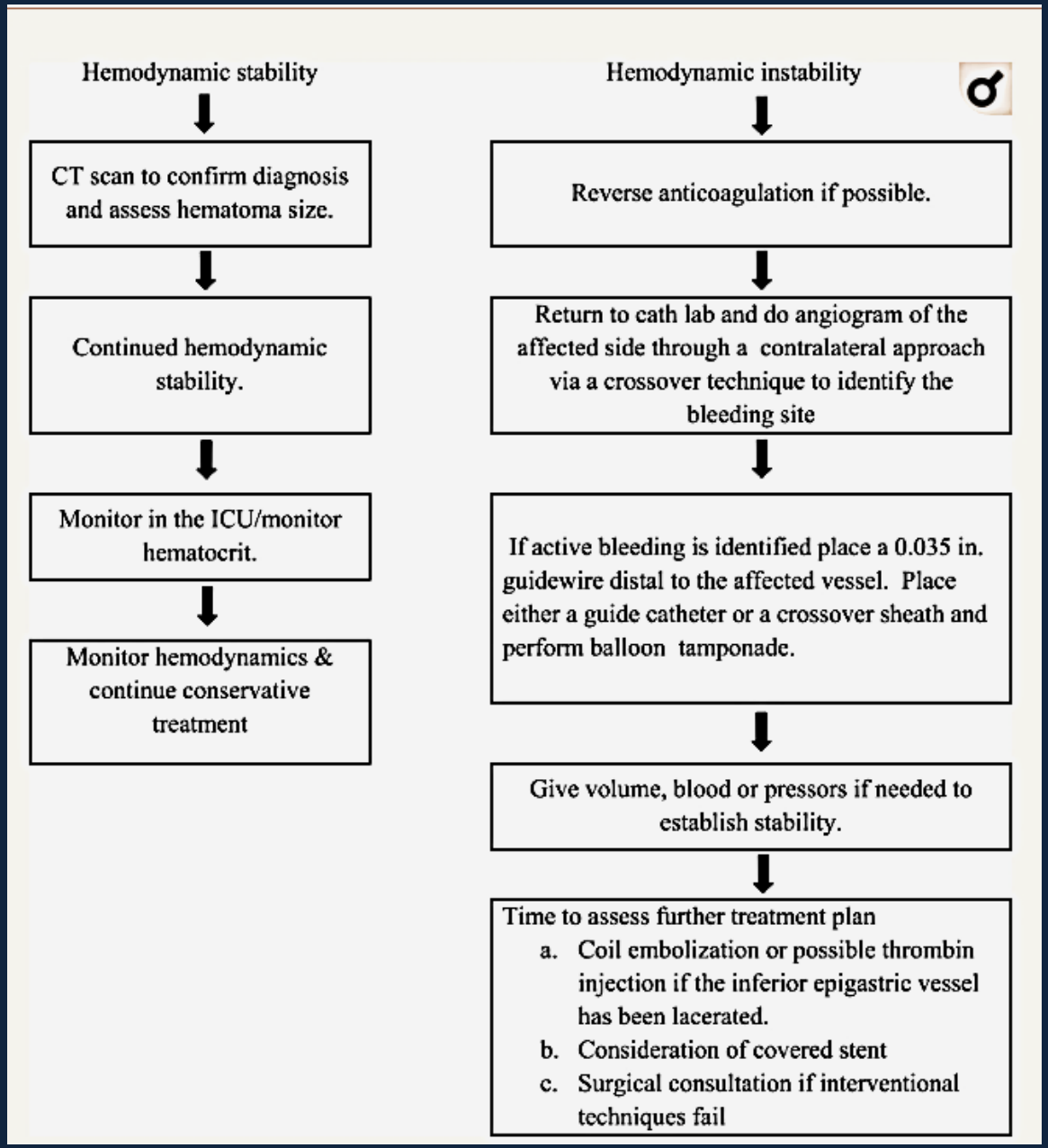
- Hypovolemic shock, need blood transfusion and increase length of stay

- **Abdominal Compartment Syndrome** :
  -Rare but serious complication
  -often present as acute renal failure with severe abdominal pain, distention causing respiratory distress and cardiovascular collapse
  - Emergent surgical or CT-guided drainage

- Femoral neuropathy - weakness of iliopsoas (hip flexion) and quadriceps (knee extension) muscles and dysesthesia involving anterior/medial thigh and medial calf

- Majority resolve with conservative therapy but severe cases may require surgical decompression

Management of Retroperitoneal Hematoma



Contrast Induced -Acute Kidney Injury

- Contrast induced Nephropathy
- **Definition** : 25% increase in Serum Cr from baseline OR 0.5mg/dL (44umol/L) increase in Absolute Value within 48-72 hrs after IV contrast
- **Mehran Risk Score :**

  8 variables : Hypotension
  IABP
  CHF
  CKD
  DM
  AGE> 75 yrs
  Anemia
  Contrast Volume

Prevention of CIN

- Strongest predictors of CI-AKI : DM; CrCl; Contrast Volume
- ADEQUATE IV Volume Expansion / Prehydration with isotonic NaCl or Na HCo3
- Oral N-Acetylcysteine (? Controversial Data)

Extra Caution in Impaired Renal function :

- Biplane
- Ultra-low Contrast usage (just for Adequate opacification)
- Low or iso- osmolar contrast
- Smaller diameter catheters
- Staged procedures

* Complex CTO w Retrograde approach (just < 10 – 15 ml contrast used !!)
(IVUS guidance; Previous Angiogram references; Co-registration etc)

Maximum Allowable Contrast Dose - MACD

- Healthy adult individuals, the maximum allowable volume of intravenous **iodine** contrast is:

  ≤300mL (with Iodide concentration 300mg /mL)

- Patients with renal insufficiency - As low as reasonable (ALARA) principle

  Should not exceed

  440 x Bwt (kg) / creatinine (µmol/L) mL

  5 x Bwt [kg] / creatinine (mg/dL) mL

  (with concentration 300mg Iodine /mL)

Others :

Use **Ratio of Contrast Volume/ Cr CL** : **(Should be < 3)** for PCI procedures

- The Lower ; The Better

Words to Live By:

A Non-Diagnostic Angiogram Should be Considered a Cath *COMPLICATION*

Ajay Kirsten; USA

Pitfalls of Coronary Angiogram

1. **Inadequate vessel opacification-** May give impression of ostial stenoses, missing side branches or thrombus.

