The Vascular System and It's Impact on Wound Development and Care: The Need for an Accurate Vascular Assessment

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Disclosures

- I have no disclosures.

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Objectives

- Describe the anatomy and function of the vascular system as it relates to its role in wound development and healing.
- Identify wounds with possible vascular etiology and the associated risk factors contributing to their development.
- Discuss potential treatment modalities and interventions aimed at addressing vascular ulcers to assist with wound healing.

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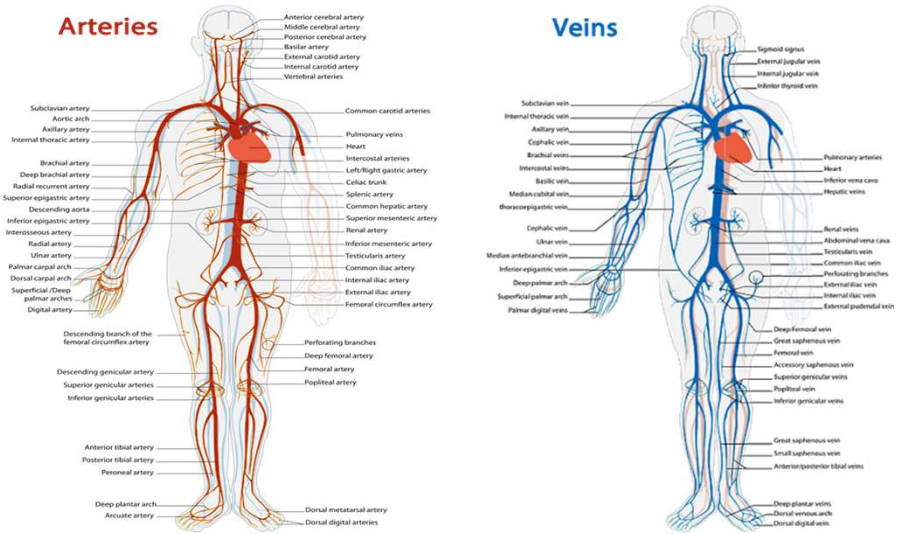
The Vascular System



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Why care about blood flow

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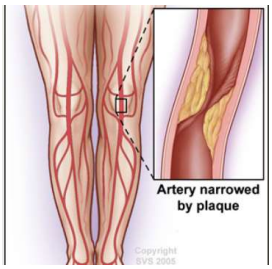
Peripheral Arterial Disease (PAD)

- Acute (thrombosis or trauma) vs chronic (atherosclerosis)
- Macrovascular and microvascular circulation
- Critical Limb Ischemia
- Co-morbidities



Meyer, A., Schilling, A., Kott, M., Rother, U., Lang, W., & Regus, S. (2018). Open versus Endovascular Revascularization of Below-Knee-Arteries in Patients with End-Stage Renal Disease and Critical Limb Ischemia. Vascular and Endovascular Surgery, 52(8), 613-620. doi: 10.1177/1538574418789036
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Risk factors

PAD

- Smoking
- Age
- Diabetes
- HLD
- CAD
- Obesity
- Sedentary lifestyle
- ESRD

Chronic wounds

- Smoking
- Age
- Diabetes
- Obesity
- Sedentary lifestyle
- Venous Insufficiency
- CAD
- ESRD

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Arterial ulcers

- Distal part of leg (malleoli, dorsum, toes)
- Eschar, gangrene (dry or wet)
- Punched out appearance
- Pale and low granulation appearance
- Decreased bleeding
- Deep or shallow, with exposed structures

- Health History
- Smoking status
- Decreased hair growth
- Decreased or lack of pedal pulses
- Dependent rubor
- Pain with leg elevation
- Rest pain

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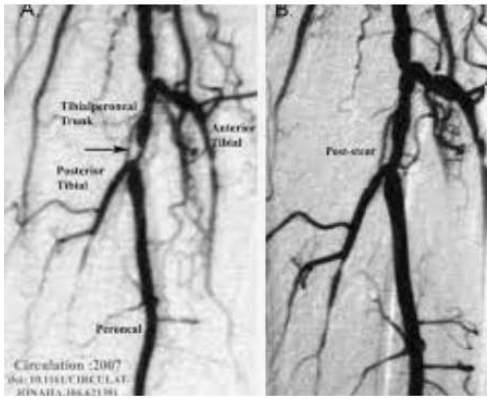
Diagnostic tests

- Non-invasive vascular labs:
  - ABI and TBI
  - Doppler segmental arterial study
  - Arterial duplex
  - TCPO2
- Radiologic imaging:
  - CT angiogram
  - MRA
  - Angiogram



