Vessel Preparation Strategies and Impact on Outcomes in Complex Lesions

A roundtable discussion on the various devices, methods, and data surrounding challenging PAD in the SFA.

WITH BRIAN G. DERUBERTIS, MD, FACS; BRYAN T. FISHER, MD; LOUIS LOPEZ, MD; ANTONIO MICARI, MD, PHD; GEORGE A. PLIAGAS, MD; ERIC C. SCOTT, MD; GREGORY A. STANLEY, MD; AND ERIK G. STILP, MD, FACC, RPVI

Drug-coated balloons (DCBs) have become a critical component of the armamentarium of most operators, as these devices have been shown in several randomized controlled trials to reduce restenosis and result in superior primary patency compared to standard percutaneous transluminal angioplasty (PTA) alone.[1-8] Although head-to-head comparisons are lacking between DCBs and stents, DCBs have shown primary patency rates that are similar to those historically achieved with stents, and there are now good data to support treatment of the superficial femoral artery (SFA) without the need for a permanent scaffold. However, as the IN.PACT Global Registry imaging cohorts and other prospective registries have shown us, increasing lesion complexity (beyond those lesions represented in the investigational device exemption trials for our available DCBs) is associated with higher rates of bailout stent usage, up to 46% in some series.[9] The intuitive explanation for this is that DCBs will address the issue of biologic restenosis, but cannot alter the morphology of the plaque itself, and therefore dissections or the residual plaque burden left behind can result in the need for bailout stenting and can impact patency rates. In the following article, my colleagues and I will delve into a panel discussion regarding how the proper use of vessel prep tools and techniques can be used to minimize dissection and therefore the need for bailout stenting.

— Brian G. DeRubertis, MD, FACS

DIRECTIONAL ATHERECTOMY

With Brian G. DeRubertis, MD, FACS; Louis Lopez, MD; Eric C. Scott, MD; and Gregory A. Stanley, MD

Why do you predominantly use directional atherectomy for vessel prep? What factors drive your decision?

Dr. DeRubertis: The term *vessel prep* can refer to any number of different strategies for altering the properties of a vessel before delivering a definitive therapy, and the choice of vessel preparation may change depending on whether the ultimate therapy is a permanent implant, a drug-eluting stent (DES), or delivery of drug by a DCB. However, atherectomy is rapidly becoming a standard for vessel preparation due to its ability to achieve luminal gain and reduce the residual mechanical forces that act on the lumen of the vessel. Although the term *atherectomy* is broadly applied to a number of different devices, directional atherectomy (also referred to as excisional atherectomy) is particularly suited for vessel preparation due to its ability to act focally, and even eccentrically, in regions of heavy plaque burden. It has a unique ability to achieve dramatic lumen gain in heterogeneous types of plaque, including organized thrombus, restenotic intimal hyperplastic tissue, soft atherosclerotic plaque, and calcium.

Most complex lesions have a variety of plaque morphologies, and it is important to be able to

address these with a single device, the way directional atherectomy can. In my experience, an important predictor of patency is luminal gain, which is accomplished to a greater degree with directional atherectomy than other atherectomy devices.

Dr. Scott: I use vessel prep in hopes that following DCB use, I will attain maximal lumen gain without need for stenting and have no significant residual stenosis or dissection. If vessel prep alone or in conjunction with PTA can provide satisfactory lumen gain with a low risk of dissection, then stenting is unnecessary. I think of directional atherectomy as my "endovascular scalpel"—it can provide a very tailored and lesion-specific therapy in a wide range of lesion morphologies. It's a powerful tool for lumen gain.

Dr. Stanley: I use primary directional atherectomy because of its wide versatility, including the ability to effectively treat calcium. There are few lesions that cannot be adequately addressed with directional atherectomy, whether I'm approaching a focal eccentric lesion, chronic total occlusion (CTO), patent diffuse calcific plaque, or a long-segment heavily calcified CTO. The design characteristics of the latest-generation directional atherectomy catheters (HawkOne™ LX, LS, M, and S atherectomy devices, Medtronic) highlight this versatility: blade rotation speed and catheter wall apposition increases efficiency, contoured teeth on the cutter blade effectively cut/remove calcium, and several individual catheters that can safely address multilevel disease.[10]

I find tremendous benefit in controlling the outcome of the procedure—I actively decide exactly where to remove plaque and how much to remove in real time during the case. There is incremental benefit to making each additional cut with a directional atherectomy catheter, and therefore I can choose when the case is a success.

When you use vessel prep, what are the steps you take and how do you define success?

Dr. Scott: I use vessel prep primarily as a tool for anticipated DCB use, in the hopes that DCB will be the final therapy delivered and that stenting will be unnecessary. If I didn't care about femoropopliteal stent usage, I wouldn't care about vessel prep either. If you look at rates of stenting in our real-world data sets of DCB, you will find bailout stent rates of 20% to 40% in longer lesions.[11-13] To me that is too high. These figures point to the real potential for vessel prep techniques to significantly lower these percentages. One day, I think we will judge differing vessel prep tools specifically on their ability to lower stent utilization in the femoropopliteal segment. When you excise plaque to achieve lumen gain, the risk of dissection becomes very low, as does the need for stenting (2.3% flow-limiting dissection rate, 3.2% provisional stenting rate in the DEFINITIVE LE trial).[14] In my practice, I keep stenting in this segment to < 10% by primarily using directional atherectomy as a vessel prep tool prior to finishing with DCB.

