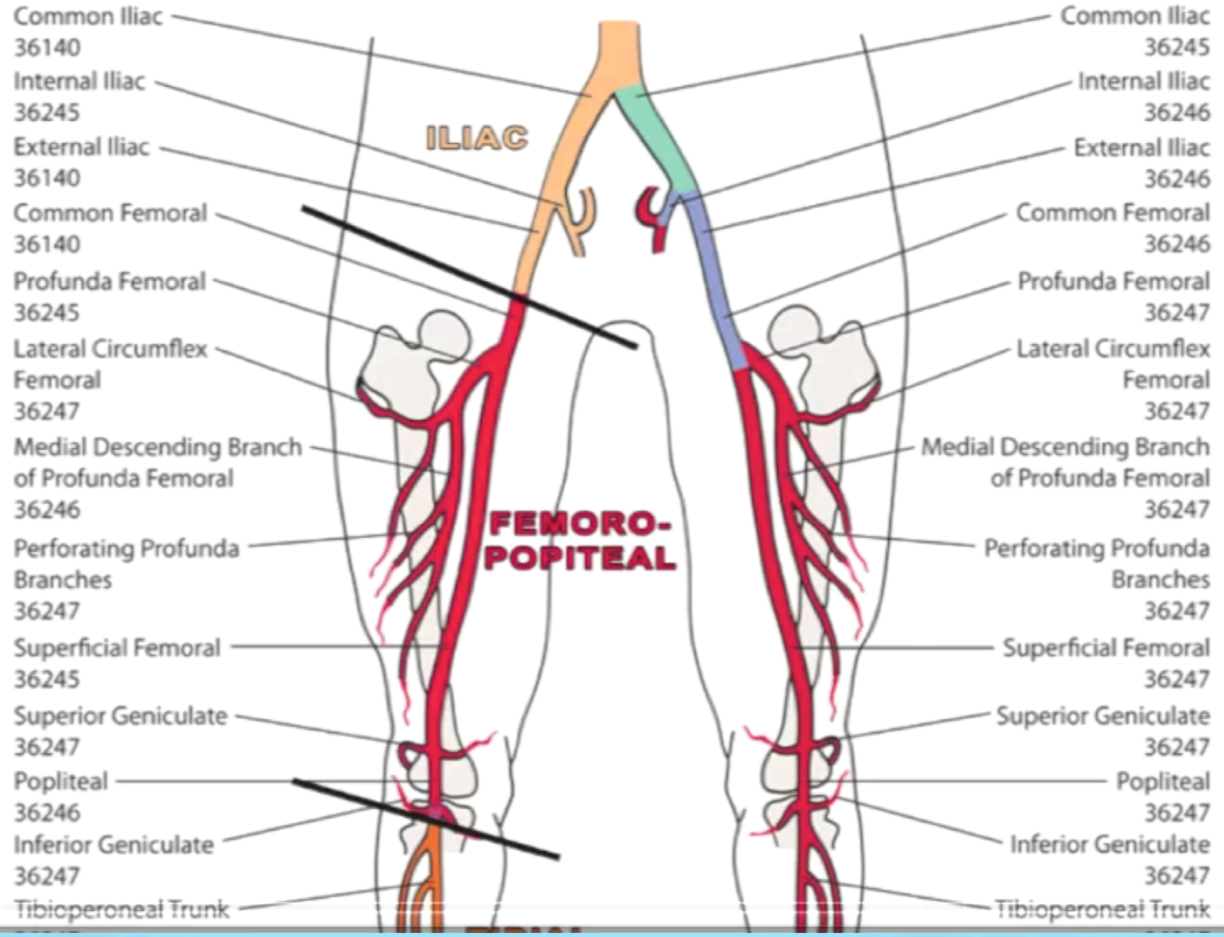
Lower Limb Arterial System Anatomy, Evaluation & Imaging

