

## ROUNDTABLE DISCUSSION

# Percutaneous AV Fistulae: What to Expect in the Learning Curve

Perspectives on patient candidacy, technical challenges and follow-up protocols, considerations for cannulation, and steps for handling inadequate flow.

**WITH BART DOLMATCH, MD; ALEXANDROS MALLIOS, MD; NEGHAE MAWLA, MD;  
TOBIAS STEINKE, MD; AND ALLISON TAN, MD**



## Bart Dolmatch, MD

Palo Alto Medical Foundation  
Mountain View, California  
duster54@sbcglobal.net  
*Disclosures: Consultant/speaker for BD;  
consultant to Merit Medical Systems,  
Black Swan Vascular, Bluegrass Vascular,  
and Medtronic.*



## Tobias Steinke, MD

Head of Vascular and Endovascular  
Surgery  
Schön Klinik Düsseldorf  
Düsseldorf, Germany  
info@dr-steinke.com  
*Disclosures: Consultant to BD/Bard,  
Medtronic, and Merit Medical.*



## Alexandros Mallios, MD

Vascular Surgery Service  
Institut Montsouris  
Paris, France  
alexandrosmallios@gmail.com  
*Disclosures: Director of training in Europe  
and shareholder in Avenu Medical.*



## Allison Tan, MD

Assistant Professor of Radiology  
Division of Interventional Radiology  
Thomas Jefferson University Hospital  
Philadelphia, Pennsylvania  
allison.tan@jefferson.edu  
*Disclosures: None.*



## Neghae Mawla, MD

Interventional Nephrology  
Dallas Nephrology Associates—  
Vascular Center Plano  
Plano, Texas  
mawlamd@gmail.com; @NMawlaMD  
*Disclosures: Speaker/consultant to Avenu  
Medical and BD/Bard.*

**What are your keys to determining patient candidacy for a percutaneous arteriovenous fistula (pAVF)? Which patients do you categorically rule in or out?**

**Dr. Mawla:** We use ultrasound vein mapping to determine AVF candidacy. Perforating vein and deep vein anatomy dictate whether we use the Ellipsys (Avenu Medical) or WavelinQ endovascular AVF (endoAVF; BD Interventional)

device for the endo-anastomosis. At the time of the vein mapping consultation, discussions with the patient are a primary driving factor for what site is chosen for access.

First, we look at the superficial veins for sizing. A vessel < 2 mm will exclude that site for an AVF (surgical or endovascular). Then, at the anastomotic zones, we size out the deep (radial and ulnar) veins and perforating veins. The next step is to identify the communication from the endo-anastomosis to the superficial outflow (cephalic, cubital basilic, or dual outflow). Then, we look for and consider competitive flow, which can be at the superficial or deep level. Dual outflows usually carry more flow into the median cubital branch, so we might have to consider ligation/embolization of one branch. If the brachial veins seem large enough to take away to superficial flow, an endo-anastomosis may not flow into the superficial network. At minimum, this will require coil embolization to drive flow superficially. At worst, the deep flow may never allow the superficial vessels to mature. Finally, we identify cannulation zones to estimate if an intervention or superficialization may be required down the line. Endo-basilic AVFs allow cannulation across the cubital fossa, so in our practice, few transpositions or elevations are required. Endo-cephalic AVFs have been the easiest to cannulate and use. Dual-outflow AVFs are initially planned for split cannulation, with one needle into each vein.

The most involved discussions are when there are multiple options for access, particularly when a patient is a candidate for both an endoAVF and a forearm AVF in the same arm or a dominant arm endoAVF and non-dominant arm surgical AVF. As a team, with the patients' guidance, we proceed with the access that best fits the patient's goals, wishes, and needs.

