

Deep Venous Intervention Techniques

A panel of venous experts shares insights on referrals, imaging, and stenting.

PARTICIPANTS



William Marston, MD, is Chief, Division of Vascular Surgery, University of North Carolina Chapel Hill in Chapel Hill, North Carolina. He has disclosed that he is a research investigator for the VIDIO trial and is a consultant for Veniti, Inc.



Raghu Kolluri, MD, RVT, FACC, FSVM, is System Medical Director for Vascular Medicine, OhioHealth Health System, and practices at Riverside Methodist Hospital, Columbus, Ohio. He has disclosed that he is a consultant and speaker for Medtronic, Boston Scientific Corporation, Volcano Corporation, and Merck.



Patricia Thorpe, MD, FSIR, is an interventional radiologist at Arizona Heart Hospital in Phoenix, Arizona. She has disclosed that she is a medical advisor and speaker for Volcano Corporation.

away, and the other one-third comes from more distant states and other countries. There is a mix of self and physician referrals. Locally and regionally, physician referrals are from primary care physicians and other vascular specialists.

How do you reach out to patients?

Dr. Marston: We mainly perform physician outreach, so we spend a lot of time traveling to primary care offices and informing them of our venous program.

Dr. Kolluri: We have a vascular institute structure in our system, which includes approximately 10 hospitals. I'm part of the peripheral vascular service at Riverside Methodist Hospital, which includes five interventional cardiologists primarily performing peripheral interventions and myself. Our group holds physician education and engagement events to inform potential referrers about the advanced services we provide, for example: reaching pedal vessels in patients with critical limb ischemia and helping patients with iliofemoral DVT to reduce postthrombotic syndrome (PTS) risk.

Dr. Thorpe: I have a website, which many individuals say needs to be modernized. I give outreach talks here in the city, and I also present at meetings. I ask referring doctors to have the patient call me directly, which apparently is very novel because most doctors don't take calls from patients. These phone calls help patients who live far away. I have also had patient referrals through their support network. Good results help referring doctors identify other patients who need help. I send referring physicians before and after images of the venograms and legs.

PATIENT REFERRALS AND OUTREACH

Who refers patients to you, and how do they find you?

Dr. Marston: It's usually through our vein center or wound clinic; these are patients with advanced CEAP C3 to C6 venous disease.

Dr. Kolluri: I moved from Illinois to Columbus, Ohio, approximately 2 years ago, and one of my charges was to set up a vein center within (or adjacent to) our wound clinic. We now have six podiatry colleagues who see wound center patients and refer patients with venous ulcers for potential superficial or deep venous intervention.

In my vascular clinic, I'm referred patients with a generic diagnosis of limb swelling; recurrent, deep venous thrombosis (DVT); as well as those with a hypercoagulable condition and prior DVTs.

Dr. Thorpe: For years, I have tracked our referrals, and approximately 33% live locally, 33% live < 500 miles

How do you manage patient referrals with your interventional cardiology, vascular surgery, and interventional radiology colleagues?

Dr. Marston: The University of North Carolina (UNC) is a pretty big system with roughly nine hospitals and multiple practices. There are a couple interventional radiologists who work with us in our vein clinic. There aren't any cardiologists at the University Hospital who

Sponsored by Volcano Corporation

do vein work, but there are certainly some at other UNC-affiliated practices who do. In general, we collaborate and encourage them to refer patients with more advanced venous disease.

Dr. Kolluri: Our vascular institute involves all specialties. We are extremely collegial with the interventional radiologists and vascular surgeons across the system. At Riverside Methodist Hospital, our vascular surgeons are cardiothoracic-vascular surgeons, so they don't perform venous interventions. From other large hospitals in the system, vascular surgeon colleagues will refer patients to me to manage the medical aspects of venous disease. In that setting, if I find obstructive lesions, the patient goes back to the consulting vascular surgeon, who will perform the appropriate procedure. In terms of interventional radiologists, I frequently refer my patients with vascular pelvic congestion who need, for example, uterine vein embolization.