Dr V L Jayaprakash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Medial Descending Branch
of Profunda Femoral
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Perforating Profunda
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Common Iliac
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Medial Descending Branch
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Branches
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AO
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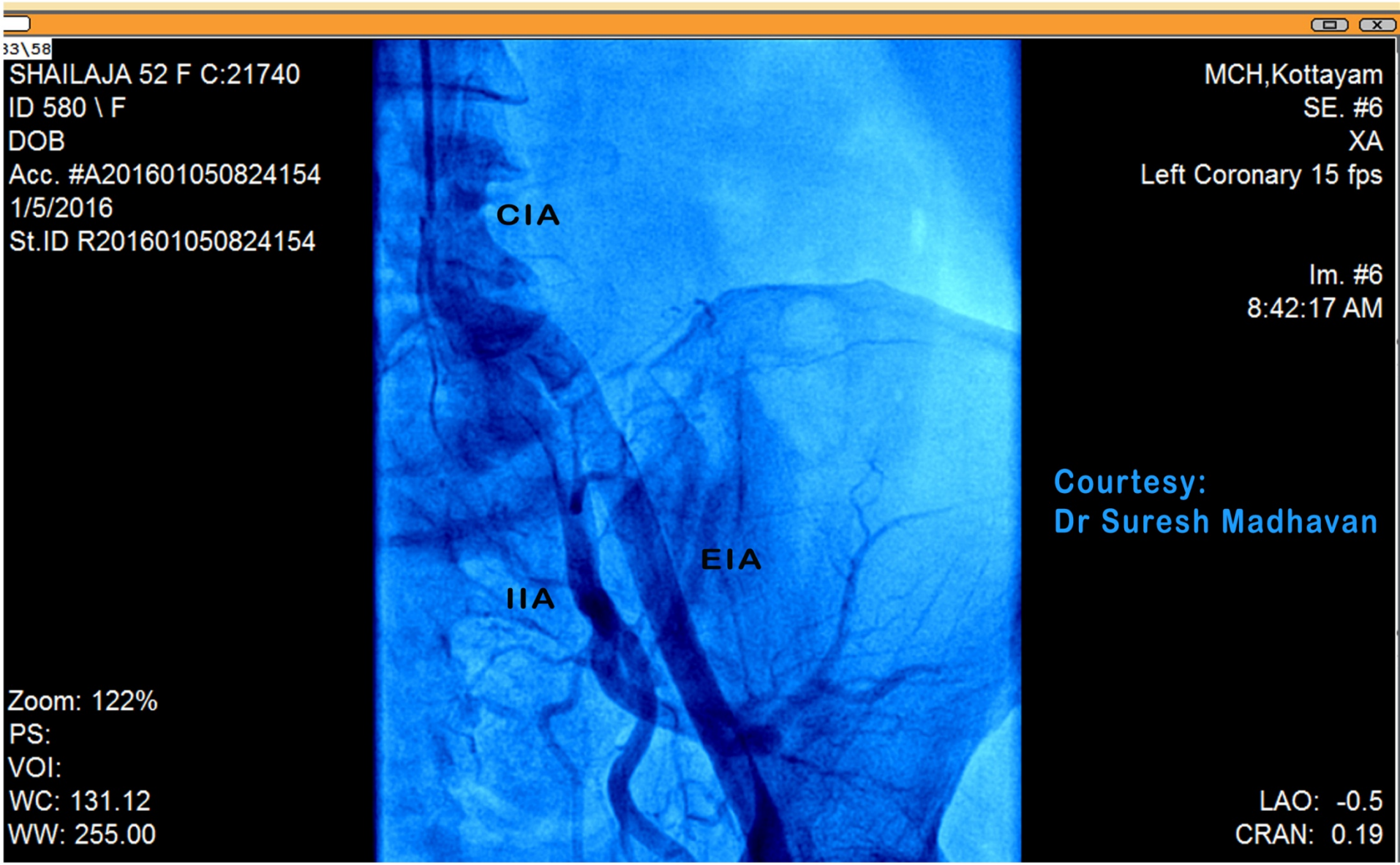
W: 255 L: 127.5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Left Coronary 15 fps
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Dr Suresh Madhavan
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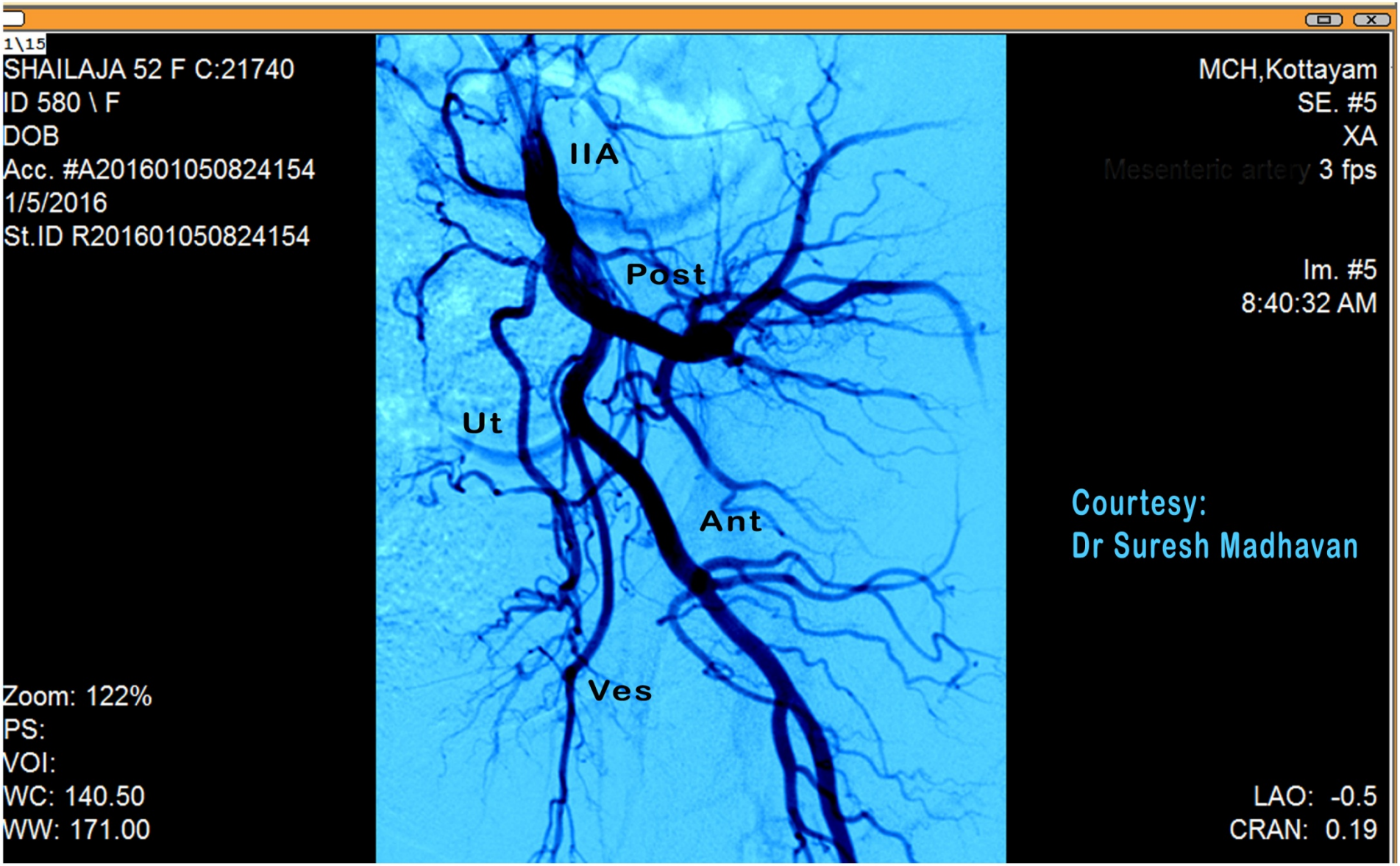