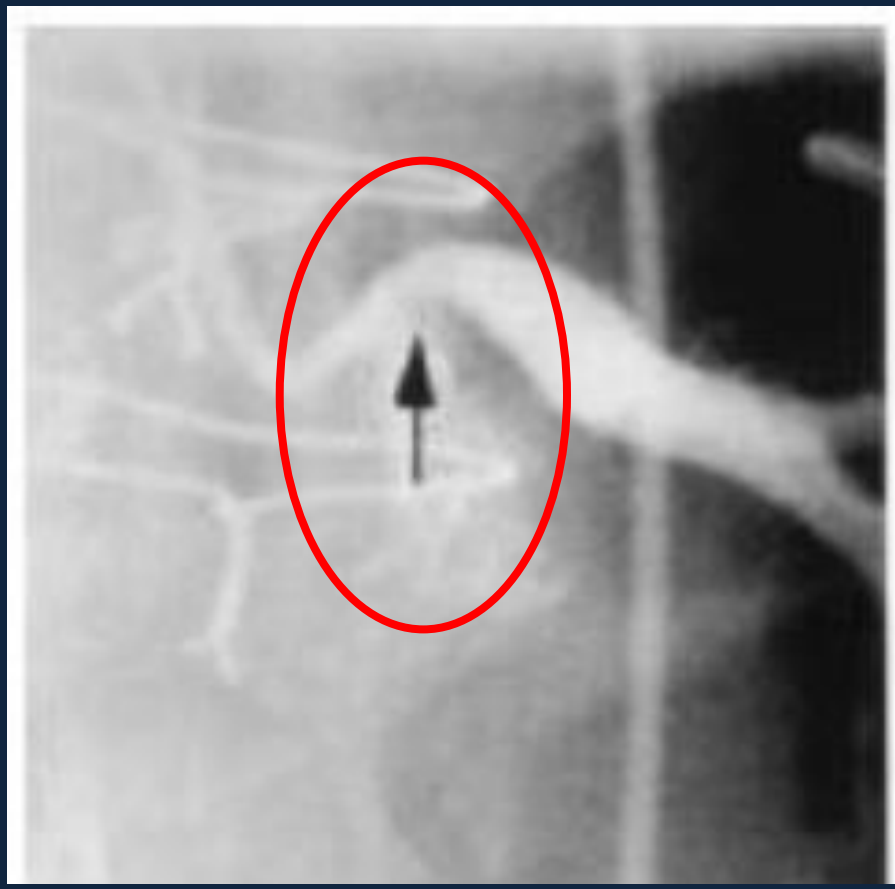
2. **Eccentric stenosis-** Coronary atherosclerosis often leads to eccentric or slit–like narrowing than central narrowing; so if the long axis of the vessel is projected, the vessel may appear to have a normal or near normal caliber.

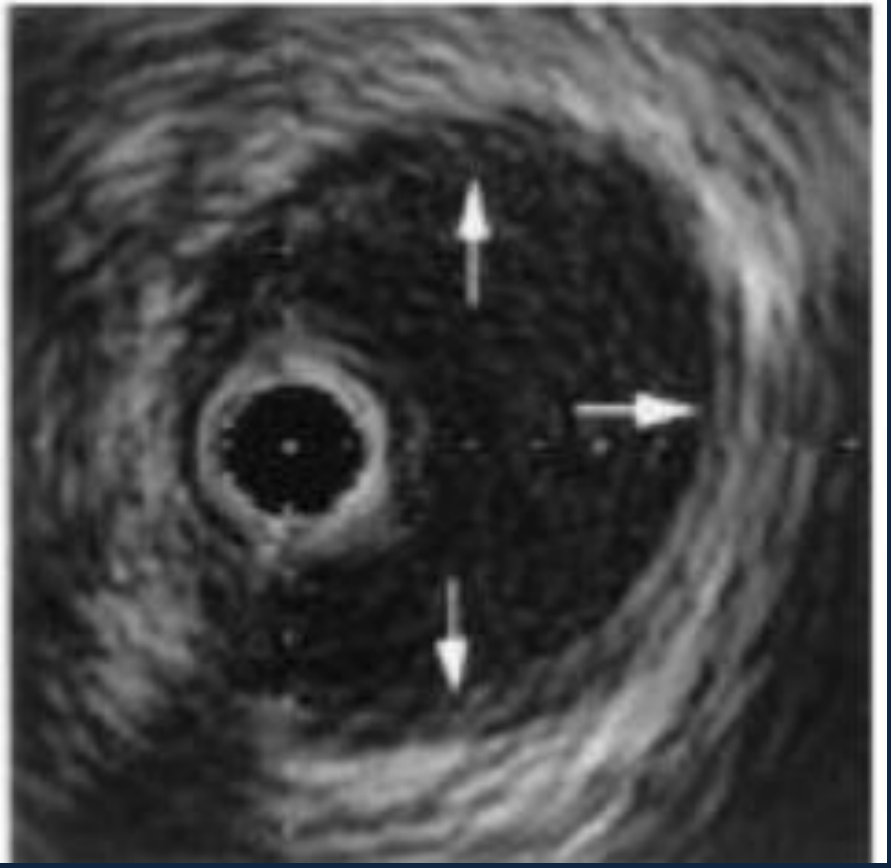
3. **Superimposition of branches**

4. **Foreshortening** of the stenotic segment due to projectional defect

Pitfalls of QCA LM assessment

- Diffuse atherosclerotic involvement affects the %DS calculation because of ***the lack of a normal reference segment***
- ***Short LMCA*** also makes identification of a normal reference segment difficult
- Ostial lesion can be miss
  - Guiding engagement; damping of pressure
- Positive remodeling





