The Ever Changing Role of Diagnostic Testing

- Donna M Mendes MD, FACS

Learning objectives

- Understand the reliability and cost effectiveness of:
  - History and physical exam
  - Non-invasive physiologic testing
  - Ultrasound for venous and arterial imaging
  - Contrast utilizing imaging
- When to use:
  - Non-invasive physiologic testing
  - Venous imagining tests
  - Arterial imagining test
  - Lymphatic imaging studies
- Understand the difference between functional testing and imaging
- Understand the role for emerging technologies

The History
The Physical Exam

Initial assessment

- A time to develop mutual trust between you and the person “signing out” to you
- Tailor to flow to the presenting problem, but should be comprehensive enough to understand the complete picture of the patient
- Remember test results (pulse exam) must be correlated with clinical impression
- If there is a discrepancy between the clinical impression and the findings the provider must develop a workable explanation

General Vascular History

- Previous heart attack, angina, coronary intervention
- Previous arterial vascular surgery
- Medication – reconciliation
- Leg swelling, history of DVT, history of venous surgery

The History

- Venous History
  - How long have the varicose veins been present
  - How long has there been swelling
  - How long has an ulcer been present

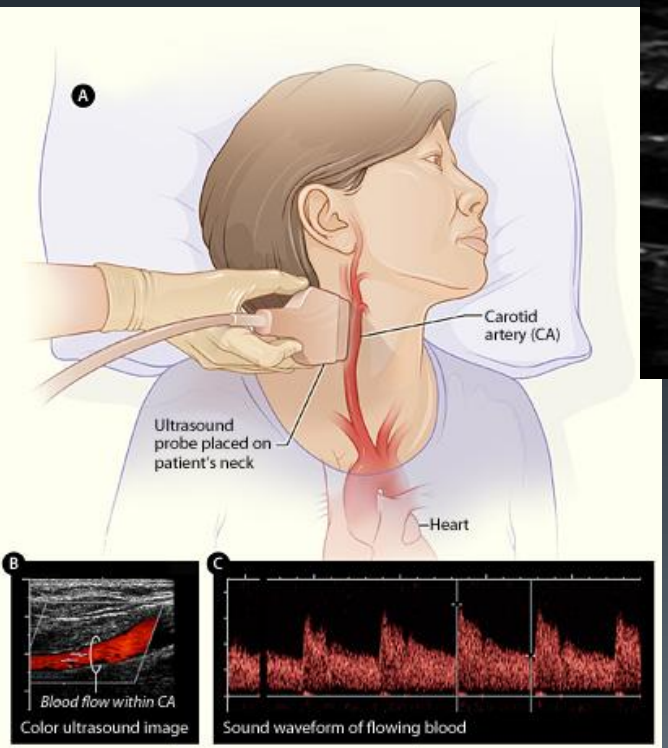
The History

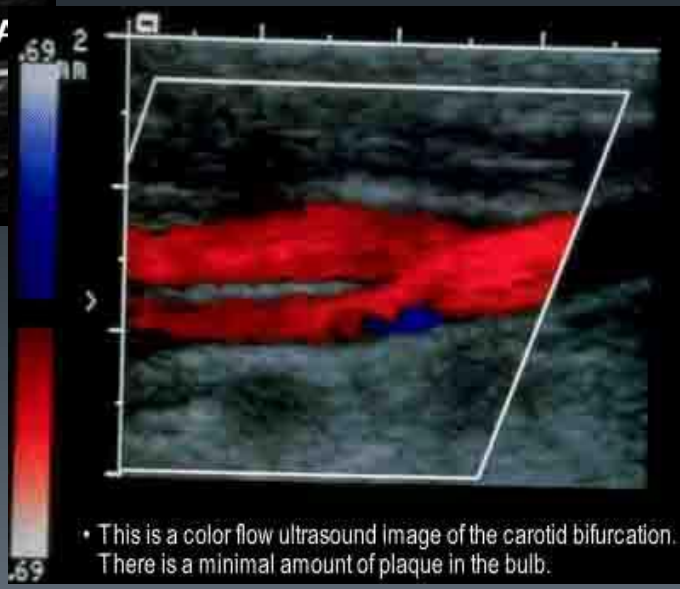
- Arterial history – typical features
  - Pain brought on by exercise, relieved by rest (claudication)
    - Most commonly in the calf
    - *Nocturnal cramps have no known vascular basis
  - Pain in the forefoot at nighttime (rest pain)
  - In the diabetic patient a complete lack of pain is normal
  - *Pain that is intermittently present in the foot or leg and occurs with exercise, BUT is also present at rest is not related to arterial disease
    - Other differentials include: Osteoarthritis, Neurospinal compression, chronic compartment syndrome

The History

- Lymphatic
  - The duration of swelling of the leg
  - When was the onset of symptoms
  - Previous malignancy, previous surgery, previous radiotherapy

CAROTID DUPLEX ULTRASOUND OR CAROTID DOPPLER

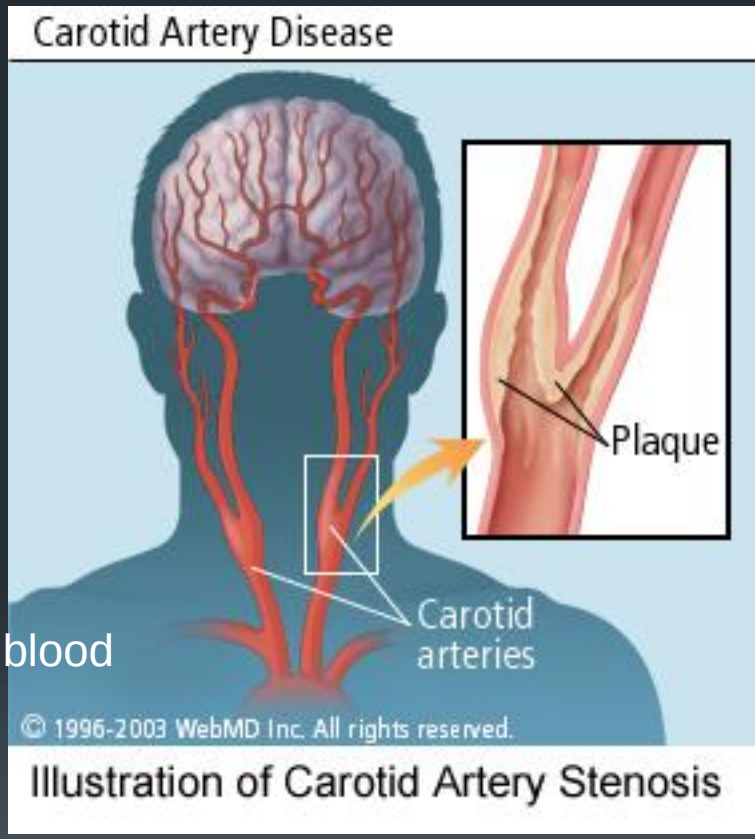




• This is a color flow ultrasound image of the carotid bifurcation. There is a minimal amount of plaque in the bulb.

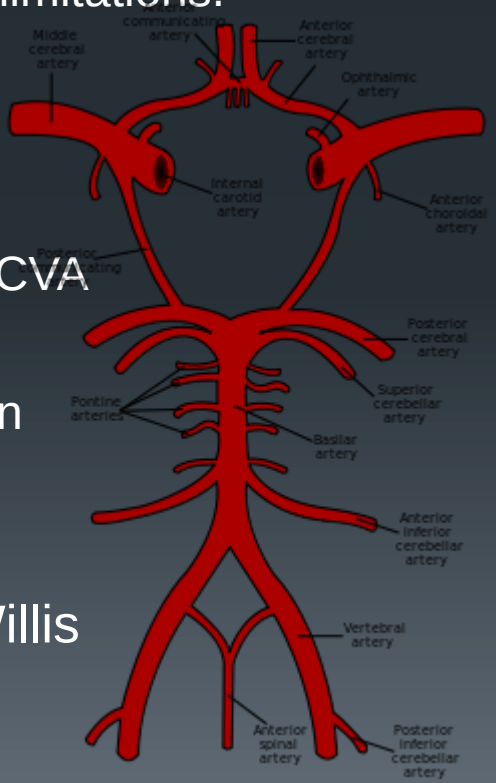
Carotid duplex study- extracranial

- Indications
  - TIA-transient ischemic attack
  - CVA – cerebrovascular accident
  - Bruit
- Symptoms
  - Amourosis Fugax
  - Numbness/Weakness (unilateral)
  - Speech difficulty
  - Dizziness
- Used as a frontline or screening test
  - No prep for test and no harm to patient
  - Internal carotid artery supplies 80% of the blood to the brain
  - Vertebral arteries are the other 20%
- Diagnostic criteria
  - Laboratory variability
  - Incidence of CVA in the next year with intervention vs. conservative treatment



