Classification Systems for Acute and Chronic Limb Ischemia

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Anatomic Classifications

Joint Endovascular and Noninvasive Assessment of Limb Perfusion (JENALI) Classification

JENALI scoring system divides each tibial vessel (anterior tibial artery, posterior tibial artery, and peroneal artery) into proximal, mid-, and distal segments [1]. The segment is considered patent and assigned a score of 1 if contrast is visualized within the vessel. If the segment is occluded, it is assigned a score of 0. The segment will be considered patent, so long as there is constant contrast line regardless if it fills through direct antegrade flow or indirect retrograde flow. A maximum score of 9 signifies that all the tibial vessels are patent, and a minimum score of 0 signifies that none of the segment is angiographically patent. The strength of the scoring system lies in its simplicity [1].

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Angiosomes

In 1987, Dr. Taylor, the anatomist and plastic surgeon, introduced the angiosome concept, separating the body into distinct three-dimensional blocks of tissue fed by source arteries [2]. Angiosomes of the foot are defined by different branches of the three main arteries (Fig. 3.1) [3, 4]. The *anterior tibial artery* supplies the anterior ankle which turns into the dorsalis pedis and subsequently supplies the dorsum of the foot. The *posterior tibial artery* supplies the heel through the calcaneal artery, instep through the medial plantar artery, while the lateral plantar artery supplies the lateral midfoot and forefoot. The *peroneal artery* breaks off into two segments which are the anterior perforating branch which supplies lateral anterior portion of the ankle and calcaneal branch which supplies the plantar portion of the heel.

TransAtlantic Inter-Society Consensus (TASC) Document II Classification

The foundations for TASC were laid in 2000 in an attempt to discuss how to treat arterial disease [5]. In an attempt to discuss key aspects of diagnosis and management, update the research, and provide more emphasis on management for the population with diabetes, the TASC group reconvened and updated the guideline in 2007 (TASC II system) [6]. TASC II system has graphically presented and thus is more easily and uniformly applied. Classifications of aortoiliac lesions and femoral-popliteal lesions are summarized in Figs. 3.2 and 3.3, respectively.

Endovascular therapy is the treatment of choice for type A lesions, and surgery is the treatment of choice for type D lesions. Endovascular treatment is the preferred treatment for type B lesions, and surgery is the preferred treatment for good-risk type C lesions. The patient's comorbidities, the fully informed patient preference, and the local operators' long-term success rates must be considered when making treatment recommendations for TASC B and C lesions.

