

**WFAI**

# **Protocol for ABI / TBI**

**Arterial Screening for Peripheral Vascular Disease  
Etiology and Treatment**

## Atherosclerotic Peripheral Arterial Disease – PAD

- A progressive stenosis, occlusion or aneurysmal dilatation of the aorta and its non coronary non intracranial branch vessels.
  - Presence of PAD has implications:
    - a. Depression,
    - b. Reduced quality of life
    - c. Significantly higher risk of cardiovascular events.
- ❑ 5-year rate of nonfatal CV events (MI and stroke) in pts with symptomatic PAD is 20%
  - ❑ 5-year mortality is 15-30%

# Hazard Ratio (survival analysis)

- **Hazard Rate** represents the instantaneous risk or probability that an event (recovery, relapse or death) will occur at any moment.
- **HAZZARD RATIO :**  
$$\frac{\text{Hazard Rate of treated group}}{\text{Hazard Rate of control group}}$$
- HR = 1, no difference between groups
- HR  $\geq$  treatment group HIGHER RATE
- HR  $\leq$  treatment group has lower risk or outcomes

# Hazard Ratio for Peripheral Vascular Disease

Wickstrom et al Eur J Vasc Endovasc Surg 2017 May, 53 (5) 696-703

Those PVD patients with TBI < .25 and TP < 30 result in  
CV mortality/Amputation/all cause mortality

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Patients with Peripheral Vascular Disease in general

# **TP $\leq$ 30mmhg/ TBI $\leq$ 0.25**

**Wickstrom,J.E., et al Eur J. Vasc. Endovasc Surg 2017 May;53 (5):696-703**

## **• CV mortality :**

- HR 2.84, 95% confidence interval TP**
- HR 3.68, 95% confidence interval TBI**

## **• All cause mortality:**

- HR 2.05, 95% confidence interval TP**
- HR 2.53, 95% confidence interval TBI**

## **Amputation or death :**

- HR 2.05, 95% confidence interval TP**
- HR 2.46, 95% confidence interval TBI**



# Peripheral Vascular Disease

- **Impactful disease \***
- **Significant Decrease on quality of life**
- **Significant Increased mortality**



**SHOULD BE EASY TO DEVELOP A DIAGNOSIS**

# Classic Symptom of PAD

## Intermittent Claudication

pain forcing rest to relieve the pain

**This is not an Objective  
finding but a Subjective  
Finding**

**Only Lower Extremity?????**



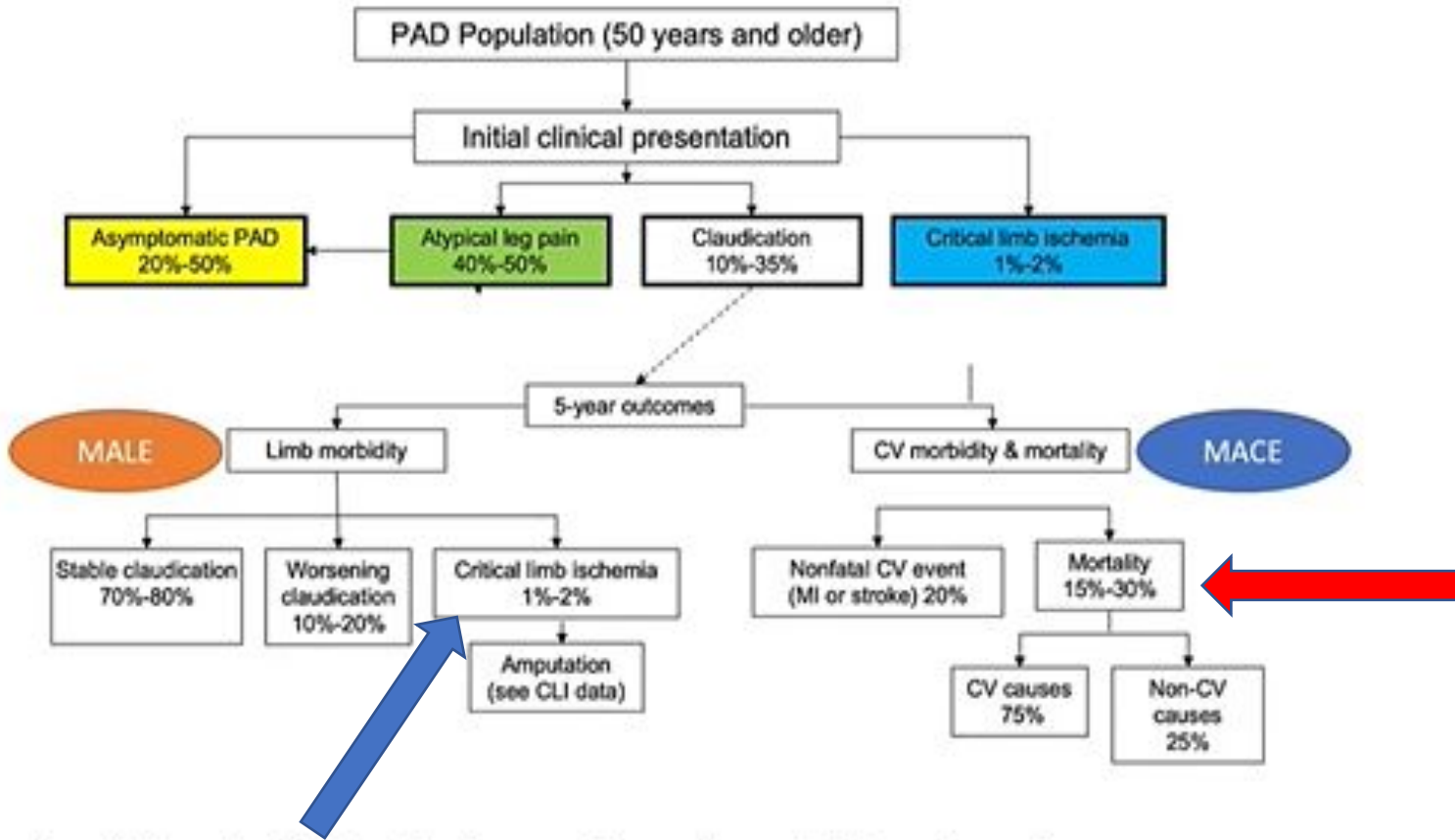
# Peripheral Vascular Disease

A close-up photograph of a microscope's objective lens and stage. The lens is metallic and has "0X/0.25" engraved on it. A small, circular, reddish-brown specimen is visible on the stage below the lens. The background is a soft, out-of-focus blue and grey.

- **Where is the Disease?**
- **What OBJECTIVE testing can be done**
- **What Clinical signs present themselves**

A pair of black-rimmed glasses is positioned over a surface covered with scattered, small, white rectangular pieces of paper, each containing a single black letter. The letters are scattered across the entire frame, with some appearing more clearly through the lenses of the glasses. The background is a light, slightly textured surface. The text "Let's Look Deeper" is overlaid in a bold, red, serif font, centered horizontally and partially overlapping the right lens of the glasses.

• **Let's Look Deeper**



# Claudication S/Sx ?

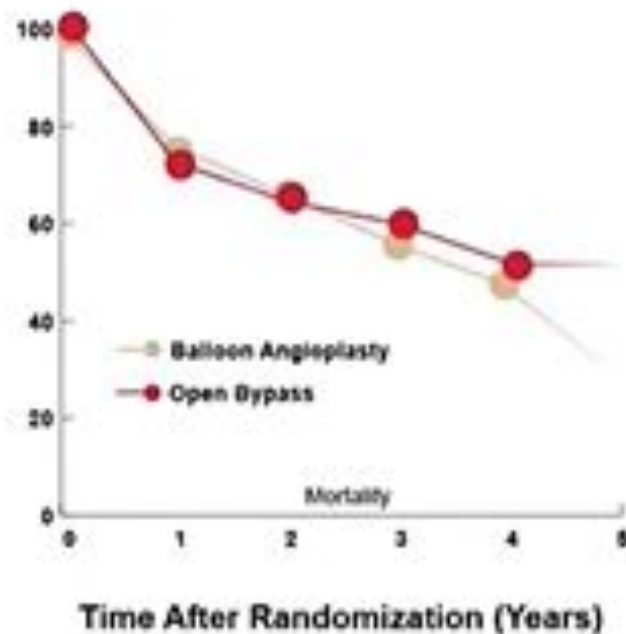
CLI leading to  
amputation is 1-2%

Non-CV mortality 25%

MALE = major adverse limb events; MACE = major adverse cardiovascular events; CV = cardiovascular.  
Hirsch AT, et al. *Circulation*. 2006;113(11):e463-e654.

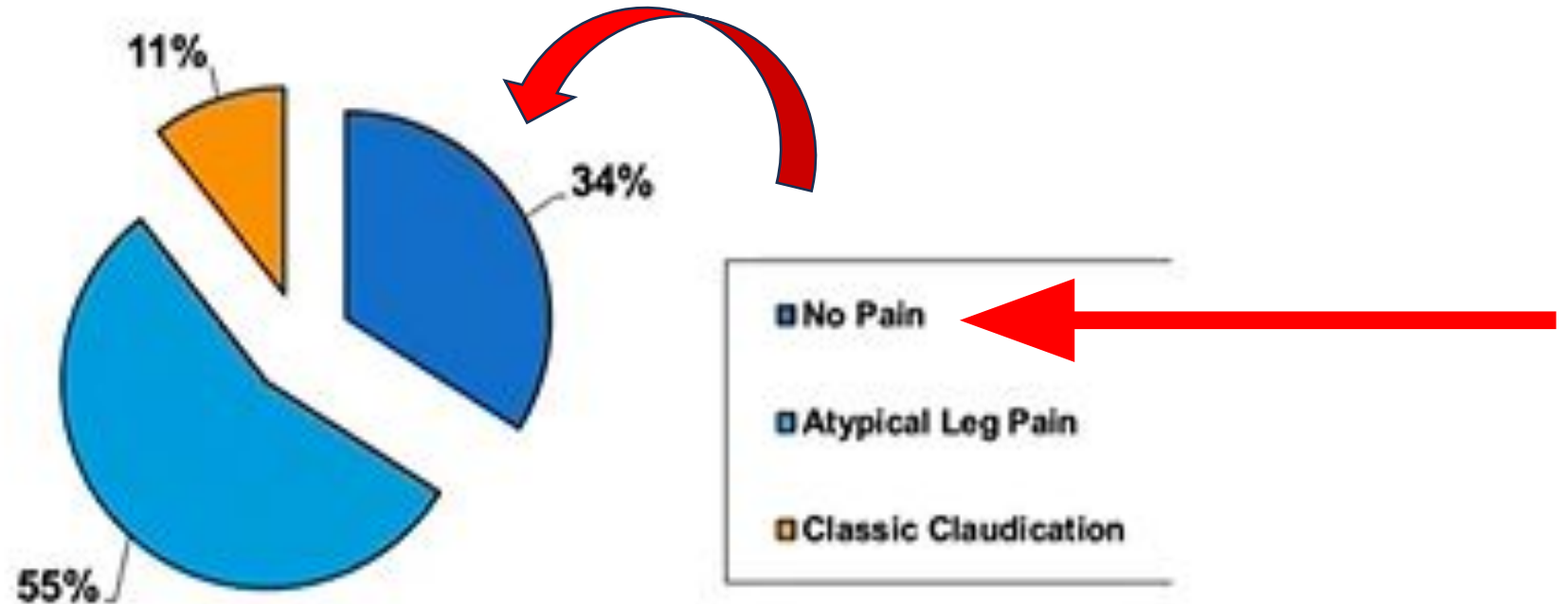
# Critical Limb Ischemia (CLI) is a Deadly Disease

- 50% of CLI patients are dead in 5 years
- Fundamental problem in CLI is reduced tissue perfusion



# Distribution of PAD

Hirsch et al,  
J.A.M.A., 2001



89

89% of patients no or atypical pain

# Approximately **8 million people** in the US have PAD



Noninvasive Physiologic Vascular Studies: A guide to diagnosing Peripheral Arterial Disease.