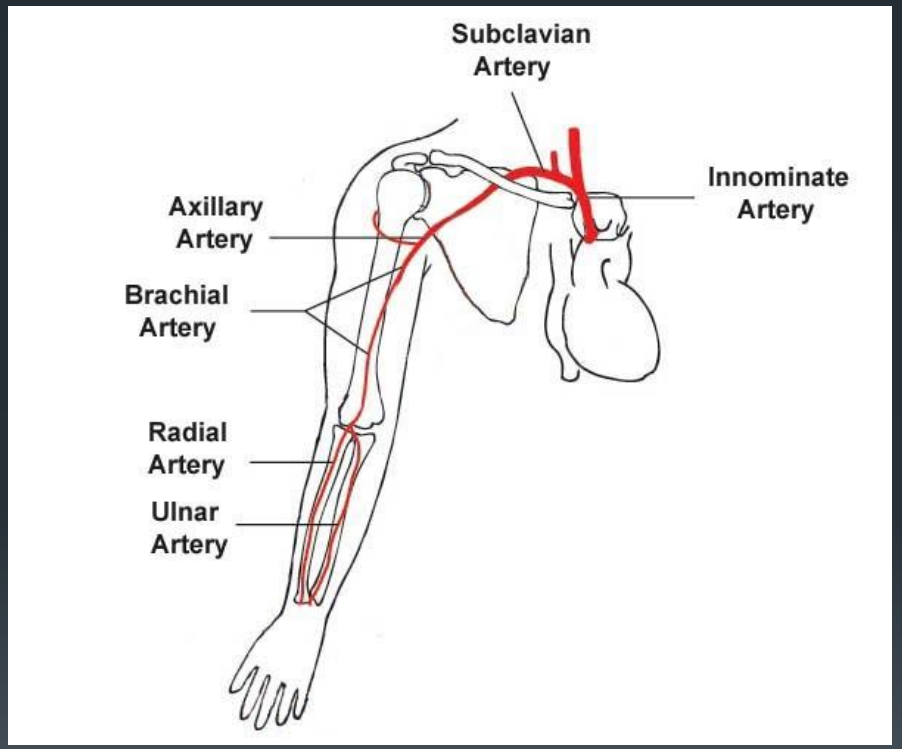
Transcranial Doppler (TCD) Intracranial circulation

- This test is a Doppler only
  - Recent advances have added M-mode doppler which increases the accuracy of the test and B-mode imaging with Color doppler: although imaging is not widely used and has serious limitations.
- Indicatons
  - CVA
  - TIA
  - Sickle cell anemia- as a tool to determine risk of TIA/CVA
  - monitoring for vasospasm and vasculitis
  - assessing initial collateral blood flow and embolization during carotid endarterectomy (shunt placement to reduce the risk of stroke)
- Evaluates the arteries the make up the Circle of Willis



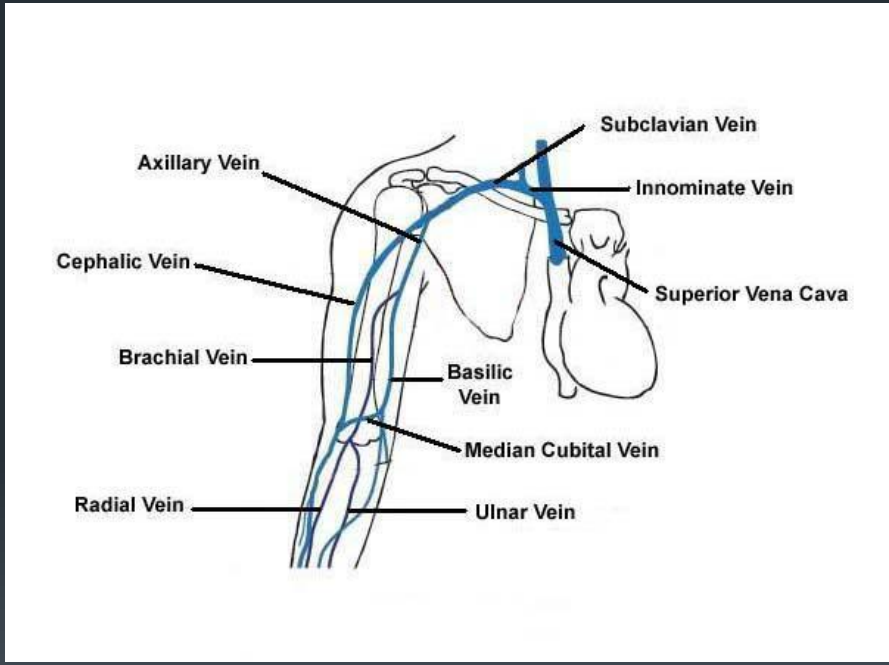
Upper extremity duplex ultrasound -arteries

- Indications
  - Palmer arch assessment prior to radial artery harvesting for cardiac bypass surgery
  - Suspected digital embolization
  - Evaluation of A-V fistula/Hemodialysis grafts
  - Arm Claudication
- Symptoms
  - Cold hands/fingers (vasospasm/Raynaud's)
  - Non-healing finger wounds
  - Hand or finger pain
  - Problem with hemodialysis pressures/maturation



Upper extremity duplex ultrasound - veins

- Indications
  - Vein mapping prior to vascular or cardiac surgery,hemodialysis
  - DVT (deep vein thrombosis)
- Symptoms
  - Arm pain
  - Acute or chronic swelling



The Examination

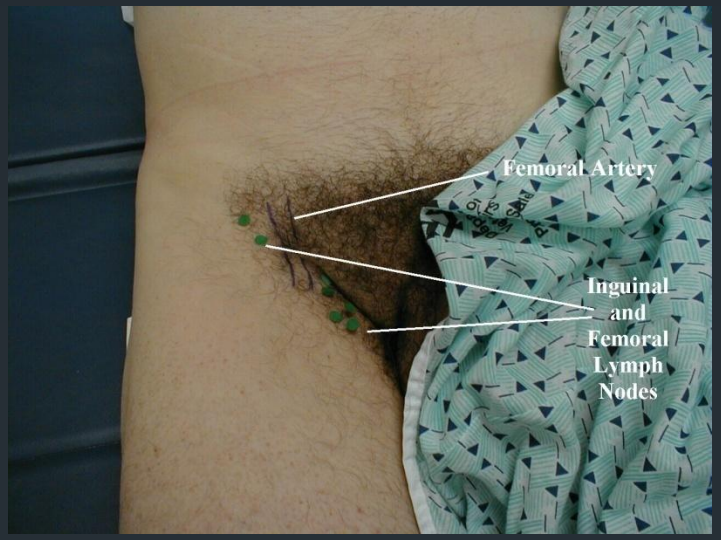
- Palpation
  - Temperature
    - Cool suggest poor circulation
  - Pitting edema
    - Test on dorsum of foot, if present on the dorsum of the foot
  - Capillary refill
    - Should be less than 3 seconds

The Examination

- Arterial pulses
  - Dorsalis pedis artery pulse – on the dorsal of the foot, running lateral to the tendon of the first toe – missing in 10% of normals
  - Posterior tibial artery pulse – posterior and inferior to the medial malleolus
  - Popliteal artery pulse – behind the knee, typically done with both hands, examiner facing the patient. The patient needs to relax the leg
  - Femoral artery pulse – in the femoral triangle/halfway between the anterior superior iliac spine and pubic symphysis

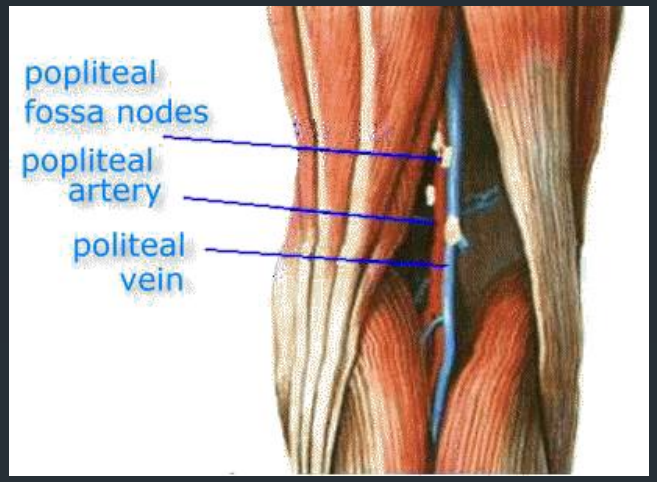
Pulse Exam Lower Extremity

- Femoral
  - Easy to palpate
  - May be obscured in obesity
  - Can examine lymph nodes
  - Femoral hernia



Pulse Exam-LE

- Popliteal
  - More difficult to palpate
  - Femoral condyles/muscle
  - Slightly flex and relax leg
  - One hand – Pop aneurysm



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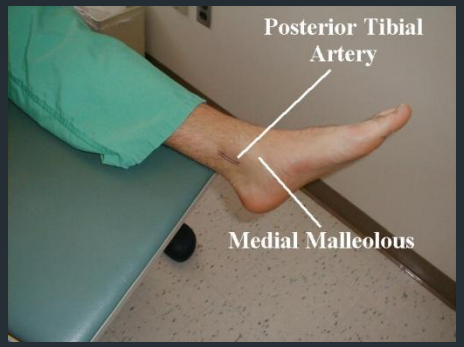
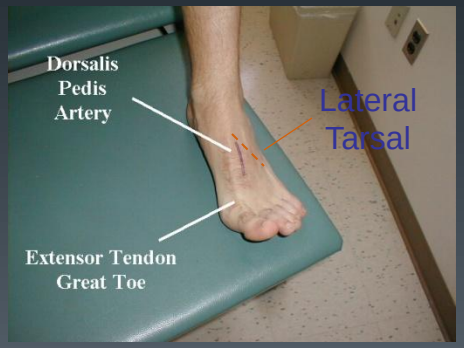
Pulse Exam-LE