Dr. Thorpe: The vascular surgeons here are very busy, and although I refer arterial problems occasionally, they usually give me the venous work that is outside their scope of practice. I'll advise on difficult venous access for the electrophysiology doctors dealing with implantable leads, and I'm always willing to help with chronic cases that they do not treat. It's very collegial. We have a cardiovascular conference every Thursday morning that gives everyone the opportunity to hear about cases and exchange information. My practice is a dedicated deep venous practice, and there are relatively few interventionists who do this full time.

SCREENING AND PREPROCEDURE NONINVASIVE IMAGING

How do you screen your patients for potential venous stenting?

Dr. Marston: There is a specific assessment pathway we go through (the algorithm was published in *J Vasc Surg.* 2011;53:1303-1308.). The first step is to determine whether or not the patient is amenable to intervention; for example, if the risk profile is too high, or if the patient is not active enough to benefit from intervention, then we favor conservative management.

For patients who are candidates for intervention, we start with duplex ultrasound (DUS), specifically looking at the venous outflow portion of the study. If the waveform within the common femoral vein (CFV) is normal, outflow obstruction is not ruled out; however, if it is abnormal (eg, no respiratory variation), it's almost certain that the patient has ilio caval tract obstruction. If DUS reveals an abnormal CFV waveform, we go directly

Institutionally, acute DVT protocols are beginning to take off. We have shared our vascular institute protocol for DVT with our ER physicians and ER council. Patients with acute DVT will be referred from the ER to our local vascular institute experts.

—Dr. Kolluri

to our interventional suite for percutaneous venography and intravascular ultrasound (IVUS) with the aim to intervene. In our published study, if the CFV waveform was normal, and if there was no history of DVT or deep venous reflux, there was never ilio caval outflow obstruction. These are patients who have superficial reflux or no venous disease. If the duplex CFV waveform is normal, and the patient does have a history of DVT or deep venous reflux, then we order a CT venogram (CTV) or MR venogram (MRV), depending on the radiology group's strengths, preferences, and scanner scheduling availability. If a good-quality CTV or MRV shows obstruction, we proceed to percutaneous venography and IVUS with possible intervention. If the CTV or MRV is normal, no further work-up is required (with the infrequent exception of patients for whom the index of suspicion is high enough to justify an invasive assessment).

Dr. Kolluri: A lot boils down to the patient's history and clinical findings. The only time I order a CTV, along with a CT of the abdomen and pelvis, is to rule out malignancy and/or abnormal lymphadenopathy as a cause of venous compression. We rely heavily on DUS of the inferior vena cava (IVC) and iliac veins in our vascular lab. Although one can't definitively make the diagnosis with surface DUS, we have highly skilled sonographers and get close to making the diagnosis before referring to the cath lab when you combine this with clinical history and physical findings. At that point in our system, there is little additional value in obtaining a CTV or MRV. An exception involves adolescent patients who need to be evaluated for congenital venous anomalies; these patients will often have an atretic IVC, so I'll order an MRV.

Dr. Thorpe: My referrals are usually prescreened, although sometimes, studies are inadequate because they don't involve the iliacs. Patients with nonhealing stasis ulcers are likely to have iliac compression, so

patient history is a good starting point. Certain questions can help screen for compression, including: "Is your left leg heavy? Does it swell during the day? Does it hurt in your groin area when you sit a long time? Is your left shoe tight? Has it always been tighter than your right shoe?" I also perform a complete lower extremity physical examination (bilateral or unilateral, depending on symptoms).