> I think of directional atherectomy as my "endovascular scalpel"—it can provide a very tailored and lesion-specific therapy.
>
> — Eric C. Scott, MD

> I find tremendous benefit in controlling the outcome of the procedure, meaning I actively decide exactly where to remove plaque and how much to remove in real time during the case.
>
> — Gregory A. Stanley, MD

Dr. Stanley: I define procedural success as the re-establishment of a lumen to < 20% residual stenosis with atherectomy alone. To achieve this result, I employ the techniques described in a case report of a patient with claudication who was treated with directional atherectomy to revascularize the SFA.[15] I obtain diagnostic images and begin atherectomy with the image intensifier in the contralateral oblique position (~30°) and excise the plaque to < 20% residual stenosis angiographically in this view. A standard angioplasty balloon sized 1:1 to the reference vessel diameter is then inflated in the treated segment to low pressure (1 to 2 atm only), demonstrating either residual plaque that must be excised with additional atherectomy or an adequate result.

Once residual stenosis is < 20% in this view, the image intensifier is rotated to an ipsilateral oblique

KEY TAKEAWAYS FROM DEFINITIVE LE[14]

Patient Demographics and Primary Endpoints	• Singe-arm, multicenter, prospective evaluation of 800 patients treated with directional atherectomy as a primary modality • Enrolled 598 claudicants with primary endpoint of primary patency at 12 months • Enrolled 201 CLI patients with a primary endpoint of freedom from major unplanned amputation of target limb at 12 months

Results	• Device success (defined as ≤ 30% residual angiographic stenosis after directional atherectomy without adjunctive interventions): 75%
	  • Following postdilatation: 89%
	• Bailout stent rate: 3.2%
	• Primary patency at 1 year in claudicants: 78%
	  • No significant difference in primary patency between diabetics and non-diabetics (77% vs 78%, *P* > .001 when testing for noninferiority)
	  • Limb salvage at 1 year in CLI patients: 95%
	• Primary patency of tibial lesions treated with directional atherectomy in claudicants: 90%
	  • Primary patency of tibial lesions treated with directional atherectomy in CLI patients: 78%
	• Flow-limiting dissections (2.3%) were universally treated endovascularly

view (~30°). Any remaining plaque in this orientation is removed with the atherectomy catheter, again to < 20% residual stenosis. Another low-pressure balloon inflation confirms I have restored the lumen to near reference vessel area (validated with intravascular ultrasound [IVUS], angiography, intra-arterial pressure measurements, and intra-arterial waveforms). With minimal remaining plaque, the risk of dissection during postdilatation with either a DCB or standard angioplasty balloon is insignificant. This technique is identical for the femoropopliteal and tibial segments.

What data drive your decision to use directional atherectomy?

Dr. Lopez: The question remains: does pretreatment with atherectomy provide enhanced vessel patency compared to DCB alone? Dr. Zeller's DEFINITIVE AR study showed an incremental benefit to pretreatment with atherectomy prior to DCB, especially in heavily calcified arteries.[16] The REALITY trial (NCT02850107) is currently enrolling patients for that specific lesion set.

In my own experience, I have documented excellent patency rates in remarkably complex lesions using atherectomy followed by IN.PACT™ Admiral™ DCB (Medtronic). I studied 120 sequential patients; the average lesion length was 23 cm, 29% were CTOs, 59% had diabetes, and 49% were restenosis lesions. One-year patency with directional atherectomy followed by DCB was 87.5%, which was equivalent to the randomized IN.PACT SFA Trial but comprised a much more complex subset of patients with much longer lesions.[2,17] Pretreatment with atherectomy allowed me to avoid dissections, and I had no bailout stenting.

As our treatment options have evolved and our data on outcomes grows, many operators attempt to leave nothing behind. Stents are metal. All metal eventually fatigues, and when it does, stent struts can fracture. This is a well-known mechanism of restenosis and can create a challenging lesion to correct.[18] Vessel prep with atherectomy virtually eliminates this issue. That said, I also acknowledge that stent design is improving. Drug elution for peripheral stents is improving and stents will continue to serve a need in the interventional lab.

Dr. Stanley: The DEFINITIVE LE[14] data support that directional atherectomy is safe and effective in both the femoral-popliteal and tibial segments, is equally effective in diabetics, and has very good efficacy in the setting of critical limb ischemia (CLI). Additional data with longer follow-up, more complex lesions, and comparative treatment arms is highly needed to further define this technology within the current peripheral artery disease (PAD) treatment landscape.

How is the directionality and versatility of directional atherectomy helpful in treating complex lesions?

Dr. DeRubertis: The different devices that are collectively described as atherectomy catheters vary considerably in their technical properties, clinical benefits, and safety profiles. While some are more suited to calcified lesions, and others are more apt to perform well in soft or thrombotic lesions, I believe that the versatility of directional atherectomy is most useful across a range of patients and lesion types. Directional atherectomy has the benefit of allowing the operator to focus the excisional cuts toward the region of plaque burden and allows for repeated cuts until the lesion has adequately been debulked without affecting adjacent normal tissues. The inherent directionality of the catheter allows for treatment of eccentric and concentric lesions of various plaque compositions.

Although focal lesions can easily be treated with directional atherectomy, these catheters perform safely even in long-segment occlusions, as the harvested atherosclerotic debris can be efficiently contained in the nose-cone of the device and removed without significant risk of embolization when used properly. This combination of properties makes these devices useful in simple focal disease or challenging complex lesions.