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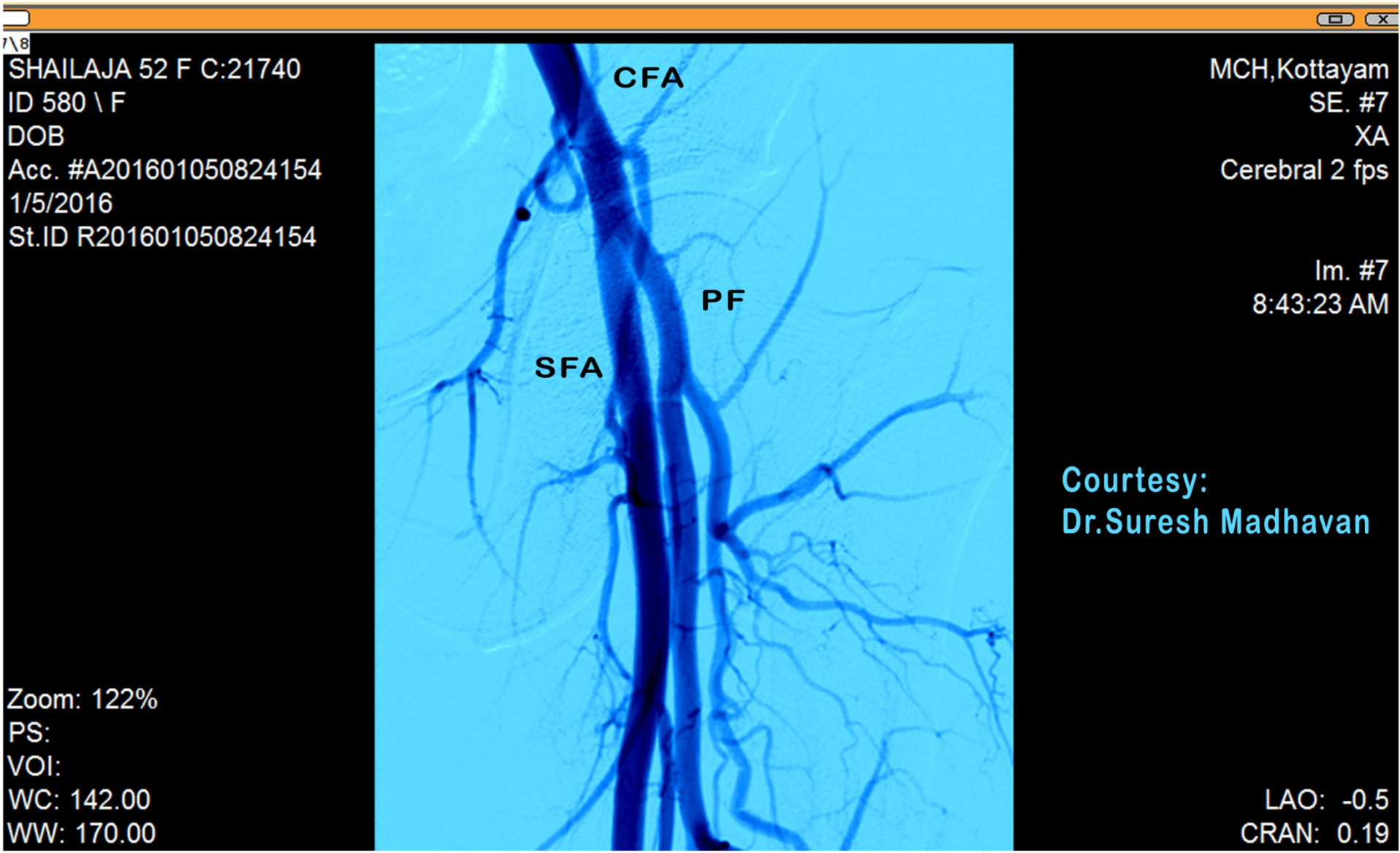
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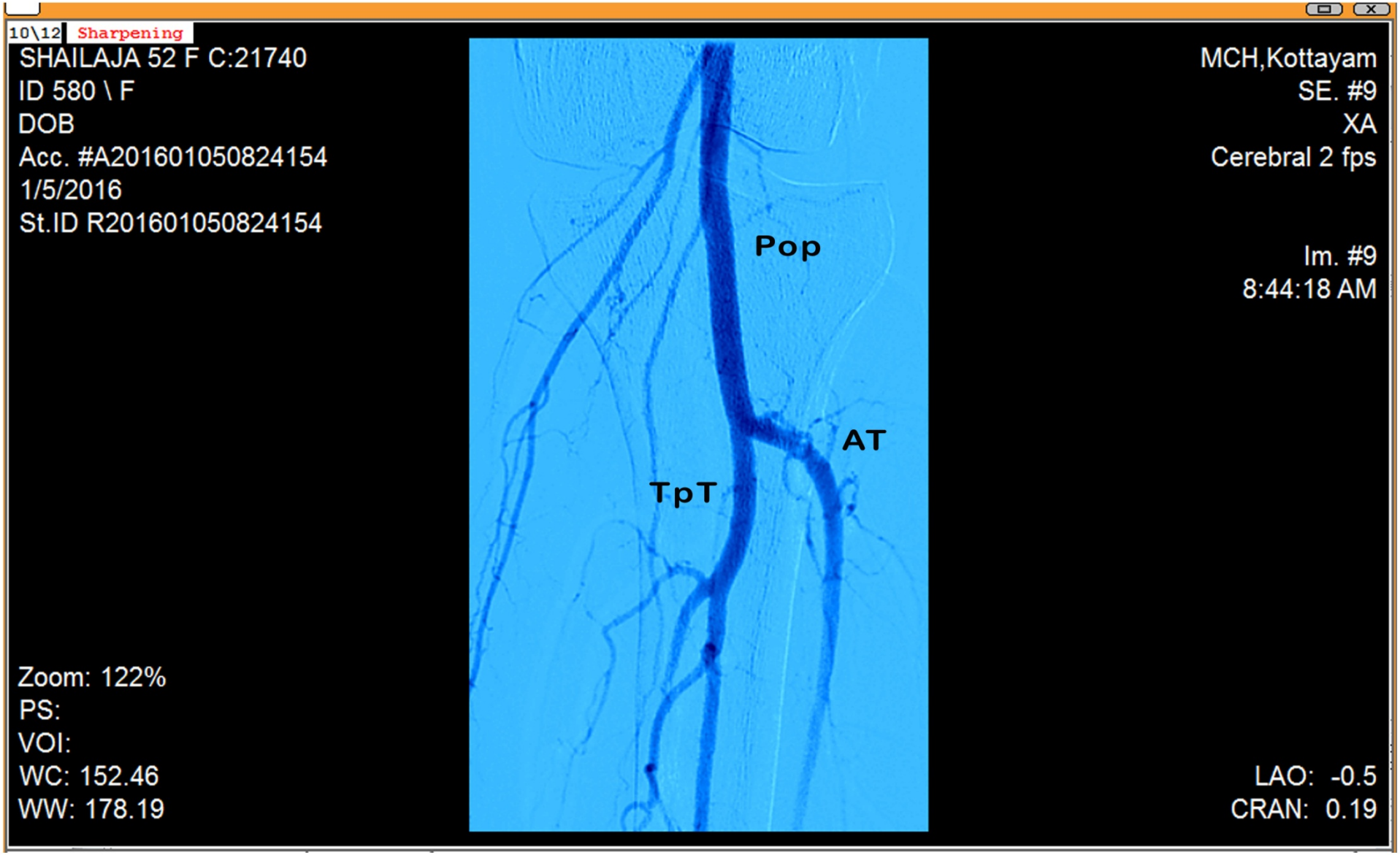
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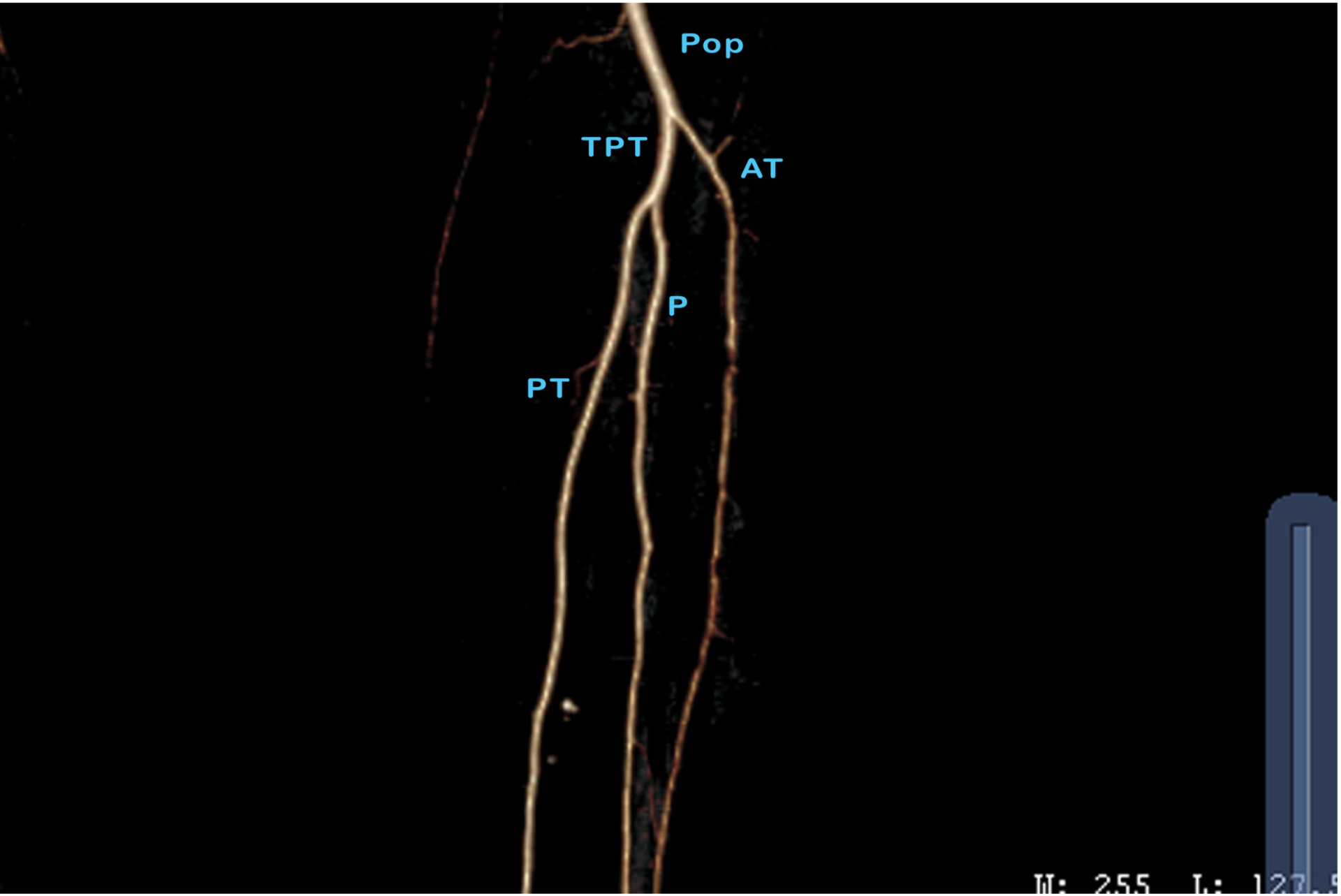
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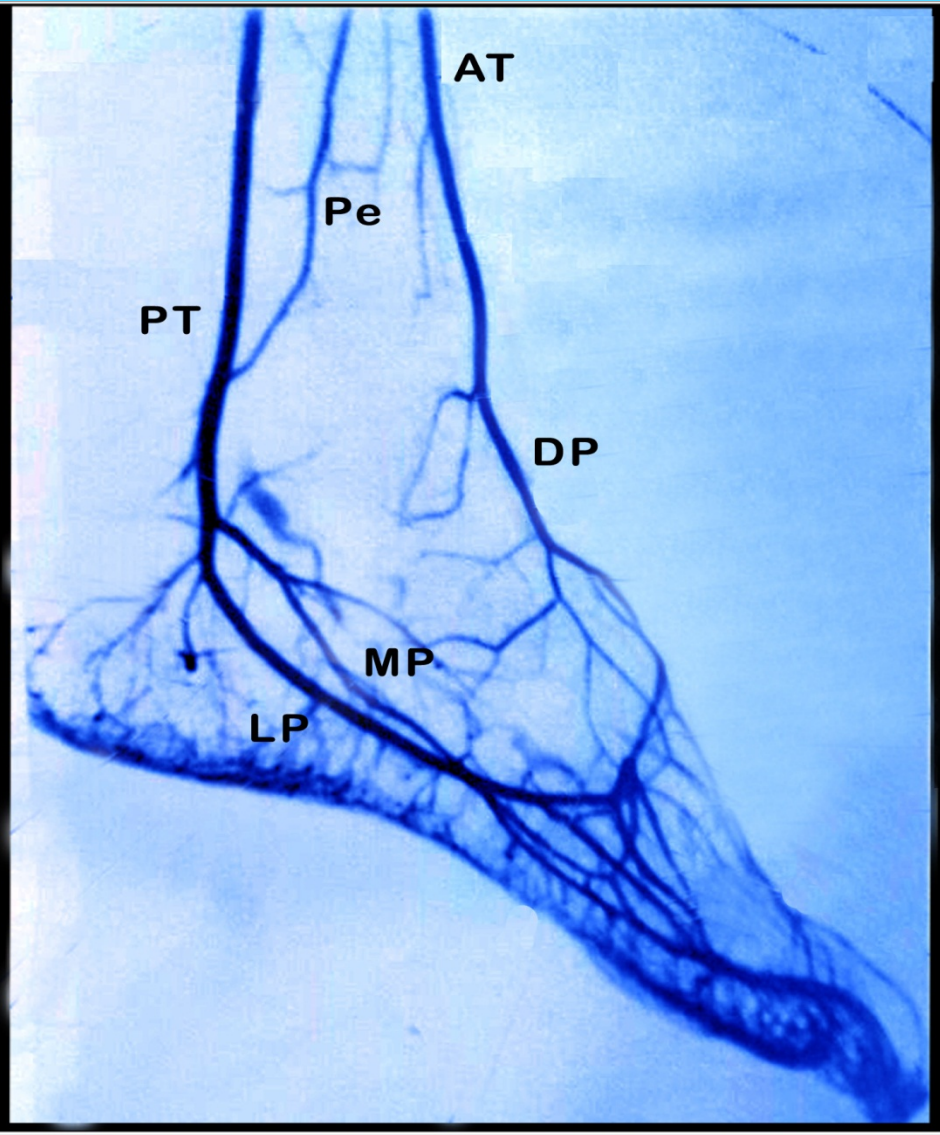