**Dr. Steinke:** Each pAVF procedure requires the presence of a median cubital vein perforator. This is the most consistent communication between the deep and superficial venous systems at the level of the elbow and is crucial to connect the superficial venous system to the target pAVF creation site. Continuity of the perforator with the superficial cephalic and/or basilic veins should be assessed and a central venous stenosis should be ruled out (venous outflow assessment). Checking the arterial inflow is the same as in surgical procedures. Vessel diameter, pulse quality, confirmation of a complete palmar arch, the level of bifurcation of the brachial artery, and the amount of calcification in the vessel wall (especially in diabetic patients) should be evaluated properly. Using wrist access for the procedure additionally requires the investigation of the access site. Most important here is the vessel diameter of > 2 mm and a nontortuous anat-

omy. So, patients without a perforator, small vessel size (< 2 mm), or/and heavy calcifications are ruled out.

**Dr. Tan:** Clinical history and ultrasound mapping are the most important tools for determining patient candidacy for pAVF creation. The anticipated outflow veins must be intact, free from stenosis or obstruction, and have a minimum diameter of 2 to 2.5 mm, including the perforating vein that brings blood from the deep veins in the arm to the cannulatable superficial veins. Therefore, patients who have had previous upper arm fistula or graft surgeries are not candidates for pAVF creation.

The target site for pAVF creation must have minimum arterial and venous diameters of 2 mm to allow enough flow for fistula maturation. Additionally, the target artery cannot be heavily calcified, which can impede proper function of the device. If vessel caliber is not ideal for pAVF, in discussion with a surgeon, pAVF can still be performed to improve the quality of the upper arm vessels for subsequent surgical AVF creation.

Importantly, patients who are also candidates for a radiocephalic fistula should be referred for that procedure first. A more peripheral surgical procedure does not prohibit subsequent pAVF creation if and when additional dialysis access is needed.

**Dr. Mallios:** All patients who are not good candidates for a distal surgical AVF are good candidates for a pAVF with the Ellipsys vascular access system as long as they meet the vascular anatomy criteria requiring that a perforating vein and radial artery are  $\geq 2$  and  $\leq 1.5$  mm from one another. In particular, elderly diabetic patients at a high risk for a nonmaturing distal fistula may benefit from a proximal radial artery inflow that improves maturation rates while maintaining a low risk for steal syndrome and high-flow AVF, which are both inherent to brachial artery inflow.

**Dr. Dolmatch:** We have less experience than many others—now about 10 cases. Nevertheless, in our first few cases, we considered creating a pAVF if the patient had suitable vascular anatomy and was a candidate for a surgically created upper arm AVF. However, we overlooked the depth of the intended cannulation vein(s) and thoracic central vein obstruction (TCVO). This caused one patient who had unrecognized TCVO and a successful pAVF to develop arm swelling that was later treated successfully. Two patients had successful pAVF creation but it was too deep for reliable cannulation. It is unclear how deep veins should be managed in potential or subsequent pAVF patients. Are patients with deep veins suitable for pAVF? Should a two-step procedure be done with subse-

quent lipectomy, superficialization, or some way to mark the cannulation sites? Or are these patients not suitable for pAVF creation? We aren't sure yet.

**Can you describe any technical challenges you have encountered, whether frequently or infrequently, and how these can be managed when they occur or prevented before they do?**

**Dr. Steinke:** In my opinion, puncturing the relatively small veins under ultrasound guidance at the level of the wrist remains the most challenging part of the procedure. However, the benefit of this approach is that crossing the valves with the wire against the bloodstream is avoided. The medial and lateral deep veins are connected by small venous branches, so take care not to cross over because the venous catheter may not reach the designated creation site. With the current system in curved anatomy, several attempts to position the 4-F catheter may be necessary to get the best possible adaptation of the magnets. I believe the key to success is to create the endoAVF as near as possible to the perforator, so I suggest a sophisticated pre- and intraoperative ultrasound evaluation. You should never use closure devices for the brachial artery.

**Dr. Mawla:** Cases using the Ellipsys system were harder to visualize at first, given I had little previous ultrasound experience, but this quickly improved with experience. The ongoing challenges depend on the course of the perforating vein to the radial artery. Curved and tortuous veins are harder to maneuver through. The entry and crossing point into the radial artery can have various degrees of difficulty, especially if it is a side entry into the artery. Study the vessel anatomy in both transverse and longitudinal views. Planning the needle approach often helps with these challenges. Surface markings on the arm for vessel entry and crossover location also help with the needling process. Vasospasm during the approach can make visualization of the needle tip difficult. Sometimes antispasmodic agents help, but other times it is better to pull back and retry another time.