Dr. Lopez: Many operators prefer to find one device and apply it to all cases. Diversity of lesions and anatomy simply do not allow that, but directional atherectomy does provide a broad range of applications. It is effective in both soft and heavily calcified plaque. It can be used to literally cut out a dissection flap. It is safe and effective in total occlusions, even if the wire crossing was subintimal. When subintimal, extra care should be given to direct the cutting blade toward the true lumen, which can be visualized via fluorography as the wire will tend to bias towards the advential side of the vessel—often a change in fluoro orientation is needed to optimize the view of the vessel. Directional atherectomy also allows one to directly treat a recalcitrant area in a vessel until an acceptable reduction in residual stenosis has been obtained.

The device is easy to deploy even when traversing severe tortuosity in the aortoiliacs. It captures the plaque for removal from the body rather than sending particulate matter into the distal microvasculature. Ability to directionally remove plaque and the efficiency of the cutter enables the operator to achieve optimal reduction in plaque burden and ability to achieve < 30% residual stenosis. Directional atherectomy is limited by the fact that it is a rear-cutting device and requires a fair-sized landing zone if one wishes to use a distal embolic protection filter.

> **The versatility of directional atherectomy allows luminal gain even in areas of eccentric calcified plaque, thereby removing the mechanical forces exerted by these lesions on the lumen, a factor that likely contributes to patency loss over time.**
>
> — Brian G. DeRubertis, MD, FACS

Rotational atherectomy is a front-cutting device, which is sometimes needed with heavily calcified disease. By design, rotational atherectomy sends particulate matter downstream. In my own practice, I consistently use distal embolic protection to minimize the possibility of significant distal embolization. Front-cutting devices have the advantage of needing only a tiny landing zone for the filter. Rotational atherectomy is limited in the degree of plaque removal by the size of the rotational atherectomy device. This makes directional atherectomy a better option in large-diameter vessels. Although directional atherectomy and rotational atherectomy are fundamentally different, both are effective at changing vessel compliance and minimizing the chance of a dissection. Both provide excellent pretreatment prior to DCB angioplasty.

Why is it important that directional atherectomy actually removes plaque from the patient?

Dr. DeRubertis: The ability to remove the plaque has two distinct advantages: (1) plaque excision and removal maximizes luminal gain and thus likely impacts patency rates, and (2) plaque storage in the catheter nose-cone followed by removal from the patient limits the risk of embolic complications.

Residual stenosis has been correlated to patency rates in prior studies and is likely the method by which directional atherectomy can attain patency rates similar to stent implantation.[1] Additionally, the versatility of directional atherectomy allows luminal gain even in areas of eccentric calcified plaque, thereby removing the mechanical forces exerted by these lesions on the lumen, a factor that likely contributes to patency loss over time.

Embolic complications are a concern with any percutaneous lower extremity intervention, but

> **Mechanically, optimal atherectomy produces a larger lumen and greater acute gain. Biologically, removing the barrier between the vessel and DCB should allow for improved drug uptake and enhanced drug effect.**
>
> — Louis Lopez, MD

this concern is heightened in procedures involving atherectomy.[19] The DEFINITIVE LE study showed an extremely low rate of distal embolization of 3.8% in cases involving directional atherectomy, and this is likely due to the catheter's ability to contain the excised debris in the device and remove it from the body.[14]

Dr. Scott: I think of plaque excision via directional atherectomy as a completely different way to treat arterial stenosis or occlusion from our two preceding therapies, angioplasty and stenting. If you can fully excise a lesion with atherectomy, you don't need either of those modalities. Admittedly, there are longer lesions where the plaque volume exceeds what any device can fully remove, but even in these circumstances, directional atherectomy can be a helpful adjunct in creating lumen gain and reducing the workload of PTA.[16] We have also seen a trend towards improved patency in DEFINITIVE AR for patients who had directional atherectomy to residual stenosis of ≤ 30% prior to DCB compared to patients who had residual stenosis of > 30% after directional atherectomy prior to DCB.[16] These are interesting early data that indicate DCBs may actually be more effective if atherectomy is used to accomplish substantial lumen gain first. Whether this improvement in patency is a function of lumen gain, enhanced penetration of drug, or both remains to be determined.

Dr. Lopez: Mechanically, optimal atherectomy produces a larger lumen and greater acute gain. That means for a fixed degree of late loss, we retain a larger lumen at 1 year. Biologically, removing the barrier between the vessel and DCB should allow for improved drug uptake and enhanced drug effect. We still need more data on this issue to adequately judge. Pretreatment with atherectomy undeniably reduces dissections, reduces elastic recoil, reduces the need for bailout stenting, and improves vessel compliance, allowing for improved vessel expansion with the DCB.

What do you do in your practice that allows you to be efficient with directional atherectomy in complex lesions?

Dr. DeRubertis: As atherectomy is thought to be more time consuming than primary stent implantation, it is important to be efficient and recognize that certain techniques can facilitate this. Oftentimes, long-segment occlusions are the result of a few focal areas of severe disease that arrest flow through the vessel, while much of the vessel may in fact be patent and "hibernating." This can be demonstrated by passing the catheter through the entire lesion in the "off" position, and then performing an angiogram after this dottering technique. Typically, this results in in-line flow through the previously occluded segment, while the true culprit lesions are unmasked. Alternatively, predilate the lesion with an undersized balloon (eg, long 3- or 4-mm balloon for the SFA). Finally, lesions that are suspected to be highly laden with organized or acute thrombus can be treated with an on-table 20-minute infusion of tissue plasminogen activator (tPA) prior to treatment with atherectomy to clear the underlying thrombus and turn an occluded segment into a series of focal stenoses.

Dr. Scott: I've made several changes over the past few years. First, I use the latest HawkOne atherectomy devices almost solely now. The HawkOne 7-F device is 100 µm smaller in profile than the TurboHawk™ 7-F atherectomy device (Medtronic), has an improved hydrophilic coating, and is directed more easily through sheaths placed over the aortic bifurcation. The cutter is more effective as well due to higher RPM speed, enhanced torque from the redesigned drive shaft, and optimized cutting blade apposition due to the refined curvature (or jog) near the cutting window of the device.

