# A Stepwise Approach to Percutaneous AVF Candidacy and Decisions

Planning is the fundamental step for pAVF success.

**By Robert Shahverdyan, MD**

With the emergence of two percutaneous arteriovenous fistula (pAVF) devices several years ago, new opportunities for the creation of a native (and hopefully long lasting) dialysis access became available not only for surgeons but also for interventional nephrologists and interventional radiologists. Several essential steps are important to consider for successful pAVF creation and utilization, especially for those who have not previously created a vascular access. In my experience, those steps are (1) planning (ie, ultrasound mapping); (2) creation of the pAVF; (3) close surveillance and maintenance, if necessary, including planned or unplanned secondary interventions; and (4) successful cannulation of the pAVF. However, planning is one of the most fundamental steps for pAVF success and includes a thorough understanding of the vasculature of the upper extremities, specifically the arterial as well as the superficial and deep venous anatomy, and vessel mapping using ultrasound.

## AN OVERVIEW OF THE AVAILABLE pAVF SYSTEMS

Although both Ellipsys (Medtronic) and WavelinQ (BD Interventional) have undergone some modifications in recent years, both still require specific anatomic inclusion and exclusion criteria for a successful procedure and outcome. Generally, candidacy for a pAVF does not differ much from a surgically created AVF (eg, intact arterial system with triphasic flow and unobstructed peripheral and central venous outflow). Similarly, patients should have adequate left and right ventricular function and either a predialysis chronic kidney disease, a requirement for hemodialysis, or a requirement for apheresis.

Moreover, both pAVF systems use the perforator vein at the proximal forearm for successful transition of AVF flow from the endovascularly created arteriovenous anastomosis to the superficial target veins of the upper arms. Each pAVF system creates an anastomosis at slightly different locations, with different catheters, and by different means. There are not only significant dissimilarities in how and where to create the anastomosis but also in how to advance the catheter(s) of each pAVF system to the anastomosis creation site. Similar for both pAVF systems is that all patients considered for pAVF require the perforator vein and at least one suitable outflow vein (upper arm cephalic and/or basilic) with inner diameters of ≥ 2 mm using tourniquet. For both pAVF systems, the specific anatomy is required in addition to common anatomic inclusion criteria. The only specific exclusion criteria are not meeting the anatomically suitable vessel requirements according to the inclusion criteria (completely or even partially).

### Tips for pAVF Creation With WavelinQ

The 4-F WavelinQ system uses two catheters (venous with an electrode and arterial with a ceramic saddle/backstop) and radiofrequency energy to create the anastomosis between either the proximal radial artery and radial vein or the proximal ulnar artery (also known as the ulnar trunk) and ulnar vein. The location of the anastomosis should be as close as possible to the perforator vein, peripherally rather than cranially, so that the blood flow is directed through the perforator vein into the superficial upper arm vein(s). This can be supported by intraprocedural coil embolization of a dominant outflow brachial vein, which leads to increased resistance and improves superficial vein flow. We do not recommend coil embolization of several brachial veins and/or their branches because it can lead to negative short- or long-term outcomes (eg, increased venous congestion of the arm if peripheral venous outflow stenosis or occlusion occurs). Generally, our experience shows that both the lateral radial and ulnar veins are the more commonly suitable for the anastomosis location due to their communication with the perforator vein.

The inclusion criteria for WavelinQ pAVF are a proximal radial artery or ulnar trunk and accompanying vein with an inner diameter ≥ 2 mm using a tourniquet, < 1-mm distance between the artery and the to-be-anastomosed vein (the anastomosis is not fused at the time of the creation, hence a higher risk of extravasation and pseudoaneurysm if the distance between the vessels is > 1 mm), and access vessels for both arterial and venous catheters suitable to accommodate a 4-F device (ie, ≥ 1.5-mm diameter). Depending on the site of anastomosis creation, the access vessel options are mid to distal brachial, distal radial, or distal ulnar arteries and veins. Either parallel (both catheters introduced from the same distal or proximal site) or antiparallel (one catheter introduced from the proximal site and the other from the distal) approaches are possible when the anatomy is suitable. The access site vessels must directly communicate with the vessels at the site of the planned anastomosis creation to advance them parallel, align successfully, and create the anastomosis.

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to watch the accompanying video.

**Tips for pAVF Creation With Ellipsys**

With the Ellipsys system, the anastomosis is created exactly at the level of the perforator vein between the vein and proximal radial artery using a single catheter and thermal energy, leading to direct and mostly dominant outflow through the perforator vein into the superficial upper arm vein(s). The location of an Ellipsys anastomosis is slightly cranial than that of a WavelinQ-created anastomosis, making it possible to create an Ellipsys pAVF after a WavelinQ pAVF.

For successful Ellipsys pAVF creation, the perforator vein should be as straight as possible. With more experience, it is possible to guide the needle from the access site (median or lateral cubital vein 4-5 cm cranially to the expected anastomosis creation site) through the perforator vein to the proximal radial artery. For the first five to 10 cases, we recommend performing the procedure in patients with straighter perforator veins. The distance between the proximal radial artery and perforator vein should be ≤ 1.5 mm to avoid extravasation.