Cases using the WavelinQ system provide a different set of challenges. It is often easy to find an adequate target anastomotic zone, but getting to that zone can sometimes be difficult, particularly through the venous network. A brachial vein approach means crossing valves, and sometimes the brachial veins do not communicate well to the ulnar or radial veins. Wrist veins may not be large enough to support sheath sizing for access. A detailed preoperative study of the deep venous network with ultrasound and a planned approach have been very useful. Also, using ultrasound during wire manipulation helps ensure you are in the intended venous path to the target zone.

In fact, detailed ultrasound for mapping, guidance, access, and approach has been the biggest boon for both devices. Become familiar with the upper extremity vessels and their variations under ultrasound. A good-quality ultrasound device and probe are critical components. Like any procedure, be aware of complications for each device and step and have a contingency plan for salvage, if needed.

**Dr. Mallios:** The puncture can be tricky when you do your first cases. Our refined technique, which has been presented at Controversies in Dialysis Access and published in the *Journal of Vascular Surgery*,<sup>1</sup> has made this difficulty obsolete for new users for the most part as long as they choose a patient with reasonable anatomy (ie, not very small or tortuous vessels that can make the puncture more challenging). Careful mapping by the operating surgeon at the clinic when the case is scheduled and confirmation of the anatomy after administration of locoregional anesthesia are keys to success.

**Dr. Dolmatch:** The two-catheter radiofrequency pAVF system that we use requires precise apposition of the venous and arterial catheters to create a durable pAVF. In our limited series, we've had two cases where the catheters seemed to align nicely but no AVF was created, and we repositioned the catheters (or in one case used new catheters) with ultimate technical success. In two cases (one of the initially failed cases), sluggish pAVFs were created but failed before 1 month. Could these small pAVFs have been treated with percutaneous transluminal angioplasty (PTA) earlier than 1 month? We've been concerned with dilating a newly created pAVF to improve the arterial-venous communication, but perhaps this is something worth considering.

**Dr. Tan:** I use the WavelinQ system, so I can only comment on my experience with that device. The most common challenges for me are room setup and operator comfort. Our interventional suites have a ceiling-mounted C-arm, which is not ideal for upper extremity procedures. A mobile C-arm unit is reported to be much more ergonomic for the proceduralist, and I plan on trying this setup with future cases. A rare technical issue I have experienced is device malalignment, resulting in failure of fistula creation. When aligning the WavelinQ pAVF system, there is a point in which you position the image intensifier so that the space between the artery and vein is the widest possible, called "widest view." In most patients, it is obvious when you are in the widest view; however, in some patients, the vessel anatomy can make distance changes with image intensifier rota-

tion very difficult to perceive. If the wrong projection is selected, the device components will not align properly, resulting in failure of pAVF creation.

Finally, on occasion, the magnets on the arterial and venous components can fail to appose adequately for deployment due to vessel curvature, proximal location of creation, or rarely, stiff atherosclerotic vasculature. This can usually be corrected by either squeezing the forearm to manually coapt the catheters, changing the vein selected for creation (medial vs lateral), or by moving the location of pAVF creation further down the arm. The new-generation 4-F WavelinQ system reportedly has more flexible catheters and a new rotational indicator location, which will hopefully address some of these issues.

### What is your standard follow-up protocol for a pAVF? Does this differ from surgically created AVF or other means?

**Dr. Tan:** Patients return to the clinic for postprocedure follow-up and ultrasound imaging at 2 weeks and again at 4 to 6 weeks. The 2-week ultrasound is crucial for identifying patients who may need additional interventions to facilitate maturation. Any additional follow-up is then tailored to an individual's needs. Although I don't do surgical fistulas, I believe this follow-up protocol is generally similar.

