Tibial Artery Velocities in Diagnosis and Follow-up of Peripheral Artery Disease

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DISCLOSURE

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Duplex Scanning Peripheral Arteries

Introduced in late1980s.

Early work University of Washington, Cedars Sinai.

Emphasis on common femoral, superficial femoral and popliteal arteries.

First large series of evaluation of tibial arteries from OHSU in 1992.

Duplex Mapping

DUPLEX VISUALIZATION OF ARTERIAL SEGMENTS (INFRAGENICULATE VESSELS)

286 LOWER EXTREMITIES

Artery	Number of Segments Visualized by Angio	Percent Angio Visualized Segments Visualized by Duplex
Anterior Tibial*	539	94
Posterior Tibial*	525	96
Peroneal*	506	83
Total	1570	91

**Proximal - mid - distal thirds analyzed seperately and pooled for table*

Duplex Mapping: Tibial Arteries
(Sensitivity/Specificity/PPV for predicting continuous patency)

	Anterior Tibial	Posterior Tibial	Peroneal
A (80 limbs)	85/80/96	———*	———*
B (44 limbs)	100/100/100	100/100/100	73/100/100
C (117 limbs)	96/73/85	100/75/88	76/72/79
D (45 limbs)	81/85/89	89/71/92	57/58/71
TOTALS (286 limbs)	93/75/88	97/74/91	71/75/82

** Analysis not performed if less than 5 noncontinuous arteries*

Duplex Scanning Tibial Arteries

AT, PT, Peroneal PSVs roughly the same.

Can detect tibial artery flow down to 2 to 3 cm/sec in adults, children and infants.

Low tibial artery velocities can be detected in some patients when the ABI is 0.0.

Peak systolic velocities >100 cm/sec are very infrequent in tibial arteries; preliminary analysis likely <0.5% of measured tibial artery velocities.

Duplex Scanning Tibial Arteries

No specific velocity criteria for tibial artery stenosis.

Difficult to precisely interpret angiographic/CTA stenosis of tibial arteries because of calcification, small size with potential to magnify errors, multiple tandem lesions and segmental occlusions.

Focus has been on using peak systolic tibial artery velocities as a measure of distal perfusion.

Objective Performance Goals

Suggested objective performance goals and clinical trial design for evaluating catheter-based treatment of critical limb ischemia

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-A way to measure the efficacy of revascularization.
-Traditional clinical measures may not apply to catheter based treatments.
-Challenges in comparing hemodynamic success in open vs. endovascular therapies.
-Trials should include measures of sustained hemodynamic effect

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Intervention Follow-up

Clinical Variables

- Primary Patency
- Amputation
- Amputation Free Survival
- Target Lesion Revascularization

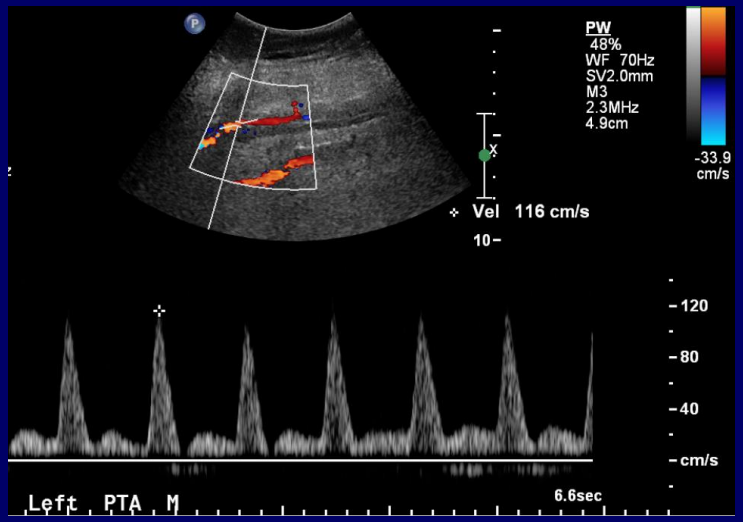
Hemodynamic Effectiveness

- ABI
- PVR

- ABI is still the most widely used objective performance measure to follow patients with PAD.
  -Limitations in patients with diabetes, renal failure (Incompressible vessels).

ABI for Intervention Follow-up

We hypothesized that tibial artery velocities could be used as an alternative, or in addition to, to ABI as an objective performance measure following endovascular therapy.



Tibial Artery Velocities

Relationship of tibial velocities and PAD severity is not well-understood.

