
SPECTRUM
VASCULAR & GENERAL SURGERY
FARRER PARK
HOSPITAL
FRONTLINE
VASCULAR CARE
2026
Peripheral Arterial Disease:
Diagnosis and Management
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COMFORT · FAIRNESS · VALUE

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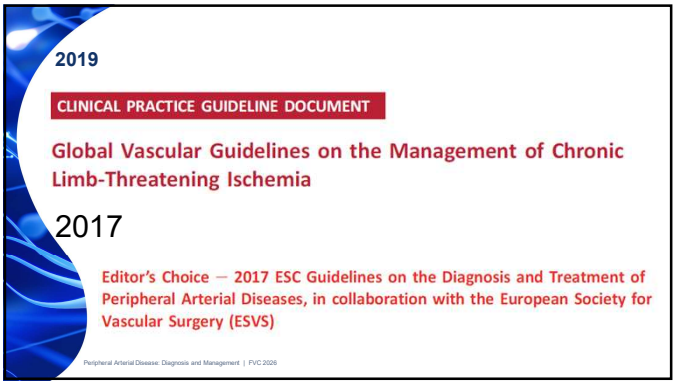
2019
CLINICAL PRACTICE GUIDELINE DOCUMENT
Global Vascular Guidelines on the Management of Chronic Limb-Threatening Ischemia
2017
Editor's Choice – 2017 ESC Guidelines on the Diagnosis and Treatment of Peripheral Arterial Diseases, in collaboration with the European Society for Vascular Surgery (ESVS)

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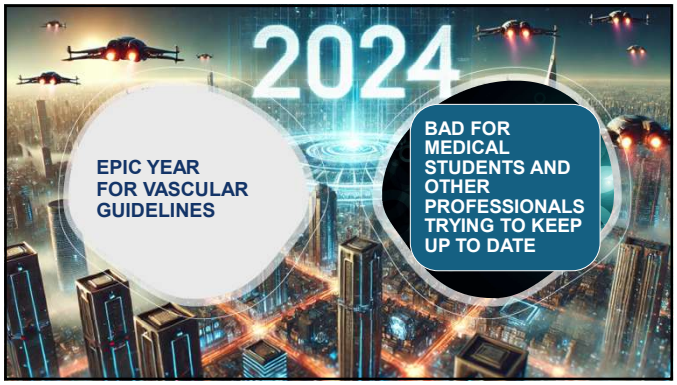
2024
EPIC YEAR FOR VASCULAR GUIDELINES
BAD FOR MEDICAL STUDENTS AND OTHER PROFESSIONALS TRYING TO KEEP UP TO DATE

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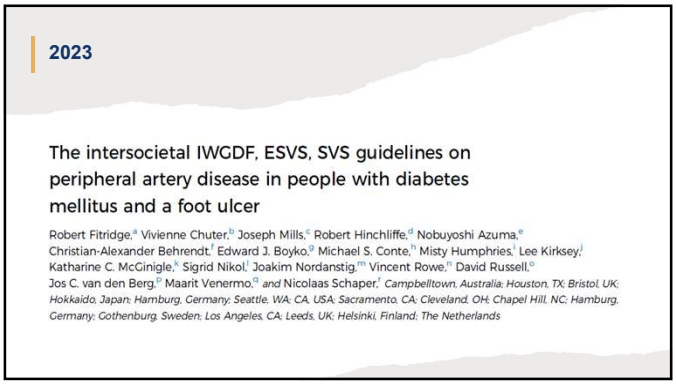
2023
The intersocietal IWGDF, ESVS, SVS guidelines on peripheral artery disease in people with diabetes mellitus and a foot ulcer

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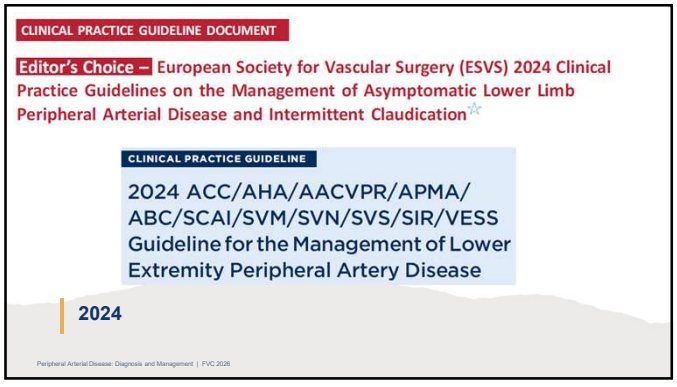
CLINICAL PRACTICE GUIDELINE DOCUMENT
Editor's Choice – European Society for Vascular Surgery (ESVS) 2024 Clinical Practice Guidelines on the Management of Asymptomatic Lower Limb Peripheral Arterial Disease and Intermittent Claudication
CLINICAL PRACTICE GUIDELINE
2024 ACC/AHA/AACVPR/APMA/ABC/SCAI/SVM/SVN/SVS/SIR/VESS Guideline for the Management of Lower Extremity Peripheral Artery Disease
2024

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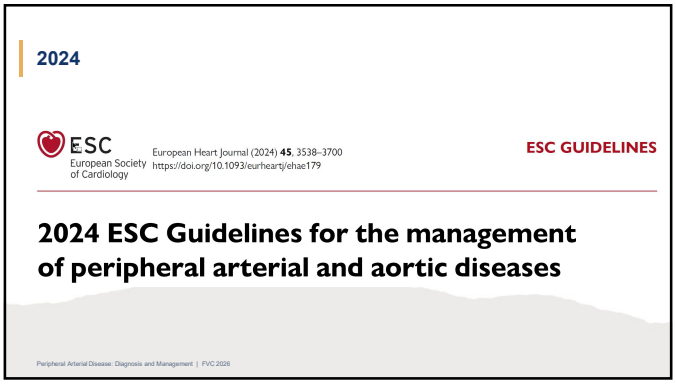
2024
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European Society of Cardiology
ESC GUIDELINES
2024 ESC Guidelines for the management of peripheral arterial and aortic diseases

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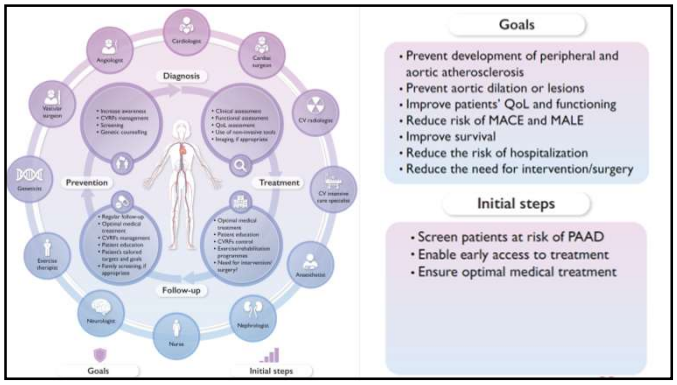
Diagnosis
Prevention
Treatment
Follow-up
Goals
Initial steps
Goals
• Prevent development of peripheral and aortic atherosclerosis
• Prevent aortic dilation or lesions
• Improve patients' QoL and functioning
• Reduce risk of MACE and MALE
• Improve survival
• Reduce the risk of hospitalization
• Reduce the need for intervention/surgery
Initial steps
• Screen patients at risk of PAAD
• Enable early access to treatment
• Ensure optimal medical treatment

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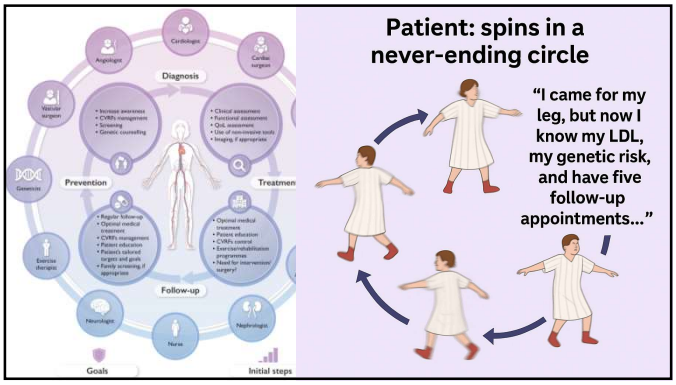
Diagnosis
Prevention
Treatment
Follow-up
Goals
Initial steps
Patient: spins in a never-ending circle
"I came for my leg, but now I know my LDL, my genetic risk, and have five follow-up appointments..."