Patient of Atypical Chest pain , borderline treadmill

ANGIOGRAM : Severe Ostial LMN diseases

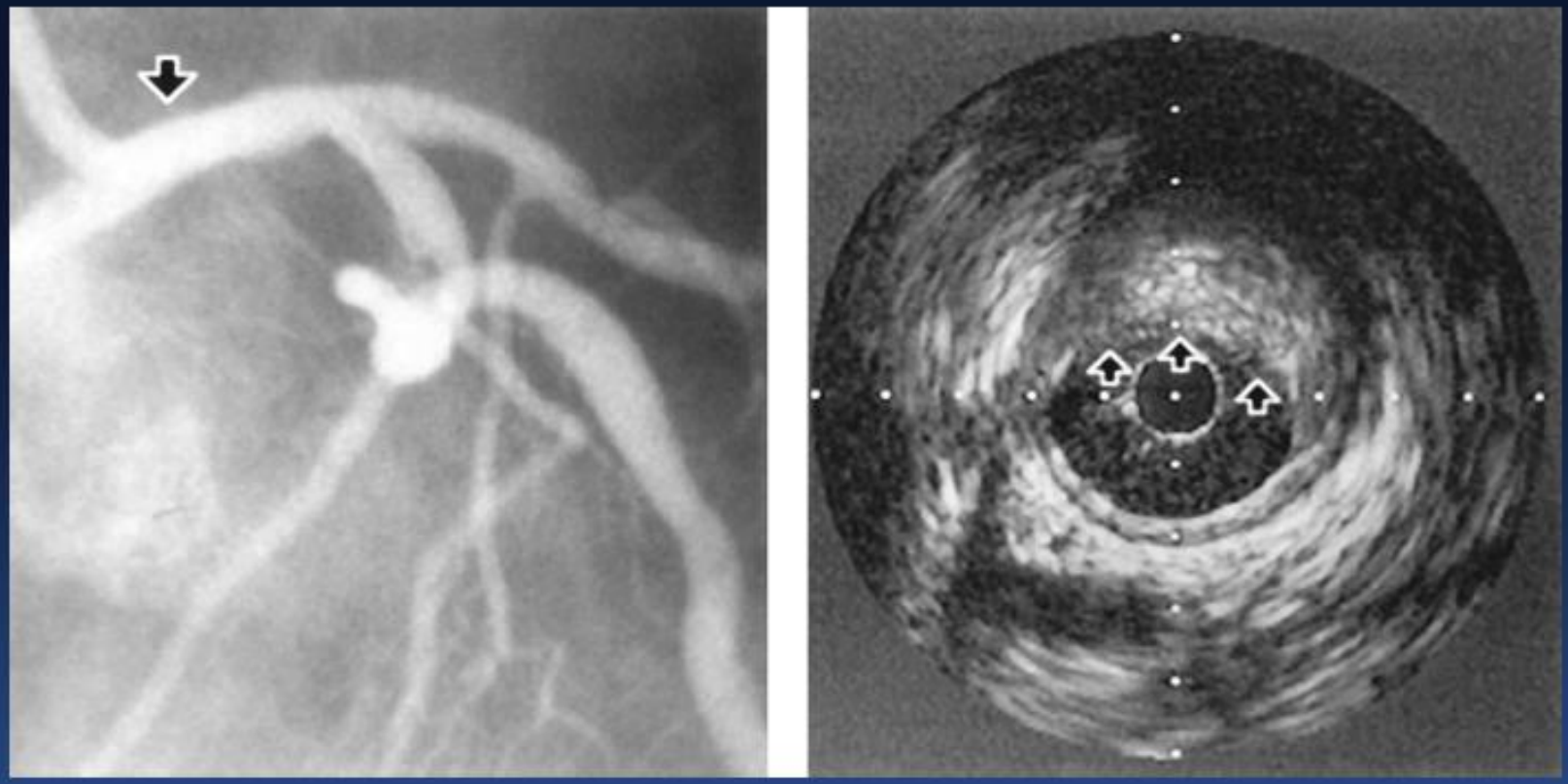
CABG done

No improvement of symptoms and SVG Grafts closed very quickly

IVUS – LMN : **No** significant plaque burden seen !! !

ONLY mild diffuse atheroma

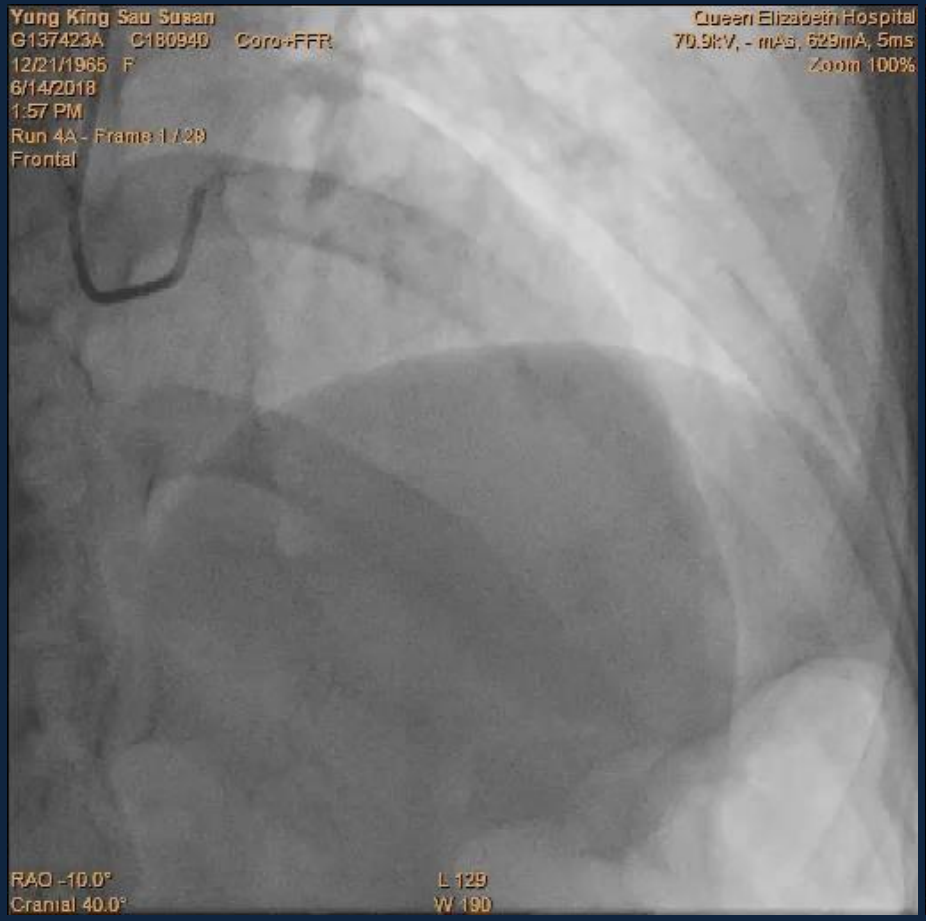
Angiographically unrecognized left main coronary artery disease.