## OUR ULTRASOUND MAPPING ALGORITHM

As previously noted, preoperative ultrasound assessment of every upper arm artery and vein is crucial for planning a pAVF (or any vascular access). At our vascular access center, we have established an ultrasound mapping algorithm that includes complete mapping of the arterial and venous systems of the upper extremities and should make planning easier. It includes both surgical and pAVF considerations. The mapping algorithm is based on my extensive experience of several years and > 1,000 mapping cases, with planning and creation of both surgical AVF and pAVF, and it represents my experience only. It shouldn't be necessarily identically adopted by everyone, and an individual approach to successful mapping should be customized by each interventionalist/surgeon if the outcomes are successful. I would strongly recommend that present and future adopters of pAVF systems perform the vessel mapping themselves and in a standardized manner (see video online).

After initial examination (bilateral blood pressure, palpable pulses, and Allen/Barbeau test), we start with the superficial veins. First, we identify upper arm options. Starting from the proximal upper arm cephalic vein to the elbow and proceeding to the median cubital vein (if available) to the basilic vein gives us an idea of which upper arm outflow vein(s) are available and suitable (ie, ≥ 2 mm inner diameter). Then, the perforator vein is identified. If not available or if < 2 mm in diameter, both pAVF systems can be excluded instantly. If the perforator vein is suitable for a surgical Gracz-type fistula, we assess suitability for an Ellipsys pAVF by identifying the possible tortuosity of the perforator vein and measuring the proximal radial artery (≥ 2 mm) and the distance between the two (≤ 1.5 mm). At this stage, we can include/exclude the possibility of creating an Ellipsys pAVF. It can also be easily identified whether a lateral or medial cubital access is necessary for the procedure.

After determining suitability of the forearm cephalic vein for a possible radial-cephalic fistula, we proceed to the arterial and deep venous system. Simultaneous mapping would help us recognize arterial pathologies, as well as identify possible access sites for the WavelinQ catheters. Importantly, it is necessary to identify a possible high axillary artery bifurcation (for future flow measurements, secondary interventions, etc).

At the level of the proximal radial artery, we then evaluate the size, distance between the artery/vein, course of the radial veins compared to the artery (tortuous, straight, spiral), and junction of the perforator vein into the radial vein(s). The size of the vessels should be ≥ 2 mm from the suitable radial vein at the site of the anastomosis creation into the perforator and outflow vein. If the anastomosis can be created between the radial artery/vein, we then proceed to the wrist and evaluate both the radial artery and selected radial vein for the possibility of access from the wrist. If radial anastomosis is not possible, evaluation of the distal radial veins is unnecessary.

Next, we evaluate the ulnar anastomosis site, which is the most challenging in my experience but is important for creation of an ulnar WavelinQ pAVF. First, we evaluate the ulnar trunk, accompanying ulnar veins, distance between the artery and the vein, and ulnar-to-perforator vein bridge. Similarly, the size of the vessels should be ≥ 2 mm from the suitable ulnar vein at the site of anastomosis creation into the perforator and outflow vein. For the ulnar region, a combination of transverse and longitudinal views can sometimes be helpful to better evaluate the anatomy. Again, if the anastomosis can be created between the ulnar trunk/ulnar vein, we then proceed to the wrist and evaluate both the ulnar artery and selected ulnar vein for the possibility of access from the wrist. If ulnar anastomosis is not possible, evaluation of the distal ulnar veins is unnecessary.

It is important to note that both the radial and ulnar veins might have a spiral course around the artery, so in some cases, it is possible to access the medial/lateral vein at the wrist but reach the contralateral (lateral/medial) vein at the site of the anastomosis. Therefore, complete evaluation of the course of the deep veins is strongly recommended—from the wrist to the anastomosis creation site.

Lastly, we again evaluate the access options from the brachial artery/veins as plan B, in case the wrist access is not feasible or is unsuccessful during the procedure.

## OUR VASCULAR ACCESS CREATION ALGORITHM

How do the pAVFs fit into the vascular access creation algorithm? Based on a patient's individual dialysis and end-stage kidney disease life-plan, the first choice is generally a distal forearm surgical AVF, starting in the snuffbox location. If radial-cephalic AVF is not possible, ulnar-basilic AVF is rarely the possible next choice. The next consideration is a proximal forearm AVF option. Here, due to the location of the anastomoses, we consider a WavelinQ pAVF first and then Ellipsys pAVF. The next choice in the sequence plan is a proximal forearm surgical AVF, such as the typical or modified Gracz-type AVF, generally if pAVF is anatomically not feasible or has failed. If no proximal forearm options are available, we then proceed to the upper arm for brachial-cephalic and then brachial-basilic AVFs, which is rare because > 80% of our patient population have a suitable perforator vein and are candidates for either a pAVF or a Gracz-type AVF.

## CONCLUSION

By applying the distal to proximal approach, the choice for percutaneous vascular access, which is always individually based, is typically considered at our vascular access center when a radial-cephalic AVF is not possible or not wished by the patient, which happens very rarely. The aforementioned anatomic inclusion criteria are always considered. ■

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