Catheterization and Cardiovascular Interventions

SCAI Appropriate Use Criteria for Peripheral Arterial Interventions: An Update

Journal:	*Catheterization and Cardiovascular Interventions*
Manuscript ID	CCI-17-0716
Wiley - Manuscript type:	Core Curriculum
Keywords:	AID - Aorto-Iliac Disease, ENDI - Endovascular Intervention, PINT - Peripheral Intervention, RADI - Renal Artery Disease, SPVD - Surgery, Peripheral Vascular

SCAI Appropriate Use Criteria for Peripheral Arterial Interventions: An Update

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Word Count: 13,404

Abbreviations:

BE = balloon expandable.

BMS = bare metal stent.

BP = blood pressure.

CIA = common iliac artery.

CKD = chronic kidney disease.

CTO = chronic total occlusion

DCB = drug coated balloon.

DES = drug eluting stent.

EIA = external iliac artery.

EVT = endovascular therapy.

FP = femoral-popliteal.

GDMT = guideline directed medical therapy.

HTN = hypertension. IP = infra-popliteal.

LASER = light amplification by stimulated emission of radiation.

PFA = profunda femoris artery.

PVAD = percutaneous ventricular assist device.

PTA = percutaneous transluminal angioplasty.

RAS = renal artery stenosis.

RC = Rutherford classification.

SE = self-expanding.

TAVR = transcatheter aortic valve replacement.

TLR = target lesion revascularization

Introduction

In 2014, the Society for Cardiovascular Angiography and Interventions (SCAI) published the first Appropriate Use Criteria (AUC) for endovascular therapy (EVT) for atherosclerotic peripheral artery disease (PAD) involving the aorto-iliac, femoral-popliteal, infra-popliteal and renal arterial circulations. [1-4] These documents were developed to assist clinicians' decision-making, to improve patients' understanding regarding relative risks and benefits of a procedure, and to guide future research. Clinical scenarios were described in which catheter-based intervention was classified as "appropriate," "may be appropriate," or "rarely appropriate", incorporating the best clinical and scientific evidence, cost-effectiveness data and the consensus of experts within the SCAI Peripheral Vascular Disease Committee.

The purpose of this update is to provide a focused review of new clinical evidence regarding EVT, to identify novel technologies and practice changes that have been introduced since the original documents were published and to provide updated recommendations.

Methodology

The definition of appropriate use (AUC) is largely consistent across technologies and procedures. AUC considers the risks and benefits of a procedure while applying this balance across clinically relevant scenarios. An appropriate diagnostic or therapeutic procedure is one in which the expected clinical benefit exceeds the risks of the procedure by a sufficiently wide margin such that the procedure is generally considered acceptable or reasonable. [5,6]

Experts were nominated and selected based upon their intellectual integrity and expertise with consideration of industry and intellectual bias. The writing group members are familiar with the application of the techniques and strategies under consideration to ensure that the clinical scenarios were constructed to capture the clinical applicability and limitations of the therapies.

In general, the SCAI modified Delphi panel methodology employed an expert panel of clinicians who rated a series of clinical scenarios on a nine-point scale (Appropriate 7-9, May Be Appropriate 4-6, and Rarely Appropriate 1-3). The panel participated in a minimum of three rounds of ratings, with communication among the panelists after the first round. Each panelist had equal weight in determining the final rating. A synthesis of the updated scientific literature was prepared for each anatomical area for review by the rating panel. After review of the updated literature, panelists were asked to review each clinical scenario and to score it. Agreement among panelists was achieved when none of the ratings for any of the scenarios fell outside the 2-point margin of the mean score.

For renal arterial revascularization, the benefits included: blood pressure improvement, renal function improvement or stabilization, and improved cardiac destabilization syndromes (heart failure and angina exacerbations) weighed against the risks of the procedure. For lower extremity arterial revascularization, the benefits included: survival or health outcomes such as symptom improvement, limb salvage, functional status and/or quality of life, weighed against the risks of the procedure.

"Appropriate Care" implies that the benefits generally outweigh the risks of the procedure. The procedure is an effective option for individual care although not always required or necessary; the procedure is generally acceptable and reasonable for the indication.

"May Be Appropriate Care" describes an option that is generally accepted with variable levels of supporting evidence or expert consensus regarding the risk to benefit ratio. There may be utility in selected cases based upon clinical experience in the absence of comparative evidence. The appropriateness of a specific procedure in any individual must be determined by that patient's physician in consultation with the patient considering the risk to benefit ratio. This category of procedures may be acceptable and may be reasonable for the clinical scenario.

"Rarely Appropriate" care describes an option for the management of a patient with an adverse or uncertain risk to benefit ratio. The option is not commonly used as an effective therapy and the rationale for choosing this option needs to be documented. The procedure is recognized to be effective in selected situations but is not generally applied and is not generally reasonable for the indication. Procedures in this category require justification through the documentation of individual patient circumstances.

AUC Methodology and Assumptions

1. The clinical scenarios chosen for this document are not intended to be all-inclusive. Not every clinical scenario can or will be addressed.
2. Lesion characteristics are arbitrarily divided into focal, intermediate, and diffuse for each anatomical subset as defined below.
3. When not specifically stated, assume that patients are being treated with guideline-directed medical therapy (GDMT).
4. Scenarios were scored independently of each other. There is no "ranking" of indications. This means that two different scenarios regarding aorto-iliac intervention may be scored the same value (i.e. 7 (appropriate), even if the scenarios are different.
5. The cost of care was considered in determining appropriateness. For example, a procedure that is ten-times more expensive than another, but equally effective, should be rated lower. Device cost, complication rates, durable patency and length of hospital stay all contribute to the cost of care.
6. It is assumed that interventions are performed by the "average" interventionalist, who is credentialed by their hospital to perform the procedure being considered, and not the most experienced expert, nor the most recent graduate from fellowship training. In each of the depicted clinical scenarios, the assumption is made that the approach to EVT was carefully

considered in terms of the clinical need, the opportunity for benefit, as well as the potential risks.

7. For device scenarios, assume the intention is to use the device as the ultimate or definitive device, regardless of lesion preparation. Percutaneous transluminal angioplasty (PTA) can be chosen as the intended definitive treatment, even if it may be necessary to "bail out" with a stent. DCB can be chosen as the intended definitive treatment with the knowledge the lesion will be prepared and pre-dilated with an uncoated balloon first. Rotational atherectomy can be considered as the definitive treatment modality if the procedure could not be completed without its use, an undilatable lesions for example, despite the need for subsequent PTA or stent placement to complete the procedure.
8. Rarely Appropriate (1 - 3) means that a particular procedure will be appropriate only in selected circumstances. It does not mean "never", although a score of 1 (one) is as close to never as one can get.
9. May Be Appropriate (4 - 6) means that a procedure is indicated under certain circumstances, and not in others.
10. Appropriate (7 - 9) means that a procedure is usually indicated, with a score of 9 (nine) representing usual care.

General Definitions

1. Occlusion describes complete cessation of flow through the arterial segment.
2. Provisional stenting implies PTA with bail-out stent placement if a flow-limiting dissection or significant residual stenosis occurs.
3. Primary stenting implies the intention to place a stent regardless of the outcome of any pre-dilation or pre-treatment.
4. Multiple lesions are more than one focal lesion in non-contiguous arterial segments.

Definitions for Renal Artery Lesions:

1. Severe renal artery stenosis (RAS) is >70% diameter stenosis by visual estimation, or 50% to 70% visually estimated stenosis with a mean resting or hyperemic translesional gradient of ≥ 10 mm Hg or a systolic resting or hyperemic translesional gradient of ≥ 20 mm Hg, or a renal fractional flow reserve (Pd/Pa) of ≤ 0.8 (Table 1). Moderate RAS is 50% to 70% visually estimated stenosis without measurement of a translesional gradient, or with a resting or hyperemic translesional mean gradient < 10 mm Hg or a translesional systolic resting or hyperemic gradient of < 20 mm Hg.
2. Resistant hypertension is uncontrolled hypertension (e.g. >140/90 mmHg) on three or more maximally tolerated antihypertensive medications including a diuretic.
3. CKD class II is a GFR of 60-89 mL/min; CKD class III is GFR of 30 - 59 mL/min; CKD class IV is GFR < 30 mL/min.

Definitions for Aorto-Iliac Lesions:

1. Focal aorto-iliac lesions are ≤ 4 cm in length.
2. Diffuse aorto-iliac lesions are > 4 cm in length.

Definitions for Femoral-Popliteal Lesions:

1. Focal femoral-popliteal lesions are ≤ 10 cm, intermediate are 10 - 20 cm, and diffuse are > 20 cm.

Definitions for Infra-Popliteal Lesions:

1. One-vessel infra-popliteal disease implies that two tibial arteries are without hemodynamically significant stenosis (≥70% or occlusion); Two-vessel infra-popliteal

disease implies that one tibial artery is without hemodynamically significant stenosis or occlusion (tibioperoneal trunk disease affects both the posterior tibial and peroneal arteries which is consistent with two-vessel infra-popliteal disease); Three-vessel infra-popliteal disease implies that all three tibial arteries have hemodynamically significant stenosis and/or occlusion.

2. A focal infra-popliteal lesion is a discrete area of narrowing ≤ 4 cm long. An intermediate infra-popliteal lesion is a continuous segment of disease 4 to 10 cm long. A diffuse infra-popliteal lesion is a continuous segment of disease > 10 cm long.

Renal Interventional Updates (Table 2)

Introduction: Renal hypoperfusion leads to the activation of the renin-angiotensin-aldosterone axis. This results in vasoconstriction, sodium and water retention, aldosterone secretion, and sympathetic nervous system activation[1,7], which in turn can lead to systemic hypertension or cardiac destabilization syndromes (flash pulmonary edema, refractory heart failure and/or unstable angina). Renal hypoperfusion may also lead to ischemic nephropathy and chronic kidney disease (CKD). There has been great interest in relieving renal hypoperfusion when it is secondary to atherosclerotic stenosis at the renal artery ostium and/or proximal aspect of the renal artery or arteries with stent deployment.[8] Table 3 summarizes the most current ACC/AHA guidelines update on renal intervention.[9]

Several prospective, multicenter registries have demonstrated improvements in systolic and diastolic blood pressure (SBP, DBP) and improvement and/or stabilization of renal function for renal stent placement with excellent safety profiles, but have not shown any improvement in major adverse cardiovascular events.[1,10-12] A large multicenter randomized controlled CORAL (Cardiovascular Outcomes in Renal Atherosclerotic Lesions) trial[13] demonstrated that for patients with hypertension and newly diagnosed renal artery stenosis, the most appropriate therapy was to

maximize medical therapy before considering revascularization. The CORAL study found that the primary composite end point (death from cardiovascular or renal causes, myocardial infarction, stroke, hospitalization for congestive heart failure, progressive renal insufficiency, or the need for renal replacement therapy) in patients with renal artery stenosis (>60% diameter stenosis) and hypertension did not differ between groups treated with GDMT alone compared to GDMT with renal stenting.[14]

The CORAL trial has limitations similar to other previous comparative renal artery stent trials.[15,16] These include enrolling patients with moderate hypertension receiving only two antihypertensive medications, not requiring maximally tolerated doses, and the majority of enrolled patients having moderate (68% diameter stenosis) renal artery stenosis and without hemodyanmic confirmation of the severity of obstruction.