In longer CTOs of the SFA, I often begin with a 4- to 5-mm predilation using the longest balloons on the shelf. Using low pressure only, this often identifies portions of the artery that are most diseased and identifies portions of the CTO that will open nicely by PTA alone. I can target use of the atherectomy device at what I believe were causative lesions of the CTO. I let DCB safely take care of the rest.

Dr. Stanley: Device selection is a key component to maintain efficiency. In complex femoropopliteal lesions, I use the HawkOne LX atherectomy device as much as possible. This is a large-vessel device, making it very efficient in gaining lumen and provides the largest nose-cone capacity available, thus limiting the number of cleanings required during the case. In addition, working in a

proximal to distal orientation allows for lumen creation as the device advances, thereby relieving friction in the proximal segments that can sometimes impede control in more distal segments.

How has your approach with directional atherectomy evolved with the rise of DCBs?

Dr. DeRubertis: Directional atherectomy can work effectively as an adjunctive therapy to DCBs by altering this plaque morphology and removing the mechanical forces that act to reduce patency over time. The adjunctive use of directional atherectomy with DCB offers an opportunity to manage both mechanical forces and biologic restenosis effectively, thus reducing the need for stent placement. Additionally, the effectiveness of DCBs have been shown to be reduced as degree of calcium increases in a lesion, and this may suggest that calcium poses a barrier for drug delivery,[14,15] meaning plaque excision with directional atherectomy may enable improved drug delivery. These are among the questions we are currently exploring in the VIVA-sponsored REALITY trial using the HawkOne atherectomy system and the IN.PACT Admiral DCB.

Atherosclerotic lesions of the lower extremity vary considerably in their composition and complexity, and it remains true that some lesions will ultimately require scaffold implantation to optimize outcomes. We now have improved options (woven nitinol stents and next-generation designs) when stenting is required. However, the advent of atherectomy and DCBs also provides us with ways of treating the SFA that offer excellent clinical outcomes that don't require lining the SFA with a permanent implant, and this practice has certainly fallen out of favor for most experienced interventionalists. Once a permanent implant is placed, the consequences of failure of that implant include stent fractures, in-stent restenosis/occlusion, and loss of potential bypass targets. Each of these issues complicates retreatment of that vessel and limits our future options.

PERCUTANEOUS TRANSLUMINAL ANGIOPLASTY

With Antonio Micari, MD, PhD

Why do you predominantly use optimal PTA for vessel prep? What factors drive your decision?

Dr. Micari: PTA is the most utilized technology for managing symptomatic PAD. Progress in the field has led to its use for complex lesions; however, restenosis occurs frequently. Drug-coated technologies are used to improve results of PTA and achieve long-term patency. The mechanical effect of PTA is crucial for the mid and long-term result of drug-elution techniques. DCBs have the most robust clinical program promoting evidence-based medicine. To transfer paclitaxel to the vessel wall, DCBs need to touch the vessel wall and stay inflated long enough to hopefully overcome challenges such as calcium. It is important to prepare the vessel to enhance the drug-elution process. Optimal PTA has a double effect: mechanical, to obtain the maximum lumen gain; and preparatory, so most of the drug penetrates the vessel wall.

When you use vessel prep, what are the steps you take, and how do you define success?

Dr. Micari: Usually, complex femoropopliteal lesions are long, calcified, and often involve the popliteal segment. After crossing the lesion, I dilate the occlusion with a slightly undersized balloon and maintain inflation for 3 minutes before inflation of a DCB for at least 3 minutes. If the result is suboptimal (residual stenosis or dissection affecting the flow), I use a 1:1 balloon:vessel ratio for more time at low pressure. Sometimes along the lesion, some spot residual lesions or stenoses persist; in this case, I apply a short 1:1 balloon to inflate at that specific point. I have a satisfactory result when I obtain

> We know that the full metal jacket or extensive stenting use in the SFA and popliteal artery is not a winning strategy.
>
> — Antonio Micari, MD, PhD

a reasonable lumen gain in absence of focal calcified residual stenosis and no flow-limiting stenosis.

Could you provide an overview of your DCB Long data, and the efficiency of PTA as vessel prep in long lesions?

Dr. Micari: In our SFA-Long Study (105 patients; mean lesion length, 25 cm), we demonstrated satisfactory patency of 89% and 71% at 1 and 2 years, with a very low stenting rate (10.5%).[21,22] We used stenting as bailout in case of residual stenosis or flow-limiting dissection after aggressive postdilatation. Our data were comparable with other studies and registries in terms of patency results but differed in the rate of bailout stent usage, likely due to our consistent vessel preparation.

When and why do you use more than PTA for vessel prep?

Dr. Micari: Angioplasty alone will not be sufficient to obtain a good vessel preparation in all situations. The real enemy is calcium. Very calcified vessels, especially circumferential calcium, do the worst in terms of acute results or long-term patency results. To treat these vessels effectively, we need to debulk or use a specialty balloon to more effectively address the plaque.

What do you perceive as the value in minimizing metal left behind and why that's important in the SFA/popliteal segment?