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ABI and TBI

- ABI is a non-invasive test that uses inflatable cuffs to gauge arterial circulation and measure blood pressure (systolic) between the lower extremity (DP or PT) and the upper extremity (brachial)
- Can be done quick and without expensive equipment or in accredited vascular lab

- TBI is also a non-invasive test that uses an inflatable cuff to measure blood pressure (systolic) between the great toe and the upper extremity (brachial)
- Important test to get when diabetic, CKD, and advanced age as concern for calcification of vessels

"A"nkle / "B"rachial = "I"ndex

Rac-Albu, M., Iliuta, L., Guberna, S. M., & Sinescu, C. (2014, September). The Role of Ankle-Brachial Index for Prediction Peripheral Arterial Disease. *Maedica*, 9(3), 295-302. Retrieved March 24, 2024, from NIH database
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ABI value	Interpretation	Recommendation
Greater than 1.4	Calcification/essel hardening	Refer to vascular specialist
1-1.4	Normal	None
0.9-1	Acceptable	None
0.8-0.9	Some arterial disease	Treat risk factors
0.4-0.8	Moderate arterial disease	Refer to vascular specialist
Less than 0.4	Severe arterial disease	Refer to vascular specialist

Segment	Right				Left			
	Waveform	Pressure	PI	PVR	Waveform	Pressure	PI	PVR
Brachial A		140	0.92			152	1	
CFA	Triphasic				Triphasic			
POP A	Triphasic				Triphasic			
Ankle (PT) Posterior Tibial	Triphasic	150	0.99	Good	Triphasic	150	0.99	Good
Ankle (DP) Dorsalis Pedis	Triphasic	134	0.88	Good	Triphasic	142	0.93	Good
Big Toe		82	0.54	Fair		76	0.5	Fair

Right lower extremity ABI: 0.99
Left lower extremity ABI: 0.99

Range	Interpretation
> 0.75	Normal
0.5 – 0.75	Mild
0.35 – 0.5	Moderate
0.25 – 0.35	Moderate-Severe
< 0.25	Severe

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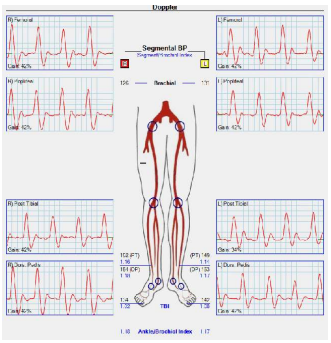
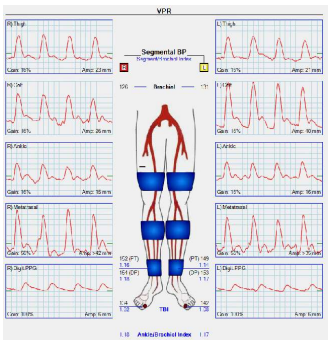
Doppler arterial study with PVR

Segmental Doppler



Pulse Volume Recording



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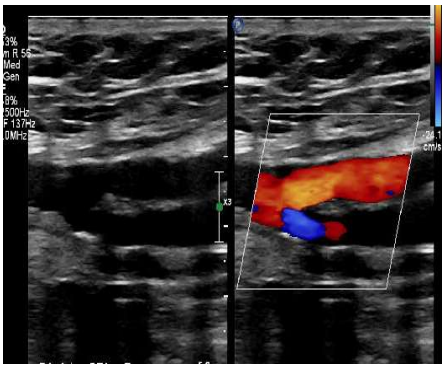
Arterial duplex



Segment	Right				
	SI	PSV	PStructure	PSurface	Waveform
CFA	<50%	141	heterogenous	irregular	Triphasic
DFA PROX	<50%	241	heterogenous	irregular, calcified	Triphasic
SFA PROX (1)	<50%	158	heterogenous	irregular, calcified	Biphasic
SFA MID (1)	>50%	276	heterogenous	irregular, calcified	Biphasic
SFA DIST	<50%	98.8	heterogenous	irregular, calcified	Biphasic
POP A	<50%	84	heterogenous	irregular, calcified	Biphasic
BK Popliteal	NSD	64.5			Biphasic
Prox PTA	<50%	91.6	heterogenous	calcified	Biphasic
Mid PTA	<50%	60.6	heterogenous	calcified	Biphasic
Distal PTA	<50%	62.8	heterogenous	calcified	Biphasic
Prox ATA	<50%	61	heterogenous	calcified	Biphasic
Mid ATA	>50%	145	heterogenous	calcified	Biphasic
Distal ATA	<50%	31.5	heterogenous	calcified	Biphasic