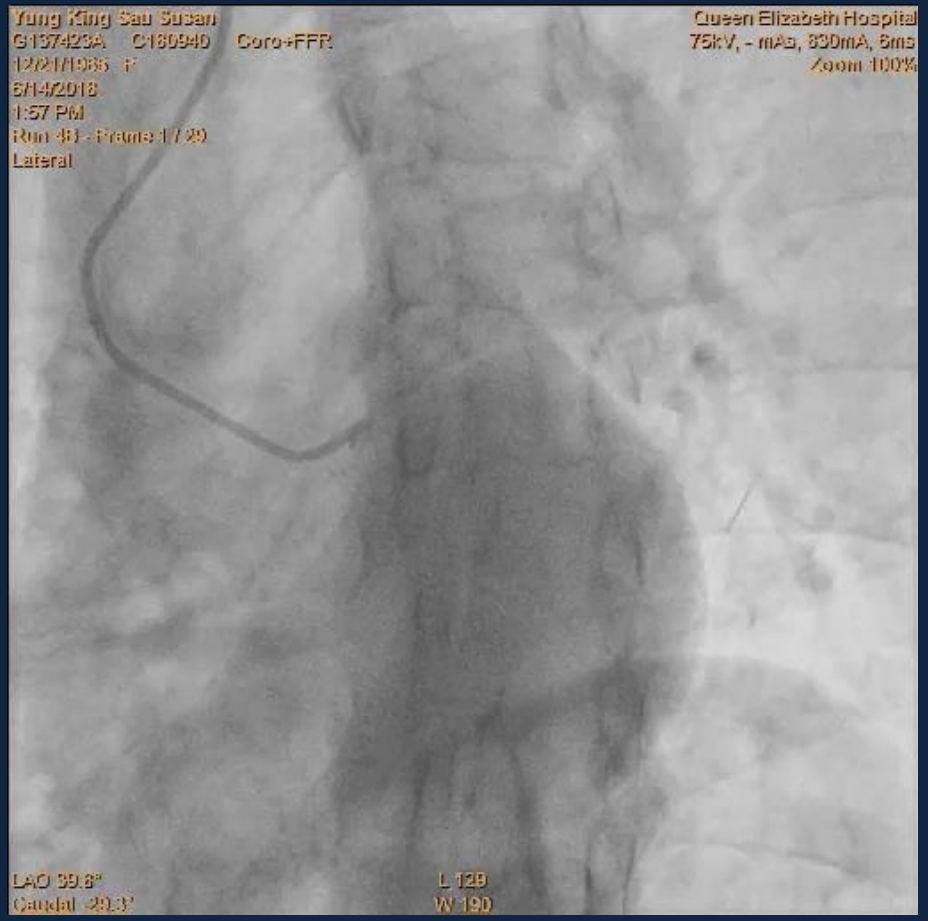


IVUS- Severe plaque burden in LMN

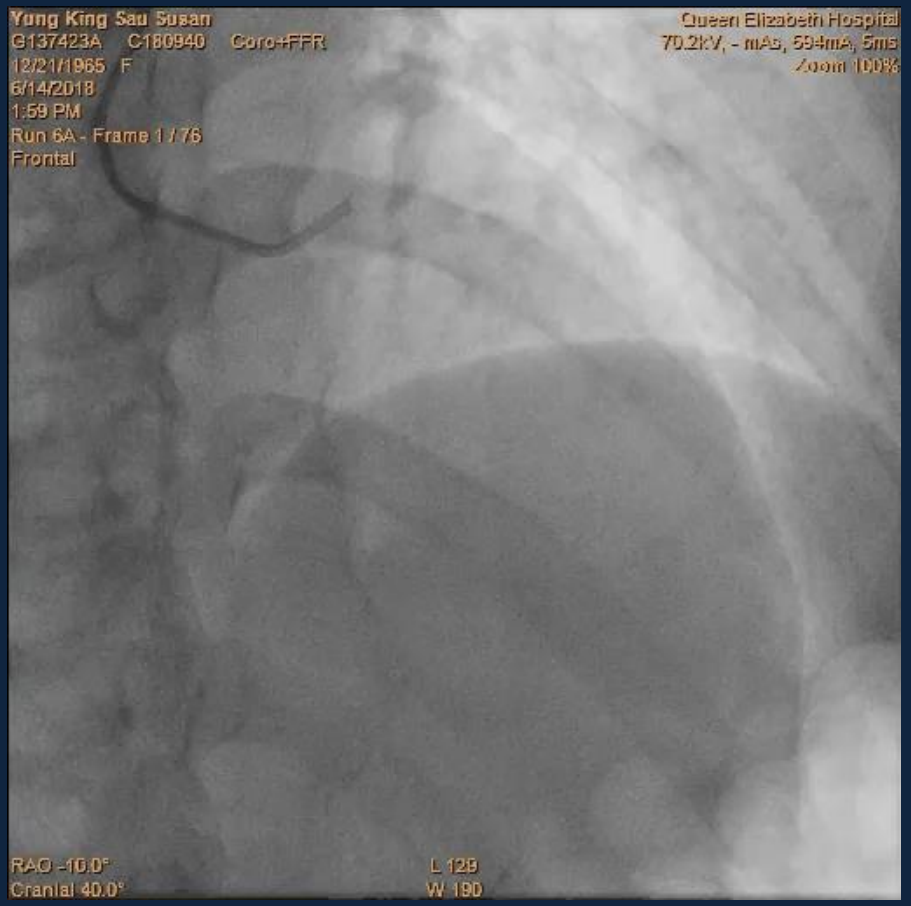
EJ Topol et al. Circulation 95:92; 2333-342

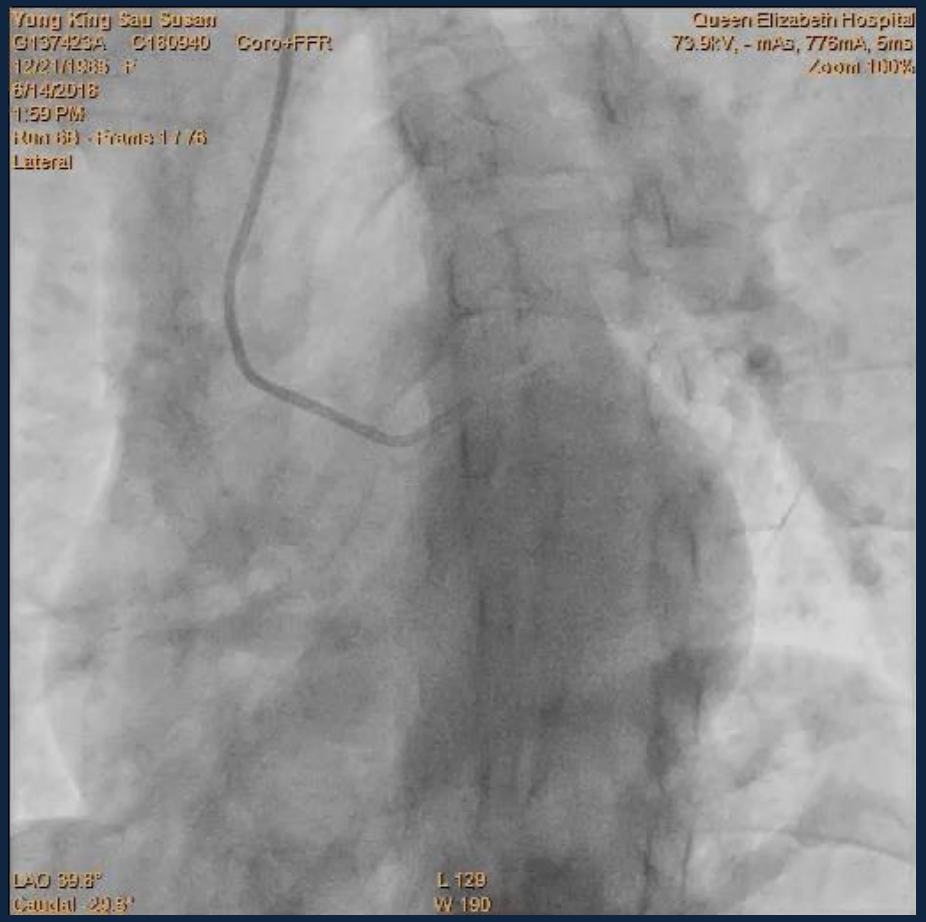
Diagnostic Coronary Angiogram





Coronary Angiogram





Use Different catheter

Tips and Tricks For Poor Opacification

- Identify Causes
- Proper configuration catheters
- **COXIAL Alignment** - most important
- Huge coronaries - change catheters
  (even Guide catheters)
- Proper/ Constant hand injection techniques
  (**FOCUS** on Pressure Tracing)
- Automatic injector
- Others: IVUS ; OCT etc in special cases