Dr. Micari: In complex lesions, reducing the stent usage can be very important. First of all, we know that the full metal jacket or extensive stenting use in the SFA and popliteal artery is not a winning strategy. Claudicant patients are typically in their late 60s with a life expectancy similar to the standard population and the chance to have a reintervention is quite high. Having no permanent prosthesis makes the reintervention easier and safer. Popliteal involvement makes the usage of the stent not desirable being that the stent is placed behind the knee in a bending zone. This is dangerous for stent fracture and may result in thrombosis. Data from the IN.PACT Global study shows no difference between the stented and non-stented subgroups when DCBs are used.[23] My primary treatment goal is to avoid leaving a long stent inside the vessel without compromising long-term outcomes and thereby preserving future treatment options.

SPECIALTY BALLOONS

With Bryan T. Fisher, MD; George A. Pliagas, MD; and Erik G. Stilp, MD, FACC, RPVI

When and where do you use specialty balloons for vessel prep? What factors drive your decision?

Dr. Fisher: Vessel preparation is absolutely key to achieving an optimal and more durable result compared to simple balloon angioplasty. Conceptually, we are ultimately trying to remodel the artery with minimal injury to the adjacent normal vessel with the hopes of pushing the boundaries of patency well beyond the standard 2-year mark.

I prefer to use specialty balloons for advanced complex lesions that are classically resistant to traditional therapy. Lesions with heavy calcification and those that are longer in length tend to fall into this complex category. Especially below the knee, specialty balloons have allowed me to consistently achieve patency long enough for wound healing, though consistent patency beyond 6 to 12 months remains elusive.

> Vessel preparation is absolutely key to achieving an optimal and more durable result compared to simple balloon angioplasty.
>
> — Bryan T. Fisher, MD

Dr. Pliagas: The degree and location of calcification is a huge obstacle in our ability to create microchannels that allow DCB permeation into the internal elastic tissue and the media. This is where specialty balloons and atherectomy devices help to enhance the uptake of the drug by creating a conducive microvascular environment for drug uptake into the media. I use the Chocolate™ PTA balloon (Medtronic),

which incorporates a nitinol-constraining structure, creating a complex pattern of pillows and grooves.[24] Using appropriate insufflation, the Chocolate PTA balloon allows for uniform and atraumatic dilatation. This unique property can be utilized safely in the ostium of the SFA, the junction of the P2 and P3 segments of the popliteal, the P3 segment of the popliteal, and the origins of the tibial vessels. In my experience, the Chocolate PTA balloon has lower rates of dissections compared to other uncoated balloons and bare-metal stents.

Dr. Stilp: PAD is a chronic and debilitating disease that affects both quality and quantity of life on two legs, and specialty balloons have become an essential tool in treating infrainguinal PAD safely and effectively. I consider specialty balloon use in all but primary stent situations, which are now few and far between. The up-front angiographic success and symptom relief seen with infrainguinal stents is often not worth the long-term pain for both patients and operators.

Specialty balloons can allow for more aggressive treatment in "no-stent zones" such as the across-knee popliteal and common femoral arteries. They augment treatment of heavily calcified lesions without as much concern for flow-limiting dissections or perforations and minimize need for bailout stents. They are often successful stand-alone options in tibial arteries, where a preponderance of limb-threatening disease lies but where treatment options in the United States are currently most limited.

When you use vessel prep, what are the steps you take, and how do you define success?

Dr. Fisher: The term *vessel prep* does not have a standard definition. Generally, the operator is trying to fulfill four objectives:

1. Achieve luminal gain (< 20%–30% residual stenosis prior to delivery of definitive therapy)
2. Minimize dissection both within and adjacent to the target lesion
3. Remodel the vessel acutely to change vessel compliance
4. Prepare for the delivery of antiproliferative therapy.

Specifically, I routinely perform IVUS before, during, and after treatment in order to get a definitive idea of whether I have achieved the above-mentioned goals. After assessing the vessel size (including variations along the length of the lesion), depth of my wire, and lesion composition, I then choose an atherectomy device to modify the lesion. Next, I dilate the vessel in a selective fashion with regards to diameter choice as there is often large variation in vessel size and lumen along a complex lesion. Below the knee, specialty balloon use has been especially helpful in treating patients with wounds that require a variable window of increased perfusion to achieve healing.

> I choose to lead with the controlled dilatation of a Chocolate PTA specialty balloon except in the rare circumstances where my procedural plan is primary stenting, or where there isn't any significant fluoroscopic calcium.
>
> — Erik G. Stilp, MD, FACC, RPVI

Dr. Stilp: Success in specialty balloon use in my practice is based largely on three metrics:

1. Do they allow me to dilate otherwise non-dilatable disease? There are simply some lesions that won't expand without them. While it's nice to both expand them and not have to stent, a small subset of lesions just need to dilate in order to get adequate stent expansion and apposition, and specialty balloons allow for this.
2. Do they decrease my bailout stent rate in segments treated with drug? I see DCBs primarily as paclitaxel transporters, and only in the softest of femoropopliteal lesions do they double as safe vessel preparers. Although predilatation is now at the discretion of the physician in currently available DCB instructions for use, I find that predilatation increases procedural success with DCBs and minimizes stenting.
3. Do they minimize flow-limiting dissections in long-segment tibial disease? While the PARADISE trial and others have shown DESs to be an effective option for focal tibial lesions in patients with CLI, until below-the-knee (BTK) DCBs or BTK DESs are proven effective, we're left with atherectomy and PTA as options for these patients.[25] In my view, specialty balloons in tibial disease can minimize the degree of intervention needed and provide for adequate stentless angiographic outcomes.

Please provide a brief overview of the data in support of your specialty balloon choice.