Segment	Left				
	SI	PSV	PStructure	PSurface	Waveform
CFA	<50%	188	heterogenous	irregular, calcified	Biphasic
DFA PROX	<50%	182	heterogenous	irregular, calcified	Biphasic
SFA PROX (1)	<50%	101	heterogenous	irregular, calcified	Biphasic
SFA PROX (2)	>50%	224	heterogenous	irregular, calcified	Biphasic
SFA MID (1)	>50%	230	heterogenous	irregular, calcified	Biphasic
SFA MID (2)	>50%	218	heterogenous	irregular, calcified	Biphasic
SFA DIST	<50%	66.3	heterogenous	irregular, calcified	Biphasic
POP A	<50%	72.4	heterogenous	irregular, calcified	Biphasic
BK Popliteal	NSD	60.8			Biphasic
Prox PTA	<50%	45.2	heterogenous	calcified	Biphasic
Mid PTA	<50%	40.8	heterogenous	calcified	Biphasic
Distal PTA	<50%	38.9	heterogenous	calcified	Biphasic
Prox ATA	<50%	43.5	heterogenous	calcified	Biphasic
Mid ATA	<50%	43.2	heterogenous	calcified	Biphasic
Distal ATA	<50%	34.2	heterogenous	calcified	Biphasic

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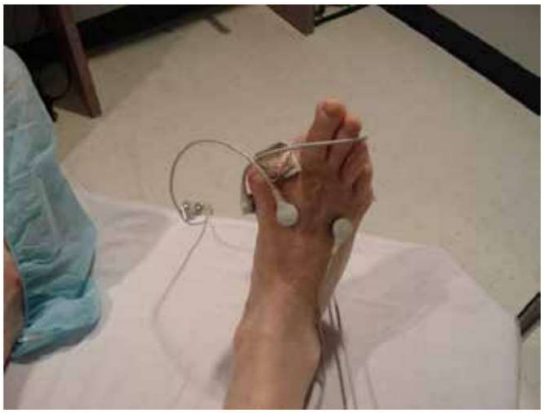
TCPO2

- Evaluates oxygen as it diffuses across the skin from cutaneous capillary bed-microcirculation
- Helpful in predicting wound healing potential
- Used to help with HBOT qualification and determining amputation level

- Is time consuming (30-45 min)
- Edema/swelling/scar tissue/acute infection can lead to erroneously low values due to greater distance of oxygen diffusion
- Unreliable if leads placed over bony prominences



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Interventions

Non-surgical

- Betadine
- Debridement
- Passive warming
- HBOT
- Inspection of feet, footwear
- Smoking cessation
- Medication
- Arterial Pump

Surgical

- Angiogram-stent, angioplasty, atherectomy, thrombectomy, lithotripsy
- Bypass-vein or synthetic graft
- Amputation
- Skin grafting

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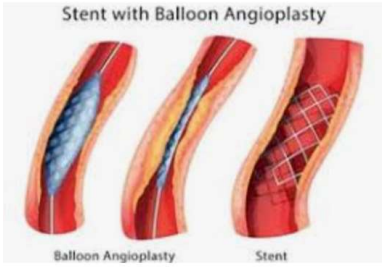

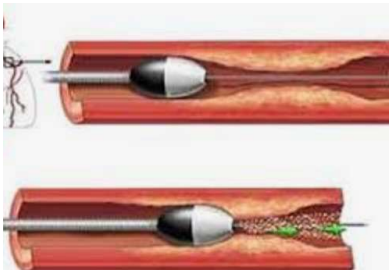

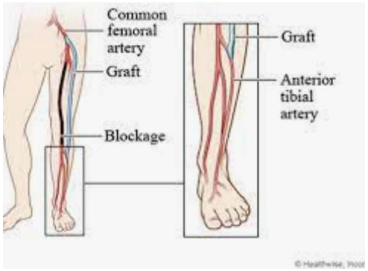

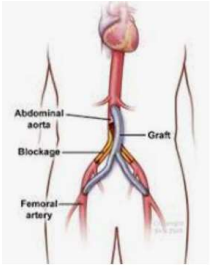

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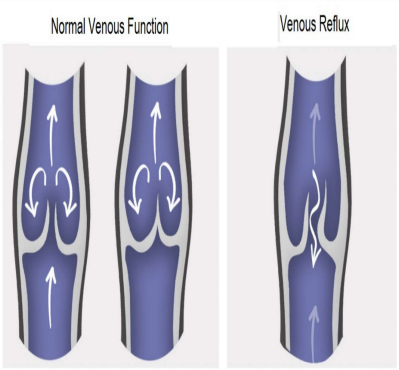
Venous Insufficiency

