PANEL DISCUSSION

The Most Challenging Chronic Deep Venous Occlusions

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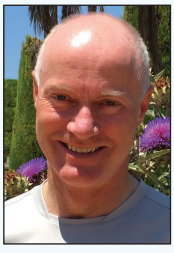

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In which deep venous occlusion cases will you definitively not stent?

Dr. Desai: In cases where inflow is irreparably compromised, any iliofemoral stent is often consigned to fail. With postthrombotic occlusions, this is most frequently when the femoropopliteal segment and, more importantly, the profunda femoris are occluded such that there simply is no flow to support stent patency. In these cases, I feel that placing a stent has a much greater likelihood of failure than success. As we all know, restoring patency can be enormously difficult when stents fail, and an occluded stent may exclude patients from any future therapies that would more definitively restore inflow and support a future stent reconstruction.

Dr. Murphy: Although stenting for deep vein occlusions can be extremely rewarding, these cases can also prove challenging. I find that the outcomes of these cases are highly dependent on sound judgment and attention to the technical details of the operation. I avoid stenting patients when a good outcome is unlikely, even if the best operative techniques are employed to achieve the best-case scenario technical result. The most frequent reason for operative exclusion in my practice is severely diseased, two-vessel, occlusive inflow disease (profunda and femoral veins [FVs]). If these vessels are wholly occluded, the likelihood of a successful outcome is very low. My inflow requirements include at least one suitable inflow vessel (femoral or profunda), or if both inflow vessels are involved, I look for < 50% occlusive disease in both. In borderline patients, I may stent in conjunction with inflow venoplasty, although this achieves inconsistent results. On occasion, I may offer endophlebectomy to patients initially excluded from stenting based on inflow, if the inflow vessels 1 to 2 cm caudal to the confluence are healthy.

In addition to anatomic exclusions, I do not offer stenting to patients with medical conditions I feel would unreasonably limit the benefits of stenting. Examples include patients with severe morbid obesity (body mass index > 40-45 kg/m^2) or other advanced prohibitive medical conditions (chronic obstructive pulmonary disease on oxygen, decompensated heart failure). These conditions cause increased operative risk as well as significantly elevated venous pressures, which limits the benefits of intervention. Lastly, I do not offer high-risk interventions (ie, those with severe inflow disease) to patients who are routinely noncompliant until a track record of follow-up compliance proves otherwise.

Miss Wilton: Our main reason for not stenting is inadequate inflow, as this is required to maintain stent patency. This would have been assessed prior to undertaking the reconstruction. You need to stent from normal vein to normal vein to try to ensure stent patency over time. However, it is very rare that if we were able to cross the occlusion satisfactorily, we wouldn't stent in the iliac vein/common femoral vein (CFV) region. Consideration also needs to be given to the patient's age and the proposed extent of stenting, particularly iliocaval reconstructions. However, as with all venous cases, severity of symptoms, quality of inflow, and patient factors all need to be balanced.

Drs. Jalaie and Barbati: Case selection is a key factor when patients are considered for endovascular treatment. If the inflow is severely impaired (eg, involvement of both the FV and deep FV [DFV]) and the probability of a long-term patency rate is really low, then recanalization and stenting should be avoided. In our opinion, in such a case, neither a hybrid procedure nor stenting into one of the inflow veins is advisable. Moreover, in most patients with asymptomatic chronic venous obstruction, when anticoagulation is contraindicated and in immobile patients, conservative treatment should be considered as the treatment of choice.

When do you consider an arteriovenous fistula (AVF)?

Dr. Murphy: Patients with extensive CFV disease are generally treatable with endovascular methods alone (ie, stenting to the profunda femoral confluence), as long as there is adequate inflow. Therefore, I reserve AVF creation for patients with poor femoral and profunda inflow. Endophlebectomy and AVF creation may be helpful in these cases. Occasionally, AVF without endophlebectomy is performed in cases of single-vessel diseased inflow proven insubstantial for stent maintenance.