At baseline, CORAL participants were taking 2.1 ± 1.6 anti-hypertensive medications with a systolic blood pressure of 150 ± 23 mmHg. At the conclusion of the trial, both the medical therapy cohort and the group that underwent renal revascularization had increased the number of medications required, 3.5 ± 1.4 versus 3.3 ± 1.5, respectively (P=ns) and both groups had comparable decreases in systolic blood pressure, 15.6 ± 25.8 mm Hg in the medical therapy group and 16.6 ± 21.2 mm Hg in the stent group. These findings indicate that relatively few patients with refractory hypertension were enrolled in the CORAL trial.

Anatomic Considerations: Expert consensus and experimental evidence have determined that a hemodynamically severe renal artery diameter stenosis is present when there exists a resting or hyperemic translesional mean pressure gradient of ≥10 mm Hg, a resting or hyperemic peak systolic translesional pressure gradient of ≥20 mm Hg or renal fractional flow reserve (FFR) ≤0.8 (Table 1).[17-20] The pressure gradient is best measured with an 0.014" pressure wire and not a catheter; even the use of a 4Fr catheter results in a 75% overestimation of the translesional systolic

pressure gradient.[21] Moreover, patients with global renal ischemia (i.e. those with bilateral, hemodynamically significant RAS or those with unilateral RAS with a solitary functioning kidney) are thought to be more likely to respond to renal artery stent placement.

Clinical Considerations: Several meta-analyses[22,23] have shown that fewer anti-hypertensive medications are required to achieve desired blood pressure reduction following renal artery revascularization. Future trials may yield the most robust insights into the value of renal artery stenting if: they only enroll patients with hemodynamically-significant lesions, as determined by invasive measurement in a controlled, standardized fashion; if they include an assessment of anti-hypertensive medication compliance; and if they are based on accurate blood pressure assessment, including ambulatory 24 hour blood pressure monitoring.

It is difficult to demonstrate the cost-effectiveness of renal artery stenting without unequivocal clinical benefit in the populations studied. The few available cost-effectiveness analyses have predated publication of most randomized controlled trials. Nevertheless, a German economic analysis of hypertensive patients with renal artery stenosis used a decision analytic model to predict 3-year costs.[24] They observed a cost benefit of €11,663 ($13,044), €36,454 ($40,771), €51,752 ($57,881) and €78,766 ($88,095), for stenting, surgery, PTA and medical therapy, respectively, and concluded that a strategy of primary renal stenting was the most cost-effective strategy in this setting.

Technical Considerations: The increasing adoption of transradial arterial access for coronary and peripheral vascular intervention has inspired significant interest into the application of this approach for renal artery stenting. Since most renal arteries have a natural downward angulation, they may often be easier to engage with a catheter advanced from a superior approach (i.e. the arm) compared with a catheter directed from the femoral approach. The availability of 125

cm guiding catheters and balloons and stents with longer shafts (e.g. 150 cm) make renal artery stenting from the transradial approach feasible for most patients.

Aorto-Iliac Interventional Updates (Table 4)

Introduction: The goals of therapy for patients with aorto-iliac atherosclerotic disease have not changed. The key objectives are to reduce or alleviate the symptoms associated with vascular insufficiency, to improve functional status and quality of life (QOL), and to reduce cardiovascular morbidity and mortality with GDMT, supervised exercise therapy, and in selected patients, revascularization. There are additional indications for aorto-iliac endovascular therapy in patients who do not experience symptoms of lower extremity arterial insufficiency; these include situations where large-bore arterial access is required for hemodynamic support devices (e.g. intra-aortic balloon pumps (IABP) or other catheter-based ventricular assist devices), for structural, valvular (e.g. TAVR), and vascular (e.g. endovascular aortic aneurysm repair (EVAR)) procedures.

Since the publication of the SCAI Aorto-Iliac AUC document[2], two trials have been completed evaluating the impact of supervised exercise therapy (SET) and EVT for aorto-iliac arterial disease. The Claudication: Exercise Versus Endoluminal Revascularization (CLEVER) trial was a randomized clinical trial (RCT) that compared EVT, optimal medical therapy (OMT) and SET. At 18 months, the peak-walking time improved for both SET and EVT and was not different between the two groups. Improvement in claudication onset time was greater for SET compared with OMC, but not for EVT compared with OMC. Many disease-specific quality-of-life scales demonstrated durable improvements that were greater for EVT compared with SET or OMC. In summary, the CLEVER trial demonstrated an improvement in QOL and peak walking time with EVT or with SET when compared to OMT alone after 18 months of follow-up (Figure 1).

The CLEVER investigators conducted a 5-year cost-effectiveness analysis using the 18-month follow up data.[25] Assuming that the quality of life benefits associated with each treatment

strategy would dissipate over time, they calculated incremental cost-effectiveness ratios of $24,070 and $41,376 per quality adjusted life year gained for supervised exercise and stenting, respectively, when compared with optimal medical therapy alone. They concluded that supervised exercise and stenting were both economically attractive by US standards.

The Endovascular Revascularization and Supervised Exercise for Peripheral Artery Disease and Intermittent Claudication (ERASE) trial [26] randomized patients with claudication due to aorto-iliac and femoral-popliteal arterial disease to receive EVT together with SET or to receive SET alone. The ERASE trial demonstrated that those who received both EVT and SET had greater improvement in walking distance and health-related QOL compared with those who received SET alone. These trials support SET as an effective alternative to revascularization, but indicate that combining SET with EVT, in the presence of GDMT, may represent the best option overall. The ERASE trial suggests that combination therapy of EVT with SET should be considered in suitable patients given the marked gains in QOL and walking distance.

The updated ACC/AHA Peripheral Artery Disease guidelines[27] continue to support EVT, with primary or provisional stenting, as first-line therapy for symptomatic aorto-iliac occlusive disease states that "Endovascular procedures are effective as a revascularization option for patients with lifestyle limiting claudication and hemodynamically significant aorto-iliac occlusive disease". Due to its high success rates and lower morbidity/mortality compared to surgical revascularization, EVT, with primary or provisional stenting may be considered a first-line treatment strategy for aorto-iliac disease. [28-31]

Anatomic Considerations: The TASC-II document[32], recently updated[33], has traditionally been used to describe the anatomic characteristics of lower extremity atherosclerotic disease as they relate to therapeutic options (Figure 2). The initial writing group had a preference for surgical intervention in more anatomically complex lesions (TASC C/D). Over the decade since the

document's publication, however, advances in technology and operator technique now permit safe, effective, and relatively durable treatment of even the most complex (TASC C/D) lesions with EVT.[33] A recent large retrospective study from Japan[34] demonstrated that in a cohort of 2,096 patients with complex aorto-iliac disease, of which 395 had TASC D lesions (remaining 2,206 patients were TASC A-C), there was no difference in the 5 year primary patency (77.9% vs. 77.1%, P = 0.17) or major adverse cardiovascular and limb events (30.5% vs. 33.4%, P = 0.42) between the less complex lesions (TASC A-C) and the more complex lesions (TASC D). The study did confirm the technical challenges associated with EVT in complex lesion subsets, yielding a lower procedural success rate (91.6% vs. 99.3%, P < 0.01) and a greater rate of procedure-related complications (11.1% vs. 5.2%, P < 0.01) in the TASC D group when compared to the TASC A-C lesion cohort.

The STents *versus* AnGioplasty (STAG)[35] trial randomized primary stenting against PTA for iliac occlusion and was stopped early due to a high rate of embolic complications in the PTA treatment group. Primary stenting improved technical success and lowered major procedural complication rates, but there was no statistical difference for patency after 1 and 2 years.

The BRAVISSIMO[36] (Belgiane Italian tRial investigating Abbott Vascular Iliac StentS In the treatMent of TASC A, B, C, & D iliac lesiOns) study was a prospective multicenter registry treating 325 patients with aorto-iliac lesions. The technical success was 100%, which reflects advances in operator techniques and device technology including re-entry catheters, crossing devices, and stent design. The overall 24-month primary patency rate was 87.9% (88.0% for TASC A, 88.5% for TASC B, 91.9% for TASC C, and 84.8% for TASC D (P = not significant)). Neither TASC category nor lesion length was predictive of restenosis, providing further support for an "endovascular first" strategy regardless of TASC classification.