- PT
  - Gentle pressure best
  - Relax & dorsiflex ankle



- DP
  - 2 hands to palpate
  - Absent in 10%
  - May have lateral tarsal



Pulse Exam-LE

- May need to press through edema
- Calcified vessels

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The Hand Held Doppler

- Bedside Ankle Brachial Index
  - Compare the systolic occlusion pressure of the brachial artery with the systolic occlusion pressure of the posterior tibial artery, and dorsalis pedis artery
- Artificially elevated in diabetes mellitus, chronic renal disease, old age
- Listen to the ultrasound
  - Normal triphasic ultrasound
  - Proximal disease – biphasic ultrasound
  - Severe – monophasic ultrasound

The Hand Held Doppler

- Inexpensive
- Widely available
- Does not offer detailed description of length, severity, or type of the diseased vessel
- Time and labor consuming
- The PAD screening score using the hand held Doppler has the greatest diagnostic accuracy

The Vascular Laboratory
Arterial

- Plethysmography
- Noninvasive Extremity Pressure Measurements
- Doppler Waveform Analysis
- Transcutaneous Oximetry

Goals of Testing

- Does the Patient Have Disease?---P=I
- How Does the Disease Relate to the Patient's Presentation?----P alone
- Where Is the Disease Located?----I>P
- What Are the Therapeutic Options?---I>>P
- What Are the Results of Therapy?---P alone

P= physiologic I= imaging(Anatomic)

From: Brenenati, JF, 2005

Physiologic Tests

- Ankle-Brachial Index (ABI)
- Pulse Volume Recordings, i.e. Segmental Plethysmography (PVRs)
- Exercise PVRs

- *Does the patient have the disease, is it related to their symptoms, where is the general location of the disease*

Plethysmography

- A plethysmograph is a device that measures or records variations in:
  - The volume of an organ or extremity
  - The blood contained in or passing through

  - Most commonly used Segemental air plethysmography

Segmental Air Plethysmography

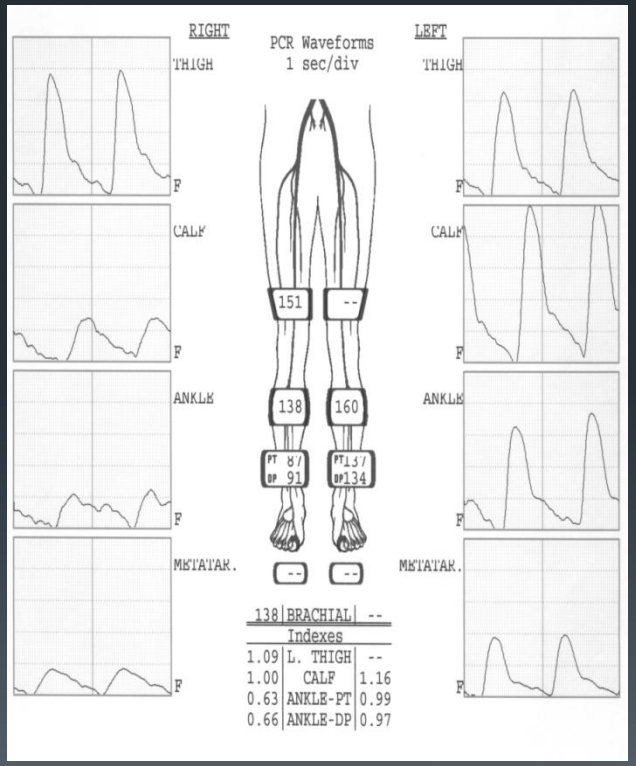
- The change in volume of an extremity between systole and diastole
- The change in volume is completely dependent upon pulsatile blood flow
- The **P**ulse **V**olume **R**ecording (PVR) was developed in the 1970s specifically for arterial diagnosis
- The cuffs are off appropriate diameter to the location on the limb
- They are inflated to 65 mmHg to ensure appropriate contact between the cuff and the extremity

PVRs

- Pneumatic cuffs of specific size placed at thigh, calf, ankle, and transmetatarsal level
- Inflated to 65mm Hg
- Measure volume changes at each level
- Generates pulse waveform

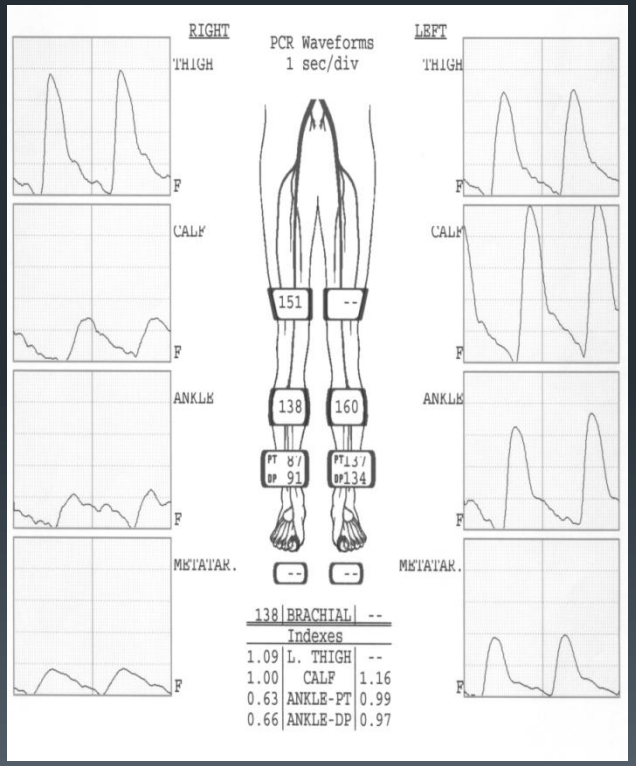
Segmental Air Plethysmography

- Most laboratories report qualitative interpretation
- A normal trace displays a sharp systolic rise and prominent dicrotic notch
- As disease progresses the wave flattens
- Quantitative methods of reporting have been described but are not widely applied



Segmental Air Plethysmography

- Most commonly used in conjunction with segemental pressure measurements
- PVR not affected by vessel wall stiffness
- Not effected significantly by edema



Noninvasive Extremity Pressure Measurements

- Ankle pressure
  - Patient should rest for 15 minutes in the supine postion
  - A standard 12 cm cuff is placed above the malleolus
  - A continuous wave (CW) doppler is used to listen to the DP/PT signals
  - The cuff is inflated until the flow stops and then is gently deflated
  - The highest occlusion pressure from the DP/PT is used as the ankle index
  - This is then interpreted in relation to the highest brachial occlusion pressure
  - Primary source of error is calcification of the vessel wall: 5-15% of patients

Noninvasive Extremity Pressure Measurements

- Segmental Pressures
  - These detect the level of significant disease
  - Determine what disease exists at a single level or multiple levels
  - Pressure cuffs are placed high on the thigh, above the knee, below the knee, on the ankle and the forefoot
    - Many do not use the proximal cuff due to leg girth
  - * The recommended cuff width for accurate blood pressure measurement is 1.2 times the diameter of the extremity under the cuff

Doppler Waveform Analysis

- The arterial waveform is determined by:
  - Cardiac pulsations
  - Viscosity of the blood
  - Elasticity of the arterial wall
  - Location and extent of atherosclerotic oclussive diseas
- Many vascular laboratories assess Doppler waveform qualitatively and assign it a category
- Proximal stenosis dampens the peak systolic ; normal arteries have a reversal of flow in early diastole

Doppler Waveform Analysis

- Pulsatility Index – Quantitative analysis of doppler waveforms
  - The difference between the highest velocity and the lowest velocity divided by mean velocity

ABI

- Ratio of ankle SBP to brachial SBP
- Measure ankle pressure at DP & PT
- Use the higher value for ankle pressure