Drs. Jalaie and Barbati: Please bear in mind that AVF creation is not a routine procedure in daily practice. It should be considered a temporary solution in carefully selected patients to improve the inflow and keep the affected vein segments patent. The more important aspects after venous intervention are long-term patency rates and clinical improvement of the patients thereafter. Artificially improved inflow into the iliocaval segment in a patient with obstructed FV and DFV will increase venous hypertension and likely even increase complaints and discomfort of the affected leg. Moreover, after closing the AVF, the preexisting insufficient inflow is not enough to keep the treated segments open. Unfortunately, a standardized technique to measure the venous flow in chronic obstructed venous segments and the threshold

of minimum necessary inflow could not be quantified until now.

Creation of AVF should be considered in the following patients/situations: (1) those who have vigorous synechiae at the level of femoral confluence covering the ostium of a patent DFV and need an endophlebectomy to ensure sufficient inflow; (2) to keep the reconstruction patent in patients with early reocclusion after successful initial thrombus removal and in whom the reason of the rethrombosis is unclear; and (3) patients with an acute iliofemoral thrombosis who have undergone a surgical thrombectomy.

Miss Wilton: In our opinion, an AVF temporarily maintains stent patency but does not address the underlying inflow issues and may in fact potentiate them. We prefer endovascular strategies to improve inflow rather than AVF, which we rarely perform.

Dr. Desai: Creation of an AVF may have a role when the inflow is of such poor quality that the stent is doomed to fail. However, as our surgical colleagues will probably attest, the outcomes of these interventions are incompletely described. Do AVFs address a short-term problem (ie, maintaining immediate stent patency) without a clear signal of long-term symptom reduction in any significant number of patients? Do the AVFs remain open relatively unassisted? I do believe that they have a role, but we need to define it a bit better.

With a compromised CFV, is it technically better to go from above or below?

Miss Wilton: We generally try from below first and are usually successful. However, there are certain disease patterns that commonly require dual access from the right internal jugular vein (IJV) as well as the FV, for example in patients with a history of intravenous drug misuse. This is because the disease is isolated to the lower external iliac vein (EIV) and CFV, and the occlusion does not have the usual trabeculations and microchannels but has a more obliterative, hard, fibrotic appearance.

Drs. Jalaie and Barbati: Even with a compromised CFV, an antegrade (popliteal or midfemoral) approach should be the first choice. The advantages of this access are the ability to evaluate the quality of inflow veins, no need for longer wires and catheters (compared to transjugular access), more stability of wires on recanalizing the iliofemoral obstruction without needing to change to a longer sheath, and more accessibility to the contralateral side in cases of bilateral iliocaval obstruction.

The advantage of a jugular approach is easy access for DFV vein dilation and stenting. Consequently, the jugular approach should be the first choice only in patients with planned DFV stenting. However, it remains a very important option because jugular assistance will be necessary in some cases to traverse the occlusion. In our daily work, we always position, prep, and drape the patient in a way that bilateral femoral access and jugular approach are feasible.

Dr. Desai: I think this is a matter of operator preference. I know several in both camps who have had tremendous success. My personal approach is to work from below the occlusion. For me, this means from an access in the popliteal fossa. I achieve access in the small saphenous vein immediately caudal to the saphenopopliteal junction (if the patient has one), the high calf posterior tibial vein immediately caudal to the popliteal vein, or my least preferred, the popliteal vein itself. These accesses require that the patient is prone. Others use the mid-FV, which is again a matter of preference. Coming at the occlusion from below has the benefit of working with flow, meaning you can directly observe what the inflow to a stent will be. Working from below has the disadvantage of potentially needing a reverse-curve catheter to select the profunda femoris should it be necessary, although this is not terribly cumbersome in my experience.