Regardless of stent selection, operators must recognize the pretreatment risk factors predictive of late restenosis/occlusion which include: occlusion versus stenosis, longer lesions, external iliac over common iliac lesion location, and smaller arteries especially those with

circumferential calcification.[37] The long-term patency of endovascular intervention of the aorto-iliac arteries may differ by gender with lower patency rates in women, although this finding may reflect smaller vessel diameter. [38]

Clinical Considerations: Since 2014, there has been a marked increase in the use of TAVR via the transfemoral approach. Computed tomographic angiography (CTA) is routinely used to size the aorto-iliac arteries and to identify potential impediments to transfemoral valve delivery. Physicians with the endovascular skills necessary to repair aorto-iliac and femoral arterial trauma secondary to large caliber trans-femoral devices (e.g. used for structural, valvular, or hemodynamic support), should be available to avoid or minimize potentially catastrophic complications. TAVR teams should have immediate access to large diameter balloons and covered stents in case of aorto-iliac rupture or perforation. Current appropriate use criteria support endovascular intervention for asymptomatic aorto-iliac arterial disease to allow vascular access for life-saving devices (e.g., mechanical circulatory support, or TAVR). This can be accomplished with primary or provisional stent placement. [2]

Internal iliac artery intervention is effective in patients with lifestyle limiting buttock or hip claudication due to stenotic disease. Internal iliac revascularization may be appropriate when there is a significant stenosis and vasculogenic impotence, although the current guidelines do not address the treatment of vasculogenic impotence and the data supporting revascularization are limited to small single center studies.[39]

Technical Considerations: Both nitinol and stainless steel self-expanding stents perform well in the iliac location with low restenosis rates.[40-44] A recent multicenter trial randomized 660 patients with Rutherford Classification (RC) 1 - 4 to treatment with either a balloon expandable (BE) or self-expanding (SE) stent. The primary patency at 12 months favored the SE over BE with

an SE restenosis rate of 6.1% and 14.9% after BE (P=0.006).[45] Usually, balloon-expandable stents are chosen for ostial lesions where precise placement is a priority, or when significant recoil is anticipated, while self-expanding stents more readily contour to tapering and tortuous vessels. While drug-eluting stents (DES) and drug coated balloons (DCB) have not been evaluated in iliac arteries, in highly selected cases, they may be useful in an appropriately sized vessel with in-stent restenosis.[46]

The overall results for TASC B, C, and D lesions in the COBEST (COvered versus Balloon Expandable Stent Trial) trial[47] did not find any differences for binary restenosis or freedom from occlusion at 18 months between the covered and non-covered balloon expandable stents. However, the more complex TASC C and D lesion cohort of that trial did have an improved primary patency rate when covered balloon-expandable stents were used as compared to bare metal stents (BMS). The recently published 5-year data from this trial continue to demonstrate an advantage for covered versus BMS in TASC C and D iliac artery lesions.[48] A recent meta-analysis of RCTs and observational studies found that covered stents in iliac arteries were not associated with a significant improvement in primary patency, but were associated with a higher ankle-brachial index and a lower reintervention rate.[49]

There has been rapid adoption of transradial access for coronary angiography and interventions. There is growing interest in the transradial approach for renal, mesenteric and lower extremity intervention in suitable patients. [50,51] Pre-procedural planning is required to ensure that large diameter balloons and stents on shaft lengths of at least 150 mm may be delivered through radial access arterial sheaths (4-7 French).[52]

An essential aspect of appropriate care is the determination of the clinical and hemodynamic significance of aorto-iliac lesions. Given the limitations of two-dimensional angiography, physicians should consider assessing the severity of moderate (50% to 70% diameter stenosis) lesions by measuring translesional gradients using microcatheters or pressure wires. A

translesional mean gradient of ≥ 10 mmHg, at rest or with hyperemia, is considered significant in this vascular bed given the size of these vessels and the peak flow that occurs with exercise. [53,54]

Femoral-Popliteal Interventional Updates (Table 5)

Introduction: The goals of endovascular therapy for patients with PAD are driven by the severity of the patient's clinical condition, and by the anatomic features and distribution of the vascular disease. The clinical objective in treating a patient who is functionally impaired due to claudication is the relief of symptoms with as durable a treatment as possible. Endovascular therapy, no matter how expertly performed, may be hampered by restenosis and the recurrence of symptoms.

In the patient presenting with CLI, with threatened limb or tissue loss, the objective is to restore perfusion of the ischemic tissue as rapidly as possible, in order to relieve the ischemia, prevent or limit the amount of tissue loss, and restore ambulation. In treating patients with CLI, durable patency remains desirable; but once the wound has healed, restenosis may not place the limb in jeopardy unless re-injury occurs.

Several trials have shown significant patient benefit with OMT and SET therapy in relieving symptoms of claudication at one year. [55-57] In 2014, the IRONIC [58](Invasive Revascularization or Not in Intermittent Claudication) trial which randomized patients with both aorto-iliac and femoral-popliteal disease to revascularization (endovascular or surgical, n=79) plus OMT or to OMT alone (n=79) demonstrated superiority for EVT plus OMT for onset of claudication and quality of life (QOL) outcomes compared to group treated with OMT alone (P=0.003).

A recent meta-analysis[59] of over 7,000 patients of SET vs. OMT vs. EVT showed that only SET increased median walking distance, although both EVT and SET improved QOL scores compared to OMT alone. Another meta-analysis compared the four different approaches to treating with PAD and claudication, i.e. surgery, EVT, SET and OMT alone. In this review of 1,548 patients[60],

the authors found that surgery, EVT and SET were superior to OMT with respect to walking distance, and claudication. Another comparative effectiveness study examined the utility of EVT for femoral-popliteal disease causing claudication and also confirmed improved walking parameters and QOL.[60-62]

Anatomic Considerations: The 2007 TASC II document recommended surgical intervention for more complex femoral-popliteal lesions (TASC C/D) with EVT reserved for less complex TASC A and B lesions. The 2015, TASC update endorses an "endovascular first" recommendation for experienced operators and teams (Figure 3).[33] With advances in technique and technology including strategies to approach complex chronic total occlusions with re-entry techniques and crossing devices , complex TASC D lesions are often approached with EVT first. The most recent ACC/AHA guidelines on PAD provide a class IIA recommendation (Level of Evidence (LOE) B) for EVT. [27] These recommendations emphasize that the benefit of EVT in claudicants is related to durable patency, which is influenced by numerous patient and lesion specific characteristics. Given the smaller vessel diameter, longer lesion length, association of dense calcification and complex biophysical forces[63], the femoral-popliteal arteries have lower long-term patency rates compared to the iliac arteries. The recently updated ACC/AHA guidelines and the updated TransAtlantic Inter-Society Consensus (TASC II) supplement recommend an endovascular-first approach when possible and that "the choice of endovascular therapy as a revascularization approach for claudication due to femoral-popliteal disease should include a discussion of outcomes, addressing the risk of restenosis and repeat intervention, particularly for lesions with a poor likelihood of long-term durability".[27,33]

Common femoral endarterectomy (CFE) has been the gold standard for the treatment of common femoral arterial (CFA) disease based upon single center series and expert consensus.[64] However, a recent report from a large national database (American College of Surgeons: National

Surgical Quality Improvement Program [ACS-NSQIP]) on 1,843 patients undergoing CFE found an overall 15% risk of combined mortality/morbidity (3.4% mortality, 8% wound-related complications, 10% surgical take-backs).[65] They concluded that CFE was not as "benign" a procedure as has been previously believed.

Recently published evidence supports an endovascular-first approach to CFA disease with registry data reporting mortality/morbidity rates of ≤ 7.2%. [66] Long-term, 5-year follow-up of CFA stenting demonstrates a very favorable freedom from target lesion revascularization (TLR) of 79%. The Endovascular Versus Open Repair of the Common Femoral Artery (TECCO)" trial (ClinicalTrials.gov identifier NST01353651) randomized 117 patients comparing CFE to EVT for isolated CFA lesions. [67] The primary outcome, the morbidity and mortality rate within 30 days, occurred in 16 of 61 patients (26%) in the CFE group and 7 of 56 patients (12.5%) in the EVT group (odds ratio, 2.5; 95% CI, 0.9 to 6.6; P=0.05). The mean duration of hospitalization was significantly lower in the EVT group (3.2 ± 2.9 days versus 6.3 ± 3 days; p<0.0001). At 24-months, the sustained clinical improvement, the primary patency rate, and the target lesion and extremity revascularization rates were not different in the two groups. This trial demonstrates that for de-novo CFA lesions, EVT can achieve comparable two-year patency rates with CFE and offer significantly lower 30 day morbidity and mortality rates.

Clinical Considerations: Clinically relevant femoral-popliteal disease is defined as a ≥70% diameter stenosis. Moderate lesions are defined as 50%–69%, and mild lesions consist of <50% diameter stenosis. The severity and clinical impact of a lesion is also affected by its length, reference vessel diameter, arterial calcification, and quantity of atherosclerotic plaque (plaque burden). At this time, there are no published data regarding the use of translesional pressure gradients to assess the severity of femoral-popliteal PAD. [3]

An economic analysis was performed based upon National Institute for Health and Care

Excellence (NICE) guideline-recommended treatment of symptomatic femoral-popliteal artery disease with PTA and bailout BMS versus primary BMS placement, or DCB, or DES treatment. Over a 24 month period, the benchmark TLR for de novo lesions with PTA of 36.2% was reduced to 17.6% by DCB at a cost of £43 ($65), to 19.4% by DES at a cost of £44 ($67) and to 26.9% by BMS at a cost of £112 ($170). There was a cost-effective benefit for quality-adjusted of life year, with a small cost reduction in the price of DCB and DES making drug-eluting therapy preferable.[68] A cost-effectiveness analysis of the IN.PACT SFA II (IN.PACT Admiral Drug-Coated Balloon vs. Standard Balloon Angioplasty for the Treatment of Superficial Femoral Artery [SFA] and Proximal Popliteal Artery [PPA]) trial compared the DCB (IN.PACT Admiral DCB (Medtronic, Santa Rosa, California) used in the trial to standard PTA.[69] They concluded that for patients with femoral-popliteal disease, DCB angioplasty is associated with better 2-year outcomes and similar target limb–related costs compared with standard PTA. A formal cost-effectiveness analysis suggests that use of the DCB angioplasty is likely to be economically attractive. An important caveat is that the efficacy of DCB and DES, may not represent a "class effect", but that the dose of drug and/or excipient used to bind the drug may make uniquely affect each device's cost-effectiveness profile unique.[70]

Technical Considerations*:* There have been significant technological advances and further development of the evidence base for the treatment of femoral-popliteal arterial lesions since the original SCAI appropriate use document was published. [3,71] I

Drug-Coated Balloons (DCB): There have been several clinical trials involving DCBs in femoral-popliteal arteries since the 2014 SCAI AUC publication. Several RCTs involving the use of drug-coated balloons (DCB) have demonstrated significant improvement in vessel patency rates compared with PTA alone. [72-75] The IN.PACT SFA (Randomized Trial of IN.PACT Admiral Drug Eluting Balloon vs. Standard PTA for the Treatment of SFA and Proximal Popliteal Arterial Disease) trial[72] randomized a paclitaxel DCB (Medtronic, Santa Clara, CA) to an uncoated PTA balloon in

patients with femoral-popliteal PAD (mean lesion length of 8.94 ± 4.89 cm). Total occlusions were present in 25.8% of the DCB and 19.5% of the PTA groups (P=0.22). The DCB group had higher primary patency (82.2% vs. 52.4%; P<0.001) at 12 months and a very low rate of clinically driven TLR (2.4% in the DCB arm vs. 20.6% in the PTA arm; P<0.001). These benefits persisted at 24 months with higher primary patency (78.9% vs. 50.1%; P < 0.001) and lower rates of clinically driven TLR were 9.1% and 28.3% (P < 0.001).[76] A formal analysis based on the two-year results suggests a 70% to 80% likelihood that the DCB is an economically attractive strategy.[69]

Additional evidence supporting the use of DCBs in the femoral-popliteal segment comes from the LEVANT (Lutonix Paclitaxel-Coated Balloon for the Prevention of Femoropopliteal Restenosis) I and II trials, which used a different, lower-dose, paclitaxel DCB (Lutonix, Bard, Tempe, AZ). Both LEVANT studies confirmed the safety profile of this DCB and demonstrated improved patency at 12 months compared to PTA alone (65.2% vs. 52.6%; P=0.02). The proportion of patients free from primary safety events was 83.9% with the DCB and 79.0% with uncoated PTA (P = 0.005 for non-inferiority).