Sibley et al, Radiographics 2017; 37: 346-357

\* 48.3% of patients with an ABI less than 0.9 were  
asymptomatic or had atypical pain

AHA Postgraduate Education Committee of AHA W/L circulation study:

Peripheral artery disease (PAD) and evidence-based medicine.

### PAD: 10 EVIDENCE-BASED FACTS

- The risk of PAD increases substantially with age [15]
- >50% of PAD patients are asymptomatic [14]
- The presence of PAD is associated with a 2-fold increase in the prevalence of heart failure [16]
- 20–30% of individuals with PAD have diabetes mellitus [17]
- Diabetic patients have 2–4 times the risk of developing PAD, CAD, and ischemic stroke [8]
- Smokers have 2.5 times the risk of developing PAD [3]
- Atherosclerosis accounts for more than 90% of cases of PAD [14,18]
- Compared to whites, the likelihood of PAD is 55% lower among Chinese and 50% greater among African Americans [19]
- The femoral and popliteal arteries are affected in 80–90% of symptomatic PAD patients [18]
- The prevalence of amputation in PAD patients is 3–4% [19,20]

Age / ssx

MACE

DIABETES

LOCATION

The image features a white background densely populated with small, light-colored wooden blocks. Each block has a black question mark printed on its top surface. The blocks are scattered across the entire frame, creating a textured, repetitive pattern. In the center of the image, the text "WHAT OBJECTIVE TESTING CAN BE DONE" is overlaid in a large, bold, black serif font. The text is arranged in three lines: "WHAT OBJECTIVE" on the top line, "TESTING" on the middle line, and "CAN BE DONE" on the bottom line. The font is slightly shadowed, giving it a three-dimensional appearance as if it's resting on or slightly above the wooden blocks.

**WHAT OBJECTIVE  
TESTING  
CAN BE DONE**



# ABI Testing

**Due to silent progression of PAD  
AHA and ACC now recommend PAD  
screening:**

**All pts. over age 65**

**All pts.  $\geq 50$  with DM/HTN/HC or F/H**

**Pat  $\leq 50$  and DM with HTN or HC**

# ABI Studies

- **Am. College of Cardiology / Am. Heart Association**
- **Joint Practice Guideline:**
  - **All patients  $65 \geq$**
  - **Patients  $\geq 50$  with atherosclerotic risk factors / family hx of PAD**
  - **Patients  $\leq 50$  with DM and 1 RF (HBP,  $\uparrow$ Cholesterol, Smoking)**

# **ABI studies**

## **Transatlantic Intersociety Consensus Document on Management for Peripheral Arterial Disease II,**

- **ACC and Am Heart Assoc. are not alone in their recommendations**
- **advocates screening of PAD with ABI**
- **all patients' who have exertional leg symptoms,**
- **pts 50-69 with CV risk factors \***
- **all pts greater than 70 \***
- **pts with Framingham risk score of 10-20%**

# **WHY/ WHAT are Noninvasive vascular Studies**

- **WHY.....**

- **PAD silent disease with potential mortality**

- **Easy, noninvasive, inexpensive test, to determine the presence of arterial occlusion.**

- **Allows for early identification of disease**

# **PVD TESTING**

- **TWO PARAMETERS:**

- **INDICES**

- **WAVE FORMS**



# ABI Indices

## **ABI is composed of Indices and PVR wave forms:**

Both results should be evaluated to provide full status of flow  
Indices obtained by dividing LE by UE (ankle/arm)

## **Lower Extremity pressure:**

48.3% of patient with ABI less than 0.9 were Asymptomatic or Atypical pain  
Blood flow limitation from areas of stenosis cause s/s associated with PAD

## **Brachial pressure:**

Base line with which to conduct LE evaluation

If bilateral **brachial pressure differ by 20mmHg** evaluate for subclavian stenosis,  
extrinsic compression of arterial supply to UE, and aortic dissection.

**All factors = stenosis decreasing vessel radius by 50%  
leads to a 16-fold reduction in flow**

Noninvasive Physiologic Vascular Studies: a guide to diagnosing peripheral arterial disease, Sibley et al, Radiogra, vol 37, no.1

**Indices are  
% at different  
Levels when  
Lower Extrem  
Upper Extrem**

# ABI Indices

• **Abi = LE / UE**

• **Non compressible**  $\geq 140\text{mm Hg}$

• **Normal** 1.00 – 1.4

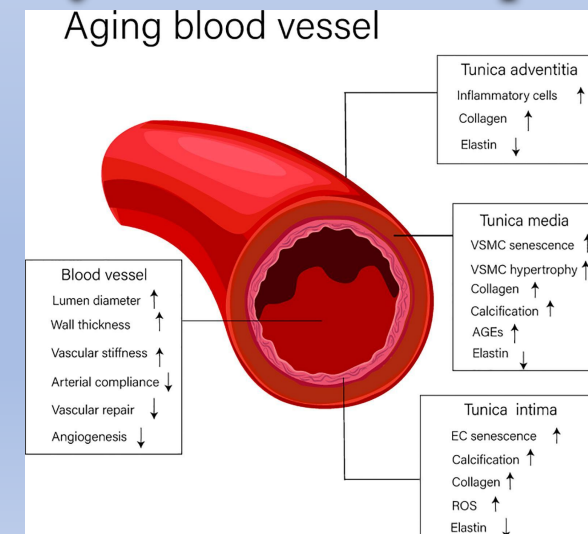
• **Borderline** 0.9- 1.0

**\*Abnormal**  $\leq 0.9$  (95% sensitivity and 100% specificity)

• **Mild pvd** 0.7-.89

• **Moderate pvd** 0.51-.69

• **Severe pad**  $\leq 0.50$



### Vessel Disease

Calcified Vessel



**ABI**

> 1.4

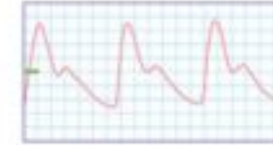
**TBI**

unaffected

**Doppler**



**PVR**

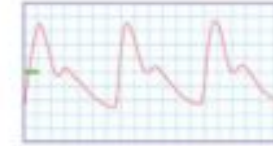


Normal



0.9 - 1.4

> 0.6

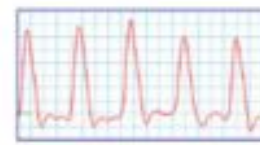


Mild PAD



0.7 - 0.89

0.34 - 0.59



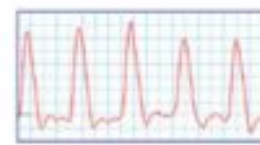
Moderate PAD

50% decrease radius



0.51 - 0.69

0.12 - 0.34



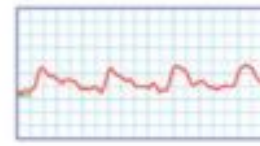
16-fold decrease flow

Severe PAD

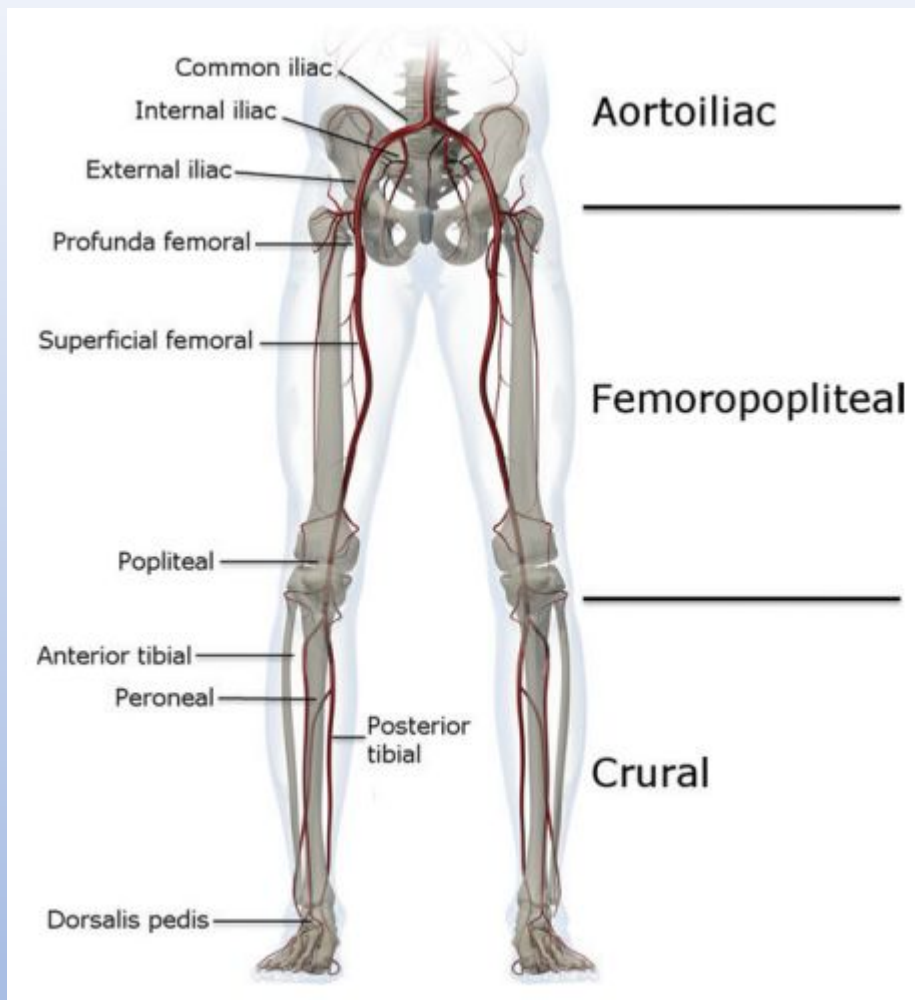


≤ 0.5

≤ 0.11



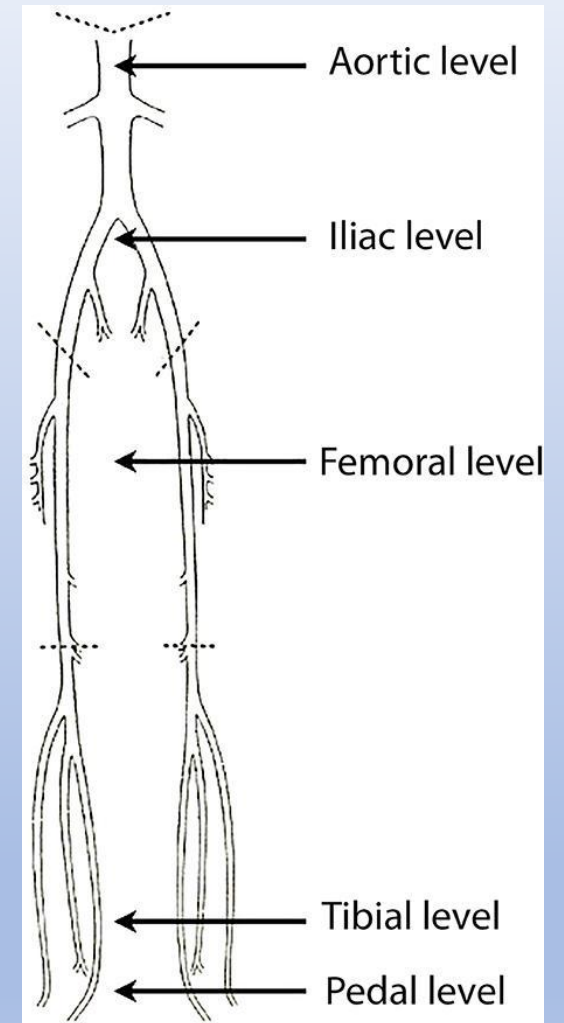
Pressure/indices/PVR - What are we looking at?