**Dr. Dolmatch:** We see our patients 1 week after pAVF creation and again a few weeks later as they approach the time for cannulation. Because we have a high-quality ultrasound unit in our clinic, we look at the pAVF during the visit. Volume flow can be derived from the diameter and flow velocity in the pAVF and inflow artery. If there are questions regarding flow, we have a noninvasive vascular lab around the corner from our clinic and refer patients for a more thorough study.

**Dr. Mawla:** The first follow-up visit is usually 2 weeks postoperatively, but postoperative flow rates < 400 mL/min are seen after 1 week. They are then followed by monthly visits until the AVF is mature and cleared for use. If any subsequent flows drop or if significant flow is seen in the brachial veins during the maturation phase, then intervention is usually planned.

**Dr. Steinke:** Initially, we checked patients on the first postoperative day and again after 2, 4, and 6 weeks with ultrasound. After review, we have now changed our practice and only check the patients immediately postoperatively and again after 4 weeks. The remaining controls are done by the nephrologists, and we only see the patients again for special questions or in case of nonmaturation.

**Dr. Mallios:** Initially, we would see the patients 3 to 4 days after creation. As we have become more confident with the procedure and our results are improving with more experience, we follow surgical and percutaneous AVF the same way. The difference is that a surgical AVF needs wound care for a couple of weeks, but for pAVF, the dressing is removed on day 1 postprocedure and you are done. So, patients with pAVFs will be seen at 1 week, 4 weeks, and then at 2 to 3 or 6 months after the procedure depending on whether the patient is predialysis and if the AVF is maturing.

### When do you typically aim to cannulate, and what factors will affect whether you do?

**Dr. Mawla:** Maturation depends on flow values and sizes. We wait until the cannulation zones are 5 mm in diameter, but dual outflow vessels tend to dilate slower. For a single-vessel outflow (endo-cephalic or endo-basilic), we aim for > 500 mL/min flow, but for dual outflows, we aim for > 700 mL/min for split cannulation. We plan for cannulation around 10 to 12 weeks, but if parameters are met sooner, then we can cannulate sooner.

**Dr. Mallios:** We aim for pAVF to be usable at 4 to 6 weeks postcreation, but it is possible to puncture them earlier in about 10% of patients and as early as the first week for a few of them. On physical exam and with a tourniquet, the patient is a candidate for cannulation if the target vein is palpable and there is a good thrill. Under ultrasound, this usually correlates to the typical 6-6-6 criteria of the Kidney Disease Outcomes Quality Initiative guidelines.

**Dr. Dolmatch:** Cannulation starts around 2 months after pAVF creation for us. Assessment of the size and depth of the vein are key parameters, as well as any palpable features of the pAVF. Although the flow volume in the vein is important, it's more important that the vein can be reliably cannulated and the flow is adequate for sufficient clearance during hemodialysis. To assure successful cannulation, a clinical support representative from industry goes to the dialysis unit when the patient is first cannulated to work with the staff and assure non-traumatic cannulation. On occasion, a physician will also go to the dialysis unit to assist with cannulation. If there are any issues, further clinical support may be needed at the dialysis unit or the patient may be referred back to us for examination with/without a duplex ultrasound study. Cannulation of a pAVF is entirely new for the dialysis personnel, and instruction for cannulation is essential.

**Dr. Tan:** The earliest a WavelinQ pAVF can be cannulated is 4 weeks, with some requiring longer to mature. What I look for on ultrasound is a flow volume of at least 500 mL/min, vessel diameter > 4 mm, and depth < 6 mm from the skin surface. If these parameters are met, I will recommend attempted cannulation. If a patient has an existing catheter, there is an option to initiate single-needle cannulation, which can facilitate further AVF maturation and allow progression to two-needle cannulation over time. However, there are some nuances to flow rates for cannulation that I discuss in a subsequent answer.

### Do you have any tips for training others on staff to cannulate?

**Dr. Dolmatch:** As mentioned in the preceding question, instruction and observation of cannulation at the dialysis unit is critical. Cannulators are typically uncertain about where to cannulate because the landmarks of a surgically created AVF are absent. A downstream tourniquet is helpful. Cannulation of the median cubital vein (or median cephalic or basilic veins) at the antecubital fossa is nontraditional but a very good place for cannulation of a pAVF because the vein is typically easy to identify, often superficial, and palpable due to higher pressure (closer to the pAVF).