The THUNDER (Local Taxan With Short Time Contact for Reduction of Restenosis in Distal Arteries) trial[77] also investigated the treatment of femoral-popliteal arteries with a paclitaxel-coated balloon and recently reported the 5-year results.[78] At 5 years, the TLR rate (21% vs. 56%; P = 0.0005) favored DCB treatment versus PTA alone with no signs of drug-related local vessel abnormalities.

The use of DCBs prior to bare metal stenting also has been evaluated in the Drug Eluting Balloon in Peripheral Intervention for the Superficial Femoral Artery (DEBATE-SFA) trial[79] which randomized the use of a paclitaxel DCB vs. PTA for femoral-popliteal disease. In both groups, bailout stenting was performed with bare metal stents (BMS). In 104 patients (110 lesions) with a mean lesion length for DCB of 94±60 vs. 96±69 mm for PTA, the primary endpoint (one-year restenosis) was lower in the DCB group (17% vs. 47.3%); P = 0.008). Registry data supports the

effectiveness of DCBs in long femoral-popliteal disease (> 15 cm) reporting that 105 consecutive patients with RC 2 to 4 and a treated lesion length of 25 ± 7 cm obtained a one-year patency rate of 83.2% with only 11% requiring bailout stents. [80]

Drug-eluting stents (DES): The Zilver PTX DES (Cook Medical, Bloomington, IN) continues to show promise with data from real-world registries[81] and 5-year data from the randomized Zilver PTX trial also demonstrated continued safety and clinical durability in comparison with PTA.[82] This trial had a 2-stage randomization with initial randomization to DES (n=236) or PTA (n=238). Patients who were initially randomized to PTA (n=238) and experienced flow-limiting dissections and/or recoil requiring stenting then were secondarily randomized to provisional BMS (n=59) or DES (n=61). The remaining 118 patients (not randomized to DES or BMS) were in the standard care group. At 5 years, DES showed a significant clinical benefit compared to PTA alone for freedom from persistent or worsening symptoms of ischemia (79.8% versus 59.3%, P < 0.01), patency (66.4% versus 43.4%, P < 0.01), and freedom from TLR (83.1% versus 67.6%, P < 0.01). In patients who did undergo a second randomization to either DES or BMS, there was a sustained benefit of DES. At 5 years, the provisional DES recipients when compared to the BMS group had improved clinical benefit (81.8% versus 63.8%, P=0.02), patency (72.4% versus 53.0%, P=0.03), and freedom from TLR (84.9% versus 71.6%, P=0.06). These results represent a >40% relative risk reduction in restenosis and TLR through 5 years for the overall DES in comparison with standard care and for provisional DES in comparison with provisional BMS. The cost-effectiveness of DES for the treatment of femoral-popliteal PAD remains to be rigorously studied.

Covered Stents: Two randomized controlled trials, VIASTAR[83] (VIABAHN Endoprosthesis with Propaten Bioactive Surface versus Bare Nitinol Stent in the Treatment of Long Lesions in Superficial Femoral Artery Occlusive Disease) and VIBRANT[84] (VIABAHN Endoprosthesis versus Bare Nitinol Stent in the Treatment of Long Lesion (≥ 8 cm) Superficial Femoral Artery Occlusive Disease) have demonstrated an inconsistent patency advantage for covered stents compared to

self-expanding BMS in the femoral-popliteal territory.

The one-year patency in the VIASTAR group was 70.8% by intention to treat with no statistical advantage over the BMS group (55.1%, P = 0.11), but when analyzed by treatment received, the covered stent's 1-year patency was 78.1%, which was superior to BMS (53.5%, P = 0.009).[83] The patency rates for the covered stent fell considerably at two years (63.1%)[85] and even further at three years (24.2%).[84]

Non-Stent Options: There is no comparative evidence supporting directional, rotational or orbital atherectomy as a superior treatment to PTA alone in de-novo femoral-popliteal lesions. All studies to date involving these modalities have been registries and subject to limitations and bias inherent to single arm registries. In addition, debulking tools such as atherectomy and LASER carry a risk of distal embolization. Embolic protection devices are often used to decrease this potential complication. Additionally, operator experience and meticulous attention to technique is required with each of these devices to ensure the safety of the procedure. In the DEFINITIVE LE (Determination of EFfectiveness of the SilverHawk_ PerIpheral Plaque ExcisioN System (SIlverHawk Device) for the Treatment of Infrainguinal VEssels / Lower Extremities) registry, distal embolization occurred in 3.8% and arterial perforation occurred in 5.3% of cases.[86] A recent single-center study of femoral-popliteal patients undergoing directional atherectomy with the routine use of distal embolic protection demonstrated presence of macroemboli in 62% of patients.[87]

The treatment of femoral-popliteal in-stent restenosis (ISR) is exceptionally challenging due to high rates of reoccurrence. The Femoral Artery In-Stent Restenosis (FAIR) trial[88] randomized 119 patients with femoral-popliteal ISR to either DCB (n=62) or PTA (n=57). These lesions were short to intermediate in length (mean lesion length was 82.2±68.4 mm) with nearly 30% being occlusions and another 25% with moderate to severe vessel calcification. Based on duplex ultrasonography the primary end point of recurrent in-stent restenosis was 15.4% (8 of 52) in the DCB and 44.7% (21 of 47) in the PTA group (P = 0.002) at 6 months. DCB treated vessels had a

greater freedom from TLR (DCB 96.4% vs. 81.0% ; P =0.012) at 6 months and at 12 months (90.8% vs. 52.6%; P <0.0001). Clinical improvement, an improvement in Rutherford class by ≥ 1 without the need for TLR, was observed in 78% of the DCB patients vs. 52% of the PTA patients (P = 0.015) at one year.

For those patients presenting with ISR, several studies suggest that an initial strategy focused on debulking of the restenotic tissue may be helpful. LASER atherectomy was evaluated in two studies for the treatment of ISR, resulting in an FDA-approved indication for ISR. The Excimer LASER Randomized Controlled Study for Treatment of Femoropopliteal In-Stent Restenosis (EXCITE-ISR) trial[89] was a randomized controlled study of excimer LASER atherectomy (ELA) plus PTA versus PTA alone for femoral-popliteal ISR in 250 patients. The study was stopped early secondary to early efficacy demonstrated at the interim analysis. A total of 169 ELA plus PTA patients (62.7% male; mean age 68.5 ± 9.8 yr) and 81 PTA patients (61.7% male; mean age 67.8 ± 10.3 yr) were enrolled with a mean lesion length of 19.6±12.0 cm vs. 19.3±11.9 cm, respectively. One third of patients had chronic total occlusions. Those patients treated with ELA plus PTA demonstrated superior procedural success (93.5% vs. 82.7%; p=0.01) with significantly fewer procedural complications. Six-month freedom from TLR was 73.5% (ELA-PTA) vs. 51.8% (PTA) (p<0.005), and 30-day major adverse event rates were 5.8% vs. 20.5% (p<0.001), respectively. Overall, ELA+PTA was associated with a 52% reduction in TLR for the treatment of femoral-popliteal ISR.

Another trial[90] of ELA for the treatment of ISR involved CLI patients with occlusion of the femoral-popliteal segment secondary to ISR. These 48 patients were randomized to DCB vs. ELA+DCB. The results suggest that debulking of the ISR tissue prior to the use of DCB was beneficial in this challenging patient population. In the ELA + DCB group, the patency rates at 6 and 12 months (91.7% and 66.7%,) were significantly higher (p=0.01) than in the DCB only patients (58.3% and 37.5%, respectively). TLR at 12 months was 16.7% in the ELA + DEB group and 50% in

the DEB only group (p=0.01).

Infra-Popliteal Interventional Update (Table 6)

Introduction: Revascularization of infra-popliteal PAD is generally limited to those patients presenting with critical limb ischemia (CLI) where in-line flow to the foot is the standard of care for wound healing and/or resolution of rest pain. [91] In general, non-ambulatory patients with a shortened life expectancy and extensive lower extremity tissue necrosis should undergo primary amputation at the lowest level possible to ensure healing of the surgical site. Patients who have the opportunity to regain ambulatory function should undergo non-invasive testing with an ankle-brachial index (ABI), toe-brachial index (TBI), or other modalities such as $TcPO_2$ or skin perfusion pressure. However, the ABI ,may be normal or non-compressible in approximately 30% of patients with isolated infrageniculate disease. [92,93] In these individuals, non-invasive modalities such as magnetic resonance angiography (MRA) or computed tomographic angiography (CTA) may be necessary. However, in most cases digital subtraction angiography (DSA) is the gold standard to visualize the extent of lower extremity arterial disease including foot and pedal arch. [27]

Anatomic Considerations: Patients with CLI typically have disease involving multiple levels (i.e., aorto-iliac, femoral-popliteal and infra-popliteal), but less than 10% of patients with CLI have hemodynamically significant disease at all three levels. The updated 2015 TASC document includes, for the first time, an anatomic classification for infra-popliteal atherosclerotic disease (Figure 4).[33] Infrainguinal PAD can be further subdivided into those with predominantly isolated infra-popliteal disease (~33%) and those with both femoral-popliteal and infra-popliteal disease (~67%).[94-97] Isolated infra-popliteal disease is mainly seen in the elderly (>80 years old), diabetic, or patients with advanced stages of chronic kidney disease.[95] This arterial bed consists of relatively small caliber arteries, which are often calcified and associated with diffuse, multi-segment disease.[4]

These patients are at higher risk for amputation and have a shorter amputation-free survival (AFS) compared to those with combined femoral-popliteal and infra-popliteal disease.[96] Prior to considering infra-popliteal intervention, all hemodynamically significant inflow disease should be treated to normalize inflow to the infra-popliteal circulation. Then, if deemed clinically necessary, one may proceed with revascularization of the infra-popliteal disease.