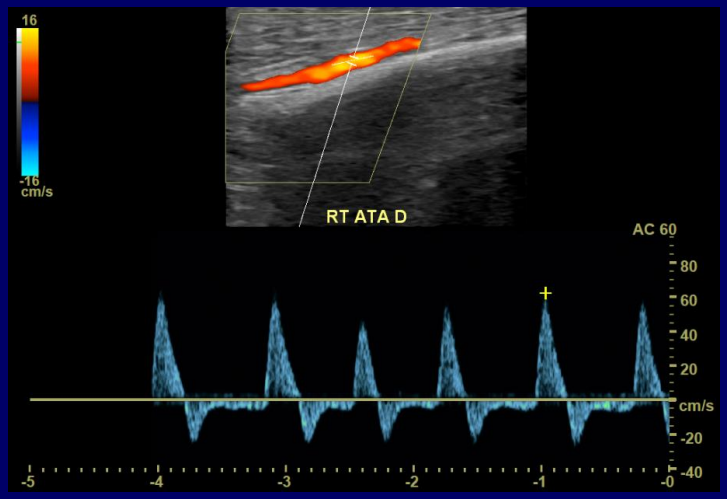
What are expected tibial artery velocities in PAD and non-PAD patients?

How do tibial artery velocity measurements change with arterial intervention?

Objectives

1. Characterize tibial velocities in normals, patients with severe PAD, and in PAD patients pre and post endovascular intervention.

2. Can tibial velocities be used as a measurement of improvement following endovascular intervention?



Velocity Parameters

Peak systolic velocity (PSV)

- Proximal, mid and distal segment each artery
- Mean PSV calculated for each artery

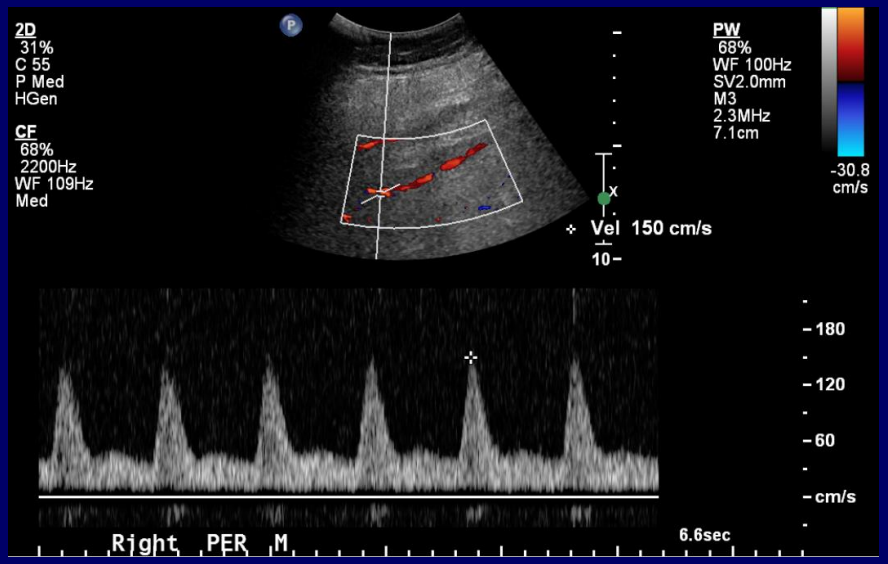
Ankle Parameters:

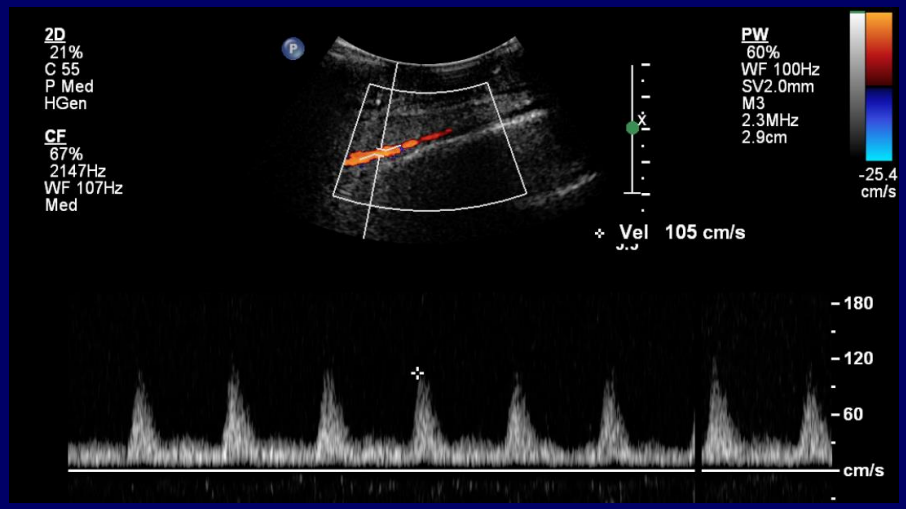
Average ankle velocity (**AAV**) = Average of distal PSV of PT, AT and peroneal