- Estimated over 2.5 million Americans experience chronic venous disease
- Approximately 20% experience venous stasis ulcer
- VLU recurrence rate up to 70%
- Valvular incompetence



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Risk Factors

- Trauma (crush, surgery)
- DVT
- Recurrent infection
- Lifestyle
- Congenital venous abnormality
- Limited mobility (impaired calf pump)
- HF
- Family history
- Pregnancy
- Age
- Mixed disease
- Where sleeping
- OSA
- Obesity

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VLU

- H&P
- Swelling/edema
- Varicosities
- Hyperpigmentation
- Lipodermatosclerosis
- Location-medial malleolus, lower part of calf
- Flat, irregularly shaped
- Drainage
- Atrophie blanche
- Scarring
- Pain
- Skin dermatitis

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Diagnostic test

- CEAP classification
- Venous duplex
- Varicose vein study
- Venogram
- ABI

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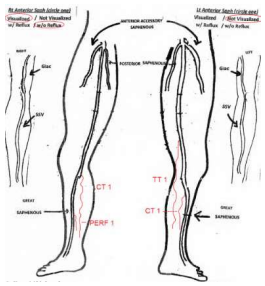
Varicose Vein Study

- Long study, ~90 minutes
- Shows deep, superficial, perforator, and tributary vein
- Evaluates the reflux time and vein diameter



Segment	Right								
	Spont	Ph	Aug	Compr	Reflux Time	Reflux	Thromb	SI	D-AP (cm)
CFV	Normal	Phasic	Normal	Complete	3.47	Present	None	Normal (Patent)	
DFV	Normal	Phasic	Normal	Complete		Absent	None	Normal (Patent)	
FV Prox	Normal	Phasic	Normal	Complete	0.356	Present	None	Normal (Patent)	
FV Mid	Normal	Phasic	Normal	Complete		Absent	None	Normal (Patent)	
FV Dist	Normal	Phasic	Normal	Complete		Absent	None	Normal (Patent)	
POPV	Normal	Phasic	Normal	Complete	0.38	Present	None	Normal (Patent)	
PTV	None	None	Decreased	Partial	0.348	Present	Chronic	Partially Occluding	
PERV	None	None	Decreased	Partial	0	Absent	Chronic	Partially Occluding	
SFJ	Normal	Phasic	Normal	Complete	4.33	Present	None	Normal (Patent)	1.78
GSV - Mid Thigh					0.54	Present	None	Normal (Patent)	0.33
GSV - Dist Thigh					4.77	Present	None	Normal (Patent)	1.09
GSV - Prox Calf					3.74	Present	None	Normal (Patent)	0.89
GSV - Mid Calf					1.94	Present	None	Normal (Patent)	0.41
GSV - Ankle					1.32	Present	None	Normal (Patent)	0.45
Anterior Saph					0	Absent	None	Normal (Patent)	0.33
Tributaries Thigh 1					2.17	Present	None	Normal (Patent)	2.12
Giacomini				Complete	0	Absent	None	Normal (Patent)	0.44
SSV - Prox Calf				Complete	0	Absent	None	Normal (Patent)	0.27
SSV - Mid Calf				Complete	0	Absent	None	Normal (Patent)	0.5
SSV - Ankle				Complete	0.392	Present	None	Normal (Patent)	0.27
Tributaries Calf 1				Complete	1.32	Present	None	Normal (Patent)	0.35
Tributaries Calf 2				Complete	3.04	Present	None	Normal (Patent)	1.28
Tributaries Calf 3				Partial	1.53	Present	Chronic	Partially Occluding	0.54

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Intervention

Non-surgical

- Compression
- Exercise
- Pumps
- Referral to PT or lymphedema therapy
- Sclerotherapy

Surgical

- Vein ablation
  - Radiofrequency
  - Laser
- Medical glue
- Stab phlebectomies
- Stents

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Case Study

- PmHx: HLD, statin intolerance, tobacco use of 1 ppd for 40+ years, history of trauma to RLE including transection of right popliteal artery
- Surg Hx: Right knee replacement (multiple revisions), pelvic fixation with right femur and ankle ORIF, right SFA-popliteal bypass with contralateral GSV and fasciotomies