However, even if major amputations are avoided, complete wound healing may be elusive with inframalleolar disease. Recent evidence shows that delayed, and/or incomplete wound healing adversely affects quality of life and social rehabilitation. Several trials have also demonstrated the negative influence of inframalleolar disease on wound healing rates.[98 99]

Clinical Considerations: Patients with infra-popliteal disease and claudication should be preferentially treated with cilostazol (if a candidate), a supervised exercise program, and guidelines-based anti-atherosclerotic medical therapy, before considering a revascularization procedure. The most recent ACC/AHA guidelines emphasize this with a class IIb level of evidence (LOE) C (limited data (LD)) stating that "The usefulness of endovascular procedures as a revascularization option for patients with claudication due to isolated infra-popliteal artery disease is unknown".[27]

Infra-popliteal EVT is generally reserved for patients with CLI. For patients with claudication, only moderate to severe (≥50% diameter stenosis) lesions and multivessel tibial disease (≥ 2 tibial vessels) should be considered for revascularization. The goals of therapy for CLI patients (Rutherford 4–6) with infra-popliteal arterial disease include: relieving pain, healing ulcerations, preventing major amputation, improving the patient's QOL, and prolonging survival.[4] Angiographically, severe infra-popliteal stenosis is defined as a luminal diameter stenosis of ≥70% in at least one infra-popliteal artery.[96,100,101] Moderate stenosis is defined as a luminal reduction of 50–69% and mild stenosis is defined as a luminal reduction of <50%. Obstructive disease in the

below-knee popliteal artery limits blood flow to the three tibial vessels (anterior, posterior and peroneal) and is equivalent to three vessel disease, while narrowing of the tibioperoneal trunk affects two tibial arteries (peroneal and posterior tibial) and is equivalent to two-vessel disease. A focal infra-popliteal lesion is a discrete area of narrowing ≤ 4 cm long. An intermediate infra-popliteal lesion is a continuous segment of disease >4 to 10 cm long. A diffuse infra-popliteal lesion is a continuous segment of disease >10 cm long..[64]

Infra-popliteal intervention procedural success is commonly defined as the re-establishment of direct "in-line" pulsatile flow to the foot. It is currently unknown whether healing rates are improved when in-line flow to the foot is established through more than one artery, but maximizing blood flow through more than one artery is particularly attractive in patients with inadequate collateral circulation, disease of the plantar arch vessels, or limb-threatening ischemia.[4]

An angiosome is a vascular territory supplied by a specific source artery and was a principle originating from the plastic surgery literature. This concept is based on areas of the foot (angiosomes) identified by injection of dye into cadaveric lower limbs without arterial insufficiency and therefore does not take into consideration any collateral circulation which is often present in CLI patients. There remains uncertainty regarding the value of angiosome-guided revascularization with some studies finding no correlation between the angiosome-directed concept and lower limb revascularization outcomes.[102-104] and other studies showing improved healing rates when compared to revascularization of the non-angiosome territory, particularly if there is poor pedal arch collateralization.[99,105-107] In a small retrospective report, direct revascularization (angiosome based) versus indirect revascularization with good collateral circulation had similar outcomes whereas, indirect revascularization with poor collateral circulation fared the worst.[108] However, realistically the angiosome-based revascularization strategy may be limited by the length and/or complexity of underlying disease, the extent of collateralization, and the anatomic variability among patients, including anatomic anomalies.[95]

The cost-effectiveness of infra-popliteal intervention is difficult to ascertain without robust randomized data. Using a Markov simulation model, Barshes and colleagues examined various treatment strategies for patients with CLI and compared these to wound care plus amputation as needed.[109] They determined that endovascular intervention and surgical bypass with endovascular revision as needed were more effective and less costly than wound care with or without amputation as long as the initial wound healing rates were ~50% and ~70%, respectively. The relative cost-effectiveness of an endovascular or surgical-first strategy is being determined in the ongoing BEST-CLI trial.[110]

Technical Considerations: When focal disease of the infra-popliteal arteries required intervention, stenting with a coronary balloon expandable BMS stents was the primary revascularization strategy.[111] PTA with bail-out stenting for an unsatisfactory PTA result with a self-expanding stent, has been compared to primary stenting with a self-expanding BMS in the EXPAND (Primary Self-EXPANDing Nitinol Stenting vs Balloon Angioplasty With Optional Bailout Stenting for the Treatment of Infra-popliteal Artery Disease in Patients With Severe Intermittent Claudication or Critical Limb Ischemia) study.[112] Ninety-two patients with infra-popliteal PAD and severe claudication or CLI were randomized 1:1 to either primary or provisional stenting with a self-expanding nitinol stent (Astron Pulsar/Pulsar-18 nitinol stent, Biotronik, Lake Oswego, OR)). There was no difference in clinical improvement (74.3% versus 68.6%, freedom from TLR (76.6% and 77.6%), mortality (7.4% versus 2.1%), or amputation [8.9% (major 6.7%) versus 13.2% (major 8.7%) all (P>0.05)] at one year for primary versus provisional stenting with a self-expanding BMS.

Drug-Eluting Stents (DES): There have been five randomized trials[113-118] and several meta-analyses [119-123] analyzing outcomes of infra-popliteal DES versus either PTA, BMS, or DCB. The ACHILLES[124] (Comparing Angioplasty and DES in the Treatment of Subjects With Ischemic Infra-popliteal Arterial Disease) trial randomized 200 patients with infra-popliteal disease to PTA or DES

(Cypher Select Sirolimus Eluting Stent, Cordis, Bridgewater, NJ, USA) and found superior patency rates at 1 year for the DES group (DES 75% versus PTA 57.1%, P = 0.025). At 6 months, there was better wound healing with DES versus PTA (95% healing versus 60% healing, P = 0.048), but at 1 year, the rates of complete wound closure with DES versus PTA (72.9% versus 55.6%; p = 0.088, respectively) were not different. The QOL score improved significantly up to 1 year in the DES cohort (P < 0.0001), but not with the PTA group. There was a trend of more QALYs gained with DES compared with PTA up to 1 year after randomization. For patients with total lesion lengths < 120 mm, the 1-year restenosis rate for DES over PTA were 22.4% versus 41.9%, (P = 0.019) a difference that was even larger for diabetics (DES: 17.6% versus PTA: 53.2%, P < 0.001) who constitute the majority of patients with peripheral infra-popliteal disease. There was no difference between the PTA or DES groups for death, amputation rates, or improved functional status.

The DESTINY[100] (Drug-Eluting Stents in the Critically Ischemic Lower Leg) study randomized 140 de novo CLI patients (RC 4,5) with infra-popliteal disease comparing BMS (Multi-LinkVision, Abbott Laboratories, Abbott Park, IL, USA) to DES (Xience V, Abbott Laboratories, Abbott Park, IL, USA). Over 12 months of follow up, there was no difference for the percentage of patients with good functional outcomes (RC 0-1) between DES (60%) and BMS (56%) at 1 year, and there were very few amputations. DES had superior patency (DES 85% versus BMS 54%, P = 0.0001) and freedom from TLR (DES 91% versus BMS 66%, p=0.001). [113]

The YUKON-BTX (YUKON-Drug-Eluting Stent Below the Knee) trial[125] randomized 161 patients with severe claudication and CLI to infra-popliteal treatment with BMS or DES (Sirolimus eluting YUKON stent, Translumina, Hechingen, Germany)[125]. Primary patency at 1 year for the DES group was 80.6% versus 55.6% with BMS (P = 0.004). At three years of follow-up there was significant clinical benefit for the DES group for event-free survival (DES 65.8% versus 44.6% for BMS, P = 0.02), reduced amputation rates (DES 2.6% versus BMS 12.2%, P = 0.03) and TLR rates (DES 9.2% versus BMS 20% (P = 0.06).[117]

The IDEAS (Infra-popliteal Drug- Eluting Angioplasty Versus Stenting) Randomized Controlled Trial[115] compared a paclitaxel DCB (IN.PACT Amphirion (Medtronic, Brescia, Italy) to DES in long (>70 mm) infra-popliteal lesions in patients with Rutherford classes 3 to 6. Fifty patients were randomized to infra-popliteal DCB angioplasty (25 arteries in 25 limbs; PCB group) or primary DES placement (30 arteries in 27 limbs; DES group). At 6 months, the angiographic restenosis rate was significantly lower in DES (28% versus 57.9% in DCB; p = 0.046). There were no significant differences with regard to TLR (7.7% in DES versus 13.6% in DCB; p = 0.65). In this comparison for longer below knee lesions, DES were associated with significantly reduced restenosis rates at 6 months compared to DCB.

The PADI (Percutaneous transluminal Angioplasty versus Drug eluting stents for Infra-popliteal lesions) trial was designed to compare the performance of paclitaxel-eluting DESs and PTA-BMS of infra-popliteal lesions in a population consisting solely of CLI patients. [118] Recently, the five-year follow data were published confirming the long-term advantage of coronary paclitaxel DES over a PTA with provisional BMS stenting (PTA-BMS) for RC class ≥4 patients with infra-popliteal lesions. The 5-year clinical outcomes of amputation and event-free survival (survival free from major amputation or reintervention) the DES arm was superior to the PTA-BMS group (31.8% versus 20.4%, P=0.043; and 26.2% versus 15.3%, P=0.041, respectively). Survival rates were comparable. The results showed higher preserved patency rates after DESs than after PTA-BMS at 1, 3, and 4 years of follow-up. These data, including several meta-analyses, provide convincing evidence (Class 1, LOE B) favoring infra-popliteal DES over PTA and BMS for 1) improved patency, 2) reduced re-interventions, 3) reduced amputation, and 4) improved event-free survival. [117,119-123]

Drug-Coated Balloons: The evidence supporting the use of DCB for infra-popliteal lesions is less certain. The DEBATE-BTK[79] (Drug-Eluting Balloon in Peripheral Intervention for Below the Knee Angioplasty Evaluation) trial randomized 158 infra-popliteal lesions in diabetic patients with CLI to either DCB (In.Pact Amphirion, Medtronic, Minneapolis, MN, USA) or PTA. The mean lesion

length was 129 ± 83 mm, significantly (~100 mm) longer than those in the infra-popliteal DES randomized trials. The primary endpoint, restenosis at 1 year occurred in 27% of DCB and 74.3% of PTA groups (P < 0.001). Twelve-month major adverse events occurred less frequently in the DCB (31%) than in the PTA (51%) group (p=0.02), driven mainly by a reduction in TLR and improved ulcer healing. However, there was no difference in the rate of amputation, limb salvage, or mortality between the groups.