Approaching an occlusion from above allows you to easily select critical branch vessels such as the profunda with a standard angle-tip catheter. However, you will be working against flow. The operator needs to advance the catheter past the area of interest for adequate venography. Working from the neck also requires some ergonomic adjustments. We are all used to working with our tools on a table, and adjustments need to be made to work from above so that you are not working in the air. One potential benefit of working from above, particularly in an occluded CFV, is that it allows you to "stick the landing" of a stent at the profunda origin so that it is not inadvertently covered. Again, numerous skilled operators have done remarkable work from a neck access. It is a matter of what works for you.

Dr. Murphy: Ultrasound-guided ipsilateral FV access in the upper to midthigh is my preferred access for iliofemoral occlusive disease. This location gives excellent pushability for crossing diseased venous segments. The access must be low enough in the thigh so that the sheath tip lies below the lesser trochanter (the expected location for the profunda femoral confluence), allowing visualization and treatment of the entire CFV.

This approach has a high success rate even in FV occlusions, which often accompany extensive CFV disease. Venous occlusions are not solid but rather trabeculated, and the wire usually passes with ease.

Alternatively, access from above via the right IJV can be a solid choice. This access is particularly well suited for a patient with a patent ipsilateral cranial common iliac vein (CIV). However, patients with a compromised CFV often have accompanying ipsilateral EIV and CIV disease. In these cases, the presence of a tight stenosis or occlusion of the cranial CIV may prohibitively increase the difficulty of selecting the vessel from above. Occasionally, if crossing the occlusion is challenging, an approach from above and below to cross the lesion with an eventual body floss technique is also helpful.

In inferior vena cava (IVC) occlusions, do we need to be more careful with renal vein inflow?

Drs. Jalaie and Barbati: Stent placement across the ostium of renal veins is very common during iliocaval stent reconstruction and is necessary in patients with postthrombotic trabeculation extending into the juxtarenal and suprarenal IVC.

Until now, there was no or minimal evidence of renal function impairment after IVC stenting with jailing of renal veins. A literature search showed that there was only one report of renal function impairment and one report of renal vein thrombosis without renal dysfunction after overstenting the renal veins.[1-3] In our own patient population, we haven't seen any detectable renal function impairment or renal vein thrombosis after stenting across the renal vein inflow. We are confident that implanting a stent in an already obstructed IVC and jailing renal veins with porous dedicated venous stents will not further decrease the renal venous flow.

Dr. Murphy: IVC occlusions most often involve the distal portion of the IVC up to the level of the renal veins. Less commonly, occlusions will involve the suprarenal IVC or even the intrathoracic IVC. I generally use Wallstents (Boston Scientific Corporation) in the nonbranched portion of the IVC because they are available in sizes large enough to accommodate the IVC (22-24 mm). The Wallstent is used in combination with Z-stents (Cook Medical) across the renal and hepatic veins as needed. Z-stent interstices are significantly larger than the small interstices of the Wallstent. These larger openings may prevent the jailing of confluences over time. An additional technical detail to avoid jailing the renal veins is to avoid overlapping stents across the vessel conflux with the IVC.

When stents do cross the renal vein confluence with the IVC, anticoagulation can likely help preserve renal blood through stent sidewalls in the same way that anticoagulation helps prevent contralateral deep vein thrombosis after confluence jailing by iliac vein stents. Indefinite anticoagulation is already required in most patients undergoing caval reconstructions secondary to complex stent configurations, associated compromised inflow, and concomitant thrombophilias. Protection against renal vein compromise secondary to jailing is another reasonable consideration for use in these patients.

Notably, although I follow these practices to preserve renal flow, it does not greatly concern me when closed-cell stents cross the renal veins. This is because the renal veins are very high flow, which is often enough to maintain flow through the stent sidewalls. In addition, as stated, most patients are on anticoagulation, which is likely protective. Lastly, the renal outflow is typically very well collateralized. Thus, renal vein compromise is often without significant deleterious effects.

In summary, we should mind the renal venous inflow with attention to technique and consideration in anticoagulation decisions. However, in cases where they are compromised, minimal clinical impact is expected.