Ankle-profunda index (**API**) = $\frac{\text{AAV}}{\text{Profunda PSV}}$

Patients

- 68 normal controls
- mean ABI: **1.08 ± 0.09**
- 103 severe PAD patients, mean ABI: 0.64 ± 0.25
- 36 patients pre and post endovascular intervention
- Excluded: acute limb ischemia, patients without DUS

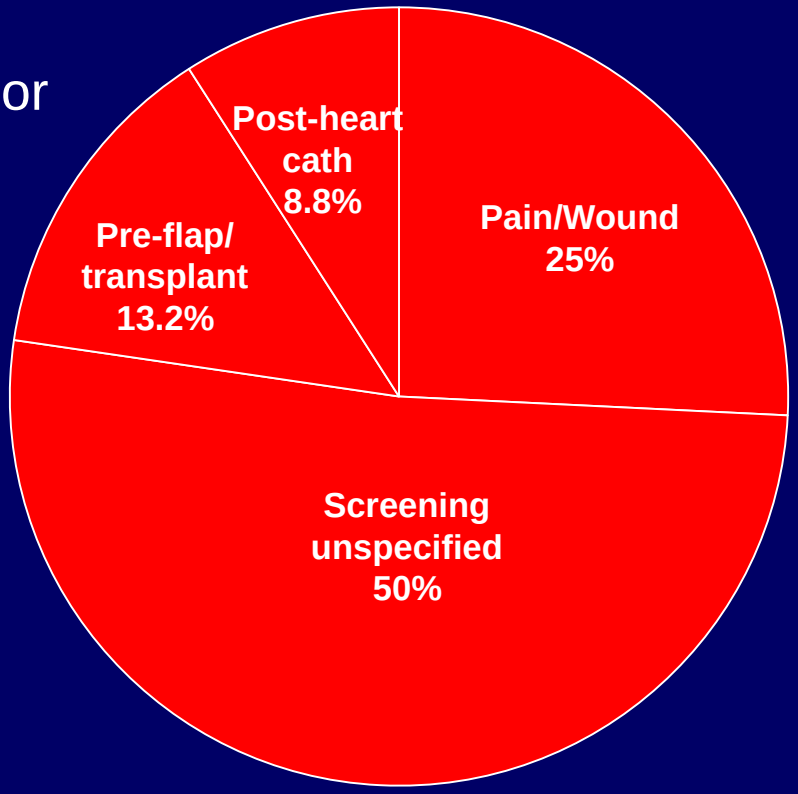




Controls

Myofascial free-flap or

Renal or cardiac transplantation



Screening unspecified:

PCP screening evaluation

Rheumatology evaluation

Erroneous test

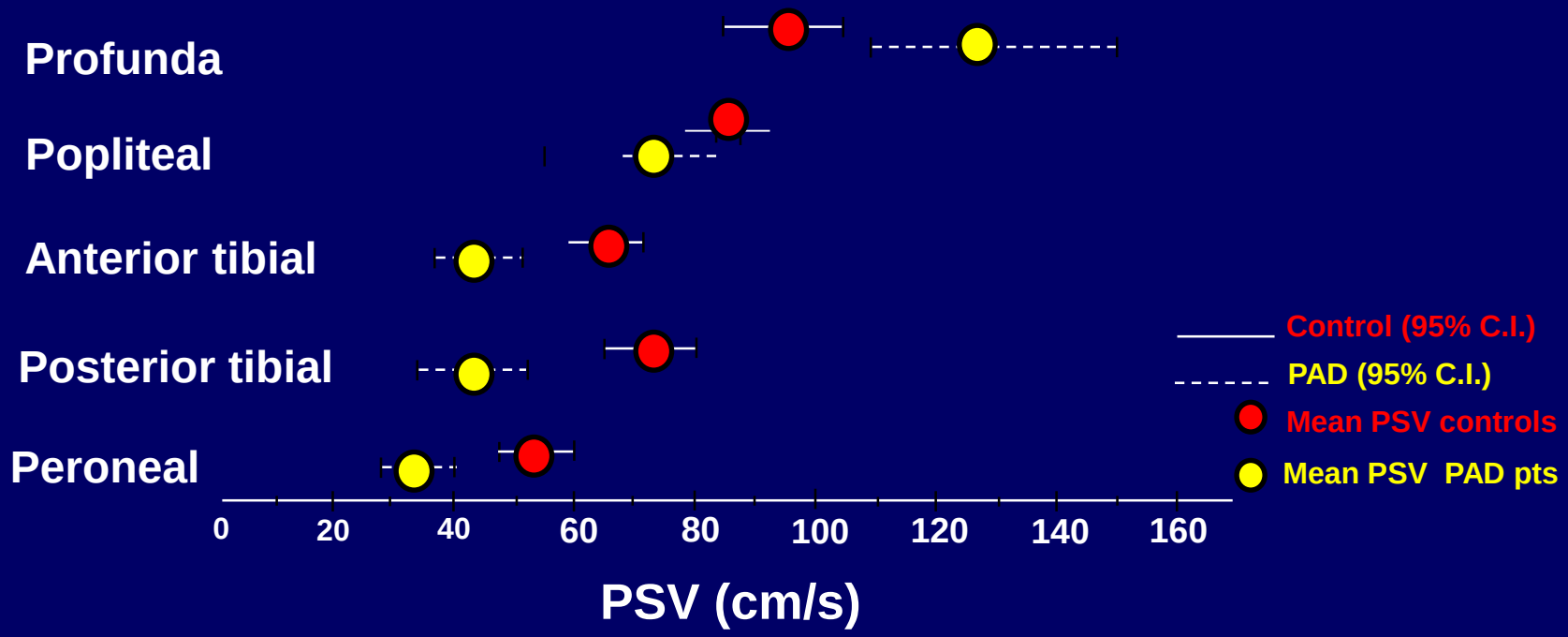
Characteristics: PAD patients and controls