The In.Pact Deep CLI trial[126] DCB resulted in this balloon (In.Pact Amphirion, Medtronic, Minneapolis, MN, USA) being withdrawn from the market worldwide by the sponsor. The trial enrolled 358 CLI patients with infra-popliteal lesions and randomized them 2:1 to DCB and PTA, respectively. The primary efficacy endpoints were not different for 1) 12-month late lumen loss for the DCB (0.61 ± 0.78 mm) group or the PTA (0.62 ± 0.78, p=0.95) group, and 2) the clinically driven TLR for the DCB (17.7%) group or the PTA (15.8%, p=0.66) group. There was a non-significant trend toward higher amputation rates in the DCB (8.8%) compared to the PTA group (3.6%, P=0.08).

There are no data to suggest that procedures on infra-popliteal arteries should be performed to prevent CLI. This is confirmed in the recent ACC/AHA guidelines that state: "Endovascular procedures should not be performed in patients with PAD solely to prevent progression to CLI." [54] This is based on data showing that though feared, the rate of progression to CLI and/or amputation remains relatively low. [127-129]

Conclusion

The Society of Cardiovascular Angiography and Interventions, conducted an appropriate use review of common clinical presentations for PAD to determine the appropriateness for devices and strategies for revascularization. This document summarizes new information updating the prior AUC documents published for aorto-iliac, femoral-popliteal, infra-popliteal and renal arterial

circulation.[1-4] The intent is to improve clinical decision making by practitioners, to improve our patients' understanding of the potential risks and benefits of intervention, and to provide interventionalists with an updated review of the current literature regarding the most recent advances in the field of EVT.

Figure Legends:

Figure 1: Upper panel: Peak Walking Time (PWT): Patients with 18-month follow-up visit only. Lower panel: Claudication Onsent Time (COT): Patients with 18-month follow-up visit only. (Figure 1 reproduced with permission)[57]

Figure 2: Trans-Atlantic Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC) classification of aortoiliac lesions. AAA, abdominal aortic aneurysm CFA, common femoral artery; CIA, common iliac artery; EIA, external iliac artery (Figure 1, reproduced with permission).[33]

Figure 3: Trans-Atlantic Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC) classification of femoral popliteal lesions. CFA, common femoral artery; SFA, superficial femoral artery (Figure 2, reproduced with permission). [33]

Figure 4. Trans-Atlantic Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC) classification of infra-popliteal lesions. The unshaded area represents the target lesion; area inside the shaded rectangle represents typical background disease (Figure 3, reproduced with permission).[33]

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Table 1. Assessing Renal Artery Stenosis Significance

Angiographic Stenosis Severity*	Physiologic Testing	Significance
<50%	None	Mild
50-70%	None	Indeterminate
50-70% with	Resting or hyperemic mean pressure gradient** ≥10mmHg	Significant
50-70% with	Resting or hyperemic systolic Pressure Gradient ≥20mmHg†	Significant
50-70% with	Renal Pd/Pa ≤ 0.8†	Significant
≥70%	None	Significant

* = visual estimation. ** = translesional gradient measured with a non-obstructive catheter, ie ≤ 4 fr or with an 0.014-in pressure wire (Pd/Pa). † Hyperemia may be induced with intrarenal bolus of papaverine 30mg or dopamine at 50μg/kg. Excludes patients who have been on hemodialysis ≥ 3 months and those with non-viable kidneys, i.e. a pole to pole length of ≤ 7 cm.

Table 2

RENAL INTERVENTIONAL SCENARIOS	AUC
Cardiac Disturbance Syndromes (Flash Pulmonary Edema or acute coronary syndrome (ACS)) with [illegible]	9
CKD IV bilateral moderate RAS with a resting mean translesional gradient of ≥ 10 mmHg with kidney size > 7 cm in pole-to-pole length.	8
CKD IV and global renal ischemia (unilateral severe RAS with a solitary kidney or bilateral severe RAS) without other explanation.	7
Resistant HTN (uncontrolled hypertension having failed maximally tolerated doses of at least three antihypertensive agents, one of which is a diuretic) and bilateral or solitary severe RAS.	7
Resistant HTN (uncontrolled hypertension having failed maximally tolerated doses of at least three [illegible]	6
CKD IV and unilateral moderate RAS with a resting translesional mean gradient of ≥ 10 mm Hg without other explanation.	6
Recurrent CHF with unilateral moderate RAS with a resting translesional mean gradient of ≥ 10 mmHg.	5
CKD class II with bilateral severe RAS.	5
CKD class III, stable for 1 year, with bilateral severe RAS.	5
Resistant HTN (uncontrolled hypertension having failed maximally tolerated doses of at least three antihypertensive agents, one of which is a diuretic) with severe unilateral RAS and anatomically challenging or high risk lesion (early bifurcation, small vessel, severe concentric calcification, and severe aortic atheroma or mural thrombus).	4
Resistant HTN (uncontrolled hypertension with failure of maximally tolerated doses of at least three antihypertensive agents, one of which is a diuretic, or intolerance to medications) and unilateral moderate (50% [illegible]	3
CKD III progressing to CKD IV over 6 months with solitary, severe RAS, with kidney size < 7 cm in pole-to-pole length.	3
Resistant HTN (uncontrolled hypertension having failed maximally tolerated doses of at least three antihypertensive agents, one of which is a diuretic) with unilateral chronic total occlusion of the renal artery.	2
BP ≥ 150/100 mmHg on two medications (one a diuretic) with severe unilateral RAS.	2
BP ≥ 150/100 mmHg on a single anti-hypertensive medicine with severe unilateral RAS.	2
Solitary severe RAS with controlled BP and normal renal function.	2
Bilateral severe RAS with controlled BP and normal renal function.	2
CKD III progressing to CKD IV over 6 months with unilateral, severe RAS with kidney size < 7 cm in pole-to-pole length.	2
CKD class II with unilateral severe RAS.	2
Bilateral severe RAS with controlled BP and normal renal function.	2
Bilateral severe RAS with chronic end stage renal disease on hemodialysis >3 months.	2
Unilateral severe RAS with controlled BP and normal renal function.	1

ACS = acute coronary syndrome; AUC = appropriate use criteria; BP = blood pressure; CHF = congestive heart failure; CKD = chronic kidney disease; RAS = renal artery stenosis. Hemodynamically significantmoderate RAS = 50% to 70% diameter stenosis with a resting or hyperemic mean translesional gradient of ≥ 10 mmHg, or a resting or hyperemic peak translesional gradient of ≥ 20 mmHg measured with a small diameter catheter or pressure wire. A severe RAS ≥ 70% diameter stenosis by visual estimation.

Table 3. Summary of AHA/ACC Guideline recommendations for renal intervention [9].

Resistant Hypertension	Ischemic Nephropathy	Cardiac Disturbances
RAS with accelerated, resistant, or malignant hypertension, hypertension with unilateral small kidney, and hypertension with medication intolerance. (Class IIa, LOE B).	CKD with bilateral significant RAS or RAS of a solitary kidney (Class IIa; LOE B).	Hemodynamically significant RAS with recurrent unexplained heart failure or sudden explained pulmonary edema. (Class I, LOE B)
	CKD with unilateral significant RAS (Class IIb; LOE B)	RAS with unstable angina. (Class IIa, LOE B)
	Asymptomatic unilateral, bilateral, or a solitary viable kidney with hemodynamically significant RAS. (Class IIb; LOE C)	

RAS = renal artery stenosis; CKD = chronic kidney disease; LOE = level of evidence

Table 4

AORTO-ILIAC INTERVENTIONAL SCENARIOS	Mean	Appropriate
Provisional or primary stenting for significant ≥ 50% aorto-iliac arterial disease in a patient who requires vascular access for another device (e.g., mechanical circulatory support, or TAVR).	8	
Provisional or primary stenting for aorto-iliac stenosis < 50%.	2	
Claudication (RC 2-3)		
Provisional or primary stenting for distal abdominal aorta or common iliac artery (CIA)) with ≥ 50% stenosis and/or resting mean or hyperemic translesional gradient ≥ 10 mmHg after having failed pharmacologic and supervised exercise therapy.	9	
Provisional or primary stenting for external iliac artery (EIA) ≥ 50%stenosis and/or resting mean or hyperemic translesional gradient ≥ 10 mmHg after having failed pharmacologic and supervised exercise therapy.	9	
Provisional or primary stenting for aorto-iliac artery stenosis ≥50% and/or resting mean or hyperemic translesional gradient ≥ 10 mmHg without having failed pharmacologic and supervised exercise therapy.	6	
Provisional or primary stenting for internal iliac artery with ≥50% stenosis and/or resting mean or hyperemic translesional gradient ≥ 10 mmHg.	5	
Critical Limb Ischemia (RC 4-6)		
Provisional or primary stenting for distal abdominal aorta or common iliac artery (CIA)) with ≥50% stenosis and/or resting mean or hyperemic translesional gradient ≥10 mmHg.	9	
Provisional or primary stenting for external iliac artery (EIA) ≥50%stenosis and/or resting mean or hyperemic translesional gradient ≥ 10 mmHg.	9	
DeNovo ≥ 50% -70% stenosis with ≥ 10mm Hg resting or hyperemic gradient or a severe stenosis (> 70% diameter stenosis) and an Aorto-Iliac lesion (RC 2-6).		
PTA: Focal	8	
BMS: Diffuse	8	
BMS: CTO	8	
BMS: Focal	8	
Covered stent: CTO	7	
Covered stent: Diffuse	7	
Endovascular-first strategy for TASC D lesions (RC 2-6).	7	
Provisional or primary stenting for internal iliac artery ≥50% stenosis with vasculogenic impotence.	5	
PTA: Diffuse	5	
PTA: CTO	4	
DCB: Focal	6	
DCB: Diffuse	5	
DCB: CTO	5	
DES: Focal	5	
DES: Diffuse	6	
DES: CTO	5	
Covered stent: Focal	5	