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HANDOUTS ON WEBSITE
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Peripheral Arterial Disease: Diagnosis and Management | FVC 2026

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PERIPHERAL ARTERIAL DISEASE
Infrainguinal
Anterior View
Posterior View
Below-the-Knee

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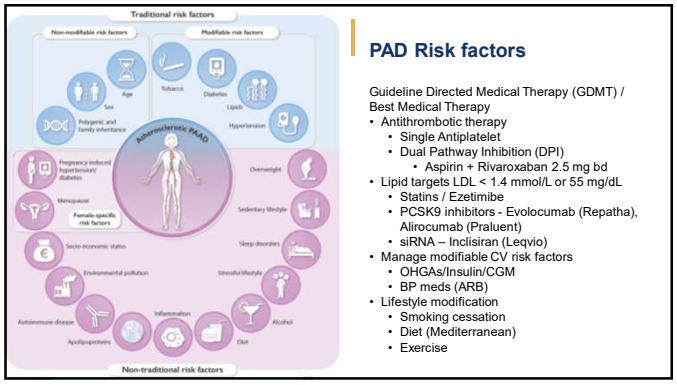
Traditional risk factors
Non-modifiable risk factors
Modifiable risk factors
Atherosclerotic PAAD
Non-traditional risk factors
PAD Risk factors
Guideline Directed Medical Therapy (GDMT) / Best Medical Therapy
• Antithrombotic therapy
• Single Antiplatelet
• Dual Pathway Inhibition (DPI)
• Aspirin + Rivaroxaban 2.5 mg bd
• Lipid targets LDL < 1.4 mmol/L or 55 mg/dL
• Statins / Ezetimibe
• PCSK9 inhibitors - Evolocumab (Repatha), Alirocumab (Praluent)
• siRNA – Inclisiran (Leqvio)
• Manage modifiable CV risk factors
• OHGAs/Insulin/CGM
• BP meds (ARB)
• Lifestyle modification
• Smoking cessation
• Diet (Mediterranean)
• Exercise

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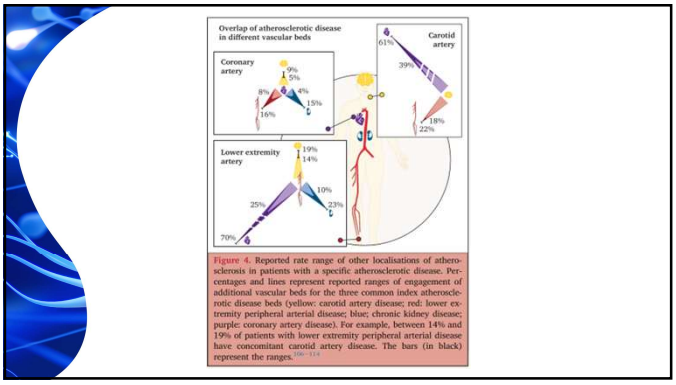
Overlap of atherosclerotic disease in different vascular beds
Coronary artery
Carotid artery
Lower extremity artery
Figure 4. Reported rate range of other localisations of atherosclerosis in patients with a specific atherosclerotic disease. Percentages and lines represent reported ranges of engagement of additional vascular beds for the three common index atherosclerotic disease beds (yellow: carotid artery disease; red: lower extremity peripheral arterial disease; blue; chronic kidney disease; purple: coronary artery disease). For example, between 14% and 19% of patients with lower extremity peripheral arterial disease have concomitant carotid artery disease. The bars (in black) represent the ranges.

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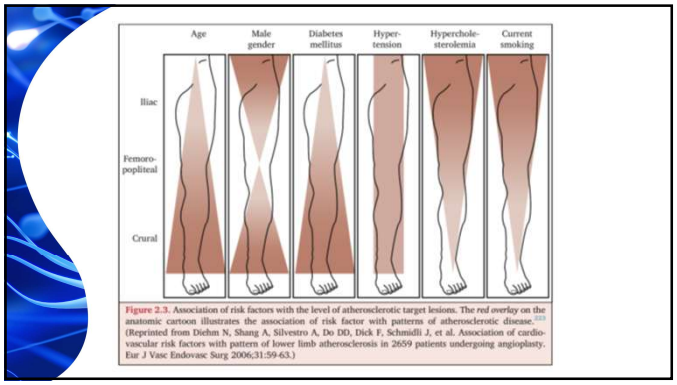

Figure 2.3. Association of risk factors with the level of atherosclerotic target lesions. The *red overlay* on the anatomic cartoon illustrates the association of risk factor with patterns of atherosclerotic disease.[223] (Reprinted from Diehm N, Shang A, Silvestro A, Do DD, Dick F, Schmidli J, et al. Association of cardiovascular risk factors with pattern of lower limb atherosclerosis in 2659 patients undergoing angioplasty. Eur J Vasc Endovasc Surg 2006;31:59-63.)

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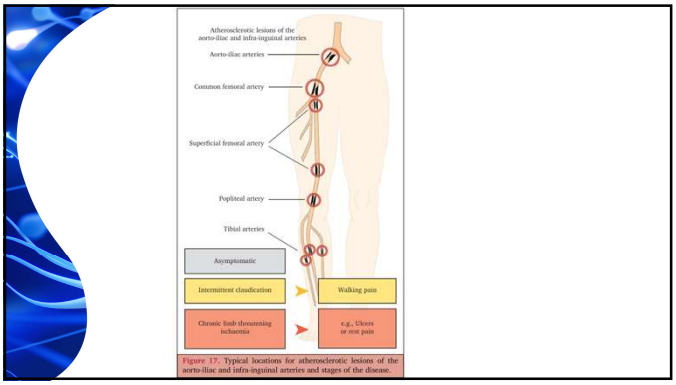

Figure 17. Typical locations for atherosclerotic lesions of the aorto-iliac and infra-inguinal arteries and stages of the disease.

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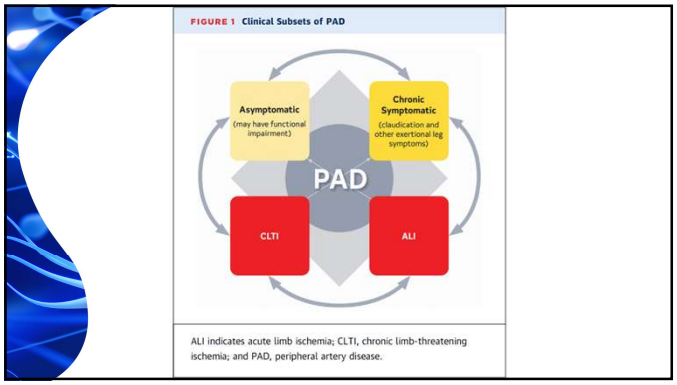

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Asymptomatic PAD

- May self-limit activity to remain below ischemic threshold to avoid leg pain.
- Majority of asymptomatic PAD develop symptoms during an objective walking test despite not reporting any exertional leg symptoms
- Functional impairment comparable to patients with claudication (chronic symptomatic)
- Associated with increased risk of major adverse cardiac events, including mortality

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What is intermittent claudication?