**Dr. Mallios:** Communication between the physician and the dialysis center is imperative. Because there is no scar to indicate the fistula location (unless a transposition was performed), the physician should mark the fistula outflow with a permanent marker (include suggested needle sites). The dialysis center should always use a tourniquet to engorge the fistula because manual compression won't work if there are multiple outflow veins. Additionally, the use of ultrasound to help visualize the target vessel and plastic cannulas decrease the chance of injury to the vessel.

**Dr. Tan:** I work closely with a WavelinQ clinical specialist who supports all of my pAVF cases and follows all patients through to cannulation. When a patient is ready for cannulation, the clinical specialist travels to the dialysis center to provide pAVF education and patient-specific cannulation training. This hands-on training is provided until the dialysis center is confident with the patient's anatomy and cannulation options. The clinical specialist then continues to be accessible to the dialysis center on an as-needed basis.

The cannulation technique is no different from any surgical fistula, but the lack of surgical scars can cause confusion about the anatomy and fistula type, especially if that particular dialysis center has no prior pAVF experience. Additionally, the location of the pAVF in the forearm

is associated with lower flow volumes than upper arm surgical fistulas, which is great for combating aneurysm formation and steal syndrome issues but can result in a less prominent cannulation vein that is softer to palpation. Tourniquet application and/or gentle clamp compression of the nontarget superficial vein can significantly improve palpation of the vein targeted for cannulation.

Some patients will also have split venous outflow between the basilic and cephalic veins, creating options for dialysis needle placement in either the basilic vein, cephalic vein, or one in each. Split outflow is beneficial because it allows for needle rotation, which can prevent skin thinning, aneurysm formation, and fistula fatigue, ultimately prolonging the life of the fistula.

**Dr. Mawla:** There are a few things to consider about cannulation. Cannulation zones are at or near the cubital fossa, so the location itself is novel for many. A tourniquet is a must, due to the multi-outflow system. Inspect and feel the vessels because a visual inspection can be misleading. Ultrasound is helpful not only in localizing the cannulation zone but also in showing how superficial the vessel travels. Planning a shallow angle of entry and a shorter needle (3/5 inch) will help prevent through-and-through trauma. There is definitely a learning curve, so extra patience and education are needed.

### How do you define and determine adequate flow?

**Dr. Tan:** Target flow volume to attempt cannulation is 400 to 500 mL/min as measured by ultrasound, noting that ultrasound measurements may be off by as much as 30%. A flow volume > 500 mL/min is important for function of the "arterial" cannulation needle, but for the "venous" cannulation needle, a flow volume of only > 300 mL/min is required. This can expand options for needle rotation and successful two-needle cannulation in patients with split venous outflow but uneven flow volumes.

**Dr. Steinke:** Adequate flow means that two needles can be used to dialyze with a sufficient flow volume of at least 600 mL/min. Blood pump speeds vary from country to country and may affect AVFs. In the United States, blood pump speeds are often in the 400- to 450-mL/min range, whereas in Australia, Japan, and Europe, blood pump speeds tend to be lower, often just 250 to 300 mL/min.

In my view, the higher flow rates that are common in the United States are mainly used to allow for shorter dialysis, perhaps for economic reasons. But, there are data suggesting that shorter treatments are linked with worse overall outcomes. The other question is: Can higher blood pump speeds—on their own—harm an AVF?

Shared flow (more than one outflow vessel) in endoAVFs may favor the durability of this type of AV access because the lower blood flow rate may facilitate the maintenance of the AVF, which has been observed in Japan for classical surgical fistulas (using a lower pump speed and creating more distal radiocephalic AV fistulas, which are known to have a lower AV access flow).

**Dr. Mallios:** The brachial artery should have a flow between 500 and 700 mL/min to provide adequate flow for dialysis. This can be split between cephalic and basilic veins that can be used at the elbow crease with plastic cannulas. If this is a problem, we can always do a tiny incision and ligate the median cubital vein to prioritize flow to the cephalic vein if needed.