Transcutaneous ultrasound is very important. The technologist examines the IVC, iliacs, and both lower extremities for all patients with limb edema, recurrent DVT, and/or PTS. It seems to be the general practice to omit the pelvic vein examination in ultrasound exams performed in the emergency room (ER) or clinic; this is, however, something I oppose. We check for nonphasic flow in the CFV because this a key point in identifying proximal obstruction. It is not 100%, as collateral flow can change hemodynamics. Although it is an important positive finding, if it is negative, it doesn't completely exclude proximal obstruction. We also look at tibial veins carefully. Just as one would not place an aortobifemoral graft without distal runoff, achieving optimal, long-lasting clinical results with a proximal venous intervention requires good deep vein inflow. That includes adequate flow in the tibial, popliteal, and femoral segments.

I use CT angiography (CTA) to view the relationship of the right and left iliac arteries to the iliac veins. The ideal format is, of course, CTV plus CTA with an injection through both feet or popliteal sheaths with intravascular contrast while running the CTA protocol. This yields beautiful images, but it's somewhat labor intensive.

How frequently do you stent based on this protocol?

Dr. Marston: For patients entering our algorithm with C5 or C6 disease, approximately 30% will end up with venography and IVUS; for patients with C3 or C4 disease, roughly 10% to 20% are taken to the cath lab (caveat: I usually don't perform an invasive assessment for patients with mild C3 findings). Of the patients who go to the lab, I would estimate that approximately 85% to 95% are found to have a significant obstruction and are treated with venous stents. Part of the uncertainty here relates to the fact that we don't know how much obstruction is hemodynamically significant, but there seems to be a recent trend to be a bit more liberal with stenting. We really need to have more data on correlating the amount of obstruction with improvement after treatment.

Dr. Kolluri: We have gotten very proficient with our clinical algorithm and DUS screening protocol. I can only recall a couple of patients over the past 2 years who

went to the cath lab but did not get stented. I would estimate that more than 90% of our patients undergoing venography and IVUS receive a stent.

Dr. Thorpe: Even though I may suspect iliac compression, all patients are examined with IVUS if there is unexplained edema. About 30% of acute DVT patients do not have an iliac compression of > 50% associated with symptomatic tibial, popliteal, or femoral DVT on the left. On the other hand, with IVUS, we have discovered a higher incidence of right-sided stenoses than one would expect based on physical exam.

As for the patients who are not even being considered for evaluation, how are they currently being managed?

Dr. Kolluri: Institutionally, acute DVT protocols are beginning to take off. We have shared our vascular institute protocol for DVT with our ER physicians and ER council. Patients with acute DVT will be referred from the ER to our local vascular institute experts. The front-line physicians are the ER doctors, and to a lesser extent, primary care. From the vascular lab perspective, the diagnosis of an acute iliofemoral DVT should trigger a physician-to-physician call. The referring physician needs to be informed of this diagnosis right away and that advanced venous therapies may be a consideration. Regarding non-thrombotic or PTS patients, wound centers should be targeted; 60% to 70% of lower limb ulcerations are of venous etiology (superficial reflux, deep reflux, and/or outflow obstruction). So, the three main points of outreach should be ERs, vascular labs, and wound centers/podiatrists.

Dr. Thorpe: Patients who are not being managed are likely sitting at home with swollen legs and being told by primary care physicians that there is nothing that can be done other than wearing compression stockings. I'm an advocate for public awareness due to the physicians' lack of understanding regarding patients they are likely seeing. There is a great deal of bad press about venous stents because of failed stents that are implanted without good inflow or outflow, so more education is needed. Moreover, I think that people in this country wear pants, don't expose their swollen legs, and do the best they can because they don't want to whine. As a result, many people just carry on and don't know there is a treatment option. It seems like highly motivated patients search the Internet and find information, which, at present, is rather confusing. About 10 years ago, information was more sparse but perhaps not as confusing. The ATTRACT trial will probably help create a different algorithm for referring patients.

Sponsored by Volcano Corporation

How sensitive do CTV and MRV imaging studies appear to be, and what factors influence this sensitivity?