- Excellent predictor for all CV risk

ABI

- Interpretation

  1.1 NL (systolic pressure augmented in periphery)

  0.9-1.09 - Asx

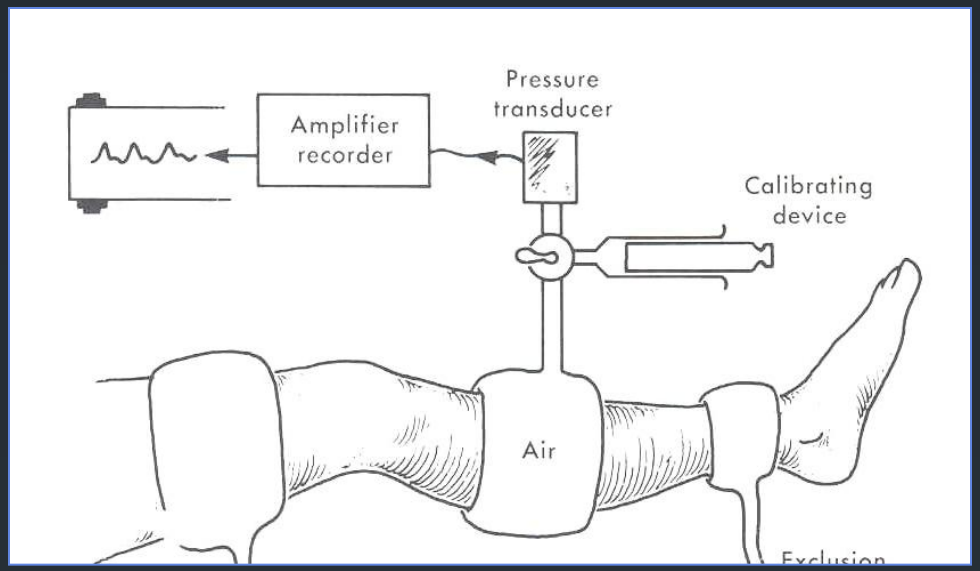
  0.7-0.89 - Mild claudication

  0.5-0.69 - Mod-severe claudication

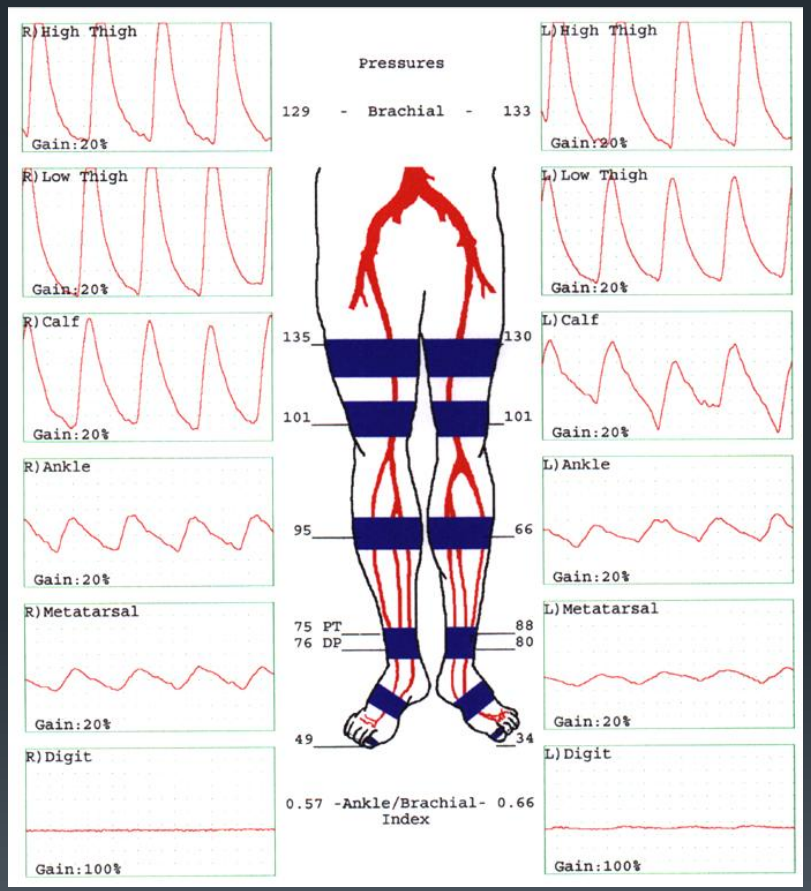
  0.2-0.49 - Rest pain, tissue loss

- Falsely Elevated (can be >1.5)
  - ✓ Extensive Calcification (incompressible)
  - ✓ Subclavian or other UE stenosis

PVRs


Amplifier recorder
Pressure transducer
Calibrating device
Air
Exclusion

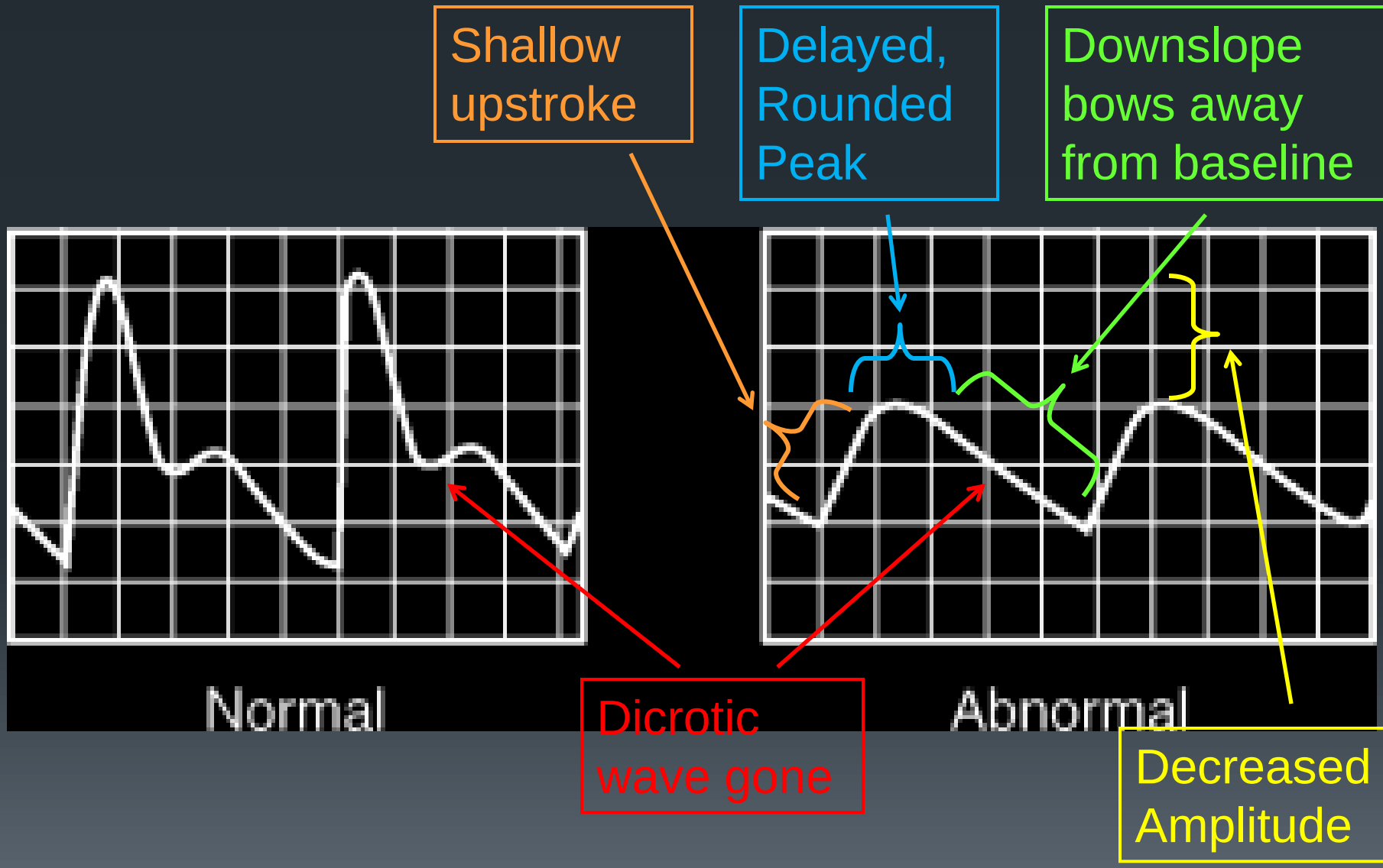

Circulation. 2007;115:e624-e626


R) High Thigh
Gain:20%
Pressures
129 - Brachial - 133
L) High Thigh
Gain:20%
R) Low Thigh
Gain:20%
L) Low Thigh
Gain:20%
R) Calf
Gain:20%
135
130
101
101
L) Calf
Gain:20%
R) Ankle
Gain:20%
95
66
L) Ankle
Gain:20%
R) Metatarsal
Gain:20%
75 PT
76 DP
88
80
L) Metatarsal
Gain:20%
R) Digit
Gain:100%
49
34
0.57 -Ankle/Brachial- 0.66
Index
L) Digit
Gain:100%

PVRs

- Reveals pulse waveform
- Measure volume changes at each level
- Determine level of disease
- Reflects overall flow