Table 4. Classical symptoms of intermittent claudication, modified from Rose.[81]

Exertional leg pain that:
Does not begin at rest
Involves the calf, thigh and or buttock
Causes the patient to reduce their walking speed or stop walking
Resolves within 10 minutes of rest

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HISTORY

Family history of CVD (coronary artery disease, cerebrovascular disease, aortic aneurysm, LEAD), and premature CVD (fatal or non-fatal CVD event or/and established diagnosis of CVD in first degree male relatives before 55 years or female relatives before 65 years).	Abdominal pain, particularly if related to eating and associated with weight loss
Personal history of: • Hypertension • Diabetes • Dyslipidaemia • Smoking (present and/or past), passive smoking exposure • Prior CVD • Chronic kidney disease • Sedentary life • Dietary habits • History of cancer radiation therapy • Psycho-social factors	Walking impairment/claudication: • type: fatigue, aching, cramping, discomfort, burning • location: buttock, thigh, calf, or foot • timing: triggered by exercise, uphill rather than downhill, quickly relieved with rest; chronic • distance
Transient or permanent neurological symptoms	Lower limb pain (including foot) at rest, and evolution at upright or recumbent position
Arm exertion pain, particularly if associated with dizziness or vertigo	Poorly healing wounds of the extremities
Symptoms suggesting angina, dyspnoea	Physical activity assessment: • Functional capacity and causes of impairment
	Erectile dysfunction

CVD = cardiovascular disease; LEAD = lower extremity artery disease.

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TABLE 7 Alternative Diagnosis for Leg Pain or Claudication Not Related to PAD (Normal Physiological Testing)

Condition	Location	Characteristic	Effect of Exercise	Effect of Rest	Effect of Position	Other Characteristics
Hip arthritis	Lateral hip, thigh	Aching discomfort	After variable degree of exercise	Not quickly relieved	Improved when not bearing weight	Symptoms variable; history of degenerative arthritis
Foot/ankle arthritis	Ankle, foot, arch	Aching pain	After variable degree of exercise; may also be present at rest	Not quickly relieved	May be relieved by not bearing weight	Symptoms variable
Nerve root compression	Radiates down leg	Sharp lancinating pain	Induced by sitting, standing, or walking (variable)	Often present at rest	Improved by change in position	History of back problems worse with sitting; relief when supine or standing
Spinal stenosis (eg, degenerative disc disease or tumor)	Often bilateral buttocks, posterior leg	Pain and weakness	May mimic claudication	Variable relief but can take a long time to recover	Relief by lumbar spine flexion	Worse with standing and extending spine
Symptomatic popliteal (Baker's) cyst	Behind knee, down calf	Swelling, tenderness	With exercise	Also present at rest	None	Not intermittent
Venous claudication	Entire leg, worse in calf	Tight, bursting pain	After walking	Subsides slowly	Relief speeded by leg elevation	History of iliofemoral deep vein thrombosis edema; signs of venous stasis
Chronic compartment syndrome	Calf muscles	Tight, bursting pain	After strenuous exercise (jogging)	Subsides very slowly	Relief with rest	Typically heavy muscled athletes

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Table 5. Potential differential diagnostic alternatives causing lower limb pain, that may either present with intermittent claudication symptoms or be misclassified as intermittent claudication.

Condition	Location	Characteristics	Effect of exercise	Effect of rest	Effect of position
Baker's cyst	Behind knee	Swelling behind knee and distally. When ruptured, tenderness and calf pain	Worsening of symptoms	None	None
Deep vein thrombosis and venous claudication caused by chronic venous obstruction	Entire lower limb	Ipsilateral oedema, tightness, worse in calf	Worsening of symptoms	Subsides slowly	Relief by elevation
Thromboangiitis obliterans – Buerger's disease	Often bilateral	Young age smokers, pain (most commonly) located in the foot	Worsening of symptoms	Relief with rest	Worse with elevation
Spinal cord stenosis	Often bilateral buttock and lower limbs	Pain, weakness, numbness	May mimic claudication	Variable relief and may take a long time to recover	Relief with lumbar spine flexion
Nerve root compression	Radiates down along the posterior aspect of the lower limb	Sharp pain	Induced mainly by standing and walking	Present at rest and on sitting	Improved by change in position
Hip arthritis	Ipsilateral lower limb – thigh	Pain and discomfort	Worse with exercise	Relief but it takes time	Less symptoms when not weight bearing
Foot or ankle arthritis	Ankle or foot	Pain and discomfort	Worse with exercise	Relief but it takes time	Fewer symptoms when not weight bearing or related to activity level
Chronic exertional compartment syndrome	Lower limb	Pain, swelling, disability	Worse with exercise	Pain even at rest, relief takes time	Worsening or improvement according to position
Popliteal artery entrapment syndrome	Lower limb	Cold feet after exercise Tingling or burning in calf Numbness in the calf area	Worse with exercise	Relief with rest	Flexion of foot results in worsening of symptoms
Cystic adventitial degeneration of the popliteal artery	Calf, always unilateral	Exercise induced pain and discomfort, most common in younger patients	Worse with exercise	Relief with rest	None
Lymphangitis or cellulitis	Entire lower limb, mostly in calf	Ipsilateral pitting oedema, worse in calf	Heaviness	None	None

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Table 2.2 • Rutherford classification of the severity of PAD

Grade	Category	Description
0	0	Asymptomatic
I	1	Mild claudication
I	2	Moderate claudication
I	3	Severe claudication
II	4	Ischaemic rest pain
II	5	Minor tissue loss
III	6	Major tissue loss

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Rutherford classification for chronic limb ischaemia 1997

is preferred. Walking for 5 minutes at a treadmill speed of 2 mph (176 ft/min) is roughly equivalent to walking three blocks (900 ft) at average speed.

Convert units

Length

900 = 274.32

Foot Meter

FORMULA for an approximate result, divide the length value by 3.2808399

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Table 8. The Fontaine and the revised Rutherford peripheral arterial disease classifications.

Fontaine		Rutherford			
Class	Symptoms	Grade	Category	Symptoms	Objective criteria
Stage I	Asymptomatic	0	0	Asymptomatic	Normal treadmill or reactive hyperaemia test
Stage II	Claudication pain in limb IIA: Claudication at a distance ≥ 200 m	I	1	Mild claudication	Completes treadmill exercise; AP after exercise > 50 mmHg but at least 20 mmHg lower than resting value
	IIB: Claudication at a distance < 200 m		2	Moderate claudication	Between categories 1 and 3
			3	Severe claudication	Cannot complete standard treadmill exercise, and AP after exercise < 50 mmHg
Stage III	Rest pain, mostly in the feet	II	4	Ischaemic rest pain	Resting AP < 40 mmHg, flat or barely pulsatile ankle or metatarsal PVR; TP <30 mmHg
Stage IV	Ulceration and or gangrene of the limb	III	5	Minor tissue loss – non-healing ulcer, focal gangrene with diffuse pedal ischaemia	Resting AP < 60 mmHg, ankle or metatarsal PVR flat or barely pulsatile; TP < 40 mmHg
			6	Major tissue loss – extending above transmetatarsal level, functional foot no longer salvageable	Same as category 5

AP = ankle pressure; PVR = pulse volume recordings; TP = toe pressure.