Dr. Marston: Study quality, for either modality, seems to depend on the skill sets of the radiology group. Properly timing the CT acquisition to achieve good opacification during the venous phase can be a challenge, but in my opinion, CTV and MRV can be equally effective. From a scheduling perspective, I can typically get a CTV on the day I order it; for MRV, this is often not the case. I don't know of any publications comparing sensitivity of CTV/MRV to IVUS, but our group did present a poster on a small case series (approximately 15 patients) comparing CTV with IVUS. We performed three-dimensional CTV reconstructions with centerline imaging (analogous to aortic aneurysm CTs) and found that—if the contrast bolus was well timed—there was very close correlation to IVUS. Ultimately, to really be cost effective with our screening protocol, we will probably need to reduce the use of those modalities (CTV and MRV) because they are fairly expensive.

Dr. Kolluri: In my personal opinion, the sensitivity of CTV/MRV really depends on your radiology department. Levels of expertise vary greatly. In my current system, the quality of the scans is good, and my interventional radiology colleagues are knowledgeable and willing to review cases, so the studies are informative.

Dr. Thorpe: CTV is useful for evaluation of the IVC and iliac segments. We generally use a CTA protocol with delayed imaging. It is most useful when assessing large people for whom abdominal DUS is more challenging. CTA may require special authorization with insurance, and it gives off a significant dose of radiation. We don't use MRV as a rule.

Any tips and tricks you have found beneficial with your screening tools of choice?

Dr. Marston: There is no one right protocol. Much depends on what fits within your system; for instance, in some circumstances, CTV or MRV are rarely if ever performed, and more patients are taken directly to the angiography suite. Regarding DUS, a great deal depends on how good and experienced the technologists are. DUS is highly operator dependent, so training techs to know what to look for is important and achievable.

Dr. Kolluri: Our vascular lab techs augment venous return from the thigh rather than the calf to maximize flow during assessment of the iliacs; another tip is to vary patient position (eg, Trendelenburg) to augment venous

... we almost always perform IVUS to help determine if a patient needs stenting, and even more importantly, the extent of stenting required. We use IVUS to help us identify the maximum areas of compression.

—Dr. Marston

return during the DUS studies. Reviewing old studies such as CTs or MRs performed for other indications can also provide valuable clues.

Dr. Thorpe: Ultrasound imaging depends on the expertise of the registered vascular technician and the patient's body habitus; but the advantage includes acquisition of velocities and waveform analysis. Initial screening and follow-up DUS exams are essential. Perhaps the most important asset is an experienced and dedicated venous ultrasound person on your team.

ROLE OF IVUS IN VENOUS STENTING When do you use IVUS in your interventions and why?

Dr. Marston: In general, I like to perform venography first as a road map for guidewire access and to look for collaterals. If I see contrast flow quickly up the iliacs into the cava without seeing any collaterals open up, I'm more skeptical regarding the presence of significant obstruction, but we almost always perform IVUS to help determine if a patient needs stenting, and even more importantly, the extent of stenting required. We use IVUS to help us identify the maximum areas of compression.

If the patient has severe PTS, it is usually quite straightforward—there is often significant obstruction. After crossing PTS lesions, we use IVUS to help identify the start and end points for the stent. If it's a more equivocal case, for example a patient with approximately 50% obstruction from nonthrombotic compression, then we use IVUS to help us obtain specific measurements of intraluminal area at the maximal point of compression and at an adjacent segment of normal vein to calculate the percentage narrowing. Then, in the absence of data, there is the discussion of whether or not there is sufficient obstruction to stent; as a guideline, if there is < 50% area reduction and no collaterals, I generally don't stent. If there is a ≥ 50% area reduction, I typically do stent and use IVUS to help determine proximal and distal landing zones. Then, after we deploy the stent (or stents)

and postdeployment balloon, we perform IVUS again to make sure the stent is fully expanded with good vein wall apposition and that the vein lumen is as large as we'd like it to be.