ENDING the Procedure

- **Proper DISENGAGE** the Catheter ; Pressure Tracing recorded

- MUST CAREFULLY **REVIEW ALL Images** FIRST

- **DECISION MAKING** --- ARE you Going to do CABG or PCI for the patient based on these Images ???
  - Quality of Images
  - Lesions Severity
  - Separate LMN Origin
  - Anomalous origin
  - Conus branches supplying collaterals to occluded vessels
  - Anomaly ; AV fistula etc
  - Formulate Management Plan

- Patient Counselling / Explanation / Postop Care / Report

KNOW the Other Alternative Tests

- **Anatomy** : CT Coronary
  MRI Heart
- **Functional** Tests :
  Stress Echocardiography
  Radioactive studies - Sestamibi; thallium
  CT perfusion
  MRI perfusion
  Invasive FFR, iFR

CT Coronary Angiogram

- Minimal invasive test
- Sensitivity and specificity of 95 % and 98% respectively
- ? Take over invasive angiogram in diagnostic situations :
  - preop coronary angiogram for valve surgery
  - dilated CMP
  - atypical chest pain with equivocal noninvasive tests
- New Modalities : CT-FFR ; CT Perfusion studies

FINAL ADVICE

- Stay Foolish; Stay Hungry
  - by Steve Jobbs; in 2005 -Standford University Graduation ceremony
- Stay Happy ; Stay Humble (by KTChan at HK)
- Being **Independent** Means : You are **(独立)**

  Responsible; Accountable; Proficient; Professional; Self- Confident; Respectable .....

  Act as a **"TEAM "-** Know When to **ASK x HELP**

  Not ACT arbitrarily !

  (不是獨斷獨行 !!)

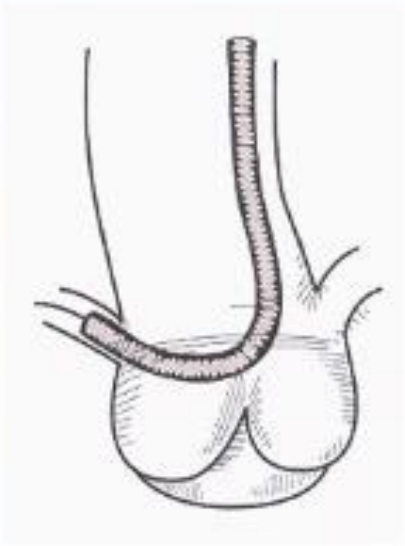
Thank You very much

- **ADDITIONAL SLIDES**

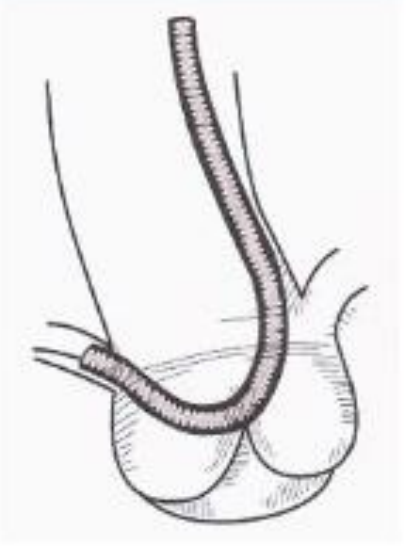
Rotational Angiogram

- X-ray system rotates around the patient during the acquisition of a single run
- Significant reduction in both contrast agent usage and radiation dose of up to 30%, without compromising image quality
- Contrast medium is injected automatically (3 mL /s for the LCA and 2 mL/s for the RCA) range 12-18 cc
- After this preload, rotation of the C-arm was started automatically and X-rays taken

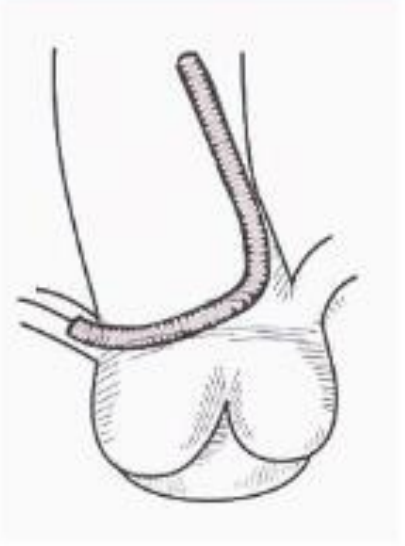
Possible Solutions to Difficult Right Coronary Guide Catheter Selection



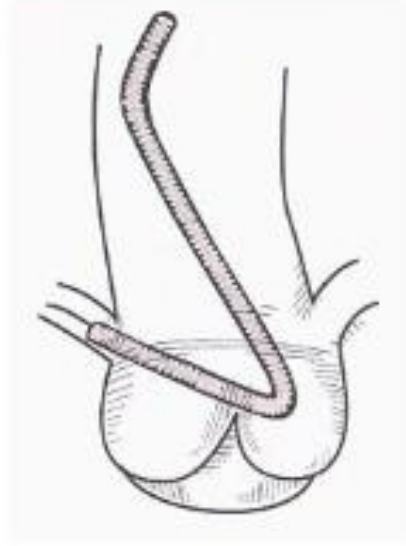
Hockey Stick



Amplatz



Left Venous Bypass Graft



Arani or XBRCA

Incidence of Radial artery spasm (RAS)

- **22%** (8% on med.) - Kiemeneij F, et al (N=100)