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Physical examination

- T – active infection?
- BP
- HR – ? AF ? PPM/AICD/CRTD
- LL
  - Tissue loss: Ulcer, Gangrene (wet/dry), New amputation wound
  - Cold, Trophic skin changes
  - Mottling / Paraesthesia / Paralysis
- Peripheral pulses
  - LL
  - UL
- AAA
- Renal bruit
- Carotid pulses/bruit

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	Perf ese
1. Wash your hands	
2. Introduce yourself to the patient and explain what you are about to do	
3. Palpate carotid pulse for rate and rhythm	
4. Listen for carotid bruit	
5. Check bilateral arm blood pressure	
6. Inspect upper limbs for muscle atrophy, tissue loss, embolic phenomenon, capillary refill	
7. Palpate bilateral brachial and radial pulses	
8. Cardiac auscultation for arrhythmias and murmurs	
9. Expose abdomen	
10. Palpate for pulsatile abdominal mass	
11. Auscultate abdomen for renal and other bruits	
12. Inspect lower limbs for gangrene/ tissue loss/ pallor	
13. Palpate feet for difference in skin temperature	
14. Elevate limb and check for elevation pallor and dependent rubor	
15. Palpate for bilateral femoral, popliteal, posterior tibial and dorsalis pedis pulses	
16. Ascultate femoral arteries for bruits	
17. Suggest using Doppler to check for pulses and ABI	

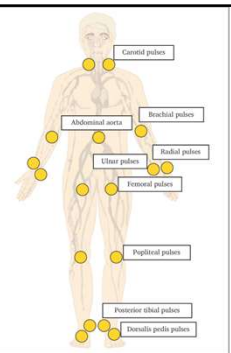

Figure 5. Pulse examination of patients with lower extremity peripheral arterial disease.

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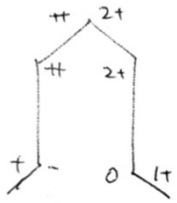
Rating of LL extremity pulses?



Rating of Pulses	Clinical Finding
0	Absent
1	Diminished
2	Normal
3	Bounding

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Investigations

- FBC – infection, anaemia, ?polycythaemia
- RP – renal impairment
- LFT / Lipid panel
- PT/PTT GXM → transfusion required?
- CXR
- ECG, CE/TnT
- TTE
- ABPI/TBI
- Toe pressure
- US Arterial Duplex LL
  - Confirm diagnosis, determine anatomical location and degree of stenosis
  - Routine surveillance after lower limb bypass, stenting
- US LL / UL vein mapping
- CT peripheral angiogram for aortoiliac / CFA disease
- MRA – beware nephrogenic systemic fibrosis in CRF patients
- Laser Doppler/TCOM
- ? XR/MRI tro OM

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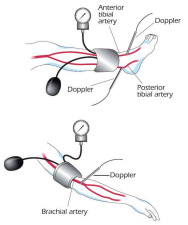
ABPI

2. How to measure the ABI?
In supine position, with cuff placed just above the ankle, avoiding wounded zones. After a 5–10 minute rest, the SBP is measured by a Doppler probe (5–10 MHz) on the posterior and the anterior tibial (or dorsal pedis) arteries of each foot and on the brachial artery of each arm. Automated BP cuffs are mostly not valid for ankle pressure and may display overestimated results in case of low ankle pressure. The ABI of each leg is calculated by dividing the highest ankle SBP by the highest arm SBP.



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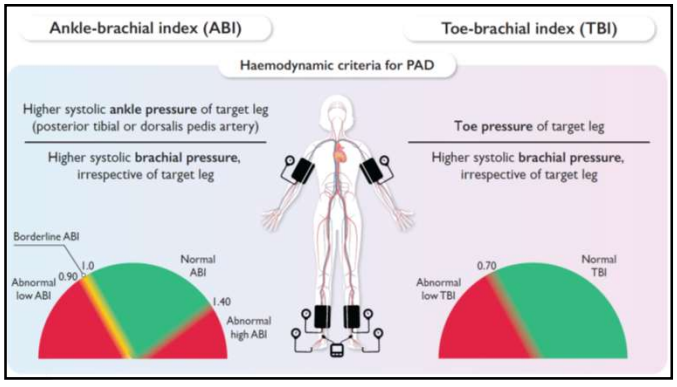

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MANAGEMENT

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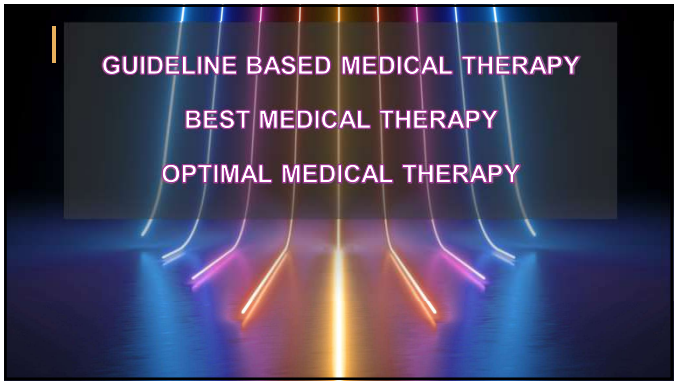

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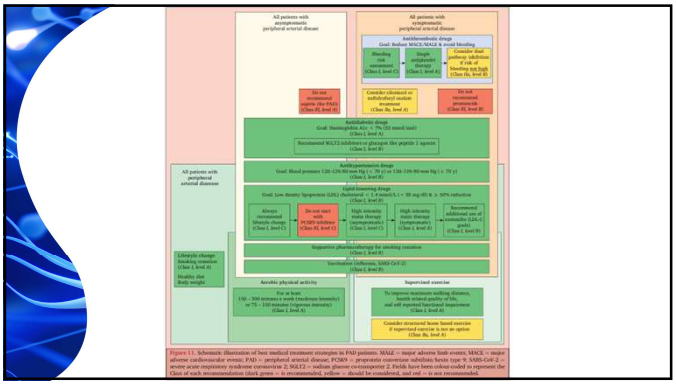

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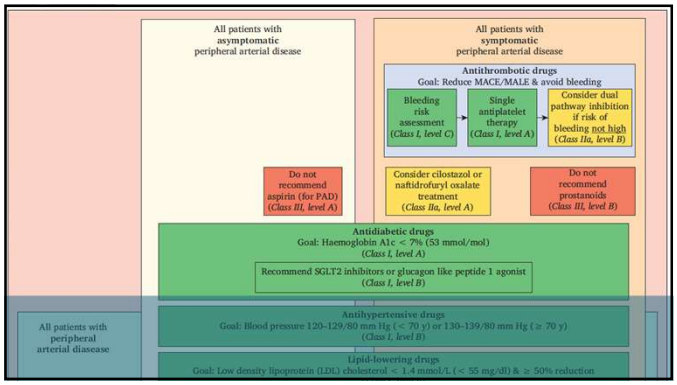