Dr. Pliagas: The ultimate struggles we face in the world of intervention is long-term patency and avoidance of amputation. Limitations of endovascular therapy are many but include the presence of calcium, lesion complexity, and lesion length. An article by Cotroneo et al indicated that cutting balloons were a valuable tool in the endovascular treatment of these lesions with no dissections and improved patency at 12 months and 2 years.[26] Another similar article by Iezzi et al from July 2015 described cutting balloon as a safe and effective tool in the routine treatment of short and ostial infrapopliteal lesions.[27]

Dr. Stilp: Postmarket registry data support the use of specialty balloons in the femoropopliteal space. Femoropopliteal lesions were analyzed after treatment with Chocolate PTA alone, and 93.1% were free of stent afterwards in a cohort that included 32% CLI, 20% severely calcified lesions, and 23% CTOs (n = 263 total subjects).[28] There were no grade E/F flow-limiting dissections after Chocolate PTA. Freedom from target lesion revascularization (TLR) at 12 months was 78.5%.

In a single-center cohort that added DCB angioplasty after Chocolate PTA for 81 patients with femoropopliteal lesions and severe claudication, freedom from TLR at 12 months was 98%.[29] The core lab–adjudicated BTK cohort of the Chocolate BAR registry included 226 patients with CLI who underwent Chocolate PTA. The results, which were recently presented at TCT, showed < 30% residual stenosis and a lack of flow-limiting dissection achieved in 85% of lesions.[30] There was 97% freedom from stenting and 97% freedom from major amputation at 6 months.

When do you lead with a specialty balloon versus use it provisionally?

Dr. Fisher: Cost and overall efficacy have to be considered when using specialty balloons regardless of setting. Below the knee, I prefer the use of Chocolate PTA balloon over plain balloon angioplasty. On completion IVUS, there is a difference in the acute remodeling of the vessel with lesion intrusion of dissection flaps into the newly dilated lumen. Also consistent with previous operators, longer inflation times (> 3 minutes) acutely remodel the vessel, resulting in less luminal flap occlusion. The long-term patency and the clinical significance of this observation is not known.

Dr. Stilp: I choose to lead with the controlled dilatation of a Chocolate PTA specialty balloon except in the rare circumstances where my procedural plan is primary stenting, or where there isn't any significant fluoroscopic calcium. In provisional use, I will typically not continue to inflate standard PTA balloons if there is any fluoroscopic evidence of significant stenosis at the target lesions at nominal pressures, but rather deflate and replace with a specialty balloon to minimize dissections and adequately prepare for DCB therapy.

> **The use of specialty balloons such as Chocolate PTA avoids the torsional, radial, and longitudinal stress of PTA while allowing the pillows to uniformly act on vessel dilatation in a controlled manner.**
>
> — George A. Pliagas, MD

What do you see as the value in minimizing metal left behind in the femoropopliteal segment?

Dr. Fisher: The goal of lower extremity treatment is to cause chronic vessel remodeling that is resistant to recurrence secondary to vessel wall injury during treatment. To this end, bare-metal stenting has not eliminated the need for redo interventions. DCBs, on the other hand, have become a proven tool capable of achieving improved patency compared to PTA and bare-metal stenting used to treat long complex lesions in the SFA and popliteal artery.

Dr. Pliagas: For years, complex femoropopliteal pathology was treated with balloon angioplasty and stenting. The physiologic forces exerted on the nitinol self-expanding stent left behind in the SFA/popliteal location lead to a number of suboptimal results including fractures, restenosis, migrations, and ultimately both early and late occlusions.[31] We may see fewer stents used as new treatment algorithms encompassing vessel preparation techniques and drug-eluting technology becomes common practice. As we proceed into the future with new technologies, it will be important to assess which specific preparatory steps, or perhaps which combinations of preparatory steps, ultimately lead us to the best patency rates and reduced amputations. The next challenge will come when we evaluate and assess all of these technologies in their respective settings both above and below the knee.

Dr. Stilp: Repeat procedures expose our patients to more risk and more expense. They stress our labs and ultimately can make it more difficult to get new patients with urgent revascularization needs treated in a timely fashion. Femoropopliteal stents, especially long-segment and overlapped stents in high-torsion zones, tend to readily fracture, restenose, and thrombose.[31-33] Moreover, PAD patients, especially CLI patients who stand to lose the most from recurrent disease, have a staggering number of comorbidities.[34] Many of these conditions necessitate intermittent cessation of antiplatelet and anticoagulant medications. Stented areas are the first to occlude, often leading to limb-threatening ischemia during these periods. Let's consider the case of an elderly woman who shows up to our lab with foot-threatening ischemia. We find that a bit more effort, time, and potentially product cost to minimize stenting during that elderly woman's initial procedure is worth it, as the likelihood of a getting her through a fall with femoral head fracture or severe diverticular bleed in the future is much greater if she doesn't have metal from her mid-SFA through the P2 popliteal.

Please provide an overview of your single-center experience, data, and tools/techniques.

Dr. Pliagas: Our current treatment protocol incorporates all of the aforementioned techniques. Vessel preparation requires a meticulous vessel- and patient-centered approach. In addition to angiography, the use of IVUS in the assessment of calcium burden allows better focus on the atherectomy technique. Appropriate escalation angioplasty then allows the activation of nitrous oxide, which leads to vasodilatation, endothelial regeneration, and inhibition of smooth muscle cell proliferation.[35] The use of specialty balloons such as Chocolate PTA avoids the torsional, radial, and longitudinal stress of PTA while allowing the pillows to uniformly act on vessel dilatation in a controlled manner. The grooves of the Chocolate balloon allow dispersion of the additional angioplasty forces exerted back by the vessel plaque thereby minimizing dissection.[24] Drug-coated technology can be instituted as necessary following vessel preparation allowing for optimal outcomes.