## Areas of Examination

# Indices Analysis

- Proximal to Distal decrease  $\geq 20$  mm Hg = PVD
- Decrease in Segmental BI  $\geq 0.15$  = PVD
- Difference of 30 mm Hg at same level = PVD



# TBI

## Toe Brachial Index



# Toe Brachial Index

- Ratio : Toe pressure / Brachial pressure
- ABI increase due to arterial wall resistance (calcification)
- ABI increased with chronic kidney dis, CHF, smoking
- In presence of tunica media sclerosis ABI not accurate (high ABI readings)
- Toe unaffected by media sclerosis
- Ratio  $\geq 0.71$  no arterial insufficiency, no medial sclerosis
- Sensitivity of 90-100% / Specificity 65%-100%
  
- Park, S., C.: Utility of Toe Brachial Index for Diagnosis of Peripheral Artery Disease
- Arch Plast Surg, 20212, May; 39(3); 227-231
- Martin et al, Peripheral Arterial Disease in Diabetic Patients: The Utility of TBI, Med Clin (Barc) 2008; 130: 611-612

# Toe Brachial Indices

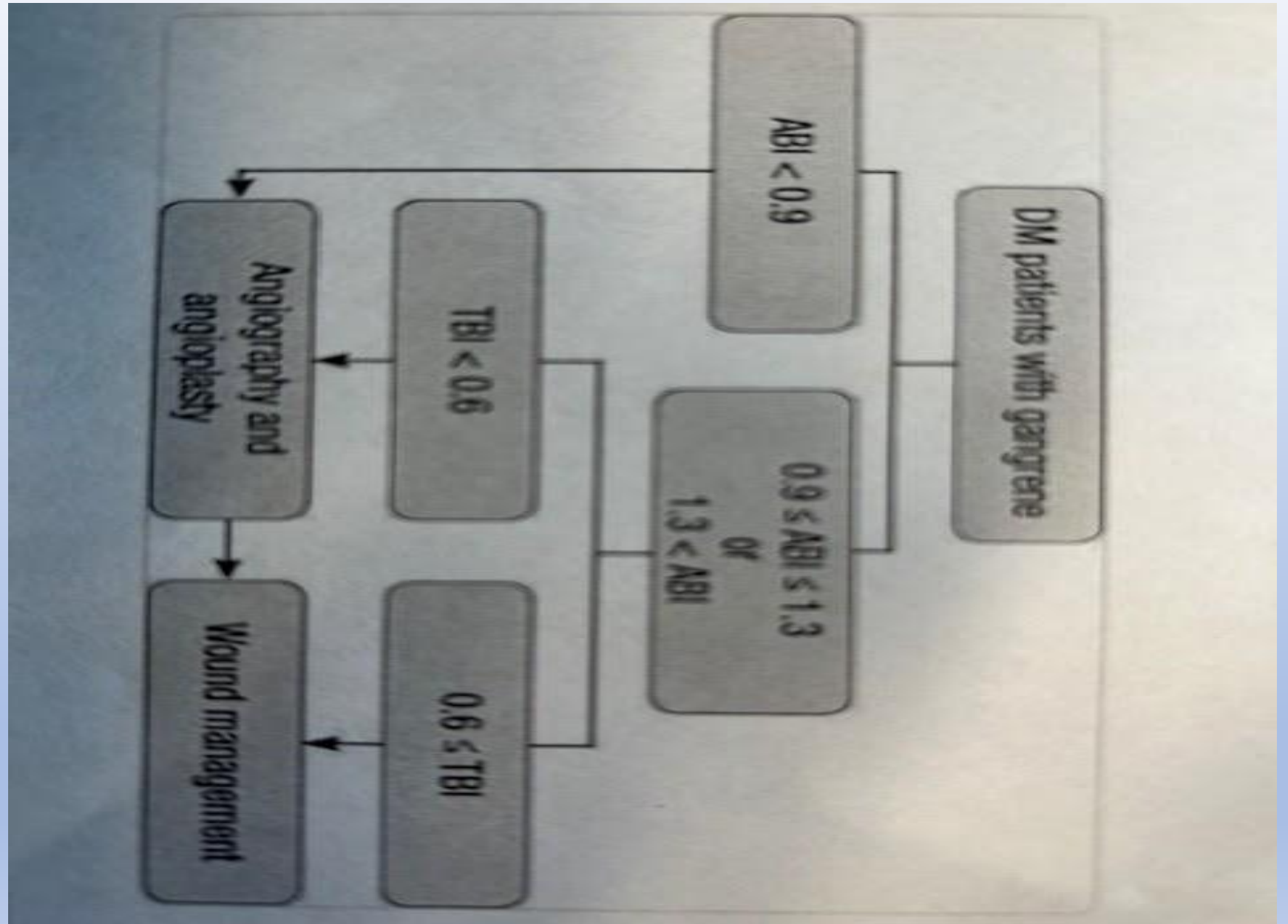


- **TBI less than 0.7 is abnormal**
- **TBI less than 0.11 is associated with ischemic rest pain.**
  
- **TBI over 30 mm Hg required for wound healing**
- **However,**
- **In DM TBI greater than 45-55mm Hg may be necessary**

# TBI Protocol

Park et al

Arch Plast Surg, 2012,  
May; 39 (3): 227-231




**TBI or not TBI: that is the question.**  
**Is it better to measure toe pressure than ankle pressure  
in diabetic patients?**

Brooks, B., Dean, R., Patel, S., Wu, B. Molyneaux L., Yue,  
Diabetic Med 2001 Jul;18 (7) : 528-32

- \* Agreed with ABI published values
- \* TBI and ABI associated with CV and overall mortality

....agreement between the tests (ABI vs TBI)  
when ABI is low or normal



ABI	TBI
.95-1.29	>.7
.50 - .94	.5 - .69
0.21-0.49	.35 - .49

### Conclusion

In the majority of patients with **Diabetes**, **assessment of TBI conveys no advantage over ABI** in determining perfusion pressure of the lower limbs. Only in those patients with **OVERT CALCIFICATION**, which gives an ABI > or = 1.3 are toe pressure measurements superior.

**Doppler Waveform**

**VS**

**PULSE VOLUMIN**

**RECORDING**

**Doppler Waveform** – (duplex ultrasonography) Velocity detector (4-5 mhz) senses the Doppler shift of reflected sound waves bouncing off moving red blood cells

**Analysis of Blood flow VELOCITY**

- **Pulse Volume Recording** – (PVR) utilizes Pneumoplethysmography (Doppler) along with Segmental pressure readings to determine vascularity

- **MEASURES CHANGE IN BLOOD VOLUMIN**

# Doppler vs Pulse Volume Recording

- **Doppler**, measures speed of blood flow
  - Use ultrasound
  - Provides waveform of blood flow patterns
  - Often utilized to diagnose vascular conditions
  - More sensitive to changes in speed of flow
- **Pulse Volume Recording**, measures volume of blood
  - PVR uses Plethysmographic sensor
  - Provides a graph of changes over time
  - PVR used to evaluate arterial insufficiency
  - Better for evaluation of overall perfusion
  - Needs blood pressure cuff and sensor

# ABI Analysis

- **PVR developed in 1970s (MIT)**
- **1 mmHg change in cuff produces 20mm deflection on recorder**
- **Critical that the cuffs are fitted properly**
  - **Width of cuff should be 40% of circumference of limb or 20% wider than limb diameter**



# Definition of Pulse Volume Recorder (PVR) Categories

*Definition of Pulse Volume Recorder (PVR) Categories*

PVR Category	Chart Deflection (in mm)	
	Thigh and Ankle	Calf
1	>15*	>20*
2	>15†	>20†
3	5-15	5-20
4	<5	<5
5	Flat	Flat

\*With reflected wave.

†No reflected wave.

**Mild.....**

2

**Moderate..**

3

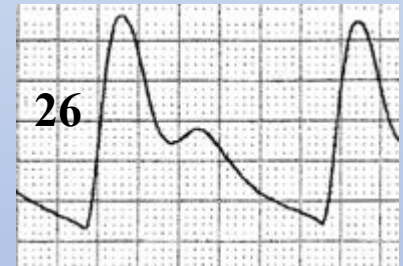
**Severe.....**

4

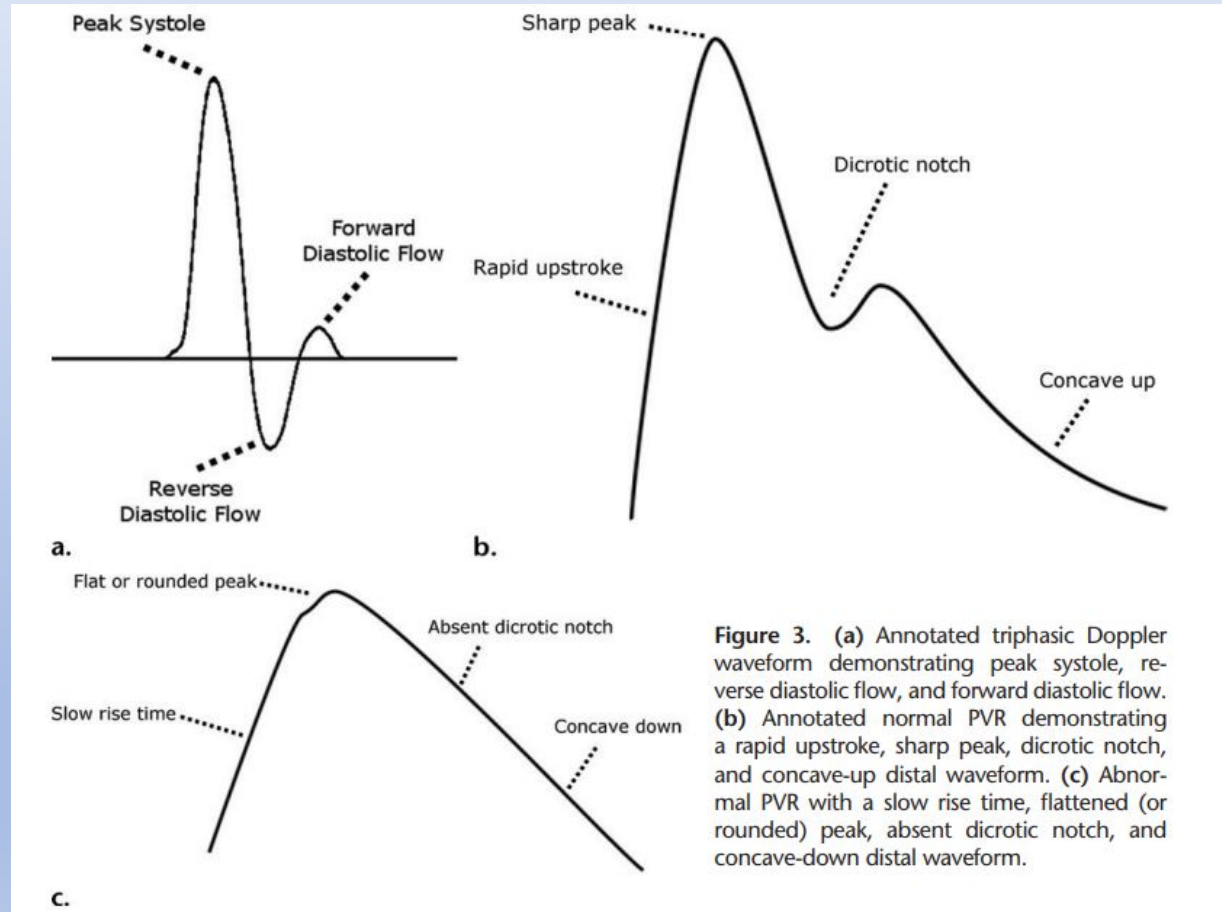
**Limb Loss.**

5

26



# Doppler Wave Form Analysis



**Figure 3.** (a) Annotated triphasic Doppler waveform demonstrating peak systole, reverse diastolic flow, and forward diastolic flow. (b) Annotated normal PVR demonstrating a rapid upstroke, sharp peak, dicrotic notch, and concave-up distal waveform. (c) Abnormal PVR with a slow rise time, flattened (or rounded) peak, absent dicrotic notch, and concave-down distal waveform.