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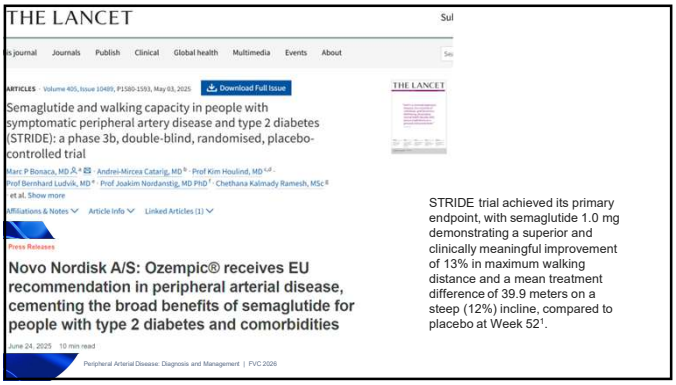

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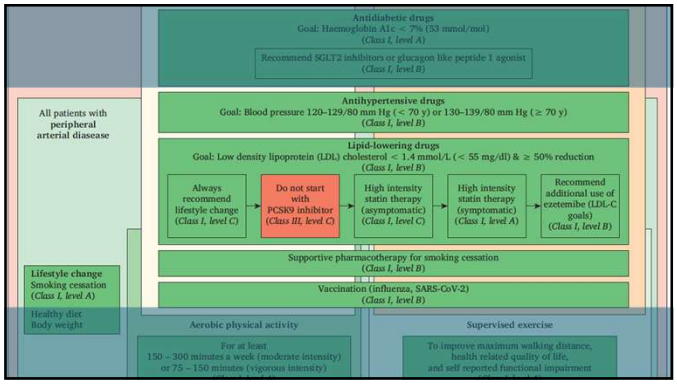

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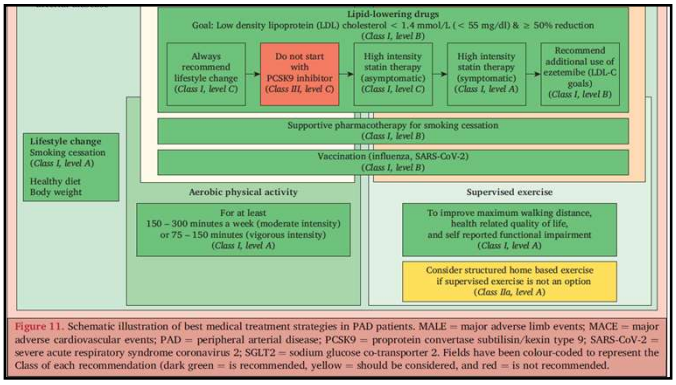

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Revascularisation for Asymptomatic PAD?

COR	LOE	RECOMMENDATIONS
2a	B-NR	1. In patients with asymptomatic PAD, it is reasonable to perform revascularization procedures (endovascular or surgical) to reconstruct diseased arteries if needed for the safety, feasibility, or effectiveness of other procedures (eg, transfemoral aortic valve replacement, mechanical circulatory support, endovascular aortic aneurysm repair).[1-8]
3: Harm	B-NR	2. In patients with asymptomatic PAD, revascularization procedures (endovascular or surgical) should not be performed solely to prevent progression of disease.[9-16]

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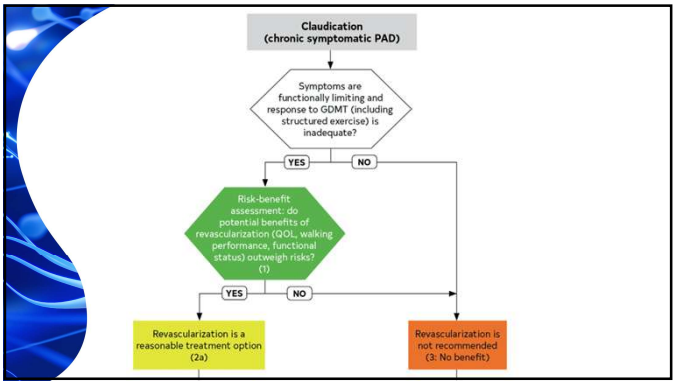

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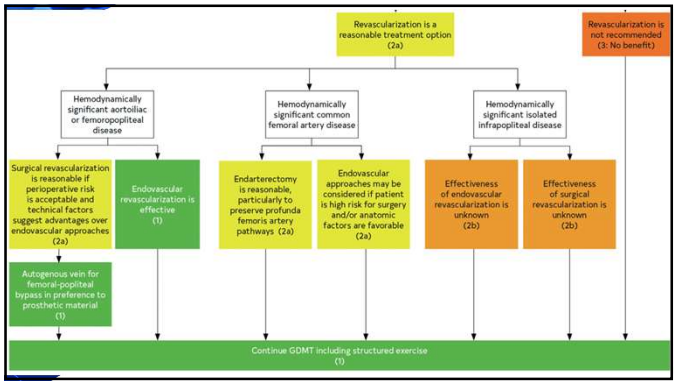

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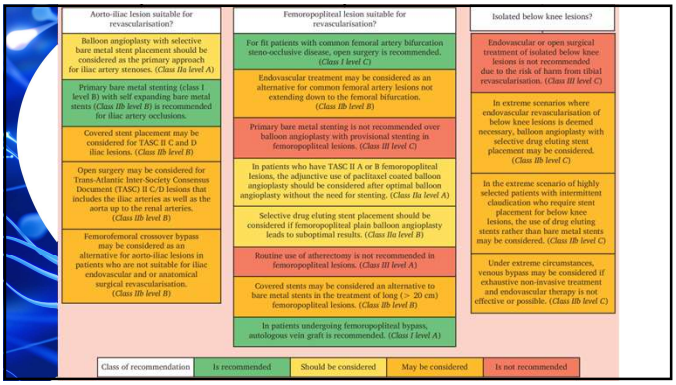

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CLTI
CHRONIC LIMB THREATENING ISCHAEMIA

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CRITICAL LIMB ISCHAEMIA

- Critical limb ischaemia
  - >= 2 weeks duration
  - Ischemic rest pain, ulceration or gangrene
  - AND
    - Ankle pressure < 50mmHg or toe pressure < 30mmHg
    - ABPI < 0.40
    - $TcPO_2$ < 30 mm
- Fails to encompass the full spectrum of patients who are evaluated and treated in modern practice

OUTDATED

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CHRONIC LIMB THREATENING ISCHAEMIA

- CLTI = clinical syndrome / wide spectrum of disease
  - >= 2 weeks duration
  - Ischemic rest pain, ulceration or gangrene
  - Objectively documented PAD on haemodynamic testing
- Stage severity of limb threat → risk of major amputation using Wounds, Ischemia, and foot Infection (WIfI) classification

Very low = VL = clinical stage 1
Low = L = clinical stage 2
Moderate = M = clinical stage 3
High = H = clinical stage 4
Clinical stage 5 would signify an unsalvageable foot

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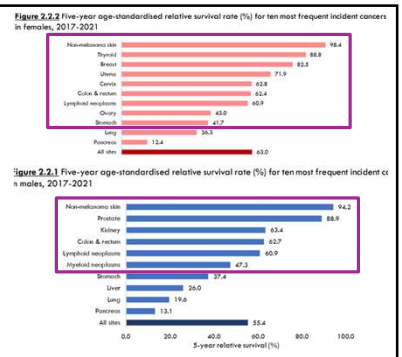
CLTI "Arterial cancer"

- End-stage manifestation of systemic atherosclerosis
- Mortality
  - 1 year 24%
  - 5 year 60% ~ 40% survival
  - Stage 3 Colon cancer 28% ~ 72% survival

Charts extracted from Singapore Cancer Registry Annual Report 2021
Published August 2023