AORTO-ILIAC INTERVENTIONAL SCENARIOS	Mean	Appropriate
0% -70% stenosis with ≥ 10mm Hg resting or hyperemic gradient or a severe		
[illegible]	[illegible]	[illegible]
l stent: CTO	8	
l stent: Focal	7	
ɔcal	7	
ffuse	7	
ΓO	7	
cal	6	
fuse	5	
'O	4	
ɔcal	6	
ffuse	6	
ΓO	6	
cal	6	
ffuse	6	
'O	6	
tomy:	3	

Table 5

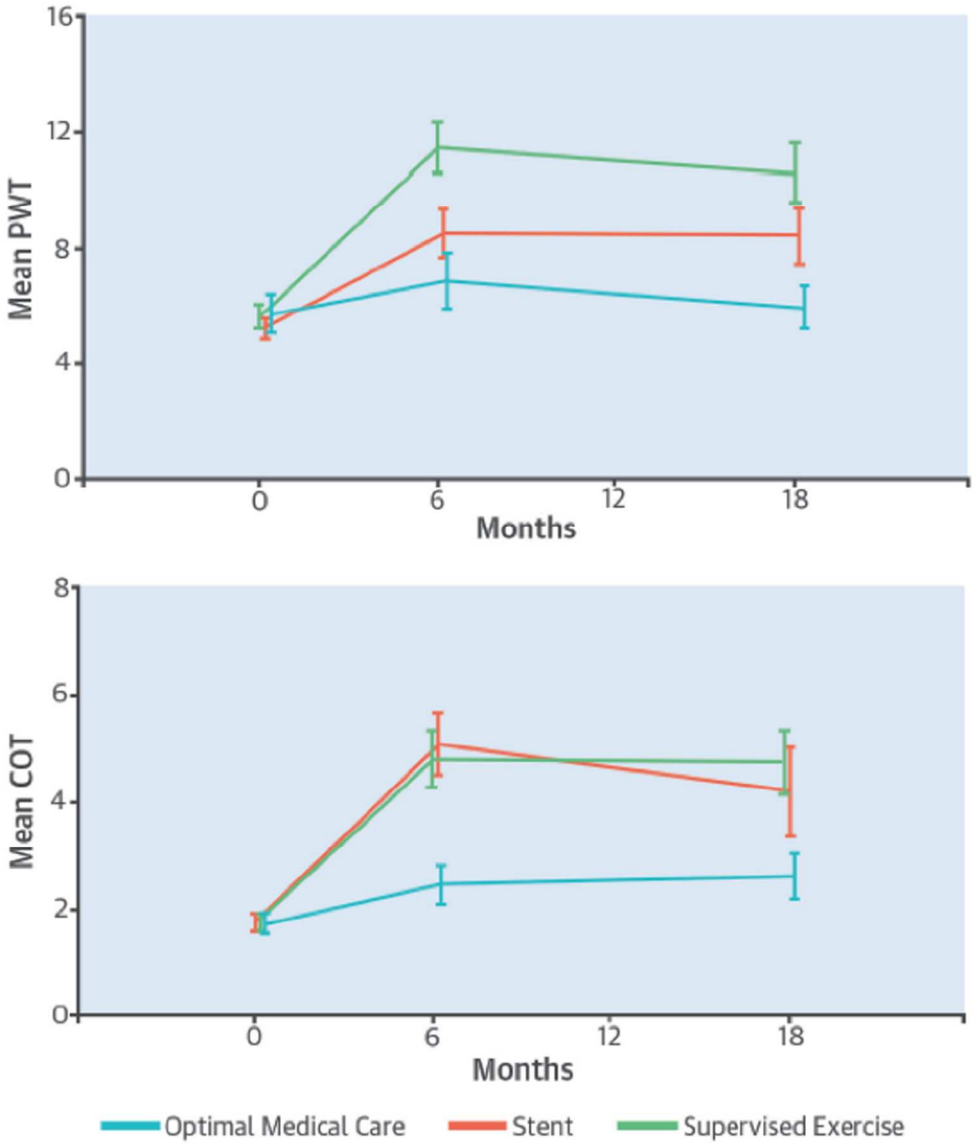
	PTA	BMS	DES	DCB	LASER	Directional Atherec	Rotational atherec	Cutting B
RC 0-1, severe (≥70%) FP diffuse lesion.	2	1	1	2	1	1	1	1
RC 0-1, severe (≥70%) FP, ISR.	2	1	2	2	1	1	1	1
RC 0-1, FP, CTO.	2	1	1	1	1	1	1	1
RC 0-1, severe (≥70%), FP, focal undilatable lesion.	1	1	1	1	1	1	2	2
RC 2-3, severe (≥70%) FP disease, focal lesion.	7	7	7	8	3	4	3	1
RC 2-3, severe (≥70%) FP, moderate lesion.	6	7	8	8	4	3	2	1
RC 2-3, severe (≥70%) FP diffuse lesion.	4	6	7	8	4	3	3	1
RC 2-3, severe (≥70%), FP, ISR.	4	5	7	8	7	3	3	3
RC 2-3, FP, CTO.	3	6	8	8	5	3	3	3
RC 2-3, severe (≥70%), FP, focal undilatable lesion.	2	2	2	2	6	3	8	7
RC 4-6, severe (≥70%) FP disease, focal lesion.	7	7	7	8	3	4	3	1
RC 4-6, severe (≥70%) FP moderate lesion.	5	7	8	8	4	3	3	1
RC 4-6, severe (≥70%) FP diffuse lesion.	4	7	8	8	4	3	3	1
RC 4-6, severe (≥70%), FP, ISR.	4	6	7	8	7	3	3	3
RC 4-6, FP, CTO.	3	6	8	8	5	3	3	3
RC 4-6, severe (≥70%), FP, focal undilatable lesion.	2	2	2	2	5	3	8	8

* = Rotational Atherectomy is defined as atherosclerotic plaque ablation achieved by devices such as the rotablator and orbital atherectomy among others that spin along their longitudinal axis. BMS = bare metal stent; CTO = chronic total occlusion; DCB = drug coated balloon; DES = drug eluting stent; FP = femoral-popliteal; ISR = in-stent restenosis; LASER - light amplification by stimulated emission of radiation; PTA = percutaneous transluminal angioplasty. RC = Rutherford classification. With the exception of patients with vocational limiting claudication, moderate to severe claudication should be preferentially treated pharmacologically and a walking program before considering any revascularization procedure. The clinical scenarios assume that moderate to severe claudication has been refractory to pharmacologic and exercise therapy.

Table 6

	PTA	BMS	DES	DCB	LASER	Directional atherec	Rotational atherec*	Cutting
RC 0-1, severe (≥70%) two-vessel IP disease, moderate length stenosis.	1	1	1	1	1	1	1	1
RC 0-1, severe (≥70%) three-vessel IP disease, moderate length stenosis.	1	1	1	1	1	1	1	1
RC 0-1, severe (≥70%) two-vessel IP disease, diffuse stenosis.	1	1	1	1	1	1	1	1
RC 0-1, severe (≥70%) three-vessel IP disease, diffuse stenosis.	1	1	1	1	1	1	1	1
RC 0-1, severe (≥70%) ISR.	1	1	1	1	1	1	1	1
RC 0-1, severe (≥70%) CTO.	1	1	1	1	1	1	1	1
RC 0-1, severe (≥70%) undilatable lesion.	1	1	1	1	1	1	1	1
RC 2-3, severe (≥70%) two-vessel IP disease, focal stenosis.	5	2	7	2	1	2	1	1
RC 2-3, severe (≥70%) three-vessel IP disease, focal stenosis.	6	3	7	3	1	2	2	1
RC 2-3, severe (≥70%) two-vessel IP disease, moderate length stenosis.	5	3	5	3	1	2	1	1
RC 2-3, severe (≥70%) three-vessel IP disease, moderate length stenosis.	6	3	5	3	1	2	1	1
RC 2-3, severe (≥70%) two-vessel IP disease, diffuse stenosis.	5	2	4	3	2	2	2	2
RC 2-3, severe (≥70%) three-vessel IP disease, diffuse stenosis.	5	2	5	3	2	2	2	2
RC 2-3, severe (≥70%) ISR.	7	3	7	4	6	2	2	2
RC 2-3, severe (≥70%) CTO.	7	4	8	4	4	3	3	2
RC 2-3, severe (≥70%) undilatable lesion.	1	2	2	2	5	3	7	7
RC 4-6, severe (≥70%) two-vessel IP disease, focal stenosis.	8	4	7	4	2	3	2	2
RC 4-6 severe (≥70%) three-vessel IP disease, focal stenosis.	8	4	8	4	2	3	2	2
RC 4-6, severe (≥70%) two-vessel IP disease, moderate length stenosis.	7	3	7	4	2	2	2	1
RC 4-6, severe (≥70%) three-vessel IP disease, moderate length stenosis.	8	3	7	4	2	2	2	1
RC 4-6, severe (≥70%) two-vessel IP disease, diffuse stenosis.	7	3	6	4	4	3	3	2
RC 4-6 severe (≥70%) three-vessel IP disease, diffuse stenosis.	8	3	5	4	4	3	3	2
RC 4-6, severe (≥70%) ISR.	7	3	7	4	6	2	1	2
RC 4-6, severe (≥70%) CTO.	7	4	7	4	4	2	2	2
RC 4-6, severe (≥70%) undilatable lesion.	1	2	2	1	5	3	8	8

* = Rotational Atherectomy is defined as atherosclerotic plaque ablation achieved by devices such as the rotablator and orbital atherectomy among others that spin along their longitudinal axis. BMS = bare metal stent; CTO = chronic total occlusion; DCB = drug coated balloon; DES = drug eluting stent; FP = femoral-popliteal; ISR = in-stent restenosis; LASER - light amplification by stimulated emission of radiation; PTA = percutaneous transluminal angioplasty. RC = Rutherford classification. With the exception of patients with vocational limiting claudication, moderate to severe claudication should be preferentially treated pharmacologically and a walking program before considering any revascularization procedure. The clinical scenarios assume that moderate to severe claudication has been refractory to pharmacologic and exercise therapy.