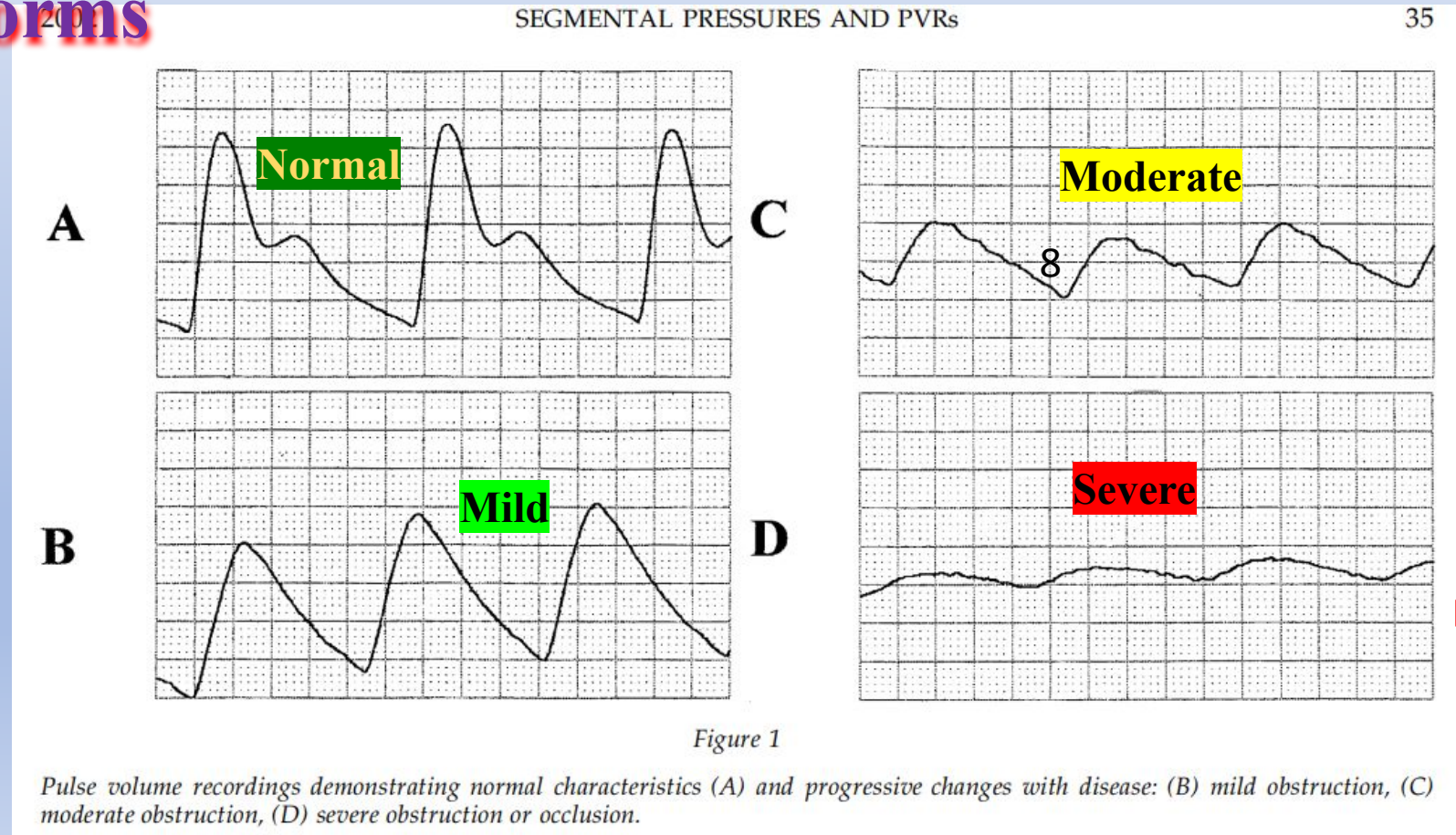
Amplitude of less than 5 mm from trough to peak has been used as criterion for diagnosing Vascular Claudication

Abrupt changes in amplitude and contour indicate occlusion between two levels

Heat induced vasodilation leads to loss of dicrotic notch

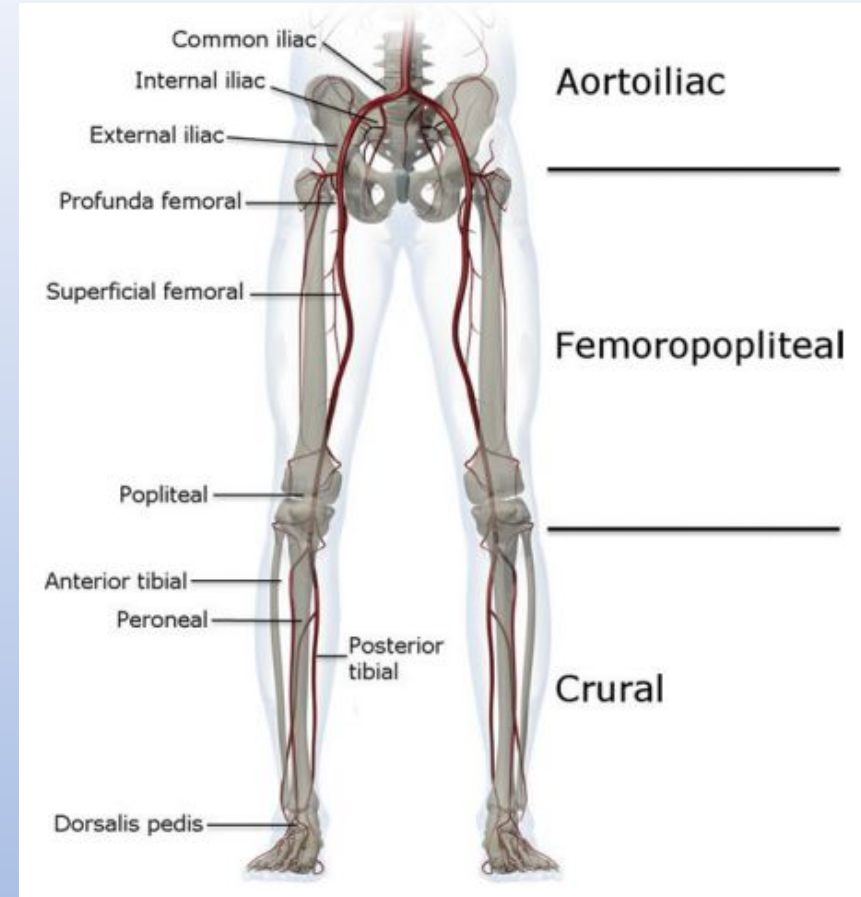
arterial collaterals PVR may be relatively preserved compared with Doppler Waveform

## PVR waveforms



## TEACHING POINTS

- In PAD, the level of the lesion is grouped into three categories: aortoiliac, femoropopliteal, and crural (tibiopedal).
- An ABI less than 0.90 is diagnostic for PAD in patients with claudication or other signs of ischemia, with 95% sensitivity and 100% specificity.
- A proximal-to-distal decrease in sequential pressures greater than 20 mm Hg or a decrease in segmental-brachial index greater than 0.15 indicates occlusive disease and correlates with the level of the lesion.
- A normal lower extremity arterial Doppler velocity tracing is triphasic, with a sharp upstroke and peaked systolic component, an early diastolic component with reversal of flow, and a late diastolic component with forward flow. A biphasic signal is considered abnormal if there is a clear transition from triphasic signal along the vascular tree. Monophasic waveforms are always considered abnormal.
- Abnormal PVR findings include decreased amplitude, a flattened peak, and an absent dicrotic notch.



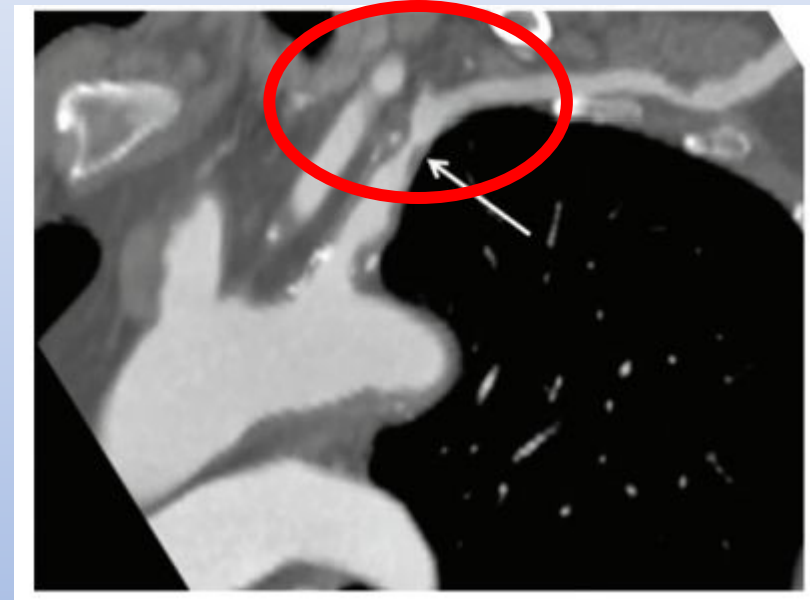
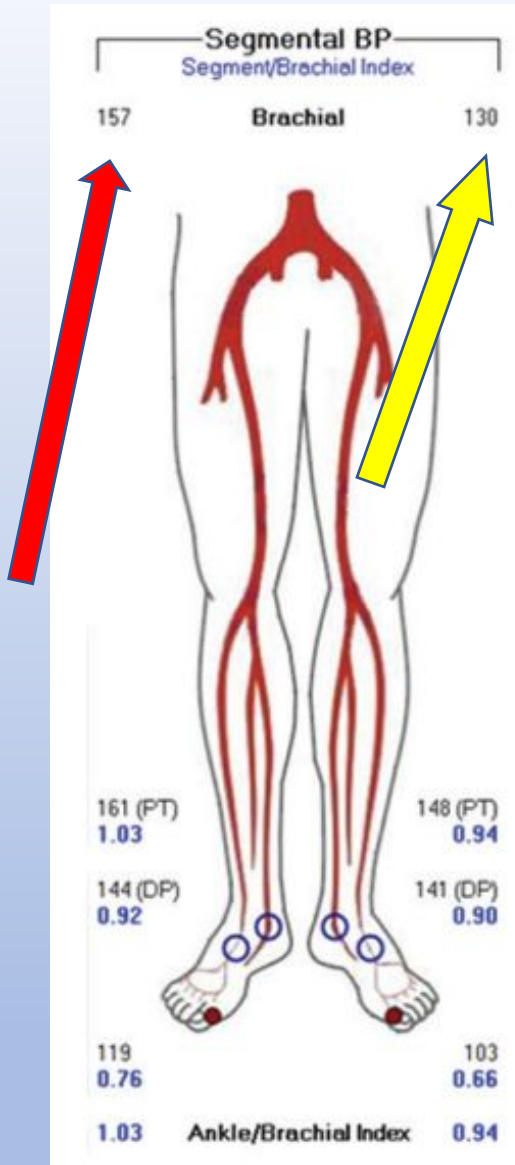
# ABI – Analysis

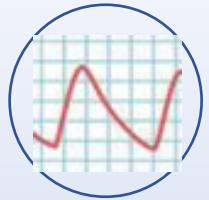
- \* **Brachial pressures** should be equal. Difference more than 20mmHg indicates abnormality. Low pressure area is considered diseased
- \* Both **PT and DP arteries** used to determine ankle pressure. Each pressure should not differ more than 10mmHg.
- \* **Ankle systolic pressure** normally is greater than brachial systolic pressure by 12-24 mmHg.
- \* **Contralateral evaluation** difference of 30 mm Hg at the same level is also considered abnormal