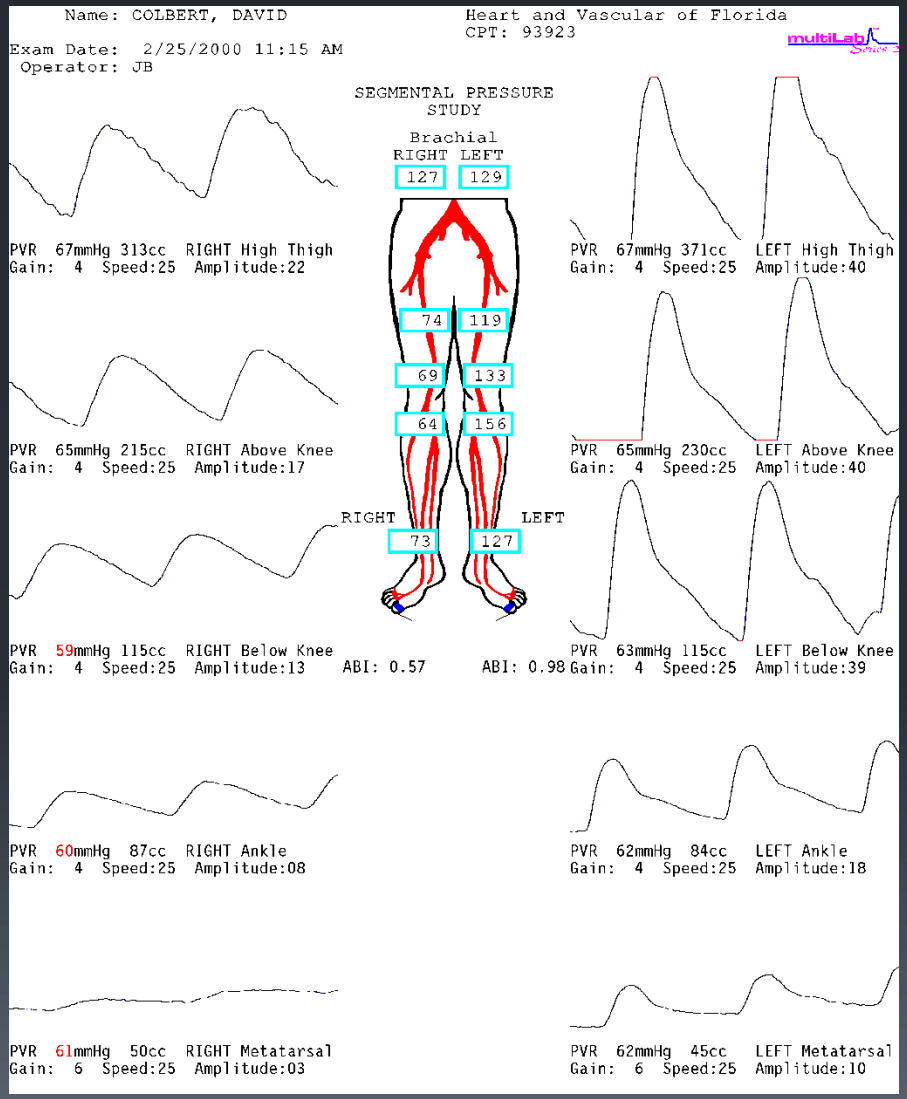
PVRs

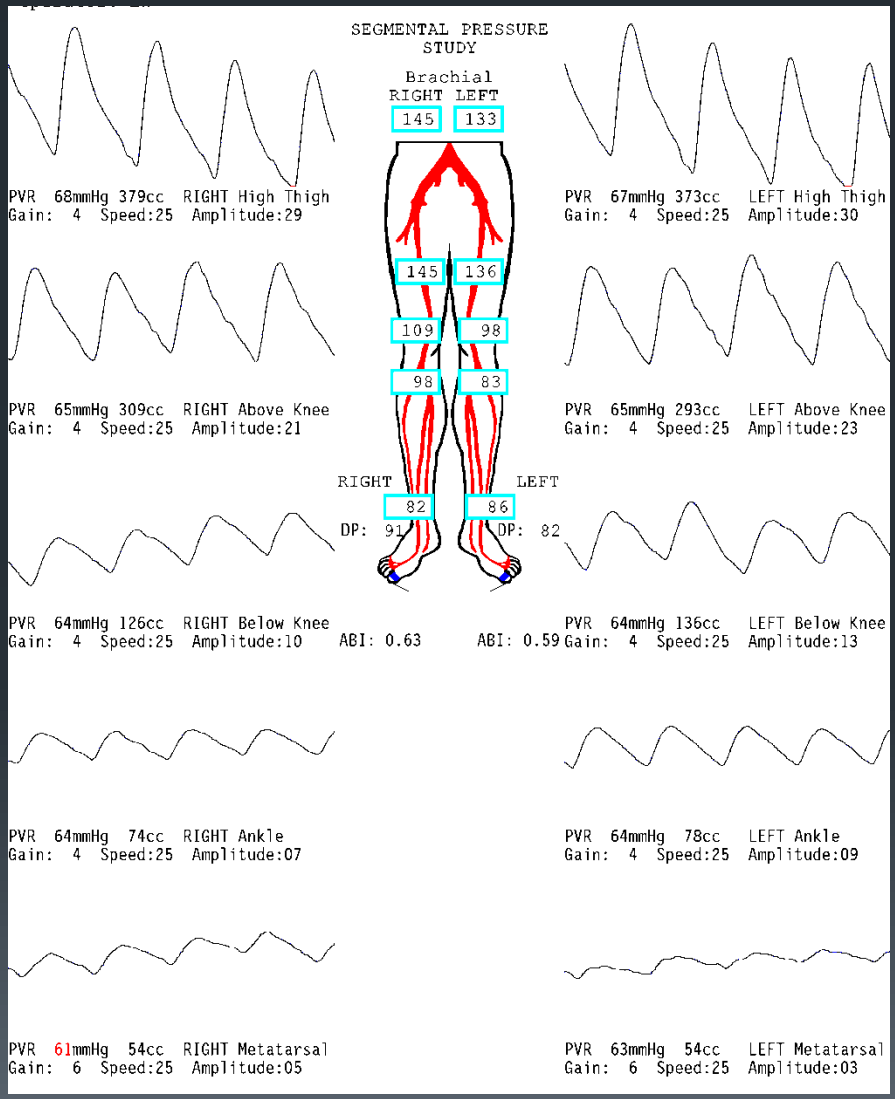


Zierler R, Sumner D, Physiologic Assessment of PAD, In Rutherford, Vascular Surgery, Elsevier, 2005

Iliac disease

Bilateral Fempop disease





From: Neumyer, M, 2005

Exercise Testing

- Performed in patients with normal pulses and/or normal resting studies
- Useful in those with minimally abnormal studies
- To evaluate whether exercise induced symptoms are reflected by a change in the arterial waveform
- Correlate symptoms & physiology

Exercise Testing

- Pt rests for 15-20 min
- Measure resting pressures
- Exercise x 5 min or sxs
- Treadmill (2 mph, 12 deg grade)
- If sxs - note quality, quantity, duration
- Complete exercise
- Measure serial pressures x 10 min

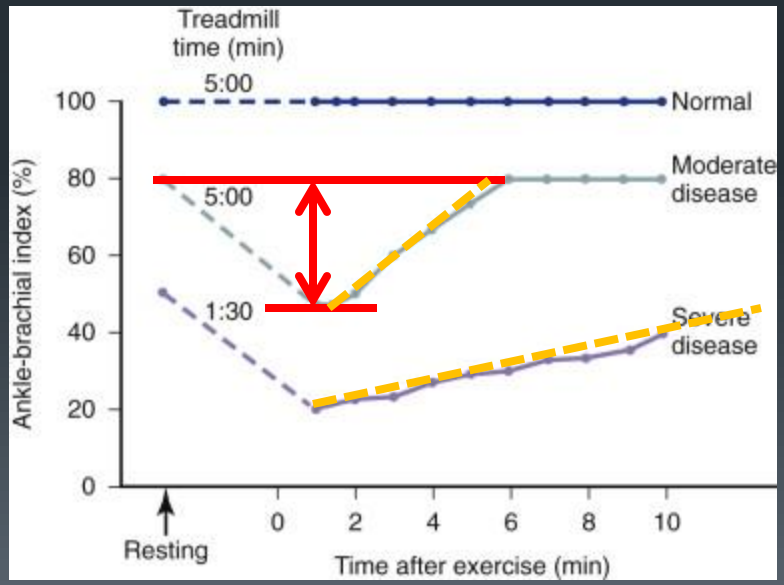
Exercise Testing

Evaluate

1. Change in waveform

2. Decrease in ABI

3. Time to recovery



Rutherford's vascular surgery, Cronenwett, Johnston, Eds, 7th ed., 2010, Elsevier

Transcutaneous Oximetry

- Probes contain a heating element to heat the skin to 43ºC; this acts to optimize gas exchange and capillary blood flow
- A 20-30 min equilibration period is necessary
- Normal subjects have values in the 40 to 70 mmHg range
- In claudication there is significant overlap with normals
- Main advantage is the use in patients with rest pain and tissue loss
- Has been used to predict healing of wounds and amputation level
- Also predictive of patients that will have a favorable response to hyperbaric therapy

Transcutaneous Oximetry

- Drawbacks:
  - Long time required for equilibration
  - On avg 25 minutes per site studied
  - Skin thickening and edema
  - Decreased baseline levels with age

Imaging

Arterial

- Ultrasound
- Computerized Tomography
- Magnetic Resonance
- Invasive – contrast based

Venous

- Ultrasound
- Computerized Tomography
- Magnetic Resonance
- Invasive – contrast based

Arterial Ultrasound

- This is an imaging test/ NOT a physiologic test
- Can help determine the length of a lesion
- Can help determine the severity of a lesion
- Can find suitable distal revascularization targets
- Time consuming
- Technologist dependent
- Inexpensive to payor/expensive to provider

Anatomic Tests

- Duplex Arterial mapping
- Conventional Arteriography
- CT Angiography
- MR Angiography

- *What is the anatomy (where is the disease located, lesion characteristics), what are the therapeutic options?*

Anatomic Tests

- Real time flow information (collaterals)
- Invasive
  - Needles (Arterial vs venous access)
  - Contrast
  - Radiation
- Calcification
- Visualize previous grafts
- Bony/surface landmarks

Anatomic Tests

- Soft tissue/non-vascular information
- Cost
- Operator dependent
- Ability to perform therapeutic intervention at same setting
- Portable

Principles

- Use anatomic tests that
  - Are less invasive as first line
  - Can guide further invasive testing if required
  - Address specific anatomic issues such as calcification and the presence of previous interventions
- Information gained from anatomic tests should *add to* and not simply *duplicate* information from previous studies

Arterial Duplex

Advantages

- Non-invasive, Non-toxic,
- No radiation, No contrast
- Readily available, Easily repeatable
- Inexpensive
- Provides functional information
- Better in larger vessels
- Portable (can be brought to the patient)

Duplex Arterial Mapping

UNIVERSITY OF WASHINGTON MEDICAL CENTER - VASCULAR DIAGNOSTIC SERVICE

LOWER EXTREMITY ARTERIAL DUPLEX EXAM

HISTORY: 83 year old female w/ nonhealing wound of ⊕ mid anterior tibial region. This is possible osteomyelitis vs. extremity ischemia.

DATE

UH#

NAME

D.O.B.