	Severe PAD n=103 (%)	Controls n=68 (%)	p
Age (years mean ± SD)	**68.6 ± 11.8**	**59.8 ± 17.1**	**<0.001**
ABI (mean ± SD)	**0.64 ± 0.25**	**1.08 ± 0.09**	**0.006**
Male	51 (49.5)	43 (63.2)	ns
Diabetes	**50 (48.5)**	**19 (27.9)**	**0.007**
Coronary artery disease	**79 (76.7)**	**23 (33.8)**	**<0.001**
Hypertension	**78 (75.7)**	**39 (57.4)**	**0.011**
Hyperlipidemia	54 (52.4)	24 (35.3)	ns
Smoking	**83 (80.6)**	**43 (63.2)**	**0.012**
History of CVA/TIA	16 (15.5)	8 (11.8)	ns
Chronic kidney disease	27 (26.2)	12 (17.6)	ns
Antiplatelet	**85 (82.5)**	**33 (48.5)**	**<0.001**
Anticoagulant	17 (16.5)	5 (7.4)	ns

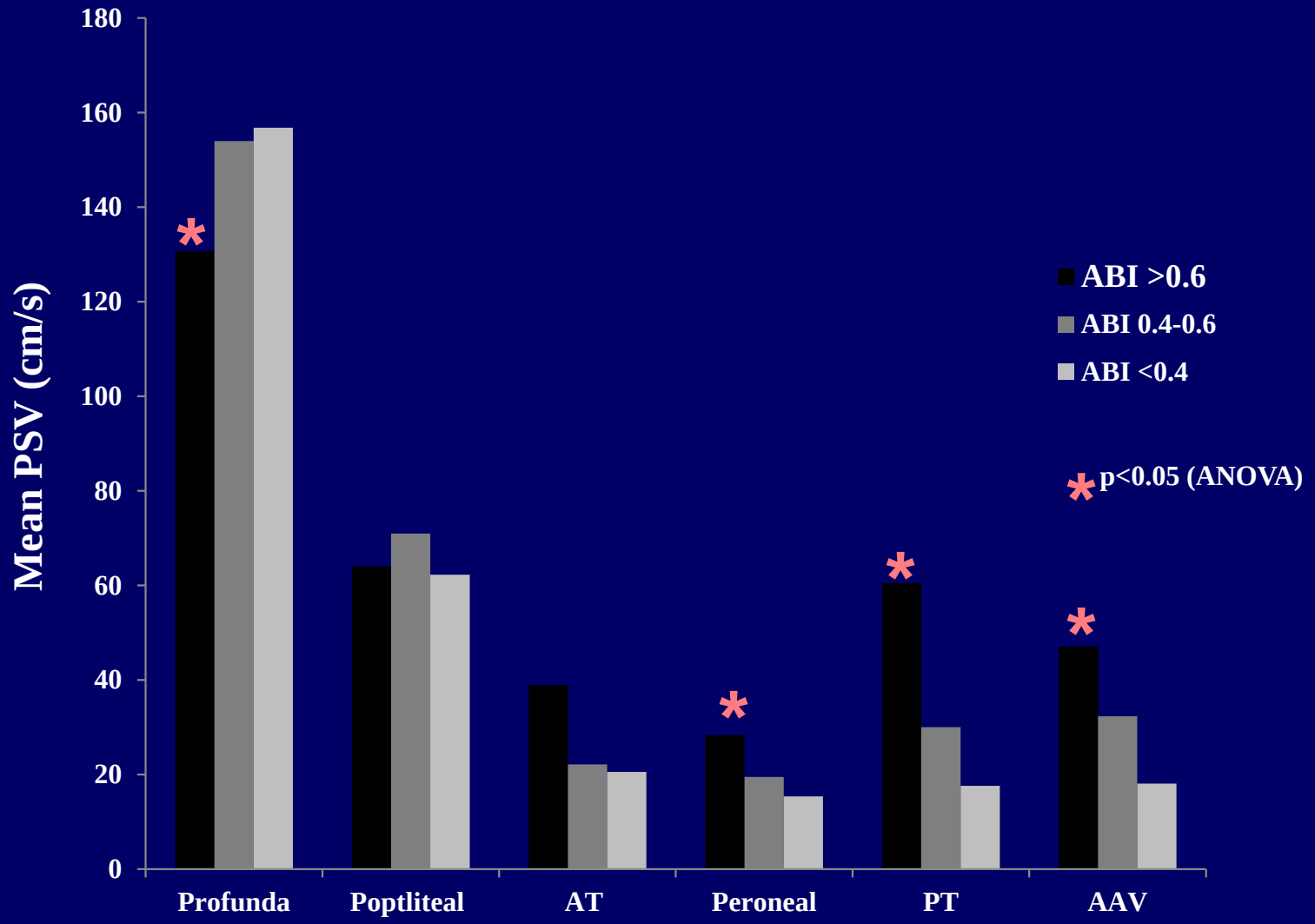
Established Reference Values

Artery	**Severe PAD (cm/s)**	**Controls (cm/s)**	**p**
Profunda femoris	113.9 – 149.1	85.5 – 106.9	0.001
Popliteal	56.2 – 73.0	69.1 – 83.2	0.037
Anterior tibial	37.1 – 50.2	59.5 – 71.3	<0.001
Posterior tibial	34.6 – 52.1	66.9 – 81.3	<0.001
Peroneal	28.7 – 40.0	48.3 – 59.4	<0.001
Tibial Parameters			
Average ankle velocity	31.9 – 42.8	59.0 – 69.9	<0.001
Ankle-profunda index	0.34 – 0.52	0.68 – 0.82	<0.001

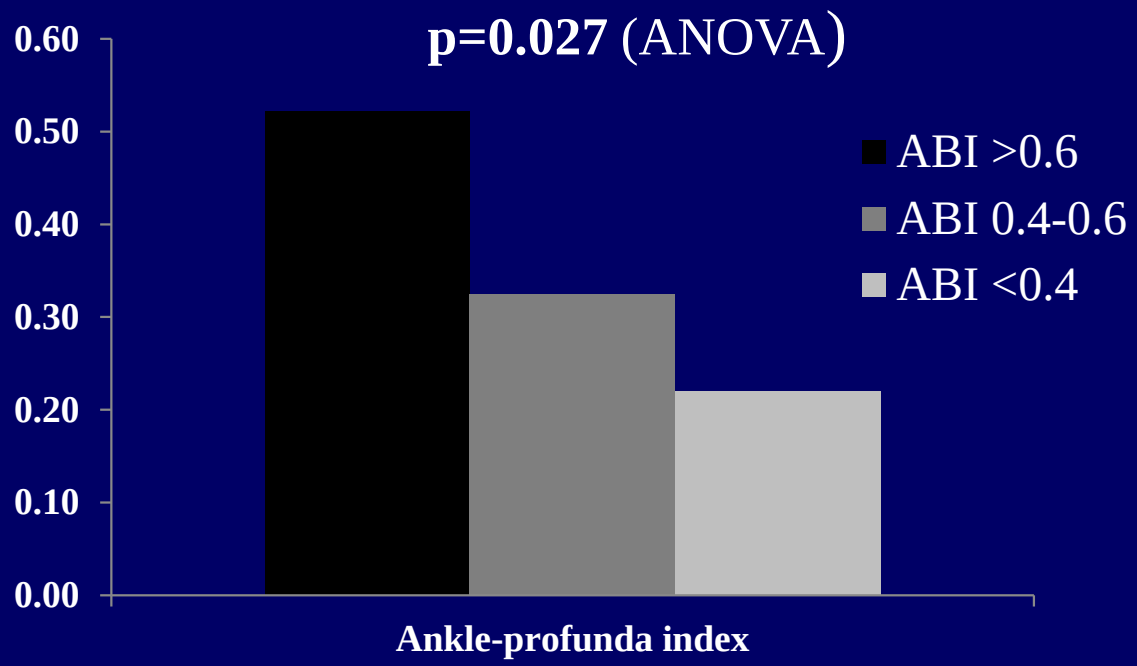
Mean PSV and 95% C.I.