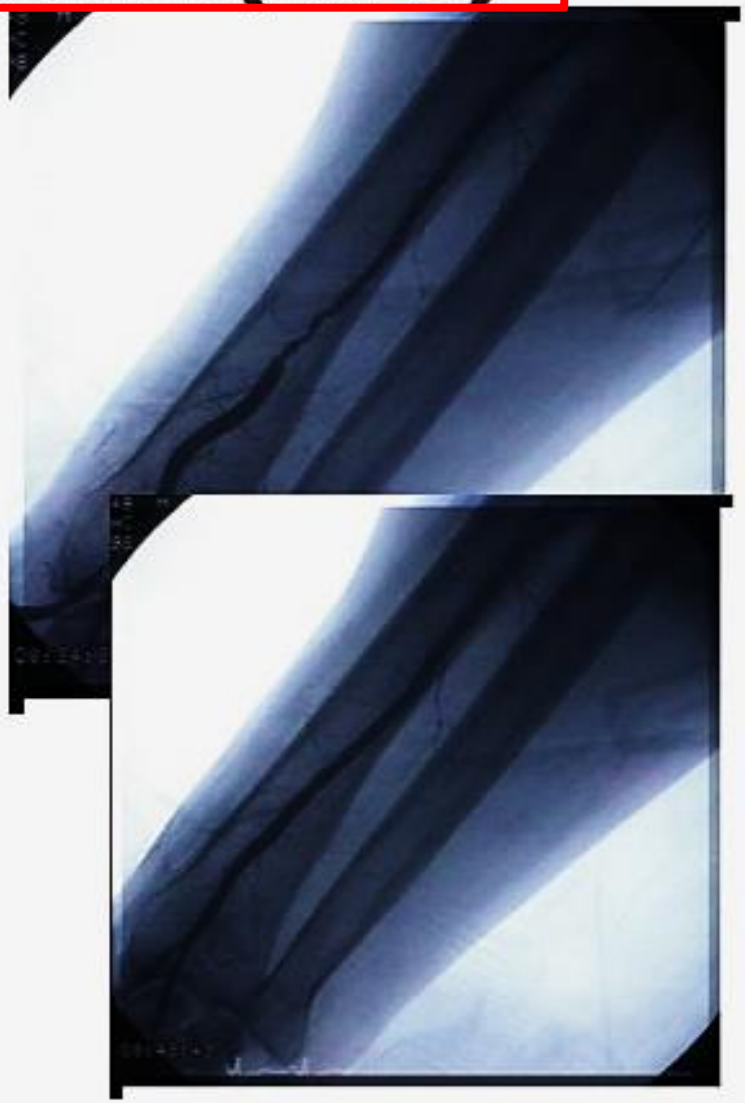
  (CCI 2003;58:281–284)

- **22.2%** - The SPAMS study (N=1,219)

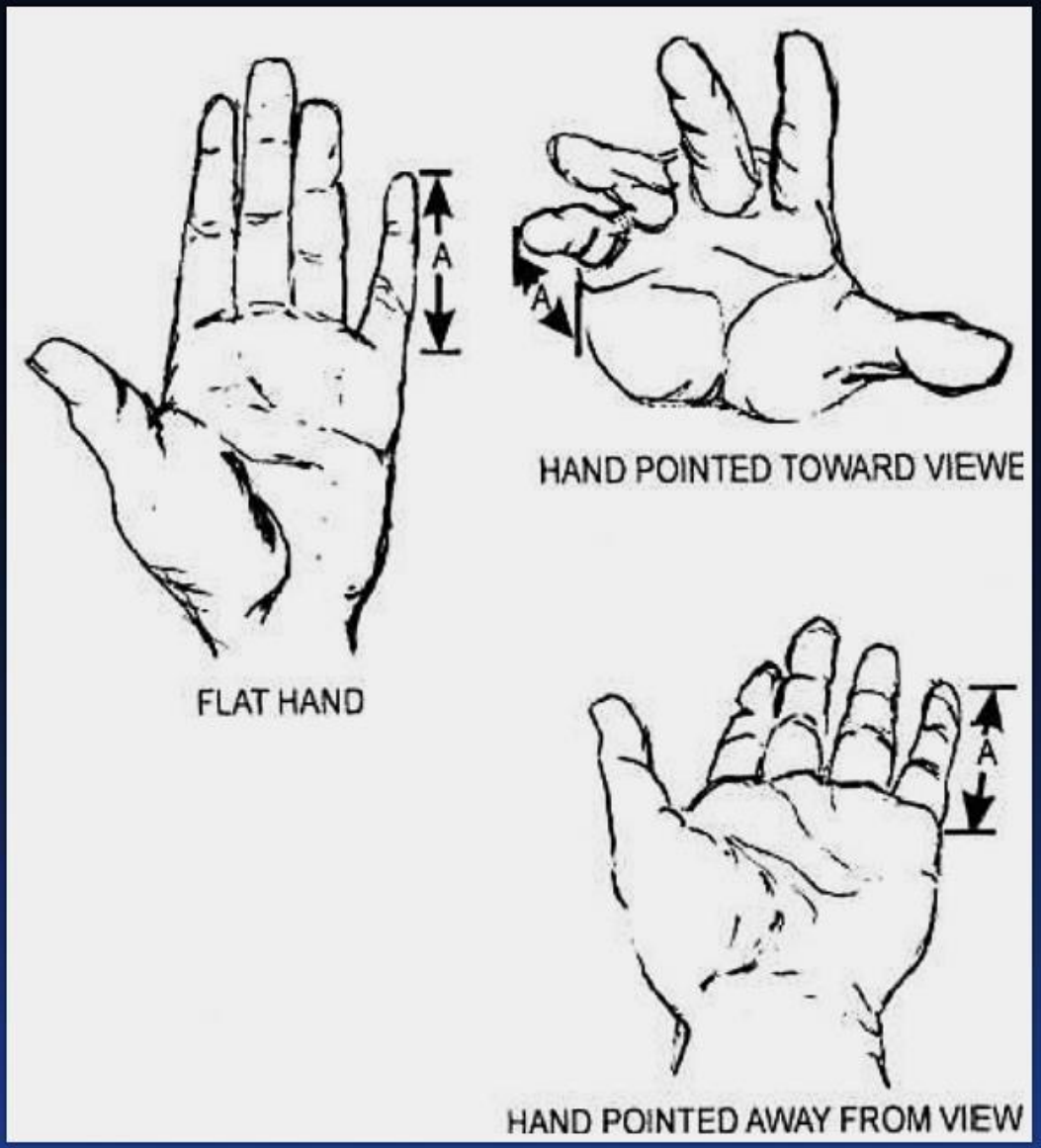
  (CCI 2006;68:231-235)

- Fukuda, et al diagnosed RAS through radial artery angiography and found that RAS occurred in **most patients** through transradial approach.