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Case Study

Subjective:
- RLE has always felt "cool" since his trauma with chronic pain
- Lacks sensation in foot since trauma and surgeries
- Unable to tell if walking distance decreased
- Leg swelling worsening, right worse than left
- Has tried compression but too painful
- Leg elevation hurts
- Sleeping in chair with legs dependently down

Objective:
- Unable to palpate pedal pulses
- RLE cool to touch
- Significant swelling to BLE
- Wound to right pre-tibial area that is irregularly shaped, superficial, wound bed mix of yellow slough/fat necrosis, gangrene, and red tissue
- Peri-wound skin red and violaceous with scattered reticular/telangiectasia veins
- Pack of cigarettes hanging out of shirt pocket
- Contrast allergy
- Compliance

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Case Study

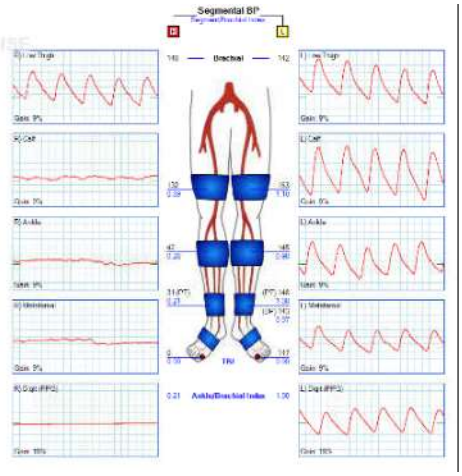
Pressures/Indices

	Right	Indices		Left	Indices
Brachial	148mmHg		Brachial	142mmHg	
Low Thigh	132mmHg	0.89	Low Thigh	163mmHg	1.10
Calf	42mmHg	0.28	Calf	145mmHg	0.98
Ankle(PT)	31mmHg	0.21	Ankle(PT)	148mmHg	1.00
Ankle(DP)	0mmHg	0.00	Ankle(DP)	143mmHg	0.97
Digit	0mmHg	0.00	Digit	147mmHg	0.99
ABI	0.21		ABI	1.00	

Conclusion
1. Distal femoral-popliteal bypass graft with at least 50% of the proximal graft without a definitely visualized distal anastomosis, possibly occluded.
2. Occlusion of the popliteal artery, the anterior tibial artery, and non-visualization of the peroneal concerning for occlusion.
3. Monophasic waveform in the distal posterior tibial artery suggestive of significant upstream narrowing.

Conclusion
No sonographic evidence of DVT in the right or left lower extremity.
The left greater saphenous vein is absent consistent with prior surgical harvesting.
The right greater saphenous vein is dilated measuring a maximal diameter of 11.7 mm and demonstrating prolonged axial reflux.
The left small saphenous vein measures a maximal diameter of 8.1 mm and demonstrates prolonged axial reflux.
Incompetent perforating branch vessel about the left ankle with prolonged axial reflux.

Deep venous insufficiency is noted in the left common femoral vein along with the bilateral femoral and popliteal veins.



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Case Study

Treatment:
- Get wound bed dry until arterial flow can be improved
- No compression until arterial flow can be improved
- Passive warming
- Work on smoking cessation

- RLE angiogram-showed occlusion of the SFA and popliteal arteries, unable to visualize anterior and peroneal arteries. 1 vessel runoff via PT artery
- Vein mapping for bypass options
- Right femoral to proximal posterior tibial artery bypass with reverse GSV, along with excisional I&D of the wound

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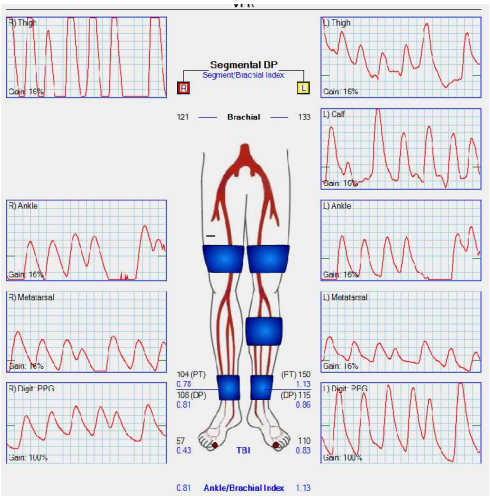
Case Study



- Patient stated his leg has never felt as warm as it did post bypass
- Overall pain starting to reduce
- Able to sleep in bed
- Improvement in leg swelling
- Walking more
- Wound slowly healing
- Down to less than ½ ppd
- Indifferent on compression use

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Case Study

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