Dr. Thorpe: IVUS is used to document and measure anterior-posterior and transverse diameters as well as relative luminal area when determining the need for iliac stenting. It allows us to evaluate normal baseline size compared to the vein affected by compression or thrombus. IVUS helps determine the IVC/iliac transition point. With chronic iliac disease, I often place it over the bifurcation to look at the "normal side" to obtain baseline diameters. It is also important to evaluate stent expansion. Sometimes, it looks very good on fluoroscopy, but IVUS shows that the stent is actually not expanded very well. We also evaluate the amount of residual thrombus after thrombectomy. This evaluation allows us to determine the need for additional catheter-directed thrombolysis. IVUS is the best way to identify restenosis in stents when patients present with recurrent symptoms of venous hypertension.

What does IVUS offer that makes it a valuable imaging modality to you?

Dr. Marston: Challenging cases are obstructions in which we would like to get the vein open to 12 mm or larger; sometimes, this procedure is difficult due to the extent of scarring, but we use IVUS to help measure how large it is and will balloon again if we are not happy with the diameters. I don't think you can do that with venography; you can't get those measurements of the poststent size very well. It also takes much longer with venography (eg, need for two planes), whereas with IVUS, I have been able to get the answer more quickly.

IVUS is also important to evaluate stent expansion. Sometimes, it looks very good on fluoroscopy, but IVUS shows that the stent is actually not expanded very well.

—Dr. Thorpe

Dr. Kolluri: I have been impressed with IVUS's imaging capabilities, which have helped to detect spurs, membranes, trabeculae, and webs. I have seen an example of venous stent thrombosis caused by a fractured strut

protruding into the vessel lumen. This strut served as the nidus for thrombus formation in this case and was not visible by CTV. IVUS showed it and facilitated placement of a short stent within the existing stent to crush the protruding strut against the vein wall. IVUS has also revealed what in-stent intimal hyperplasia looks like that was not visible by venography.

Dr. Thorpe: IVUS provides the most accurate dimensions of the vessel diameter. Specifically, the AP diameter of the common iliac vein is best appreciated with IVUS. Fluoroscopy and contrast venography do not show apposition of the stent to the vein wall as well as IVUS does. With IVUS, I can observe progression of thrombolysis and acquire chronological images, which provide information on how thrombus behaves. I find it very helpful to image with IVUS after thrombectomy because the venogram generally does not show the full amount of residual thrombus. It is invariably more than suggested by the venogram.

POSTTREATMENT FOLLOW-UP

What is your follow-up protocol for stented patients (eg, medications, compression stockings, follow-up imaging, etc.)?

Dr. Marston: I believe compression stockings do have a role after stenting for most patients because stenting usually improves, but does not completely resolve, edema. Longer term, some patients with CEAP C3 and C4 disease may cease to have edema and can then stop using compression stockings.

After stenting, I usually follow patients with non-thrombotic disease using DUS at 1, 6, and 12 months after stenting, and yearly thereafter. I wouldn't anticoagulate a nonthrombotic patient unless there was a thrombotic event during the index procedure (eg, thrombus was seen on the stent).

Patients with PTS tend to have a higher risk of rethrombosis, so I like to see them back for DUS within 2 weeks of stenting. If everything looks good, I will follow-up at 3, 6, and 12 months, and yearly thereafter. Antiplatelet therapy is used, unless the patient was already on a long-term anticoagulant regimen. For patients treated with more severe disease, I like to treat with anticoagulation for 6 weeks to 6 months after stenting, depending on risk factors and flow velocities.

Dr. Kolluri: Depending on complexity, I see my patients back for DUS somewhere between 6 weeks and 3 months. If stents are extended below the inguinal ligament, I may opt to see the patient back for DUS at 4 weeks. Most commonly, however, I see my patients

Sponsored by Volcano Corporation

Venous lesions have a different feel when they are crossed compared to arterial lesions. I think much can be gained from working with an experienced venous interventionist on cases to see how they do it.