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Evaluation

Clinical

IC vs CLI

single level vs multilevel

Site	Location
Aorto-iliac	Buttock,hip, thigh
Int.Iliac	Gluteal, Impotence
Femoral or branch	Thigh, calf
Popilteal	Calf,ankle,foot
Tibial-peroneal	Foot

PHYSICAL EXAM

6 Ps -Paresthesia, Paralysis
Pain,Pallor,pulselessness
poikilothermia

CVS

Bruits

Pulses

AAA

CKD,DM,Smoking

Non-invasive Vasular testing

ABI- Ankle Brachial Index
TBI - Toe Brachial Index
SLP- Segmental Limb Pressures
Doppler Wave form analysis
Treadmill Test
Duplex US
MRA
CTA

Invasive Vascular testing

Angio
DSA

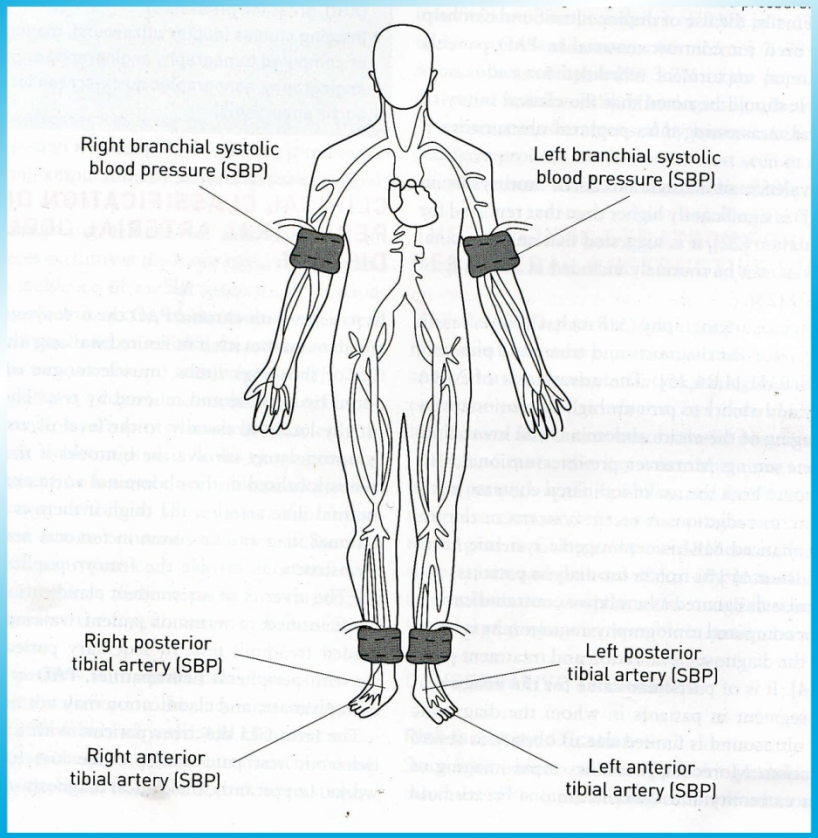
Clinical classification of chronic peripheral arterial disease

FONTAINE CLASSIFICATION		RUTHERFORD CLASSIFICATION	
STAGE	CLINICAL DESCRIPTION	CATEGORY	CLINICAL AND OBJECTIVE DESCRIPTION
Stage I	Asymptomatic		Asymptomatic, normal treadmill test
Stage IIa	IC, pain-free walking distance >200 m	Grade 1	Mild IC, treadmill exercise limited to 5 minutes; ankle pressure after exercise >50 mmHg, but ≥20 mmHg lower than at rest
Stage IIb	IC, pain-free walking distance <200 m	Grade 2	Moderate IC, between Rutherford 2 and 3 disease
Complicated Stage II	Trophic skin lesions, no haemodynamic evidence of CLI	Grade 3	Severe IC, treadmill exercise limited to <5 minutes; ankle pressure after exercise <50 mm
Stage III	Rest pain	Grade 4	Rest pain, ankle pressure <40 mmHg and/or great toe pressure <30 mmHg; pulse volume recording barely pulsatile or flat
Stage IV	Ischaemic lesion (ulcer, gangrene, necrosis)	Grade 5	Limited ischaemic skin lesion; ankle pressure <30 mmHg; pulse volume recording barely pulsatile or flat
		Grade 6	Extended ischaemic skin lesion (above metatarsal level)

IC: intermittent claudication. CLI: critical limb ischaemia.

Ankle Brachial Index

- Simple and inexpensive, accurate method
- Hemodynamic efficacy post revascularisation
- ABI < 0.9 – 95% sensitivity & 99% specificity
- Rest for 15 to 30 minutes prior to measuring
- Continuous wave Doppler probe
- ABI for each lower extremity
  - dividing the higher ankle pressure (dorsalis pedis or posterior tibial artery) in each lower extremity by the higher of the two brachial artery systolic pressures


Right branchial systolic blood pressure (SBP)
Left branchial systolic blood pressure (SBP)
Right posterior tibial artery (SBP)
Left posterior tibial artery (SBP)
Right anterior tibial artery (SBP)
Left anterior tibial artery (SBP)

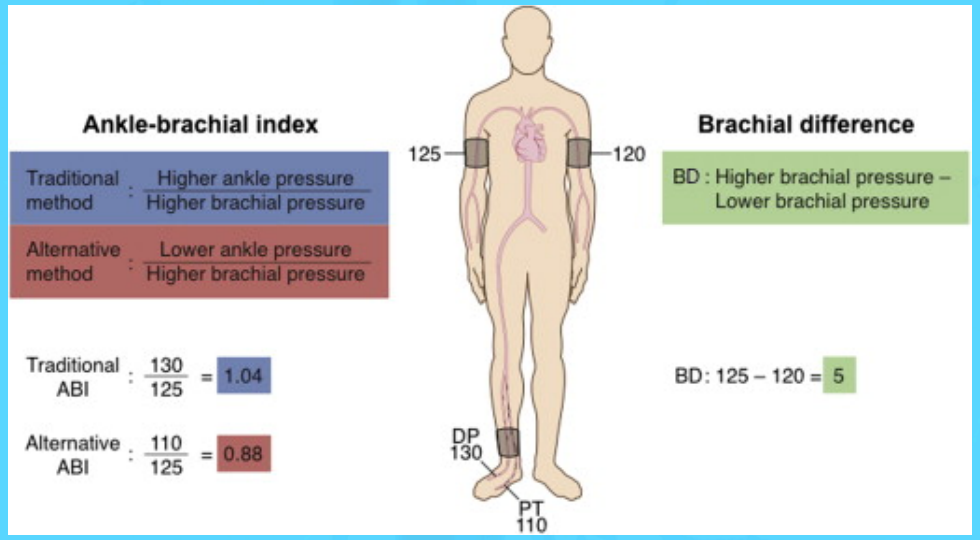
ABI

ABI	Interpretation
Noncompressible vessel	> 1.40
Normal	1.00 to 1.40
Borderline	0.91 to 0.99
Mild	0.70 to 0.90
Moderate	0.40 to 0.69
Severe	<0.40