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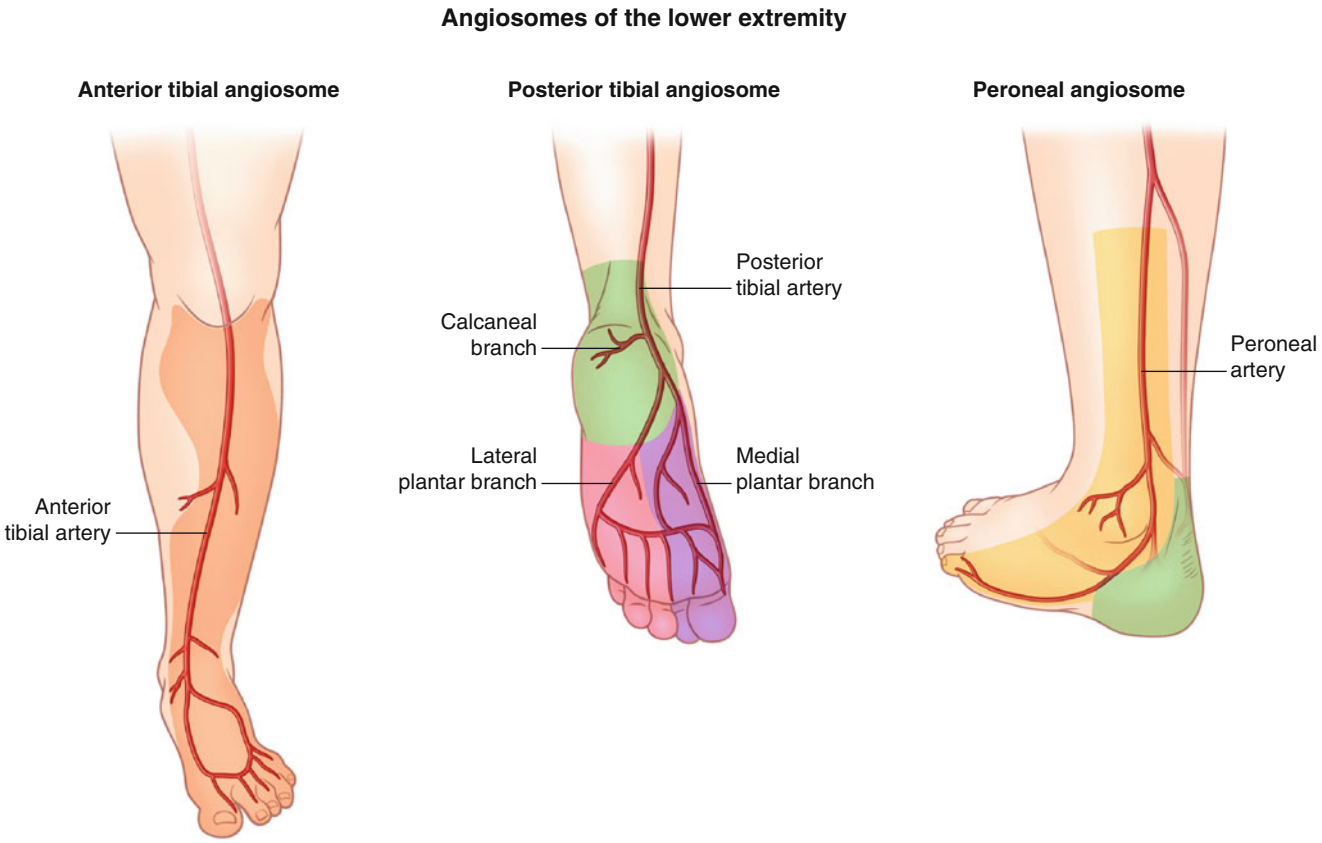


Fig. 3.1 Angiosome defined by arterial supply

Symptom Classifications

Critical limb ischemia (CLI) is a manifestation of peripheral artery disease that describes patients with typical chronic ischemic pain [6]. The Rutherford and Fontaine symptom classification systems are the most widely used [7, 8]. The walking distance that defines mild, moderate, and severe claudication is not specified in the Rutherford classification but is part of the Fontaine classification.

Rutherford Classification

Grade 0	Category 0: Asymptomatic Category 1: Mild claudication
Grade I	Category 2: Moderate Claudication Category 3: Severe Claudication
Grade II	Category 4: Rest pain
Grade III	Category 5: Ischemic ulceration not exceeding ulcer of the digits of the foot Category 6: Severe ischemic ulcers or frank gangrene

Fontaine Classification

Stage 1: No symptoms
Stage 2: Intermittent claudication subdivided into: Stage 2a: Claudication at a distance greater than 200 m Stage 3b: Claudication at a distance less than 200 m
Stage 3: Nocturnal and/or rest pain
Stage 4: Tissue necrosis and/or gangrene in the limb

Wound, Ischemia, and Foot Infection (WIfI) Classification

Rutherford and Fontaine classifications are based on symptom severity from perfusion. However, perfusion is only one determinant of outcome. Wound extent and the presence and severity of infection also greatly impact the threat to a limb. Therefore, a new classification was implemented by the Society for Vascular Surgery Lower Extremity Guidelines Committee [9]. The estimated risk of amputation of each stage is summarized in Fig. 3.4.