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Component	Score	Description
W (Wound)	0	No ulcer (ischaemic rest pain)
	1	Small, shallow ulcer on distal leg or foot without gangrene
	2	Deeper ulcer with exposed bone, joint or tendon ± gangrenous changes limited to toes
	3	Extensive deep ulcer; full thickness heel ulcer ± calcaneal involvement ± extensive gangrene

I (Ischaemia)		ABI	Ankle pressure (mmHg)	Toe pressure or $TcPO_2$
	0	≥0.80	> 100	≥60
	1	0.60–0.79	70–100	40–59
	2	0.40–0.59	50–70	30–39
	3	<0.40	<50	<30

fI (Foot Infection)		
	0	No symptoms/signs of infection
	1	Local infection involving only skin and subcutaneous tissue
	2	Local infection involving deeper than skin/subcutaneous tissue
	3	Systemic inflammatory response syndrome

Estimate risk of amputation at 1 year for each combination*

	Ischaemia – 0				Ischaemia – 1				Ischaemia – 2				Ischaemia – 3			
W-0	VL	VL	L	M	VL	L	M	H	L	L	M	M	L	M	M	H
W-1	VL	VL	L	M	VL	L	M	H	L	M	H	H	M	M	H	H
W-2	L	L	M	H	M	M	H	H	M	H	H	H	H	H	H	H
W-3	M	M	H	H	H	H	H	H	H	H	H	H	H	H	H	H
	fI-0	fI-1	fI-2	fI-3	fI-0	fI-1	fI-2	fI-3	fI-0	fI-1	fI-2	fI-3	fI-0	fI-1	fI-2	fI-3

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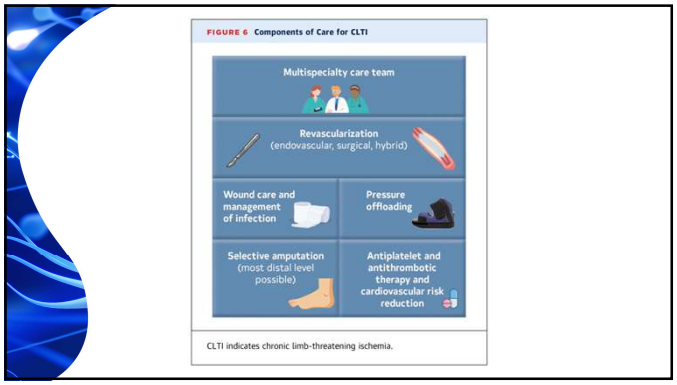

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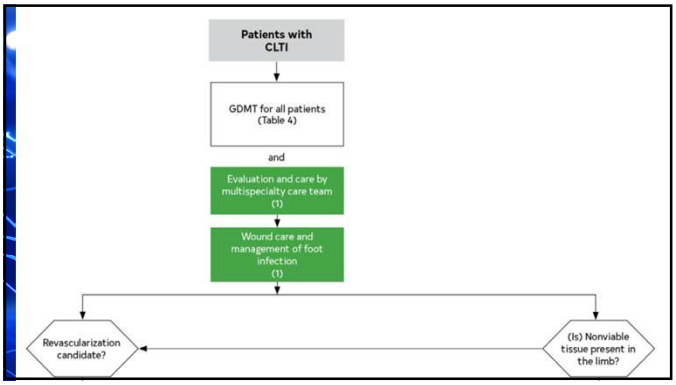

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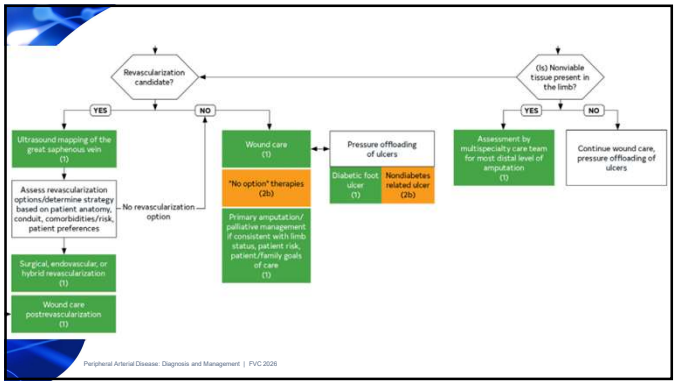

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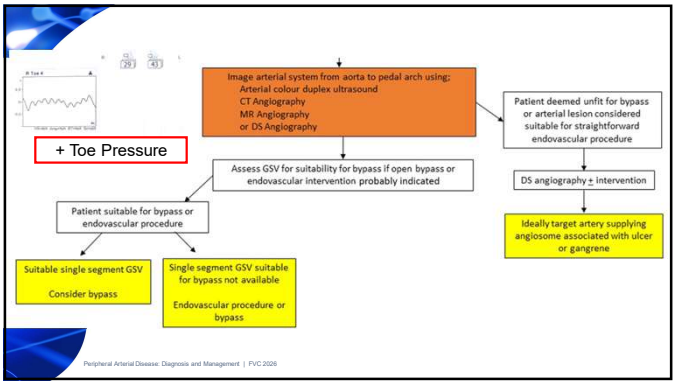

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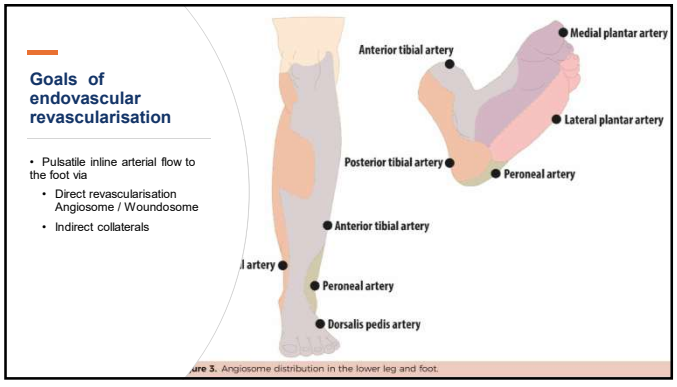

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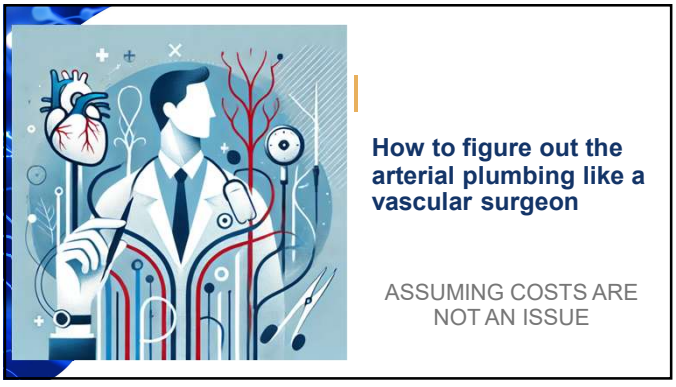

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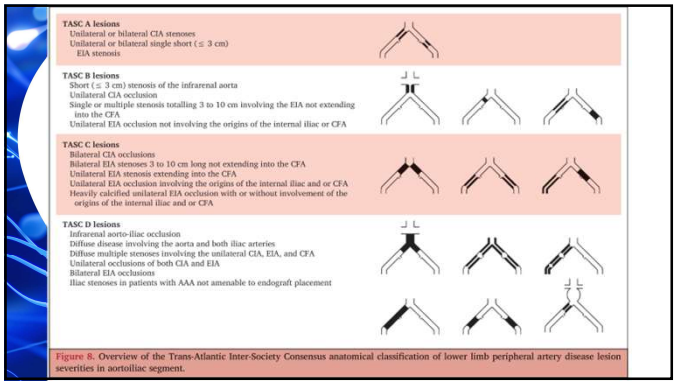