Alternate ABI

Limitations

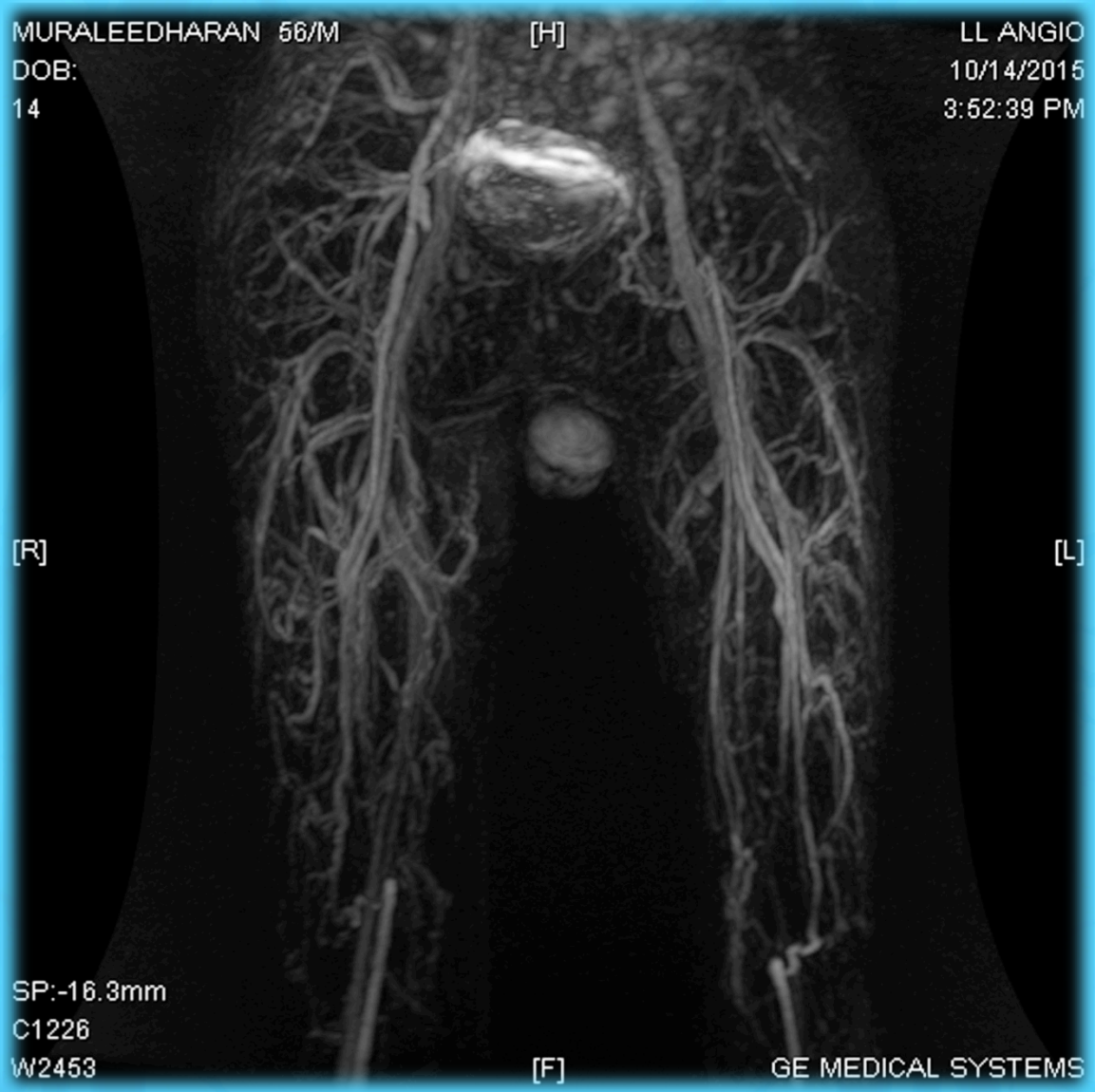
- **N in aorto-iliac disease & well collateralized**
- **Non-compressible vessels**
- **Location not defined**



Duplex Ultrasonography

- Combines B-mode imaging and PWD
- Accurate, cost-effective, noninvasive
- No contrast administration or radiation
- Morphologic changes in the arterial wall
- Estimation of the degree of stenosis based on the blood flow velocity
  - peak systolic velocity >200 cm/s or correlates with an obstruction of more than 50%
- Serial monitoring
- Time consuming
- Accuracy is operator dependent
- Visualization of the aorta and renal, mesenteric, and iliac arteries
- Severe calcification, overlying skin disorders, or edema interfere

MR Angio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GE MEDICAL SYSTEMS

MRA

- "Single greatest advance in diagnosis of PAD"
- Types
  - Contrast MRA (Gadolinium based MRA)
  - TOF (Time of flight) MRA
    - Stationary saturated tissue vs unsaturated blood
- In PAD
  - Gadolinium based MRA
    - "Bolus chase technique"
    - 0.3 mmol/kg
  - 2 D TOF – GFR < 30ml/hr
    - 5ml contrast
  - 3 D TRICKS (Time Resolved Imaging on Contrast Kinetics)
    - Increase frame rates
    - Better resolution
    - Less time

MRA - Advantages

- MRA meets or exceeds the quality of traditional catheter-based angiography
- Better identification of small runoff vessels
- Sensitivity and specificity of more than 90% and 97%, respectively esp infrapopliteal
- Excellent soft tissue imaging
- Vessel wall information
- Qualitative aspects of plaque, intraplaque hemorrhage

Limitations of MRA

- Claustrophobia
  - Open MRI
- Patients with pacemakers, prosthetic valves and intracranial arterial aneurysm clips
- Increased venous contamination in patients with critical limb ischemia or diabetic foot ulcers owing to rapid arterial-venous transit
  - circumvented by the use of venous cuffs and judicious use of timing techniques
- Nephrogenic systemic fibrosis
- Severe renal insufficiency (GFR <30–35 mL/min)
- Artefacts

MRA artifacts

- Technical issues
  - Long TE
  - Vessel not fully in 3D slab
  - Low spatial resolution
- Inadequate SNR
  - Insufficient Gd dose
  - Bad Gd timing
  - Thin slices
  - Small field
  - Inadequate field strength
- Miscellaneous
  - Metal clips
  - Arm wraps
  - Bright fat, hemorrhage/GI contents