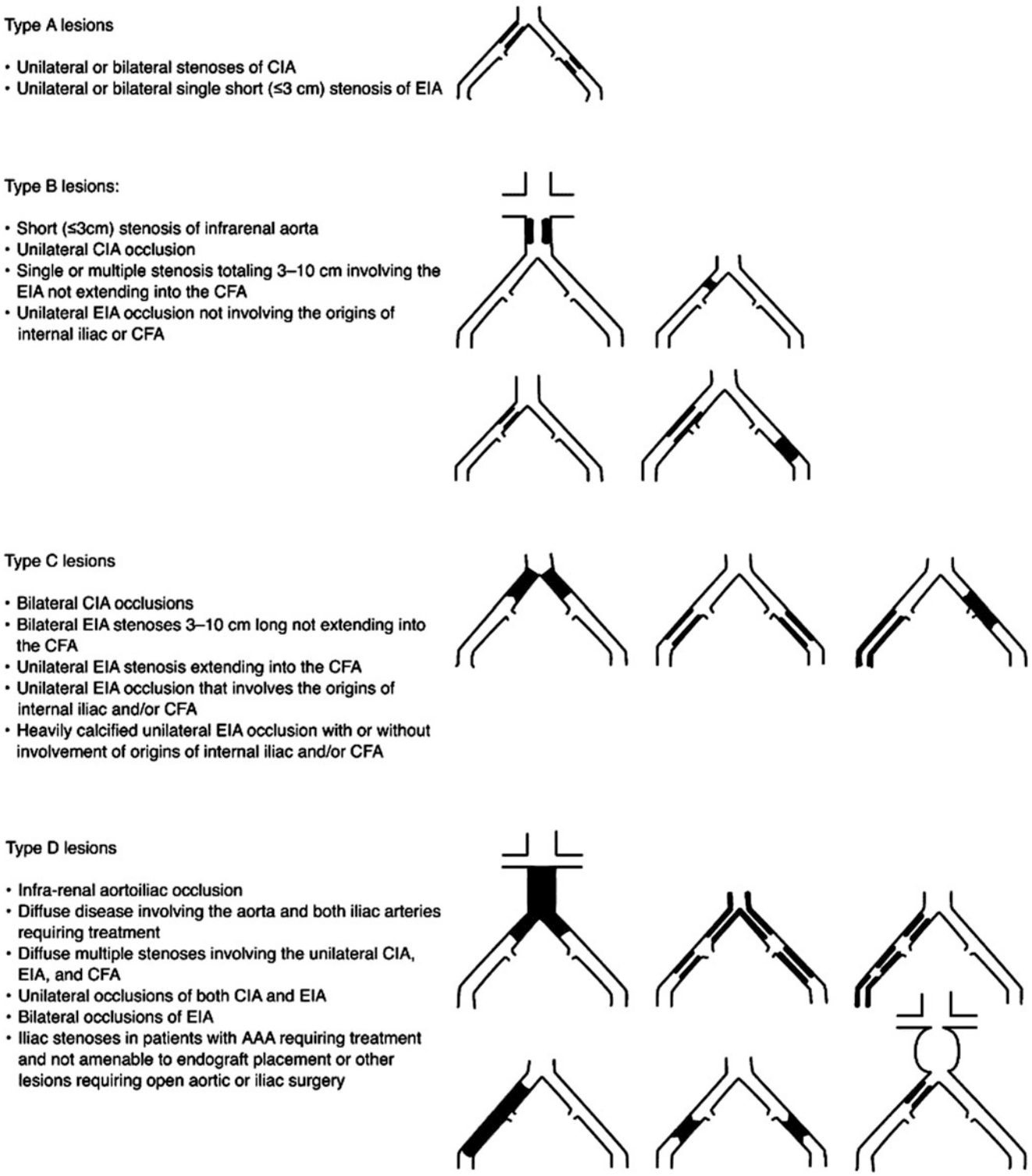
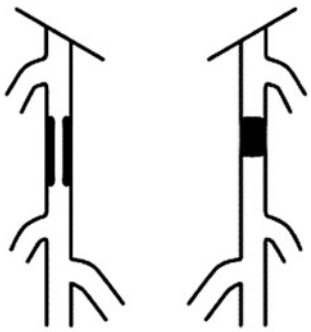


Fig. 3.2 TASC classification of aortoiliac lesions. *CIA* common iliac artery, *EIA* external iliac artery, *CFA* common femoral artery, *AAA* abdominal aortic aneurysm. From Norgren et al. Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). Journal of Vascular surgery 45:1 Supplement 2007. With permission from Elsevier Science and Technology Journals