Dr. Stilp: I find that time spent sizing specialty balloons 1:1 with the arterial segment being treated, especially in tibial intervention, minimizes my dissections and therefore my use of stents, while maximizing luminal gain and longer-term outcomes. Tibial interventions are classically undersized, but with either IVUS or extravascular ultrasound, or tedious attention to serial upsizing of balloons with angiographic guidance, specialty balloons can be utilized to their greatest potential.[36] Enough emphasis cannot be placed on the importance of prolonged low-pressure PTA, after adequate sizing. I will frequently leave a Chocolate PTA balloon, sized 1:1 with IVUS, inflated at nominal pressure across long-segment tibial disease for 8 to 10 minutes; 4 to 5 minutes is certainly a necessity. ■

1. Tepe G, Schnorr B, Albrecht T, et al. Angioplasty of femoral-popliteal arteries with drug-coated balloons: 5-year follow-up of the THUNDER trial. JACC Cardiovasc Interv. 2015;8:102-108.
2. Tepe G, Laird J, Schneider P, et al. Drug-coated balloon versus standard percutaneous transluminal angioplasty for the treatment of superficial femoral and popliteal peripheral artery disease: 12-month results from the IN.PACT SFA randomized trial. Circulation. 2015;131:495-502.
3. Laird JR, Schneider PA, Tepe G, et al. Durability of treatment effect using a drug-coated balloon for femoropopliteal lesions: 24-month results of IN.PACT SFA. J Am Coll Cardiol. 2015;66:2329-2338.
4. Schneider PA, Laird JR, Tepe G, et al. Treatment effect of drug-coated balloons is durable to 3 years in the femoropopliteal arteries: long-term results of the IN.PACT SFA randomized trial. Circ Cardiovasc Interv. 2018;11:e005891.
5. Rosenfield K, Jaff MR, White CJ, et al. Trial of a paclitaxel-coated balloon for femoropopliteal artery disease. N Engl J Med. 2015;373:145-153.
6. Scheinert D, Schulte KL, Zeller T, et al. Paclitaxel-releasing balloon in femoropopliteal lesions using a BTHC excipient: twelve-month results from the BIOLUX P-I randomized trial. J Endovasc Ther. 2015;22:14-21.
7. Krishnan P, Faries P, Niazi K, et al. Stellarex drug-coated balloon for treatment of femoropopliteal disease: 12-month outcomes from the randomized ILLUMENATE pivotal and pharmacokinetic studies. Circulation. 2017;136:1102-1113.
8. Schroeder H, Werner M, Meyer DR, et al. Low-dose paclitaxel-coated versus uncoated percutaneous transluminal balloon angioplasty for femoropopliteal peripheral artery disease: one-year results of the ILLUMENATE European randomized clinical trial (randomized trial of a novel paclitaxel-coated percutaneous angioplasty balloon). Circulation. 2017;135:2227-2236.
9. Tepe G. IN.PACT Global drug-coated balloon for treatment of chronic total occlusions in the SFA. Paper presented at: the 38th Charing Cross Symposium; April 26-29, 2016; London, UK.
10. Katsanos K, Spiliopoulos S, Reppas L, Karnabatidis D. Debulking atherectomy in the peripheral arteries: is there a role and what is the evidence? Cardiovasc Intervent Radiol. 2017;40:964-977.
11. Thieme M, Von Bilderling P, Paetzel C, et al. The 24-month results of the Lutonix Global SFA Registry: worldwide experience with Lutonix drug-coated balloon. JACC Cardiovasc Interv. 2017;10:1682-1690.
12. Schmidt A, Piorkowski M, Gorner H, et al. Drug-coated balloons for complex femoropopliteal lesions: 2-year results of a real-world registry. JACC Cardiovasc Interv. 2016;9:715-724.
13. Scheinert D, Micari A, Brodmann M, et al. Drug-coated balloon treatment for femoropopliteal artery disease: The IN.PACT Global study long lesion imaging cohort. Circ Cardiovasc Interv. 2018;11.
14. McKinsey JF, Zeller T, Rocha-Singh KJ, et al. Lower extremity revascularization using directional atherectomy: 12-month prospective results of the DEFINITIVE LE study. JACC Cardiovasc Interv. 2014;7:923-933.
15. Stanley GA, Winscott JG. Maximizing lumen gain with directional atherectomy. J Endovasc Ther. 2016;23:648-652.
16. Zeller T, Langhoff R, Rocha-Singh KJ, et al. Directional atherectomy followed by a paclitaxel-coated balloon to inhibit restenosis and maintain vessel patency twelve-month results of the DEFINITIVE AR study. Circ Cardiovasc Interv. 2017;10:e004848.
17. Lopez L. Combination therapy with atherectomy followed by DCB: 1-year outcomes with Lutonix DCB anf 1-year outcomes with IN.PACT DCB. Presented at: Leipzig Interventional Course (LINC) 2018; January 30–February 2, 2018; Leipzig, Germany.
18. Scheinert D, Scheinert S, Sax J, et al. Prevalence and clinical impact of stent fractures after femoropopliteal stenting. J Am Coll Cardiol. 2015;45:312-315.
19. Wasty N, Khakwani MZ, Kotev S et al. Ubiquitous nature of distal athero/thromboembolic events during lower extremity atherectomy procedures involving the superficial femoral artery. Int J Angiol 2016;25:252-257.
20. Fanelli F, Cannavale A, Gazzetti M, et al. Calcium burden assessment and impact on drug-eluting balloons in peripheral arterial disease. Cardiovasc Intervent Radiol. 2014;37:898-907.
21. Micari A, Vadalà G, Castriota F, et al. 1-year results of paclitaxel-coated balloons for long femoropopliteal artery disease: evidence from the SFA-Long study. JACC Cardiovasc Interv. 2016;9:950-956.
22. Micari A, Nerla R, Vadalà G, et al. 2-year results of paclitaxel-coated balloons for long femoropopliteal artery disease: evidence from the SFA-Long study. JACC Cardiovasc Interv. 2017;10:728-734.
23. Ansel GM. Stented versus non-stented outcomes at 2 years: a sub-analysis of the IN.PACT Global study. Presented at: Leipzig Interventional Course (LINC) 2018; January 30–February 2, 2018; Leipzig, Germany.
24. Charisse Ward C, Mena-Hurtado C. Novel use of pillows and grooves: the Chocolate® PTA balloon catheter. Endovasc Today (insert). 2014;5:24-28.
25. Feiring AJ, Krahn M, Nelson L, et al. Preventing leg amputations in critical limb ischemia with below-the-knee drug-eluting stents: the PaRADISE (PReveneting Amputations using Drug eluting StEnts) trial. J Am Coll Cardiol. 2010;55:1580-1589.
26. Cotroneo AR, Pascali D, Iezzi R. Cutting balloon versus conventional balloon angioplasty in short femoropopliteal arterial stenoses. J Endovasc Ther. 2008;15:283-291.
27. Iezzi R, Posa A, Santoro M, et al. Cutting balloon angioplasty in the treatment of short infrapopliteal bifurcation disease. J Endovasc Ther. 2015;22:485-492.
28. Mustapha JA, Lansky A, Shishehbor M, et al. A prospective, multi-center study of the chocolate balloon in