REFERRED BY

PHONE

ADDRESS

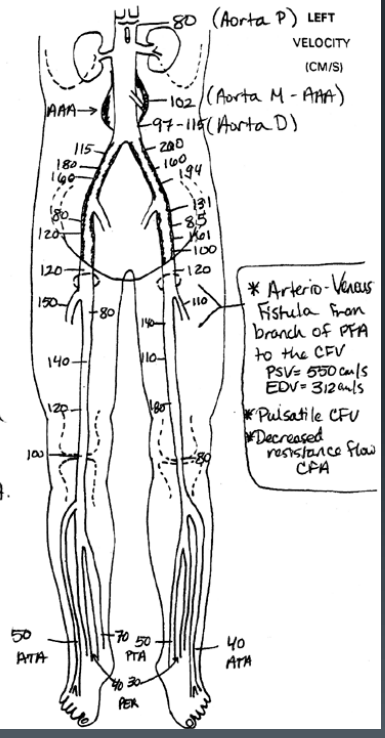
RISK FACTORS	
HTN	⊕ oral meds (2)
SMOKING	⊕ 20+ yr. x 1 pack/day
DIABETES	⊖
LIPIDS	⊕ oral meds (1)
CAD/PVD	ØCVA; MI x 1

SYSTOLIC PRESSURES:	R	L
BRACHIAL ARTERY	110	104
POST TIBIAL ARTERY	80	50
ANT TIBIAL ARTERY	74	66
PERONEAL ART		
ANKLE/ARM INDEX	0.72	0.60

DUPLEX FINDINGS

RIGHT VELOCITY (CM/S)

LEFT VELOCITY (CM/S)



Abdominal Aortic Aneurysm: (Diameter)

Prox: 1.5 cm

Mid-AAA: 6.3 cm x 6.2 cm x 6.0 cm length

Dist: 2.15 cm

Intramural, nonocclusive thrombus in AAA.

	RIGHT	LEFT
TECH KO		
TAPE #		

PHONE/PRELIMINARY REPORT IN CHART:

DICTATED:

DR. SIGNATURE/DISTRIBUTION:

Duplex Scanning in Vascular Disorders, 3rd Ed, 2002, Lippincott Williams & Wilkins

LE Arterial Duplex

- Scans selective portions or all (LE arterial mapping) of LE circulation
- Is time consuming
- Operator dependent
- Requires knowledgeable, dedicated technologist
- Information should be used in conjunction with physiologic studies

Duplex Arterial Mapping

Advantages

- Non-invasive, Non-toxic, No radiation
- Readily available, Easily repeatable
- Inexpensive
- Provides functional information
- Better in larger vessels
- Portable (can be brought to the patient)

Duplex Arterial Mapping

Disadvantages

- Operator dependent
- Requires dedicated, knowledgeable technologist
- Time consuming
- Results depend on criteria chosen

Duplex Arterial Mapping

Primary Utility

- Large vessels (pelvis, fempop)
- Surveillance of interventions
  - Open
  - Endovascular
- Procedural guidance
  - Eliminate radiation exposure
  - Easier conversion to an outpatient setting

Venous Ultrasound

- Use to determine the ..EAP portion of the CEAP…

Etiologic classification
- Ec: congenital
- Ep: primary
- Es: secondary (post-thrombotic)
- En: no venous cause identified

Anatomic classification
- As: superficial veins
- Ap: perforator veins
- Ad: deep veins
- An: no venous location identified

Pathophysiologic classification

- Pr: reflux
- Po: obstruction
- Pr,o: reflux and obstruction
- Pn: no venous pathophysiology identifiable

Venous Ultrasound

- Venous tests performed in the vascular laboratory are done for two primary reasons
  - **first done to determine if reflux or obstruction is causing hypertension**
  - **then to identify the location of the reflux or obstruction**
- Doppler ultrasound and color duplex scanners are used to obtain information about the venous system.

Venous Ultrasound

- Capable of characterizing partial and complete anatomic obstruction as well as valvular incompetence in the deep, superficial and perforating veins
- Duplex ultrasonography accurately identifies and localizes segmental venous reflux, the relationship of these findings to global venous hemodynamic does not correlate directly
- Abnormal direct venous pressure measurements are only present in 80% of those with common femoral or popliteal venous reflux detected by duplex

Arterial CT

- With the history and physical exam CTA can evaluate significant occlusive disease
  - Helpful in atypical disease
    - Popliteal entrapment
    - Medial cystic degeneration
- However, not very cost effective
- Large bolus of dye necessary (>100 cc)
- Spiral CT evaluation of vascular disease in the thigh and popliteal area may be more accurate than angiography
- CTA evaluation of the tibial arteries much more diffcult
  - Calcium can also confound the CT (Hint: Look at using bone windows)

CT Arteriography

- Are still artifacts
- Is 2-D, can do 3-D reconstructions
- Protocol dependent
- Post-processing is an important component

Fillinger in Rutherford, Vascular Surgery, 6th ed

CT Arteriography

Advantages

- Allows precise calculation of stenosis in 3-D
- Assessment of calcification
- Location of previous interventions regardless of status
- ? Status of previous interventions
- Assessment of other pathology, vascular and non-vascular
- Identifies concomitant aneurismal disease

CT Arteriography

Disadvantages

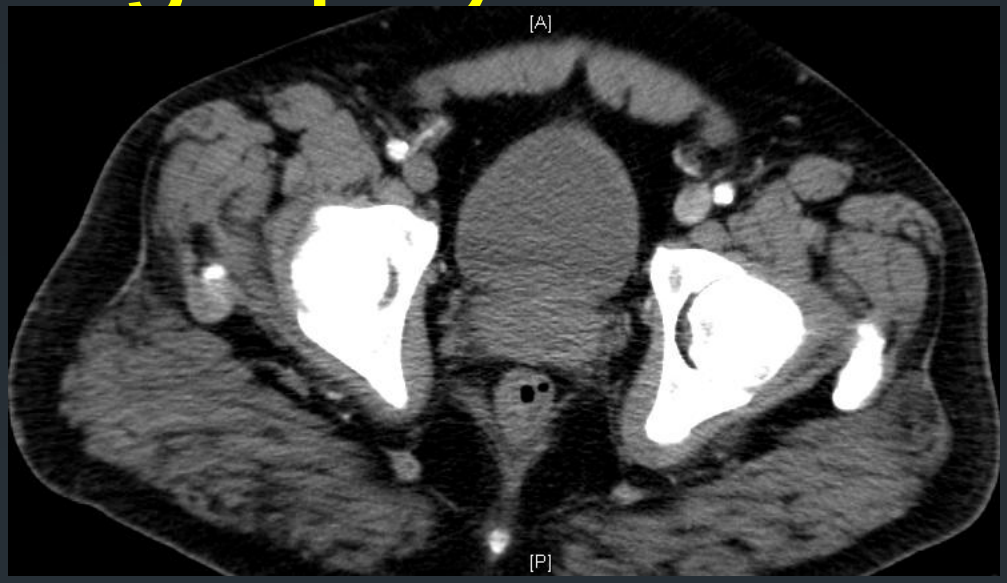
- Radiation exposure
- Requires contrast
  - Nephrotoxicity (different types, amount)
  - Other reactions
- Somewhat Invasive, IV, local complications
- Protocol dependent
- No real time flow information
- Relatively Expensive

CT Arteriography

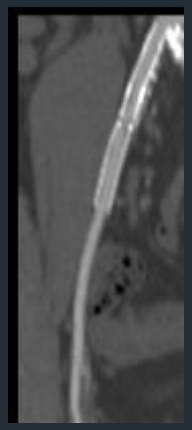
Primary Utility

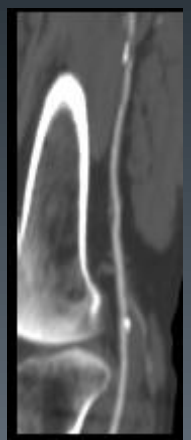
- Large vessels (Aortoiliac, fempop)
- In setting of previous interventions
- Extensive calcifications
  - Decreased image quality
  - Beneficial for planning intervention
- With concomitant aneurismal disease