# Lets Look at Some Examinations

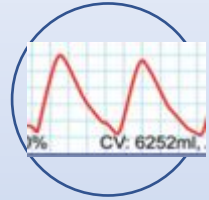


Analyze proximal to distal -  
Subclavian stenosis effecting brachial indicia  
Left LE Posterior Tibial blockage

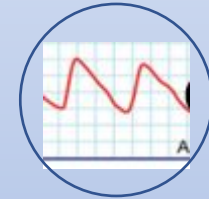




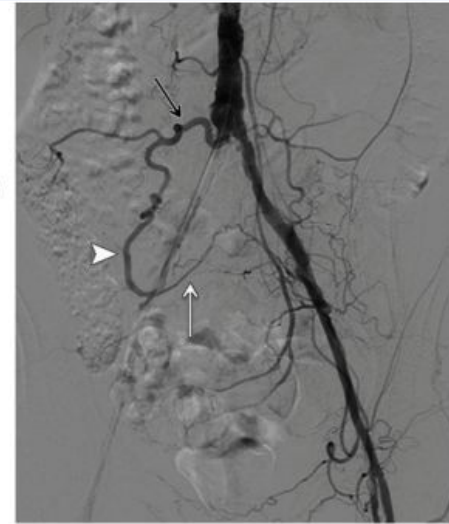
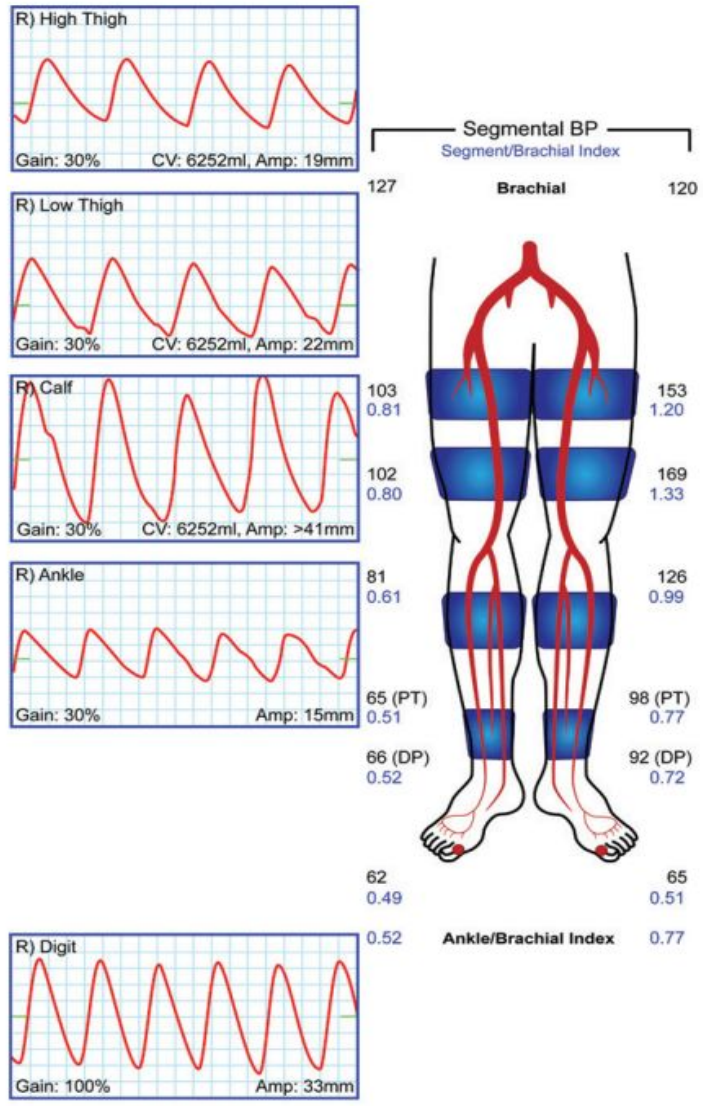
1.



2.



3.



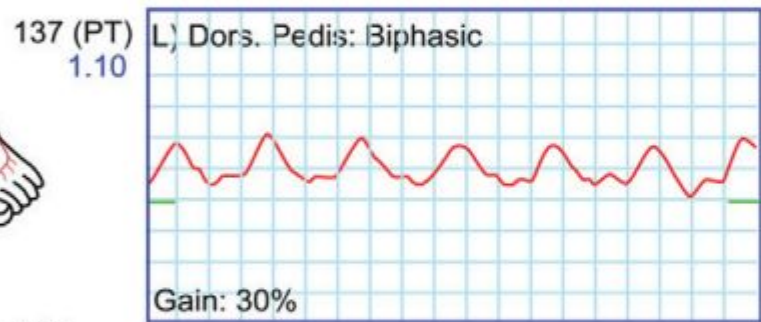
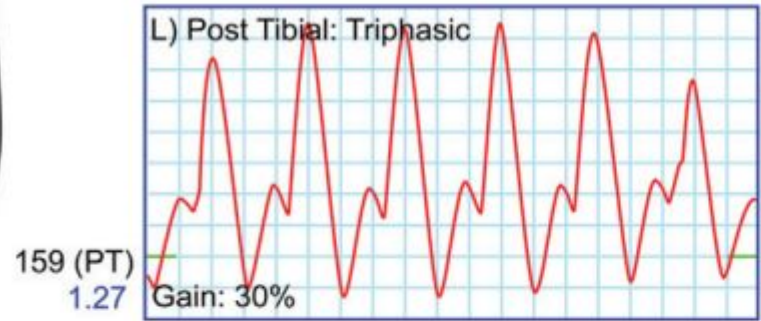
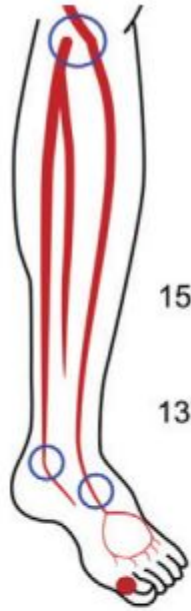
b.



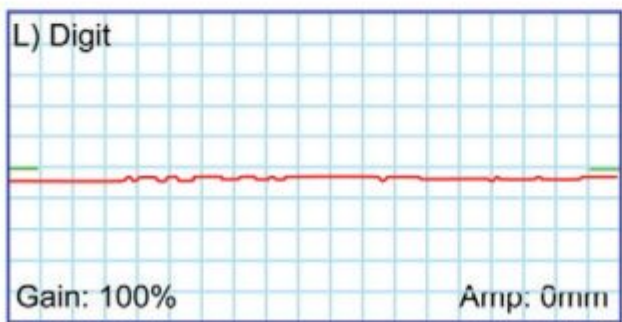
**Bilateral LE claudication after walking 1 blk**

1. Non triphasic – monophasic wave
2. Loss of dicrotic notch
3. Wide wave forms

**Right Femoral blockage**



Ankle Brachial Index 1.27

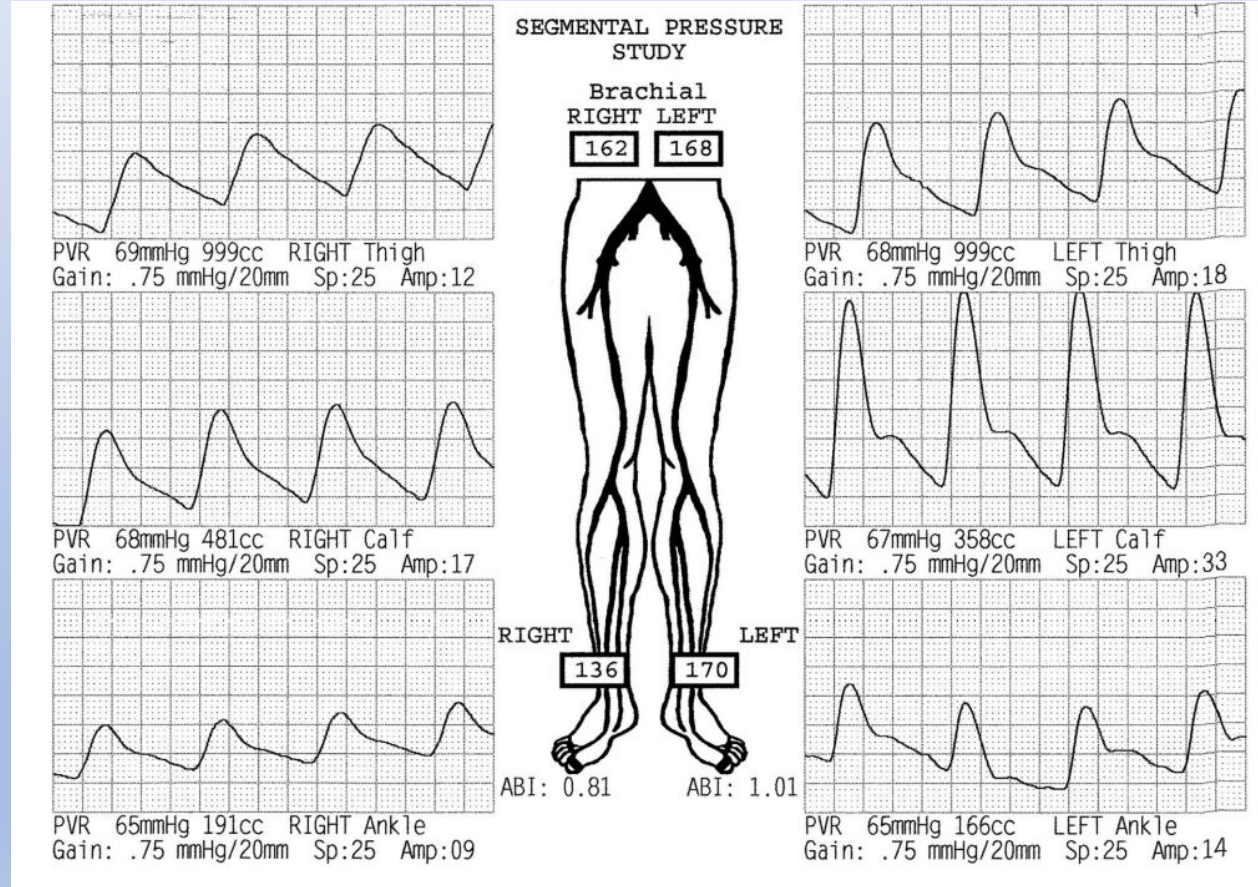


**Occlusion of anterior tibial artery  
post placement of fibular plate**

A PVR study demonstrating abnormal inflow to the right leg. These waveforms are consistent with iliofemoral disease. The left leg is within normal limits.