Dr. Desai: This is a frequent area of debate. We have heard anecdotal discussions of caval side branch occlusion, such as the renal veins, when stents extend across the ostia. The issue arises when the occlusion approximates these major side branches such that appropriate stent placement mandates at least a portion of the stent will cover the branch ostia. My personal preference in these cases is to place large-diameter, large-interstice tracheobronchial stents in an off-label application at the level of the caval side branches. Then, I place double-barrel-configuration nitinol stents the level of major caval side branches. On the other hand, we have all seen cases where no normal renal vein inflow into the cava is present, and the kidneys drain via collaterals to the azygos or phrenicoadrenals. Is this concern justified? It is unclear. One area where narrow-interstice stents may be an issue is adjacent to the hepatic veins. Here, hepatic vein occlusions may theoretically cause Budd-Chiari syndrome, which could cause portal hypertension and liver failure. Like so much of what we are discussing, the bottom line is that we have a lot to learn.

Miss Wilton: Stenting across the renal vein inflow when treating IVC occlusions is something we do consider, but as with all venous disease, the key is to ensure that the entire disease segment is treated. The limited

evidence and our experience show that it is safe to stent across the renal vein inflow if required. We have not had any compromise in renal function or other complications from stenting across the renal vein inflow, such as renal vein thrombosis.

Is it acceptable or justifiable to perform complex deep venous reconstruction without (1) good-quality preoperative MR venography (MRV) or CT venography (CTV) or (2) intraoperative intravascular ultrasound (IVUS)?

Dr. Murphy: In my opinion, the short answer is no. These cases are complex, and appropriate preoperative planning with high-quality duplex imaging and CTV (or MRV) helps plan the access, predict likely stent landing zones, prevent surprises, and guide outcome expectations, which can guide patient and physician decision-making.

In complex venous cases, IVUS is often a key determinant of eventual stent outcomes, and it is essential to select appropriate stent landing zones, protect confluences, and ensure maximal technical success. It is significantly harder to fix stent errors or occlusions resulting from shortcuts than to do these procedures correctly the first time.

Miss Wilton: We always perform cross-sectional imaging with either an MRV or CTV prior to undertaking any complex deep venous reconstruction. This allows discussion and planning of our operative approach in detail before undertaking the procedure. It also allows us to decide on extra strategies that we may need to employ to try to cross the lesion—for instance, whether to access from the FV and/or the right IJV. We also think of adjuncts that may be needed during the procedure to help cross the occlusion, such as a Rösch-Uchida access set (Cook Medical). We are also aware of the anatomy to help guide us across the occlusion. Cross-sectional imaging is useful to ensure that there is no other cause for the occlusion, such as malignancy or external compression. Additionally, to ensure adequate inflow, we perform direct venography on a separate occasion before undertaking complex deep venous reconstruction.

We use IVUS in all cases to confirm we are in the correct place, plan stent placement from normal vein to normal vein, and accurately land the stent. With IVUS, we can also assess the stent once it has been deployed to ensure there is no compromise, such as residual compression, loss of luminal diameter, and flattening of the stent. We also find it useful to reduce the radiation dose to both patient and operator.

Dr. Desai: So much of the procedure is in planning. You need high-quality imaging to determine the cause of occlusion (ie, in a caval occlusion, is it a filter?) because this will significantly impact your procedure, from your access sites to what tools you'll need (eg, filter removal tools, sharp recanalization techniques) to your anesthetic plan and how long it will take to get it done! So, preprocedural imaging is mandatory in my opinion. In the most complex venous occlusions, I think CTV of the abdomen/pelvis is mandatory. I prefer CTV based on its availability and how quickly it can be obtained, but use of MRV is perfectly valid. The exception for MRV is for filter-related occlusions as the filter will cause a terrible artifact with MRV.

I used to perform these cases without IVUS, but I would not now. IVUS provides so many tangible benefits, including addressing inflow, outflow, and postplacement stent expansion. It has given me more confidence in the intervention and has likely prevented many occlusions from occurring by demonstrating areas that I have not sufficiently addressed.