PSVs Correlate with ABI



Ankle-Profunda Index Correlates with ABI



Ankle-profunda index (**API**) = $\frac{\text{AAV}}{\text{Profunda PSV}}$

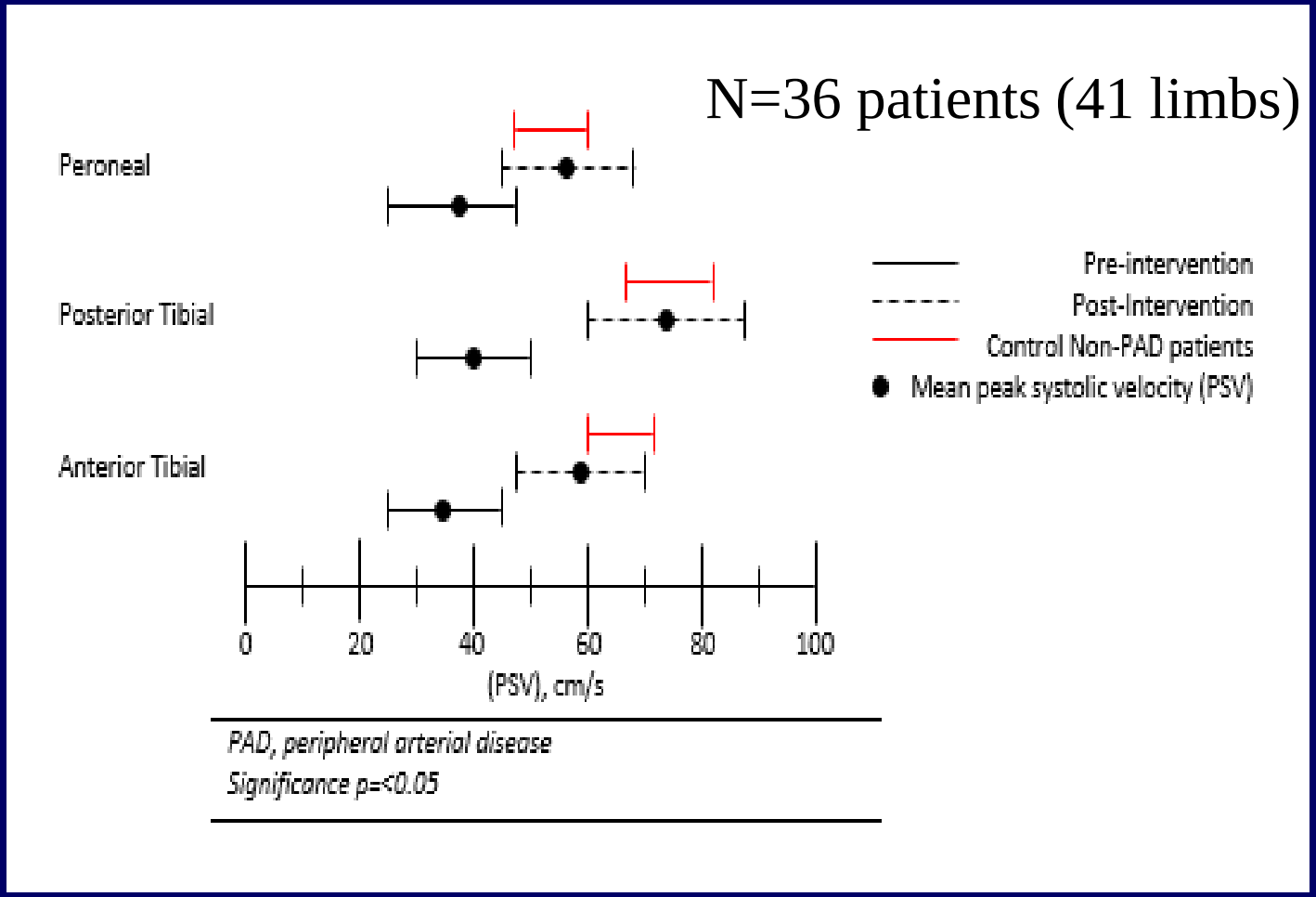
Average ankle velocity (**AAV**) = Average of distal PSV of PT, AT and peroneal PSVs