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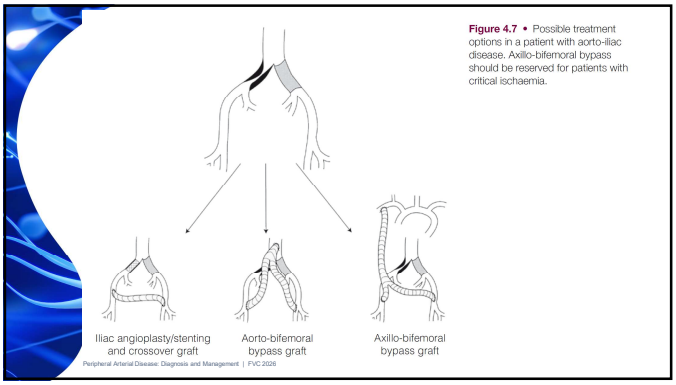

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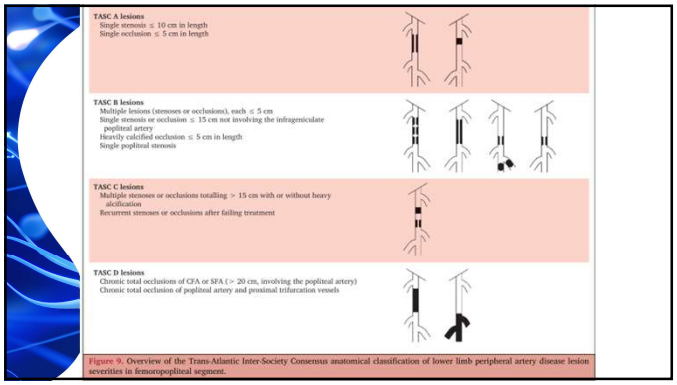

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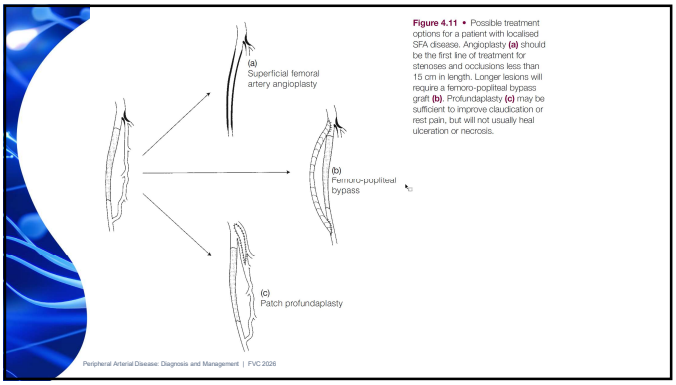

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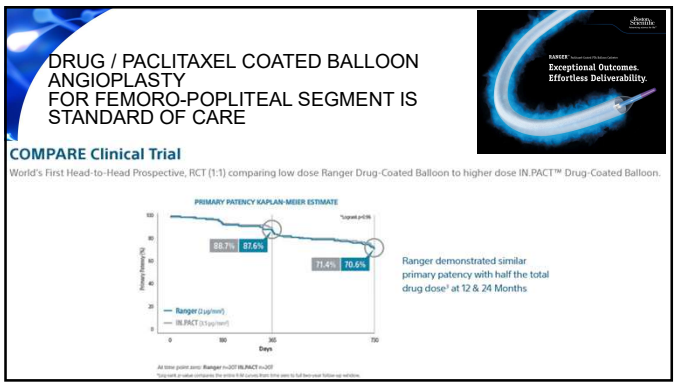

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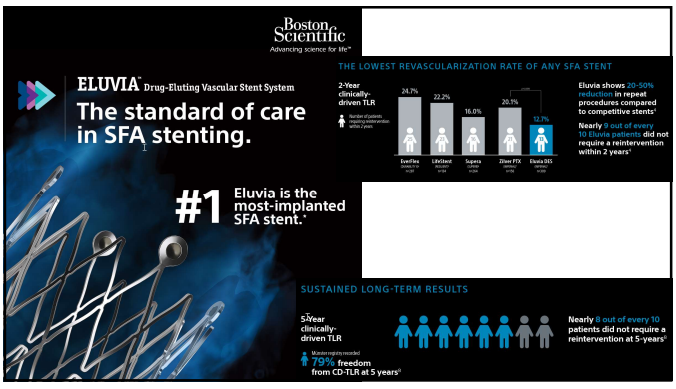

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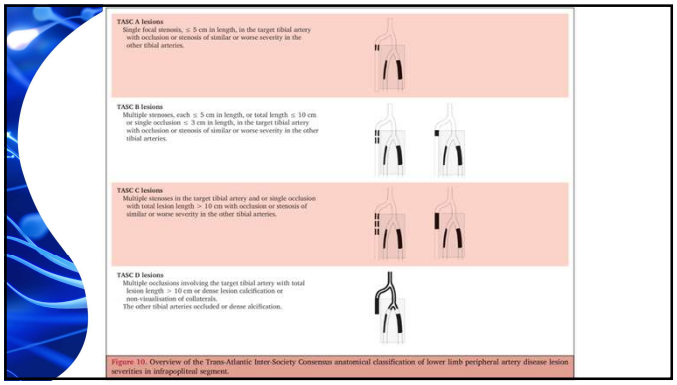

Figure 10. Overview of the Trans-Atlantic Inter-Society Consensus anatomical classification of lower limb peripheral artery disease lesion severities in infrapopliteal segment.

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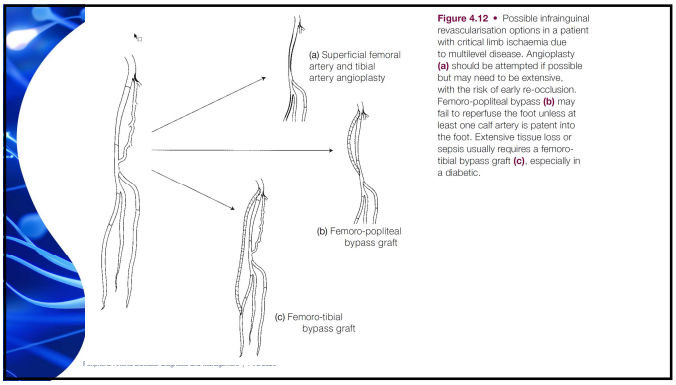

Figure 4.12 • Possible infrainguinal revascularisation options in a patient with critical limb ischaemia due to multilevel disease. Angioplasty **(a)** should be attempted if possible but may need to be extensive, with the risk of early re-occlusion. Femoro-popliteal bypass **(b)** may fail to reperfuse the foot unless at least one calf artery is patent into the foot. Extensive tissue loss or sepsis usually requires a femoro-tibial bypass graft **(c)**, especially in a diabetic.

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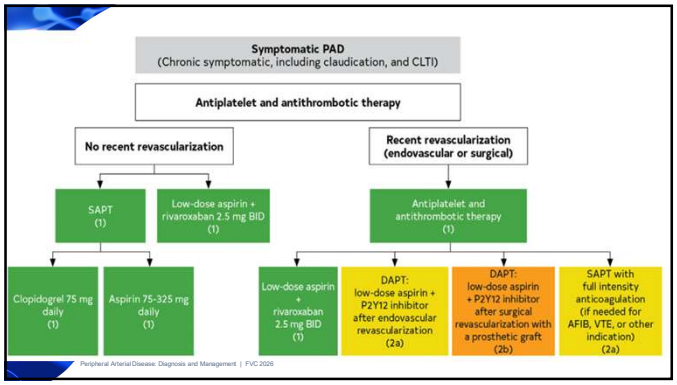

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No Option CLTI

Recommendations for Approach to the "No Option" Patient With CLTI
Referenced studies that support the recommendations are summarized in the Online Data Supplement.