**Dr. Mawla:** Flows of 500 mL/min are the baseline threshold. This value is sufficient for a single outflow (endo-cephalic or endo-basilic). Dual-outflow fistula cannulation tends to be more problematic, so we prefer flows > 700 mL/min. If the brachial veins take a considerable amount of flow, then we will consider coil embolization as well.

**Dr. Dolmatch:** A duplex ultrasound study of the arterial inflow is not that useful because there is usually dual venous outflow from a pAVF. Therefore, duplex flow studies of the dominant cannulation veins (cephalic vein and basilic vein in the upper arm) should be performed. However, the calculated flow volume from the duplex study may not be directly related to the ability of a pAVF to sustain adequate flow for successful hemodialysis. More work needs to be done to better define “inadequate” flow volumes in a pAVF.

### What do you do if the fistula doesn't flow well enough?

**Dr. Steinke:** For me, this is one of the most interesting questions. Currently, you won't find a widely accepted standard of care, and I believe there are two reasons for this. First, there are only a few centers performing a high number of cases. Second, there might be a bias to favor the new percutaneous procedure. For example, a podium talk noted that there are no complications or reinterventions in endoAVF. Yet, in talking to experienced colleagues, we discovered a typical phenomenon for both endoAVF procedures on the market, which we would call a “juxta-anastomotic stenosis equivalent.” This occurs near or only a few centimeters downstream from the anastomotic site and can be treated successfully with PTA, high-pressure PTA, or even by using a drug-coated balloon.

If the attempt of a balloon-assisted maturation fails, there are still surgical options available. A surgical revision dissecting the anastomotic site and creating a Gracz AVF is challenging but allows both superficial veins to mature. In situations of a basilic dominant outflow, the endoAVF can be left in place and an additional side-to-side anastomosis can be created at the level of the elbow during the elevation procedure. In this case, the basilic vein is ideally situated to the brachial artery and an additional anastomosis located there does not hinder later use.

By using the WavelinQ system, you accept a multiple outflow situation that can rarely lead to a venous hypertension and mild swelling of the forearm. Coil embolization is beneficial in most cases. If this side branch perfusion results in a nonmaturation, the treatment is the same. Only in circumstances with uncontrollable swelling (rarely due to demasking of a previously undetected central venous stenosis because of an increasing shunt volume), abandoning of the endoAVF may be necessary. This should primarily be achieved with intervention from the arterial or the venous side by implanting a stent graft. In some cases, the anastomosis develops a clinically relevant pseudoaneurysm, which needs to be repaired.

**Dr. Dolmatch:** It begs the question of how inadequate flow has been determined. If it's based on physical exam or duplex flow calculations, then further duplex ultrasound imaging may give some insight. If the flow isn't adequate for hemodialysis, then the patient is taken to the angio suite to define the issue(s) and possibly correct the problem.

Inadequate flow for hemodialysis can be due to many factors, including preferential flow into the deep (brachial) veins, small diameter of the arterial-venous communication, small cannulation vein, underlying stenosis that wasn't recognized before or developed after pAVF creation, arterial inflow obstruction, suboptimal position of the cannulation needles during attempted dialysis, or even erroneous duplex flow calculations. Each of these problems has a group of approaches that can improve flow, such as PTA, coil embolization, training at the dialysis unit, intraprocedural flow measurements, balloon-assisted maturation, accessory vein ligation, banding, surgical revision, and so on.

**Dr. Tan:** Low flow volumes can be due to many different factors after pAVF creation, and ultrasound examination is usually sufficient to identify the causes. First, the artery should be assessed to ensure adequate inflow. Next, all the possible outflow veins are studied. If blood is not traveling via the desired basilic and cephalic veins, what alternate path has been found to return to the heart?

The most common culprit is the paired brachial vein that remains uncoiled. Less commonly, other collateral veins such as recurrent veins can divert flow. Coil embolization of these vessels can significantly improve flow rates in the target superficial veins.