  (Jpn Heart J 2004; 45: 723-731)

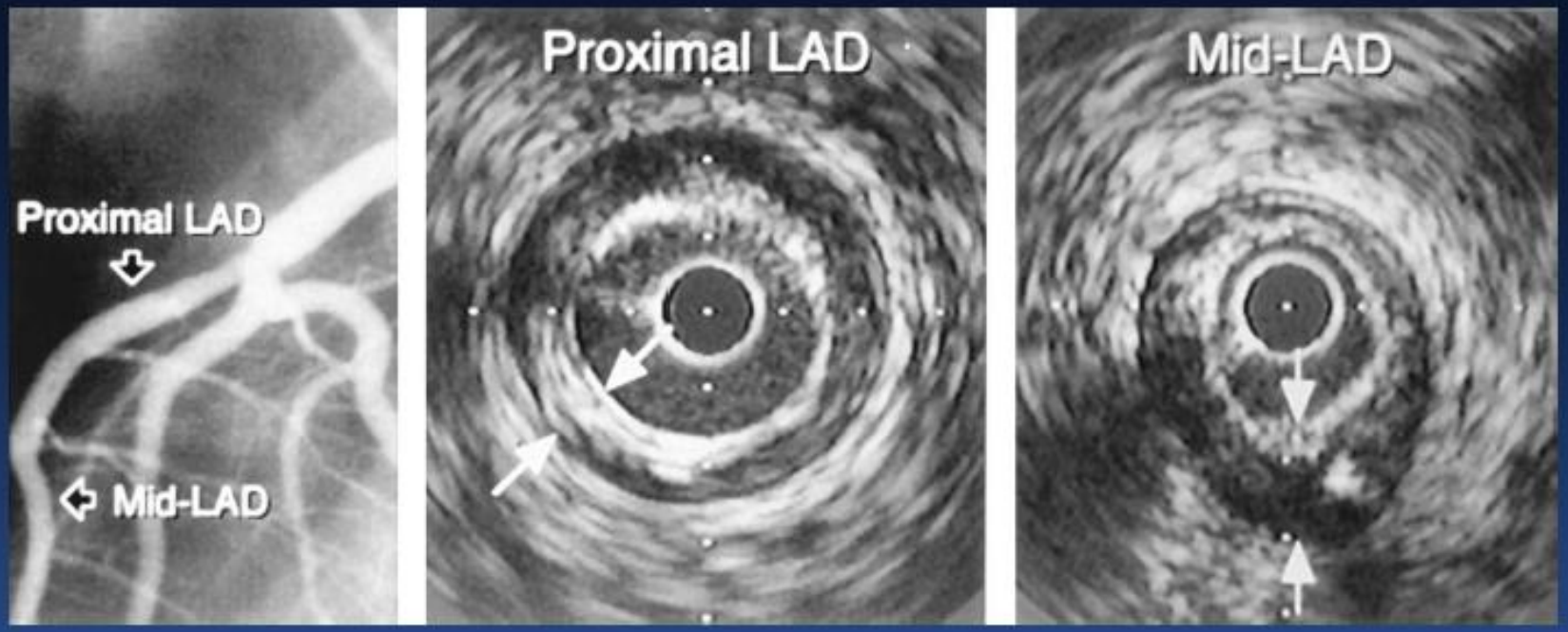


What is "Foreshortening?"



C. Von Birgelen
TCT 2009

Concealment of severe coronary disease by diffuse concentric involvement.



EJ Topo; et al. Circul;ation 1995; 922333-2342

A Word about Radiation Safety

Terms for RADAIATION MEASUREMENT

	Standard System (Traditional)	Metric Equivalent or Système Internationale (SI)
Exposure (C/kg)	Roentgen (R) 3.88 x 10 R =	Couloumb per kilogram 1 c/kg
Dose	Radiation absorbed dose (RAD) 100 rads =	Gray (GY) 1 Gy
Dose equivalent	Radiation equivalent man (REM) 100 rems =	Sievert (Sv) 1 Sv

Patients Exposure in VARIOUS Procedures

Diagnostic procedure	Effective dose (mSv)	Equivalent number of PA chest radiography each (0.02mSv)
Chest X-ray	0.02	1
Coronary angiography	7 (2-16)	350 (100-800)
Percutaneous coronary intervention	15 (7-57)	750 (350-2800)
Radiofrequency ablation	15 (7-57)	750 (350-2800)
Dilatation chronic coronary occlusion	81 (17-149)	4050 (850-9600)
Aortic valvuloplasty	39	1950
Endovascular thoraco-abdominal aneurism repaire	76-119	3800-5950
64-slice coronary CT	15 (3-32)	750 (150-1600)
Coronary calcium CT	3 (1-12)	150 (50-600)
Sestamibi stress test (1 day)	9	450

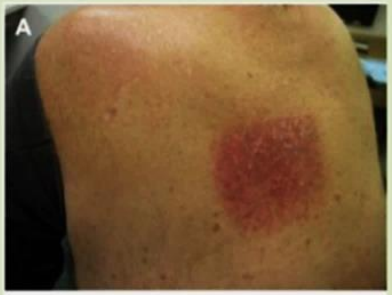
RADIATION- Deterministic and Stochastic Effect

Biologic Effects of Radiation

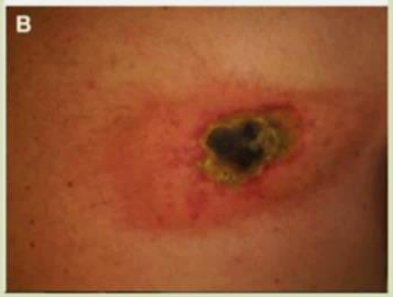
Deterministic		Yes	Hair Loss Skin Damage Tissue Necrosis Cataracts Sterility Decreased WBC
Stochastic	*"Probabilistic"*	No	Cancer Genetic Defects

- **Deterministic effects, which only occur above a certain dose threshold**
- **Stochastic effects, which have a chance of occurring at any range of dose**

Biologic Effects of Radiation :
Radiation skin (deterministic) effects



A. Dry desquamation (Poikiloderma) at one month in a patient receiving 11 Gy calculated peak skin dose.



B. Skin Necrosis at 6 months in a patient who received 18 Gy calculated peak skin dose.

PRINCIPLE in RADIATION PROTECTION

CAUTION

ALARA

AS
LOW
AS
Reasonably
Achievable

The meaning behind the numbers

Post-procedure

Document radiation dose in records

FT: Fluoroscopy Time

AK: Air Kerma

DAP: Dose-Area Product

A Word on Radiation Safety

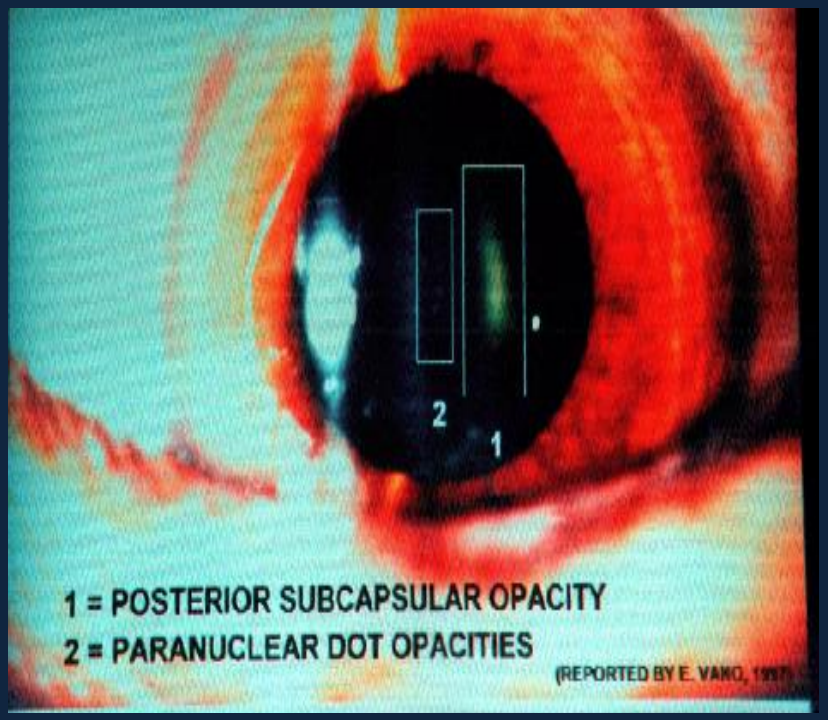
Precautions to Minimize Exposure to Patient and Operator