CT Arteriography

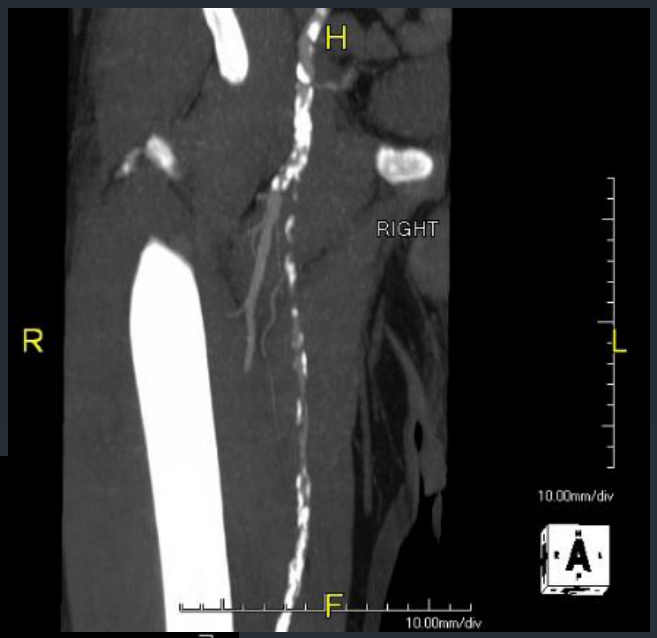


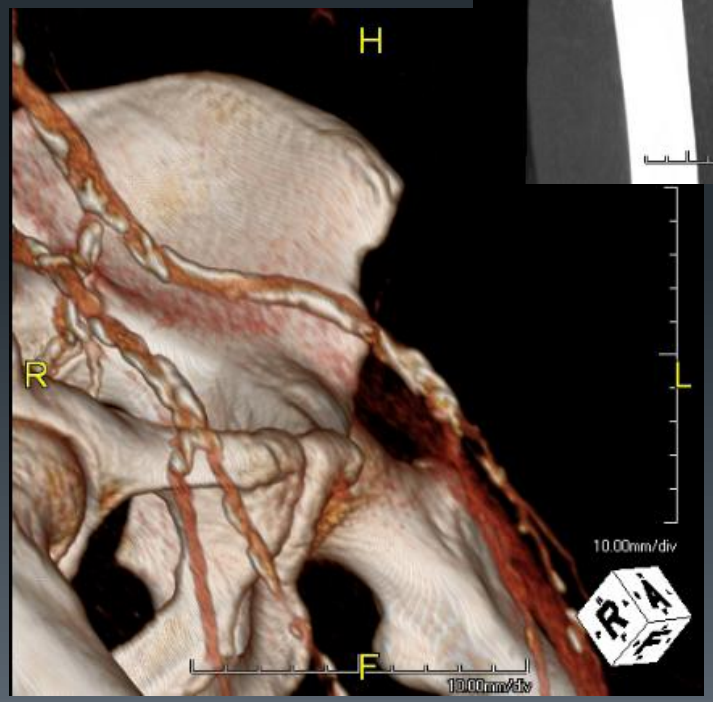
CT Arteriography

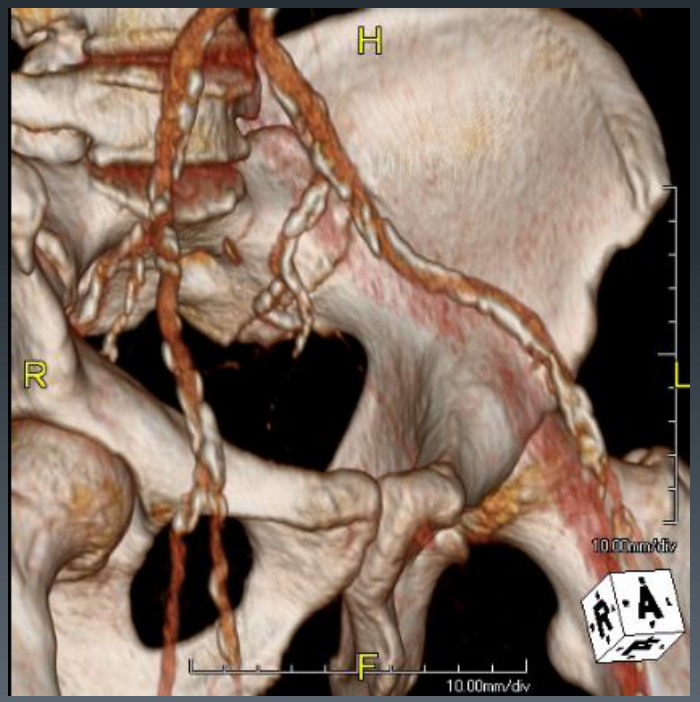




CT Arteriography







Venous CT

- Very useful for pelvic DVT.
- However, must time the contrast correctly
- Not dynamic enough for most leg pathology
- Best for possible pelvic obstructive disease
  - Intravascular and extravascular compressive disease

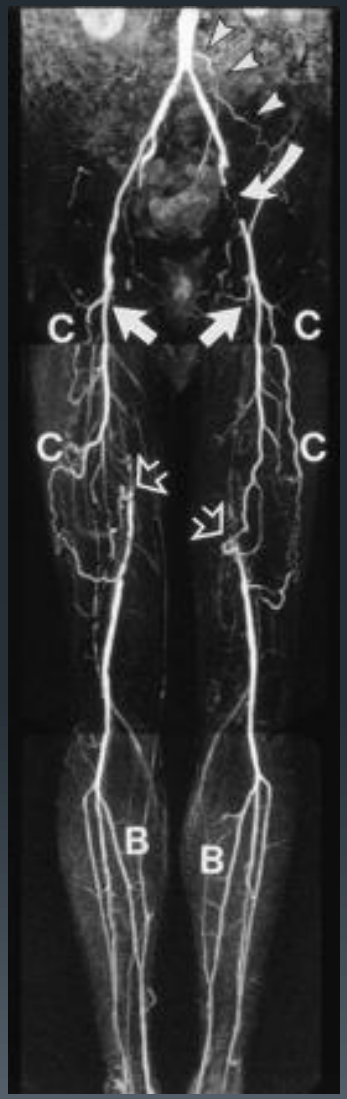
Arterial MR

- MRA is concordant with conventional runoff angiography in all cases
- MRA has a sensitivity of 99.6%, a specificity of 100%, a positive predictive value of 100%, and a negative predictive value of 98.5%
- MRA appears superior to conventional angiography for evaluating runoff vessels
  - MRA is significantly more sensitive than conventional angiography in identifying patent runoff vessels
  - This is because MRA only depends on local flow at velocities as low as 2 cm/sec

Arterial MR

- In one study of MRA 80 patients with MRA were noted to have a 100% correlation to intra-operative findings
- MRA can identify patients that are candidates for bypass procedures that were thought not to be candidates based upon traditional subtraction angiography
- Therefore it is recommended that prior to deeming a patient non-operative that an MRA be done
- MRA is more cost effective than traditional angiography as long as it used as the only modality
- However, now contra-indicated in patients with renal failure of any amount

MR Arteriography



Radiology, 211, 1999, 59-67

www.healthimaging.com

MR Arteriography

- Is not an X-ray, no radiation
- Subject is magnetized – 3 types of magnetic fields combined to produce a signal, amplified, digitized, Fourier transformation
- 3-D reconstruction
- Images depend on magnet strength 1, 1.5, 3 Tesla
- Can be “closed” or “open”

Insko in Rutherford, Vascular Surgery, 6th ed

MR Arteriography

- MRA with or without (time of flight) contrast
- Contrast enhances by effect on water molecules, not direct visualization of contrast – as each contrast molecule has an effect on multiple water molecules - can use less
- Safety issues – implants, metallic objects
- Are still artifacts
- Protocol dependent
- Post-processing is an important component

Insko in Rutherford, Vascular Surgery, 6th ed

MR Arteriography

Advantages (depends on magnet)

- Allows calculation of stenosis in 3-D
- No radiation exposure
- ? Status of previous interventions
- Assessment of other pathology, vascular and non-vascular

MR Arteriography

Disadvantages

- Requires contrast
  - Nephrotoxicity, systemic toxicity
- Somewhat Invasive, IV, local complications
- Magnet & Protocol dependent
- Does not differentiate calcium
- Overestimates stenoses
- No real time flow information
- Relatively Expensive

MR Arteriography

Primary Utility

- Depends on magnet
- Most uses as in traditional arteriography and CT Arteriography

Venous MR

- In one study of 101 lower extremity MRVs were compared with duplex ultrasound and contrast venography and found to have near 100% specificity and sensitivity for DVT
- MRV is very sensitive for pelvic vein and IVC pathology, in addition the internal iliac and deep femoral veins can be imaged
- In addition MRV is very good for identifying compressive venous syndromes such as May Thurner etc.

Arterial – Subtraction angiogram

- Subtraction of the radiodensities surrounding the arterial tree enhances the ability to see surrounding vessels significantly
- Associated with a minor and major complication rate of up to 8%
- 29% of patients having peripheral angiograms have some baseline renal dysfucntion
- Low sensitivity for detecting patent runoff vessels secondary to proximal oclussions

Arterial – Subtraction angiogram

- The not so “Gold” – “Gold Standard”
  - Pitfalls-
  - Motion artifact
  - Overlying vessels
  - 2 D Image
  - Radiation exposure
    - The operator and the patient

Contrast Arteriography

- X-ray with radiopaque contrast injected into vessels
- “Cut-film” → Long leg changer → video radiography → Cineradiography → Digital Subtraction Angiography (DSA)
- Is 2-D
- Post-processing is an important component

Contrast Arteriography

Contrast Arteriography

Advantages

- Provides functional information (flow patterns)
- Assess collateral circulation
- Allows precise calculation of stenosis
- Measure pressure gradients
- Fine details in small vessels
- Therapy can be performed

Contrast Arteriography

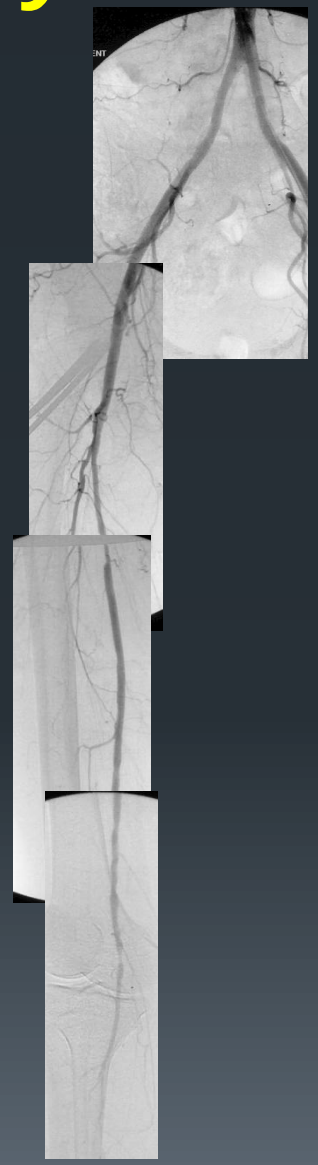
Disadvantages

- Radiation exposure
- Requires contrast
  - Nephrotoxicity (contrast types, load)
  - Other reactions
- Invasive
  - Bleeding, pseudoaneurysm, dissection
  - Embolization
- Requires Cath Lab setting, Expensive