Another unique, noninvasive method of encouraging maturation is to use a gentle clamp to compress the nontarget superficial upper arm vein for 1 hour, one to two times a day. Clamping the nontarget superficial vein forces blood to reroute through the target superficial vein, which can “train” it to naturally become more dominant. This inexpensive clamp can also be used during dialysis cannulation to temporarily increase flow during treatment.

**Dr. Mallios:** Our algorithm of maintenance for pAVF has been recently published in the *Journal of Vascular Surgery*.<sup>1</sup> All of our maintenance procedures are performed under ultrasound only, and in most cases, distal radial artery access is adequate to complete all cases. PTA of the perforating vein with a 6-mm balloon is the most frequent intervention. If this is not enough, PTA can be performed on the preanastomotic artery with a 4-mm balloon. Banding or ligation of the median cubital vein or the brachial vein can be considered when the cephalic vein is difficult to puncture and ultrasound-guided puncture is not an option.

**Dr. Mawla:** We perform maturation procedures if the flows or sizes are below target, and this usually occurs around 6 to 10 weeks. Angioplasty can be at the anastomosis, the deep veins, perforating vein, and/or the cubital outflow veins. Coil embolization may be needed if a significant component of the flow is seen in the brachial veins. These procedures are via arterial access at the wrist, either the ulnar artery or distal radial artery, depending on the endo-anastomosis. This has consistently been the easiest way to image and access all locations of the endoAVF, particularly the deep vessels.

### What were some of the initial hurdles in initiating a pAVF practice?

**Dr. Mawla:** Our initial challenges were more logistical. We needed to manage a workflow to incorporate AVF screenings, creations, and follow-ups into a relatively busy schedule in our ambulatory surgical center. Learning how to set up the room and equipment for optimal efficiency was another curve. The other hurdle was cannulation education of the access, with patients scattered all across the metroplex in a large number of units.

**Dr. Mallios:** As with anything new, the biggest challenge is people’s habits, and unfortunately dialysis units,

nephrologists, and nurses are often used to and prefer high-flow aneurysmal fistulas because they are easier to puncture in the short term. Also, a challenge was the idea of a “distal” fistula creation at all costs for all patients, without taking into consideration that patients with distal AVFs frequently require reinterventions and eventually end up with an elbow fistula or a catheter.

**Dr. Dolmatch:** We are not yet over the hurdles, and “initial” hurdles persist! As an interventional radiologist (IR), the first hurdle is to accept pAVF as one component in a dedicated approach for caring for patients who require renal replacement. pAVF is not a procedure, but rather a method that should be part of a complete approach to the patient. The hurdle is that historically, many IRs have not thought very much about creating useful AV dialysis access but instead focused on maintaining and salvaging surgically created hemodialysis access circuits. To apply pAVF technology, IRs need to think beyond their historical role and consider the patient’s perspective as well as the nephrologist’s and surgeon’s views.

The second hurdle is the development of referrals. IRs are at a disadvantage because we have never had the role of creating AV access. Working with nephrologists means that IRs need to understand their concerns, provide insight to the advantages of pAVF, and effectively communicate as part of a team. Nephrologists have a long-term commitment to their end-stage renal disease (ESRD) patients, whereas IRs have traditionally had a spot-welding approach to care—only seeing ESRD patients when something is broken. If IRs remain spot welders, it’s likely that nephrologists will continue to refer ESRD patients to surgeons for surgical hemodialysis access. We hold educational sessions with our nephrologists and surgeons and communicate our pAVF successes and failures with them. We as IRs handle problems and failures, ensure successful cannulation, and manage pAVF issues until the pAVF is successful; if the pAVF isn’t suitable, we refer the patient until a new access has been established.

The final major hurdle is thinking like a surgeon and referring to a surgeon when necessary. IRs need to understand vascular anatomy for AV access creation and refer for surgical creation when it’s not suitable for pAVF. IRs also need to be prepared for failure. Up to 60% of surgically created AVFs are not ready for cannulation at 4 to 5 months, and many of them will be abandoned. Surgeons who create hemodialysis access recognize this and live with it. During the early phase of a pAVF program, failures are expected, and you have to be ready to recognize, accept, and manage them. It can be frustrating, but that’s part of hemodialysis access creation.