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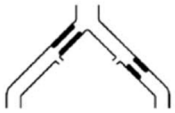
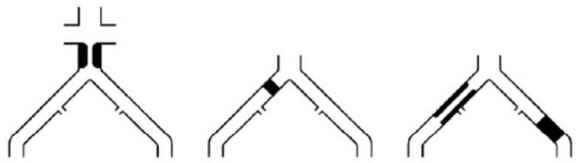
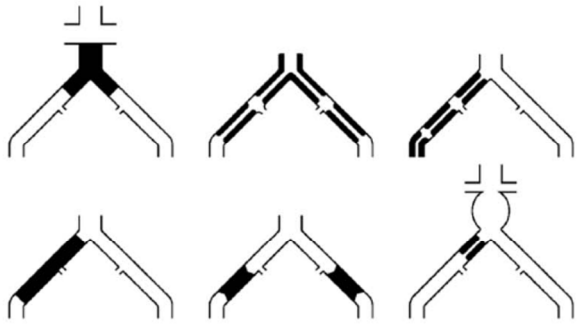
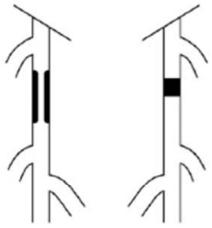
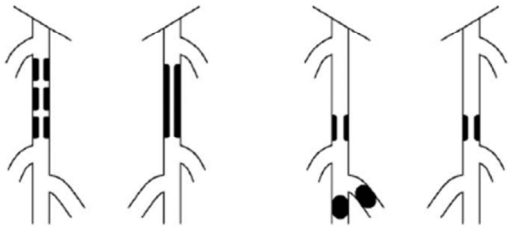
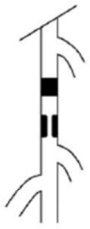
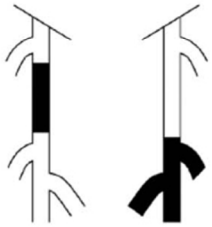
TASC A lesions • Unilateral or bilateral CIA stenoses • Unilateral or bilateral single short (≤3 cm) EIA stenosis	
TASC B lesions • Short (≤3 cm) stenosis of the infrarenal aorta • Unilateral CIA occlusion • Single or multiple stenosis totaling 3 to 10 cm involving the EIA not extending into the CFA • Unilateral EIA occlusion not involving the origins of the internal iliac or CFA	
TASC C lesions • Bilateral CIA occlusions • Bilateral EIA stenoses 3 to 10 cm long not extending into the CFA • Unilateral EIA stenosis extending into the CFA • Unilateral EIA occlusion involving the origins of the internal iliac and/or CFA • Heavily calcified unilateral EIA occlusion with or without involvement of the origins of the internal iliac and/or CFA	
TASC D lesions • Infrarenal aortoiliac occlusion • Diffuse disease involving the aorta and both iliac arteries • Diffuse multiple stenoses involving the unilateral CIA, EIA, and CFA • Unilateral occlusions of both CIA and EIA • Bilateral EIA occlusions • Iliac stenoses in patients with AAA not amenable to endograft placement	

369x358mm (266 x 266 DPI)

TASC A lesions • Single stenosis ≤10 cm in length • Single occlusion ≤5 cm in length	
TASC B lesions • Multiple lesions (stenoses or occlusions), each ≤5 cm • Single stenosis or occlusion ≤15 cm not involving the infrageniculate popliteal artery • Heavily calcified occlusion ≤5 cm in length • Single popliteal stenosis	
TASC C lesions • Multiple stenoses or occlusions totaling >15 cm with or without heavy calcification • Recurrent stenoses or occlusions after failing treatment	
TASC 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	

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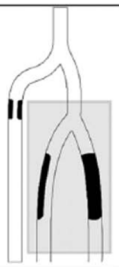
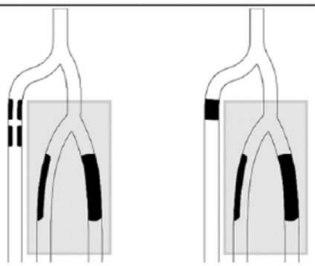
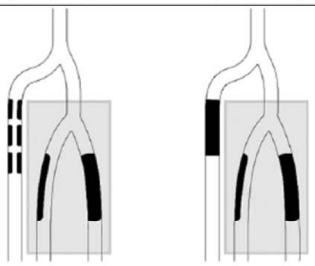
TASC A lesions Single focal stenosis, ≤5 cm in length, in the target tibial artery with occlusion or stenosis of similar or worse severity in the other tibial arteries.	
TASC B lesions Multiple stenoses, each ≤5 cm in length, or total length ≤10 cm or single occlusion ≤3 cm in length, in the target tibial 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.	

371x397mm (266 x 266 DPI)

Author_RWI

Author	Consultant	Speaker's Bureau	Ownership/ Stock Owner/ Shareholder	Grants or Research Support	Salary	Institutional or Organizational	Expert Witness	Advisory Board/Member
Andrew J. Klein, MD, FSCAI	none	none	none	none	none	none	none	none
Michael R. Jaff, DO, FSCAI	Abbott Vascular		Embolitech					
	Boston Scientific		PQ Bypass					
	Cordis	none	Vascular Therapies	none	none	none	none	Micell
	Medtronic		none					
	American Orthotics and Prosthetics Assoc.		none					
Bruce H. Gray, DO, FSCAI	none	none	none	none	none	none	none	none
Herbert D. Aronow, MD, MPH, FSCAI	none	none	none	none	none	none	none	none
Robert M. Bersin, MD, MPH, FSCAI	Abbott Vascular	Abbott Vascular	none	none	none	none	none	none
	none	none	Ablative Solutions	none	none	none	none	none
	Cardinal Health	none	none	none	none	none	none	Cardinal Health
	Cook Medical	none	none	none	none	none	none	none
	Endologix Corp	none	none	none	none	none	none	none
	none	none	Med Alliance SA	none	none	none	none	Med Alliance SA
	Medtronic	none	none	none	none	none	none	none
	none	none	Omeros Corp	none	none	none	none	none
	none	none	QT Vascular	none	none	none	none	none
	Spectranetics Corp	none	none	none	none	none	none	none
	Transverse Medical	none	Transverse Medical	none	none	none	none	Transverse Medical
	none	none	Vatrix Medical	none	none	none	none	none
	W. L. Gore	none	none	none	none	none	none	none
Larry J. Diaz-Sandoval, MD, FSCAI	Medtronic	none	none	none	none	none	none	none
	CSI	none	none	none	none	none	none	none
	Bard	none	none	none	none	none	none	none
	Abbott Vascular	none	none	none	none	none	none	none
	Terumo	none	none	none	none	none	none	none
	Spectranetics Corp	none	none	none	none	none	none	none
	Phillips-Volcano	none	none	none	none	none	none	none
Robert S. Dieter, MD, RVT, FSCAI	none	none	none	none	none	none	none	none
Douglas Drachman, MD, FSCAI	Abbott Vascular	none	none	none	none	none	none	none
	St. Jude Medical	none	none	none	none	none	none	none
	Corindus Vascular Robotics	none	none	none	none	none	none	none
	none	none	none	Atrium Medical	none	none	none	none
	none	none	none	Bard/Lutonix	none	none	none	none
Dmitriy N. Feldman, MD, FSCAI	none	none	none	none	none	none	none	none
Osvaldo S. Gigliotti, MD, FSCAI	Terumo	none	none	none	none	none	none	none
	Cook Medical	none	none	none	none	none	none	none
Kamal Gupta, MD, FSCAI	none	none	none	none	none	none	none	none
Sahil A. Parikh, MD, FSCAI	Abbott Vascular	none	none	Abbott Vascular	none	none	none	Abbott Vascular
	Boston Scientific	none	none	Boston Scientific	none	none	none	none
	Medtronic	none	none	Medtronic	none	none	none	Medtronic
	Spectranetics Corp	none	none	none	none	none	none	Spectranetics Corp
	Abiomed	none	none	Abiomed	none	none	none	none
Duane S. Pinto, MD, MPH, FSCAI	Medtronic	none	none	none	none	none	none	Medtronic
	Medicines Company	none	none	none	none	none	none	Medicines Company
	Chiesi	none	none	none	none	none	none	none
	Abiomed	none	none	none	none	none	none	none
	Boston Scientific	none	none	Boston Scientific	none	none	none	none
	Amarin	none	none	Amarin	none	none	none	none
	Medicure	none	none	none	none	none	none	none
Mehdi H. Shishehbor, DO, MPH, PhD, FSCAI	Abbott Vascular	none	none	none	none	none	none	Abbott Vascular
	Medtronic	none	none	none	none	none	none	Medtronic
	Spectranetics Corp	none	none	none	none	none	none	Spectranetics Corp
	Boston Scientific	none	none	none	none	none	none	Boston Scientific
Christopher J. White, MD, MSCAI	none	none	none	Astra-Zeneca	none	none	none	none

Reviewer_RWI

Author	Consultant	Speaker's Bureau	Ownership/ Stock Owner/ Shareholder	Grants or Research Support	Salary	Institutional or Organizational	Expert Witness	Advisory Board/Member
Jeff Olin	none	none	none	none	none	none	none	Merck
Josh Beckman	Astra Zeneca Abbott Vascular Astra Zeneca Sanofi Aralez	none	none	Astra Zeneca Merck	none	none	none	none
			Janacare EMX					
Laurence Garcia				Abbott Vascular Medtronic Boston Scientific				Abbott Vascular Medtronic Boston Scientific
			Scion Cardiovascular Primacea Syntervention CV Ingenuity Spirox Essential Medical Arsenal Trireme Inovation Vascular Partners					
Rajan Patel	none	none	none	none	none	none	none	none
Ehtisham Mahmud	none	none	none	none	none	none	none	none
Ehrin Armstrong	Abbott Vascular	none	none	none	none	none	none	none
	Boston Scientific	none	none	none	none	none	none	none
	Cardiovascular Systems	none	none	none	none	none	none	none
	Spectranetics	none	none	none	none	none	none	none
J. Michael Bacharach	Boston Scientific	Boston Scientific	none	none	none	none	none	none
	none	Bristol Myers Squibb	none	none	none	none	none	none
	none	Cook Medical	none	none	none	none	none	none
	none	none	none	none	none	none	none	Intersocietal Accreditation Commission
	W.L. Gore	W.L. Gore	none	none	none	none	none	none
Jay Giri	none	none	none	St. Jude Medical	none	none	none	none
Beau Hawkins	none	none	none	none	none	none	none	none