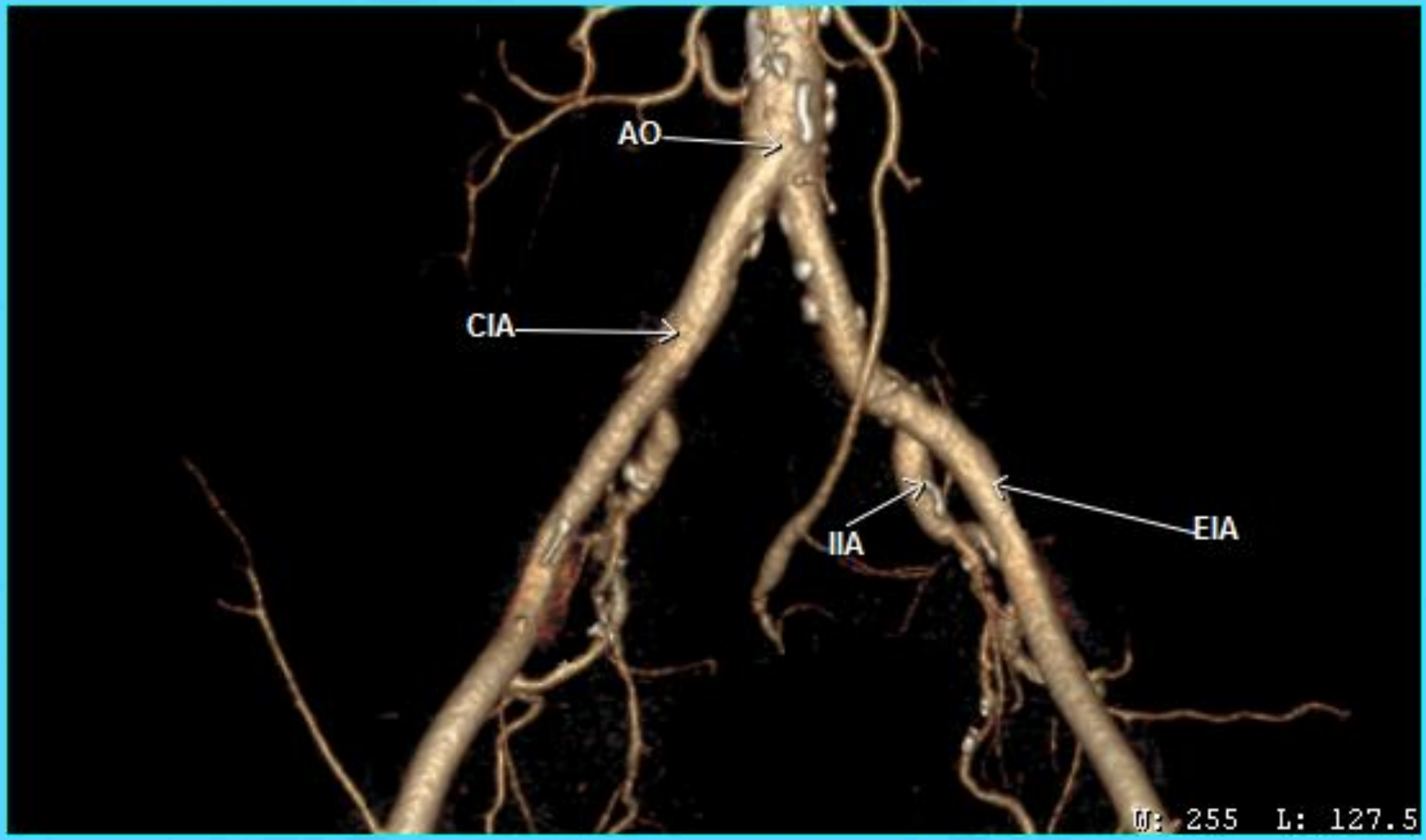
Safety screening before MR

- Absolute contraindications
  - Pacemakers, ICDs
  - Aneurysm clips
  - Cochlear implant
  - Electronic implants
- No contraindications
  - Stents, coils, filters (after 4 – 6 weeks)
  - Vascular access ports
  - Dental devices & materials
  - Orthopedic materials
  - Heart valves after 1983

Nephrogenic Systemic Fibrosis

- 2.5 and 5 percent ; eGFR <30 mL/min per 1.73 m^2
- Dose-response relationship
- Greater with linear than with macrocyclic preparations
  - Gadodiamide (Omniscan), gadoversetamide (OptiMARK), and gadopentetate dimeglumine (Magnevist) should be avoided
- Activation of the transforming growth factor (TGF)-beta-1 pathway
- Directly stimulates the bone marrow to produce CD34+ circulating fibrocytes
- IL-4, IL-6, and IL-13
- Symmetrical, bilateral fibrotic indurated papules, plaques, or subcutaneous nodules
- "cobblestone" , "woody" , or peau d' orange appearance
- Muscle induration, Joint contractures
- Fibrosis in lungs, diaphragm, myocardium, pericardium, pleura , dura mater
- Calcification

CT Angio



CT Angio

- "Real-feel" view of the arterial tree
- Advantages
  1. More accurate depth perception
  2. 3D reconstructions - multiplanar reconstruction in coronal, sagittal, and axial images
  3. Visualization of the arterial wall,surrounding soft tissues, other adjacent anatomic structures
  4. Arterial calcification, plaque ulceration, intravascular thrombus, stent fracture, in-stent restenosis, or intimal hyperplasia
  5. Less invasive
  6. Fewer complications
  7. sensitivity and specificity of greater than 95%

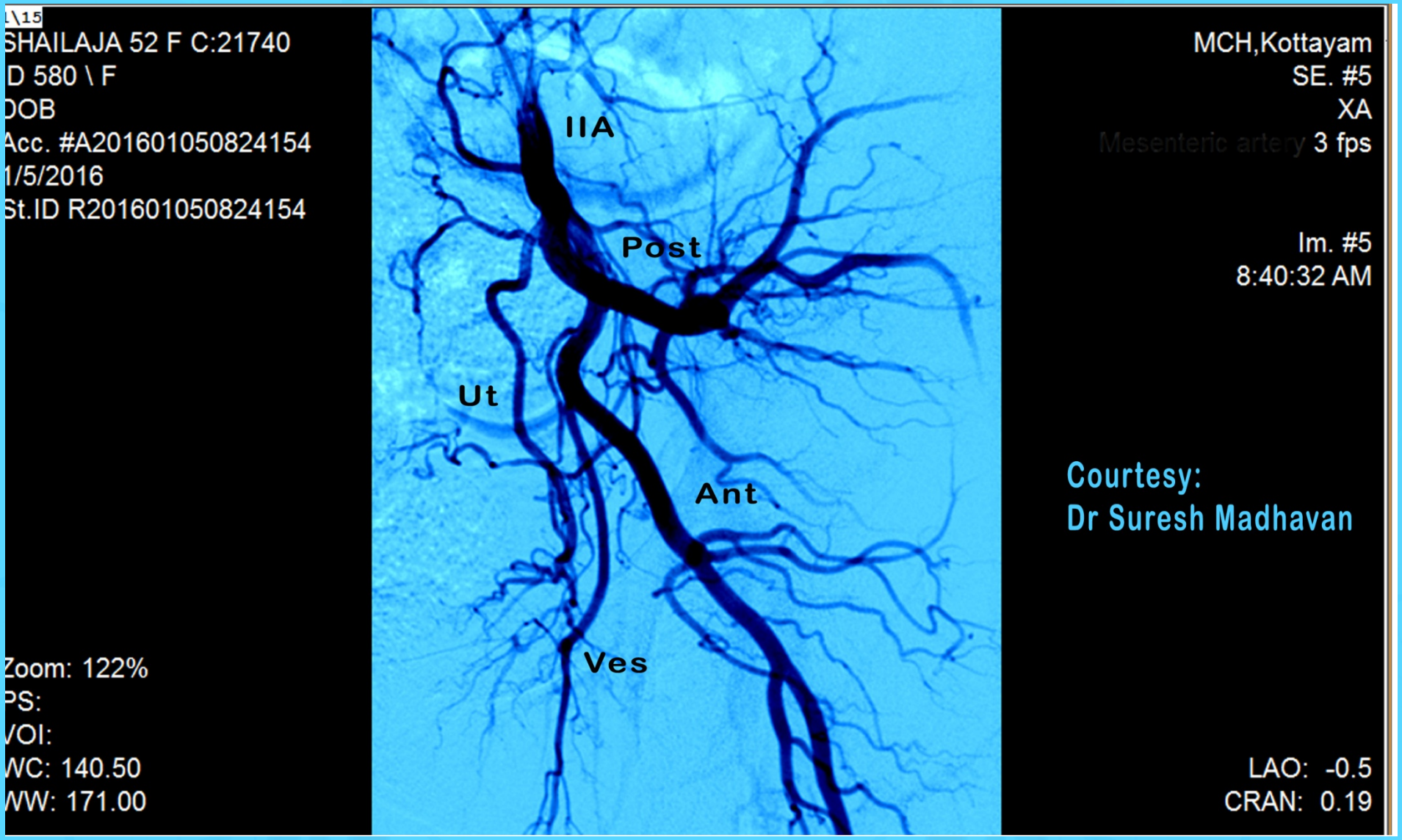
CT angio

- Limitations
  - Ionizing radiation
  - Iodinated contrast (100-150ml)
  - Lengthy acquisition times
  - Extensive vascular calcification can obscure the lumen, overestimate the degree of stenosis