Right Iliac Disease



**Risk Factors** Other specified peripheral vascular diseases Body Mass Index: 33.7 (obese)

**Assoc. Illness**

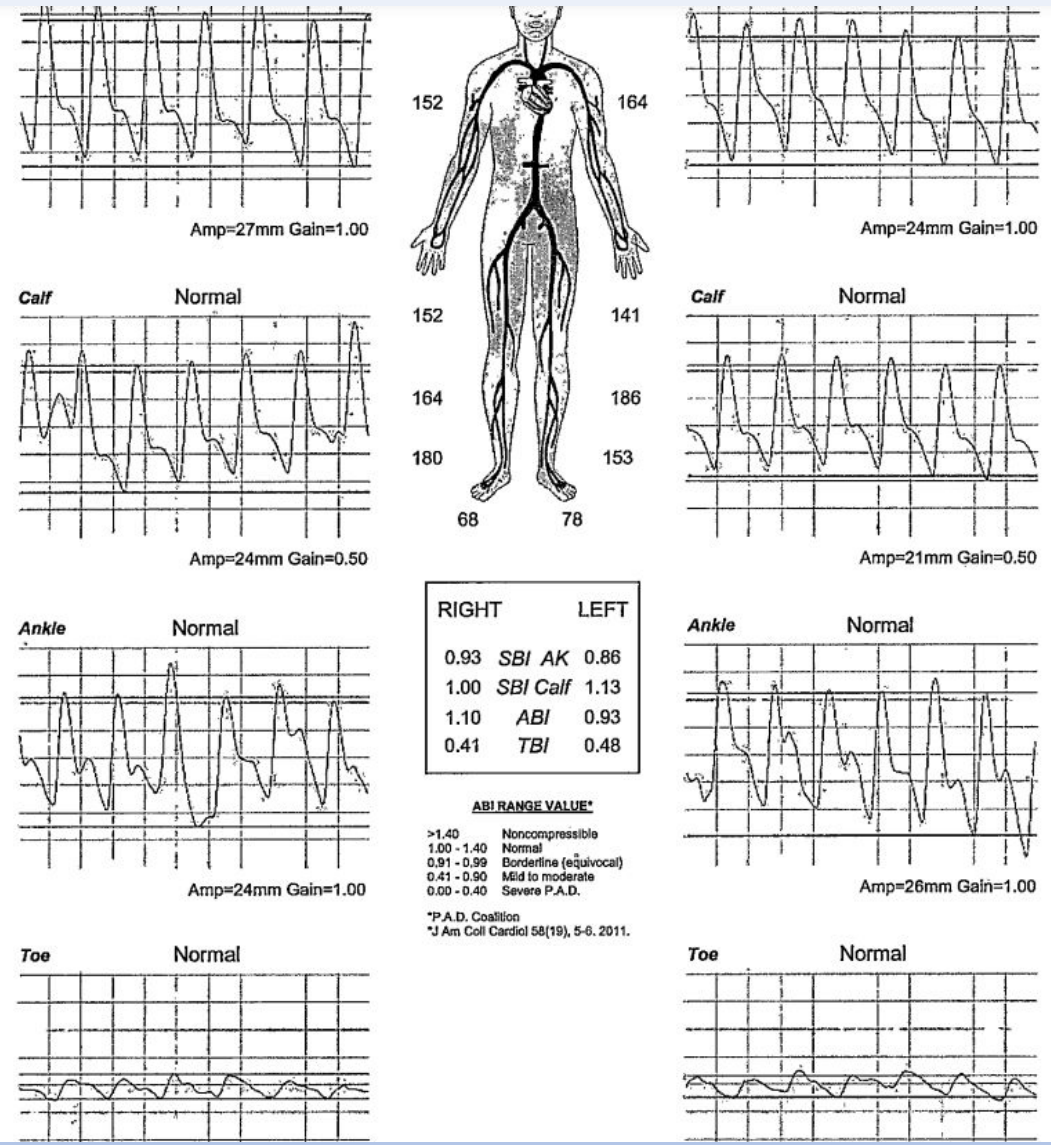
**Indications** Peripheral vascular disease, unspecified : Intermittent claudication, PAD, PVD Unspecified

**Notes**

Right		Results		Left	
<b>Pressures</b>					
Brachial	152			Brachial	164
Above Knee	152	SBI	0.93	Above Knee	141
Calf	164	SBI	1.00	Calf	186
Ankle	180	ABI	1.10	Ankle	153
Toe	68	TBI	0.41	Toe	78
<b>PVR Waveforms</b>					
Above Knee	Normal			Above Knee	Normal
Calf	Normal			Calf	Normal
Ankle	Normal			Ankle	Normal
Toe	Normal			Toe	Normal

**Interpretation**

No evidence of significant peripheral arterial disease at rest in the right leg. No evidence of significant peripheral arterial disease at rest in the left leg. The right ankle/brachial index is 1.10 and the left ankle/brachial index is 0.93. Segmental pressure drop between left leg segments of more than 20mmHG is indicative of a function deficit and should be correlated with the waveforms.



**Digital Occlusion ( Small Vessel Disease ) Bilateral**

Right		Results		Left	
<b>Pressures</b>					
Brachial	162			Brachial	180
Above Knee	183	SBI	1.02	Above Knee	161
Calf	186	SBI	1.03	Calf	188
Ankle	151	ABI	0.84	Ankle	157
Toe	167	TBI	0.93	Toe	71
<b>PVR Waveforms</b>					
Above Knee	Normal			Above Knee	Normal
Calf	Normal			Calf	Normal
Ankle	Normal			Ankle	Normal
Toe	Mild			Toe	Mild

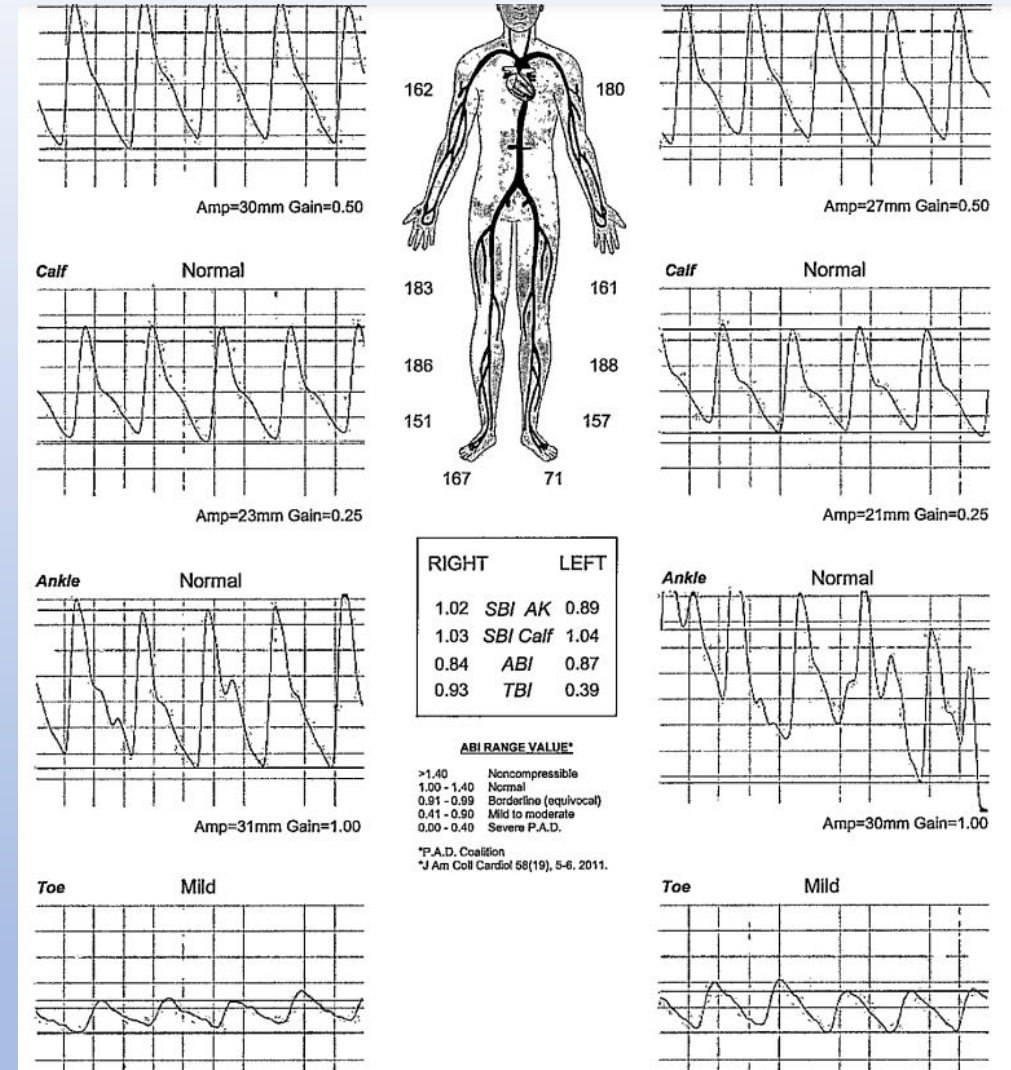
**ABI RANGE VALUE\***

>1.40 Noncompressible  
 1.00 - 1.40 Normal  
 0.91 - 0.99 Borderline (equivocal)  
 0.41 - 0.90 Mild to moderate  
 0.00 - 0.40 Severe P.A.D.

\*P.A.D. Coalition  
 \*J Am Coll Cardiol 58(19), 5-6, 2011.

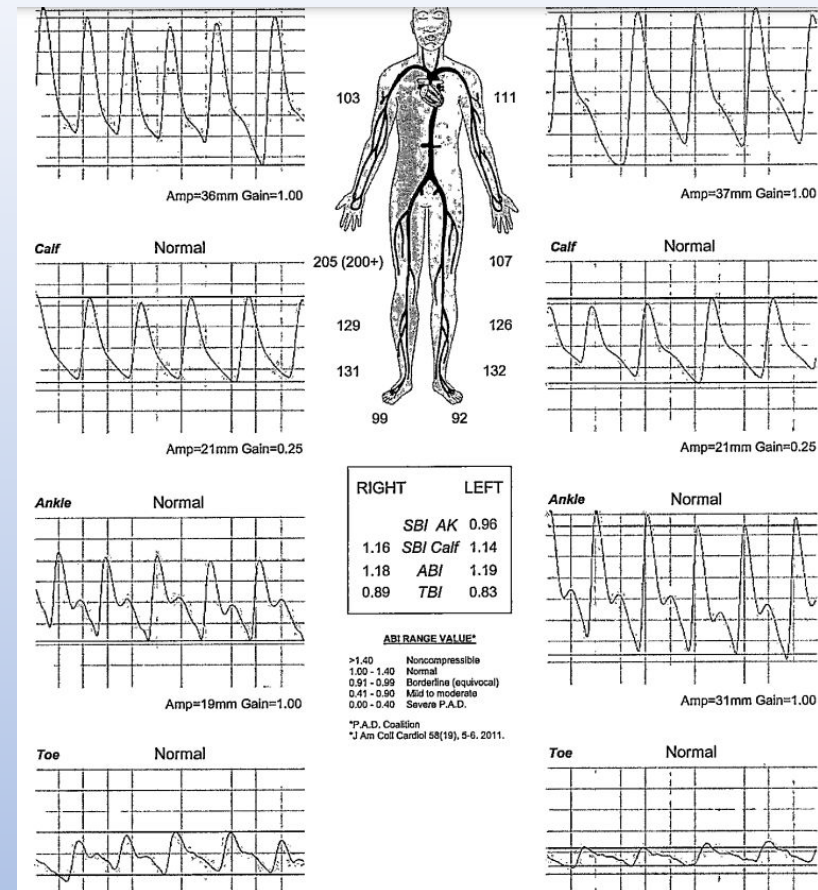
### Interpretation

Evidence of mild peripheral arterial disease in the right leg. Evidence of mild peripheral arterial disease in the left leg. The right ankle/brachial index is 0.84 and the left ankle/brachial index is 0.87.



Digital Occlusion ( Small Vessel Disease )

# Posterior Tibial Disease



Right		Results		Left	
<b>Pressures</b>					
Brachial	103			111	
Above Knee	205 (200+)	SBI	1.85	107	SBI 0.96
Calf	129	SBI	1.16	126	SBI 1.14
Ankle	131	ABI	1.18	132	ABI 1.19
Toe	99	TBI	0.89	92	TBI 0.83
<b>PVR Waveforms</b>					
Above Knee	Normal			Normal	
Calf	Normal			Normal	
Ankle	Normal			Normal	
Toe	Normal			Normal	



**ABI RANGE VALUE\***

>1.40 Noncompressible  
 1.00 - 1.40 Normal  
 0.91 - 0.99 Borderline (equivocal)  
 0.41 - 0.90 Mild to moderate  
 0.00 - 0.40 Severe P.A.D.

\*P.A.D. Coalition  
 \*J Am Coll Cardiol 58(19), 5-6, 2011.