Contrast Arteriography

Primary Utility

- All vessels
- When therapy is likely



Venography

- A powerful tool in the evaluation of both acute and chronic DVT
- A very high diagnostic accuracy for the presence of deep venous disease
- Ideally the table has a tilt capability and can actually go to the > 40º upright position
- A radio-opaque ruler is placed upon the patient to facilitate future recording of location of the lesions

Venography

- Ascending venography
  - Demonstrates the location and extent of post-thrombotic disease
    - Identifies: occlusion, venous recanalization, collateral channels, and superficial varicosities
- Descending venography
  - Identifies the level of deep vein reflux
  - Morphology of the venous valves

Venographic categories of deep vein reflux

- Grade 0 – Normal valvular function with no reflux
- Grade 1 – Minimal reflux confined to the upper thigh
- Grade 2 – More extensive reflux to the lower thigh, no reflux into calf, due to competent popliteal vein valve
- Grade 3 – Grade 2 but with popliteal vein valve incompetence
- Grade 4 – Virtually no valvular competence, with immediate and dramatic filling of the calf

Lymphatic Evaluations

- Lymphscintiogram
- Lymphangiogram
- CT of lymphatics
- MR of lymphatics

Etiologic Classification of Lymphedema

- I Primary Lymphedema
  - A Congenital (onset before 1 yo)
    - Nonfamilial
    - Familial (Milroy's disease)
  - B Preacox (onset 1 to 35 yo)
    - Non-familial
    - Familial (Meige's disease)
  - C Tarda
- II Secondary Lymphedema – Filariasis, LN excsion ± radiation, tumor invasion, infection, trauma, other

Lymphoscintigraphy

- Radiolabeled serum albumin or sulfer coloid is injected in the foot
- Gamma camera takes multiple images in one hour (ex 12)
- Normal transit time is between 15 and 60 minutes, less than 15 minutes indicates rapid transport, > 60 minutes delayed transport
- Qualitative interpretation of images is associated with a 92% sensitivity, and a 100% specificity

Lymphatic CT and MR

- CT
  - Best used to look for obstructing mass
  - Tubular, nonenhancing structures in the subcutaneous tissue
- MR
  - Differentiates – lipedema, chronic venous edema and lymphedema
    - Lipedema – increased subQ fat without increased veins or edema fluid
    - Lymphedema - Honeycomb pattern in subQ, No change in subQ to fascial comparment
    - Venous stasis – Increased veins and increased fluid
  - Also good at delineating LN anatomy

Lymphangiography

Normals

- 5-15 lymph channels on medial aspect of the thigh
- Valves every 5 to 10 mm
- Lateral lymphatics and deep lymphatics not seen
- Nl LN have a ground glass appearance

Abnormals

- Primary
  - Obstruction
  - Complete obliteration distally
- Secondary
  - With pelvic obstruction the inguinal and iliac nodes are few or absent
  - Leg lymphatics distended and tortuous

Other technologies

- Laser doppler
- Near infrared spectroscopy
- Hyperspectral imaging

Hyperspectral imaging

- Quantifies cutaneous tissue hemoglobin oxygenation
- Generates anatomically relevant tissue oxygenation maps
- A healing index photograph derived from oxygenation and deoxy values was used to assess the potential for healing
- Sensitivity was 80%, Specificity was 74%, positive predictive value 90%
  - These were better when osteomyelitis cases and heavily callused cases removed

Near Infrared Spectroscopy (NIRS)

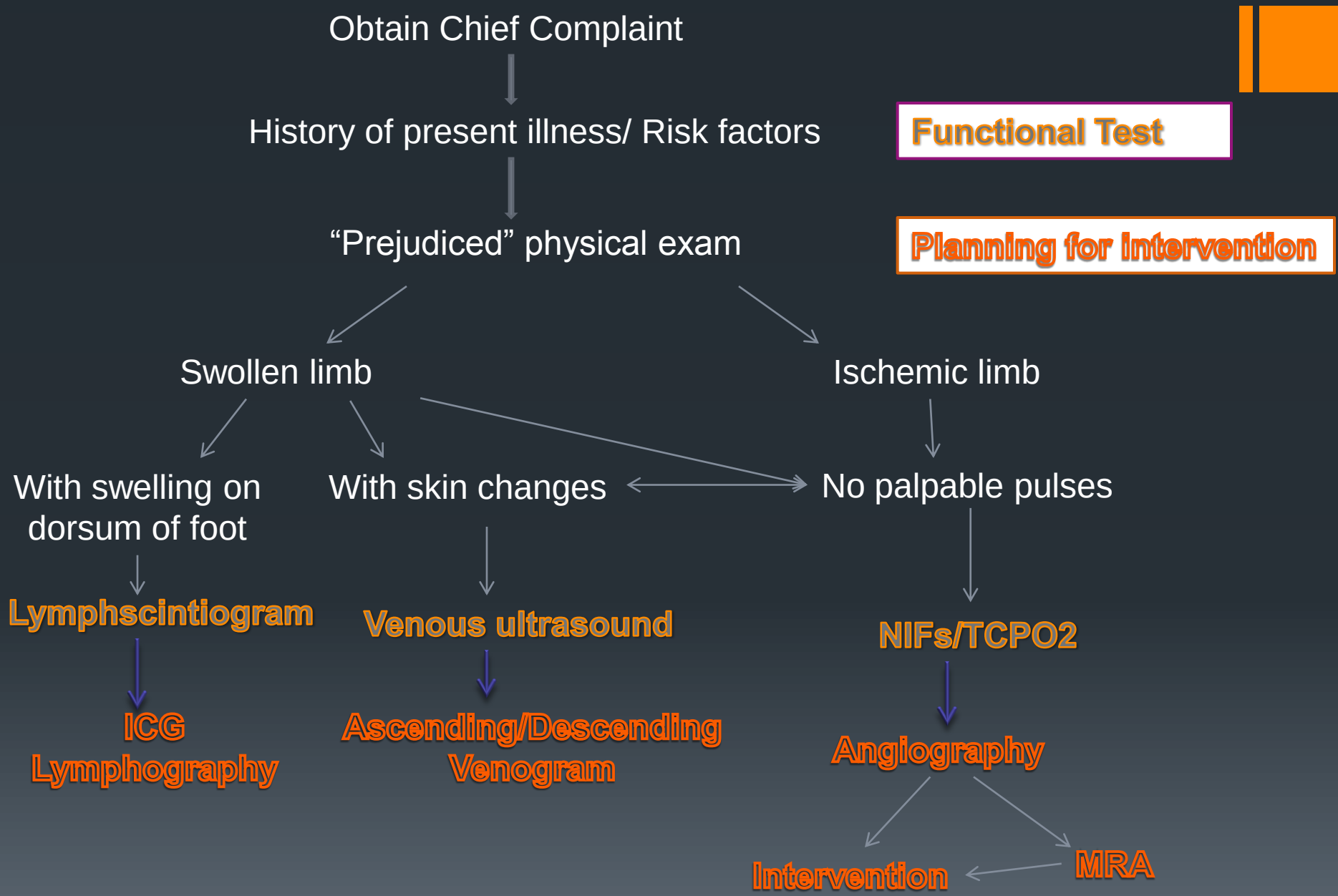
- Continuous monitoring of oxygen saturation, oxygenated hemoglobin (Oxy Hb) and deoxygenated hemoglobin (deoxy Hb)
- Seems to have better predictive value in severe disease
- However, some patients have probably adapted to very low peripheral flows and their Oxy Hg was higher and their Deoxy Hb lower than may have been expected

Laser Doppler

- Gives a relative index of cutaneous blood flow
- Output is expressed in millivolts (mV)
- mV is roughly proportional to the avg, blood flow in a 1.5 mm^3 0.8 to 1.5 mm below the skin surface
- Normal skin
  - Pulse waves that coincide with the cardiac cycle
  - Vasomotor waves that occur four to six times per minute
  - A mean blood flow velocity that is represented by the elevation of a tracing
  - In the foot – highest velocities are under the skin of the big toe

Laser Doppler

- In limbs with PVD
  - Pulse waves are attenuated
  - Mean velocities are decreased
  - Vasomotor waves disappear
- Prediction of healing
  - Mean velocity > 40 mV and pulse wave amplitude > 4mV – 96% healing rate
  - Mean velocity < 40 mV and pulse wave amplitude < 4mV – 79% healing rate
  - * Not as accurate as TCPO2


Obtain Chief Complaint
History of present illness/ Risk factors
"Prejudiced" physical exam
Functional Test
Planning for Intervention
Swollen limb
Ischemic limb
With swelling on dorsum of foot
With skin changes
No palpable pulses
Lymphscintiogram
Venous ultrasound
NIFs/TCPO2
ICG Lymphography
Ascending/Descending Venogram
Angiography
Intervention
MRA

CEAP Determination

Etiologic classification
- Ec: congenital
- Ep: primary
- Es: secondary (post-thrombotic)
- En: no venous cause identified

Anatomic classification
- As: superficial veins
- Ap: perforator veins
- Ad: deep veins
- An: no venous location identified

Pathophysiologic classification
- Pr: reflux
- Po: obstruction
- Pr,o: reflux and obstruction
- Pn: no venous pathophysiology identifiable