—Dr. Marston

back after 3 months because that is when I'm making decisions about duration of anticoagulation therapy, whether or not the clopidogrel needs to be extended, etc. After that, I usually see these patients on a yearly basis. For patients with extensive swelling from iliofemoral DVTs, I first treat with medium stretch compression wraps for 4 weeks, then I see them in the clinic; once the leg shrinks, I then switch to compression stockings, typically for 1 year.

For nonthrombotic patients, in the absence of data-driven guidelines, our practice is to use aspirin and clopidogrel for 3 months, and then aspirin indefinitely. If family or patient history reveals risk factors for hypercoagulability, and if the risk of bleeding is low, I typically treat for 3 months with a new oral anticoagulant and 81 mg of aspirin for at least 1 year (longer, depending on other risk factors). We pattern this after the peripheral arterial practice because data are lacking for venous stents. In post-DVT patients, the anticoagulation regimen I follow is not affected by the absence or presence of a stent; I adhere to post-DVT anticoagulation guidelines. It is also important to investigate what caused the DVT in the first place.

Dr. Thorpe: After stenting nonthrombotic iliac compression, I will put the patient on clopidogrel and perform a follow-up DUS within 1 month. If the patient has hypercoagulability, I will also place him or her on warfarin. The follow-up DUS exams, including velocities, are requested for all patients at 3, 6, and 12 months, then annually thereafter. In symptomatic patients, I look for changes in velocities, which indicate the presence of intimal hyperplasia. We then evaluate with IVUS to document "venaplasia" and treat with angioplasty. Of course, this may occur years later, so continued follow-up is important.

Patients with PTS can present with or without chronic thrombus in the femoral, popliteal, or tibial segments. If we just place stents in the iliac system, and the inflow is excellent without substantial residual distal thrombus, patients are placed on clopidogrel and 6 to 12 months of

warfarin. People with a history of recurrent thrombosis are maintained on long-term anticoagulation. They risk rethrombosis in the distal segments when they are not on warfarin. This can compromise stents. We have seen a number of Xa inhibitor failures and have restarted all of these patients on warfarin.

I also check for valvular reflux and advise patients to wear compression stockings to control edema.

ADVICE FOR PEERS

What advice do you have for your peers who may be new to venous stenting?

Dr. Marston: I think it would be really useful to work with someone who has performed a lot of venous stenting because there are pitfalls and lessons learned from experience that are valuable in helping the new clinician avoid complications. Venous lesions have a different feel when they are crossed compared to arterial lesions. I think much can be gained from working with an experienced venous interventionist on cases to see how they do it.

Dr. Kolluri: Learn about the disease process first. The most important thing about venous disease is to recognize that it is not "inverted" arterial disease; the anatomy is different, the clinical presentation is different, and there is a lot more art to venous pathophysiology and treatment. There is much more nuance to the venous world, so get a good textbook, visit a high-volume center, find industry colleagues who can connect you with such centers, and attend high-quality venous meetings.

Dr. Thorpe: I think it is very important to document the lesion to be stented in the best manner possible. Failures in iliac stenting generally result from failure to place the stent high enough in the IVC as well as failure to provide adequate inflow from below. Continuity of flow within the entire deep venous system must be optimized to provide the best chance for long-term patency.

Stents that are too big or too small can be problematic in their own ways. A stent that is too small or too short can embolize. A common iliac stent significantly larger than the normal external iliac segment can result in slower flow in the wider channel. Thrombus can build up on the stent wall. Much like a river, the current is stronger in the middle. Laminar flow is best achieved in a uniformly sized or minimally tapered conduit. "No-stent zones," for me, include the popliteal and distal femoral veins. An imperfect vein that works is better than a pretty stent full of thrombus. Opening chronically occluded stents is much harder than opening the native vein, so diligent monitoring of venous stents is the key to success for both the patient and physician. ■