## Interpretation

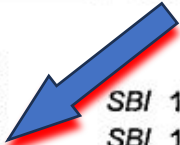
No evidence of significant peripheral arterial disease at rest in the right leg. No evidence of significant peripheral arterial disease at rest in the left leg. The right ankle/brachial index is 1.18 and the left ankle/brachial index is 1.19. Segmental pressure drop between right leg segments of more than 20mmHG is indicative of a function deficit and should be correlated with the waveforms. Right Above Knee SBI not calculated due to systolic pressure above 200.

### Right

Pressures	
Brachial	152
Above Knee	165
Calf	198
Ankle	166
Toe	83

PVR Waveforms	
Above Knee	Mild
Calf	Mild
Ankle	Mild
Toe	Moderate



### Results

**ABI RANGE VALUE\***

>1.40	Noncompressible
1.00 - 1.40	Normal
0.91 - 0.99	Borderline (equivocal)
0.41 - 0.90	Mild to moderate
0.00 - 0.40	Severe P.A.D.

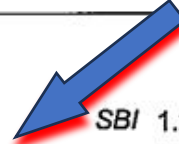
\*P.A.D. Coalition  
 \*J Am Coll Cardiol 58(19), 5-6, 2011.

### Left

Pressures	
Brachial	163
Above Knee	195
Calf	164
Ankle	162
Toe	96

PVR Waveforms	
Above Knee	Mild
Calf	Mild
Ankle	Mild
Toe	Moderate



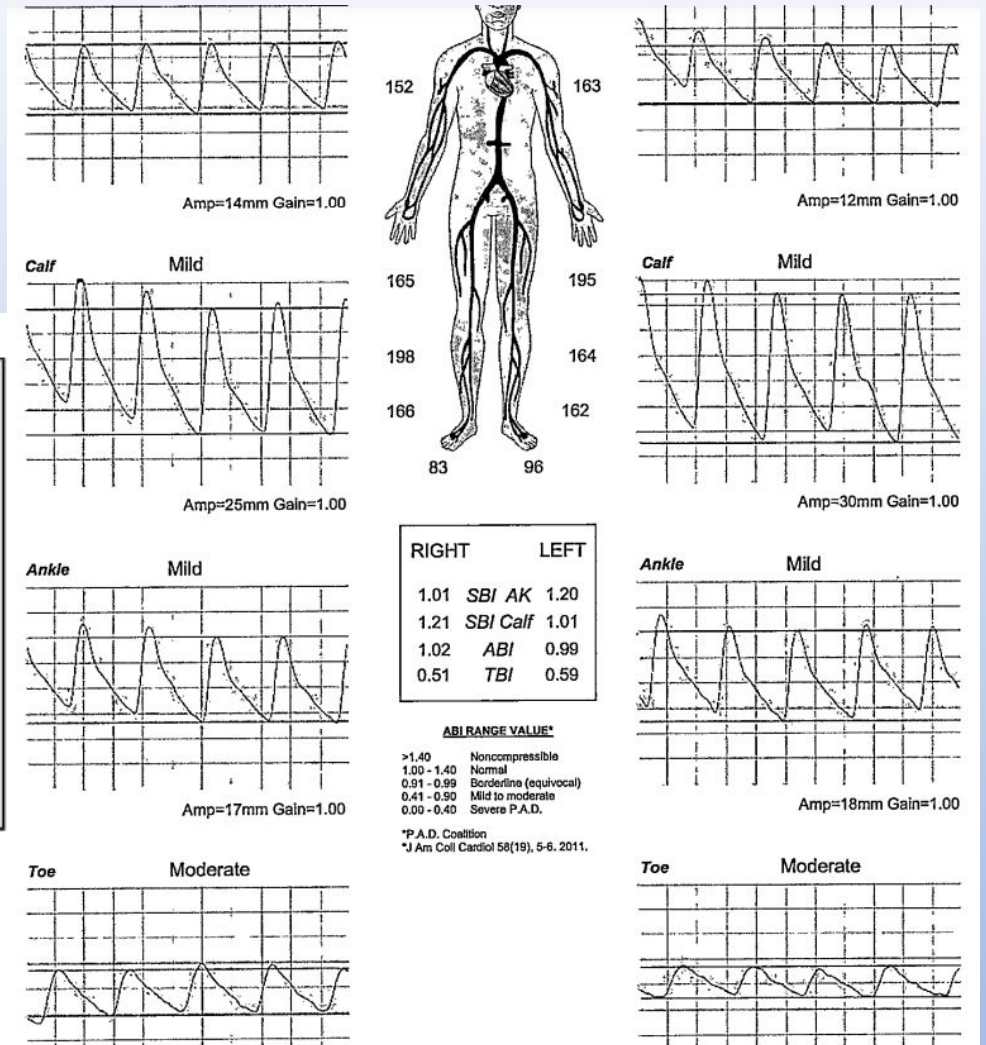
### Interpretation

Evidence of moderate peripheral arterial disease in the right leg. Disease is indicated in the tibioperoneal segment and in the digits on the right side. Evidence of moderate peripheral arterial disease in the left leg. Disease is indicated in the tibioperoneal segment and in the digits on the left side. The right ankle/brachial index is 1.02 and the left ankle/brachial index is 0.99. Segmental pressure drop between right leg segments of more than 20mmHG is indicative of a function deficit and should be correlated with the waveforms.

### Additional Comments

Moderate bilateral lower extremity infrageniculate peripheral arterial disease, right worse than left.

Follow up vascular consultation and/or arterial duplex could be performed to further evaluate extent and degree of peripheral arterial disease, as necessitated by patient's symptoms.



**Tibioperoneal segment bilateral**  
**Digital disease bilateral**

Right		
<b>Pressures</b>		
Brachial	162	
Above Knee	184	SBI 1.11
Calf	175	SBI 1.05
Ankle	79	ABI 0.48
Toe	169	TBI 1.02
<b>PVR Waveforms</b>		
Above Knee	Mild	
Calf	Mild	
Ankle	Mild	
Toe	Severe	

## Results

**ABI RANGE VALUE\***

>1.40	Noncompressible
1.00 - 1.40	Normal
0.91 - 0.99	Borderline (equivocal)
0.41 - 0.90	Mild to moderate
0.00 - 0.40	Severe P.A.D.

\*P.A.D. Coalition  
\*J Am Coll Cardiol 58(19), 5-6, 2011.

## Interpretation

Evidence of severe peripheral arterial disease in the right leg. Disease is indicated in the tibioperoneal segment and in the digits on the right side. Evidence of severe peripheral arterial disease in the left leg. Disease is indicated in the tibioperoneal segment and in the digits on the left side. The right ankle/brachial index is 0.48 and the left ankle/brachial index is 1.01. Segmental pressure drop between left leg segments of more than 20mmHG is indicative of a function deficit and should be correlated with the waveforms.

## Additional Comments

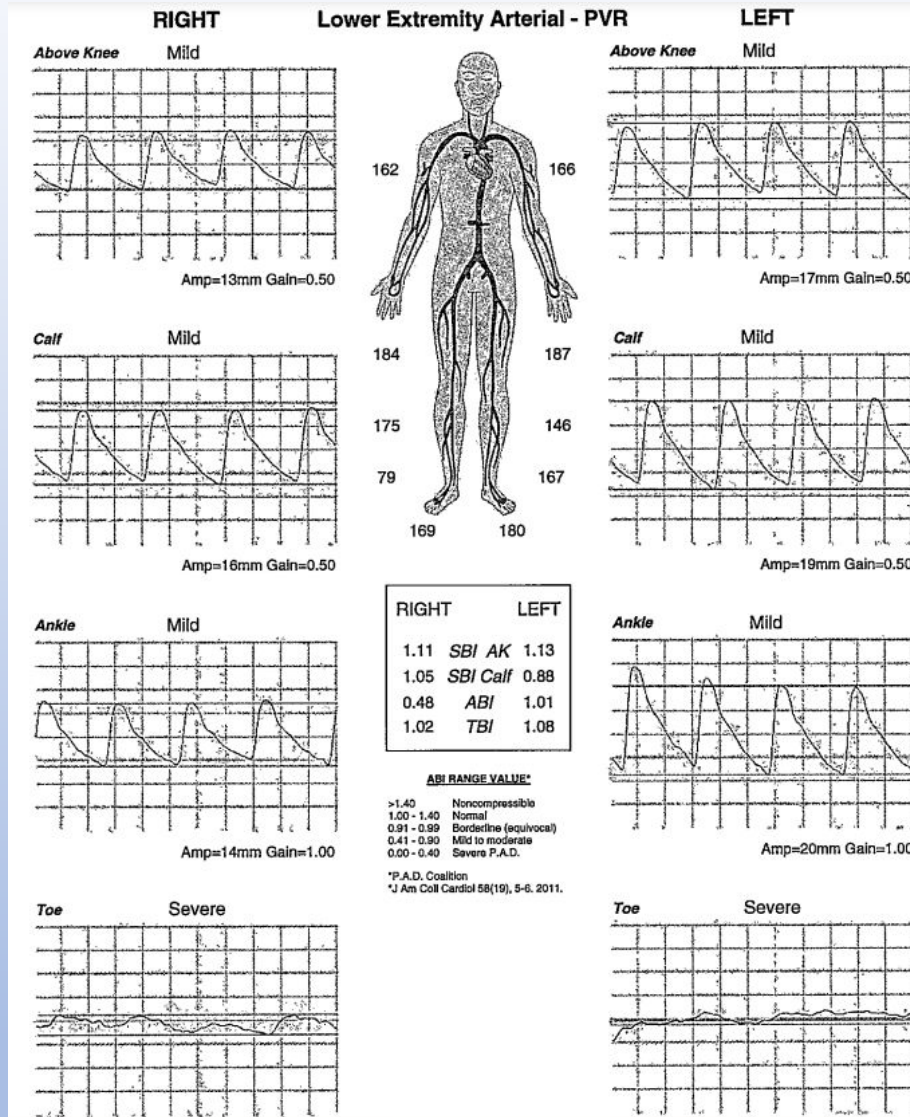
The study was submitted for interpretation on 06/01/2022 and the study was interpreted on 06/01/2022.

Severe bilateral lower extremity infrageniculate peripheral arterial disease seen, right worse than left.

Follow up vascular consultation, and/or lower extremity arterial duplex can be performed for assessment of degree and extent of peripheral arterial disease, as necessitated by patient symptoms.