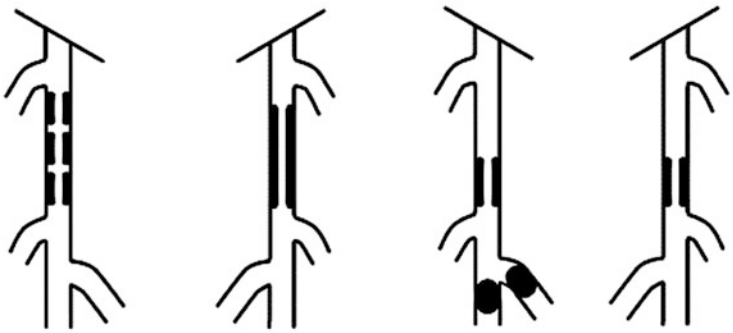
Type A lesions

- Single stenosis ≤10 cm in length
- Single occlusion ≤5 cm in length



Type B lesions:

- Multiple lesions (stenoses or occlusions), each ≤5 cm
- Single stenosis or occlusion ≤15 cm not involving the infrageniculate popliteal artery
- Single or multiple lesions in the absence of continuous tibial vessels to improve inflow for a distal bypass
- Heavily calcified occlusion ≤5 cm in length
- Single popliteal stenosis



Type C lesions

- Multiple stenoses or occlusions totaling >15 cm with or without heavy calcification
- Recurrent stenoses or occlusions that need treatment after two endovascular interventions

Type D lesions

- Chronic total occlusions of CFA or SFA (>20 cm, involving the popliteal artery)
- Chronic total occlusion of popliteal artery and proximal trifurcation vessels

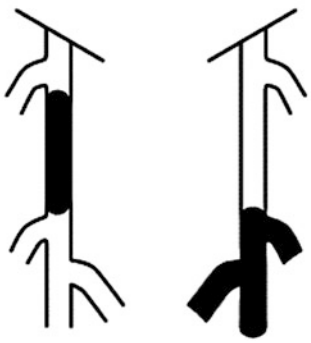


Fig. 3.3 TASC classification of femoral-popliteal lesions. *CFA* common femoral artery, *SFA* superficial femoral artery. From Norgren et al. Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). Journal of Vascular surgery 45:1 Supplement 2007. With permission from Elsevier Science and Technology Journals. For the tibial lesions, the unshaded region is the target stenosis/occlusion. The artery within the shaded rectangle is the associated, "background," disease. Permission granted from Wiley

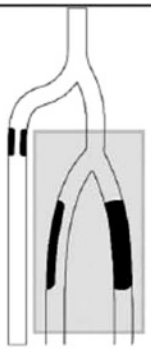
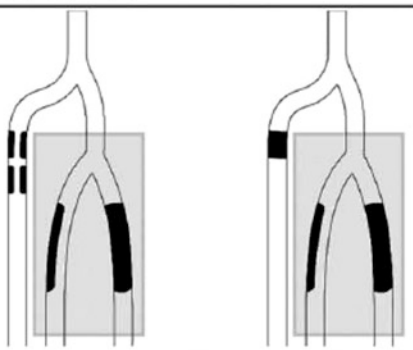
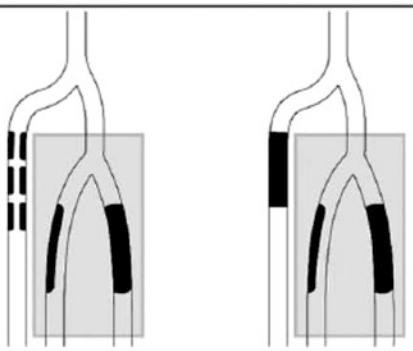
TASC A lesions Single focal stenosis, ≤5 cm in length, in the target tibial artery with occlusion or stenosis of similar or worse severity in the other tibial arteries.	
TASC B lesions Multiple stenoses, each ≤5 cm in length, or total length ≤10 cm or single occlusion ≤3 cm in length, in the target tibial artery with occlusion or stenosis of similar or worse severity in the other tibial arteries.	
TASC C lesions Multiple stenoses in the target tibial artery and/or single occlusion with total lesion length >10 cm with occlusion or stenosis of similar or worse severity in the other tibial arteries.	
TASC D lesions Multiple occlusions involving the target tibial artery with total lesion length >10 cm or dense lesion calcification or non-visualization of collaterals. The other tibial arteries occluded or dense calcification.	