COR	LOE	RECOMMENDATIONS
2b	B-R	1. In patients with CLTI for whom revascularization is not an option and a lack of outflow to the foot is observed, the usefulness of prostanoids is uncertain.[1-3]
2b	B-NR	2. In patients with CLTI for whom revascularization is not an option, arterial intermittent pneumatic compression devices may be considered to augment wound healing or ameliorate ischemic rest pain.[4-7]
2b	B-NR	3. In patients with CLTI for whom arterial revascularization is not an option and a lack of outflow to the foot is observed, venous arterialization may be considered for limb preservation.[8-12]

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COMPLICATIONS OF BYPASS

- Early
  - Bleeding
  - Thrombosis
  - Wound infection ~ 15-20% groin infection
  - Swelling (Ischaemia-Reperfusion / DVT)
- Late
  - Graft thrombosis/failure
  - Pseudoaneurysm
  - Graft infection
- Graft failure
  - Early (After 1 month) – commonly technical failure
  - Mid term (after 1 year) – Neointimal hyperplasia causing stenosis
  - Late (2-5 years) – atheromatous disease progression

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COMPLICATIONS OF ANGIOPLASTY

- Bleeding / Pseudoaneurysm / Retroperitoneal haematoma
- Vessel dissection/rupture
- Contrast-induced nephropathy
- Distal embolization → acute limb ischaemia
- Device/Stent-related
  - Failure to deploy
  - Misplacement
  - Migration
- Postop reocclusion

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CONTRAST INDUCED NEPHROPATHY

Box 2.1 • Risk factors for contrast-induced nephropathy (CIN) identified in multivariable analysis

- Chronic kidney disease (stage 3 or greater: eGFR <60 mL/min/1.73 m²)
- Diabetes mellitus (type 1 or 2)
- Volume depletion
- Nephrotoxic drug use (NSAIDs, ciclosporin, aminoglycosides)
- Preprocedural haemodynamic instability
- Other comorbidities:
  - Anaemia
  - Congestive heart failure
  - Hypoalbuminaemia

eGFR, estimated glomerular filtration rate; NSAIDs, non-steroidal anti-inflammatory drugs.

- Intra-arterial administration of iodinated contrast poses greater risk of CIN than intravenous administration
- Withhold metformin
  - 2 days before and after
  - Recheck Cr 48hrs KIV restart if <25% increase compared to baseline
- Intravenous volume expansion
  - 1-1.5ml/kg/hr x 3-12 hours before and continue 6-24 hours afterwards
  - Insufficient data for oral fluids
- No role for N-acetylcysteine or sodium bicarbonate drip

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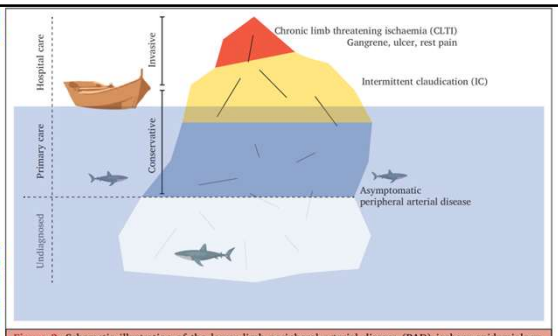

Figure 3. Schematic illustration of the lower limb peripheral arterial disease (PAD) iceberg epidemiology, indirectly illustrating the real challenges associated with reaching out to the entire patient population with any healthcare intervention. (Modified after Søgaard et al. Vasa. 2023;52:77-80.[2])

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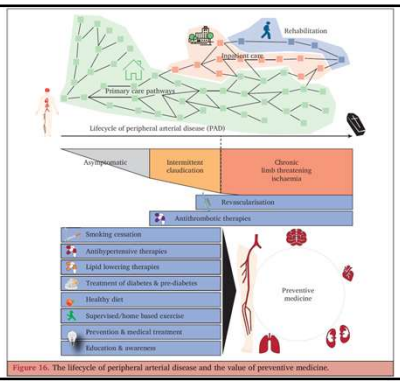

Figure 16. The lifecycle of peripheral arterial disease and the value of preventive medicine.

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CLINICAL VIGNETTE

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Clinical Deterioration

- Staph aureus clusters
- Midfoot osteomyelitis

Due to

- Tibial artery reocclusions
  - Up to 70% reocclusion within 6 months
  - Repeat revascularisation
- Ultrasonic wound debridement + Wound care
- Antibiotics

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Veraflo Granudacyn Cleanse Choice (VGCC)

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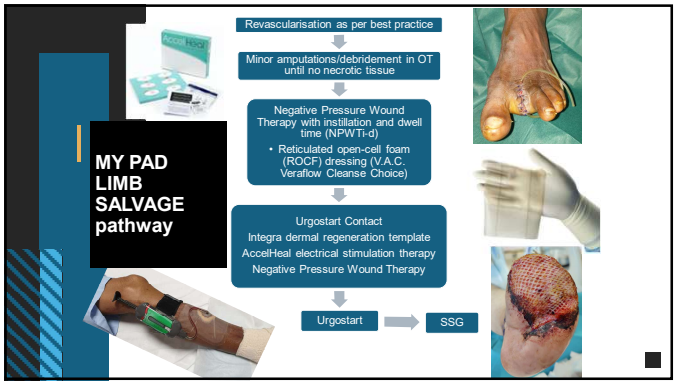
MY PAD LIMB SALVAGE pathway
Revascularisation as per best practice
Minor amputations/debridement in OT until no necrotic tissue
Negative Pressure Wound Therapy with instillation and dwell time (NPWTi-d)
• Reticulated open-cell foam (ROCF) dressing (V.A.C. Veraflow Cleanse Choice)
Urgostart Contact
Integra dermal regeneration template
AccelHeal electrical stimulation therapy
Negative Pressure Wound Therapy
Urgostart
SSG

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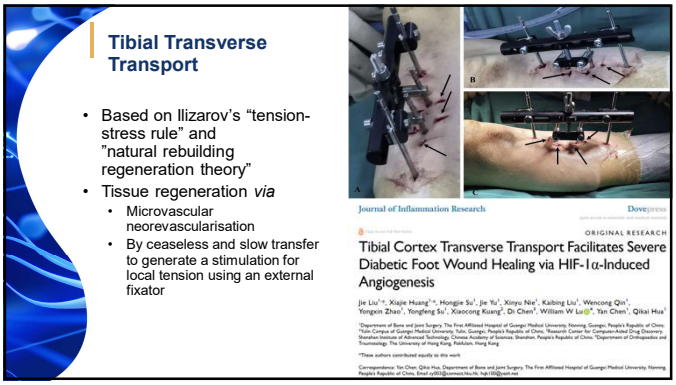
Tibial Transverse Transport
• Based on Ilizarov's "tension-stress rule" and "natural rebuilding regeneration theory"
• Tissue regeneration *via*
• Microvascular neorevascularisation
• By ceaseless and slow transfer to generate a stimulation for local tension using an external fixator
Journal of Inflammation Research
ORIGINAL RESEARCH
Tibial Cortex Transverse Transport Facilitates Severe Diabetic Foot Wound Healing via HIF-1α-Induced Angiogenesis

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