Recommended injection protocol for PAD imaging

Suggested Injection Protocol	
Contrast Agent	Low-osmolar nonionic 350–370 mg/mL
Site of Bolus Detection	Aorta, below diaphragm
Scan Time	Fixed at 40 s
Injection Duration	35 s
Pitch	Variable and adjusted to scan time of 40 s
Delay	Bolus trigger to occur on reaching threshold of 150–200 HU
Weight-based Biphasic Injection Rate (sustained opacification of the arterial system)	<55 kg: 20 mL (4 mL/s) + 96 mL (3.2 mL/s) 56–65 kg: 23 mL (4.5 mL/s) + 108 mL (3.6 mL/s) 66–85 kg: 25 mL (5.0 mL/s) + 120 mL (4.0 mL/s) 86–95 kg: 28 mL (5.5 mL/s) + 132 mL (4.4 mL/s) >95 kg: 30 mL (6.0 mL/s) + 144 mL (4.8 mL/s)

DSA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Contrast Angiography

- Detailed information about arterial anatomy
- When revascularization is contemplated
- Contrast reaction should be documented
- DSA is recommended- enhanced imaging capabilities
- Selective or super selective catheter placement
- Patients with baseline renal insufficiency should receive hydration

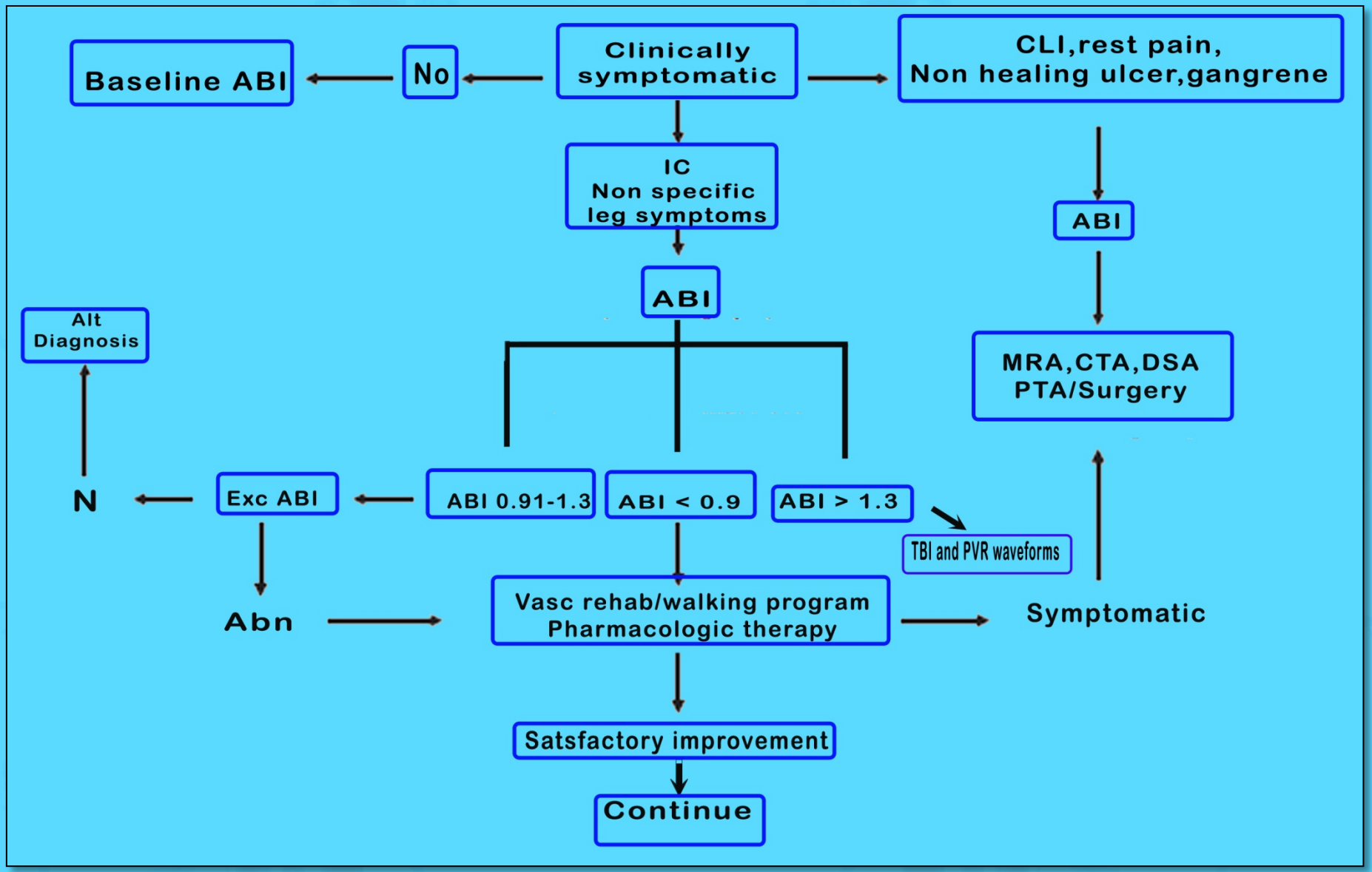
Contrast Angiography

- Advantages
  - ability to selectively evaluate individual vessels
  - obtain physiologic measurements, pressure gradients across stenotic lesions
  - IVUS - investigate the vessel wall
  - 3D reconstruction, virtual histology
  - Peripheral OCT developing
  - perform a therapeutic intervention in the same setting
- Limitations
  - ionizing radiation
  - iodinated contrast agents, CIN
  - risk of complications from vascular access and catheterization

DSA views

Vessel	View
Distal Ao	AP
CIA	AP
EIA	10 – 30 RAO, contralat
IIA	10 – 30 RAO, contralat
Rt CFA & PF	20 – 30 RAO, ipsilat
Lt CFA & PF	20 – 30 LAO, ipsilat
SFA	AP
Pop	AP
AT	AP / steep oblique
Peroneal	AP / steep oblique
PT	AP / steep oblique

Algorithm


Clinically symptomatic
No
Baseline ABI
CLI,rest pain, Non healing ulcer,gangrene
IC Non specific leg symptoms
ABI
ABI
MRA,CTA,DSA PTA/Surgery
Alt Diagnosis
N
Exc ABI
ABI 0.91-1.3
ABI < 0.9
ABI > 1.3
TBI and PVR waveforms
Abn
Vasc rehab/walking program Pharmacologic therapy
Symptomatic
Satsfactory improvement
Continue

Summary

- Patients with known risk factors for PAD or symptoms should be evaluated with appropriate physical examination and diagnostic testing
- Different imaging techniques play a role in the evaluation, management, and follow-up of patients with PAD & each with its own advantage and disadvantage
- Once a diagnosis of PAD is established, appropriate treatment – conservative, percutaneous intervention or surgery to be undertaken
- Patients should be placed in surveillance programs, typically using duplex ultrasonography

Thank You