Fig. 3.3 (continued)

a, Estimate risk of amputation at 1 year for each combination

	Ischemia – 0				Ischemia – 1				Ischemia – 2				Ischemia – 3			
W-0	VL	VL	L	M	VL	L	M	H	L	L	M	H	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

b, Estimate likelihood of benefit of/requirement for revascularization (assuming infection can be controlled first)

	Ischemia – 0				Ischemia – 1				Ischemia – 2				Ischemia – 3			
W-0	VL	VL	VL	VL	VL	L	L	M	L	L	M	M	M	H	H	H
W-1	VL	VL	VL	VL	L	M	M	M	M	H	H	H	H	H	H	H
W-2	VL	VL	VL	VL	M	M	H	H	H	H	H	H	H	H	H	H
W-3	VL	VL	VL	VL	M	M	M	H	H	H	H	H	H	H	H	H
	f-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

fI, foot Infection; I, Ischemia; W, Wound.

Premises:

1. Increase in wound class increases risk of amputation (based on PEDIS, UT, and other wound classification systems)
2. PAD and infection are synergistic (Eurodiale); infected wound + PAD increases likelihood revascularization will be needed to heal wound
3. Infection 3 category (systemic/metabolic instability): moderate to high-risk of amputation regardless of other factors (validated IDSA guidelines)

Four classes: for each box, group combination into one of these four classes

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

Fig. 3.4 Risk/benefit: clinical stages by expert consensus. *IDSA* Infectious Diseases Society of America, *PAD* peripheral artery disease, *PEDIS* perfusion, extent/size, depth/tissue loss, infection, sensation, *UT* University of Texas. From Mills et al. Society for Vascular Surgery Document J. Vasc Surg 2014;59:220–34. With permission from Elsevier Science and Technology Journals

Wound

Grade 0: Rest pain; no wound, no ulcer, no gangrene
Grade 1: Small shallow ulcer(s) on the distal leg or foot, any exposed bone is only limited to distal phalanx (i.e., minor tissue loss: limb salvage possible with simple digital amputation [one or two digits] or skin coverage)
Grade 2: Deeper ulcer on distal leg or foot with exposed bone, joint, or tendon or shallow heel ulcer without involvement of the calcaneus (i.e., major tissue loss: salvageable with >3 digital amputations or standard transmetatarsal amputation plus skin coverage)
Grade 3: Extensive deep ulcer of the forefoot and/or midfoot or full-thickness heel ulcer with or without involvement of the calcaneus (i.e., extensive tissue loss: salvageable only with complex foot reconstruction or nontraditional TMA [e.g., Chopart or Lifranc amputation])

Ischemia

Grade 0: ABI ≥ 0.8, ankle systolic pressure > 100 mmHg, toe pressure (TP)/transcutaneous oxygen ($TcPO_2$) ≥ 60
Grade 1: ABI 0.6–0.79, ankle systolic pressure 70–100 mmHg, TP/$TcPO_2$ 40–59
Grade 2: ABI 0.4–0.59, ankle systolic pressure 50–70 mmHg, TP/$TcPO_2$ 30–49
Grade 3: ABI ≤ 0.39, ankle systolic pressure <50 mmHg, TP/$TcPO_2$ < 30

Foot Infection

Grade 0: No symptoms or signs of infection
Grade 1: Infection is present and at least two of the following are present: local swelling or induration, erythema >0.5 to ≤2 cm around ulcer, local tenderness or pain, local warmth, or purulent discharge. Other causes of inflammatory response of the skin have been excluded
Grade 2: Local infection is present as defined for Grade 1, but extends >2 cm around ulcer, or involves the structures deeper than the skin and subcutaneous tissues (e.g., abscess, osteomyelitis, septic arthritis, fasciitis). No clinical signs of systemic inflammatory response
Grade 3: Local infection is present as defined for Grade 2, but clinical signs of systemic inflammatory response are present as manifested by two or more of the following: temperature >38 °C or <36 °C; heart rate >90 beats per minute, respiratory rate >20 breaths per minute or PaCO2 < 32 mmHg; white blood cell count >12,000 or <4000 (cu/mm) or >10 % immature band forms present