Drs. Jalaie and Barbati: Complex venous reconstruction requires profound preoperative preparation consisting of anamnesis, clinical examination, and imaging. A good MRV or CTV, in addition to a thoroughly performed duplex ultrasound, is mandatory and a premise for good results. It is important to carefully assess the inflow veins and the CFV to plan the procedure and predict the outcome. We also must remember the importance of having a detailed, reliable preoperative conversation with the patient about the procedure, patency rate, and probable clinical outcome. During the procedure, it is highly recommended to use IVUS to determine the proximal and distal landing zones.

What is your stent type of choice for crossing the inguinal ligament: open-cell nitinol, closed-cell nitinol, or a braided design? If you believe that one particular type of stent is preferred to cross it and go to the ligament, where should the overlap zone be, and why? How would you achieve this stent placement?

Dr. Desai: Stent placement across the hip is a hot topic at the moment. There is increasing recognition that not placing a stent into the CFV when it is obstructed is a frequent cause of occlusion. However, this is counterbalanced by concerns of stent fracture. One of the stent trials demonstrated a single-digit rate of fracture for closed-cell stents, but it is not clear whether fracture routinely impacted patency. I have seen some instances of fracture with open-cell nitinol stents and

with braided stents as well less frequently. Work done by several venous leaders, including Stephen Black, MD, and colleagues, has shown that the ligament is likely not the cause of fracture. Rather, it is caused by the superior pubic ramus and stress placed on the stent in leg extension.[4]

Technique is key. Stent overlap at the level of the ligament or the femoral head/pubic ramus can lead to failure because the "stent joint" is then at a dynamic position. I aim to have my stent overlap occur above the ligament (in the pelvis) and have a single stent exit the pelvis, cross the joint, and terminate at the profunda inflow. Thankfully, this is easier to do now that we have long dedicated venous stents.

Miss Wilton: When treating chronic iliac venous occlusions, we regularly place a stent across the inguinal ligament (84% of our cases) because the disease often extends from the caval confluence to the CFV confluence. In the vast majority of cases, we've used a closed-cell nitinol stent. The overlap zone is in the EIV proximal to the pelvic brim. This is to ensure that the overlap zone is not on a bend where the flexion/extension movement would increase the risk of stent fracture. We achieve this using IVUS. We land the distal stent accurately just at/proximal to the CFV confluence.

Drs. Jalaie and Barbati: There is no best stent for crossing the ligament. This area has the highest range of motion and high external compression, so ensuring flexibility and radial force is crucial. Overlapping segments of two stents will have less flexibility and should be avoided at the level of the ligament. We have very rarely seen fracture of dedicated venous stents in our patients, and none of the fractures we did see resulted in obstruction of the reconstruction or relapse of patient symptoms. Amid measuring the length of the pathologic segment that needs to be stented, it should be noted that the overlapping zone remains at the level of the EIV.

Dr. Murphy: Dedicated venous stents are relatively new to the venous space. Although there is a long-standing track record of braided stents crossing into the CFV without fracture, a lack of deployment predictability and precision motivated the development of newer nitinol stents. As the clinical experience has increased, we've found that some more contemporary stent designs are associated with infrequent fractures when extending past the ligament. Trials have yet to demonstrate whether these fractures are clinically deleterious or insignificant over time. Nonetheless, when faced with stenting into the CFV, we have stents that are associated with stent fracture and stents that are not. To this point, when crossing the ligament, I tend to rely on either braided elgiloy stents or open-cell nitinol stents that have no known incidence of stent fracture in this scenario. However, in the absence of clinically impactful data, I cannot voice a strong recommendation.

Regardless of stent selection, avoiding stent overlap under the ligament is important because this likely increases the risk of stent fracture. With the increased availability of longer stents, overlap zone location should be easily controlled and is part of appropriate stent selection. ■

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