Intervention Patients

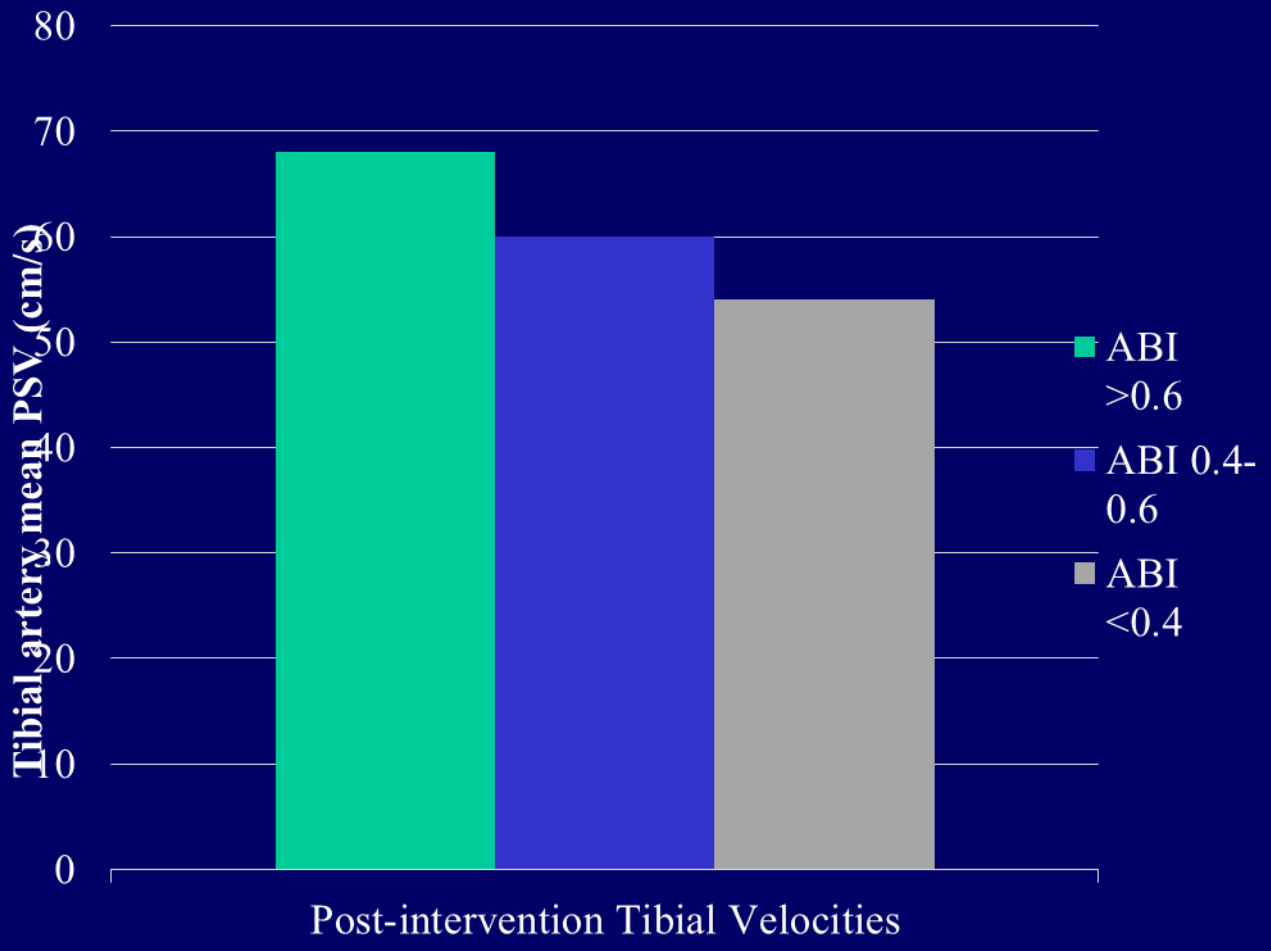
Age (IQR)	74 years (64, 87)
Diabetes mellitus	18 (50)
Chronic kidney disease	11 (31)
Coronary artery disease	29 (81)
Hypertension	34 (94)
Hyperlipidemia	33 (92)
Tobacco	30 (83)
Statin	24 (67)
Beta blocker	17 (47)
ASA/plavix	29 (81)
Warfarin/lovenox	7 (19)
Intervention **Angioplasty (PTA) only** **Stent placement**	 15 (37) 26 (63)

Interventions targeted the iliac (n=9), and femoral (superficial and common) (n=27), and proximal popliteal arteries (n=11).