Wagner Ulcer Classification System

Grade 1: Superficial diabetic ulcer
Grade 2: Ulcer extension involving the ligament, tendon, joint capsule, or fascia with no abscess or osteomyelitis
Grade 3: Deep ulcer with abscess or osteomyelitis
Grade 4: Gangrene to the portion of the forefoot
Grade 5: Extensive gangrene of the foot

Peripheral Academic Research Consortium (PARC) Classification

The goal of the PARC group was to develop standardized definitions for patients with lower extremity PAD allowing for clinical characterization and evaluation of therapies on the basis of imaging or clinical outcomes [10]. The Fontaine and Rutherford classifications were modified to use descriptive, rather than numeric, terms to classify the severity of PAD limb symptoms (Table 3.1). The limitation of current Rutherford classification system in part was felt to be due to the changing demographics of critical limb ischemia (CLI) patients with increased rates of diabetes and renal disease. PARC has also presented hemodynamic definition for CLI patients in the same article (Table 3.2).

ORC Classification

Finally, in an effort to combine anatomy, physiology, and patient comorbidities, the "ORC" scheme, initially proposed by Dr. Raymond Dieter, Jr. for oncological surgery: "O" is for operability (from a physiological stress standpoint (including renal function), which is best for patient—open surgery or endovascular therapy); "R" is for resectability, but here it would indicate the ability to revascularize either with open bypass (conduits/distal, vasculature/infection, etc.) or perform endovascular therapy; and "C" is for curability (if the patient has life-threatening gangrene or an ulceration that ultimately will never heal, then amputation rather than revascularization may be preferred). Table 3.3 summarizes ORC classification modified for CLI treatment.

Table 3.1 Proposed clinical symptom classification by PARC group

Fontaine classification					Rutherford classification		
Stage	Symptoms	<-->	Proposed PARC universal data elements	<-->	Grade	Category	Symptoms
I	Asymptomatic				0	0	Asymptomatic
II	Intermittent claudication/ other exertional limb symptoms		Mild claudication/limb symptoms (no limitation in walking)	<-->	0	1	Mild claudication
IIa		<-->	Moderate claudication/limb symptoms (able to walk without stopping >2 blocks or 200 m or 4 min)		1	2	Moderate claudication
IIb			Severe claudication/limb symptoms (only able to walk without stopping <2 blocks or 200 m or 4 min)	<-->	1	3	Severe claudication
III	Ischemic rest pain	<-->	Ischemic rest pain (pain in the distal limb at rest felt to be due to limited arterial perfusion)	<-->	II	4	Ischemic rest pain
IV	Ulceration or gangrene	<-->	Ischemic ulcers on distal leg Ischemic gangrene	<-->	III III	5 6	Ischemic ulceration Ischemic gangrene

Adapted from Patel et al. JACC 2015;65:931–41

Table 3.2 Hemodynamic definitions of critical limb ischemia

Patients with tissue loss	Patients with ischemic rest pain
Ankle pressure <80 mmHg	Ankle pressure <50 mmHg
Toe pressure <50 mmHg	Toe pressure <30 mmHg
$TcPO_2$ < 40 mmHg	$TcPO_2$ < 20 mmHg
Skin perfusion pressure <40 mmHg	Skin perfusion pressure <30 mmHg (23)

The PARC group provided hemodynamic support for the definition of CLI. Atypical leg symptoms are symptoms that are worsened by exertion but that do not meet the classic definition of intermittent claudication. These patients should have objective/confirmed evidence of PAD by noninvasive testing

CLI critical limb ischemia, *PAD* peripheral arterial disease, *PARC* Peripheral Academic Research Consortium, *TcPO2* transcutaneous oxygen pressure

Adapted from Patel et al. JACC 2015;65:931–41

Table 3.3 ORC classifications modified for CLI treatment

"O"—operability	Is the patient an acceptable candidate for either endovascular or open surgical repair
"R"—resectability	Revascularization—is there a distal target for bypass; is endovascular lesion crossing possible/trentable
"C"—curability	Will healing occur after revascularization, or are there significant comorbid conditions (e.g., infection, edema, immobility, etc.) that preclude healing

Modified from Dr. Ray Dieter's surgical oncology scheme [11]

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