The Ankle Brachial Index may be artifactually elevated in the setting of asymmetric, and/or calcified atherosclerotic

Left		
<b>Pressures</b>		
Brachial	166	
Above Knee	187	SBI 1.13
Calf	146	SBI 0.88
Ankle	167	ABI 1.01
Toe	180	TBI 1.08
<b>PVR Waveforms</b>		
Above Knee	Mild	
Calf	Mild	
Ankle	Mild	
Toe	Severe	



**Mild disease in legs**  
**Severe disease in digits**

# Findings and Reports



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• **Pressure + indicia + Wave form = results**









# ABI Indices Concern

One potential of false Reading is due to cuff size. PAD net has only one cuff size  
Cuff too narrow, reading falsely high - Cuff too wide reading falsely low

*Inappropriate cuff use produces error of 8.5mmHg*

**AHA recommends bladder width 40% of circumference of limb or 20% wider than limb diameter**

*Recommended Cuff Bladder Width for Lower Limb Pressures in the Average Adult*

Cuff Level	Cuff Width (in cm)
Upper thigh	11
Lower thigh	19
Single contoured thigh cuff	22
Calf	12
Ankle	10-12
Transmetatarsal	7-8
Toe	2.5-3

# PROBLEM

Operator error - Technical error - Reading error

conflicting assessments of ABI/PVR

# SOLUTION

**Standardized criteria for determination and stratification  
of Arterial Occlusive Disease**

# ABI testing

# Reproducibility

## Operator error

- a. Twice yearly Tech training, esp. proper cuff utilization and placement
- b. Scan for error on the fly
- c. Attempt to utilize cuff as close to proper size and width as possible

(width 20% > diameter or cuff width 40% of circumference)

# WFAI Report Expectations

## Report Reading Outline

- a. Reports will have remarks on PRESSURE/INDICIA/PVR
- b. Comments on abnormal findings of each category
- c. Summary of Condition based on cumulative three categories

## Report Guidelines

Findings based on Literature accepted definitions of reported disease for each category

# Reported Guidelines of Normal and Abnormal ABI Results



# ABI Valuation (BASED ON RATIO OF PRESSURE)

>1.4 (1.3?)	Non compressible
1.0 – 1.4 (1.3?)	Normal
.91 - .99	Borderline
< .90	<u>Abnormal</u>

ABI < 0.9 is diagnostic for PAD with 95% sensitivity  
and 100% specificity

# Classification of ABI < 0.90

<b>0.70 – 0.89</b>	<b>Mild PAD</b>
<b>0.51 – 0.69</b>	<b>Moderate PAD</b>
<b>≤ 0.50</b>	<b>Severe PAD</b>

- ◆ **<.5 Associated with increased mortality**
- ◆ **severe PAD associated with multilevel disease, non healing ulcers, gangrene, and ischemic rest pain**



# Toe Brachial Index Valuation

**Park et al, Arch Plast Surg, 2012 May; 39(3): 227–231**

**Hoyer, C., Sandermann., Petersen.: J. Vas Surgery. 2013 Jul;58 (1): 231-8**

**Wickstrom et al, Euro J Vas and Endovascular Surgery, Vol 53, No., 5, p 611-764**

**Brooks, B., Dean, R., Patel, S., Wu, B., Molyneaux, L., Yue, D.K., Diabet Med 2001 Jul;18 (7) : 528-32**

**Peta Ellen Tehan et al, Vasc Med. 2016 Aug;21 (4): 382-9**

**Mirjami Laivuori et al J. Vas Surgery 2021 Feb; 73 (2): 641 - 649**



## Utility of Toe – Brachial Index for Diagnosis of Peripheral Artery Disease

Park, S.C.; Choi, C.Y.; Ha, Y.I.; Yang, H.E.;

Arch Plast Surg. 2012 May ; 39(3): 227 -231

### Results

Patients with an ABI of 0.9-1.3 showed almost no difference between the 2 measurements.

~~The patients with TBI >0.6 had no arterial insufficiency.~~

~~The patients with TBI <0.6 required vascular intervention with ballooning.~~

After the angiography, the gangrenous wounds decreased in size more rapidly than they did prior to the intervention

- Our findings suggest that TBI is the method of choice for evaluating lower limb perfusion disorders. This result requires further studies of TBI in a larger number of patients. Future long-term studies should therefore evaluate the utility of TBI as a means of screening for PAD and the present findings should be regarded as preliminary outcomes.

# **The toe-brachial index in the Diagnosis of Peripheral Arterial Disease**

**Hoyer, Sandermann, Petersen**

**J Vas Surg. 2013 Jul; 58 (1): 231-238**

- **The TBI had a sensitivity of 90% to 100% and a specificity of 65% to 100% for the detection of vessel stenosis.**
- **Recommend < .7mmHg as cut off**

**Toe Pressure and Toe Brachial Index are predictive of Cardiovascular Mortality, Overall Mortality, and Amputation Free Survival in patients with Peripheral Arterial Disease**

**Wickstrom, J.E., Laivuori, M., Aro, E., Sund, R. T., Hautero, O., Venermo, M., Jalkanen, J., Hakovirta, H.,**

**Euro J of Vas and Endovas Surg. 2017 May (15)5:696-703**

**• For TP < 30 mmHg and TBI < 0.25 the risk of cardiovascular mortality was hazard ratio [HR] 2.84, 95% confidence interval**

**A systematic review of the sensitivity and specificity of the toe–brachial index for detecting peripheral artery disease**

**Peta Ellen Tehan et al, Vasc Med. 2016 Aug;21 (4): 382-9**

**Sensitivity of the TBI for PAD was reported in all seven studies and ranged from 45% to 100%; specificity was reported by five studies only and ranged from 16% to 100%.**

**In conclusion, this review suggests that the **TBI has variable diagnostic accuracy** for the presence of PAD in specific populations at risk of developing the disease.**

## Toe pressure should be part of a vascular surgeon's first-line investigation in the assessment of lower extremity artery disease and cardiovascular risk of a patient

Mirjami Laivuori et al J. Vas Surgery 2021 Feb; 73 (2): 641 - 649

**Results:** The poorest survival was in patients with ABI >1.3 (10-year survival, 15.3%; hazard ratio, 2.2; 95% confidence interval, 1.9-2.6; P < .0001; reference group, ABI 0.9-1.3), followed by the patients with TP <30 mm Hg (10-year survival, 19.6%; hazard ratio, 2.0; 95% confidence interval, 1.7-2.2; P < .0001; reference group, TP ≥80 mm Hg). The best 10-year survival was in patients with TP ≥80 mm Hg (43.9%). Of the 642 patients with normal ABI (0.9-1.3), 18.7% had a TP <50 mm Hg. The highest cardiovascular death rate (64.6%) was in the patients with TP <30 mm Hg, and it was significantly lower than for the patients with TP >50 mm Hg.

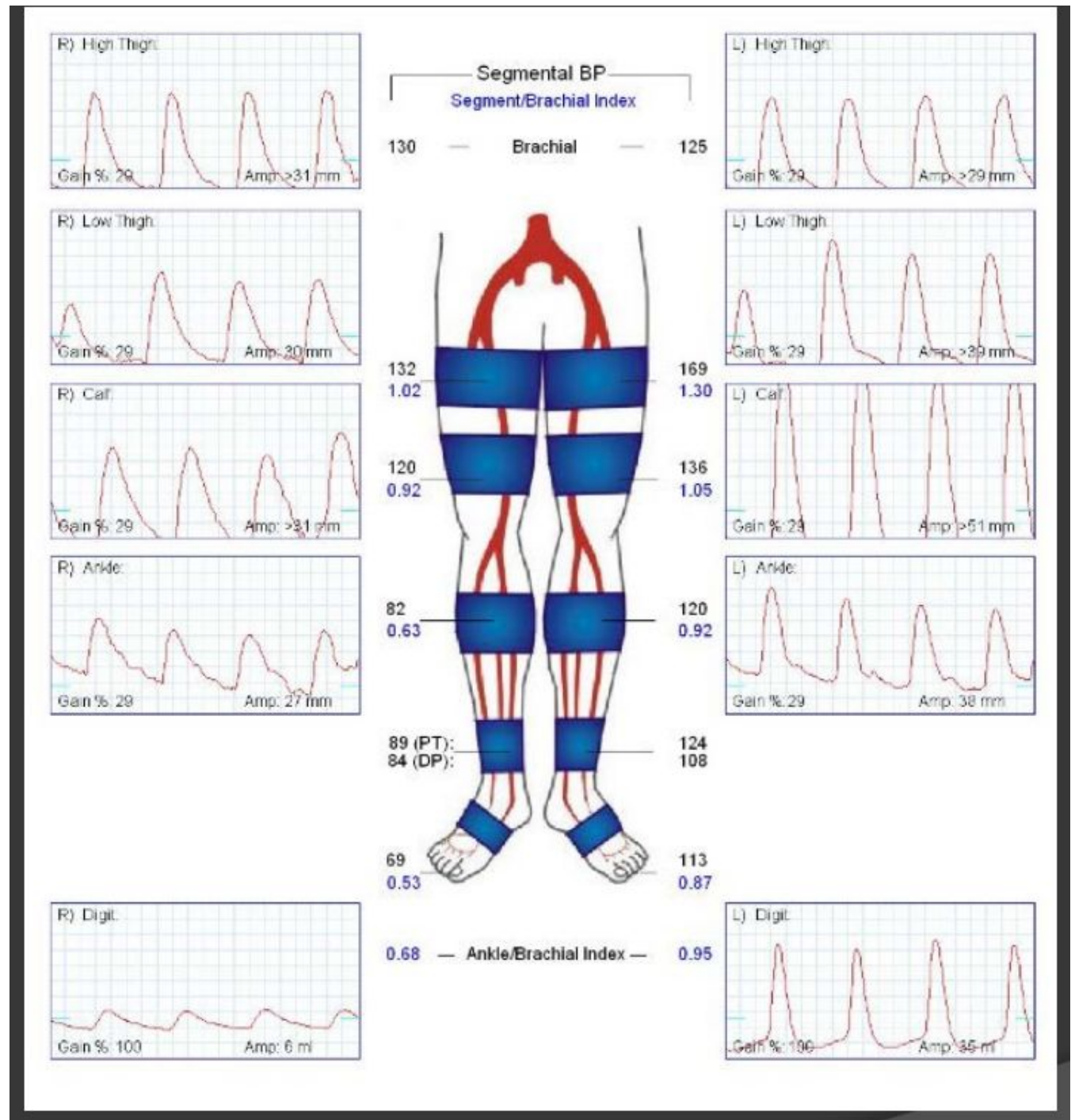
**Conclusions:** Low TP is associated significantly with survival and cardiovascular mortality. Patients with a normal ABI may have lower extremity artery disease (LEAD) and a considerable risk for a cardiovascular event. If only the ABI is measured in addition to clinical examination, a substantial proportion of patients may be left without LEAD diagnosis or adequate treatment of cardiovascular risk factors. Thus, especially if ABI is normal, LEAD is excluded only if TPs are also measured and are normal.

# Toe Brachial Index for reliable data

## Diagnostic Criteria for TBI

Range	Interpretation
• >0.7	Normal
• 0.5-0.7	Mild
• 0.35-0.5	Moderate
• <0.35 toe pressure > 40 mmHg	Moderate-Severe
• <0.35 toe pressure < 30 mmHg	Severe

• Right toe pressure and amplitude low



# TBI - gain

*Original Criteria for the Pulse Volume Recorder (PVR)*

Anatomic Level	Bladder Size	Inflation Pressure	Inflation Volume	Gain
Thigh	36 × 18 cm	65 mmHg	400 ± 75 cc	1
Calf and ankle	22 × 12 cm	65 mmHg	75 ± 25 cc	1
Transmetatarsal	12 × 7 cm	65 mmHg	50 ± 10 cc	2.5
Digits	9 × 3 or 7 × 2 cm	40 mmHg	5 ± 3 cc	5

# Pressure – Indicia - PVR

## Pressure

Drop in pressure of 20 mmHg – **ABNORMAL**

Difference in contralateral pressure of 20-30 mmHg - **ABNORMAL**

## Indicia

Drop in indicia of 1.5 – **ABNORMAL**

## PVR

Drop in height of 5 mm – **ABNORMAL**

Loss of aortic notch

Widening of wave – concave down on diastole

# WFAI Protocol Summary

## ABI Valuation

>1.4	Non compressible
1.0 – 1.4	Normal
.91 - .99	Borderline
<b>&lt; .90</b>	<b><u>Abnormal</u></b>
0.70 – 0.89	Mild PAD
0.51 – 0.69	Moderate PAD
≤ 0.50	Severe PAD

## Toe Brachial Index for reliable data

### Diagnostic Criteria for TBI

Range	Interpretation
• >0.7	Normal
• 0.5-0.7	Mild
• 0.35-0.5	Moderate
• <0.35 toe pressure 40 mmHg	Moderate-Severe
• <0.35 toe pressure < 30 mmHg	Severe

# Definition of Pulse Volume Recorder (PVR) Categories

## *Definition of Pulse Volume Recorder (PVR) Categories*

PVR Category	Chart Deflection (in mm)	
	Thigh and Ankle	Calf
1	>15*	>20*
<b>Mild.....</b> 2	>15†	>20†
<b>Moderate..</b> 3	5–15	5–20
<b>Severe.....</b> 4	<5	<5
<b>Limb Loss.</b> 5	Flat	Flat

\*With reflected wave.

†No reflected wave.



# Title Slide