- ✓ Utilize radiation only when imaging is necessary .Avoid the"heavy foot"
- ✓ Minimize use of cine.
- ✓ Minimize use of steep angles of X-ray beam.(LAO Cr – AP Cr)
- ✓ Minimize use of magnification modes.
- ✓ Minimize frame rate of fluoroscopy and cine.(7.5 frames/sec fluoroscopy setting)
- ✓ Keep the image detector close to the patient (low subject-image distance)
- ✓ Utilize collimation to the fullest extent possible.
- ✓ Monitor radiation dose in real time.

NCRP Staff Exposure Limits

(National Council of Radiation Protection- USA)

- Whole Body*
  5 rem (50 mSv)/yr
- Eyes*
  15 rem (150 mSv)/ yr
- Pregnant Women
  50 mrem (0.5 mSv)/month
- Public
  100 mrem (1.0 mSv)/yr



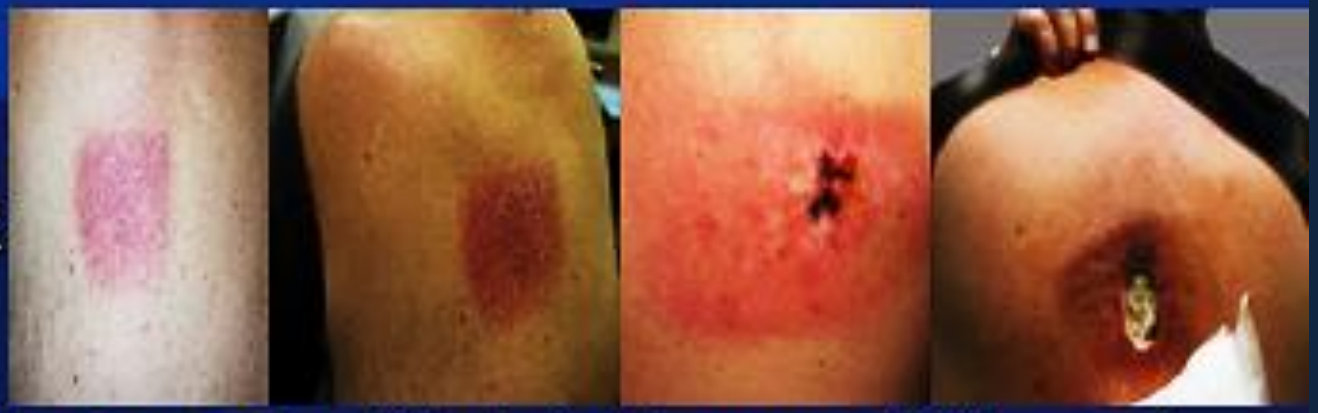
Cataract in eye of interventionist after repeated use of over table x-ray tube

***ICRP movement to 20 mSv/yr**

1 rem = 10 mSv (0.001 Sv)

www.ircp.org

Post-Procedure Issues



- *Cardiac Catheterization Reports* should include Fluoroscopic Time, and Total Air Kerma at the Interventional Reference Point (IRP) Cumulative Air Kerma ($K_{a,r}$, Gy) , and/or Air Kerma Area Product (P_{KA} ,$Gycm^2$) .
- FT is the least useful, P_{KA} multiples of 100 in Gy/cm^2 of the $K_{a,r}$ in Gy.
- *Chart Documentation* following the procedure for $K_{a,r}$ doses $\geq$5 Gy.
- *Follow up* at 30 day is required for $K_{a,r}$ of 5-10 Gy. Phone calls or visit.
- *For $K_{a,r} > 10$ Gy*, a qualified physicist should perform a detailed analysis.
- Contact risk management within 24 hrs for calculated PSD $\geq$ *15 Gy*.
- *Adverse Tissue Effects* is best assessed by history/exam. Biopsy only for uncertain diagnosis as the wound from the biopsy may result in a secondary injury potentially more severe than the radiation injury.

Prevention of Complications

- Proper patient selection
- Proper patient preparation
- Attention to details
- Experience
- Skills

Measures : eg.

- use of low/ iso-osmolar contrast

- lower profile diagnostic catheters

- measures to reduce bleeding Etc

CHOLESTEROL EMBOLI

- Cholesterol crystals from friable vascular plaques
- Distal embolization of cholesterol crystals after angiography, major vessel surgery, or thrombolysis causes a systemic syndrome (1)
- Diagnosis is suggested clinically :
  - discoloration of extremities in a mottled purple pattern of livedo reticularis,

    OR digital cyanosis or gangrene, or neurological or renal involvement
- Renal involvement is characteristically slowly progressing over a two to four week period following angiography
- Diagnosis is confirmed by biopsy of affected tissues showing deposition of cholesterol crystals
- Accompanying eosinophilia and elevated C-reactive protein are common laboratory features
- Incidence reported in prospective studies is generally less than 2% (2)

Cholesterol Emboli

- Autopsy reported a much higher incidence = (25-30%)
- many of these events are asymptomatic (3)
- further supported by the discovery of plaque debris from > 50% of all guiding catheters in a prospective study of 1,000 patients (4)
- No significant difference in the risk of atheroembolism between brachial and femoral approaches exists, suggesting that the ascending aorta is the predominant source
- Major risk factors include advanced age, repeat procedures, diffuse atherosclerotic disease, and elevated pre-procedure C-reactive protein. Treatment is mostly supportive but one retrospective study reported decreased incidence of cholesterol emboli with pre-procedural use of simvastatin.(Woolfson & Lachmann, 1998)
- Besides statins, management with steroids and prostaglandins has not resulted in significant benefit

1. (Keeley & Grines, 1998).
2 Fukumoto, Tsutsui, Tsuchihashi, Masumoto, & Takeshita, 2003; Saklayen, Gupta, Suryaprasad, & Azmeh, 1997)
3. (Fukumoto et al., 2003; Ramirez, O'Neill, Lambert, & Bloomer, 1978)
4.) (Keeley & Grines, 1998).

Shapes used for coronary grafts