**Dr. Steinke:** In this context, the framework conditions of national health systems must be considered—in particular, the financing of this new endovascular procedure over traditional surgical approaches. Furthermore, rivalries between competing specialties or the lack of acceptance of the technology among local nephrologists can hamper its application and widespread use. Limited operating room resources or restricted angio suite capacity and an initial learning curve with extended operating times can be obstacles.

**Dr. Tan:** The first hurdle encountered was the lengthy process to obtain institutional approval to onboard a new device. This is very variable between institutions, but if the process is long, it's important to use that wait time to focus on other aspects of practice development. We used this time to start notifying potential referring physicians of the new procedure, provide education, and work together to develop a plan to incorporate this procedure into the existing dialysis patient algorithm.

As with any new service line, identifying and growing a referral base is a complicated process but extremely important to the success of your practice. Unfortunately, there is no standard outline for this that easily applies to every clinical setting. As an IR, I had to integrate our services into the working relationship that already existed between the nephrologists and surgeons. Fortunately, we had a well-established collaborative relationship with our core group of referring physicians on which we are able to build.

The most time-intensive and rewarding part of building a pAVF practice has been continuously providing outreach to other physicians and patients about the availability of this procedure, creating ongoing opportunities for education to a wide array of clinical services, and ensuring that I am always available for questions and consultations.

### Finally, has your approach to access selection and the use of pAVF in particular changed in the initial time since the coronavirus began affecting your region?

**Dr. Mawla:** Not significantly. We recognize access work as essential, not elective. We also recognize the risk of prolonged catheter usage. So, we continue to schedule and perform pAVF creations with the coronavirus screening protocols established for all patients at our ambulatory surgical center.

**Dr. Steinke:** For basic therapy decisions, the answer for my clinic is a clear “no.” I personally feel that patients' needs should not be put aside during the pandemic. For

a dialysis patient, a functioning AV access is vital for survival. Most procedures can be done with local or regional anesthesia not requiring ventilators. Fortunately, we have sufficient resources in the German health care system so that the care of ESRD patients can continue at a high level. However, regarding the pAVF system, I have to say that these have only been rarely indicated. The limited time resources in the remaining surgical and interventional facilities have been reserved for methods that can be planned precisely and calculated well in terms of time and resources.

**Dr. Dolmatch:** The timeline for pAVF has been somewhat pushed out due to hospital policy that has restricted these cases for fear of outstripping resources that may be needed for pandemic care, as well as exposing the ESRD patients to potential viral risk. But, for better or worse, our ESRD pAVF referrals remain slow, and we can typically do video visits, send patients for outpatient vascular mapping, and anticipate a future date for creating a pAVF while the patient has renal replacement via a functioning hemodialysis catheter or is (slowly) progressing toward renal replacement without a catheter.

**Dr. Tan:** There has been a slight decline in patient referrals during the time of coronavirus, as providers are delaying initiation of dialysis access creation as long as possible to avoid exposure risk to their patients. I am also seeing more delay in postprocedural follow-ups because patients have either traveled out of the area to stay with family or are understandably nervous about venturing out of their homes. This can result in delaying identification of those who need postprocedure interventions to facilitate maturation. However, I have not altered my candidacy evaluation process or access recommendations and continue to prioritize dialysis patients and interventions during the coronavirus pandemic.

**Dr. Mallios:** Elective cases of all types of procedures were canceled in France to make space for COVID patients and avoid having intensive care unit beds occupied. Unfortunately, we don't have outpatient procedure centers in France as they do in the United States. If that were the case, pAVF creation would be definitely a great solution because it is minimally invasive, does not require a hospital setting, and would help avoid unnecessary delays for getting patients a good access and avoid long catheter times. ■

1. Mallios A, Bourquelot P, Franco G, et al. Mid-term results of percutaneous arteriovenous fistula creation with the Ellipsys vascular access system, technical recommendations and an algorithm for maintenance. *J Vasc Surg.* Published online April 7, 2020. doi: 10.1016/j.jvs.2020.02.048