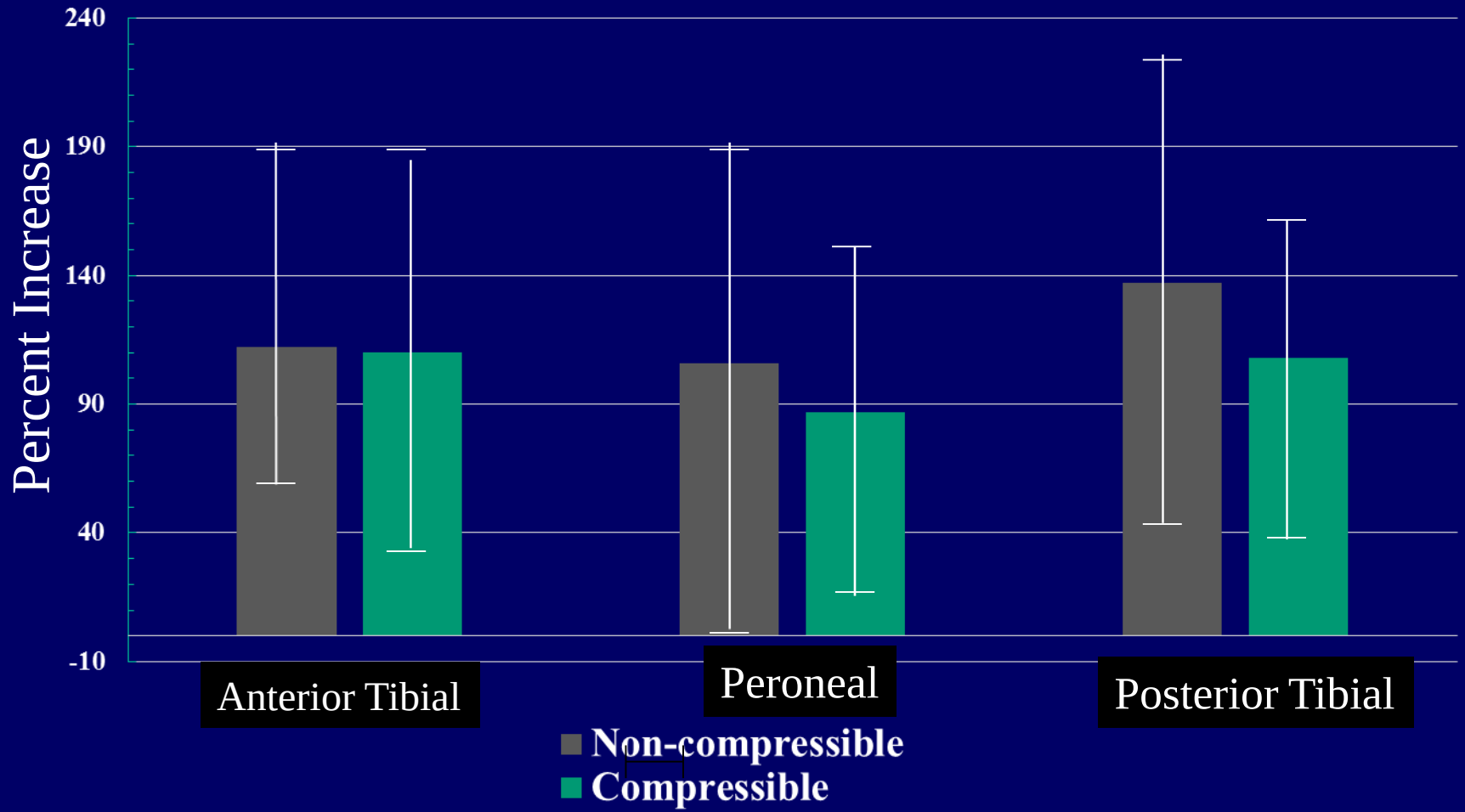
Mean Peak Systolic Velocities pre and post-Endovascular Intervention



Post intervention Tibial Artery Peak Systolic Velocity Parallels ABI



Average Percent Increase from Pre- intervention Peak Velocities in Compressible and Non-compressible Tibial Arteries



Conclusions: Tibial velocities for Follow-up

- Following above knee endovascular intervention tibial artery mean peak systolic velocities fall within or near confidence intervals for normal control patients without PAD.
- The average percent increase in tibial mean peak systolic velocities from pre endovascular intervention are similar in both compressible and non-compressible patients.
- Tibial artery mean peak systolic velocities can be used to supplement ABI as an objective performance measure.

Future Work

Implications of very low tibial artery velocities in chronic and acute limb ischemia in children, trauma victims and patients with atherosclerotic and embolic critical limb ischemia.

Prevalence, distribution and demographics of tibial artery peak systolic velocities >100 cm/sec.

Questions?

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OHSU KNIGHT CARDIOVASCULAR *Institute*