femoropopliteal peripheral artery disease: The Chocolate BAR registry. Catheter Cardiovasc Interv. 2018;91:1144-1148.
29. Sirignano P, Mansour W, d'Adamo A, et al. Early experience with a new concept of angioplasty nitinol-constrained balloon catheter (Chocolate®) in severely claudicant patients. Cardiovasc Intervent Radiol. 2018;41:377-384.
30. Bouras G. Outcomes from the Chocolate BAR: a large, multi-center, prospective, post-market study on use of the Chocolate percutaneous transluminal angioplasty (PTA) balloon. Presented at: Transcatheter Cardiovascular Therapeutics (TCT) 2016; October 29–November 2, 2016; Washington, DC.
31. Krankenberg H, Tübler T, Sixt S, et al. German multicenter real-world registry of stenting for superficial femoral artery disease: clinical results and predictive factors for revascularization. J Endovasc Ther. 2014;21:463-471.
32. Lin Y, Tang X, Fu W, et al. Stent fractures after superficial femoral artery stenting: risk factors and impact on patency. J Endovasc Ther. 2015;22:319-326.
33. Banerjee S, Sarode K, Mohammad A, et al. Femoropopliteal artery stent thrombosis: report from the Excellence in Peripheral Artery Disease (XLPAD) Registry. Circ Cardiovasc Interv. 2016;9:e002730.
34. Criqui MH, Aboyans V. Epidemiology of peripheral artery disease. Circ Res. 2015;116:1509-1526.
35. Barbato JE, Tzeng E. Nitric oxide and arterial disease. J Vasc Surg. 2004;40:187-193.
36. Mustapha JA, Diaz-Sandoval LJ, Saab F. The drug-coated balloon: not just a balloon. Cath Lab Digest. 2014;22. Available at: https://www.cathlabdigest.com/article/Drug-Coated-Balloon-Not-Just-Balloon. Accessed September 11, 2018.

PARTICIPANTS

Brian G. DeRubertis, MD, FACS
Associate Professor of Surgery
Division of Vascular & Endovascular Surgery
David Geffen School of Medicine at UCLA
Los Angeles, California
bderubertis@mednet.ucla.edu
Disclosures: Consulting agreements, advisory board participation, and/or speaker's bureau agreements with Abbott Vascular, Medtronic, Cook Medical, WL Gore, and BD/Bard.

Bryan T. Fisher, MD
Chief of Vascular Surgery
TriStar Centennial Medical Center
Nashville, Tennessee
Disclosures: Consultant to Medtronic.

Louis Lopez, MD
Interventional Cardiologist
Director, Cardiac Catheterization Lab
President of the Medical Staff
St. Joseph Hospital
Fort Wayne, Indiana
Disclosures: Consulting agreements with Medtronic and Boston Scientific Corporation.

Antonio Micari, MD, PhD
Codirector Cath Lab
Humanitas Gavazzeni Hospital
Bergamo, Italy
micariantonio@gmail.com
Disclosures: Advisory board for Medtronic; consultant for Boston Scientific Corportation and Terumo; speaker's bureau for Bard and InspireMD.

George A. Pliagas, MD
Vascular Surgeon
Premier Surgical Associates
Vascular Division
Tennova Physicians Regional
Medical Center
Knoxville, Tennessee
Disclosures: Medtronic, Cardiovascular Systems, Inc.; Cook Medical, and Penumbra.

Eric C. Scott, MD
Vascular Surgeon
The Iowa Clinic
West Des Moines, Iowa
escott@iowaclinic.com
Disclosures: Consultant/speaker for Medtronic and Boston Scientific Corporation.

Gregory A. Stanley, MD
Sanger Heart & Vascular Institute
Carolinas HealthCare System
Charlotte, North Carolina
Disclosures: Consultant to Medtronic.

Erik G. Stilp, MD, FACC, RPVI
Vascular and Coronary Intervention
Ascension – Columbia St. Mary's
Milwaukee, Wisconsin
Disclosures: Consultant/speaker: Medtronic, Bard PV, Philips, Abbott Vascular.